Fundamentals of Nursing Pharmacology - 2nd Canadian Edition

Fundamentals of Nursing Pharmacology - 2nd Canadian Edition

A Conceptual Approach

ANDREA SULLIVAN DEGENHARDT

THOMPSON RIVERS UNIVERSITY, OPEN PRESS
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Fundamentals of Nursing Pharmacology: A Conceptual Approach – 2nd Canadian Edition
Adapted by Andrea Sullivan Degenhardt, Thompson Rivers University

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This edition includes revisions to reflect Canadian nursing practice,

updated pharmacological knowledge, accessibility improvements, and enhanced learning supports.

Recommended Citation (APA 7th Edition)

Degenhardt, A. S. (2026). *Fundamentals of nursing pharmacology: A conceptual approach* (2nd Canadian ed.). Thompson Rivers University, TRU Open Press. https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/

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This book was produced with Pressbooks (https://pressbooks.com) and rendered with Prince.

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Acknowledgements

This 2nd Canadian Edition of *Fundamentals of Nursing Pharmacology: A Conceptual Approach* was adapted by Andrea Sullivan Degenhardt at Thompson Rivers University and published through TRU Open Press.

This work builds upon the *1st Canadian Edition*, developed by the British Columbia Institute of Technology Nursing Faculty (Amanda Egert, Kimberly Lee, and Manu Gill) with support from BCcampus Open Education, and the original work created by Chippewa Valley Technical College The first edition of Open RN *Nursing Pharmacology* won an Award for Excellence from OE Global in 2020. For more information about the award, visit the 2020 OE Awards for Excellence site. We gratefully acknowledge the foundational contributions of these authors and institutions, whose commitment to open education has made this work possible.

Updates in the Second Edition

This edition has been revised and expanded to better reflect Canadian nursing practice, current evidence-based pharmacological knowledge, and accessible, student-centered learning design. Updates include revised and current medication information with an expanded mechanism of action and nursing consideration sections that provides more robust and detailed information. There are more interactive and multimedia learning supports within each chapter, including more diagrams, videos and H5P learning activities. There is the addition of a Pain Management virtual simulation learning activity at the end of the Pain and Mobility chapter to assist learners in consolidating their learning. Lastly, two additional chapters were added: Chapter 3 Medication

Safety: preventing medication errors and Chapter 11 Endocrine System Oral Anti-diabetic Medications.

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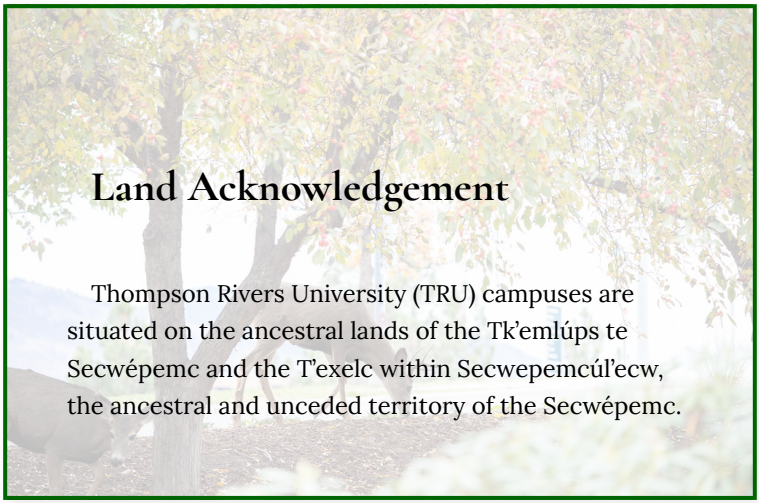

The rich tapestry of this land also encompasses the territories of the St'át'imc, Nlaka'pamux, Tŝilhqot'in, Nuxalk, and Dakelh. Recognizing the deep histories and ongoing presence of these Indigenous peoples, we express gratitude for the wisdom held by this land. TRU is dedicated to fostering an inclusive and respectful environment, valuing education as a shared journey. TRU Open Press, inspired by collaborative learning on this land, upholds open principles and accessible education, nurturing respectful, reciprocal relationships through the shared exchange of knowledge across generations and communities.

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This project reflects a collaborative effort involving faculty authors, student contributors, research assistants, editors, and production specialists. It is part of a broader commitment to making education more accessible, inclusive, and responsive to the needs of learners.

Preface

About the Book

This textbook is the second Canadian edition of the open access Nursing Pharmacology. It builds on the work by previous editions which have laid an invaluable foundation for this current edition. This is a free open educational resource with CC-BY 4.0 licensing.

This textbook is designed specifically for the entry-level undergraduate nursing students. It is also applicable to other health disciplines for use. It provides a fundamental understanding of the mechanism of action of different drug classes and their therapeutic uses, with a focus on nursing considerations. Each chapter begins with an overview of the physiology of that body system and then common health issues, which is then followed by the drug classifications. Each chapter has interactive activities at the end of each unit, and then clinical judgement and decision-making questions to help consolidate the learner's understanding.

This book is not intended to be used as a drug reference guide in the practice setting, as drug information is always changing. Nurses should always consult current evidence-based resources to review current recommendations before administering specific medication.

About the Author

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Andrea (Sullivan) Degenhardt is an Associate Teaching Professor in the School of Nursing at Thompson Rivers University (TRU) situated in Kamloops, BC Canada. She considers herself a lifelong

learner, with a passion for evidence-based practice in the acute care setting. Her nursing career has focused on adult intensive care and emergency care nursing, as well as home health nursing, before transitioning into teaching undergraduate BScN students. Her teaching has focused on pharmacology, assessment skills, simulation throughout the BScN program, acute medical-cardiac practice and preceptorship.

Notable Contributors for this Edition

Two research assistants have assisted in the creation of this textbook. Cheltey Berlinguette and Sheila Odubote, both third year TRU BScN nursing students, have contributed in creating the interactive learning activities in each chapter, creating some of the diagrams and providing an invaluable student perspective. It was a pleasure working with both of them.

Christina Hamaguchi, Assistant Teaching Professor in the School of Nursing at Thompson Rivers University, has contributed to the Cognition and Mood chapter with clinical reasoning questions. As an expert in mental health nursing, her contributions were invaluable in creating realistic questions to promote nursing practice in the mental health setting.

I would also like to thank Dr. Tracy Christianson with the TRU School of Nursing for her support and guidance in taking on this project.

This textbook would not have happened without the incredible support from TRUs Open Press team.

Content Reviewer

Steven Ross, Associate Teaching Professor in the School of Nursing

at Thompson Rivers University. Steve was able to make important contributions and provide a critical lens with his review of the content.

Student Reviewers

This textbook is for students, and the student perspective of the usability and accessibility of this textbook is invaluable. Thank you to the following BScN students who supported the textbook by completing two reviews and providing their perspectives: Shadi Arab, Denise Chicas, Maria Dimatulac, Heather Girodat and Ime Stavinga.

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That said, accessibility has been an important consideration in this 2nd Canadian Edition. Improvements have been made where possible, particularly in areas such as structure, navigation, and readability. We also recognize that some barriers remain and are committed to addressing these over time.

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- Some **H5P interactive activities** may not fully meet accessibility standards, particularly those that include multimedia content
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- Pharmacology – Diabetes Medication by A. Hasudungan (2016)
- How Antiviral Drugs Work: The Virus Lifecycle by High Impact (2021)
- Psychosis (Schizophrenia) | Mental State Examination (MSE) | OSCE Guide | SCA Case | UKMLA | CPSA by Geeky Medics (2023)

Potential Future Improvements

Future updates may include:

- Adding and refining **alternative text descriptions**
- Improving **captioning and transcripts** for multimedia content
- Enhancing the accessibility of **interactive activities**
- Reviewing content against current accessibility standards (e.g., WCAG)

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CHAPTER 1 - INTRODUCTION TO PHARMACOLOGY

1.0 Introduction to Pharmacology

Learning Objectives

1. Identify and describe the processes of pharmacokinetics.
2. Apply principles of evidence-based practice to identify pertinent information related to drugs.
3. Consider pharmacodynamic differences across the lifespan.
4. Differentiate among prescription drugs, over-the-counter drugs, herbals, and dietary supplements.

Introduction

To be able to administer medications safely and effectively, registered nurses require specific knowledge, skill, and judgment to ensure safe, client-centred care. To provide this safe care, nurses need a strong foundation in pharmacology, which can be defined as "the study of drugs and their interactions with living systems" (Burcham & Rosenthal, 2019), which includes learning about:

- the physical and chemical properties of drugs;
- how the drug works in the body;

- the uses of drugs for different health conditions;
- the intended and adverse effects;
- drug interactions; and
- important assessments and monitoring following administration.

The topic of pharmacology is expansive, with thousands of medications available, not including combination formulas and natural health products (Government of Canada, 2015), and each have their own therapeutic applications and characteristics. As such, this text will focus on what information is clinically relevant for nurses by learning about different medication classifications, key information about each med, and nursing considerations for safe medication administration.

Is It a Drug or a Medication?

These two terms are often used interchangeably, but they have distinct definitions. A drug is a chemical agent that is capable of producing a biological response within the body (Adams et al., 2018). A drug is considered a medication if it is medically therapeutic. This definition excludes food and other agents such as cosmetics. In most of the literature and in this text, you will see drug and medication both used and sometimes interchangeably.

The Ideal Medication

If you were developing a new medication, what would be important characteristics? You will likely consider a medication that is safe (no harmful effects to the client), effective (achieves intended therapeutic outcomes most of the time), and selective (does exactly

what it is intended to do and nothing else). Other qualities you might consider would be whether the medication is easily accessible, inexpensive, convenient, or fast acting with no drug interactions. These qualities would be ideal, but unfortunately, no medication has all these characteristics. No medication is 100% effective all the time with no negative effects. All medications have the potential to produce harmful effects regardless if they are used correctly or incorrectly. For example, if a prescriber fails to account for individual factors such as renal or hepatic function, or prescribes a larger dose, this can increase the risk of toxicity or adverse effects. Sometimes, medications prescribed are used correctly but have a different effect than what was expected (adverse reactions or idiosyncratic reactions). Some medications are over-the-counter (OTC), making them highly accessible and inexpensive but open to incorrect usage. For example, Ibuprofen is a highly effective pain reliever and anti-inflammatory. However, if dosages exceed recommendations or someone takes the medication for a long time, it can lead to a risk of gastric issues and drug interactions.

If there is no ideal drug, what factors determine how well a drug meets its therapeutic objective? All practitioners base their practice decisions on evidence-based practice. Evidence-based practice (EBP) is "to use the best available evidence to make informed patient-case decisions that ultimately improve the treatment outcomes and safety of treatment for patients." (Vallerand & Sanoski, 2021). All drugs are decided with a risk-benefit balance, namely, does the benefit of this drug outweigh the potential risks? Further, many factors influence a drug's capability and how the same drug can work differently in different people. In the upcoming units on pharmacokinetics and pharmacodynamics, we will examine many of these factors.

To improve the client outcomes when taking any medications, a collaborative health care team approach is needed that includes the prescriber, such as a physician or nurse practitioner, the pharmacist, the nurse, and other allied health members. In **Chapter**

2.7 Deprescribing Medications, we will explore the implications of overprescribing, especially in the older population, and the role that all health care team members have in minimizing polypharmacy.

Figure 1.0.1 *Idea drug qualities. (Sheila Odubote/ TRU Open Press)* CC BY-NC-SA

Safe Medication Administration in Action

Using an evidence-based approach which is foundational to nursing practice, nurses need to make many decisions about medications that have a significant impact on client well-being. This begins with taking the best medication history for a new admission (see **Chapter 2 Safety and Ethics**) and ends with completing health teaching prior to discharge. Other examples of decisions that a nurse might make during client care include:

- Is my client's heart rate within the correct range to receive this beta-blocker medication?
- Does my client have adequate renal function prior to

administering this dose of antibiotic?
- Is this pain medication effective in controlling my client's discomfort?
- My client is going home; what health teaching about this medication is important for ensuring the client uses it safely?

In summary, in order to make safe medication administration decisions, the nurse must have a strong understanding of **pharmacology**. The use of medications is strongly connected to a client's treatment plan, including symptom management, physical recovery, and individual well-being. Before a nurse reviews a medication order, checks a medication administration record, or administers a medication, it is important to have a foundational understanding of how medications work within the human body.

Nurses should understand the key components of pharmacology:

- **Pharmacotherapeutics:** The clinical purpose or reason for the medication.
- **Pharmacokinetics:** The movement of the drug through the body.
- **Pharmacodynamics:** The physiological response of the body to the drug.

These next sections will introduce pharmacokinetics and pharmacodynamics. Future chapters of this textbook will focus on the pharmacotherapeutics of specific drug classifications.

Key Terms

- **absorption**
- **adverse effects**
- **affinity**
- **agonist**
- **antagonist**
- **bioavailability**

- **blood-brain barrier**
- **clients**
- **distribution**
- **dose-response**
- **drugs**
- **duration**
- **efficacy**
- **excretion**
- **first-pass effect**
- **half-life**
- **mechanism of action**
- **medication**
- **metabolism**
- **onset**
- **peak**
- **pharmacodynamics**
- **pharmacogenetics**
- **pharmacokinetics**
- **pharmacology**
- **pharmacotherapeutics**
- **potency**
- **selectivity**
- **side effect**
- **therapeutic index**
- **therapeutic window**
- **trough**

Key Term: Clients

In British Columbia, clients are defined as, "individual consumers of healthcare services who can be either a Patient or Resident or Tenant" (Health Information Management, n.d.). In this textbook, the words 'client' and 'patient' are used interchangeably.

References

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1.1 Medication Classification

Individuals take a wide variety of substances to find relief from health issues or enhance wellness. Having an accurate record and knowledge of the different types of substances a client is taking is important to the client's medical and nursing care plan. It is also important to note any substances that are prescribed, over-the-counter, or herbal that have been taken in the past month, as some medications have a long half-life and may still be in the body with the potential to interact with new medications.

Therapeutic Agents

Drugs and medications are one category when we consider substances that have an effect on the body. Other categories include natural health products and biologics.

So, therapeutic agents include:

- medications or drugs,
- natural health products, and
- biologics and biosimilars.

Medications or Drugs

As discussed in the previous unit, a drug is a chemical agent that is capable of producing a biological response within the body (Adams et al., 2018). A drug is considered a medication if it is medically therapeutic. They are used extensively for prevention and treatment for almost any ailment, condition, or disease and ultimately produce a desirable therapeutic effect. All drugs have the risk of adverse

reactions including side effects and adverse effects. Most medications fall into two categories, prescription medications or over-the-counter.

Prescription Medications

Prescription medications are prescribed by a licensed prescriber for a specific person's use and are regulated through the Health Products and Food Branch (HPFB) of Health Canada. To obtain a prescription medication, the client is first assessed by a health care provider qualified to prescribe medications. Following a diagnosis, the medication is prescribed with attention to the dose and duration of the medication use. To learn more about HPFB approval of medications, go to the Therapeutic Products Directorate page of the HPFB website. Medication regulation and approval is also discussed in Chapter 2: Medication Safety: Professional and Legal Foundations.

Over-the-Counter Medications

Over-the-counter (OTC) medications do not require a prescription. They can be bought at a store, usually a pharmacy, and may be used by multiple individuals. OTC medications are also regulated through Health Canada and are considered safe to use if taken as instructed. There are over 80 classes of OTC drugs, including pain and fever reducers, laxatives, antidiarrheals, and cold, cough, and allergy medications. Although generally safe, they do carry risks if not taken as recommended on the label. Some prescription medications are available for purchase as OTC in smaller doses. For example, diphenhydramine (Benadryl) is commonly prescribed as 50 mg every 6 hours, and the prescription strength is 50 mg. However,

it can also be purchased OTC in 25 mg doses (U.S. Food & Drug Administration, 2017).

The Risk of Acetaminophen

Acetaminophen, a commonly used analgesic and antipyretic, is considered a safe, effective medication to relieve mild to moderate pain or to bring down a fever. If used as prescribed, it is very safe. But it can pose risks for some clients, such as those with pre-existing liver or renal disease or those who take it in much greater quantities than recommended. Acetaminophen is metabolized in the liver, and if taken as an intentional or unintentional overdose, it can lead to toxicity and a cascade of oxidative hepatocyte injury. It is the second most common cause of liver transplantation worldwide and the most common cause of liver failure in Canada. Of the more than 250 cases of serious liver injury per year in Canada related to acetaminophen, over half were unintentional overdoses (Government of Canada, 2015). As an OTC medication, health education is important!

Figure 1.1.1 *Open bottles of Extra Strength Tylenol and Extra Strength Tylenol PM. (Ragesoss/Wikimedia Commons)* CC BY-SA 4.0

Natural Health Products

Natural health products include natural plant extracts, vitamins, minerals, enzymes, and dietary supplements. Health Canada has a Natural and Non-prescription Health Products Directorate that is responsible for authorizing natural/non-prescription products that meet safety, efficacy, and quality standards (Health Canada, 2025). Although most herbal supplements are of low risk if taken correctly,

the manufacturing company must abide by the regulations and hold a valid product and site licence and follow good manufacturing practices (Health Canada, 2024).

Many people take supplements to improve their health and although most are safe, they are not without risk. One such risk is adverse effects, especially those that occur when combining supplements with a prescribed drug with similar ingredients or actions. For example, St. John's wort is easily available at natural health food stores and is sold to improve mood, among other effects. If a client uses St John's wort alongside a prescribed antidepressant, they can experience excessive serotonin symptoms. Supplements such as "protein powders" are marketed to build muscle mass and are typically very safe. However, they can also pose a risk to a client if taken in larger doses than prescribed and may not be appropriate for all individuals (Patel et al., 2023). In 2021, an audit of the Natural Health Product Regulations revealed further revisions may be coming to improve client safety through improved labelling and increased oversight (Health Canada, 2024).

Natural health product use and accessibility has increased in Canada and are an important part of many clients' diet and health regime. As such, the nurse must ask about possible use and ensure these products are part of the client's medication profile to avoid possible adverse effects.

Biologics and Biosimilars

Biologics are produced by microorganisms, such as those in animal cells or in the body. They are used to treat many health issues, such as anemia, diabetes, hormone deficiency and some forms of cancer. They are often made using biotechnology. Some examples include vaccines, hormones, and monoclonal antibodies, which are all derived from a living source. In some circumstances, such as

gene therapy, they offer targeted therapy for some conditions, such as autoimmune disorders.

Biosimilars, or a biosimilar biologic drug, are biologically derived and synthetically produced drug that is highly similar to a biologic drug that was already authorized for sale (Health Canada, 2019). They are similar in efficacy and safety and can be produced at a lower cost than the equivalent biologic drug.

All biologics and biosimilars are authorized by Health Canada for sale in Canada and go through regulatory processes similar to other drugs.

Critical Thinking Out Loud

A client, 41-year-old Jas, comes into the health clinic as they have been experiencing symptoms of depression for some time. The nurse completes a health history and asks Jas about the prescription medications they are currently taking or have taken in the recent past. Jas informs the nurse that they do not take any prescription medications and, besides their current state, consider themselves healthy. Jas sees the physician who then prescribes a selective serotonin reuptake inhibitor (SSRI) antidepressant with the plan that they will go for counselling and return in one month for follow up.

At Jas's follow up appointment, they state that they take the SSRI as prescribed and have seen a counsellor. They report feeling a bit better but have noticed a tremor in their hands and are feeling quite nauseated. This time, the nurse

asks more questions about their medication use, to best understand their symptoms. She learns that Jas takes St. John's Wort on a regular basis and has been on it for over six months. They also take other health supplements, such as protein powders and vitamin supplements.

This new information helps determine if the side effects are from the SSRI or from the combination of the other supplements, in particular St John's Wort. After seeing the physician, the nurse provides some health teaching. She explains that using St John's wort with an antidepressant can lead to some of the symptoms they are experiencing and that they need to stop taking it to avoid more negative health effects. She emphasizes that supplements should always be disclosed when providing a health history as they can have a compounding or negative effect when combined with other medications.

St. John's wort is a herbal supplement that interacts with drugs classed as selective serotonin reuptake inhibitors. It has the potential to cause a potentially fatal condition known as serotonin syndrome. When taking a medication history, it is vital nurses ask about herbals and supplements, as many interact with prescription medications.

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1.2 Pharmacokinetics and Pharmacodynamics Introduction

Learning Outcomes

1. Apply understanding of the routes of administration and related nursing considerations.
2. Correlate the pharmacology terms with their importance to medication safety.
3. Articulate the four stages of pharmacokinetics in relation to nursing practice: absorption, distribution, metabolism, and excretion.
4. Apply the principles of pharmacokinetics including first-pass effect, protein binding, onset/peak/duration, therapeutic range, and lipid and water solubility.
5. Discuss and apply pharmacokinetic principles to life span considerations.
6. Explain the various drug forms and identify the advantages and disadvantages of the dose forms and drug delivery.

Introduction

A nurse is preparing to administer some medications to a client, with the overall goal to achieve a desired effect. For a medication to reach the target cells to have this desired effect, it must first be given in sufficient quantities, produce the needed physiological changes, overcome any barriers that impede the medications effects, and then eventually be excreted from the body. This process is called **pharmacokinetics**, which is the study of what the body does to the drug. It involves the processes of absorption, distribution, metabolism, and excretion of drugs. Pharmacokinetics is probably the most important concept to understand within the study of pharmacology and will be the focus of the first part of this chapter.

Why does a medication work differently for different people? Some medications will have a dramatic effect that may include adverse reactions, while for other people, it may have the intended effect or maybe even a subtherapeutic response. These drug-induced changes in a client's physiological function and the differences in how a client responds to medications is the study of pharmacodynamics. **Pharmacodynamics** is defined as the study of what a drug does to the body or the biological response to the drug. Pharmacodynamics will be the focus of the second part of this chapter.

The Relationship Between Pharmacokinetics and Pharmacodynamics

Pharmacokinetics and pharmacodynamics both need to be considered when administering medications. Both processes are closely related but distinctly different. Practitioners need to consider both processes when prescribing a medication to be able

to make adjustments based on physiological responses and client factors (Grogan & Preuss, 2023). Nurses also must consider both processes before administering a medication; this helps them decide the best route to administer it, monitor the patient for adverse and intended effects, and evaluate the medication's overall effectiveness.

Figure 1.2.1 displays the relationship between pharmacokinetics and pharmacodynamics.

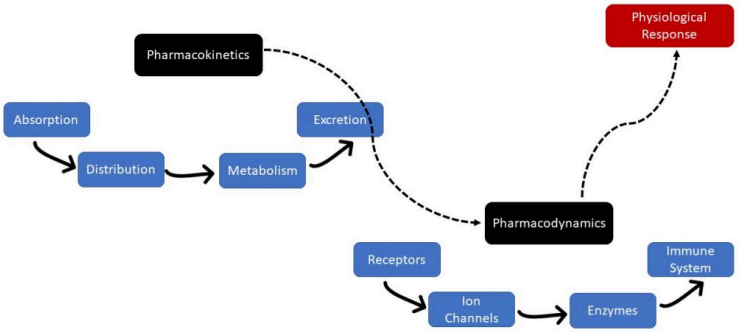

Figure 1.2.1 *The relationship between pharmacokinetics and pharmacodynamics. (Chippewa Valley Technical College et al./BCcampus)* CC BY 4.0 *[Long Description]*

Pharmacology Principles — The Movement of Drugs Through Cell Membranes

For drugs to work, they need to cross cell membranes. All phases of pharmacokinetics involve drug movement across membranes. Drugs must penetrate these membranes to produce their effects. For example, drugs cross a membrane to enter the bloodstream from the administration site, to leave the vascular system to enter

the target site, and to be excreted from the body (Burcham & Rosenthal, 2019).

Recall that cell membranes are biologic barriers composed of layers of individual cells. They selectively inhibit the passage of molecules. These layers of individual cells are very close to one another. So close that most drugs must pass through the cells instead of between the cells. Furthermore, a cell membrane is composed of a bimolecular lipid matrix that determines the membrane permeability. There are hydrophilic heads on the outside with lipophilic chains between these heads, creating a sandwich effect. Some cell membranes are slightly modified to allow more specialized functions. For example, in the renal glomerular endothelium, gaps exist between cells to allow for large molecules to pass through as part of filtration. This will be discussed in more detail in the distribution section.

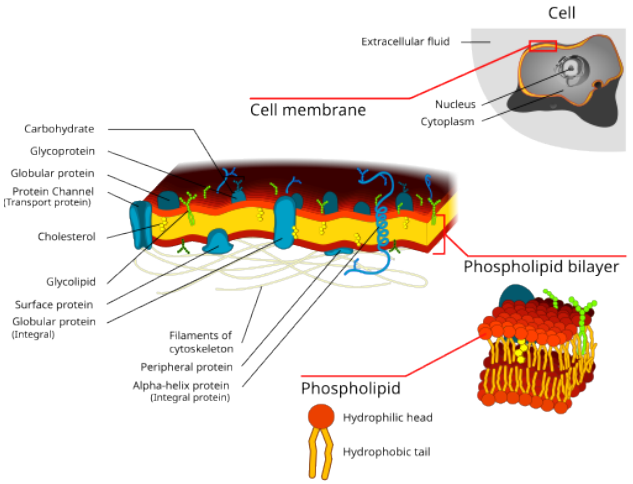

Figure 1.2.2 *A cell membrane with a double layer of molecules (Phospholipids). (Dhatfield [derivative]/Mariana Ruiz/ Wikimedia Commons)* CC BY-SA 3.0

For a drug to pass through a membrane, it can do so in two different ways: passive transport or active transport.

Passive transport implies that no energy is required for the molecule to move through the cell membrane. There are a few ways drug molecules can move by passive transport:

- **Diffusion:** Drug molecules pass through aqueous channels or pores. These channels or pores are very small and are specific to certain molecules. Water-soluble drug molecules and small molecules can move through the pore along with water. Substances that can pass through a channel are potassium, sodium, and water-soluble drugs, such as acetaminophen.

- **Passive Diffusion (most common):** Drug molecules directly penetrate the membrane. Most drugs are large molecules that cannot pass through a channel or pore and do not have a transport system to help them cross cell membranes. Passive diffusion is a movement from a high concentration area to a lower concentration one. Many drugs are weak bases or weak acids and exist in either an ionized or non-ionized form, depending on the pH. A non-ionized drug is lipid soluble and will diffuse easily through the cell membrane. With the old rule of "like dissolves like," since the cell membrane is primarily composed of lipids, a drug that is lipid soluble (lipophilic) will directly penetrate membranes. An example of lipid-soluble drugs are opiates, such as fentanyl.
- **Facilitated Passive Diffusion:** Drug molecules combine with a carrier protein to cross the cell membrane. The rate of diffusion of the drug molecule-carrier down a concentration gradient is faster than just diffusion alone. An example is a glucose molecule.

Diffusion rates are also influenced by a number of factors such as molecular size, concentration gradient, ionization, and lipid solubility. Recall that drugs can be hydrophilic (polar molecules and ions), meaning they cannot directly penetrate membranes, or lipophilic, meaning they can penetrate membranes due to the lipid bilayer. Drugs that are lipophilic are readily absorbed after administration and can easily reach target sites. We will discuss these concepts later in this chapter.

Active transport of molecules requires energy to move along the gradient:

- **Passage With the Aid of a Transport System:** A transport system or carrier can move drugs from one side of a cell membrane to the other side. All transport systems are selective (will only carry certain drugs or molecules) and need energy. Some drugs use a transport system but are limited to drugs

that are structurally similar to endogenous substances, such as vitamins or amino acids. An example of a drug using active transport is levodopa for Parkinson's Disease. In the kidney, renal excretion would be very slow if not for a transport system that pumps the drugs from the blood to the renal tubules. **P-glycoprotein (PGP)**, also referred to as a multidrug transporter protein, is the most commonly known protein that transports drugs out of cells (efflux pump). PGP is located at many sites, including the liver, kidney, placenta, intestines, and in the capillaries of the brain.

P-glycoprotein (PGP) is an example of a multi-drug transporter that transports drugs out of cells. It is a protein that is present in many cell membranes, including in the liver, kidneys, placenta, intestines, and brain capillaries. For example, it transports drugs across the membrane from the blood to the intestinal lumen, reducing drug absorption into the blood.

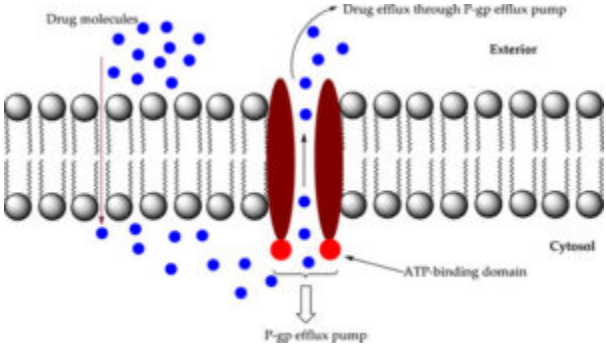

***Figure* 1.2.3** *The mechanism of drug import and efflux through P-gp efflux pump.* (*Gandla et al./Heliyon*) CC BY-NC-ND 4.0

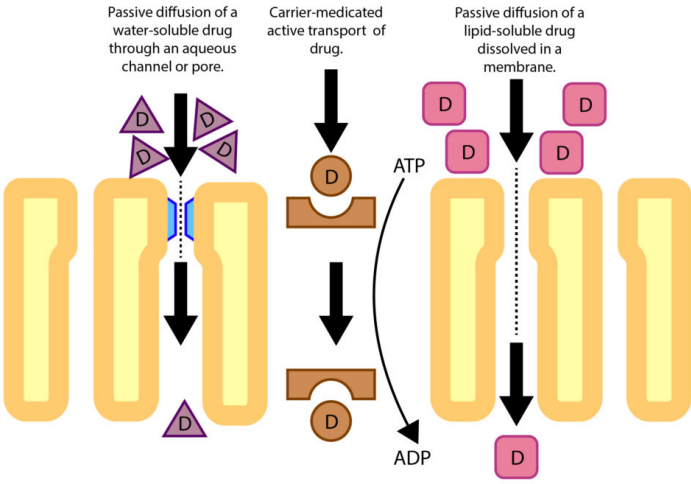

***Figure* 1.2.5** *Passive transport vs. active transport. Passive diffusion is when lipid soluble drugs go through the lipid bilayer; diffusion is when water soluble and small molecules go through open ion channels or pores; facilitated diffusion is when drug molecules combine with carriers to move across the membrane (e.g., nutrients such as glucose or amino acids); and active transport is when a carrier or transport system and energy are used to move across the membrane. (TRU Open Press, adapted from LSumi/Wikimedia Commons)* CC BY-NC-SA

Lipid-Soluble Drugs Versus Water-Soluble Drugs

Drugs can be lipid (lipophilic) soluble or water soluble (hydrophilic), although most drugs are lipophilic.

Drugs that are **lipid soluble:**

- readily diffuse across cell membranes (faster absorption),
- pass the blood brain barrier more easily,
- are stored in fat tissue, and
- have a higher lipid solubility (i.e., are more readily absorbed than those with low lipid solubility).

Drugs that are **water soluble:**

- require a transport system to penetrate the cell membrane or move through a channel,
- stay in the bloodstream longer but are not stored in fat tissue, like lipophilic drugs,
- typically easily metabolized through hydrolysis,
- undergo renal excretion faster, and
- often have fewer side effects, depending on the distribution and clearance.

What are examples of water-soluble drugs? Some vitamins are water soluble. Vitamin B and C are two examples. They are not stored in fat tissue but, instead, stay in the bloodstream or in the interstitial tissues nearby. They are also more rapidly excreted from the body.

Other hydrophilic drugs include the antibiotic gentamycin and the beta blocker atenolol.

What are examples of lipid-soluble drugs? Many drugs are lipid soluble, including phenytoin and diazepam. For vitamins, some lipid-soluble vitamins include A, D, E, and K. If taken in excess, they are stored in fat tissue.

Drugs have varying degrees of lipid solubility, with some highly lipid soluble. For example, let us compare two opioids, morphine and fentanyl. Both are lipid soluble, but fentanyl is highly lipid soluble. Consider what this may mean for the onset and duration of action.

Significance to practice: You may wonder why you need to understand drug movement and cell membranes. Understanding these basic principles will help you apply the concepts of pharmacokinetics and pharmacodynamics when administering medications and monitoring clients for their effects.

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Long Descriptions

Figure 1.2.1 Long Description:

1. Pharmacokinetics
    1. Absorption
    2. Distribution
    3. Metabolism
    4. Excretion
2. Pharmacodynamics
    1. Receptors
    2. Ion Channels
    3. Enzymes
    4. Immune System
3. Physiological Response [Return to Figure 1.2.1]

1.3 Pharmacokinetics — Absorption

Pharmacokinetics

Pharmacokinetics is the term that describes the four stages of absorption, distribution, metabolism, and excretion of drugs. **Drugs** are medications or other substances that have a physiological effect when introduced to the body.

There are four basic stages for a medication to go through within the human body:

1. **Absorption** occurs after medications enter the body and travel from the site of administration into the body's circulation.
2. **Distribution** is the process by which medication is distributed throughout the body.
3. **Metabolism** is the breakdown of a drug molecule.
4. **Excretion** is the elimination of the medication from the body.

This entire process is sometimes abbreviated as **ADME**.

Absorption

The first stage of pharmacokinetics is known as **absorption**. Absorption is defined as the movement of the drug from its site of administration into the blood (Burcham & Rosenthal, 2019). Most drugs must be absorbed to produce an effect, with a few exceptions such as intestinal anti-infectives. The ***amount*** of absorption will

determine how intense the effects will be, and the ***rate*** of absorption will determine how soon the effects will occur.

Drug absorption is impacted by a number of factors including the physical properties of the drug and the physiologic factors at the absorption site. For example, the formulation of the drug, either a tablet or liquid, determines the rate of absorption. An oral drug that is given in a tablet form must be dissolved before being absorbed, which delays absorption; whereas a liquid form of that drug does not need to dissolve will therefore have a faster absorption rate. Physiologic factors include the surface area (small intestine has a huge surface area compared to the stomach), blood flow (areas of high blood flow will absorb drugs more rapidly), lipid solubility, and pH levels. While most drugs need to be absorbed first before entering the bloodstream enroute to the target site, not all drugs do. For example, antacids are given orally and exert their actions locally in the stomach.

Absorption affects the speed and concentration at which a drug may arrive at its desired or target site. Each administration route has its own absorption characteristics, advantages, and disadvantages. The route chosen will depend on the desired effect and the type of drug preparations available. Depending on the intended response, the route is chosen based on the speed of response required (for example, the IV route is preferred for fast pain relief), duration of action, or other factors such as convenience, availability, and client factors.

Routes of Administration

Medications can enter the body through various routes of administration. The routes of administration are often divided into two major groups:

1. **Enteral**, meaning through the gastrointestinal (GI) tract,

includes all oral and rectal medications.

2. **Parenteral**, literally meaning outside the GI tract but refers to *by injection*, includes intravenous, subcutaneous, intramuscular, intrathecally, and intra-articular medications.

Common routes to administer medications include:

- Oral (swallowing an aspirin tablet),
- Sublingual (dissolved under the tongue),
- Enteral (administering to the GI tract such as via a nasogastric tube),
- Rectal (administering a Tylenol suppository),
- Inhalation (breathing in medication from an inhaler),
- Intramuscular (getting a flu shot in the deltoid muscle),
- Subcutaneous (injecting insulin into the fat tissue beneath the skin), and
- Transdermal (wearing a nicotine patch).

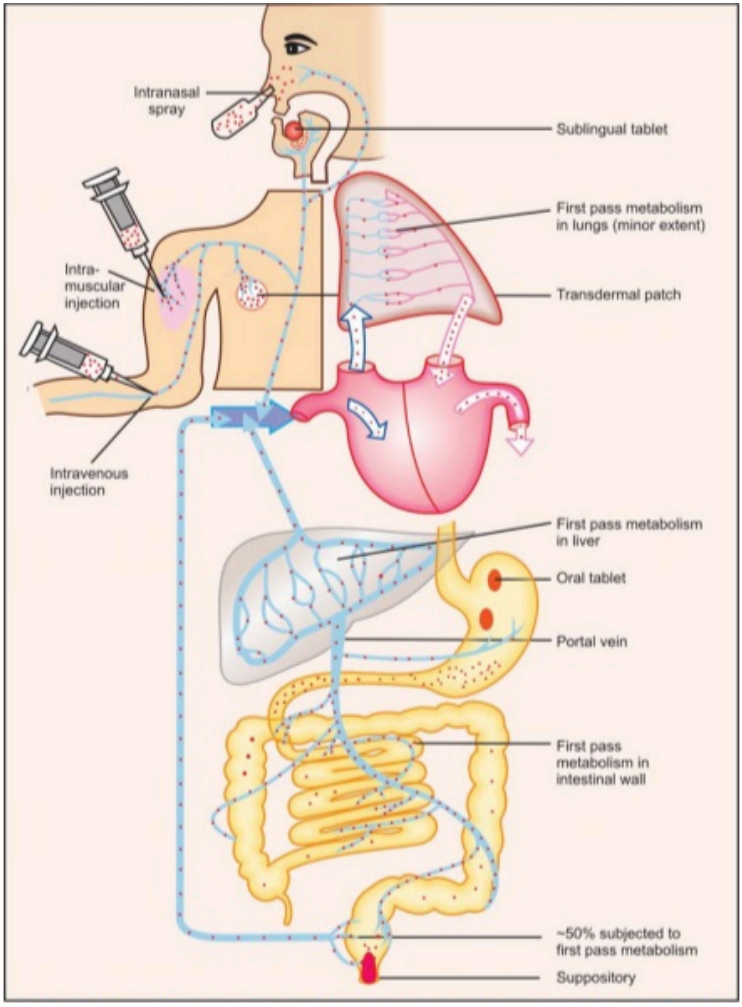


Figure 1.3a *Different routes of administration. (NIH Image Gallery/Flickr)* CC BY-NC 2.0

Characteristics of Routes of Administration

A new graduate nurse is planning on giving a client their medication

and sees the prescriber orders have a few different routes for some of the medications. Which route should the nurse choose? What factors of the route, client, or intended effect would make one route more ideal than another?

Each route has advantages and challenges that can impact the effectiveness or are not as ideal for that client. The nurse uses the nursing process and clinical judgment in making the decision of which route to use when given the option. Depending on the orders, the nurse can decide to give a medication orally, IM, or IV. For example, the IV route requires the nurse to start an IV, which can be painful but IV meds have a rapid onset of action. In an emergency, rapid onset of action is highly important. If we need a more prolonged effect, IM might be the best option, but it can also be painful. If the client is able to tolerate an oral medication and its not an emergency, the oral route might be best due to its convenience.

Refer to the **Table 1.3.2** for a review of route characteristics. The oral route will be examined more thoroughly below.

Oral Administration

The most common route of administration is the oral, or enteral, route. The drug is absorbed into the systemic circulation through the gastric mucosa, either in the stomach or small intestine. If given rectally, it is readily absorbed through the rectal mucosa.

Advantages of the oral route include convenience, affordable (compared to IV), and easy administration for most clients. The old saying, "if the gut works, use it," would apply when choosing oral medications over IV ones. Other advantages are that the oral route has a high safety margin compared to IV routes, which could risk infection or fluid overload. It may also be possible to reverse an oral medication in the case of an overdose. If the medication

was recently ingested, giving activated charcoal will bind with the medication to prevent absorption.

Figure 1.3b *Oral administration is the most common route for medications. (Ahsanjaya/ Pexels)* Pexels License

First-Pass Effect

First-pass metabolism is a major determinant of a drugs response or the peak plasma concentration of an oral dose. Medications made of protein, which are swallowed or otherwise absorbed in the stomach or small intestine, must then pass through the portal venous system and the liver

sinusoids before entering the systemic circulation. The breakdown of the drug by the liver enzymes is known as the **first-pass effect**, which reduces the concentration of the drug before reaching systemic circulation. This effect will lower the bioavailability of the oral drug.

These metabolic effects are further described in the "Metabolism" section later in this chapter. Providers who prescribe medications, as well as nurses, understand that several doses of an oral medication may be needed before enough free drug stays active in the circulation to exert the desired effect.

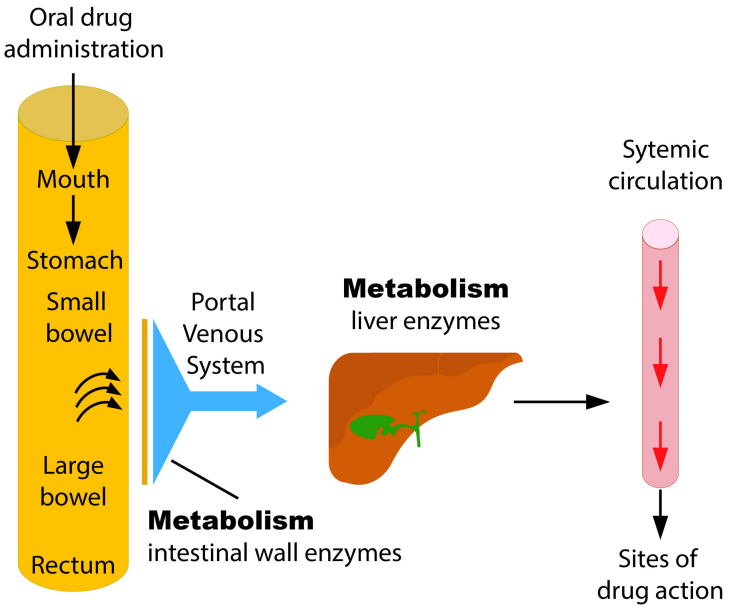


Figure 1.3c *First-pass metabolism. (TRU Open Press)* CC BY NC SA

A workaround for the first-pass effect is to administer the medication using alternate routes, such as dermal, nasal, inhalation, subcutaneous, intramuscular, or intravenous. Alternative routes of medication administration bypass the first-pass effect by entering the bloodstream directly or via absorption through the skin or lungs. Intravenous medications administered directly into the bloodstream do not undergo absorption and are fully available for distribution to tissues within the body. Inhaling drugs through the nose or mouth is another alternative route for rapid medication delivery that bypasses the liver. For example, metered-dose inhalers have been a mainstay of asthma therapy for several years, and nasal steroid medications are often prescribed for allergy and sinus problems.

Critical Thinking Out Loud

A nurse reviews some new orders for a palliative care client. The order reads: Fentanyl 50 mcq/hr via transdermal patch.The nurse recalls some details and facts before preparing this medication:

- The client has had poor pain control with end stage pancreatic cancer. They are taking very little by mouth and do not want any more injections.
- Drugs delivered transdermally enter the blood via a meshwork of small arteries, veins, and capillaries in the skin. Transdermal drug delivery is particularly useful when medication must be administered over a long period of time to control symptoms.
- Rate of delivery of the active ingredient is stable and constant, and avoids first-pass effect.
- Transdermal patch is easy to apply and can stay on for 72 hours (typically) to 7 days.
- For application, check the orders and last time it was applied, remove the old patch, check for any forgotten patches, wear gloves, apply to intact skin, and do not apply any heat to the area (heating pad).
- Always ensure the 10 rights of medication administration are followed.

Figure 1.3d *Transdermal patch. (BCIT/BCcampus)*
CC BY 4.0

Transdermal application of medication is an alternate route that has the primary benefit of slow, steady drug delivery directly to the bloodstream—without passing through the liver first. (See Figure 1.3d for an image of applying a transdermal patch.)

Bioavailability

Bioavailability is the extent of drug absorption and is the fraction of the originally administered drug that arrives in systemic circulation. It plays a critical role in achieving the desired therapeutic effects. It is affected by many factors, including the properties of the drug, the mode of administration, interactions with other substances (food, fluids, other drugs), absorption (status and blood flow to small intestine), hepatic metabolism, and excretion (Stielow et al., 2023). For example, a client with gastric paresis post-operatively will slow the transit time through the gut, leading to lower bioavailability.

A drug administered via the IV route, which bypasses the

absorption phase, will enter systemic circulation with all of the drug delivered to the target site resulting in 100% bioavailability. Orally administered drugs will have much lower bioavailability, as they must first go through the absorption phase and then be processed by digestive enzymes and the liver, which subsequently lowers the amount of drug that arrives in circulation. An example of a medication with low bioavailability is oral nitrates. Nitrates are not usually administered orally due to a very low bioavailability. Most routes have lower bioavailability than the gold standard of the IV route of administration. If two medications have the same bioavailability and also the same concentration of the active ingredient, then they are considered **bioequivalent.**

Two phrases are often heard when discussing bioavailability:

- **Bioequivalent** is if two medications given to the same client in the same dosage (concentration of active ingredient) result in equivalent concentrations of the drug in the plasma and tissues.
- **Therapeutic equivalence** is a step further and indicates that two medications given to the same client in the same dosage will have the same therapeutic and adverse effects.

It is expected that bioequivalent drugs are therapeutically equivalent. These terms are heard when comparing a generic drug with a brand-name drug.

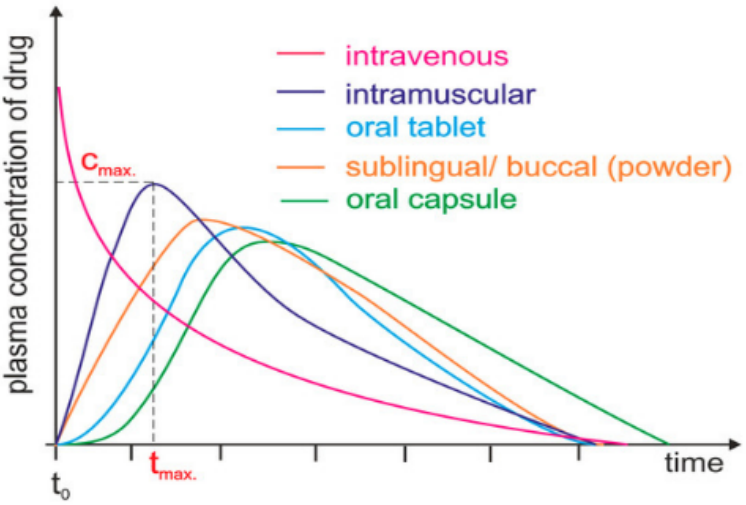


Figure 1.3e *Plasma level time curves for different types of drug administration (Stielow et al., 2023)* [MDPI Open Access]

Delivering drugs directly into the systemic circulation via IV ensures 100% bioavailability. If they are delivered by SQ or IM, most drugs show between 60–100% bioavailability due to little or no metabolism in the skin or muscle. But the time to reach its maximum concentration is much longer than IV route.

If drugs are delivered by an oral route, bioavailability is lower, due to incomplete absorption and/or elimination during the first pass through the liver. Additionally, due to the indirect path to the plasma, they are characterized by a long-time lag (Stielow et al, 2023).

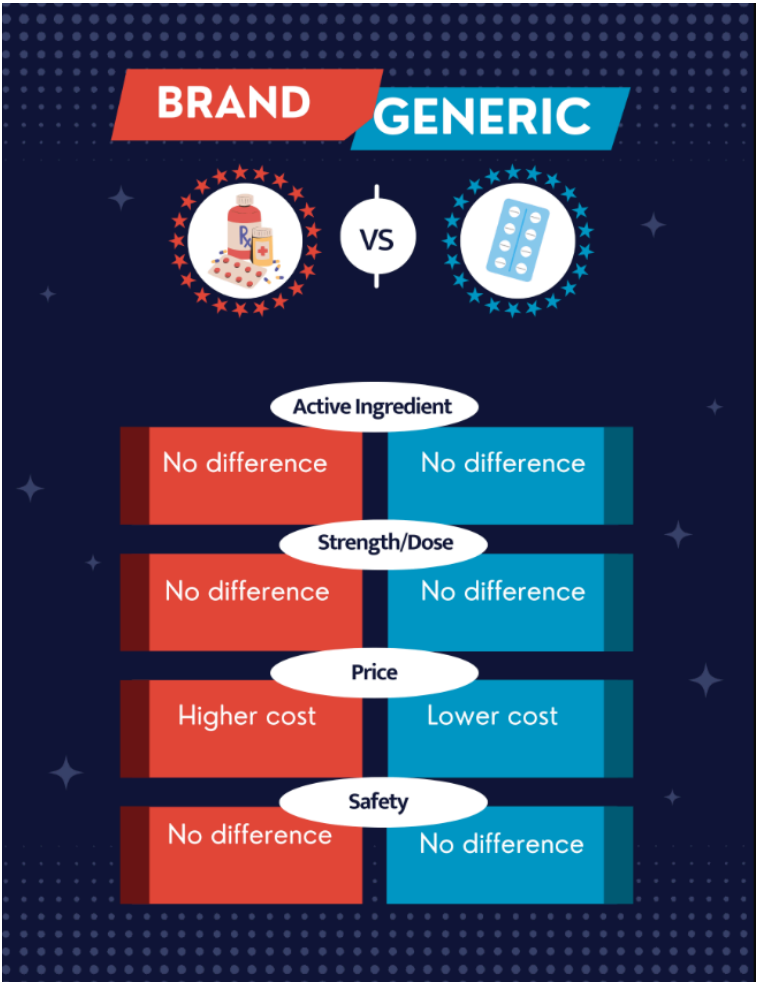


Figure 1.3f A comparison of brand name and generic medications. (Sheila Odubote/TRU Open Press) CC BY NC SA

Many clients are prescribed a generic alternative to the brand-name drug, often due to the lower cost of the generic option. For example, a client's drug plan will only cover the cheaper generic form. But is it the same? If its therapeutically equivalent, it should have the same therapeutic effects and adverse effects. If a client has more adverse effects with the generic version or does not get the same effectiveness as the brand-name product, this is called therapeutic nonequivalence. It is sometimes observed with clients who are on the brand-name drug for a long time and then switch to the generic form.

Oral Medication Preparations

The route of the medication is not the only consideration when planning on giving an oral medication. The nurse must also check for how the med is 'packaged' or formulated. This applies to oral medication types like tablets or capsules. More specifically, they include enteric-coated, delayed-release, controlled-release, and sustained-release medications. Each type has different implications for the intensity of effect and duration of action (see **Table 1.3.1**), and impacts when the nurse will reassess for onset of action and monitoring for effects.

Table 1.3.1 Oral Medication Preparation Types

Preparation Type	What Is It?	Benefits and Drawbacks
Enteric coated (EC)	The medication has been covered with a coating so it does not dissolve in the acidic environment of the stomach; instead, it dissolves in the alkaline environment of the intestine.	**Benefit:** Protects the stomach from drugs that may cause gastric irritation (e.g., Acetylsalicylic acid), or protects drugs from stomach acid. **Drawback:** EC may not dissolve, leading to variable absorption rates.
Extended Release (ER) or (XR)	Two types: controlled and sustained release. These medications contain a larger amount of the drug that is designed to be released over a period of time. The capsule should not be opened or the tablet crushed to avoid releasing all the drug at once, altering the absorption rate and duration of action.	**Benefits:** Higher safety margin for narrow therapeutic window drugs.
Controlled release (CR)	Each capsule is designed to release the same amount of drug over a specified period of time.	**Benefit:** Controlled drug concentrations at the target site.
Sustained release (SR)	Each capsule is filled with tiny spheres of the drug. The coating of the spheres dissolve at variable rates, so some will dissolve immediately and others later in the day.	**Benefit:** Less doses during the day and a steadier state of the drug. **Drawback:** More costly and some variable absorption rates.

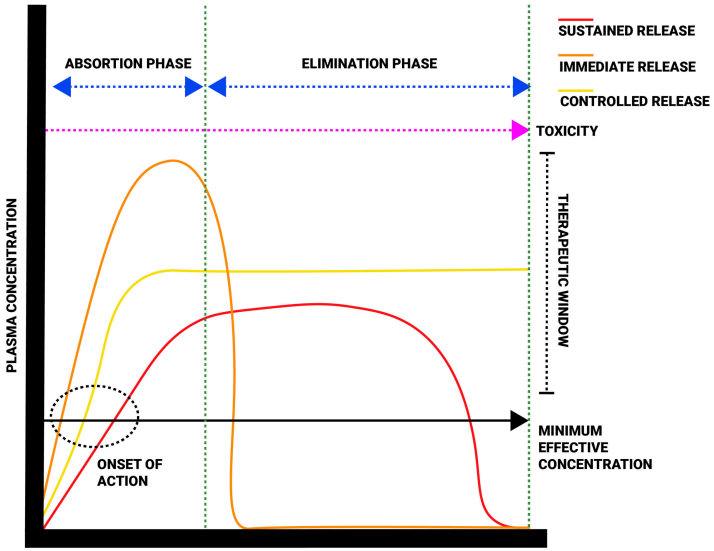


Figure 1.3g Plasma concentration over time for different drug-release formulations (TRU Open Press) CC BY NC SA

The Impact of Food on Absorption

Depending on the drug, you might see in the orders to give the medication with milk, without food, or even after a window of time where no food or drink can be taken. This is often ordered due to the impact on the absorption of that drug. Pay attention to these orders, for if they are not followed, clients may not be getting the ordered dose of that med or it can delay the onset of action leading to negative client outcomes.

There are many examples of drug-food interactions:

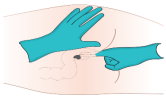
- **Tetracycline**, an antibiotic, cannot be given with food that contains calcium, iron, or magnesium, which can all delay absorption. It is best to take this antibiotic on an empty

stomach.

- **Levothyroxine**, a thyroid medication, or **lithium,** a mood stabilizer, should not be taken with milk. Dairy products can bind with these drugs to make them ineffective. Ideally, take this medication on an empty stomach.
- **Simvastatin**, a cholesterol lowering medication, should not be taken with grapefruit juice. The juice will block with enzymes that metabolize the drug, leading to higher drug amounts and stronger effects. There are many meds that should not be taken with grapefruit. See the "Metabolism" unit for more details.

Table 1.3.2 Medication Route Considerations

Medication Route	Considerations
Oral (PO), Sublingual (SL) or Enteral (NGT, GT, OGT) Ingestion ***Figure 1.3h*** *Oral administration.* (Doyle & McCutcheon / BCIT) CC BY 4.0	Oral route (PO), Enteral • Convenient, easy, and safest route • Highly variable rate and extent of absorption due to acidity of gastric contents, gastric emptying rate, dietary contents, and presence of other drugs (can interact with other drugs) • First-pass effect: Blood containing the absorbed drug passes through the liver, which can deactivate a substantial amount of the drug and decrease its bioavailability (the percentage of dose that reaches the systemic circulation). • Oral route: different formulations including enteric-coated, extended release. Sublingual/Buccal: • More rapid absorption than oral, as it avoids the first-pass effect by avoiding the stomach. • Clients need to be taught not to swallow SL medications and instead place it under their tongues. Buccal route medications are placed between cheek and gums.

Rectal (PR)  ***Figure 1.3i*** *Rectal administration.* (Doyle & McCutcheon / BCIT) CC BY 4.0	Rectal: • Rapid absorption and a good alternative if oral route not feasible due to secondary issues such as nausea, vomiting, sedation, or NPO • Local and systemic effects • Mixed first-pass effect and non-first-pass effect (PR bypasses 2/3 of first-pass effect so bioavailability is less of an impact) • May cause discomfort and be more embarrassing for client

Parenteral Injection (SC, IM, IV) **Figure 1.3j** *Parenteral injection.* (National Cancer Institute / Unsplash) Unsplash License	Subcutaneous (SQ) and intramuscular (IM) administration: • Pharmacokinetics are nearly identical for SQ and IM. Once injected, they readily enter bloodstream SQ: • Good for medications that need slow, sustained absorption • Injected under epidermis into fat and connective tissue beneath the dermis, so there is less blood flow and slower absorption • Good for insulin and palliative pain control IM: • Good for poorly soluble drugs (depot drugs). • More immediate onset compared to oral routes. • Rate of absorption varies due to blood flow to muscle and water solubility of drug (i.e., high water solubility = faster absorption) SQ and IM: • Discomfort at injection site, inconvenient, and risk of bruising, infection, local irritation, or injury • Self-administering may be difficult for clients Intravenous (IV): • Rapid onset (drug immediately enters bloodstream) so complete bioavailability, better control over the amount of drug, large volumes of fluid, can give irritating drugs to running IV, and avoids first-pass effect • Need intravenous access, which can be painful and increase risk of infection • Must be careful with two IV meds to avoid incompatibility. • Higher risk of toxicity and medication errors due to incorrect administration (dilution, concentration, rate of delivery, and monitoring). • More costly, inconvenient, inability to retrieve the medication once given, and risk of embolism and fluid overload

Pulmonary Inhalation	Inhalation: • Rapid absorption of drugs in gaseous, vaporized, or aerosol form. Drug delivered directly to lung tissues where most of these drugs exert their action. • Absorption of particulates/aerosols depends on particle/droplet size, which influences depth of entry through the pulmonary tree to reach the alveoli. The ability of the client to create successful inhalation, especially in the presence of bronchospasm, may also influence depth of entry in the pulmonary tree. • Administration technique is important (use of spacers, nebulizers, or discs may be confusing) • Need to correctly store and clean devices

Figure 1.3k *Pulmonary inhalation.* (*National Institute of Allergy and Infectious Diseases / Flickr*) [C

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Topical and Transdermal Application **Figure 1.31** *Topical and transdermal application.* (Doyle & McCutcheon / BCIT) CC BY 4.0		Topical creams, lotions, and ointments: • Generally used for local effect; minimal/no systemic effects • Easy to administer • Slower absorption through skin but has a steady, long-term effect that avoids first-pass effect • Absorption affected by blood flow Transdermal patch: • Used for systemic effect. • Constant rate of drug absorption and avoids first-pass effect • Long term effects last up to 7 days • Absorption can be affected by perspiration and body temperature • More costly, may cause skin irritation, and need safe disposal of patch

Researchers who specialize in pharmacokinetics must also pay attention to another dimension of drug action within the body: **time**. Unfortunately, scientists do not have the ability to actually see where a drug is going or how long it is active. To compensate, they use mathematical models and precise measurements of blood and urine to determine where a drug goes and how much of the drug (or breakdown product) remains after the body processes it. Other indicators, such as blood levels of liver enzymes, can help predict how much of a drug is going to be absorbed.

Principles of chemistry are also applied while studying pharmacokinetics because the interactions between drugs and body molecules are really just a series of chemical reactions. Understanding the chemical encounters between drugs and biological environments, such as the bloodstream and the oily surfaces of cells, is necessary to predict how much of a drug will be metabolized by the body.

Learning Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=1319#h5p-11

Clinical Reasoning and Decision-Making Activities

1. Choosing between two routes of administration: A nurse is planning on giving acetaminophen for a client experiencing moderate pain. The order reads:

- Acetaminophen 325-650 mg PO q 4-6 hours prn
- Acetaminophen 325-650 mg PR q 4-6 hours prn

Applying the principles of absorption for both routes, which factors should the nurse consider when considering which route to give?

2. A client is in acute 9/10 pain. The nurse wants to give the Morphine IV as opposed to IM. What is the rationale to support this decision?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

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- **Figure 1.3a** A drug's life in the body (with labels) | Medicines taken by NIH Image Gallery, via Flickr, is used under a CC BY-NC 2.0 license.
- **Figure 1.3b** Person Holding White Medication Pills by Ahsanjaya, via Pexels, is used under the Pexels License.
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- **Table 1.3g:**

- **Figure 1.3h** Administering oral medication by Glynda Rees Doyle and Jodie Anita McCutcheon (2015), via BCIT's Clinical Procedures for Safer Patient Care, is used under the CC BY 4.0 license.
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- **Figure 1.3j** Subcutaneous (SQ) and intramuscular (IM) administration by National Cancer Institute, via Unsplash, is used under the Unsplash License.
- **Figure 1.3k** Adult Using an Asthma Inhaler (29251369035) by National Institute of Allergy and Infectious Diseases (NIAID), via Flickr, is used under a CC BY 2.0 license.
- **Figure 1.3l** Applying Transdermal Patch by Glynda Rees Doyle and Jodie Anita McCutcheon (2015), BCIT's Clinical Procedures for Safer Patient Care, is used under a CC BY 4.0 license.

1.4 Pharmacokinetics — Distribution

The second stage of pharmacokinetics is the process known as drug distribution. Distribution is the process by which medication is dispersed throughout the body via the bloodstream. Once a drug enters into systemic circulation by absorption or direct administration, it must be distributed into interstitial and intracellular fluids to get to the target cells.

Factors Impacting Drug Distribution

The distribution of a drug throughout the body is dependent on a number of client-related factors. These include:

- blood flow to the tissues,
- plasma protein binding,
- body composition (fat and water),
- health issues affecting albumin,
- blood-brain barrier, and
- if the client is pregnant, the placental barrier.

All of these factors are inter-connected although we will examine each separately. All of these factors will have an impact on the **volume of distribution,** which is a reference point for plasma drug concentration.

Blood Flow to the Tissues

During the first phase of distribution, drugs are carried by the blood to organs and tissues in the body. Blood flow is one of the primary determinants of drug distribution. In a healthy person, tissues are well perfused with good blood flow, so drug distribution is not impacted. Blood flow is the primary indicator of the rate and amount of drug uptake at target sites. In certain health issues. low perfusion can impact the ability of a drug to reach its target site. For example, a client in septic shock may have reduced perfusion to their extremities leading to mottling and less blood flow to some organs to maintain hemodynamic stability. Certain conditions such as tumours or abscesses can also affect drug therapy. An abscess has no internal blood supply, so antibiotic therapy cannot reach the pathogens easily. For solid tumours, some are resistant to drug therapy due to the limited blood supply (Burcham & Rosenthal, 2019).

Drugs carried by the bloodstream will penetrate different organs or tissues at different rates. Organs with high perfusion, such as the heart, liver and kidneys will have higher distribution of drugs than bones, adipose tissue and the skin, which have lower distribution. For the latter organs, this characteristic is only a potential challenge if high concentrations of drugs are needed to be delivered to these areas. For example, a client with osteomyelitis may be on a longer course of antibiotics due to the difficulty penetrating into the bone.

Membrane permeability or membrane barriers also have an important role in drug distribution. Some membranes are more permeable to drugs so the drug can move easily from the bloodstream into the tissues. See below for the discussion on lipophilic and hydrophilic drugs.

Body Composition — Water and Fat Composition

The body's water composition reduces as we age. Young children will have a higher percentage of body water compared to older adults; however, intracellular water is stable.

Individuals also have varying degrees of fat composition, either due to age, gender, genetics, or lifestyle. For clients with a higher fat composition, lipophilic drugs will have a larger volume of distribution to fat tissues, resulting in a longer duration of action and lower blood concentrations. Conversely, hydrophilic drugs have a small volume of distribution and higher blood concentrations.

Health Issues Impacting Albumin Levels

Albumin levels can be impacted by various disease or health states, such as hypovolemia, malnutrition, inflammation, burns, or third spacing due to sepsis. In these cases of low serum albumin levels or hypoalbuminemia, the drug molecule has less sites to bind to, so more of the drug is circulating in the bloodstream and reaching target sites.

For clients who have or are at risk of hypoalbuminemia, nurses can anticipate that serum albumin levels will be drawn before drug therapy and at intervals throughout the client's treatment. Nurses can also anticipate lower drug dosages until a client's nutritional status is corrected if due to malnutrition, or replacing albumin through IV administration to correct the deficiency. This is also sometimes done for clients with liver disease.

Blood-Brain Barrier

Medications destined for the central nervous system (the brain and spinal cord) face an even larger hurdle than protein binding; they must also pass through a nearly impenetrable barricade called the **blood-brain barrier (BBB)**.

There are 3 main factors that prevent drugs or other substances from crossing the BBB:

1. **Endothelial cells** form a physical barrier with tight junctions between cells, reducing passive diffusion.
2. An **enzymatic barrier** breaks down certain molecules that may be in transit across the cell membrane.
3. **Astrocytes** are spread out along the cell membrane, and their end-feet extend down into the endothelial cells, forming a physical barrier.

Figure 1.4a Blood brain barrier. (TRU Open press). This diagram shows the capillary with tight junctions between endothelial cells and the astrocyte feet that prevent molecules from entering the brain.

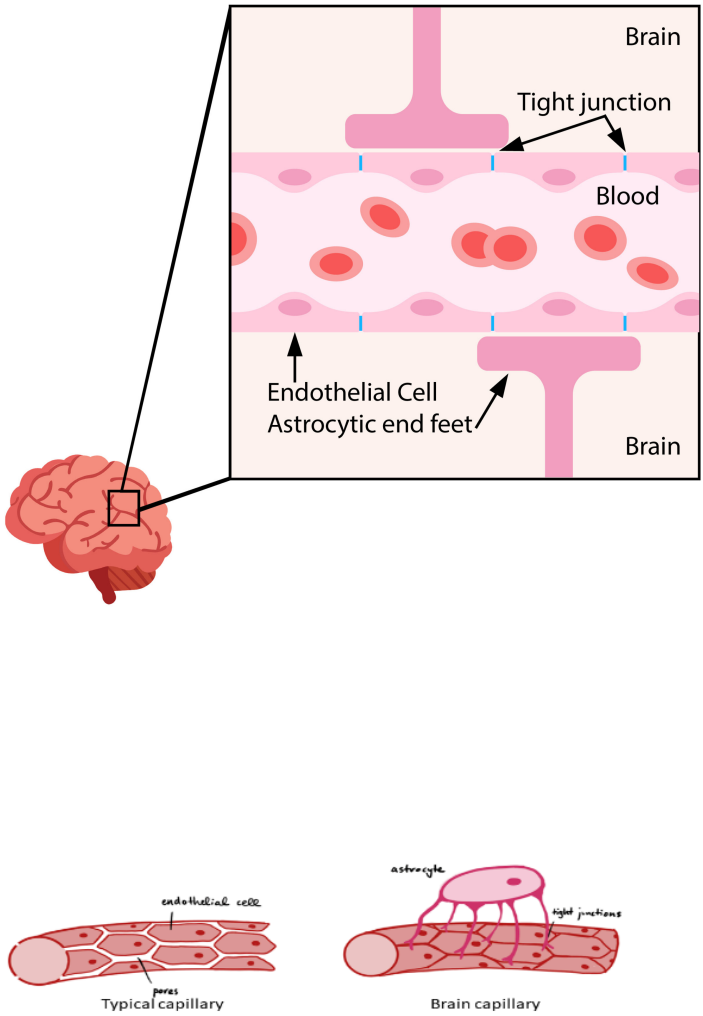

Figure 1.4b Comparison between a typical capillary and a capillary in the brain. The brain capillary prevents drugs and other substances from entering the brain due to their unique structure of tight junctions between endothelial cells, astrocytes, and an enzyme barrier that breaks down molecules.

To understand more about the Blood Brain Barrier: 2 minutes Neuroscience: Blood Brain Barrier. YouTube: Neuroscientifically Challenged https://www.youtube.com/watch?v=e9sN9gOEdG4

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=1334#oembed-1

Making it through the blood brain barrier:

How can nutrients get into the brain?

- Glucose and amino acids (small polar solutes) need transport proteins or carriers to cross the BBB. Small lipophilic molecules and gases, such as oxygen and carbon dioxide, can diffuse across the lipid membrane.

How can drugs get into the brain?

- Only certain medications that are made of lipids (fats) or have a "carrier" can get through the BBB. Research scientists have devised ways for certain medications to penetrate the BBB. An example of this is the brand-named medication Sinemet®, which is a combination of two drugs: carbidopa and levodopa. Carbidopa is designed to carry the levodopa medication across the BBB, where it enters the brain and is converted into

dopamine to exert its effect on Parkinson's disease symptoms.

- Some medications inadvertently bypass the BBB and impact an individual's central nervous system function. For example, diphenhydramine (Benadryl®) is an antihistamine used to decrease allergy symptoms; however, it can also cross the BBB, depress the central nervous system, and cause the side effect of drowsiness. In the case of a person who has difficulty falling asleep, this drowsy side effect may be useful, but for another person it may be problematic as they try to safely carry out daily activities.

Placental Barrier

It is always important to consider the effects of medication for clients who are pregnant or may become pregnant. The placenta is permeable to some medications, while others have not been specifically studied in pregnant clients. Most drugs can cross the placental barrier. Lipid-soluble nonionized drugs cross the placenta, and these compounds can pass from maternal into fetal circulation. Only drugs that are protein-bound, ionized, or highly polar cannot move easily across the placental barrier. As the pregnancy progresses, physiological changes occur that can change the distribution of drugs. As the plasma volume expands, this leads to an overall diluting effect on plasma proteins. Adipose tissue increases, which can increase the volume of distribution of medications, leading to a more prolonged effect.

During any trimester, some drugs can cause harm to the unborn fetus. In the first trimester, some drugs can cause birth defects (congenital anomalies) that can range from physical to cognitive anomalies, such as cleft palate, spina bifida, metabolic disorders, or heart defects. Other drugs can have an effect later in the pregnancy, resulting in low birth weight and premature labour.

Therefore, it is imperative to always consult a healthcare provider

regarding the safety of medications during pregnancy. Further, it is also important to ensure clients are aware that any medication, either prescribed, OTC, or a natural health remedy, is first reviewed by their practitioner. This imperative is assumed in the remaining chapters discussing medication classes, and nurses should always check the most recent, evidence-based drug references before administering medications during pregnancy.

Drug-Related Factors

Distribution is also impacted by drug-related factors such as the molecular structure of the drug, lipid solubility, and plasma protein and tissue binding.

Drugs leave the vascular system unimpeded by passing through the pores in the capillary wall. As mentioned above, drug distribution to various organs or tissues is determined by blood flow to that area, but it is also dependent on the molecular structure of the drug.

Lipid-Soluble vs. Water-Soluble Drugs

A drug's permeability across cell membranes is a key factor that influences the absorption and distribution. This is because if a drug wants to reach to the systemic circulation, it needs to cross several semipermeable cell membranes first.

Lipid-soluble drugs are distributed more completely to body tissues due to their ability to be quickly absorbed, mix with the blood, cross membranes, and then localize to tissues (Adams et al, 2018). Therefore, lipid-soluble drugs will have a higher volume of distribution and a lower blood concentration. In comparison, highly water-soluble drugs will have a smaller volume of distribution and

high blood concentration. Refer to the previous section, **1.1 Pharmacological Principles**, for a review on lipid and water soluble drugs.

Plasma Protein and Tissue Binding

In the bloodstream, drugs are transported partly as a free (unbound) drug and partly as being bound reversibly to plasma proteins (drug-protein complex). **Albumin** is the most abundant protein in the blood and the protein that most drugs bind to, although other proteins include lipoproteins and alpha-1 glycoprotein. Only unbound drugs can passively diffuse to the extravascular sites where the target cells are located. Unbound drug concentrations in the vascular system typically determine the drug concentration at the target site. This determines the **efficacy** of the drug.

The large drug-protein complexes circulate in the bloodstream until they are displaced or become unbound, which leaves the drug molecule small enough to pass through the capillary beds and reach the target sites. If this did not occur, the bound molecules could not reach the target sites, leading to a prolonged distribution phase and increased drug half-life.

Albumin

Albumin is a large protein molecule in the plasma, so large that it primarily remains intravascularly. It has no

transport system and is too large to squeeze through the pores of the capillary wall.

Normal Albumin level: 34–50 g/L

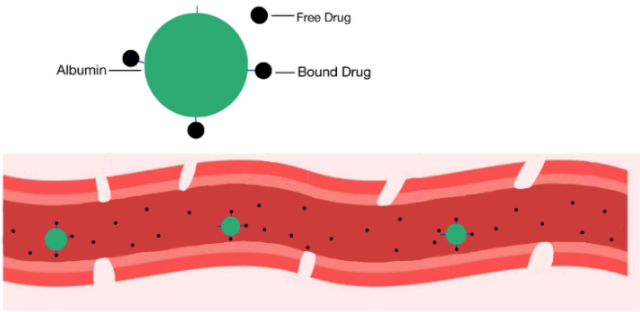

Figure 1.4c Blood vessel with large albumin molecules (green). The black dots represent free or unbound drug that can stay in the circulation or diffuse out of the blood vessel to the target site. Only drugs bound to the receptor on the albumin molecule cannot diffuse out of the blood vessel. (Sheila Odubote/ *TRU Open Press*) CC-BY-NC-SA

The major drug-binding protein in serum is albumin. Drugs exist in peripheral circulation as free (unbound) and bound to protein forms. Only free drugs are capable of crossing plasma membranes and binding with receptors for their intended action.

Displacement of Drugs From Albumin

The plasma protein albumin only has so many site for drug

molecules to bind to, so they compete with each other for those sites. Drug molecules with a higher affinity for albumin will competitively bind to plasma proteins first or will displace other drugs from the albumin binding sites. This leads to an increased concentration of the secondary drug in the bloodstream and more of the drug reaching the target site. This can lead to increased therapeutic or toxic drug levels. This is called **drug-drug interaction**. Drug-drug interaction occurs when a drug decreases or increases the response of another drug that is concurrently administered.

Figure 1.4d *Protein binding is like available seats on a bus.*

Think of protein-binding like a bus stop (see **Figure 1.4d**). Many passengers (or medication molecules) want to take a ride on the bus. Everyone is eager to get to their destination and interested in finding a seat. Some passengers are stronger and will get in the seats first (like drug molecules with greater protein-binding ability bind to the protein). Sometimes, there may not be enough seats on the bus, and some passengers are left at the bus stop. The passengers (medication molecules) left behind are "free" to move around and walk to their destination. They may strike out on their own and get

"snatched" (connected to a target receptor site) while on foot.

In a similar way, "free" drug particles that are not protein-bound are circulating in the bloodstream and connecting in a predictable fashion to receptor sites that have an affinity for that particular drug. These active drug molecules that did not bind to the protein (like those passengers that were unable to get a seat on the bus) will produce the first effect in the body. Over time, the medication molecules bound to the protein (like the passengers with seats on the bus) will get off the bus, start walking around, and get "snatched" by the receptor site that has affinity for them.

What Makes a Drug Molecule Bind to the Albumin Receptor?

A drug molecule binds to an albumin receptor because of **affinity**. A strong affinity (attraction) will have a large number of drug molecules bound to albumin, leaving a small percentage free to go to target sites. For example, the anticoagulant warfarin has a high affinity for albumin, up to 99% of the molecules are bound. The antibiotic Gentamycin has a weak affinity for albumin, so most of the drug molecule is unbound, resulting in more of the drug reaching the target site.

Are all drugs bound to albumin? The protein binding of a drug can be low, moderate, or high, whereas for some drugs such as lithium, the drug is not bound to serum protein at all.

Example in Practice:

Peter has atrial fibrillation. To manage the risk of blood clots, he takes the anticoagulant warfarin. Peter has been following the treatment plan, but he recently developed heartburn. He bought OTC cimetidine (an anti-ulcer medication H2 receptor antagonist) and started taking it over the last week. Is it alright for him to take both of these meds? It is safe?

Cimetidine has a very strong affinity for albumin, so it has a high likelihood to displace highly protein-bound drugs, increasing free drug levels and the risk of toxicity. In this case, warfarin is a highly protein bound drug, and cimetidine can displace warfarin. This will lead to more warfarin molecules free in the bloodstream and increase the risk of hemorrhage. This poses a safety concern for Peter. He should not be taking any other medications without the advice of his prescriber and without close monitoring for bleeding.

Theoretical Volume of Distribution (Vd)

The volume of distribution (Vd) is used to describe the potential volume within various areas where drugs may be distributed. These fluid compartments can be the plasma, extracellular water, total body water, or other organs and tissues. Vd has nothing to do with the actual volume of fluid in the body; instead, it relates the distribution of the drug in the body. Each drug has its own unique distribution in the body: some are distributed mostly into fat tissue,

some remain in extracellular fluid, and some are bound to tissues. Vd provides a reference point for the plasma concentration of a drug.

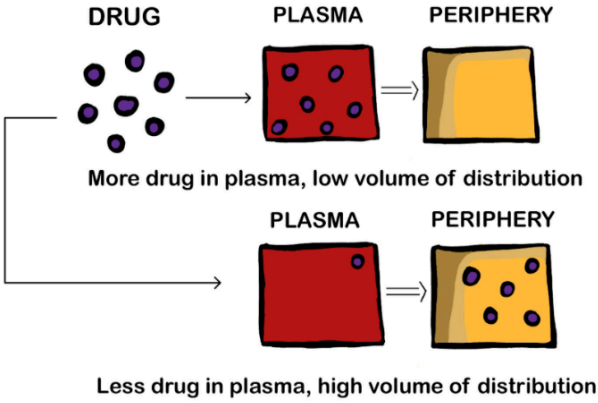

Figure 1.4e *Volume of distribution. (Sheila Odubote/ TRU Open Press). If most of the drug stays in the plasma and very little goes to the periphery (fat stores, interstitial fluids) then the drug has a low volume of distribution. If most of the drug moves to the periphery such as adipose tissue, then the drug has a high Vd and might be lipophilic.*

Drugs do not distribute equally. Each organ or body tissue will receive different amounts of a drug. Many factors can affect distribution including blood flow to the tissues, protein binding, and lipid solubility. Client factors include age, disease states, drug interactions, obesity, and malnutrition.

For example, for a highly tissue-bound drug, very little of the drug will remain in the bloodstream, and therefore the plasma concentration is low and Vd is high. Highly protein-bound drugs, such as warfarin or acetylsalicylic acid, will have a small volume of distribution.

So what does this mean in practice? Drugs with a high Vd may take longer to be eliminated from the body. They have a longer t½

and therefore their effects, including therapeutic and side effects, last for a longer period of time.

The Plasma Half-Life of a Drug

Half-life (t½) is the amount of time it takes for half of the medication to be eliminated from the body. Half-life directly correlates to the duration of the therapeutic effect of a medication. At four half-lives, only 6.25% of a drug is left in the body, which is at sub-therapeutic levels. At five half-lives, 97% of a drug will be eliminated.

Many medications are classified in terms of their half-life as it helps determine dose scheduling and when a **steady state** will occur. A steady state is when the amount of the drug removed by elimination is equal to the amount of the drug absorbed with each dose. If a drug has a long half-life, it will take longer to reach a steady state. See the unit **Examining the Drugs Effects** for further discussion on this topic.

Distribution of a medication can also cause unintended **adverse effects** or **side effects**. Drugs are designed to primarily cause one effect, meaning they bind more strongly to one specific receptor site and predictably cause or block an action. However, side effects can occur when the drug binds to other sites in addition to the target tissue, causing secondary side effects. These side effects can range from tolerable to unacceptable, resulting in the discontinuation of the medication. For example, a person might take the pain reliever ibuprofen (Advil) to treat a sore leg muscle; although the pain may be subsequently relieved, the side effect of stomach irritation may cause the person to stop taking it.

Critical Thinking Out Loud

Manjot is at 36-week gestation and has had a healthy pregnancy. In the event that Manjot needs to be given medications, which effect, if any, will her late-term pregnancy have on drug distribution?

Points to consider:

- Late-term pregnancy
- Concern with drug effects on fetus (placenta drug transfer)
- Concern if early delivery and effect on newborn
- Consider/anticipate dosage changes of medications related to pregnancy

The last term of pregnancy can impact albumin levels. The plasma volume expands, which can lead to hypoalbuminemia. Adipose tissue also increases, causing a larger distribution of the medication and leading to a prolonged duration of action and longer t ½ for medications.

Solution:

- Test serum albumin levels to determine if Manjot has hypoalbuminemia.
- Anticipate lower drug dosages. To avoid toxic drug levels, drug dosages will be lowered for two reasons:
    - drugs that are typically highly protein bound

will have more free drug circulating, and
- drugs that are highly lipophilic will have a larger volume of distribution.

Learning Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=1334#h5p-12

Clinical Reasoning and Decision Making Activities

1.Explain why seemingly small doses of morphine might have an unusually strong effect on someone with low serum albumin.

2. What if a drug is water soluble and highly protein bound? What will be its effect?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

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- Figure 1.4c Blood vessel with albumin molecules with bound and unbound drugs. (Sheila Odubote/ TRU Open Press) CC-

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- Figure 1.4d Renault, Type r321, Bus by Emslichter, via Pixabay, is used under the Pixabay Content License.
- Figure 1.4.e Volume of distribution. (Sheila Odubote/ TRU Open Press).

1.5 Pharmacokinetics — Metabolism (Biotransformation)

Once a drug has been absorbed and distributed in the body, it will then be broken down by a process known as **metabolism**. Metabolism is the process of chemically converting a drug into a form that can be more easily removed from the body (Adams et al., 2019, p. 23). Most drug metabolism takes place in the liver. Other organs that aid in metabolism include the kidneys, skeletal muscles, lungs, plasma, and intestinal mucosa. Very few drugs are not metabolized in the liver such as gabapentin or digoxin.

Almost every substance that enters the bloodstream—whether swallowed, injected, inhaled, absorbed through the skin, or produced by the body—is carried to the liver to be metabolized. Very simply, most drugs or substances (vitamins, minerals, nutrients) will be transformed by hepatic enzymes into polar metabolites, inactivating the drug and allowing it to be more easily excreted in the urine or bile.

More specifically, there are two phases to metabolism:

1. The hepatic microsomal enzyme system uses oxidation, reduction, and hydrolysis reactions to make the drug slightly more polar (water soluble).
2. Conjugation with endogenous substrates further changes the drug into a polar metabolite that is then inactive and easily excreted.

Hepatic Microsomal Enzyme System

The hepatic microsomal enzyme system, also known as the **P450 system**, is capable of catalyzing a variety of chemical reactions and aiding in the metabolism of medications. The primary effect of the enzymes is increasing drug polarity to facilitate excretion of the drug. These enzymes target lipid-soluble, non-polar drugs as they are difficult to eliminate and include the majority of the drugs. Converting lipid-soluble drugs into polar metabolites renders them less able to enter the tissues. Water-soluble medications are easily metabolized by simpler metabolic reactions such as hydrolysis.

P450 enzymes catalyze many reactions resulting in several different outcomes, including:

- accelerated renal excretion of drugs,
- drug inactivation,
- increased therapeutic action by prodrug activation (e.g., codeine is converted into morphine to enable pain relief, and losartan, an antihypertensive med, has no therapeutic activity until metabolized into an active form), and
- increased or decreased toxicity (e.g., acetaminophen is converted into a hepatotoxic form that is safe in therapeutic doses, but toxic in an overdose). (Adams et al., 2019; Le, 2024)

P450 System

The chromosome P450 is a group of 12 closely related enzyme families. Three of the P450 (CYP) families—CYP1, CYP2, CYP3—metabolize drugs. The other nine families metabolize other compounds such as steroids or fatty acids. Each of the three CYP families are also composed of multiple forms and metabolize certain drugs. They are identified by additional letters and numbers, for example, CYP2D6 and CYP3A4.

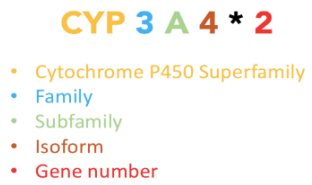

Figure 1.5a Cytochrome Nomenclature CC BY-SA 4.0

Each metabolize different drugs; for example, CYP3A4 metabolizes many drugs including acetaminophen, codeine, and erythromycin. It is actually the most abundant cytochrome in the liver and intestinal tract, and accounts for 30–40% of cytochrome activity.

Inducers and Inhibitors

Further, CYP450 enzymes can be induced or inhibited by many drugs and substances, resulting in drug interactions in which one drug enhances the toxicity or reduces the therapeutic effect of another drug.

Example: The drug Verapamil (a calcium-channel blocker) will inhibit the CYP3A4 enzyme, leading to increased drug effects and risk of side effects for some drugs.

Example: Phenobarbital is a CYP3A4 inducer, so it increases the rate of its own metabolism and of other drugs. Therefore, higher doses may be required to achieve a therapeutic effect.

Inducers and inhibitors are not just prescription or OTC drugs but can also be other substances, such as herbal remedies. St. John's Wort, an easily available herbal remedy, sometimes used for depression. It is a powerful CYP3A4 inducer, resulting in many medication to break down quickly and becoming less effective. It should not be taken with antidepressants, birth control, anticoagulants or immunosuppressants (National Center for Complimentary and Integrative Health, 2025). Nurses must always ask about clients about any supplements or herbal remedies they may be taking to avoid unwanted lower therapeutic effects.

First-Pass Effect

One of the first steps in metabolizing drugs occurs through a process known as the **first-pass effect**, in which orally administered drugs are broken down in the liver and intestines. This makes the substance easier to excrete in the urine. Medications made of protein that are swallowed or otherwise absorbed in the GI tract may quickly be deactivated by enzymes as they pass through the stomach and duodenum. If the drug enters the blood from the intestines, part of it will be broken down by liver enzymes, known as the first-pass effect, and some of it will escape to the general circulation to either be protein-bound (inactive) or stay free (and create an action at a receptor site). Thus, several doses of an oral medication may be needed to maintain enough active free drug in the circulation to exert the desired effect. Refer to 1.2 Absorption for further information about first-pass effect.

Some drugs undergo rapid hepatic metabolism via first-pass effect that leaves the drug ineffective or with a low bioavailability. In these cases, the drug will be administered intravenously so it avoids first-pass effect. For example, Morphine given orally undergoes extensive first pass metabolism. If given as the same dose as IV, there will be very low bioavailability with low therapeutic response. Therefore, the dose is adjusted to a 3:1 ratio. Morphine 30 mg po = Morphine 10 mg IV.

The Effect of Food on Metabolism

The metabolism of a drug can be impacted by other drugs, food, or supplements. Often, these drug-substance interactions are unintentional from accidental misuse or lack of knowledge. While drug-drug interactions are more widely researched, food-drug interactions are less known.

Some more common interactions include:

- **Grapefruit Juice:** Grapefruit juice (GFJ) is unique among juices as it inhibits CYP3A enzymes due to the Furanocoumarins in the juice. This can lead to an increase in oral bioavailability of medications that are CYP 3A4 substrates—like felodipine for high blood pressure or midazolam, a sedative—which can raise their concentrations above toxic levels (Bushra et al., 2011). (See below: Do you know the power of Grapefruit Juice?.)

Figure 1.5b Grapefruit juice and ripe grapefruits on a blue background." Pixabay Content License

- **Vitamin K rich foods**: Vitamin K rich foods can impact warfarin, an anticoagulant. Clients are advised to ingest a consistent level of vitamin K foods (leafy greens, avocados, soy).
- **Dietary protein**: Dietary protein levels can influence how the body metabolizes some meds. High protein diets can accelerate the metabolism of certain drugs by stimulating P450 enzymes. Low protein diets can decrease the clearance of some drugs, such as theophylline.

Thus, dietary considerations must be considered for clients taking medications that have a narrow therapeutic window or are higher-risk medications. They need to be fully informed of any potential interactions so they can take an active role in avoiding drug-food interactions.

Lifespan Considerations

Neonate and Pediatric: The developing liver in infants and young children produces decreased levels of microsomal enzymes. Because of this, a young child or neonate may have a decreased ability to metabolize medications. In contrast, older children may experience increased metabolism and require higher doses of medications once the hepatic enzymes are fully produced (Fernandez et al., 2011). Always exercise caution when administering medications to children and infants.

Older Adult: Hepatic metabolism may decline in older adults. As a result, dosages should be adjusted according to the client's liver function and anticipated metabolic rate. First-pass metabolism also decreases with aging; therefore, older adults may have higher "free" circulating drug concentrations and be at a higher risk for side effects and toxicities (Fernandez et al., 2011).

Putting It All Together

Drugs can be metabolized by a number of processes, including oxidation, hydrolysis, conjugation, condensation, or isomerization, resulting in drug molecules transforming into smaller molecules, transforming into polar metabolites, or in some cases, synthesizing into a larger prodrug. Once liver enzymes have completed metabolizing a drug, the now-inactive drug undergoes the final stage of its time in the body—excretion—as it exits via the urine or feces.

Clinical Reasoning and Decision Making Activities

Metabolism can be influenced by many factors within the body. If a client has liver damage, the client may not be able to break down (metabolize) medications as efficiently. Dosages are calculated according to the liver's ability to metabolize and the kidney's ability to excrete.

1. When caring for a client with cirrhosis, how does this condition impact the dosages prescribed for the client? What should be nurse be monitoring or evaluating?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

Did You Know the Power of Grapefruit Juice?

A Juicy Story

Did you know that, in some people, a single glass of grapefruit juice can alter levels of drugs used to treat allergies, heart diseases, and infections? Fifteen years ago, pharmacologists discovered this "grapefruit juice effect" by luck, after giving volunteers grapefruit juice to mask the taste of a medicine. Nearly a decade later, researchers figured out that grapefruit juice affects the metabolizing rates of some medicines by lowering levels of a drug-metabolizing enzyme, called CYP3A4 (part of the CYP450 family of drug-binding enzymes), in the intestines.

More recently, Paul B. Watkins of the University of North Carolina at Chapel Hill discovered that other juices like Seville (sour) orange juice—but not regular orange juice—have the same effect on the liver's ability to metabolize using enzymes. Each of ten people who volunteered for Watkins' juice-medicine study took a standard dose of felodopine (Plendil), a drug used to treat high blood pressure, diluted in grapefruit juice, sour orange juice, or plain orange juice. The researchers measured blood levels of Plendil at various times afterward. The team observed that both grapefruit juice and sour orange juice increased blood levels of Plendil, as if the people had received a higher dose. Regular orange juice had no effect. Watkins and his coworkers have found that a chemical common to grapefruit and sour oranges, dihydroxybergamottin, is likely the molecular culprit.

Thus, when taking medications that use the CYP3A4 enzyme to metabolize, clients are advised to avoid grapefruit juice and sour orange juice.

Davis, 2006

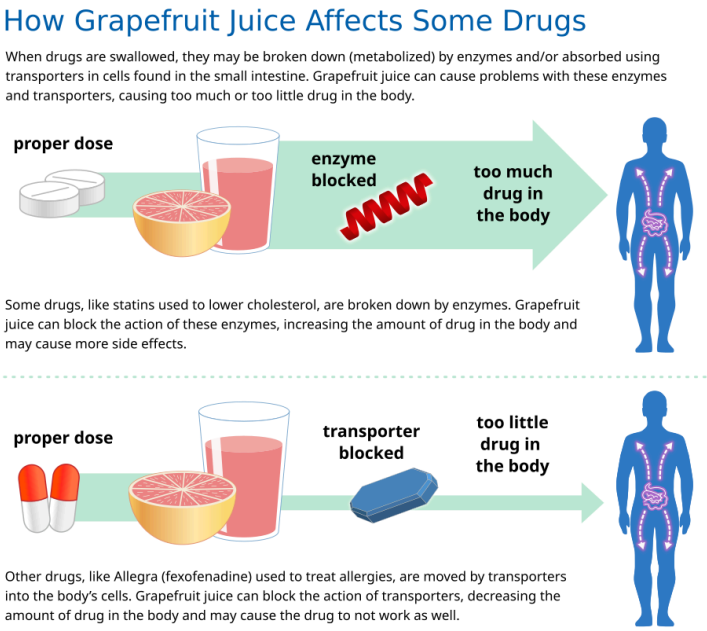

Figure 1.5c Grapefruit Juice and Medicine May Not Mix. Grapefruit can impact the metabolism of some drugs by blocking the enzyme that metabolizes the drug in the liver. This could lead to higher concentrations of the drug. CC BY-SA 4.0

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Figure 1.5c Grapefruit Juice and Medicine May Not Mix. File:Grapefruit Juice and Medicine May Not Mix (6774935740) – en.svg – Wikimedia Commons by FDA graphic by Michael J. Ermarth, Wikimedia Commons, CC BY-SA 4.0

1.6 Pharmacokinetics — Excretion

Excretion is the process by which a drug and its metabolites are eliminated from the body. Although the kidneys are the primary organ for excretion, some drugs may also be excreted through the liver by the biliary system with minimal amounts excreted through other routes such as saliva and tears.

Drug elimination is a complex process that includes excretion of an unmetabolized drug in an intact form or excretion following a metabolic transformation (Garza et al., 2023). Other factors also impact excretion such as the drug characteristics and client factors such as age, genetics, and other health issues. For example, if a client has dysfunction with their kidney or liver, drug excretion will be prolonged and can lead to undesirable adverse effects and prolonged therapeutic effects. Nurses need to consider how a delayed excretion can alter their assessment and client monitoring.

In this unit, we will look at the many factors that can impact drug excretion, including drug characteristics, routes of excretion and lifespan considerations.

Drug Characteristics

Drug excretion is impacted by the drug's characteristics, such as the polarity of the drug or the size of the drug metabolite.

Hydrophilic drugs are typically directly excreted by the kidneys. These drugs or their metabolites get filtered by the kidneys and usually do not undergo reabsorption. Drugs that are lipophilic need to first undergo biotransformation to become more polar before undergoing elimination through the kidneys (Garza et al., 2023).

Other drug characteristics, such as its molecular weight, and drug conjugation, influence its excretion characteristics. For example, drugs with molecular weights greater than 300 Da, either polar and lipophilic groups, are more likely to be excreted in bile.

Many drugs are hydrophilic and are excreted unchanged by the kidney. Some examples include metformin (anti-diabetic med), gabapentin, many antibiotics (ampicillin, amoxicillin), lithium and the ACE inhibitor lisinopril. For clients with impaired renal function, dose adjustments may be necessary as the drug will take a longer time to be excreted.

Routes of Excretion

Kidney

The most common route of excretion is the kidney. After the drug is metabolized by the liver into a more polar metabolite, the kidneys then filters the blood and the majority of drug byproducts and waste are excreted in the urine. Medications may be filtered at the glomerulus, active tubular reabsorption, or active tubular secretion, where a portion may go back into the bloodstream with the rest excreted in urine.

Free drugs, water-soluble drugs, and electrolytes are easily filtered by the glomerulus and then readily excreted. Lipid-soluble drugs cross the renal tubular membrane and are reabsorbed back into circulation, as they need to be more hydrophilic for excretion. Most drugs are polar compounds by the time they reach the kidney and are excreted. Some drugs are excreted by more than one process in the kidney. For example, for the antibiotic Penicillin G, only 10% is filtered by the glomerulus and 90% is secreted by the renal tubules (Adams et al., 2018).

Glomerular Filtration and Drug Excretion

The kidney filters approx. 180 L of fluid per day.

Glomerular barriers restrict passage of plasma proteins and red blood cells. Drugs that are bound to albumin will not be effectively filtered.

Renal blood flow influences the rate of delivery of a drug to the kidney.

GFR (glomerular filtration rate) is affected by age or disease. GFR declines with age, generally by 1% per year. Diabetes accelerates the decrease in GFR.

Factors Affecting Kidney Function

The rate of excretion can be estimated by taking into consideration several factors: age, weight, biological sex, and kidney function. With aging, the renal drug excretion decreases. By the age of 80, renal function is typically half of what it was at age 30 (Le, 2024).

Excretion can also be impacted by disorders such as acute or chronic kidney disease. Kidney function is measured by lab values such as serum creatinine, glomerular filtration rate (GFR), and creatinine clearance (CrCl). If a client's kidney function decreases, it affects their ability to excrete medication, and drug dosages must be reduced to avoid toxicity.

Other health disorders can impact drug clearance such as hypoperfusion from sepsis, disorders that affect antidiuretic hormone release or heart failure.

Drug Half-life: Recall that a drugs elimination half-life (T1/2) is

the time required for the plasma concentration to decrease by 50%. What do this mean for drug dosages?

> example: Metformin t1/2 is 17 hours. The client has CrCl of 50 mL/min. No dose adjustment is needed for mild-moderate renal impairment. If the CrCl is less than 30 mL/min, then the risk of lactic acid increases and then metformin will likely be discontinued.
>
> example: Morphine t1/2 is 2-4 hours. This means that in 4 hours, 50% of the drug is eliminated from the body. If there is renal insufficiency, morphine's active metabolites will not be excreted as readily, and its effects (pain control) and adverse effects (i.e. sedation) will linger (longer duration of action). But, if there is renal dysfunction, morphine's active metabolites accumulate especially if there is moderate to severe renal failure. Dose reduction is 75% for mild renal insufficiency, and 50% for moderate disease.

For nursing practice, clients should be more closely monitored for therapeutic and adverse effects. Nurses should know common adverse effects of the meds they are giving. When considering drug dosage adjustments, it is worth noting that in practice, doses rarely need to be altered before the GFR drops below 50 ml/min (Tom et al, 2018).

Liver and Intestinal Tract

The process of metabolism begins in the excretion phase of drug metabolites. Whether the drug is polar or non-polar will determine the degree of transformation needed for the metabolite to be more readily excreted. Hepatic metabolism increases a drug's polarity and water solubility leading to easier excretion.

Excretion in the bile is another significant form of drug elimination. As the liver filters blood, some drugs and their metabolites are actively transported by the hepatocytes (liver cells)

into bile. Bile moves through the bile ducts to the gallbladder and then on to the small intestine. During this process of biliary excretion, some drugs may be partially absorbed by the intestine back into the bloodstream. Other drugs are biotransformed (metabolized) by intestinal bacteria and reabsorbed. Unabsorbed drugs and byproducts/metabolites are excreted via the feces. This *enterohepatic recirculation* of drugs can prolong the action of the drug and is considered when determining drug dosages.

Enterohepatic Recirculation

Enterohepatic recirculation is the cycle of drug, solutes, or bile acids as they are eliminated from the liver into the bile, then reabsorbed by the intestines, then returned to the liver.

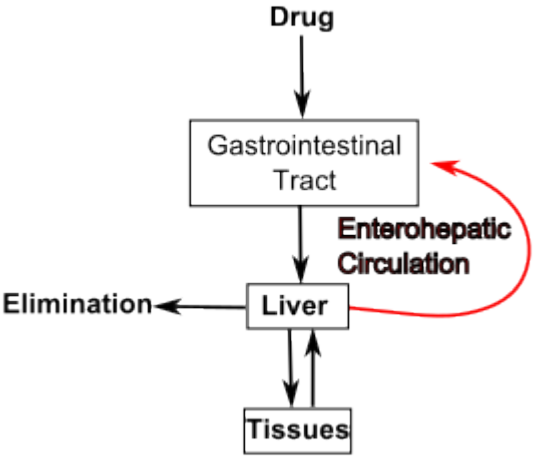

Figure 1.6a Hepatic Recirculation

If a patient is experiencing decreased liver function, their ability

to excrete a medication is affected and drug dosages must be decreased. Lab studies used to estimate liver function are called liver function tests and include measurement of the ALT and AST enzymes that the body releases in response to damage or disease.

Renal Function Lab Values

Nurses need to know their client's renal function to ensure safe med administration.

Se Creatinine (waste product of muscle metabolism):

- Men: 0.74-1.35 mg/dL
- Women: 0.59-1.04 mg/dL

Estimated glomerular filtration rate (eGFR) (how well kidneys filter waste from the blood):

- Normal: greater than or equal to 90 mL/min/1.73 m^2
- Mildly decreased: 60–89 mL/min/1.73 m^2
- CKD: less than 60 mL/min/1.73 m^2

Other renal function labs include urine albumin, blood urea nitrogen (BUN), and creatine clearance.

Other Routes to Consider

Some medications are excreted through other routes such as the lungs, breast milk, and even minimally through tears, reproductive fluids (seminal fluids), and the skin. Drugs excreted by the lungs are

anesthetic gases that are eliminated through exhalation. Following surgery, drug excretion via exhalation is dependent on the client's respiratory function, such as respiratory rate and pulmonary blood flow (Adams et al., 2018).

Drugs excreted by saliva is primarily transferred through passive diffusion from the plasma and is dependent on such factors as a drug's low protein-binding ability, ionization, polar surface area, and lipophilicity. Factors such as the saliva's pH also play a role. There are over 40 medications that can be detected in saliva including the benzodiazepine Midazolam, opioids, cannabis, and some antibiotics.

Saliva Sample for Drug Monitoring

Although the amount of the actual drug excreted through saliva is negligible, where it is valuable is with therapeutic drug monitoring and testing. Typically, therapeutic drug monitoring for high-risk medications is done through blood tests, but new research shows that testing the saliva is less invasive and just as accurate as serum testing (Nyugen et al., 2024).

Drug Excretion in Breast Milk

Drugs excreted in breast milk require special consideration even if drug levels are minimal. Breastfeeding mothers may inadvertently transfer a drug by-product to their breastfeeding infant, which can prove dangerous to the infant. Numerous medications are contraindicated for breastfeeding mothers, such as the mood stabilizer lithium which can cause lethargy and hypotonia in the infant. Many psychoactive medications such as antidepressants (Fluoxetine) can cause irritability and feeding problems. Many other medications are detectable in breast milk but pose a theoretical

risk (detectable in breast milk but no studies have been done to determine if they harm infants) and, as such, should be avoided. Similar to medication use throughout a pregnancy, medication use while breastfeeding needs to be discussed with their healthcare provider to weigh any risks versus benefits. It is important for the nurse to obtain a good health history and medication profile and to provide good health teaching to ensure infant safety.

Figure 1.6b Breastfeeding mother

Lifespan Considerations

Neonates & Pediatrics: Young patients have immature kidneys with decreased glomerular filtration, resorption, and tubular secretion. As a result, they do not clear medications as efficiently from the body. Dosing for most medications used to treat infants and pediatric patients is commonly based on weight in kilograms, and a smaller dose is usually prescribed. In addition, pediatric patients

may have higher levels of free circulating medication than anticipated, which may quickly become toxic. Therefore, frequent assessment of infants and children is vital for early identification of drug toxicity (Fernandez et al., 2011).

Older Adults: Kidney and liver function often decreases with age, which can lead to decreased excretion of medications. Subsequently, medication may have a prolonged half-life with a greater potential for toxicity due to elevated circulating drug levels. Smaller doses of medications are often recommended for older patients due to these factors, commonly referred to as "Start low and go slow" (Fernandez et al., 2011).

See the final unit in this chapter, **Lifespan Considerations for Pharmacological Principles** for more discussion on lifespan variables.

Critical Thinking Out Loud

A nurse is reviewing a 65-year-old client's lab work and sees that the eGFR for this client is 50 (normal eGFR is greater than 60mL/min). They have type 2 diabetes mellitus and have been admitted for a wound debridement. The nurse notices that many of the clients' medications are prescribed at the same dosage as pre-admission. Is this a concern? Should clients with renal insufficiency have lower dosages of all their meds?

The answer to this question is not straightforward. Many factors impact drug clearance. For example, some drugs are only 30% renally cleared, so a decreased renal function is not a concern. Some drugs are considered a low-toxicity

drug and only prescribed for a short period of time so the risk of accumulation is minimal. For example, if oral penicillin is prescribed for only a few days. Some drugs are taken for long term and have a high intrinsic toxicity, for example metformin or lithium. In these meds, a dose adjustment may be required to prevent high drug accumulation and to avoid toxicity. For example, the t1/2 of some meds will double after a 50% decrease in clearance due to impaired kidney function. This could lead to drug accumulation and risk of toxicity especially for chronic drug therapy (Tom et al, 2018; Hallare & Gerriets, 2025).

There is no absolute parameter of kidney function that necessitates a dose reduction for all meds as it depends on many variables. When considering drug dosage adjustments, it is worth noting that in practice, doses rarely need to be altered before the GFR drops below 50 ml/min. In this clients case, the nurse reviewed the adverse effects of the meds the client was taking, and made note to monitor the lab work each day. The nurse also spoke with the prescriber about any med they were concerned about and if a dose reduction or closer renal monitoring was needed.

Note: Answers to the Clinical Reasoning and Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Putting It All Together

Prescribing and administering medications in a safe manner to clients is challenging. The ultimate goal of any medication use is to

have a positive therapeutic outcome with minimal adverse effects. How a drug moves throughout the body is important to understand to ensure correct drug dosing, monitor for drug response, and evaluate the overall effect. Aging clients or other lifespan considerations, acute or chronic health conditions, drug-drug interactions, and other variables can all impact the pharmacokinetics of the drug. Safe and efficient pharmacotherapy requires collaboration with and within the healthcare team, including prescribers, pharmacists, nurses, and other allied health care members.

The next section, pharmacodynamics, will examine what the drug does to the body.

Watch Pharmacokinetics: How drugs move through the body [7:54] by Professor Dave Explains (2020).

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=1357#oembed-1

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Figure 1.6a Hepatic Recirculation. Enterohepatic.svg https://commons.wikimedia.org/wiki/File:Enterohepatic.svg

Figure 1.6b Breastfeeding mother. https://www.needpix.com/photo/794304/breast-feeding-motherhood-mother-breast-milk-child-the-birth-of-love-a-small-child

1.7 Pharmacodynamics

Complex Interactions

So far, we have learned the importance of pharmacokinetics in describing how the body absorbs, moves, processes, and eliminates a medication. Now, let us consider a drug's impact on the body, which is a series of complex interactions known as **pharmacodynamics**. Pharmacodynamics is simply what the drug does to the body. It is a crucial part of pharmacology as it looks at the safety of the drug and identifies dosage ranges to achieve a therapeutic effect.

How a drug responds in a body is not always predictable, with some clients eliciting the desired response while others may have an adverse effect or no effect at all. The study of pharmacodynamics helps practitioners understand how effective a drug might be, also known as its efficacy. It tells us how strong a drug response might be, also known as its potency. It also helps our understanding of the relationship between pharmacokinetics and pharmacodynamics and see how both influence dosing, effectiveness, and adverse effects.

Pharmacodynamics is crucial to understand the mechanisms of action, dose-response relationships, and the variability in individual drug responses. Pharmacodynamics explores how drugs exert their effects on the body, specifically the specific molecular targets referred to as receptors, enzymes, and ion channels. These interactions can either stimulate or inhibit the function of these targets, resulting in physiological changes (Hook, 2023).

Drug Receptor Interactions — Key Points

- In general, drugs or substances (chemicals) will not act unless they induce a reaction with a living organism. Drugs also cannot make a cell do something it was not designed to do. The effects of the drug will depend on the tissues or cells targeted by the drug.
- Drugs induce a reaction in several ways: either they modify the *rate* that the cell functions or modify the *strength* of function of that cell or tissue. Therefore, they only produce an effect by interacting with other chemicals or receptors.
- Drugs can bind or interact with a variety of chemicals or proteins: these are receptors, transporters, ion channels, enzymes, nucleic acids or lipids.
- Receptors families: Receptors are proteins, but they vary in their structure. They can be cell membrane-embedded enzymes, ligand-gated ion channels, G-protein-coupled receptor systems, or transcription factors.
- Drug-receptor binding can be reversible or irreversible. Most either mimic or inhibit normal physiological processes or pathological processes.
- Efficacy and potency of a drug-receptor interaction are key terms for pharmacodynamics.

Drug Interactions

The effects of a drug depend on the cells or tissue targeted by the drug. Once the drug is at the site of action, it can only mimic or

block the actions of the endogenous molecules. A drug cannot make a cell do something it was not designed to do. It can only increase or decrease the physiological activity normally controlled by that receptor. Three ways which drugs do this are receptor, enzyme, and non-selective interactions.

Receptor Interaction

Receptor interaction involves the selective joining of the drug molecule with a reactive site on the surface of a cell or tissue. This is usually a protein structure within the cell membrane. As previously mentioned, there are four primary receptor families (G-coupled, ligand-gated ion channels, cell membrane embedded, and transcription factors). Although each are distinct in their function and processes with drug binding, all work similarly with a drug (a chemical) interacting with a receptor (chemical site) to produce a physiological effect.

Once the substance (drug or chemical) binds to and interacts with the receptor, a pharmacological response is produced.

Figure 1.7a Drug-Receptor complex. When a drug binds with a receptor it produces a drug-receptor complex and results in a pharmacological response. (Sheila Odubote/ TRU Open Press). CC BY-NC-SA 4.0

The binding of a drug to a receptor is usually reversible. This drug-receptor binding can only mimic or block the action of the

endogenous regulatory molecule. The drug with the best fit or greatest **affinity** to that receptor will elicit a greater response from the cell.

Some drugs interact with a receptor and activate it fully. These are called **agonists**:

- They can only mimic or enhance what the cell was intended to do.
- They will produce the same response as the endogenous chemical.
- Examples: Many neurotransmitters (histamine, norepinephrine), hormones, and drugs (opiates, benzodiazepines) are agonists.

Some drug molecules only partially activate the receptor **(partial agonist)**:

- The response will be lesser than or weaker than an agonist.
- Example: Buprenorphine is sometimes prescribed for opioid addiction. The degree of pain relief (and other euphoric effects) will be much lower than a full agonist, such as morphine.

Other drugs block the receptor to produce no action at all **(antagonist)**:

- They block receptor activity with the effect most evident in the presence of an agonist. They will occupy the receptor and prevent the endogenous chemical from acting.
- The response of the antagonist is dependent on how much agonist drug is present.
- Example: Naloxone is given for respiratory depression from opioid overdose. Naloxone, which has a high affinity to the mu receptors, will occupy free mu receptors as well as replace the opioid from the mu receptor it is occupying. If Naloxone was given when no opioid drug was given previously, then naloxone

would produce no response.

(Marino, Jamal, & Zito, 2023; Rosow, Standaert, & Strichartz, n.d.).

Figure 1.7b represents the drug-receptor complex reactions. Before the drug is given, the body's own endogenous molecule binds with a receptor site on a cell and elicits a response. The second diagram, the agonist drug, with a similar composition as the endogenous molecule, is able to produce the same response. The third diagram, the antagonist drug binds to the receptor and only blocks the agonist's actions. No response will occur.

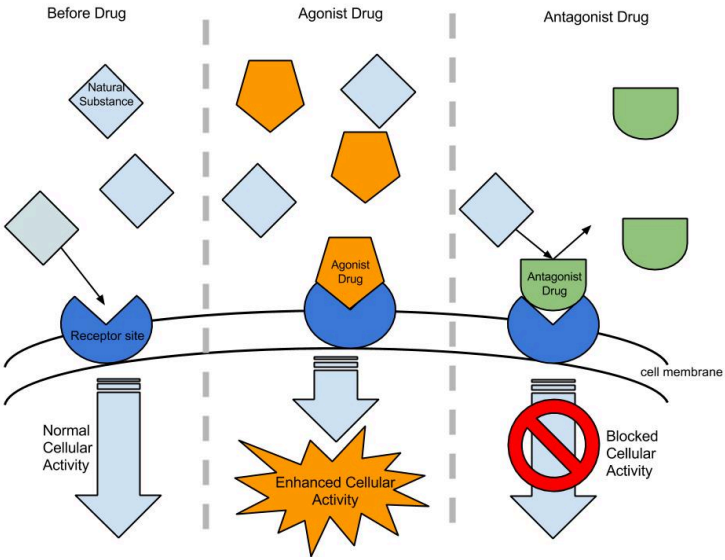

Figure 1.7b Agonist and antagonist drug-receptor responses (Dolleyj/Wikimedia Commons) CC BY-SA 3.0

In the following graph, the full agonist produces a greater response or greater activity. The partial agonist, with a similar concentration, is not able to produce the same activity.

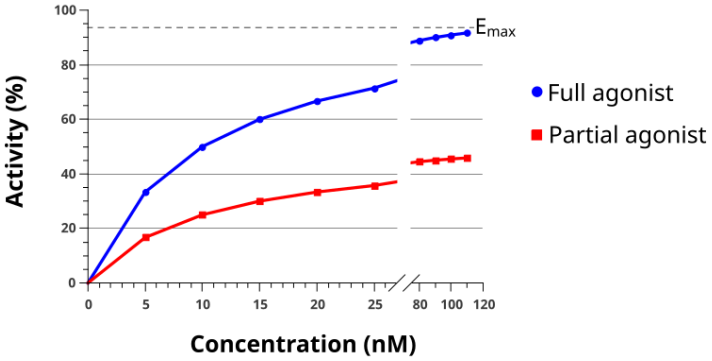

Figure 1.7c Agonist and partial agonist graph depicting the activity differences.

File: Agonist full and partial.svg. . https://commons.wikimedia.org/wiki/File:Agonist_full_and_partial.svg Creative CommonsAttribution-Share Alike 3.0 Unported license

Critical Thinking in Action

A client has heart failure and needs a medication to lower their heart rate.

Recall that beta-1 receptors are located on smooth muscle cells in blood vessels and on heart muscle cells. The hormone adrenaline is released from the nerve cell, binding to the receptors on the blood vessels or heart and tightening up the blood vessel

(leading to increased BP) or elevating the heart rate.

The prescriber orders the cardiac medication *atenolol*, a beta-1 receptor antagonist.

Atenolol will bind to the beta-1 receptors on the heart leading to:

- Slower contractions of the heart (negative inotropic effect), thus causing the heart muscle to work less;
- Heart rate decreases (negative chronotropic effect); and
- Slower heart conduction (negative dromotropic effect).

The nurse will anticipate the effects of atenolol and be able to assess and monitor appropriately.

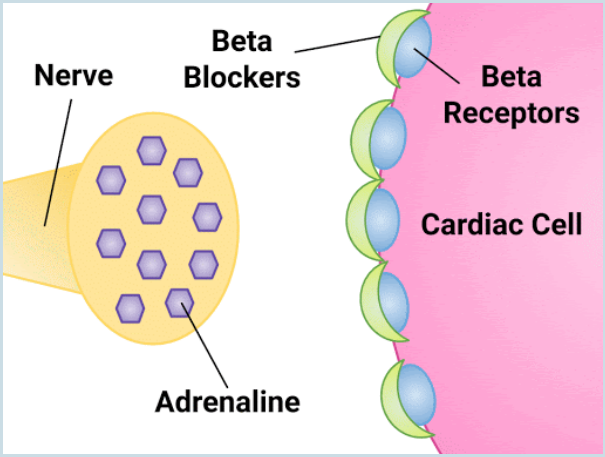

Figure 1.7d Mechanism of action of beta agonist medications (Dominic Slausen/Chippewa Valley Technical College) CC BY 4.0

Note: Answers to the Clinical Reasoning and Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Agonistic and antagonistic effects on receptors are further discussed in the **Autonomic Nervous System** chapter.

Enzyme Interaction

Enzymes are substances that catalyze nearly every biochemical reaction in a cell. The drug chemically binds to an enzyme molecule, thereby changing the physiological response.

The drug can enhance, inhibit, or deactivate the enzyme, but inhibit is the most common response. These interactions can be reversible or irreversible.

Example: Cyclooxygenase (COX) inhibitors, such as non-steroidal anti-inflammatory drugs (NSAIDs), act on one or both of the isozymes COX-1 and COX-2. The inhibition of these pathways leads to pain relief and a decrease in inflammation.

Example: Drugs can also be activated by the enzyme reaction. Metronidazole (anti-infective) enters a bacteria cell, where it is activated by bacterial enzymes, and then kills the bacteria.

Non-specific Interactions

Some drugs physically interfere with or chemically alter cell processes and cell membranes. They do not target or interact with

receptors or enzymes. This results in an improperly formed cell wall, which leads to cell lysis or, if it lacks the needed energy, cell starvation.

Example: Antibiotics that affect the bacterial cell walls. Beta-lactams such as penicillin interfere with the structure of peptidoglycan (component of the bacterial cell wall), leading to cell wall lysis.

Example: Mannitol, an osmotic diuretic, increases the blood plasma osmolarity leading to cells (brain primarily) becoming dehydrated as water moves to the bloodstream.

Example: Antacids modify stomach acid (pH) through a chemical reaction:

$$\mathrm{Mg}(\mathrm{OH})_2+2\mathrm{HCl}\rightarrow2\mathrm{H}_2\mathrm{O}+\mathrm{MgCl}_2$$

This chemical reaction neutralizes stomach acid and relives symptoms.

Important Terms — Affinity, Potency, Efficacy, and Selectivity

If a drug has a strong affinity to a receptor, does that mean it will be the most effective? Are all drugs equally selective? What happens when two drugs with similar actions are given together; will it always end up as a bigger response? The answer to these questions helps nurses understand why one drug is chosen over another drug and what we need to be monitoring to ensure client safety.

Affinity is how attracted the drug is to the receptor. A higher affinity of a drug molecule to a receptor means a tighter bond or attraction. If you have two drugs that can bind to a receptor, the drug with the higher affinity will occupy more of the receptor sites.

Potency is how much drug is needed to produce an effect. It is often measured as the concentration of the drug needed to achieve

50% of the drug's maximal effect (EC_{50} effective concentration 50). A drug with a high affinity to a receptor are more potent as they can bind to receptors at low concentrations.

Efficacy (maximum effect E_{max}) refers to a drug's maximal effect. It is the drug's capacity to produce an effect or activate a receptor, regardless of the dose. It measures how well a drug works. Note that just because a drug occupies a receptor, does not mean it will produce a maximum response. It can produce a complete response, no response or a partial response.

Intrinsic activity, related to efficacy, is the drug's ability to activate a receptor and produce a response in comparison to a full agonist.

Selectivity is how likely it is for a drug to only affect its target site. A highly selective drug will only create a response in a given target site—it causes a change in certain cells without affecting other cells. It is desirable to have a drug that is highly selective so only the desired effect is achieved. Drugs that bind with receptors beyond the target site will create unwanted effects or side effects. For example, morphine binds to mu and kappa pain receptors in the CNS to alleviate pain, but it also binds to other pain receptors (kappa, delta) outside the CNS and other non-selective receptor effects in the CNS and peripheries. This leads to side effects such as nausea or respiratory depression.

Efficacy of Two Drugs

In the diagram below, we have two drugs. Drug A is shown to have a bigger effect or response than with Drug B. Drug A is more efficacious. Drugs with a higher efficacy are often more desirable as they produce a higher therapeutic response (Yartsev, 2015).

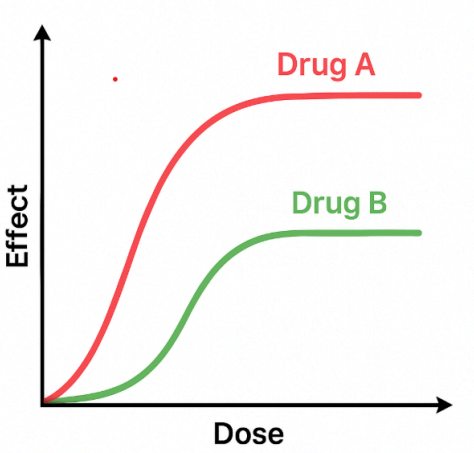

Figure 1.7e Drug A achieves a higher maximum effect than Drug B. Drug A is therefore said to be more efficacious

Figure 1.7e Comparison of efficacy between two drugs (Sheila Odubote/ TRU Open Press)

Example in Practice:

A client has congestive heart failure and needs a diuretic to treat fluid overload. Let us compare two diuretics:

- Furosemide, Drug A, is a loop diuretic that eliminates sodium and water through the ascending loop of Henle in the kidneys, leading to an fluid loss, less intravascular volume and a lower BP.
- Hydrochlorothiazide, Drug B, is a thiazide diuretic that also causes water loss through the kidneys, but its actions are less powerful and effective compared to Furosemide.

Thus, Furosemide has greater efficacy than hydrochlorothiazide.

In this diagram, figure 1.7f, Both Drug A and Drug B achieve the same maximum effect, i.e., they have equal efficacy. However, Drug

A achieves this effect at a lower dose, so Drug A has a higher potency than Drug B.

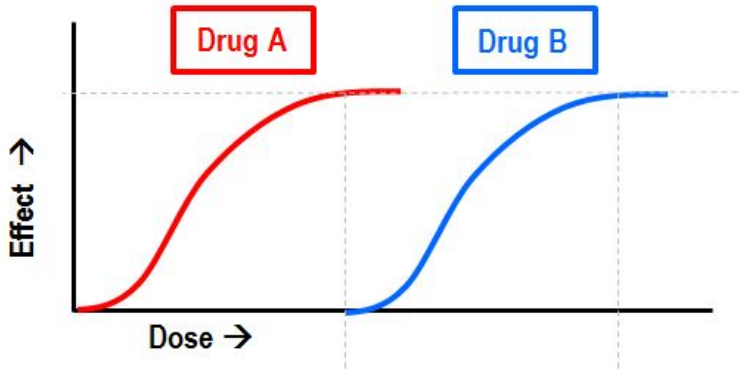

Figure 1.7f Efficacy and potency of Drug A and B (© Alex Yartsev). Used with permission.

Example In Practice:

A client needs pain control and two opioid drug options are compared. Hydromorphone 1.5 mg po is equivalent to Morphine 10 mg po. Hydromorphone is more potent than morphine although both are equally effective.

Mechanism of Action

The interaction between a drug and a receptor is the **mechanism of action (MOA)**, or "how the drug works." This is the way that a drug produces its pharmacological effect. Sometimes, drugs affect target cells through enzymes, by changing cell function, or by changing the cellular structure itself (Barbour-Taylor et al., 2024).

Example in Practice:

Let us compare two pain medications:

- Morphine, an opioid, acts directly upon mu and kappa receptors in the central nervous system and alters the perception of pain.
- Ibuprofen, an anti-inflammatory and pain reliever, works on the cyclo-oxygenase pathway by blocking prostaglandin synthesis.

Although both drugs are pain relievers, their actions affect different receptors on different pathways or cells. Why is this important? Nurses need to understand the MOA of the drugs they administer to be able to anticipate the desired effect (strong, moderate, or mild pain relief), side effects (nausea, gastric irritation, or pruritis), and adverse effects (respiratory depression or gastric bleed).

The mechanism of action is known for most medications, which helps with understanding the desired effects as well as side effects and adverse reactions. But for some medications, it is either not clearly understood or unknown. For example, the MOA for acetaminophen, a common pain reliever, is not completely understood, and neither is the weight gain associated with antipsychotic medications.

The principles discussed here are not a comprehensive list but an introduction to the ways some drugs interact with cells. Nurses need to have a firm grasp of these basic principles and apply them for safe medication administration.

Putting It All Together

A client has 8/10 pain and is given Morphine IV. Morphine is a **full agonist** that will bind to the mu receptors in the CNS to relieve pain. This client's pain is relieved, but their breathing becomes shallow and depressed leading to respiratory depression.

The nurse gives naloxone, which is an opioid **antagonist**. Naloxone has a very strong affinity to mu receptors, and in the

presence of the agonist morphine, will bind to the mu receptors, displacing morphine. By giving naloxone, the pain receptors are now not occupied by an agonist and the pain returns. But respirations will improve, which is the intended effect with giving naloxone.

While a full agonist produces the maximal response at that receptor when they bind, **partial agonists** bind to the same receptor but produce a smaller response, even when all receptors are occupied. An example is buprenorphine, which is used to treat opioid addiction. It can relieve pain like a full agonist but it has a ceiling effect so the risk of respiratory depression is minimal.

In summary, nurses need to have an understanding of the mechanism of action of medications they are giving to ensure they can effectively assess, administer, and monitor for therapeutic and side effects.

Learning Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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Clinical Reasoning and Decision-Making 1.7

1. A nurse is reading in the drug manual that a drug is potent. The nurse considers what potent means, and thinks it refers to the drug highly likely to cause adverse or toxic effects. Is this nurse correct? Explain.

Note: Answers to the Clinical Reasoning and Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

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- Figure 1.7d Mechanism of Action" by Dominic Slausen at Chippewa Valley Technical College is licensed under CC BY 4.0 license.

- Figure 1.7e Comparison of efficacy between two drugs (Sheila Odubote/ TRU Open Press)
- Figure 1.7f Efficacy and potency between two drugs (Sheila Odubote/ TRU Open Press).

1.8 Pharmacology Principles — Lifespan Considerations

The safe use of medications requires healthcare providers to consider the unique pharmacokinetics and pharmacodynamics of drugs for different age groups and between the sexes. The nurse should consider the following questions:

- Are there special considerations related to the client's age before I give this medication?
- Is the dose within acceptable limits?
- Do I need to check lab values before giving this medication?
- What is the client's current status that may impact this medication?
- Does the client have any other health issues?

To begin this unit, we will examine the pharmacological differences between the sexes. The majority of this unit will examine lifespan considerations.

Sex Differences

Women have been historically underrepresented in drug trials and gender-specific drug analysis is still lacking, although there has been some improvement towards fair representation (Chu, 2014). Sex (referring to sex assigned at birth) differences are evident in body weight and plasma volume, along with all four phases of pharmacokinetics. These differences can contribute to less therapeutic effect and more adverse effects. Some of the differences are outlined below. Recognize that all effects are generalized as body composition will vary between individuals.

Absorption: Women have a slower GI transit time which affects the plasma concentration and absorption of oral drugs.

Distribution: In comparison to me, women have a higher percentage of body fat and lower body water content which can affect the volume of distribution of some drugs. For example, for lipophilic drugs like opioids, the drugs accumulate in body fat, and the half-life of lipophilic drugs in women is longer.

Metabolism: Differences in the metabolism of drugs with P450 enzymes makes metabolism phase the biggest difference between genders.

Excretion: Women have both a lower renal blood flow and glomerular filtration rate resulting in a slower clearance of drugs.

Although there is some differences with alterations in receptor number and receptor binding, pharmacodynamic differences are not as significant as pharmacokinetics.

For most drugs, gender-specific dosing recommendations are not considered. Women have more overdosages with meds, and more significant adverse effects. If a woman experiences more adverse effects from a drug or less therapeutic effect, a change in dosing may be necessary (Chu, 2014; Soldin & Mattison, 2013).

Pediatric Clients

In comparison to adults, children are not small adults. Whether the child is a newborn, a toddler, school aged, or a teen, there are pharmacokinetic differences that are considered by the practitioner when ordering medications. A pediatric client is much more sensitive to drugs than an adult and therefore much more at risk for adverse effects.

It is not just about the actual size difference of a pediatric client when comparing dosages between an infant and an adult, but size is considered. Up to the age of 12 years, most medications are based on weight or body surface area. Referring to the list below, many

of these pharmacokinetic differences between adults and infants begin to diminish after the age of one, and continue to diminish until puberty. One exception are drugs that are metabolized faster in children. This requires alterations in dosing intervals or dosage amounts (Burcham & Rosenthal, 2019).

Did you know that lipophilic drugs have a higher distribution in infants than older children due to a higher body fat content— in general, 22% fat in a one year old vs 13% in a 15 year old.

Depending on the age, infants and young children will have:

- slower gastric emptying (slower peristalsis);
- reduced gastric acid secretion—increased bioavailability of acid-labile drugs (Penicillin) and decreased bioavailability of weakly acidic drugs (phenobarbital) (Tibbetts, 2020);
- more permeable intestine;
- body fat differences;
- higher body H_2O;
- thinner skin—faster absorption of drugs;
- smaller muscle mass;
- Immature blood brain barrier (BBB)—increased permeability resulting in increased permeation of drugs;
- immature liver—decreased hepatic enzyme production and decreased first-pass elimination, resulting in higher drug levels in bloodstream; and
- immature kidneys—decreased excretion of a drug.

Consider how ADME will be impacted by each of these physiological differences. Infants and very young children are particularly vulnerable and are very sensitive to drugs.

Nursing Considerations for Pediatric Clients

All drug dosing must consider:

- age,
- body weight or body surface area (BSA, calculated by number of milligrams per metre squared (mg/m2)), and
- physiological changes related to illness (dehydration, sepsis, or other significant sickness can impact pediatric dosing for some medications).

Example in Practice

For any medication, always check for pediatric dosing. With the example below, the adult doses are the same regardless of age or weight, whereas the pediatric doses are based on the weight of the child.

Pediatric dosing for acetaminophen:

- PO (Adults and Children > 12 yrs): 325–650 mg every 6 hr, 1 g 3–4 times daily, or 1300 mg every 8 hr (not to exceed 3 g or 2 g/24 hr in patients with hepatic/renal impairments).
- PO (Children 1–12 yr): 10–15 mg/kg/dose every 6 hr as needed (not to exceed 5 doses/24 hr).

(Vallerand & Sanoski, 2023, p. 97).

Promoting Pediatric Medication Safety

Without question, administering a wrong dose to a child can result

in client harm. Most adverse drug reactions (ADRs) are benign, but some can cause considerable harm and mortality. ADRs include medication errors such as a wrong dose, inappropriate use, or off-label use of a medication. A nurse working with pediatric clients needs to take additional training to ensure all procedures are followed. Some precautions that can be taken include:

- **Liquid medications:** Liquid medications are to be **drawn up in a syringe** or a med cup with measurements to ensure dosing accuracy. Spoons, teaspoons or droppers are inaccurate measuring devices and are subject to error. An oral syringe will not connect to a needleless port or accept a needle, and thus reducing the chance of a wrong route error (Smith, Leggett & Borg, 2022).
- **High-risk medications:** A nurse should **adopt independent double checks** for prescribing, preparing, and administering oral (e.g., liquid), intravenous (continuous and intermittent), or epidural medications for high-risk medications such as opioids, dopamine antagonists, and certain antibiotics among others (Smith, Leggett & Borg, 2022; Canadian Association of Pediatric Health Centers/Institute for Safe Medication Practices Canada, 2013).

Example in Practice:

Some medications are avoided in children; for example, the antibiotic Tetracycline is avoided because it stains developing teeth. Tetracycline should not be prescribed to children.

Figure 1.8a Tetracycline staining on a child's teeth. (Nizil Shah/Wikimedia Commons) CC BY-SA 4.0

Other medications are contraindicated. Acetylsalicylic acid (aspirin) is contraindicated in children due to risk of Reye's Syndrome https://www.healthlinkbc.ca/healthwise/reye-syndrome

Pregnancy

Pregnancy poses challenges with medication use as most medications cross the placenta and are secreted in breast milk. Clinical trials on new or existing drugs ethically exclude pregnant women due to the concern for the impact on the fetus. As such, data on drug safety is limited and avoiding all medications is typically advised. There are times when avoiding medications during pregnancy is not an option. Previous chronic health issues, such as asthma, and pregnancy-induced conditions, such as hypertension and gestational diabetes, require treatment. Practitioners carefully consider initiating drugs during pregnancy, and the decision is

made in collaboration with the client to review the risks and benefits to the health of the mother and the fetus.

Physiological Changes During Pregnancy

For pregnant women, the change in body composition can lead to changes in the plasma concentrations of a drug, which may result in too low of a concentration, leading to sub-therapeutic levels, or too high of one, leading to toxicity (World Health Organization [WHO], n.d.). Major physiological and anatomical changes occur in the cardiac system, liver, kidneys, and GI tract that can alter the pharmacokinetic and pharmacodynamics of the drugs administered. Depending on the trimester, delayed gastric emptying, blood volume and blood flow, renal filtration, hepatic enzymes (i.e., CYP3A, CYP2D6, CYP2C9), and transporters (P-GP) can be impacted (WHO, n.d.).

Physiological Changes during Pregnancy and Effects of Pharmacokinetics

Absorption

- Nausea
- Vomiting (reduced drug intake)
- ↓ gastric emptying, ↓ maximal drug concentration

Distribution

- ↑total body water and expanded plasma volume = ↑volume of distribution of hydrophilic drugs
- ↑ body fat = ↑volume of distribution of lipophilic drugs
- ↓ maternal albumin = ↑free drug fraction

Metabolism

- Enzyme induction/inhibition by progesterone/estrogen = change in drug metabolism

Elimination

- ↑ renal blood flow and ↑ GFR = ↑elimination of renally eliminated drugs
- ↑ hepatic blood flow = ↑ elimination of hepatic drug extraction

Ryu and Hebert, 2022

Placental Drug Transfer

Most drugs pass through the placenta and pass from the mother to the fetus by simple diffusion. Some drugs pass more readily than others, depending on the lipid solubility and molecular size of the drug, plasma drug levels in the mother, and blood flow to the placenta (Adams et al, 2018). Assume that all drugs taken during pregnancy will reach the fetus and, with that assumption, that all drugs need to be carefully considered.

Placenta

The placenta is a semi-permeable temporary membrane that slowly grows during the first 3 months of pregnancy. The placenta allows nutrition and gas exchange between the mother and fetus. This exchange

is essential for the transfer of gases, electrolytes, hormones, maternal antibodies, fetal waste, and nutrition such as water, amino acids, glucose, vitamins, and free fatty acids (Herrick, E. & Bordoni, B., 2023). The placenta offers a degree of protection from maternal blood, filtering out some harmful substances, but almost all drugs cross the placenta.

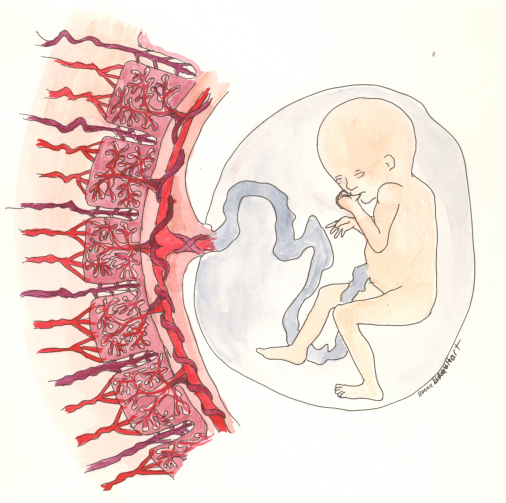

Figure 1.8c Fetus and placenta. Fetus with umbilical cord, amniotic sac, and placenta. A cross section of the placenta shows how the fetal circulation interfaces with the maternal system without the mixing of blood. (Bonnie Urquhart Gruenberg /Wikimedia Commons) CC BY-SA 4.0

Risk to Fetus

The first trimester (conception to 3 months) is the period of greatest risk to the developing fetus. This period is where skeletal and major organ development occurs and, as such, where developmental anomalies may occur. Birth defects can range from visible alterations, such as cleft palate, hydrocephalus or clubfoot,

to metabolic and neurobehavioral effects (Burcham & Rosenthal, 2019). Other risks include low birth weight, premature labour, and spontaneous abortion. Less than 1% of birth defects are caused by drugs, with most birth defects due to genetic or environmental factors. If a pregnant client needs to take a drug for health reasons, if possible, a delay until after the first trimester is strongly considered.

During the second and third trimester, exposure to substances can still pose significant harm to the fetus. For example, during the third trimester the placenta becomes thinner, so there is a higher transfer of drugs from the maternal circulation to the fetus. The ability of the fetus to metabolize drugs is still underdeveloped, leading to a prolonged duration of that drug in the fetus.

A **teratogen** is any substance that can cause or increase the chance of a birth defect (Powell-Hamilton, 2025). Teratogen exposure may occur during pregnancy through exposure to radiation (i.e., X-rays) certain medications or drugs, or substance use. Fortunately, most pregnant clients who have been exposed to teratogens have newborns without birth defects; whether birth defects are present or not is dependent on the type of teratogen and length of exposure (Powell-Hamilton, 2025). The type of birth defect will depend on the fetal organ developing at that time.

Risk to Pregnant Client

With the physiological changes that occur during pregnancy, some drugs can have an adverse effect on the pregnant client. For example, the anticoagulant heparin can result in osteoporosis, which can eventually result in spinal compression fractures. Understanding the risks of any medications is important, and weighing the risks versus benefits is an important discussion with the healthcare provider.

Some health issues pose more risk to both the pregnant mother

and fetus if left untreated, for example, pre-existing diabetes mellitus or gestational diabetes. Alternative medications can be prescribed, depending on what the client was on previously. For example, insulin is typically prescribed for gestational diabetes and is safe for the fetus with careful blood glucose control and monitoring. Other conditions such as heart failure can be treated with digoxin, which does not harm the fetus and will obviously benefit the expectant mother.

Unfortunately, some health conditions require the use of medications that may pose a risk to the fetus, or the pregnant client was exposed to a harmful drug prior to their knowledge of the pregnancy. Obtaining a drug history that includes exact dates of exposure and pregnancy dates is important to determine the risk.

Any client who is planning on becoming pregnant or is already pregnant should consult a healthcare provider. Nurses should obtain a detailed medication profile from the client that includes all prescribed medications, vitamins, over-the-counter medications, herbal supplements, and any recreational drug use. Nurses have an important role in ensuring clients are well-informed, seek the appropriate level of care, and are advocated for as needed.

Older Adult Clients

Pharmacokinetic Changes

Just like pediatric clients, older adults also needs special consideration. An older adult is defined as someone 65 years of age and older (Klotz, 2009). Changes in the body fat, water composition, and kidney and liver functioning will affect all stages of pharmacokinetics. As the client ages past middle adulthood, organ function progressively declines. Typically, the changes increase drug sensitivity due to declining renal and hepatic function.

Significant individual variations can occur depending on the client's level of fitness, lifestyle factors, and genetics.

Absorption: Although less affected by aging, older adults often have decreased gut motility and intestinal blood flow. There may be changes in the gastric (stomach) pH that may alter the absorption of certain medications. Their skin will be thinner leading to increased absorption of topical medications. Diminished fat stores can decrease the absorption of medications given transdermally.

Distribution: Older adults experience significant changes in body composition, as body fat increases and total body water and lean body mass decrease. The volume of distribution of polar drugs will decrease while lipophilic drugs will increase, requiring adjustments to drug dosages. Plasma protein binding and serum-albumin concentration changes are minimal in healthy older adults; however, if they are malnourished, it leads to a more pronounced decrease in albumin and protein binding sites. This will result in more free drugs in circulation and a higher risk of toxic drug levels.

Metabolism: With aging, there is approximately a 20–30% reduction in liver size and up to 50% reduction in hepatic blood flow. Hepatic enzymes may also diminish. With these changes, drug clearance may decrease, leading to prolonged half-lives and increased serum drug concentrations. There is significant variability with metabolism changes in older adults, with many experiencing minimal hepatic changes.

Elimination: Renal mass decreases along with a decrease in renal blood flow, which contributes to a decreased GFR. Always check renal function before giving new medications. GFR is the most accurate assessment of renal function as it is based on serum creatinine, sex, and age. Renal function is expected to decrease starting by age 40 as part of the normal aging process. By the age of 70, GFR may be reduced to 75 mL/min/1.73 m^2, signifying mild kidney impairment.

Nursing Considerations For Older Adult Clients (> 65 Years of Age)

Nurses should consider the following factors when working with older adult clients:

- Check recent and past lab values (renal, hepatic, albumin)
- Start low and go slow
- Other:
    - Weight—check for recent weight changes
    - Body mass index (BMI)
    - Thorough physical assessment including diet, bowel patterns, cardiac function, and SQ fat
    - Always consider polypharmacy and drug-drug interactions

Medication Challenges With Older Adults

As a client ages, it is expected that some clients will develop health conditions that will need medications for treatment. As discussed earlier, the pharmacokinetic changes that occur in older adults make them more susceptible to medication issues. Some issues of concern are polypharmacy, medication non-adherence, and prescribing cascades that put the client more at risk of falls, frailty, or adverse drug effects. **Refer to Chapter 3: Medication Safety: Preventing Medication Errors**

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- Figure 1.8c File:Fetal circulation.jpg by Bonnie Urquhart Gruenberg on Wikimedia Commons is used under a CC BY-SA 4.0 license.
- Figure 1.8d "Figure 1: Changes in absorption, distribution, metabolism/biotransformation and excretion during pregnancy" by World Health Organization

1.9 Examining a Drug's Effects

How do we know if the medication that was prescribed is effective? How is it determined how much of a dose is required? How much of a dose is too much leading to toxicity? This unit will examine concepts that are important for supporting safe medication dosing and therapeutic drug monitoring.

Learning Objectives

- Apply the principles of onset, peak and duration to understand dose scheduling and monitoring for effects.
- Explain the meanings of half-life and steady state of a drug and its importance in drug dosing.
- Correlate a drug's therapeutic index to its margin of safety.
- Differentiate between loading and maintenance dosing.
- Differentiate between peak and trough levels for therapeutic drug testing, and their importance for drug safety.

Onset, Peak, and Duration

Dosing considerations play an important role in understanding the effect that a medication may have on a client. During

administration, the nurse must pay close attention to the desired effect and therapeutic response, as well as the safe dose range for any medication. The nurse should have an understanding of medication **efficacy** in order to ensure its appropriateness. If a nurse is provided different medication choices according to a provider's written protocol, the nurse should select the option with the anticipated desired therapeutic response. Additionally, the nurse must be aware of the overall **dose response** based on the dosage selected.

Three additional principles related to the effect of a medication on a client are onset, peak, and duration.

Onset: the onset of medication refers to when the medication first begins to take effect

Peak : the peak of medication refers to the maximum concentration of medication in the body, and the point at which the client shows evidence of greatest therapeutic effect

Duration: the duration of medication refers to the length of time the medication produces its desired therapeutic effect

Referring to the diagram below, the therapeutic window includes the onset, peak and duration of a medication. Nurses consider these three principles when preparing to administer medications to be able to know when a med will take effect, when it will be at its peak or have the strongest response and how long the med will last.

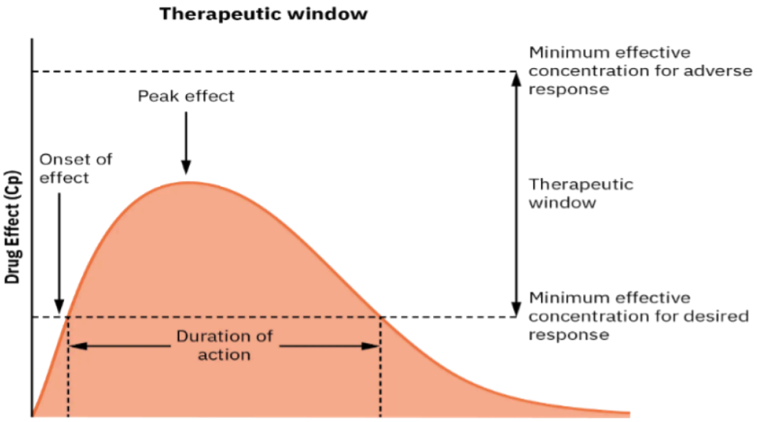

Figure 1.11a The therapeutic window of a medication includes the onset, peak, and duration of the medication. (© Rice University, OpenStax, under CC BY 4.0 license)

Consider this client care example and apply the principles of onset, peak, and duration: Gurmeet, a 67-year-old female client, who has just undergone hip replacement surgery earlier today, rings the call light to request medication for pain. She notes her pain is "excruciating, a definite 9 out of 10." Her brow is furrowed, and she is grimacing in obvious discomfort. As the nurse providing care for Gurmeet, you examine her post-operative medication orders and consider the pain medication options available to you. In reviewing the various options, it is important to consider how quickly a medication will work (onset), when the medication will reach maximum effectiveness (peak), and how long the pain relief will last (duration). Understanding these principles is important in effectively relieving the client's pain and constructing an overall plan of care.

Clinical Reasoning and Decision-Making Activity 1

1. At 0500, your client, who had a total knee replacement yesterday, rates his pain while walking as 7 out of 10. Physical therapy is scheduled at 0900. The client has acetaminophen (Tylenol) 650 mg ordered every four hours as needed for discomfort. What should you consider in relation to the administration and timing of this client's pain medication?
2. Your client is prescribed NPH insulinto be given at breakfast and supper. As a student nurse, you know that insulin is used to decrease blood sugar levels in clients with diabetes mellitus. During report, you hear that the client has been ill with GI upset during the night, and the nursing assistant just informed you he refused his breakfast tray. While reviewing this medication order, you consider the purpose of the medication and information related to the medication's onset, peak, and duration. When reviewing the drug reference, you find the NPH insulin has an onset of about 1 – 3 hours after medication administration. What should you consider in relation to the administration and timing of the client's insulin?

Note: Answers to the Clinical Reasoning and Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Therapeutic Window

For every drug, there exists a dose that is minimally effective (minimum effective concentration for desired response), anything below this level would be an ineffective dose, or subtherapeutic dose. Further, for every drug, there is a dose that is a maximum effective concentration (minimum toxic concentration), anything above this dose can cause adverse effects and toxic effects. In between these two doses is the therapeutic window, where the safest and most effective treatment will occur (see Figure 1.11a). Think of this area as the dosing "sweet spot." Therapeutic window is sometimes referred to as therapeutic range.

For example, warfarin (Coumadin) is a medication used to prevent blood clotting and is monitored using a blood test called INR. Too high a dose of warfarin would cause the INR to increase above the therapeutic window and put the client at risk of bleeding. Conversely, too low a dose of warfarin would cause the INR to be below the therapeutic window and put the client at risk of clotting. It is vital that the nurse frequently monitor INR levels for a client receiving warfarin to ensure the dosage appropriately reaches the therapeutic window and does not place the client at risk for bleeding or clotting.

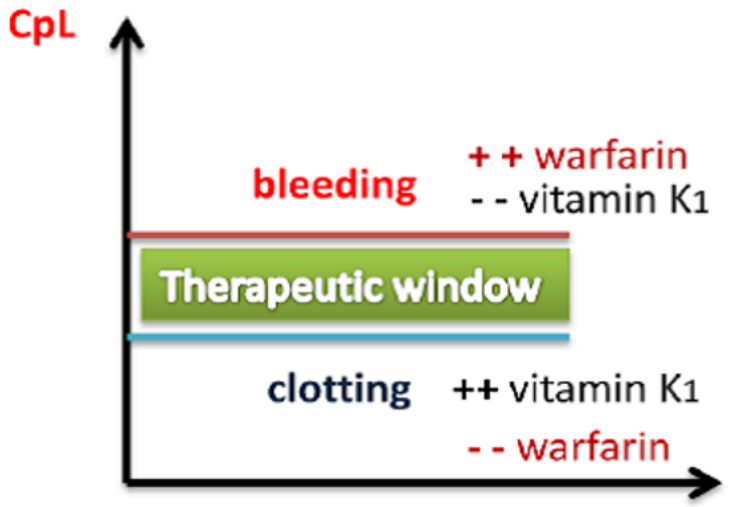

Figure 1.11b Therapeutic Window. (Shefaa ALasfoor/Wikimedia Commons) CC BY-SA 3.0

Therapeutic Index

Therapeutic Index: is a quantitative measurement of the relative safety of a drug. It is a comparison of the amount of drug that produces a therapeutic effect versus the amount of drug that produces a toxic effect. It refers to the range of dosing that is both safe and effective. Ideally, the range is wide, so the distance from peak effect and maximum concentration is large; this would be a safe med and less chance to cause toxicity.

- Small (narrow) therapeutic index: means there is a small therapeutic window between the effective concentration and

the toxic concentration. This means there is little difference between toxic and therapeutic doses. So, only a small amount of extra drug causes toxicity and a small decrease in the dosage may cause subtherapeutic effects. For example, warfarin, an anticoagulant, has a narrow therapeutic range. Too much, and the client will bleed and have a risk of hemorrhage. Too little of a dose, and the risk of blood clots is high, leading to a stroke. Medications with a narrow therapeutic range are typically monitored through therapeutic drug blood testing.

- Large (or high) therapeutic window: this means there is a large therapeutic window between the effective concentration and the toxic concentration of a medication, so the drug is relatively safe. Many drugs have a large therapeutic window and are considered quite safe and do not require drug monitoring. For example, many over-the-counter drugs are considered safe for this reason. If a client took a bigger dose than recommended, they might have more adverse effects, but not toxic effects (this does not apply to an overdose where an excessive amount is taken).

Defining Terms

You will see both therapeutic window and therapeutic index to describe the desired or therapeutic drug levels. There are differences in what they are both describing:

- Therapeutic Window. The dose range of plasma drug concentrations between the minimum concentration that is effective and the maximum concentration that is barely toxic. Between them

is the therapeutic window where most safe and effective treatment will occur.

- Therapeutic Index. This is the ratio of toxic to effective doses at the level of 50% response: TD50/ED50. Therapeutic Index is a quantitative measurement of the relative safety of a drug.

Rosow, Standaert & Strichartz, n.d.

Plasma Half-life and Steady State

Plasma Half-life (t ½)

The half-life is the amount of time for serum drug concentrations to decrease by 50%. It is the rate at which the drug is eliminated from the bod, which influences the duration of effect. Simply, it measures the drug's effects over a period of time. After 4 t1/2's, 94% of a drug is eliminated from the body. At five half-lives, 97% of a drug will be eliminated. So, after 4-5 half-lives, the amount of the drug left in the body so small to have any therapeutic effect. Plasma half-life's for drugs vary, with some only a few minutes and some drugs taking days (Rosenjack Burchum & Rosenthal, 2019).

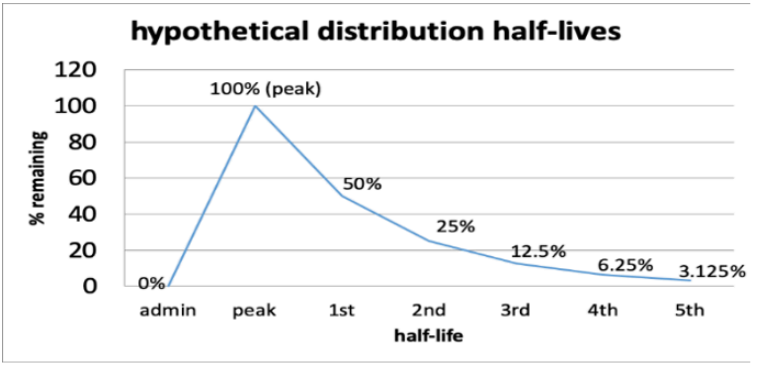

Figure 1.11c Distribution of half-lives

Example: A client is ordered drug X for blood pressure control. The dose is 100mg. The half-life of drug X is 60 minutes. After 4 half-lives, how much of the drug is left in the body?

- 60 minutes after administration, 50mg remains (first half life)
- 120 minutes after administration, 25mg remains (second half life)
- 180 minutes after administration, 12.5mg remains (third half life)
- 240 minutes after administration, 6.25mg remains (fourth half life)
- 300 minutes after administration, 3.125mg remains (fifth half life)

After the 4 half-lives (in 4 hours), only 6.25% remains and will have negligible therapeutic effects

How to calculate a drug's half-life: There are formulas to determine a drug's half-life which is directly proportional to the volume of distribution (how the drug distributes in the body) and inversely to clearance (how fast a body excretes the drug). There are online half-life calculators (to make it easy) or formulas available.

Most drug manuals state the half life, along with onset, peak and duration.

Prescribers and pharmacists examine half life to help determine drug scheduling. For nurses, it helps understand how drugs are scheduled (q 2hr vs q 4hr), when the drug will be at its peak, and how long it will have a therapeutic effect. Although a drug has a specific half-life, note that other factors such as client and drug factors will lead to variations.

Client-specific factors: There are many factors to consider and can include age (pediatric vs middle aged vs geriatric), blood flow, diet, fluid status (dehydration vs fluid overload), sex, other drugs, kidney and liver function, and genetics.

Drug-specific factors: Drug formulation (i.e. immediate release vs controlled release preparations), pharmacokinetics, route of administration, protein binding, lipid vs water solubility. (Carmen, 2025)

Look at the different examples of drug half-lives. Consider how this information impacts the nursing process:

- Fentanyl IV 3-7 hours
- Morphine IV 2 hours
- Ramipril 15 hours
- Warfarin one week

As you consider each of the half-lives for each drug, it will help you understand when to anticipate a peak effect and the duration of action of that dose. It will help you understand when to monitor a client's response and evaluate the effectiveness of that dose.

Vallerand & Sanoski, 2024

Steady State of a drug

One of the main objectives of drug administration is to have a steady amount of the drug in the body so the drug can have its therapeutic effect.

Steady state = amount of drug removed/eliminated = amount of drug absorbed with each dose.

After approximately five half-lives, with the same dose and dosing interval (ie. Every 2 hours or every 4 hours), a plateau concentration or steady state of drug concentration in the blood has been achieved. Many factors can influence achieving a steady state, which are outlined above.

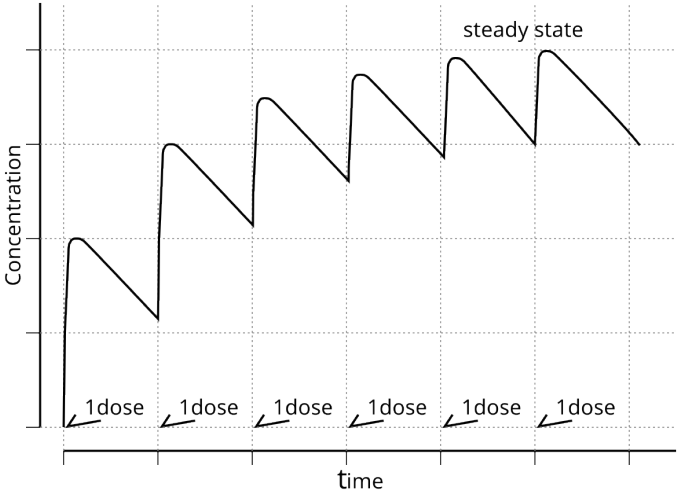

Figure 1.11d Half-life steady state. The steady state of a drug is achieved after 4-5 half-lives. (◇◇◇◇◇◇◇◇/Wikimedia Commons) CC BY-SA 3.0

Duration and Dosing

What is the significance of knowing the half life, and how does this impact the drug dosing and duration of action?

Let's consider the implication of duration and dosing. Remember the duration of medication is correlated with the elimination. If a medication has a short half-life (and thus is eliminated more quickly from the body), the therapeutic effect is shorter. These medications may require repeated dosing throughout the day in order to achieve steady blood levels of active free drug and a sustained therapeutic effect. Other medications have a longer half-life (and thus a longer therapeutic duration) and are only given once or twice per day. For example, oxycodone immediate release is prescribed every 4 to 6 hours for the therapeutic effect of immediate relief of severe pain, whereas oxycodone ER (extended-release) is prescribed every 12 hours for the therapeutic effect of sustained relief of severe pain.

Loading Dose vs Maintenance Dose

Most drugs are given in multiple doses, over a period of time, to achieve a steady state of the drug and to ultimately have the desired therapeutic effect. From what you have learnt about half-lives, this steady state can be achieved quickly if the half-life is short, or it may take days if the half life is long. But what if it is desired to speed up the time it takes to achieve therapeutic effect? For example, a client has an infection and there is concern of sepsis. The doctors would want to achieve a therapeutic dose of an antibiotic as quickly as possible. We would want to 'load' the drug to achieve the target plasma concentrations rapidly.

A loading dose is a higher amount of the first dose of the drug and is administered to prime the bloodstream to quickly achieve therapeutic effect. They can be only a single bolus (sometimes ordered IV with maintenance doses oral) or require multiple loading doses over a several hours or days.

Maintenance doses, are the subsequent doses to keep the plasma drug concentration in the therapeutic range.

Example in practice:

A client has a bleeding duodenal ulcer and is ordered pantoprazole IV. Loading dose: Pantoprazole 80 mg IV bolus, with maintenance dose 8 mg/hr continuous IV infusion for 24 hours. In this case, we would want to achieve steady state as quickly as possible due to the risk of hemorrhage.

Peak and Trough Levels

Now let's apply the idea of the therapeutic window to the administration of medications that require close monitoring. For example, some antibiotics need to be titrated to achieve a desired therapeutic effect. Titration is often accomplished by closely monitoring the blood levels of the medication. A drug is said to be within the "therapeutic window" when the serum blood levels of an active drug remain consistently above the level of minimal effective concentration (so that the medication is achieving its desired therapeutic effect) and consistently below the toxic level (so that no toxic effects are occurring).

A **peak** drug level is drawn at the time when the medication is known to be at the highest level in the bloodstream. A **trough** level is drawn when the drug is at its lowest in the bloodstream right before the next dose is given.

Medications have a predicted reference range of normal values for peak and trough levels. These numbers assist the pharmacist and prescriber in gauging how the body is metabolizing, protein-

binding, and excreting the drug, and will assist in the adjustment of the prescribed drug doses to keep the medication within the therapeutic window. When administering IV medications that require peak or trough levels, it is vital for the nurse to time the administration of the medication according to the timing of these blood draws.

Monitoring the Effects

As medications are administered, the nurse should perform careful client assessments, trend the assessment results, and monitor for side effects or any adverse effects. Careful assessment and monitoring are needed for each medication, especially those that have a low therapeutic window or for clients more at risk of adverse effects.

Therapeutic Effects: Therapeutic effects are the intended, beneficial, desired effects of a drug. Sometimes a drug will have more than one therapeutic effect. Aspirin is an example of a drug with multiple therapeutic effects—it can reduce fever, pain, and inflammation.

Adverse Drug Event: is the undesirable and potentially harmful action caused by the administration of a medication (Adams et al., 2018). It is a broad category including errors and adverse drug reactions. Medication errors that cause harm are called adverse drug events.

Adverse Drug Reactions: This is any noxious, unintended and undesired effect that occurs at therapeutic or normal doses. They can range from mildly annoying to life threatening. They are more common in the children and the older adult but can occur at any age, especially in clients who are very ill or are taking many medications (Rosenjack Burchum & Rosenthal, 2019). Medication errors that cause are also called an adverse drug event (Adams et al, 2018).

Under the term of adverse drug reactions, are side effects, allergic reactions and idiosyncratic reactions.

- **Side effects:** A drug may cause responses that are undesirable, unintended, or secondary effects. These are known as side effects and they are usually mild and predictable (Rosenjack Burchum & Rosenthal, 2019). For example, nausea is a common side effect for many drugs. Some side effects may even be desirable. Diphenhydramine is a histamine antagonist. Because it has the side effect of drowsiness, it is sometimes used at night to occasionally aid in sleep.
- **Allergic reactions**: This is an immune response that can range from mild symptoms such as itching, to a severe rash and hives to anaphylaxis. Other allergy symptoms include hives, swelling, nausea, wheezing, joint pain, or anaphylaxis. The intensity of the allergic reaction is dependent on the degree of sensitization of the immune system. Fortunately, very few medications cause severe allergic reactions.
- **Idiosyncratic reactions**: This is a reaction that is uncommon, unpredictable and results from a genetic predisposition or immune-mediated. It is an adverse reaction that does not occur in most clients treated with a drug and does not involve the therapeutic effect of the drug. They can be life-threatening (Uetrecht & Naisbitt, 2013).

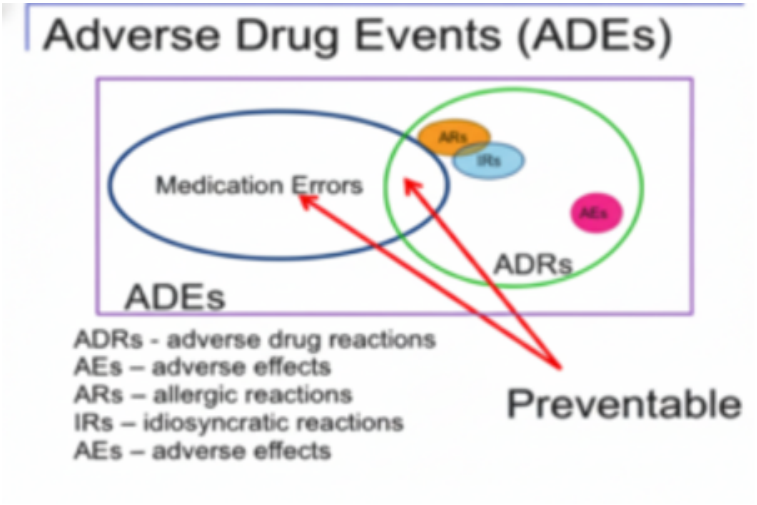

Figure 1.11e Adverse Drug Events (Sheila Odubote/ TRU Open Press)

Adverse drug reactions can be mild and annoying, to being harmful and lead to injury. Let's use aspirin as an example. An example of a common side effect is nausea, definitely annoying but often mild. A serious adverse drug effect of aspirin is gastrointestinal bleeding. Another example is morphine. Morphine, an opioid agonist, often has the side effect of constipation. However, respiratory depression is an adverse drug reaction sometimes seen with the administration of morphine and can lead to harm to client.

Drug Toxicity: Drug toxicity can occur when there is an excess accumulation of a drug in the system. The ingestion of an excessive amount of a drug might cause toxicity; however, even therapeutic doses of some drugs may cause toxicity in some clients.

Drug concentrations can also accumulate if the client has liver or renal disease and the dose was not adjusted. When a client with liver dysfunction is given a drug that is metabolized in the liver, the dosage may need to be decreased to prevent the accumulation of the drug in the body. The same is true for a client with kidney dysfunction. If the drug is primarily excreted through the kidneys,

then the dosage and frequency of the drug may need to be modified. A drug excreted by the kidneys will usually be safe for the client with liver dysfunction, and vice versa (Kommu, Carter & Whitfield, 2024).

In summary:

The aim of this chapter is to introduce the learner to the basics of pharmacology and to provide a strong foundation that is needed to safely administer medications. A firm grasp on the principles of pharmacology allows the nurse to understand the drugs actions, predict adverse effects and drug interactions, and maximize drug combinations. Using clinical judgment, this knowledge will allow the nurse to effectively monitor and evaluate the client, report any possible or occurring drug effects, and provide effective client teaching so they can safely manage their medications at home. As part of the interprofessional health care team, nurses work along side other health care providers to optimize patient outcomes with minimizing adverse medication events.

Clinical Reasoning and Decision-Making Learning Activities 2

Mr. Parker has been receiving gentamicin 80 mg IV three times daily to treat his infective endocarditis. He has his gentamicin level checked one hour after the end of his previous gentamicin infusion was completed. The result is 30 mcg/ml. Access the link below to determine the nurse's course of action.

View information on Therapeutic Drug Levels

(Within the activity link, be sure to select "click to keep reading" in order to view drugs that are commonly checked, their target levels, and what abnormal results mean).

Based on the results in the above client scenario, what action will the nurse take based on the result of the gentamicin level of 30 mcg/mL?

Note: Answers to the Clinical Reasoning and Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

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1.10 Clinical Reasoning and Decision-Making Learning Activities

Within this unit, you have been introduced to many concepts related to pharmacokinetics and pharmacodynamics. These basic concepts are important to understand as we move our study into closer examination of various medication classes, principles of administration, and consideration of how medications can be safely incorporated into the client's plan of care.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=4170#h5p-116

Clinical reasoning and decision making activity

Test your knowledge and application. Use the information in the text, as well as evidence-informed online resources, such as OpenMD, Merck Manuals and Daily Med, to read more about the medications included in the client scenarios.

1. You are working in a nursing home caring for an 86-year-old client with a history of stroke who reports left knee pain secondary to arthritis. The client has right-sided weakness and difficulty swallowing with no gag reflex. You review the client's MAR, and note the provider has prescribed acetaminophen 325 mg po or rectal route. Which route would you choose and why?
2. Mr. Johnson is a 92-year-old male admitted to the medical-surgical unit for severe pneumonia, and the provider prescribed gentamicin antibiotic therapy. Upon review of the order, you notice the initial dose is ordered at less than the standard recommended dose. What is the rationale behind the decreased starting dose for this client?
3. Sara is a nurse working on the medical-surgical floor. She is reviewing her client's chart and notes her client has a 0600 vancomycin infusion; however, the trough level is not available. The nurse phones the lab, and they state they will not be available to draw the trough level for an hour. What actions should the nurse take?
4. Sam is a nurse working on the cardiology floor. He has an order to administer a dose of atenolol (a beta-blocker medication) to a client at 0800. What assessments should the nurse take prior to

administering the medication? What is the anticipated therapeutic effect of this medication?

5. Julia is a 56-year-old client admitted to the cardiology unit with new-onset atrial fibrillation. She has been prescribed amiodarone for her irregular heartbeat and is set to receive her first dose with her morning breakfast tray. When you arrive in the room, you notice that she has grapefruit juice on her breakfast meal tray. Is this a concern? Why? What is the nurse's next action?
6. A nurse is caring for a 55-year-old male who recently was admitted to the medical-surgical unit for a total knee replacement. He is prescribed oxycodone/acetaminophen 5/325 mg (Percocet) every 4 hours for moderate pain. The client complains of pain in the knee, rating it at a "6 out of 10." Use your online resources to help you answer the following questions:
    - When does the nurse anticipate the medication will peak in action?
    - When does the nurse anticipate another dose will be needed due to the onset/peak /duration or half-life of this drug?

Note: Answers to the Clinical Reasoning and Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

CHAPTER 2 - MEDICATION SAFETY: LEGAL AND PROFESSIONAL

2.0 Medication Safety — Professional and Legal Foundations

Learning Objectives

1. Understand drug regulation for registered nurses in Canada, including the role of government and regulatory bodies.
2. Identify the scope of practice for nurses with drug administration, including autonomous practice.
3. Understand the factors that impact medication safety, including client, systemic, and healthcare providers.

Key Terms

- **Black box warnings**
- **BC College of Nurses and Midwives**
- **Canadian Nurses Association (CNA)**
- **Code of Ethics for Registered Nurses**
- **Controls on practice**
- **Cultural safety**
- **Do not crush list**
- **Drug diversion**
- **Error-prone abbreviations**

- **Health literacy**
- **High-risk**
- **Inappropriate polypharmacy**
- **Look-alike and sound-alike drugs**
- **Nursing**
- **Nursing process**
- **Polypharmacy**
- **Practice standards**
- **Professional standards**
- **Registered nurse (RN)**
- **Root cause analysis**
- **Safety culture**
- **Scheduled medications**

Medication administration is an essential task that nurses perform while providing client care. However, safe medication administration is more than just a nursing task; it is a process involving several members of the healthcare team as well as legal, ethical, social, and cultural issues. The primary focus of effective medication administration by all health professionals is client safety. Although many measures have been put into place over the past few decades to promote improved client safety, medication errors and adverse effects continue to be a common event. In Canada, 19% of hospital-employed registered nurses acknowledged a medication error involving their clients had occurred 'occasionally' or 'frequently' (Wilkins & Shields, 2015). The World Health Organization (WHO) estimates that "Unsafe medication practices and medication errors are a leading cause of injury and avoidable harm in health care systems across the world. Globally, the cost associated with medication errors has been estimated at $42 billion USD annually" (WHO, 2019).

The topic of medication safety is considerable, so this first chapter will focus on reviewing the role of government in drug regulation in Canada, including drug approval process by Health Canada, drug scheduling, and provincial regulatory bodies' responsibilities. The following chapter will examine the many factors that are important for safe medication administration and conclude with strategies to promote medication safety.

Reflection in Action: by the time you read this unit, the above-mentioned statistics on med safety will be old. Considering where

you practice nursing and the steps taken to improve safety, do you consider med safety to have improved or gotten worse?

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2.1 Professional Foundations

Canadian Nurses Association

The Canadian Nurses Association (CNA, n.d.) is a professional organization that represents the national and global interests of Canadian nurses. They represent registered nurses, nurse practitioners, licensed and registered practical nurses, registered psychiatric nurses, and retired nurses across all 13 provinces and territories (CNA, 2021). The CNA developed the *Code of Ethics for Nurses* as a guide for carrying out nursing responsibilities in a manner consistent with quality in nursing care and the ethical obligations of the profession (CNA, 2025).

CNA Code of Ethics for Nurses

The CNA publishes the ***Code of Ethics for Nurses***, which is a framework for ethical practice in nursing in Canada (CNA, 2025). The revised code of ethics encompasses all regulated nurses, which includes nurse practitioners, registered nurses, registered psychiatric nurses, and licensed practical nurses. It outlines the values the nursing profession upholds and conveys these values to clients, other healthcare professionals, employers, and stakeholders.

The code of ethics is an overarching framework with seven core professional values, each with guiding principle statements, context for practice, and ethical responsibilities.

How does this relate to pharmacology and medication administration? Consider Value 6 (CNA, 2025) and then reflect on this value in relation to practising safe medication administration:

> **Value 6:** Providing Competent Professional Nursing Practice.
>
> **Guiding Principle 6.1:** Nurses continually develop and maintain their nursing knowledge and skills to provide competent care.
>
> **Ethical Responsibilities:** Include engaging in reflective practice, using the highest level of evidence possible, participating in formal and informal education, engaging in professional development to advance knowledge and skills, and seeking feedback from clients, peers, and supervisors to identify strengths and areas for performance improvement.

Nursing

The CNA (2021) defines nursing as "the application of professional nursing knowledge, skills, and judgment for the purpose of: (a) promoting, maintaining, and restoring health; (b) preventing illness, injury, or disability; (c) caring for persons who are sick, injured, disabled, or dying; (d) assisting in pre-natal care, childbirth, and postnatal care; (e) health teaching and health counselling; (f) coordinating health care; or (g) engaging in administration, teaching, or research. A registered nurse (RN) is an individual who is educationally prepared and licensed by a province or territory to practice as a registered nurse.

In this section, the term 'nurse' will be generally used to indicate

all levels of nurses, including nurse practitioners, registered nurses, licensed practical nurses and registered psychiatric nurses.

CNA Registered Nurse Practice Framework

The CNA (2015) publishes *The Framework for the Practice of Registered Nurses in Canada*. This framework promotes a common understanding of RN practice among nurses, students, and stakeholders (including other health professionals, employers, educators, policy-makers, and the public). Given the large number of regulated and unregulated care providers in Canada, it is essential for policy-makers, decision-makers, and employers to clearly understand RN competencies and contributions as well as to know when RN care is the most appropriate.

CNA Entry-Level Competencies

CNA entry-level competencies describe a competent level of behaviour in the professional role (CNA, 2021). The competencies refer to the knowledge, skills, judgment, and attributes required of an RN to practice safely and ethically in a designated role and setting.

A total of 101 competencies are grouped thematically under nine roles. Integration of all nine roles enables an entry-level registered nurse to provide safe, competent, ethical, compassionate, and evidence-informed nursing care in any practice setting. Some concepts are relevant to multiple roles. The roles include:

- **Clinician:** Provide safe, competent, ethical, compassionate, and evidence-informed care across the lifespan in response to client needs; integrate knowledge, skills, judgment, and

professional values from nursing and other diverse sources into their practice.

- **Professional:** Commit to the health and well-being of clients; uphold the profession's practice standards and ethics and be accountable to the public and the profession; demonstrate accountability, accept responsibility, and seek assistance as necessary for decisions and actions within the legislated scope of practice.
- **Communicator:** Use a variety of strategies and relevant technologies to create and maintain professional relationships, share information, and foster therapeutic environments.
- **Collaborator:** Play an integral role in the healthcare team partnership.
- **Coordinator:** Coordinate point-of-care health service delivery with clients, the healthcare team, and other sectors to ensure continuous, safe care.
- **Leader:** Influence and inspire others to achieve optimal health outcomes for all.
- **Advocate:** Support clients to voice their needs to achieve optimal health outcomes and support clients who cannot advocate for themselves.
- **Educator:** Identify learning needs with clients and apply a broad range of educational strategies towards achieving optimal health outcomes.
- **Scholar:** Demonstrate a lifelong commitment to excellence in practice through critical inquiry, continuous learning, application of evidence to practice, and support of research activities.

Provincial Regulation

Each Canadian province and territory has its own regulatory body for nurse practitioners, registered nurses, licensed practical nurses

and psychiatric nurses. Each regulatory body or college has a mandate to ensure public safety by setting standards of practice that ensure each category of nurse practices safely, competently, and within their scope of practice. Each provincial regulatory body may have slight differences in their standards of practice. These regional bodies are responsible for further outlining the scope of practice, practice standards, and professional standards for their registrants. They also oversee the licensing process and maintain a registry of practicing nurses. The regulatory body in British Columbia is the **British Columbia College of Nurses and Midwives** (BCCNM, n.d.a).

BCCNM Professional Standards and Practice Standards

Professional Standards are "one set of standards under the umbrella of BCCNM Standards of Practice, are statements about levels of performance that nurses are required to achieve in their practice" (BCCNM, n.d.c).

- **Standard 1:** Professional Responsibility and Accountability
- **Standard 2:** Knowledge-Based Practice
- **Standard 3:** Client-Focused Provision of Service
- **Standard 4:** Ethical Practice

Nurses are guided by professional standards in all aspects of their roles, including in the administration of medications.

Practice standards guide and direct nurses' practice (BCCNM, n.d.,b). They set out levels of performance that BCCNM nurse registrants are required to achieve in their practice. They all link to other practice standards, policies, and bylaws of BCCNM.

There is a specific practice standard related to medication administration for nurses.

BCCNM Practice Standard for Medication

In British Columbia, the BCCNM (2025) has developed a practice standard for medication administration for all nurses. This practice standard outlines nurses' accountabilities for providing safe nursing care to clients when performing activities involving medication. The principles for the medication practice standard include all medication-related activities, including medication administration, dispensing medications, acting with autonomous scope of practice, and preventing medication errors. In the next unit, we will examine a nurse's scope of practice with drug schedules.

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2.2 Drug Regulation Process in Canada

There are many federal and provincial laws, as well as national guidelines, that have been established to protect public health and safety. This section will explain how Health Canada and provincial/territorial nursing governing bodies protect the public from medication harm.

Health Canada — Health Products and Food Branch

To protect the public, the Health Products and Food Branch (HPFB) of Health Canada is responsible for regulating, evaluating, and monitoring the safety, efficacy, and quality of therapeutic and diagnostic products available to Canadians. These products include drugs, medical devices, disinfectants, and sanitizers with disinfectant claims (Health Canada, 2020b). Some ways that the HPFB protects the public health regarding medications include:

- enforcing an official drug approval process based on evidence-based research;
- issuing safety warnings for medications with serious adverse reactions; and
- regulating over-the-counter (OTC) medications.

Each of these actions is further explained below.

Developing New Drugs

Canadian consumers benefit from having access to the safest and most advanced pharmaceutical system in the world. Drug companies conduct extensive research and work to develop and test a drug in a way that follows Health Canada's Development and Approval Process of Drugs (SPharm Canada, n.d.).

Health Canada Approval — What it Means

Health Canada's approval of a drug means that data on the drug's effects have been reviewed by the HPFB, and the drug is determined to provide benefits that outweigh its known and potential risks for the intended population.

The HPFB reviews all new drug submissions and all the information about the drug captured during the development process (quality, preclinical, and clinical) and evaluates the risks of the drug versus its benefits to the Canadian population. More specifically, HPFB reviews information regarding the drug's manufacturing, packaging, and labelling as well as information about the drug's therapeutic claims and side effects. What doctors and clients will be told about the drug will also be reviewed, through the drug's monographs and information sheets. All drugs allowed to be sold in Canada are reviewed to ensure that they meet the requirements of the *Food and Drugs Act and its Regulations* (Health Canada, 2025a). Once these requirements are met, the drug developer/sponsor receives a Notice of Compliance, confirming the dossier's compliance with the *Food and Drugs Act and its Regulations*.

Safety Warnings

The HPFB posts a database of safety alerts, public health advisories, press releases and other notices related to therapeutic health products. This database includes recalls from Health Canada, the Canadian Food Inspection Agency, and Transport Canada. The public can access this information online and even submit adverse reactions that they experienced with any medication. To access this website, go to the Canada Vigilance Adverse Reaction Online Database.

If a drug has a risk for serious adverse events, Canada's approach in advising the public focuses on strategies such as information on drug labels, pharmacist to client education, and detailed drug leaflets. In comparison, in the United States, if a safety problem exists, a "black box warning" is issued by the FDA and appears on the prescription drug label. The purpose is to call attention to potentially serious or life-threatening risks.

Clinical Reasoning and Decision-Making 1

Levofloxacin is an antibiotic that received FDA approval (the US equivalent of HPFB). However, after the drug was on the market, it was discovered that some clients who took levofloxacin developed serious, irreversible adverse effects, such as tendon rupture. The FDA issued a black box warning with recommendations to reserve levofloxacin for use in clients who have no alternative treatment options for certain indications, including uncomplicated UTI, acute exacerbation of chronic bronchitis, and acute bacterial sinusitis.

A nurse is preparing to administer medications to a client and notices that levofloxacin has been prescribed for the indication of pneumonia. There is no other documentation in the provider's notes related to the use of this medication.

What is the nurse's best response?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

Drug Schedules Regulation

Once a drug is approved, Health Canada will then determine if the drug will require a prescription for sale. Drugs that Health Canada has determined require a prescription for sale in Canada are listed on the Health Canada Prescription Drug List (PDL; Government of Canada, 2021) or in the schedules to the *Controlled Drugs and Substances Act* (1996) and its regulations (National Association of Pharmacy Regulatory Authorities, n.d.).

From there, the **National Association of Pharmacy Regulatory Authorities (NAPRA)**, which is the pharmacy regulatory body in Canada with a mandate to protect public interest. Its role is to regulate drugs at a national level to ensure consistency across Canada, develop model standards and manage the National Drug Schedules.

The *Drug Schedules Regulation* (1998) under the *Pharmacy Operations and Drug Scheduling Act* (2003) places all substances that are regulated under existing federal law into one of three schedules and four categories. The **National Drug Schedule** program also specifies further conditions of sale of any drug products. Other products such as natural health products or

medical devices are outside the scope of the National Drug Schedule program.

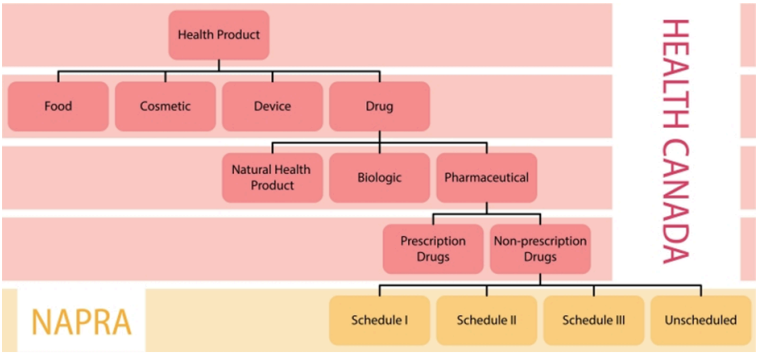

Figure 2.2a NAPRA drug schedules in Canada (Copyright © College of Pharmacy of Newfoundland and Labrador. Used with permission, ONLY.)

Health Professions and Occupations Act (HPOA)

Each province has its own health professions act that gives each healthcare profession's regulatory body the ability to regulate or set the standards and scope of practice for their profession. In BC, the Health Professions Act has been replaced on April 1, 2026, with the Health Professions and Occupations Act. HPOA represents a significant modernization of the B.C.'s regulatory framework, with "an improved ability to protect the public, reinforce transparency and accountability and better reflects cultural safety, equity and the public interest" (BCCNM, 2026). As mentioned, HPOA establishes the legal framework for each health profession's regulatory college. In BC, the British Columbia College of Nurses and Midwives (BCCNM) determine these standards of practice, as would College of Registered Nurses of Alberta in Alberta or the Nurse Association of New Brunswick.

In relation to medications, the regulatory college will determine

the nurse's authority to administer, dispense, and compound certain medications. Each nurse designation—nurse practitioner, registered nurse, licensed practical nurse, and registered psychiatric nurse—will have different regulations. It is important that nurses are aware of their standards of practice and regulations related to their licensing and regulation in the province in which they are working (BCCNM, 2025).

Scheduled Medications

The *Drug Schedules Regulation* (1998) under the *Pharmacy Operations and Drug Scheduling Act* (2003) places all substances regulated under existing federal law into one of three schedules or four categories. **Scheduled medications** are based on a substance's medical use, potential for misuse, and safety or dependence liability.

The drug schedules are based on a cascading principle, meaning drugs that need the most oversight are in Schedule 1. A drug is first assessed against factors in Schedule 1. That drug will remain as a Schedule 1 drug if it meets the above criteria. If not, the drug is assessed against Schedule II factors, such as requiring professional intervention from a pharmacist at point of sale (professional services area). If not, then the drug is sold in the self-selection area of the pharmacy under direct supervision of a pharmacist (professional products area).

Because controlled substances have a greater chance of being misused, there are additional laws and procedures in place with these medications. A controlled substance, such as opioid medications, are placed in Schedule 1A.

Table 2.2.1 outlines each schedule, the type of drug that may be placed in that schedule, and a pharmacist and nurse's responsibility in dispensing, compounding, and administering that drug.

Table 2.2.1 Drug Schedules

Schedule	Definition and RN Responsibility	Examples
Schedule I (Prescription)	Schedule I drugs require a prescription for sale and are provided to the public by a pharmacist following the diagnosis and professional intervention of a practitioner. The sale is controlled in a regulated environment as defined by provincial pharmacy legislation.	Most prescription medications For example, Atenolol, Ciprofloxacin, Enoxaparin, Tylenol #3 (Codeine + Acetaminophen)
Schedule IA (Triplicate/ Duplicate Prescription Program)	Drugs that may be sold by a pharmacist to a practitioner or on the prescription of a practitioner in accordance with Bylaw 5 (31) (6) of the bylaws to the *Pharmacists, Pharmacy Operations and Drug Scheduling Act* (2003). This bylaw aims to reduce inappropriate prescribing of selected controlled drugs and to prevent forgeries. Prescriptions for the controlled drugs specified in the program must be written on the duplicate prescription pad specially developed for this purpose.	• Fentanyl • Morphine • Oxycodone • Hydromorphone
Schedule II (Professional Service Area)	Drugs that may be sold by a pharmacist on a non-prescription basis and that must be retained within the professional service area of the pharmacy where there is no public access and no opportunity for client self-selection.	• Diclofenac (when sold as single ingredient) • Lice treatment
Schedule III (Professional Products Area)	Drugs that may be sold by a pharmacist to any person from the self-selection professional products area of a licensed pharmacy.	• Acetaminophen > 650mg • Hydrocortisone ointment < 1% • Lactulose

Unscheduled (Non-pharmacy Sale)	Drugs that may be sold by a non-pharmacist to any person (e.g., convenience stores can carry these medications due to low risk to the public).	• Acetaminophen < 650mg, in pack sizes less than 50 units • Antacids (ie. TUMS)

For all nurses working in a facility, an order is required to administer medications. For nurses working in the community, they may be able to administer certain medications following a nursing diagnosis and using a decision support tool.

Example in Practice:

- A client has a minor ailment and needs a medication for treatment. In BC, pharmacists can prescribe medications for minor ailments such as urinary tract infections, allergies, acne, cold sores, contraceptives, and certain skin and fungal infections following an assessment and diagnosis. This recent change in policy utilizes a pharmacist's full scope of practice.
- A nurse is working in a public health unit and will be giving vaccines in the flu clinic. The nurse can administer the vaccine following an assessment, nursing diagnosis, and using a decision support tool.

Acting Within Autonomous Scope of Practice (Without an Order)

In some circumstances, registered nurses (RNs) will be required to give certain medications without an order. The nurse will first need to do an assessment, and then based on a nursing diagnosis or using a decision support tool, they can give certain medications. This scope of practice is dependent on the agency policy and area of practice, and is the nurse's responsibility to know any limitations.

BCCNM — Acting Within Autonomous Scope of Practice

The *Registered Nurse: Acting within Autonomous Scope of Practice* standards, limits, and conditions apply to registered nurses and licensed graduate nurses when they are acting within autonomous scope of practice (without an order). These standards, limits, and conditions also apply to certified practice registered nurses when they are performing activities within their autonomous scope of practice (without an order) that are not within their certified practice designation.

Acting within autonomous scope of practice refers to registered nurses:

- assuming accountability and responsibility for making decisions about client care, and
- performing activities that they are competent and allowed to perform without a client-specific order.

For the complete standard, go to BCCNM's (n.d.a) Acting

Within Autonomous Scope of Practice page. Note that standards will differ between provinces or countries. Nurses must always practice under the scope of practice for that jurisdiction.

Schedule I Medications

Under BCCNM's (2025) standards of practice, RNs may prescribe, compound, dispense, or administer a limited number of Schedule I medications without an order and in an emergency. For example, in an emergency, RNs can give epinephrine for anaphylaxis or oxytocin for post-partum hemorrhage. As outlined below, nurses need to have additional education, complete an assessment and use a decision support tool prior to administration (BCCNM, 2025).

Treat:

- anaphylaxis
- cardiac dysrhythmia
- respiratory distress (clients with known asthma)
- hypoglycemia
- post-partum hemorrhage

Registered nurses may compound or administer:

- Epinephrine to treat anaphylaxis
- Epinephrine, atropine, amiodarone or lidocaine to treat cardiac dysrhythmia

- Salbutamol or ipratropium bromide to treat respiratory distress in known asthmatics
- Oral corticosteroids to treat respiratory distress in known asthmatics in emergency care settings
- D50W to treat hypoglycemia
- Oxytocin to treat post-partum hemorrhage

Registered nurses **must** follow a **decision support tool** if they:

- administer *epinephrine to treat anaphylaxis.*
- administer *epinephrine*, *atropine*, *amiodarone or lidocaine* to treat cardiac dysrhythmia and must also possess the competencies established by Providence Health Care.
- administer *salbutamol*, *ipratropium bromide*, or *oral corticosteroids* must also successfully complete additional education.
- administer *D50W.*
- administer *oxytocin* and must possess the competencies established by Perinatal Services BC (PSBC) and follow decision support tools established by PSBC (PSBC: Core Competencies for Management of Labour).

(BCCNM, 2025)

Schedule II Medications

In most cases, when nurses are treating a disease or disorder, they

require a client-specific order. RNs can also compound, dispense, or administer Schedule II medications within autonomous scope of practice to treat a condition following an assessment and nursing diagnosis. This allows nurses to administer vaccines in health clinics, give glucagon for hypoglycemia, or give sublingual nitroglycerin for chest pain (BCCNM, 2025).

Drug Diversion

Drug diversion involves the transfer of any legally prescribed controlled substance from the individual for whom it was prescribed to another person for any illicit use. The most common drugs diverted from the healthcare facility setting are opioids. Tampering is the riskiest and most harmful type of diversion.

In some cases, drug diversion can occur by healthcare providers. Substance misuse by nurses is often unidentified, unreported, and untreated; nurses may continue to practise in places where their impairment may endanger the lives of their clients. BCCNM has established a professional and ethical responsibility to report a colleague's suspected drug use. For more information about drug diversion in nurses visit BCCNM's (n.d.b) Duty to Report: Narcotic Diversion and Substance Abuse Impairing Practice page.

Prescription Monitoring Programs (PMP)

In addition to drug diversion programs, **prescription monitoring programs** (PMP) have been established in several provinces to address prescription drug misuse, addiction, and diversion (Sproule, 2015). A PMP "collects information about prescription and dispensing of controlled substances for the purposes of monitoring, analysis, and education. In Canada, it is the responsibility of the

provincial institutions to organize, maintain and run such programs" (Furlan et al., 2014). Providing valuable information about controlled substance prescriptions dispensed in the province aids healthcare professionals in their prescribing and dispensing decisions. The PMP also fosters the ability of pharmacies, healthcare professionals, law enforcement agencies, and public health officials to work together to reduce the misuse and diversion of prescribed controlled substance medications.

Proper Drug Disposal

Health Canada guidelines allow users to dispose of controlled substances in a safe and effective manner. A Johns Hopkins study on the sharing of medication found that:

- 60% of people had leftover opioids they hung on to for future use;
- 20% shared their medications;
- 8% would likely share with a friend;
- 14% would likely share with a relative; and
- only 10% securely locked their medication. (Open Resources for Nursing, 2023)

Figure 2.2b *Controlled substances collection receptacle (Open Resources for Nursing/Nursing Pharmacology (2nd ed.))* CC BY 4.0

Health Canada also has a Take-back program in all provinces and territories that allows anyone to return unused medication at any time (see **Figure 2.2.2**). Additionally, needle disposal bins (yellow

bins) are given through pharmacies for people on injectable medications.

Clinical Reasoning and Decision Making 2

1. A nurse is providing discharge education to a client who recently had surgery and has been prescribed hydrocodone/acetaminophen tablets to take every four hours as needed at home. The nurse explains that when the post-op pain subsides and the medication is no longer needed, it should be dropped off at a local **pharmacy** for disposal in a collection receptacle. The client states, "I don't like to throw anything away. I usually keep unused medication in case another family member needs it."

   What is the nurse's best response?

2. A nurse begins a new job on a medical-surgical unit. One of the charge nurses on this unit is highly regarded by her colleagues and appears to provide excellent care to her clients. The new nurse cares for a client that the charge nurse cared for on the previous shift. The new nurse asks the client about the effectiveness of the pain medication documented as provided by the charge nurse during the previous shift. The client states, "I didn't receive any pain medication during the last shift." The nurse mentions this incident to a preceptor who states, "I have noticed the same types of incidents have occurred with previous clients but didn't want to say anything.

What is the nurse's best response?

3. A nurse is working in a health clinic and is preparing to give a vaccine, a schedule 2 medication. The nurse can give the vaccine based on what actions were taken first?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

Learning Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=1597#h5p-25

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— *version of the text. You can view it online here:* https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=1597#h5p-27

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Media Attributions

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- Figure 2.2b Figure 2.2 Controlled Substances Collection Receptacle by Open Resources of Nursing, via *Nursing Pharmacology* (2nd ed.), is used under a CC BY 4.0 license.

CHAPTER 3 - MEDICATION SAFETY: PREVENTING MEDICATION ERRORS

3.0 Medication Safety — Preventing Medication Errors

Learning Outcomes

1. Identify factors that contribute to a holistic approach to medication administration, including social determinants of health, cultural safety, and health literacy.
2. Explain client-centred care and cultural safety during medication administration.
3. Understand the types of medication errors and strategies for prevention.
4. Articulate the factors that affect medication safety, including healthcare providers, systems, and client factors.
5. Understand medication safety for pediatric clients.
6. Understand medication safety for older adult clients, including polypharmacy and prescription cascades.
7. Understand strategies to promote safe medication administration, including Beers Criteria and deprescribing initiatives.

In this chapter, we will explore medication safety by considering factors that contribute to a holistic approach to pharmacotherapy and examine lifespan considerations such as factors that can put

both pediatric and the older adult at risk for medication errors. Lastly, we will focus on strategies to reduce medication errors, including using tools such as the Beers criteria, deprescribing initiatives, and nursing interventions.

3.1 A Holistic Approach to Medication Administration

Holistic nursing care involves caring for the client as a whole by considering the physical, social, spiritual, emotional, and economic needs of the client. It involves understanding the client's response to their health condition (Ambushe et al., 2023). With medication administration, a nurse should always strive for holistic care delivery as this will lead to a more comprehensive understanding of the client's needs, lifestyle, behaviour, or response to a medication regime. This first unit will examine how exploring a holistic approach can promote medication safety.

Example in Practice:

Client A, a 42-year-old male, has hypertension and is started on an anti-hypertensive. After six months on the med, their blood pressure is still high, despite dose adjustments. Before starting on a second medication, would learning about the client's lifestyle impact decisions on the type of ongoing care? The nurse learns this client is in a high stress job, has significant financial concerns with supporting his family, and eats mostly processed foods for their speed and convenience.

Client B, a 70-year-old female, is brought into a health clinic by their son due to wound infection following a gardening mishap. They are put on antibiotics and asked to return in two weeks for reassessment. When they return in two weeks, the infection has gotten worse

with redness and discharge at the site followed by increasing pain. The nurse learns the client did not take the antibiotics due to mistrust with the healthcare system. They only take herbal therapies for any ailments and have not seen a healthcare provider for over 10 years. They only came into the clinic due to their son's persistence.

In both of these situations, if the nurse took the time to learn about the client's lifestyle and other factors, it would have likely resulted in a better healthcare outcome. This unit will examine factors that are important to avoid medication errors and promote optimal medication use and positive health outcomes.

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3.2 Social Determinants of Health and Cultural Safety

Many factors will have an influence on health, including a client's health practices such as managing and treating health conditions. These health practices are significantly impacted by social and economic factors, which must be considered when providing care to a client. The social determinants of health "refer to a specific group of social and economic factors within the broader determinants of health. These relate to an individual's place in society, such as income, education or employment" (Public Health Agency of Canada, 2024). Other experiences such as discrimination, racism, and historical trauma are also important social determinants, especially for certain groups such as Indigenous Peoples, the 2SLGBTQI+ community, and Black Canadians. The Public Health Agency of Canada has identified fourteen determinants of health including:

- income and income distribution,
- education,
- unemployment and job security,
- employment and working conditions,
- early childhood development,
- food insecurity,
- housing,
- social exclusion,
- social safety network,
- health services,
- Indigenous status,
- gender,
- race, and
- disability

In nursing, and the broader healthcare field, these are important considerations when caring for clients. Nurses should understand how these determinants of health can have an impact on clients' quality of life and ability to access healthcare, including understanding their health condition and treatments, (e.g., medications).

Example in Practice:

A nurse works in a primary healthcare clinic and is with a client reviewing their medications for a number of health issues. The client nods and appears to understand the discussion and the importance of the medications. The client returns two weeks later, and the nurse learns that the client did not fill the prescriptions. It can be easy to judge a client for not following the prescription, but a lack of medication adherence can be due many factors:

- Could it be a lack of money to buy the medications?
- It is their inability to get to the pharmacy to get the prescription filled?
- Was it a language barrier and they were being polite by nodding?
- Did they not understand due to low literacy level or a language barrier?

Socioeconomic factors can prevent a client from receiving the care necessary to improve their health. The nurse should investigate

barriers to care by using simple, non-judgmental language and working with the client to discuss strategies. "Nurses must assess and respect the client's values, beliefs, personal preferences, language, learning needs, abilities, mental state, and level of understanding, to support the client (or their substitute decision maker) to be an active participant in making informed decisions." (British Columbia College of Nurses & Midwives, n.d.).

Along with determinants of health, Canadian nurses must also understand the cultural influences around medication use. Canada has become increasingly diverse in the last century. According to Statistics Canada in 2016, approximately 7,674,580 people in Canada fit into the visible minority population in Canada. Though health indicators such as life expectancy and infant mortality have improved for many, some minorities experience a disproportionate burden of preventable disease, death, and disability compared with non-minorities (Centers for Disease Control and Prevention, 2017).

To address this diverse population and to uphold the values of cultural diversity and respect for all peoples, the Canadian Nurse's Association (2025) *Code of Ethics for Nurses* has recently been updated to highlight the ethical values nurses require in today's health care setting.

For example:

- **Value 1:** Honouring the Dignity and Autonomy of all People.
- **Value 4:** Pursuing Truth and Reconciliation.

These values, among others, help guide nurses in promoting ethically competent nursing practice.

Cultural Safety

Cultural safety is defined as an outcome-based, respectful engagement that addresses power imbalances through societal and health care systems lenses. Being culturally safe in a nurse's practice provides an opportunity to fully engage in caring, where people feel safe when receiving care and are free from racism and/or discrimination (First Nations Health Authority, 2016).

When providing culturally safe care, nurses must recognize the critical component of cultural humility. Cultural humility is self-reflection of our own personal biases as well as recognition of other systematic biases. When we change our lens from one of using our nursing role as a power position, we need to consider fostering a relationship between ourselves and our clients that is built on trust and openness (First Nations Health Authority, 2016).

To help nurses achieve this goal, we turn to our practice standards for direction. British Columbia College of Nurses and Midwives (BCCNM, 2016) has developed the practice standard, Indigenous Cultural Safety, Cultural humility and Anti-Racism, with six core concepts and principles, beginning with a self-reflection exercise and ending with a strengths-based and trauma-informed practice. For the full practice standard, go to BCCNM's (n.d.) Indigenous Cultural Safety, Cultural Humility, and Anti-Racism page.

When administering medication, nurses build trust with their clients and recognize that each client has a unique life and cultural history. Nurses must follow their scope of practice for medications but also recognize that it is vital to have their clients become key

drivers in their own care. To create this relationship, nurses must consider:

- cultural barriers that could impact the full engagement of the client;
- language barriers;
- previous negative experience with a healthcare team; and
- distrust of the healthcare system.

Figure 3.2a Diversity of clients in health care

Utilizing open communication through the skills of relational practice allows nurses to develop a partnership in decision making. Listening to the needs of the client initiates an open discussion that improves health outcomes through medication adherence and an understanding of key factors (First Nations Health Authority, 2016).

Relational practice

Relational practice refers to the nurse's ability to communicate within a deeper context, such as building a foundational health relationship that promotes effective nursing care. The interpersonal connection transcends and changes shape to meet the current needs of the client (College of Licensed Practical Nurses of Alberta, 2021)

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Figure 3.2a Equity-diversity. https://pixabay.com/illustrations/friends-equality-diversity-rainbow-7822175/

3.3 Safe Medication Administration

Amanda Egert; Kimberly Lee; and Manu Gill

Safe Medication Administration

Since nurses play a pivotal and hands-on role in all aspects of client care, the responsibility of ensuring client safety during medication administration often lies with them. The following sections summarize safety considerations for medication orders, medication administration, assessment/monitoring after medication administration, and documentation.

Safety Considerations – Medication Orders

Medications must be administered in response to an order from a practitioner or on the basis of a standing order that is subsequently appropriately authenticated by a practitioner. All practitioner orders for the administration of drugs and biologicals must include at least the following:

- Name of the client
- Age and weight of the client to facilitate dose calculation when applicable. Policies and procedures must address weight-based dosing for pediatric clients as well as in other circumstances

identified in the hospital's policies. (Note that dose calculations are based on metric weight (kg, or g for newborns)).
- Date and time of the order
- Drug name
- Dose, frequency, and route
- Dose calculation requirements, when applicable
- Exact strength or concentration, when applicable
- Quantity and/or duration, when applicable
- Specific instructions for use, when applicable
- Name of the prescriber

Safety Considerations – Medication Preparation

The following safety considerations were taken from Clinical Procedures for Safer Patient Care by Glynda Rees Doyle and Jodie Anita McCutcheon (Doyle, Glynda & McCutcheon, 2021).

- Plan medication administration to avoid disruption:
  - Dispense medication in a quiet area
  - Avoid conversations with others
  - Follow agency's no-interruption zone policy
- Prepare medications for ONE client at a time.
- Follow the SEVEN RIGHTS of medication preparation (see below).
- Check that the medication has not expired.
- Perform hand hygiene.
- Check room for additional precautions (contact precautions, droplet precautions, and airborne precautions).
- Introduce yourself to client.
- Confirm client ID using two client identifiers (e.g., name and date of birth) AND check against MAR.
- Check allergy band for any allergies, and ask client about type and severity of reaction.

- Complete necessary focused assessments, lab values, and/or vital signs, and document on MAR.
- Provide client education as necessary.
- If a client questions or expresses concern regarding a medication, stop and do not administer.

Safety Considerations – Medication Administration
The Seven Rights

For the purposes of this textbook, we will discuss the **7 RIGHTS** and **3 CHECKS** of medication administration. It is important that nurses always follow their hospital and regulatory College policies and guidelines (Doyle, Glynda & McCutcheon, 2021).

7 Rights and 3 Checks of Medication Administration

The 7 RIGHTS are:

1. The right patient/client
2. The right medication (drug)
3. The right dose
4. The right route
5. The right time
6. The right reason

7. The right documentation

These RIGHTS must be checked 3 times **for each medication** the nurse is administering. The 3 CHECKS are done at the following steps in the administration process:

- When the medication is taken out of the drawer
- When the medication is being poured
- When the medication is being put away, or at bedside

Many agencies have implemented bar code medication scanning to improve safety during medication administration. Bar code scanning systems reduce medication errors by electronically verifying the "7 rights" of medication administration. For example, when a nurse scans a bar code on the client's wristband and on the medication to be administered, the data is delivered to a computer software system where algorithms check various databases and generate real-time warnings or approvals. Studies have shown that bar code scanning reduces errors resulting from the administration of a wrong dose or wrong medication, as well as errors involving medication being given by the wrong route. However, it is important to remember that **bar code scanning should be used in addition to performing the 7 rights of medication administration**, not in place of this important safety process.

Additionally, nurses should carefully consider their actions when errors occur during the bar code scanning process. Although it may be tempting to quickly dismiss the error and attribute it to a technology glitch, the error may have been triggered due to a client safety concern that requires further follow-up before the medication is administered. It is important for nurses to investigate

errors that occur during the bar code scanning process just as they would do if an error is discovered during the traditional five rights of the medication process.

Safety Considerations – Client Education

The BCCNM Practice Standard for Medication states that "nurses educate the client about the medication they receive, including, as applicable (BCCNM 2021).

- the reason the client is receiving the medication,
- the expected action of the medication,
- the duration of the medication therapy,
- specific precautions or instructions for the medication,
- potential side-effects and adverse effects (e.g., allergic reactions) and action to take if they occur,
- potential interactions between the medication and certain foods, other medications, or substances,
- handling and storage requirements,
- recommended follow-up."

The book *Preventing Medication Errors* by the Institute of Medicine (2007), lists the following additional key actions to include when teaching clients about the safe use of their medications:

- Clients should maintain an active list of all prescription drugs, over-the-counter (OTC) drugs, and dietary supplements they are taking, the reasons for taking them, and any known drug allergies. Every provider involved in the medication-use process for a client should have access to this list.
- Clients should be provided information about side effects, contraindications, methods for handling adverse reactions, and sources for obtaining additional objective, high-quality

information (Institute of Medicine, 2007).

Clinical Reasoning and Decision Making Activity 1

A nurse is preparing to administer metoprolol, a cardiac medication, to a client and implements the **nursing process**:

ASSESSES the vital signs prior to administration and discovers the heart rate is 48.

DIAGNOSES that the heart rate is too low to safely administer the medication per the parameters provided. Establishes the **OUTCOME** to keep the client's heart rate within the normal range of 60-100.

PLANS to call the physician and report this incident in the shift handoff report.

Implements **INTERVENTIONS** by withholding the metoprolol at this time, documenting the incident of the medication being withheld, and notifying the provider.

Throughout the shift, continues to **EVALUATE** the client's status after not receiving the metoprolol.

While providing client teaching to a client about the medication before discharge, the nurse provides a handout with instructions, as well as a list of the current medications.

What other information should be provided to the client?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

Safety Considerations – Assessment and Monitoring of Clients Receiving Medications

Clients must be carefully monitored to determine whether the medication results in the therapeutically intended benefit, and to allow for early identification of adverse effects and timely initiation of appropriate corrective action. Depending on the medication and route/delivery mode, monitoring may need to include assessment of:

- Clinical and laboratory data to evaluate the efficacy of medication therapy to anticipate or evaluate toxicity and adverse effects. For some medications, including opioids, this may include clinical data such as respiratory status, blood pressure, and oxygenation and carbon dioxide levels.
- Physical signs and clinical symptoms relevant to the client's medication therapy, such as confusion, agitation, unsteady gait, pruritus, etc.
- Factors contributing to high risk for adverse drug events. Although mistakes may or may not be more common with these drugs, the consequences of errors are often harmful, sometimes fatal, to clients. In addition, certain factors place some clients at greater risk for adverse effects of medication. Factors include, but are not limited to: age, altered liver and kidney function, and drug-to-drug interactions; first-time medication use may contribute to increased risk.

The nurse should consider client risk factors as well as the risks inherent in a medication when determining the type and frequency of monitoring. It is also essential to communicate information regarding the client's medication risk factors and monitoring requirements during hand-offs of the client to other clinical staff. Adverse reactions such as anaphylaxis or opioid-induced respiratory depression require timely and appropriate intervention

per established protocols and should be reported immediately to the practitioner responsible for the care of the client. An example of vigilant post-medication administration monitoring would be for a post-surgical client who is receiving pain medication via patient-controlled analgesia (PCA) pump. Narcotic medications are often used to control pain but also have a sedating effect. Clients can become overly sedated and suffer respiratory depression or arrest, which can be fatal. In addition, the client and/or family members should be educated to notify nursing staff promptly when the client experiences difficulty breathing or other changes that could be a reaction to a medication US Department of Health & Human Services, 2014).

Safety Considerations – Documentation

The BCCNM outlines documentation requirements for registered nurses in the Documentation Practice Standard. Documentation is expected to occur **after** the actual administration of the medication to the client; advance documentation is not only inappropriate but may result in medication errors. Proper documentation of medication administration actions taken and their outcomes is essential for planning and delivering future care of the client (BCCNM, 2021).

Critical Reasoning and Decision Making Activity 2

A nurse is preparing to administer morphine, an opioid, to a client who recently had surgery.

1. Explain the 7 rights that the nurse will check prior to administering this medication to the client.
2. Outline 3 methods the nurse can use to confirm client identification.
3. What should the nurse assess prior to administering this medication to the client?
4. What should be monitored after administering this medication?
5. What should the nurse teach the client (and/or family member) about this medication?
6. What information should be included in the shift handoff report about this medication?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

Putting it all together...

Safe Medication Administration

Now that you have reviewed the safety requirements and understand that safety is a critical component of medication administration, take some time to review this medication administration checklist from Clinical Procedures for Safer Patient Care by Glynda Rees Doyle and Jodie Anita McCutcheon.

This checklist is a useful resource to help you safely administer medications. Consider printing a copy for yourself to take to clinical practice (Doyle, Glynda, & McCutcheon, 2021).

SAFE MEDICATION ADMINISTRATION

Disclaimer: Always review and follow your hospital policy regarding this specific skill.

Safety considerations:

- Plan medication administration to avoid disruption:
    - Dispense medication in a quiet area.
    - Avoid conversation with others.
    - Follow agency's no-interruption zone policy.
- Prepare medications for ONE patient at a time.
- Follow the SEVEN RIGHTS of medication preparation (see below).
- Check that the medication has not expired.
- Perform hand hygiene.
- Check room for additional precautions.
- Introduce yourself to patient.
- Confirm patient ID using two patient identifiers (e.g., name and date of birth) AND check against MAR.

- Check allergy band for any allergies, and ask patient about type and severity of reaction.
- Complete necessary focused assessments, lab values, and/or vital signs, and document on MAR.
- Provide patient education as necessary.
- If a patient questions or expresses concern regarding a medication, stop and do not administer.

STEPS	ADDITIONAL INFORMATION
1. Check MAR against doctor's orders.	Check that MAR and doctor's orders are consistent. *Compare physician orders and MAR* Compare MAR with patient wristband. Night staff usually complete and verify this check as well.

2. Perform the SEVEN RIGHTS x 3 (this must be done with each individual medication): • The right patient • The right medication (drug) • The right dose • The right route • The right time • The right reason • The right documentation Medication calculation: D/H x S = A (**D** or desired dosage/**H** or have available x **S** or stock = **A** or amount prepared)	The right patient: check that you have the correct patient using two patient identifiers (e.g., name and date of birth). *Compare MAR with patient wristband* The right medication (drug): check that you have the correct medication and that it is appropriate for the patient in the current context. The right dose: check that the dose makes sense for the age, size, and condition of the patient. Different dosages may be indicated for different conditions. The right route: check that the route is appropriate for the patient's current condition. The right time: adhere to the prescribed dose and schedule.

	 Check the right patient, medication, dose, route, time, reason, documentation The right reason: check that the patient is receiving the medication for the appropriate reason. The right documentation: always verify any unclear or inaccurate documentation prior to administering medications. NEVER document that you have given a medication until you have actually administered it.

3. The label on the medication must be checked for name, dose, and route, and compared with the MAR at three different times:

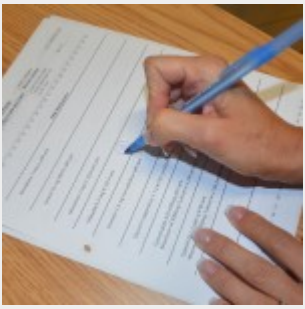
1. When the medication is taken out of the drawer
2. When the medication is being poured
3. When the medication is being put away/or at bedside

Perform seven checks three times before administering medication

These checks are done before administering the medication to your patient.

If taking the drug to the bedside (e.g., eye drops), do a third check at the bedside.

4. Circle medication when poured.

4. Circle medication when poured.	Pour medication. Circle MAR to show that medication has been poured.  *Circle medication once it has been poured*
5. Positioning: • Position patient appropriately for medication administration. • Ensure proper body mechanics for health care provider. • Position patient safely and appropriately once medication is administered.	This ensures patient safety and comfort. *Position patient appropriately for medication administration*

6. Post-medication safety check: • Complete post-assessment and/or vital signs (if applicable). • Sign MAR; place in the appropriate chart. • Perform hand hygiene.	This ensures patient safety. This step prevents the transfer of microorganisms. *Hand hygiene with ABHR*

Data source: Lilley, Harrington, Snyder, & Swart, 2011; Lynn, 2011; Perry et al., 2014

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3.4 Health Literacy and Medication Administration

Health literacy is "the ability to access, understand, evaluate, and communicate information as a way to promote, maintain, and improve health in a variety of settings across the life course" (Rootman & Gordon-El-Bihbety, 2008). According to the Canadian Public Health Association, 60% percent of adults in Canada find it challenging to obtain, understand, and act on health information or services in Canada (ABC Life Literacy Canada, n.d.).

When providing education around medications, nurses must ensure that the content is at an appropriate level for the client to understand the key concepts; it is also useful to appeal to multiple learning styles, such as writing it out, diagrams and other visuals, or recall. For more information about cultural safety, health literacy, and medication administration, you can review the following resources:

- The Centre of Literacy (n.d.b) offers an accredited online course on health literacy called *Health Literacy: You talk to your patients but do they understand? The importance of health literacy in your practice* (The Centre for Literacy, n.d.a).
- The BC Association for Child Development and Intervention (BCACDI, n.d.a) has an online repository with multiple free webinars and other resources on Indigenous cultural safety, which can be found on BCACDI's (n.d.b) Indigenous Cultural Safety page.

Clinical Reasoning and Decision-Making

A nurse is providing client education to a mother regarding a liquid antibiotic prescribed for her child to take at home. The prescription states "Amoxicillin 250 mg 1 teaspoon (5 ml) every 8 hours for 7 days." After talking with the mother, the nurse realizes the family does not have measuring spoons in their home.

What is the nurse's best response?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

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3.5 Medication Errors

Providing safe nursing care can be a challenge with the number of clients assigned to each nurse and all the complex health issues they have, including multiple medications and treatments. When adding in factors such as nurse fatigue and short staffing, it is understandable that a medication error can occur.

Medication errors are the most common and preventable cause of client injury (Tariq et al, 2024). They can occur at any stage of the process of delivering a medication, from prescribing, transcribing, dispensing, and administering the medication. Medication errors can occur with any healthcare professional involved with medications, including prescribers (physicians, nurse practitioners), nurses (LPNs, RNs, RPNs), pharmacists, and other members of the healthcare team such as healthcare assistants or support staff.

Medications errors are one type of an adverse drug event. This is defined as an undesirable and potentially harmful action caused by the administration of a medication (Adams et al., 2018). Adverse drug events is an umbrella term that includes all medication adverse events, that includes med errors and adverse reactions such as side effects, allergic reactions and idiosyncratic reactions. See Monitoring for Effects unit 1.11 for more information on these terms.

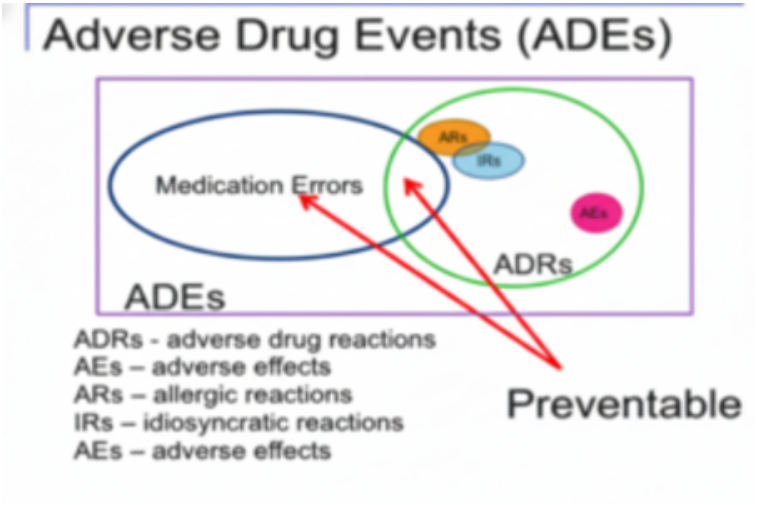

Figure 3.5 Adverse Drug Events (Sheila Odubote/TRU Open Press)

For nurses, errors typically involve administering the wrong dose or drug, using the wrong route, improper administration, or giving a medication to the wrong client. The outcome of these errors can range from no effect on the client to life-threatening injury, but fortunately, most errors cause no harm to the client. 'Near miss' events are situations or errors that place clients at risk but are recognized and managed before the client is affected. For example, a nurse prepares a medication for a client, and prior to administering the medication, recognizes they have the wrong dose.

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Image:

3.5a Adverse Drug Event (Sheila Odubote/ TRU Open Press)

3.6 Preventing Medication Errors

Despite having safety standards for prescribing, dispensing, and administering medications, medication errors continue to be a concern worldwide. Globally, medication errors and unsafe medication practices are the leading cause of client harm in healthcare systems (World Health Organization, n.d.). Medication errors occur throughout the medication use process; however, many recent studies indicate that most errors occur during prescribing and monitoring stages (World Health Organization, 2023).

Over the last few decades in Canada, there has been a national focus to reduce medication incidents with a comprehensive approach to improving client safety. Although progress has been made in client safety over the last few years, medication errors remain extremely common in both the hospital and community setting. A 2021–2022 report by the Canadian Institute of Health Information, found that 47% of the 150,000 harmful events that occurred in a hospital setting were attributed to healthcare (i.e., bed sores) and medication errors (Zelmer, 2022). In a community setting, medication incidents in pharmacies were reported at more than 24,000 incidents in 2023, with incorrect dose/frequency, incorrect quantity or incorrect drug as most reported (Institute for Safe Medication Practices Canada [ISMP Canada], 2024). In 2015, the Institute for Safe Medication Practices (ISMP) Canada published a report titled *Medication Error and Patient Safety: A Systems Approach*, which reported that more than 7.5% (or 187,500) patients in Canadian hospitals were seriously harmed by their care (Greenall, 2015).

The national healthcare system continues to implement initiatives at all levels to prevent errors. Based on results from incident report

data, the Canadian Patient Safety Institute (CPSI, 2014), in partnership with ISMP Canada, created a *Medication Safety Action Plan* to accelerate improvements in safe medication use in Canada. The action plan covers five major themes:

1. **Reporting, learning and sharing:** focus on reporting medication safety events, but also actively and mindfully share results with relevant parties.
2. **Evidence-informed practices:** focus on developing and implementing evidence-informed guidelines for clinical practice to improve medication safety.
3. **Partnering with patients:** shift the professional culture to encourage open sharing of information between providers and clients.
4. **Education:** ensure clients have access to plain-language resources related to medication safety, and ensure each member of the interdisciplinary team has a clear understanding of their roles with medication safety.
5. **Technology:** integrate healthcare system technologies, while addressing privacy concerns.

The plan outlines clear goals and actions that health authorities can take in order to mitigate medication errors.

ISMP Canada emphasized **systems-based actions** that healthcare organizations, providers, and policy-makers/regulators can take to improve medication safety. These recommendations included actions such as:

- automation or computerization of medication dispensing,
- standardization of order sets,
- electronic order sets, and
- improved policies/guidelines on medication administration.

The Institute of Medicine (IOM) and ISMP Canada also emphasize actions that individual clients can take to prevent medication errors,

such as maintaining active medication lists and bringing their medications to appointments for review (Aspden, et al., 2007; Greenall, 2015).

Health organizations have aimed to break the cycle of inaction regarding medical errors by advocating a comprehensive approach to improving client safety (Kohn et al., 2000). Part of this approach is supporting a 'safety culture' that shifts from blaming the individual for the error to one of a learning opportunity.

Safety Culture

According to the Institute of Medicine, "The biggest challenge to moving toward a safer health system is changing the culture from one of blaming individuals for errors to one in which errors are treated not as personal failures, but as opportunities to improve the system and prevent harm" (Joint Commission Center for Transforming Healthcare, 2021). The British Columbia Patient Safety and Quality Council (BCPSQC) develops effective solutions for healthcare's most critical safety and quality problems with a goal to ultimately achieving zero harm to clients. The Center has also been instrumental in creating a focus on a "Safety Culture" in healthcare organizations. A **safety culture** empowers staff to speak up about risks to clients and report errors and near misses, all of which drive improvement in client care and reduce the incidence of client harm.

Further, many health authorities in Canada also use electronic databases to collect and use evidence to support and sustain protocols that help identify drug misuse and see gaps (for example, the BC Patient Safety Learning System (n.d.)).

As a result of the focus on creating a safety culture, whenever a medication error or a 'near-miss' occurs, nurses should submit a safety event report according to their institution's guidelines. The incident report triggers a **root cause analysis** to help identify not only what and how an event occurred, but also why it happened.

When investigators are able to determine why an event or failure occurred, they can create workable corrective measures that prevent future errors from occurring (UC Davis PSNet Editorial Team, 2024).

Safety Culture in Action

In 2006, three babies died after receiving incorrect heparin doses to flush their vascular access devices (Institute for Safe Medication Practices, 2007). A root cause analysis found that pharmacy technicians accidentally placed vials containing more concentrated heparin (10,000 units/mL) in storage locations in client care areas designated for less concentrated heparin vials (10 units/mL). Additionally, the heparin vials were similar in appearance, so the nurses did not notice the incorrect dosage until after it was administered.

In response to the root cause analysis, the hospital no longer stocks heparin 10 units/mL vials in pediatric units and uses saline to flush all peripheral lines. In the pharmacy, 10,000 units/mL heparin vials were separated from vials containing other strengths. Workable corrective measures were thus implemented to prevent future tragedies from occurring as a result of incorrect doses of heparin.

Figure 3.6a Heparin vial. Heparin is one med that has many different strengths that are used for different purposes. Nurses must ensure they are using the correct heparin by carefully reading the order, the vial and doing an independent double check.

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Images

3.6a Heparin vial. PanaromicTiger – Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=7538488

3.7 Medication Safety in High-Risk Situations

Most nurses have worked in a situation where, despite their best intentions, the risk of medication errors is high.

Example in practice: A medical unit nurse with three years of experience has been floated to the emergency department as they are short staffed. The nurse is given six 'stable' ED patients but has more clients than the allowed ratio. The ages range from a 6 month old with suspected pneumonia to a 40 year old with stable angina to a 90 year old with a fractured hip and history of dementia. The nurse is given a quick orientation to the unit and then proceeds to assess her clients.

Does this scenario sound familiar? Can you identify potential risks to client safety? All these clients will be prescribed medications. What challenges can you see with the nurse administering the meds?

From the above example, it is easy to identify many areas where things could go wrong and pose a risk to the client. The following unit will examine categories to improve medication safety, including high-risk medications, healthcare provider, systems, and client factors. Note that each strategy can also be applied more broadly to other categories.

High-Risk (High-Alert) Medications

High-risk medications are drugs that bear a heightened risk of causing significant client harm when they are used in error. Medication incidents can include harmful events, no-harm events, near misses, and circumstances that can lead to harmful incidents. The Institute for Safe Medication Practices (ISMP) Canada (2020) prepared a report highlighting the degree of harm with medication in specific practice settings using data from ISMP's Individual Practitioner Reporting, Consumer Reporting, and National Incident Data Repository for Community Pharmacies and the Canadian Institute for Health Information's (CIHI) National System for Incident Reporting.

Medications Frequently Reported (ISMP, 2020)

- Community settings: methadone, metformin, levothyroxine
- Hospital settings: Insulin, hydromorphone, morphine
- Home and community care: hydromorphone, methotrexate, bisoprolol
- Long-term care: hydromorphone, fentanyl, insulin

For more information, go to the ISMP Canada site: Medications most frequently reported in harm incidents over the past 5 years (2015-2020). https://ismpcanada.ca/wp-content/uploads/Figure-4-ISMPCSB2020-i11-Medications-Reported-Harm-.jpg

https://ismpcanada.ca/bulletin/medications-most-frequently-reported-in-harm-incidents-over-the-past-5-years-2015-2020-2/

This data shows that medication incidents are not just occurring in acute care settings but in all client care settings and with similar frequency. Hydromorphone was among the top three drugs in three out of four settings reporting severe harm or death reports.

Other drugs that had a higher incidence of severe harm or death incidents included hydromorphone, morphine, methotrexate, methadone, and lorazepam; all of which are considered high-alert medications.

The ISMP (2024) has published a list of High-Alert Medication in Acute Care Settings. These medications are a heightened risk due to the risk of harm if used in error, and as such, require special safeguards to minimize the risk. For example, safeguards can include limiting access to high-alert medications or using clinical decision support tools. High-risk medication can be remembered using the mnemonic "A PINCH." **Table 3.7.1** describe the medications included in the "A PINCH" mnemonic.

Table 3.7.1 "A PINCH" Mnemonic

High-Risk Medication Group	Medication Examples
A: Anti-infective	• Amphotericin • Aminoglycosides
P: Potassium and other electrolytes	• Injections of potassium, magnesium, calcium, hypertonic sodium chloride
I: Insulin	• All insulins
N: Narcotics & Other Sedatives	• Hydromorphone, oxycodone, morphine • Fentanyl • Benzodiazepines
C: Chemotherapeutic Agents	• Methotrexate • Vincristine
H: Heparin & Antithrombolytics	• All antithrombotic agents, including warfarin, heparin, enoxaparin • Thrombolytics

Note: For the complete list, go to ISMP's (2024) List of High-Alert Medications in Acute Care Settings [PDF].

Error-Prone Abbreviations

Error-prone abbreviations are abbreviations, symbols, and dose designations that have been reported through the ISMP National Medication Errors Reporting Program as being frequently misinterpreted and involved in harmful medication errors. ISMP Canada's (2017) *Do Not Use: Dangerous Abbreviations, Symbols, and Dose Designations* should never be used when communicating medical information. Some examples of abbreviations that were commonly used that should now be avoided are qd, qod, qhs, BID, QID, D/C, subq, and APAP.

Strategies to avoid mistakes related to error-prone abbreviations include not using these abbreviations in medical documentation. Furthermore, if a nurse receives a prescription containing an error-prone abbreviation, it should be clarified with the provider and the order rewritten without the abbreviation.

Do Not Crush List

The ISMP (2022) also maintains a list of oral dosage medication that should not be crushed, commonly referred to as the **do not crush list**. These medications are typically extended-release formulations.

Strategies for preventing harm related to oral medication that should not be crushed include requesting an order for a liquid form or a different route if the client cannot safely swallow the pill form.

Look-Alike and Sound-Alike (LASA) Drugs

ISMP Canada maintains a list of drug names containing **look-alike** and **sound-alike** name pairs.

For example:

- *captopril* and *carvedilol*, and
- dimenhyDRINATE and diphenhyDRAMINE.

Figure 3.7b DimenhyDRINATE and diphenhyDRAMINE are two meds with similar sounding names, with high risk for a med error.

(*Onnifrey/Wikimedia Commons*) CC-BY-SA-4.0) (*dennissylvesterhurd/flickr*) CC BY-SA 1.0

These medications require special safeguards to reduce the risk of errors and minimize harm. For a full list of these medications, you can review the following resource ISMP's (2019) Look Alike-Sound Alike List of Medications.

Safeguards may include:

- using both the brand and generic names on prescriptions and labels;
- including the purpose of the medication on prescriptions;
- changing the appearance of look-alike product names to draw attention to their dissimilarities; or
- configuring computer selection screens to prevent look-alike names from appearing consecutively. (ISMP Canada, 2019)

Strategies for safe administration of high-alert medication include:

- standardizing the ordering, storage, preparation, and administration of these products;
- improving access to information about these drugs;
- employing clinical decision support and automated alerts; or
- using redundancies such as automated or independent double checks when necessary. (ISMP Canada, 2019)

Lastly, the above information from ISMP may differ from your agency. Always check with your area of practice for unit specific guidelines or requirements to avoid medication errors.

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Media Attributions

- Figure 3.7a. Institute for Safe Medication Practices Canada.
- Figure 3.7b DimenhyDRINATE and diphenhyDRAMINE are two meds with similar sounding names. med.(Onnifrey/Wikimedia Commons) CC-BY-SA-4.0) https://commons.wikimedia.org/wiki/File:Diphenhydramine_1_(cropped).jpg (dennis sylvesterhurd/flickr) CC BY-SA 1.0 https://flickr.com/photos/43296902@N00/26879845435

3.8 Factors Affecting Medication Safety — Healthcare Provider, Systems, and Client Factors

Healthcare Provider Factors

The act of prescribing, dispensing, and administering medicine is complex and involves several healthcare professionals. Even the most dedicated healthcare professional is fallible and can make errors. Some provider-related errors include:

- misinterpreting an abbreviation;
- misidentifying drugs due to look-alike labels and packages;
- mis-programming a pump due to a pump design flaw;
- distractions while preparing or administering medications;
- lack of therapeutic training or inadequate knowledge;
- poor communication with patients;
- a language barrier between healthcare professionals and patients;
- increased workloads;
- interruptions and distractions;
- lack of accuracy of client records;
- a poor interface between prescribers and electronic health records; and
- lack of protocols and standardized procedures in the work environment.

Systems Factors

Systems factors, also called the environment in hospitals, can contribute to error-provoking conditions for several reasons. Some factors include:

- busy or understaffed units, which can contribute to inadequate supervision or failure to remember to check important information;
- interruptions during critical processes (e.g., administration of medicines), which can have significant implications for client safety;
- fatigue and the need to multitask when busy or flustered, which can be compounded by poor electronic medical record design;
- poor interprofessional communication;
- unavailable or inaccurate client information; and
- preparing and administering intravenous medications, which are particularly error-prone.

Strategies for reducing errors include:

- checking at each step of the medication administration process;
- preventing interruptions;
- electronic provider order entry; and
- utilizing prescribing assessment tools.

Clinical Reasoning and Decision Making Activity

A nurse is preparing to administer insulin to a client. The nurse is aware that insulin is a medication on ISMP Canada's list of high-alert medications.

What strategies should the nurse implement to ensure safe administration of this medication to the client?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

Client Factors

Clients can also present risk factors. For example, it is well-known that adverse drug events occur most often at the extremes of life (in the very young and older people). As discussed in the previous chapter, pharmacokinetic factors are important considerations for any age group, but more so in children, especially infants, and in the older population.

In neonates (particularly premature neonates), elimination routes through the kidneys or liver may not be fully developed. In the older population, age-related decline in renal function is common can lead to delayed excretion of many drugs. For both age groups, they are less likely to tolerate adverse drug reactions, either because their homeostatic mechanisms are not yet fully developed or because they may have deteriorated. Additionally, certain medical conditions predispose clients to an increased risk of adverse drug reactions, particularly renal or hepatic dysfunction and cardiac failure.

Medication errors in children, where doses may have to be calculated in relation to body weight or age, are also a source of major concern. Older adults are also at risk of adverse drug events,

either due to polypharmacy, multiple health issues, or age-related pharmacokinetic changes. For example, if they receive several medications concurrently, this can lead to a synergistic effect that can pose harm to the client.

To minimize harm, interprofessional strategies are based on a systems approach with a "prescribing partnership" between the client, prescriber, pharmacist, and nurse. The development and use of medication tools such as Beers Criteria for the older adult population and KIDs list for the pediatric population can be utilized by any healthcare provider to raise awareness of problematic medications.

In the following section, medication safety in pediatrics and older adults will be explored, as well as the issue of polypharmacy, inappropriate medication use, and deprescribing initiatives.

3.9 Medication Safety Across the Lifespans — Pediatrics

AMANDA EGERT

Medication Safety in the Pediatric Population

Children are particularly vulnerable to adverse drug events, particularly infants and young children. Children are more likely to experience an adverse drug reaction compared to adults, regardless if they are in a hospital or community setting. Adverse drug reactions in children range from 0.4–10.3% (Meyers et al., 2020). Other studies found that the potential for adverse drug events (ADEs) in children was three times higher compared to hospitalized adults (Goldman & Konen, 2007). Many ADE are preventable.

Factors that increase adverse drug reactions in pediatrics include:

Drug prescribing and dosing, such as medication labelling issues, calculating errors based on weight, and lack of available dosage forms and concentrations. Most adverse reactions are due to dosing errors. For example, the '10-fold error' with weight based calculations involves a misplaced decimal point when converting milligrams to micrograms for drug dosing.

Pharmacokinetic variations are inherent in maturational changes in body composition and organ function, especially with young children. As children age, total body water decreases and body fat increases, which will affect drug transport and metabolizing enzymes. Neonates are particularly vulnerable to ADEs. For example, neonates have thinner skin, leading to increased absorption through the skin. The development of renal function (glomerular filtration) is complete by the first year of life, but prior

to that, drugs will have a delayed excretion leading to prolonged effects (Meyers et al., 2020).

Communication, such as using non-verbal communication with young children as an early detector of symptoms (Goldman & Koren, 2007). Very young children are less able to clearly communicate than an older child. Language barriers can also be a factor. Nurses need to be skilled in assessing for subtle changes.

Polypharmacy for children with complex or chronic diseases (Meyers et al., 2020). Children on multiple medications are at risk of drug interactions and more side effects, similar to the adult population, except these effects are often more pronounced. As with adults, always consider the appropriateness of all prescribed and OTC medications.

Lack of published information on labelling, safety, efficacy, and clinical use of drugs (Goldman & Koren, 2007). Clinical trials of medications on children are sparse due to ethical reasons and safety concerns. One of the challenges with drugs in pediatric clients is the limited testing when researching the drug. In general, almost all information about drugs is related to dosing in adult clients. The risk of performing research in the pediatric population and obtaining informed consent makes researching drugs a problem.

KIDs List

To improve med safety, pediatric pharmacists developed a list of medications, called the KIDs List (**K**ey Potentially **I**nappropriate **D**rugs in Pediatrics), to identify those associated with a high risk for ADEs; they planned to evaluate and enhance the quality of care, decrease costs, and identify areas of pediatric research (Meyers et al, 2020). The potentially inappropriate medications are those that should be avoided in persons younger than 18 years of age due to a high safety risk. There are 39 drugs and drug classes on the list, which is intended to be a guide and not an absolute

contraindication. The KIDs List includes two recommendation levels: avoid and use with caution.

For example:

- **Codeine:** Risk of respiratory depression and death.
- **Bismuth subsalicylate:** Risk of Reye's syndrome.
- **Tetracycline:** Risk of tooth discoloration and enamel hypoplasia.

The same principles for safe medication administration for adults are identical for children, such as performing seven (or 10) rights of medication administration or verifying unclear orders. Nursing strategies to reduce med errors in children should include:

- performing the seven rights of med administration;
- Having an independent second nurse verifier;
- confirming the correct weight on each drug chart;
- updating skills in calculating drug doses (consider age, weight, height, maturational state, and body surface area);
- verifying unusual drug volumes or doses; and
- listening to the client, parent, or caregiver (listen, answer questions, and double check orders).

Always check with your facility on procedures for drug administration with children. Many facilities will have standard policies in place to minimize drug errors.

Figure 3.9b Illustration of Boy Taking Pharmaceutical Oral Dosage Pills with Glass of Water

Figure 3.9a

Calculating Pediatric Drug Dosages

Two common ways to calculate pediatric dosages are the body weight method and the body surface area method. Sometimes, the order is already taking into account the child's weight, which is verified with the pharmacist. In this case, the calculation can simply be done with 'desire or have' formula.

Desire over Have Formula

Example in practice:

order reads: Famotidine 100mg po BID.

The suspension is 40 mg/5 mL

Desire: 100mg = x mL Have: 40 mg 5 mL 40mgx = 500 x= 500/ 40 = 12.5 mL

Body Weight Method (mg/kg)

The body weight method uses the child's weight to calculate milligrams of drug (mg/kg). Time may also be included. Although relatively easy to use, this method does not consider pharmacokinetic variables or serum concentrations of many drugs that are not proportional to body weight. Additionally, care must be taken to ensure pounds are converted to kilograms (1 kg = 2.2 lb).

Example in practice: A three-year-old child has a fever and is prescribed acetaminophen.

The order reads: Acetaminophen 10-15 mg/kg/dose every 6 hours as needed. Do not exceed 3 gms.

The child weighs 30 pounds. The nurse assesses the child's pain and decides to give the lower dose.

Acetaminophen concentration (suspension) is 160 mg in 5 mL.

Table 3.9.1 Using the Body Weight Method — Example 1

Step	Calculation
Step 1. Convert pounds to kg.	30 lb × 1 kg/2.2 lb = 13.6 kg
Step 2. Calculate the dose in mg.	13.6 kg × 10 mg/kg/dose = 136 mg/dose
Step 3. Convert the mg dose to mL.	136 mg/dose ÷ 160 mg/5 mL = **4.25 mL**

Example in practice: A one-year-old child is diagnosed with otitis media. They weigh 22 lb (10 kg)

The order reads: Amoxicillin oral suspension 40 mg/kg/day in 2 divided doses.

The suspension is available at a concentration of 400 mg/5 mL. How many milliliters should be administered to the child for each dose?

Table 3.9.2 Using the Body Weight Method — Example 2

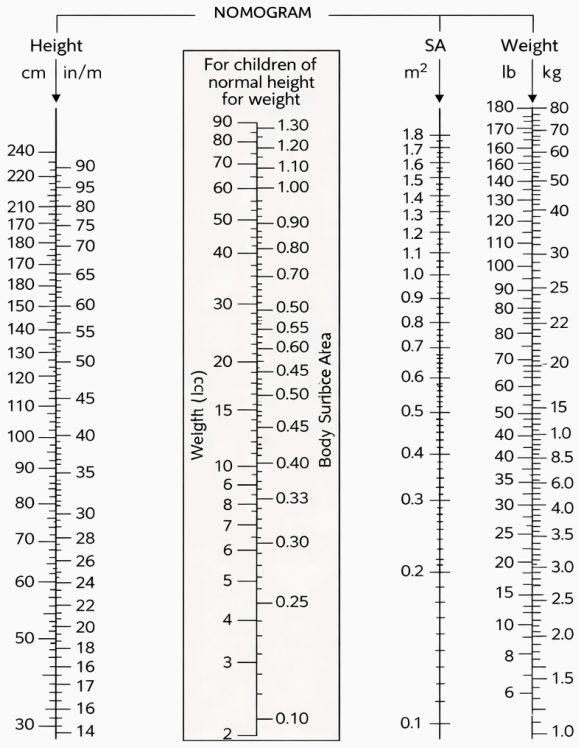
Step	Calculation
Step 1. Convert pounds to kg.	22 lb × 1 kg/2.2 lb = 10 kg
Step 2. Calculate the dose in mg.	10 kg × 40 mg/kg/dose = 400 mg/dose
Step 3. Divide the dose by the frequency.	400 mg/day ÷ 2 = 200 mg/dose
Step 4. Convert the mg dose to mL.	200 mg/dose ÷ 400 mg/5 mL = **2.5 mL**

Body Surface Area Method (mg/m^2)

Calculating pediatric drug dosages using the body surface area (BSA) method can be done using a nomogram or formula. It is used less often but still used for chemotherapy drugs. The BSA is the most accurate method as it considers physiological and pharmacokinetic differences.

Nomogram: The child's height and weight are plotted on a nomogram. The line drawn between two points and where it intersects is the BSA.

Pediatric Nomogram-Body Surface Area



Disclaimer: This image was generated for educational purposes to estimate body surface area in pediatric patients. It provides general information and should not be used as a substitute for professional medical advice or guidance, oprpropriate na fice.

Figure 3.9b Pediatric Nomogram for Body Surface Area (Sheila Odubote/ TRU Open Press).

The responsibility for preventing medication errors is a multidisciplinary approach beginning with facility policies, electronic order sets to avoid written errors (misspelled drugs or doses), prescriber actions, pharmacy guidelines and actions, nursing interventions, and client involvement (Adams et al., 2018).

Clinical Reasoning and Decision Making Activity

1. The 6-month old infant is ordered a liquid medication that is 0.75 mL. The nurse is deciding what is the best way to draw up and give this med. He looks over the syringe options (1-mL, 3-mL, 5-mL), or a calibrated plastic med cup. Which is the best option and what is your rationale?
2. A child is to receive 60 mg of phenytoin. The med is available as an oral suspension that contains 125 mg/5 mL. How many milliliters should the nurse administer?
3. Based on a child's report of pain, the plans to administer the prescribed morphine. The med is available in a 10mg predrawn syringe. The nurse will have 4 mg of waste. The wasting of the med is done by the nurse and a witness. Who can be a witness?

Check your answers in the Chapter 3 answer key section.

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

Supplemental Resource

Below are supplementary learning resources related to client safety and error prevention during medication administration.

Client Example of Medical Errors

Watch the Josie King Story to gain perspective from a family who has experienced a medical error with their child.

Introducing the Partnership for Patients with Sorrel King [4:50min] by HealthCare.gov (2011).

https://youtube.com/watch?v=ak_5X66V5Ms%3Ffeature%3Doembed%26rel%3D0

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Media Attributions

- Figure 3.9a Illustration of Boy Taking Pharmaceutical Oral Dosage Pills with Glass of Water https://www.wannapik.com/vectors/12542
- Figure 3.9b Figure 3.9b Pediatric Nomogram for Body Surface Area (Sheila Odubote/ TRU Open Press). Figure 3.9b Pediatric Nomogram for Body Surface Area (Sheila Odubote/ TRU Open Press). https://www.scribd.com/document/53587761/Nomogram

3.10 Medication Safety Across Lifespans — Older Adults

Anyone working in healthcare has experienced the influx of clients in the aging population, many who have at least one chronic health challenge and often have lifelong medications to manage chronic or acute health conditions. In 2016, one-quarter of Canadian seniors were prescribed 10 or more medications (Farrell et al., 2023). Furthermore, the prevalence of potentially inappropriate medications and polypharmacy has increased over the last 20 years, along with an increased risk of adverse drug events, drug-drug interactions, hospital admission, and mortality. Contributing to the risk of adverse effects is the pharmacokinetic and pharmacodynamic changes occurring in older adults.

Polypharmacy in Older Adults

Polypharmacy is the concurrent use of multiple medications. Although there is no standard definition, polypharmacy is often defined as the routine use of five or more medications. This includes over-the-counter, prescription, traditional, and/or complementary medicines used by a client. As the population ages, more people are likely to suffer from multiple long-term disorders or diseases and take multiple medications. The average intake of medications in an older adult is two to five prescription medications on a regular basis, and polypharmacy occurs in 20–50% of patients (Klotz, 2008). Although medications are quite often needed for treating or managing the symptoms of health issues, the concern is more the unnecessary use of multiple medications that does not lead to optimal client health outcomes. As such, the definition of

polypharmacy as 'more than five medications' is arbitrary, with the focus on unnecessary medication use.

Polypharmacy is one factor in the occurrence of adverse drug reactions (ADRs) in the older population, increasing the risk of drug interactions and side effects significantly. An adverse drug effect (ADE) is an injury from drug use, whereas an adverse drug reaction (ADR) is an ADE that refers to harm caused by a drug at usual dosages (Varghese et al., 2024). ADRs are seven times more likely in older adults (Burchum & Rosenthal, 2023), with the majority of these reactions related to dosages or the older adult being more sensitive to the medications. Adverse drug reactions can cause significant economic and quality of life costs resulting in more hospitalizations, falls, permanent injury, or death (Vallerand & Sanoski, 2024).

Therefore, it is essential to take a person-centered approach to ensure that medications are appropriate for an individual, to gain the most benefits without harm, and to ensure that clients are integral to the decision-making process.

Appropriate polypharmacy is present when:

- all medicines are prescribed for the purpose of achieving specific therapeutic objectives with which the client has agreed;
- therapeutic objectives are actually being achieved or there is a reasonable chance they will be achieved in the future; or
- medication therapy has been optimized to minimize the risk of adverse drug reactions, and the client is motivated and able to take all medicines as intended.

Inappropriate polypharmacy is present when:

- one or more medicines are prescribed that are not or no longer needed, either because there is no evidence-based indication, the indication has expired, or the dose is unnecessarily high;
- one or more medicines fail to achieve the therapeutic

objectives they are intended to achieve;
- a medicine or the combination of several medicines puts the client at a high risk of adverse drug reactions; or
- the client is not willing or able to take one or more medicines as intended.

High-Risk Medications

Some medications can result in potential harm to the older adult. These include:

- warfarin,
- oral antiplatelets,
- insulin and oral hypoglycemics,
- opioids, and
- digoxin.

These medications have a higher risk of harm due to their narrow therapeutic index, risk of sedation and fall risk, patient characteristics, and monitoring requirements (Institute for Safe Medication Practices Canada [ISMP Canada], n.d.). Other drugs with increased risk are those with anti-cholinergic properties. Older adults experience more cumulative effects with these drugs; for example, they can experience impaired balance, dizziness, blurred vision, or cognitive impairment.

Drug-drug interactions pose a significant risk for adverse drug events. For example:

- **Warfarin taken with NSAIDs:** Risk of upper GI hemorrhage.
- **Calcium channel blockers (verapamil, amlodipine) taken with macrolide antibiotics (erythromycin):** Risk of hypotension (CYP3A4 inhibited by macrolides and calcium channel blockers are metabolized by CYP 3A4, leading to increased effects).

(ISMP Canada, n.d.)

Drug-disease interactions also increase susceptibility for older adults. For example:

- **Antihistamine medications prescribed to clients with dementia:** The anticholinergic properties of antihistamines can lead to increased confusion, exacerbated confusion, or memory issues. (ISMP Canada, n.d.)

Prescribing Cascades

A prescribing cascade occurs when a client experiences a new symptom that is actually a side effect of one of their medications. They are then prescribed a new medication to treat the new symptom, leading to a cascade of prescriptions. This can continue as more medications are prescribed to treat the side effects of the new medications. It may seem implausible, but refer to the example below.

Example in Practice:

A 70-year-old client has chronic pain from a back injury:

- They have been taking NSAIDs, specifically ibuprofen, on a regular basis for a long time.
- They develop hypertension from the ibuprofen, which is then treated with the calcium channel blocker amlodipine.
- Amlodipine can cause peripheral edema, so they are prescribed the thiazide diuretic hydrochlorothiazide (HCTZ).
- HCTZ can cause dizziness, so they receive a prescription for prochlorperazine.

Figure 3.10a Prescribing Cascades Explained (Sheila Odubote/ TRU Open Press)

From the above example, it is easy to see how side effects can easily be treated as a new health condition but then lead to the client taking more medications and experiencing more negative effects.

It is not just older adults who are more at risk; those using multiple medicines, women, and people using 'high-risk medicines' (including cardiovascular drugs, NSAIDs, anticoagulants, and antibiotics) also have a higher risk of adverse drug reactions (Kalisch et al., 2011).

To minimize problematic polypharmacy in nursing:

- obtain a comprehensive health history,

- complete a medication reconciliation,
- check for medication adherence,
- identify any symptoms, including onset and duration,
- identify the client's concerns, preferences, and goals regarding medication treatment,
- collaborate with the prescriber and other healthcare providers to share findings and perspectives on deprescribing any medications,
- consider non-pharmacological interventions to facilitate deprescribing or when a new symptom arises, and
- if a medication is deprescribed, monitor the client for improvements, worsening symptoms, and overall management. Ensure the client and their caregivers have the needed education on recognizing any symptoms early and provide additional health teaching.

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- Figure 3.10a Prescribing Cascade. (Sheila Odubote/ TRU Open Press)

3.11 Medication Safety in Transitions of Care

A third area of the World Health Organization's (WHO, 2019a) *Medications Without Harm* initiative relates to medication safety during transitions of care. View the interactive activity below to see how medications are reconciled during transitions of care from admission to discharge in a hospital setting.

> *An interactive H5P element has been excluded from this version of the text. You can view it online here:*
> *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=1852#h5p-8*

Medication errors can occur during these changes in settings. **Figure 3.11a** is from the WHO and shows ranges of the percentage of errors that occur during common transitions of care (WHO, 2019b).

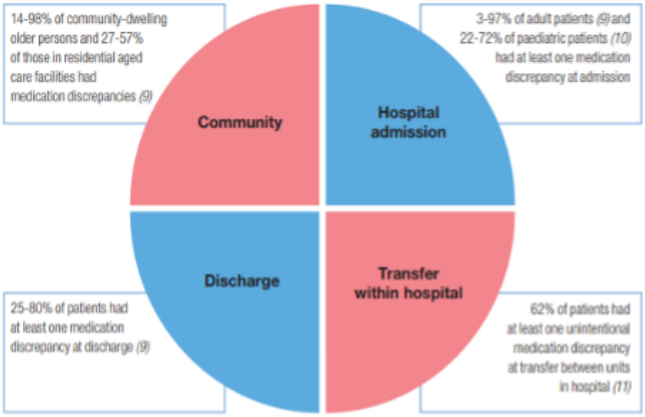

Figure 3.11a *Medication discrepancies at various transitions of care. (World Health Organization)* CC BY-NC-SA 3.0 IGO *[Long Description]*

Some suggested strategies for improving medication safety include:

- Implementing formal structured processes for medication reconciliation at all transition points of care. Steps of effective medication reconciliation include: building the best possible medication history by interviewing the client and verifying with at least one reliable information source; reconciling and updating the medication list; and communicating with the client and future healthcare providers about changes in their medications.
- Partner with clients, families, caregivers, and healthcare professionals to agree on treatment plans, ensuring clients are equipped to manage their medications safely and have an up-to-date medication list.
- Where necessary, prioritize clients at high risk of medication-related harm and provide enhanced support, such as post-discharge contact by a nurse. (WHO, 2019)

Medication Reconciliation Process

Medication reconciliation is a formal process for creating the most complete and accurate list possible of a patient's current medications and comparing the list to those in the patient record or medication orders (Institute for Safe Medication Practices Canada [ISMP Canada], 2012). It is a systematic process to obtain a comprehensive list of medications to avoid medication errors due to omissions, duplications, dosing errors, or drug interactions.

The medication reconciliation process is widely adopted across Canada in most health care facilities. This is in response to the frequency of medication errors across all healthcare settings. Nurses are very often the healthcare provider completing the 'Best Possible Medication History' (BPMH), which is the first step in the medication reconciliation process. Refer to the policy and procedure on the medication reconciliation (MedRec) process in your own facility.

Completing MedRec in primary care involves four main activities:

1. Collect and document an accurate and up-to-date medication list (the BPMH)
2. Compare the BPMH with information in the patient's medical records and identify any discrepancies (i.e., differences between various sources of medication information)
3. Correct the discrepancies as appropriate through discussion with the primary care provider and the patient; then, update the BPMH with the resolved discrepancies, thereby creating a reconciled list.
4. Communicate the resulting medication changes to the patient and verify the patient's understanding of their medication regimen. (ISMP Canada, 2012)

Medication Reconciliation

Who completes a med rec? Any practitioners, nurses, pharmacists, and allied health professionals, along with the client, families, and other care providers.

What medications are included? All prescription medications, herbals, vitamins, nutritional supplements, over-the-counter drugs, vaccines, diagnostic and contrast agents, radioactive medications, parenteral nutrition, blood derivatives, and intravenous solutions (hereafter referred to collectively as medications)

When is it completed? It is completed at the onset of care and with every transition of care, such as a change in setting, practitioner, or service. For example, a client has been in a long-term care facility and is transferred to an acute care hospital for ongoing care, and then eventually transferred back to long-term care. A MedRec would be done for each transition.

The client, family, or caregiver should be actively involved with the medication reconciliation process. To help ensure safe medication use for clients at home, ISMP is encouraging clients and their families to ask five questions about their medications when they see their health care provider.

- Why do I need this medicine? (have any medications been added, stopped or changed?)
- When do I take it?

- How long do I take it?
- How could it make me feel?
- When do I see my health team again?

For more information on resources for clients, go to the ISMP Canada website: https://www.ismp-canada.org/medrec/

Clinical Reasoning and Decision Making

A nurse is performing medication reconciliation for an elderly client admitted from home. The client does not have a medication list and cannot report the names, dosages, and frequencies of the medication they take at home.

What other sources can the nurse use to obtain medication information?

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

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World Health Organization. (2019b). *Medication safety in transitions of care*. https://www.who.int/publications/i/item/WHO-UHC-SDS-2019.9

Media Attributions

- **Figure 3.11a** Figure 5. Medication discrepancies at various transitions of care and frequency of medication-related harm from *Medication Safety in Transitions of Care* by the World Health Organization is used under a CC BY-NC-SA 3.0 IGO license.
- Figure 3.11b

Long Descriptions

Figure 3.11a Long Description: This is is a circle divided into 4 quadrants to depict 4 areas where medication discrepancy can occur:

- **Community:** 14–98% of community-dwelling older persons and 27–57% of those in residential aged care facilities had medication discrepancies.
- **Hospital admission:** 3–97% of adult patients and 22–72% of paediatric patients had at least one medication discrepancy at admission.
- **Discharge:** 25–80% of patients had at least one medication discrepancy at discharge.
- **Transfer within hospital:** 62% of patients had at least one unintentional medication discrepancy at transfer between units in hospital.

[Return to Figure 3.11.1]

3.12 Strategies Towards Medication Safety in Older Adults

Since many adverse drug events are avoidable, a few tools have been developed to assist healthcare providers in identifying medications of concern. Some tools include STOPP/START, Appropriate Medication Index, and the ones we will focus on in this unit, Beer's Criteria and Deprescribing for Safer Care.

Beers Criteria for Potentially Inappropriate Medication Use in Older Adults

To help mitigate the risk for older adults, the American Geriatric Society publishes the "Beers Criteria" (or "Beers List"), which represents a consensus list of potentially inappropriate medications that all healthcare providers can refer to. The Beers List was originally developed by Dr. Mark Beers and an American panel of experts in 1991. It was recently updated and is used to improve the safety of prescribing and use of drugs in older adults.

There are close to 100 medications or medication classes on the Beers Criteria list. The criteria to list potentially inappropriate medications for adults over 65 are ones that can put the client at risk such as drugs that have higher risk of adverse drug interactions, harmful side effects that outweigh the benefits and meds to use short term due to impaired kidney function. Some medication classes include anti-cholinergic medications, proton pump inhibitors, and benzodiazepines.

The Beers List is a tool that helps prescribers consider other

medication options or dosing to minimize the client's risk. It is designed to highlight *potentially inappropriate* medications; these medications are not absolutely unacceptable in all cases or for all people.

Beers Criteria can be accessed in most drug guides, or you can access it from the Guideline Central website at Beers Criteria for Potentially Inappropriate Medication Use in Older Adults (American Geriatrics Society, 2025).

To learn more about the Beers Criteria, refer to the Institute for Safe Medications Canada's (n.d.) Safer Medication Use in Older Persons Information Page.

Deprescribing for Safer Care

Deprescribing involves reducing or stopping medications that are causing more harm than good or are no longer needed. It is an important approach to managing polypharmacy and is not just for prescribers but also all healthcare providers (Canadian Medication Appropriateness and Deprescribing Network [CADeN], n.d.). It is also a client-centered, planned, and supervised process of drug reduction or stopping of a medication that may be causing harm or no longer providing benefit (Farrell et al., 2023).

The overall aim of deprescribing is to:

- improve quality of life;
- avoid the worsening of disease or causing withdrawal effects;
- reduce pill burden; and
- improve control of chronic conditions.

Is this medication the best choice for this client at this time? Clients are started on medications and over time, even years, they are still on that same medication. As a client gets older or has other health issues arise, that medication might not be the best

choice anymore. To best manage chronic health conditions and avoid adverse effects, the goal of deprescribing is to minimize medication burden and improve quality of life.

Can the prescriber just stop medications or switch the client to a different medication? Sometimes this is possible, but with some medications, abruptly stopping it will produce withdrawal effects or worsen the client's condition. Deprescribing is the best option and is a planned and supervised process of dose reduction. It sometimes involves stopping a medication if it is causing harm or is not beneficial. Deprescribing is client-centred and often involves a collaborative approach between the client and their healthcare providers.

The Canadian Medication Appropriateness and Deprescribing Network (CADeN) has developed algorithms and guidelines to provide support to practitioners. For example, the Proton Pump Inhibitor Deprescribing Guidelines includes a detailed algorithm and patient information sheets. To view this deprescribing algorithm along with other algorithms and guidelines, go to deprescribing.org's (n.d.a) Deprescribing Guidelines and Algorithms page.

Other medications that have deprescribing guidelines include benzodiazepines, anti-hyperglycemics, and antipsychotics.

Deprescribing involves all healthcare providers. To understand the client's medication experience, the expertise and knowledge of all healthcare providers involved with the client is invaluable. For example, physiotherapists can offer non-pharmacological strategies in managing pain or be alert to adverse reactions from prescribed medications.

What is the nurse's role in deprescribing? Registered nurses do not prescribe medications, but they do have an important role in deprescribing. When a client is actively involved in the deprescribing process, client education, ongoing assessments, and monitoring are some important roles for nurses. Take a look at some of the deprescribing algorithms or guidelines and consider how nurses have an active role in the process. To view these

deprescribing algorithms and guidelines, go to deprescribing.org's (n.d.a) Deprescribing Guidelines and Algorithms page.

Deprescribing Competencies

As part of a larger deprescribing initiative, the CADeN has identified the following framework (**Figure 3.12.1**) that all entry-to practice physicians, pharmacists and nurses should perform successfully. The seven competencies are to be applied in collaboration with the client and their family members.

Figure 3.12a Deprescribing Competencies

Retrieved from Deprescribing Network at Educational framework

for deprescribing — Do I still need this medication? Is deprescribing for you?

Look at each competency and consider how nurses' involvement in each is invaluable. As part of nurse's role in safe medication administration, and the nursing process overall, consider how adding a deprescribing lens to medication administration can be easily included.

Learning Activity

Deprescribing in Ontario Long-Term Care

Go to the Deprescribing in Ontario Long-Term Care page on deprescribing.org (n.d.b).

On the page, watch the case scenario for Agatha Smith. (The video is also available on YouTube.)

Observe how the family members' concerns are addressed. Although the family member is speaking with a physician, the nurse is very often one of the first healthcare provider families will speak to about concerns.

Healthcare providers' role to minimize the risk:

- Assess clients for new onset of symptoms that could be an adverse reaction, especially if they started on a new medication therapy. Most ADRs occur within the first four months of prescribing a new medication, so it is important to do follow-up appointments and specifically ask about any new symptoms, including onset and duration of effects.
- Provide health teaching to clients so they are aware of potential effects from their medications. Provide clear

information and use take-home pamphlets or other resources.
- Recognize that lower doses are often prescribed for older, frail clients. Inquire about orders that may be a regular or larger dose.
- When drug reactions occur, non-drug treatment strategies are likely the most appropriate first-line management, rather than starting a second medicine to counteract adverse effects.

To learn more about deprescribing, go to deprescribing.org's (n.d.c) Resources for Patients and Healthcare Providers page.

Putting It All Together

This unit focused on the many variables that can impact medication safety, including barriers and strategies to improve safety. Nurses have an important role in ensuring that clients have the least amount of risk with their medications. It starts with a thorough medication history and a patient-centered medication review. A holistic approach will help identify any barriers or supports, such as literacy levels and cultural or social factors. Nurses also need to consider medication safety across lifespans as some medications can put some clients more at risk, which will require strategies to overcome that risk. Lastly, there are many strategies and tools already developed to assist nurses and healthcare teams. It begins with an awareness of the strategies, good collaboration between healthcare team members, and a commitment to incorporate those strategies into our practices.

BC Patient Safety and Quality Council

The BC Patient Safety and Quality Council (BCPSQC) was the basis

for many references in this chapter; it also has several other resources that may be beneficial to your learning about client safety related to medication administration.

The council provides system-wide leadership for efforts designed to improve the quality of healthcare in British Columbia. Through collaborative partnerships with health authorities, clients, and those working within the healthcare system, BCPSQC promotes and informs a provincially coordinated, client-centred approach to client safety and quality. The council also provides numerous resources for healthcare professionals to help build competence in safety and quality.

To view and register for upcoming learning programs related to client safety and quality, visit the BCPSQC website.

Acknowledgements

This chapter is adapted from information provided by the Canadian Medication Appropriateness and Deprescribing Network's Healthcare Providers Committee and Education Committee.

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Figure 3.12a Deprescribing Competencies. Retrieved from Deprescribing Network at Educational framework for deprescribing — Do I still need this medication? Is deprescribing for you?

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- Healthcare.gov. (2011, May 25). Introducing the Partnerships for Patients with Sorrel King [Video]. YouTube. https://youtu.be/ak_5X66V5Ms ↵

Long Descriptions

Figure 3.12.1 Long Description: This is a circle divided into 4 quadrants to depict 4 areas where medication discrepancy can occur:

1. Community: 14-98% of community-dwelling older person and 27-57% of those in residential aged care facilities had medication discrepancies.
2. Hospital admission: 3-97% of adult patients and 22-72% of pediatric patients had at least one medication discrepancy at admission.
3. Discharge: 25-80% of patients had at least one medication discrepancy at discharge.
4. Transfer within hospital: 62% of patients had at least one unintentional medication discrepancy at transfer between units in hospital. [Return to Fig 3.12.1]

3.13 Clinical Reasoning and Decision-Making Learning Activities

Clinical Reasoning and Decision Making Learning Activity

Case Study Scenario

A nurse is preparing a home visit with a 75-year-old client, Agnes. She lives with her adult grandson in a home she has owned for 30 years. The visit is to assess the client's ability to manage their own care, including medications.

a.The nurse considers how the social determinants of health can impact medication safety. For the following factors, outline the impact of each on this client: health literacy, cultural factors, support systems, economic stability.

b. The nurse reviews the medications that the client takes, and sees that she is on over 10 medications. What are factors should the nurse consider and what actions should the nurse take?

The answers are located in Chapter 3 of the answer key. Click on the answer key link.

Note: Answers to the Clinical Reasoning activities can be found in the "Answer Key" sections at the end of the book.

Complete the following interactive activities:

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=1769#h5p-67

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CHAPTER 4: AUTONOMIC NERVOUS SYSTEM

4.0 Autonomic Nervous System Regulation Introduction

Learning Objectives

1. Understand the function of the autonomic nervous system including the different receptors and their functions.
2. Identify the classifications and actions of autonomic nervous system drugs
3. Give examples of when, how, and to whom autonomic nervous system drugs may be administered
4. Identify the side effects and special considerations associated with autonomic nervous system drugs
5. Include considerations and implications of using autonomic nervous system drugs across the lifespan
6. Include evidence-based concepts when using the nursing process and clinical reasoning related to medications that affect the autonomic nervous system

Key Terms

- **acetylcholine (ACh)**
- **adrenergic**
- **adrenergic agonists**
- **adrenergic antagonists**
- **anticholinergics**
- **autonomic nervous system**
- **catecholamines**
- **central nervous system**
- **cholinergic**
- **chronotropic**
- **fight or flight response**
- **gluconeogenesis**
- **hemostasis**
- **hyperglycemia**
- **inotropic**
- **involuntary responses**
- **motor neurons**
- **muscarinic agonists**
- **neurons**
- **nonselective beta blockers**
- **parasympathomimetics**
- **peripheral nervous system**
- **postganglionic neurons**
- **preganglionic neurons**
- **selective beta blockers**
- **sensory neurons**
- **"SLUDGE"**
- **somatic nervous system**
- **sympathetic division**
- **sympathomimetics**

Have you ever wondered what causes your heart to beat or what causes your lungs to breathe? These are examples of **involuntary responses** the brain controls without the need for conscious thought. The autonomic nervous system (ANS) works using a balance of the sympathetic and parasympathetic nervous systems that regulate the body's involuntary functions, including heart rate, respiratory rate, digestion, and sweating. Many medications are used to control various cardiovascular, respiratory, and gastrointestinal conditions by acting on ANS receptors. Beta-blockers and anticholinergic medications are commonly prescribed medications in this category.

4.1 Autonomic Nervous System Regulation Concepts

This section will review key anatomy concepts in the autonomic nervous system (ANS) related to the mechanism of action of medications. For more detailed information regarding the concepts reviewed, use the links provided to review detailed autonomic nervous system content in the Open Stax *Anatomy and Physiology book*:[1]

- Review the basic structure and function of the nervous system.
- Review the anatomy of sensory perception.
- Review the anatomy of motor responses.
- Review the divisions of the autonomic nervous system.
- Review autonomic reflexes and homeostasis.
- Review information on a few drugs that affect the autonomic nervous system.

1. Content can be found at https://openstax.org/books/anatomy-and-physiology/pages/12-1-basic-structure-and-function-of-the-nervous-system

Components and Functions of the Nervous System

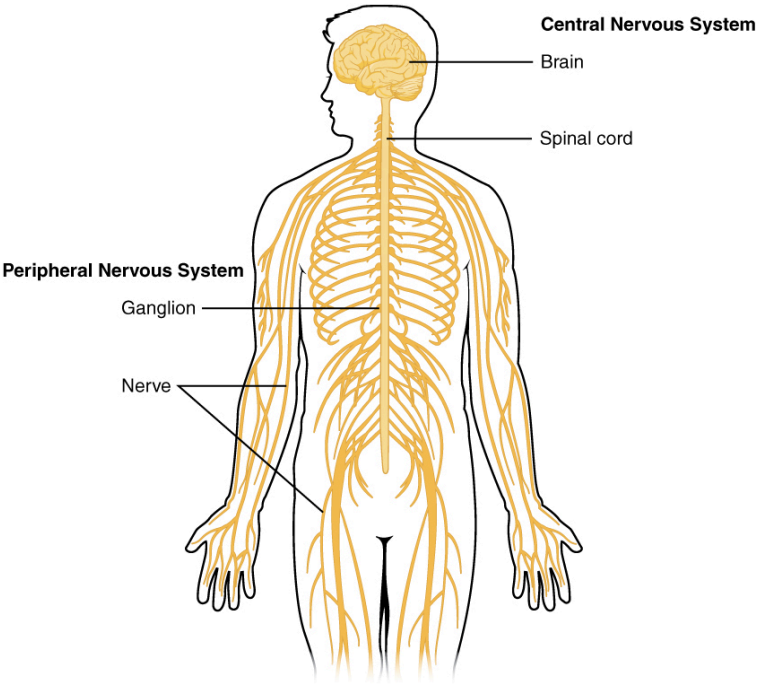

Figure 4.2a Central and Peripheral Nervous System (OpenStax, 2023) CC BY 4.0

The nervous system has two major components: the central nervous system (CNS) and the peripheral nervous system. See Figure 4.2a.[2]

2. "1201 Overview of Nervous System.jpg" by CNX OpenStax. is licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/12-1-basic-structure-and-function-of-the-nervous-system

The **central nervous system (CNS)** is composed of the brain and the spinal cord. The **peripheral nervous system** includes nerves outside the brain and spinal cord and consists of sensory neurons and motor neurons. **Sensory neurons** sense the environment and conduct signals to the brain that become a conscious perception of that stimulus. This conscious perception may lead to a motor response that is conducted from the brain to the peripheral nervous system via motor neurons to cause a movement. **Motor neurons** consist of the **somatic nervous system** that stimulates voluntary movement of muscles and the **autonomic nervous system**[3] that controls involuntary responses. This chapter will focus on the autonomic nervous system.

The two divisions[4] of the autonomic nervous system are the **sympathetic division (SNS)** and the **parasympathetic division (PNS)**. The SNS contains alpha and beta receptors, and the PNS contains nicotinic and muscarinic receptors. Each type of receptor has a specific action when stimulated (see Figure 4.2b for an image of the divisions of the nervous system and the receptors in the ANS).

3. "Component of the Nervous System" by Blaire Babbit at Chippewa Valley Technical College is licensed under CC BY 4.0
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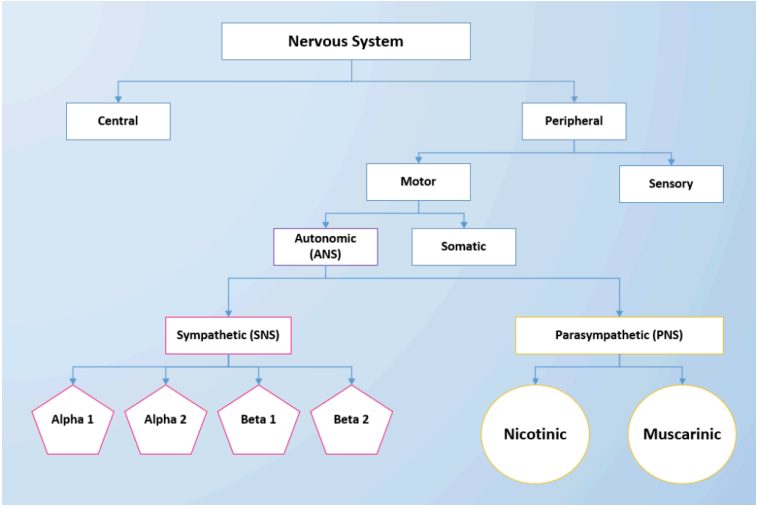

Figure 4.2b Components of the Nervous System and ANS receptors (Chippewa Valley Technical College, 2023) CC BY 4.0

SNS and PNS Functions and Homeostasis

The sympathetic system is associated with the **"fight-or-flight"** response, and parasympathetic activity is often referred to as "rest and digest." See Figure 4.2c[5] to compare the effects on PNS and SNS stimulation on target organs. The autonomic nervous system regulates many of the internal organs through a balance of these two divisions and is instrumental in homeostatic mechanisms in the body.[6]

5. Untitled image by Meredith Pomietlo for Chippewa Valley Technical College is licensed under CC BY 4.0
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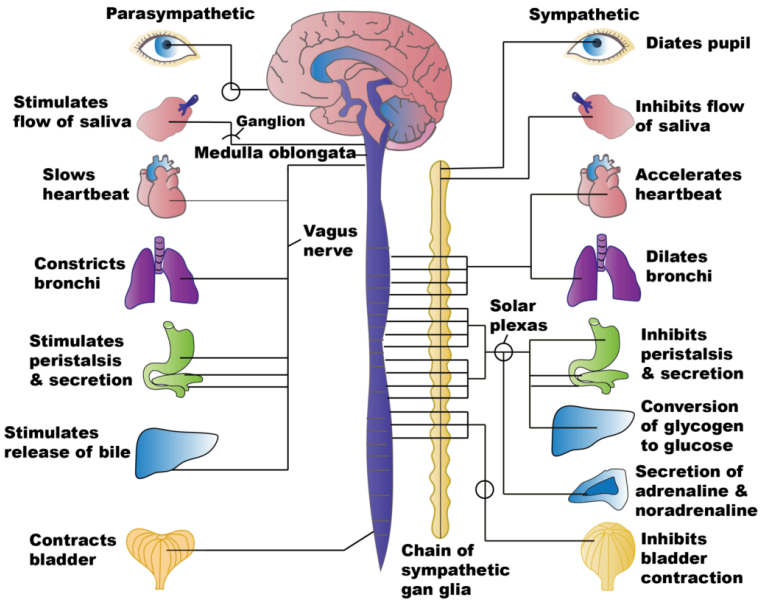

Figure 4.2c Effects of PNS and SNS Stimulation on Target Organs (Chippewa Valley Technical College/BCcampus, 2023) CC BY 4.0

Stimulation of SNS primarily produces increased heart rate, increased blood pressure via the constriction of blood vessels, and bronchial dilation. In comparison, stimulation of the PNS causes slowing of the heart, lowering of blood pressure due to vasodilation, bronchial constriction, and focuses on stimulating intestinal motility, salivation, and relaxation of the bladder.

Homeostasis is the balance between the two systems. At each target organ, dual innervation determines activity. For example, the heart receives connections from both the sympathetic and

https://openstax.org/books/anatomy-and-physiology/pages/1-introduction

parasympathetic divisions. SNS stimulation causes the heart rate to increase, whereas PNS stimulation causes the heart rate to decrease.

To respond to a threat – to "fight or flight" – the sympathetic system stimulates many different target organs to achieve this purpose. For example, if a person sees a grizzly bear in the wilderness, the individual has the choice to stand and fight the bear or to run away. For either choice, several things must occur for additional oxygen and glucose to be delivered to skeletal muscle to fight or run. The respiratory, cardiovascular, and musculoskeletal systems are all activated to breathe rapidly, cause bronchodilation in the lungs to inhale more oxygen, stimulate the heart to pump more blood, and increase blood pressure to deliver it to the muscles.[7] The liver creates more glucose for energy for the muscles to use. The pupils dilate to see the threat (or the escape route) more clearly. Sweating prevents the body from overheating from excess muscle contraction. Since the digestive system is not needed during this time of threat, the body shunts oxygen-rich blood to the skeletal muscles. To coordinate all these targeted responses, catecholamines such as epinephrine and norepinephrine are released in the sympathetic system and disperse to the many neuroreceptors on the target organs simultaneously.[8]

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Chemical Signaling in the Autonomic Nervous System

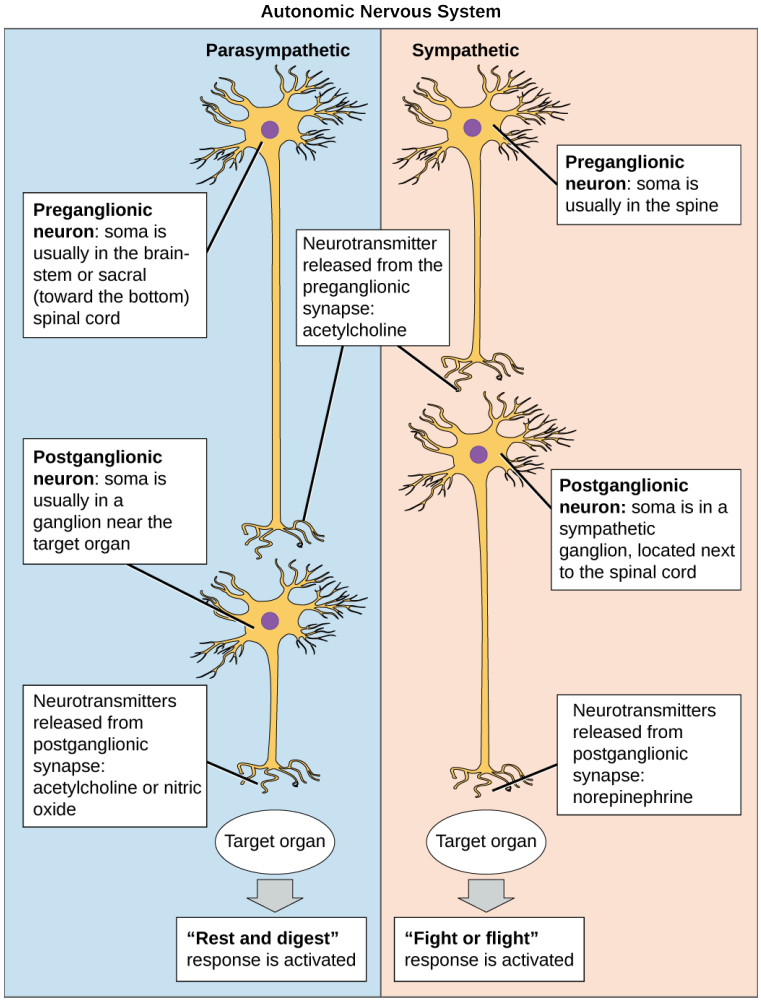

Figure 4.2d Autonomic System neurons conduct signals via the preganglionic neurons to postganglionic neurons to the target organs (Molnar & Gair, 2015/ BCcampus) CC BY 4.0

Neurons conduct impulses to the synapse of a target organ. The **synapse** is a connection between the neuron and its target cell. See Figures 4.2e[9] and 4.5[10] for images of synapse connections.

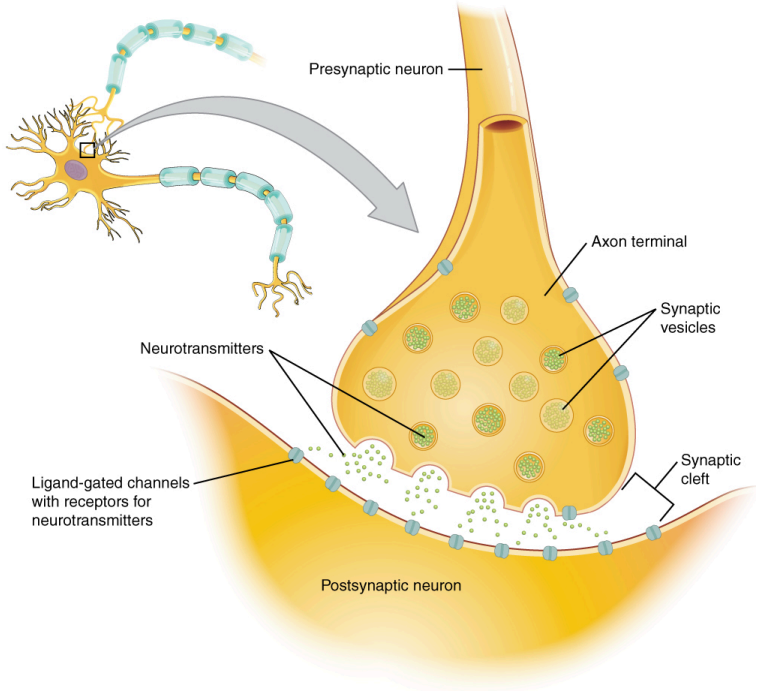

Figure 4.2e The synapse is the connection between a neuron and its target cell where neurotransmitters are released (Chippewa Valley Technical College/ BCcampus, 2023) CC BY 4.0

9. "Autonomic Nervous System" by CNX OpenStax is licensed under CC BY 4.0
10. "The Synapse" by CNX OpenStax is licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/12-5-communication-between-neurons

Preganglionic Neurons

The synapse is composed of a preganglionic (presynaptic) neuron and a postganglionic (postsynaptic) neuron. **Preganglionic neurons** release **acetylcholine (ACh)** onto nicotinic receptors on the postganglionic neuron. Nicotine, found in tobacco products, also binds to and activates nicotinic receptors, mimicking the effects of ACh. This is worth noting, because if medications were developed to impact the nicotinic receptors, then it would impact both the SNS and PNS systems at the preganglionic level. Instead, most medications target the **postganglionic neurons**, because each type of postganglionic neuron has different neurotransmitters and different target receptors.

Postganglionic Neurons

There are different types of postganglionic neurons in the SNS and PNS branches of the autonomic nervous system. Postganglionic neurons of the PNS branch are classified as **cholinergic,** meaning that acetylcholine (ACh) is released, whereas postganglionic neurons of the SNS are classifed as **adrenergic**, meaning that norepinephrine (NE) is released. The terms cholinergic and adrenergic refer not only to the signal that is released, but also to the class of neuroreceptors that each binds. (See Figure 4.2f for an image of the release of ACh and NE and their attachment to the corresponding adrenergic or nicotinic receptors.)

The cholinergic system of the PNS includes two classes of postganglionic neuroreceptors: the nicotinic receptor and the muscarinic receptor. Both receptor types bind to ACh and cause changes in the target cell. The situation is similar to locks and keys. Imagine two locks—one for a classroom and the other for an office—opened by two separate keys. The classroom key will not

open the office door, and the office key will not open the classroom door. This is similar to the specificity of nicotine and muscarine for their receptors. However, a master key can open multiple locks, such as a master key for the biology department that opens both the classroom and the office doors. This is similar to ACh that binds to both types of receptors.

The adrenergic system of the SNS has two major types of neuroreceptors: the alpha (α)-adrenergic receptor and beta (β)-adrenergic receptor. There are two types of α-adrenergic receptors, termed α1 and α2, and there are two types of β-adrenergic receptors, termed β1 and β2. An additional aspect of the adrenergic system is that there is a second neurotransmitter in addition to norepinephrine. The second neurotransmitter is called epinephrine. The chemical difference between norepinephrine and epinephrine is the addition of a methyl group (CH_3) in epinephrine. The prefix "nor-" actually refers to this chemical difference in which a methyl group is missing. [11]

The term adrenergic should remind you of the word adrenaline, which is associated with the fight-or-flight response described earlier. Adrenaline and epinephrine are two names for the same molecule. The adrenal gland (in Latin, ad- = "on top of"; renal = "kidney") secretes adrenaline. The ending "-ine" refers to the chemical being derived, or extracted, from the adrenal gland.[12]

11. "Sympathetic and Parasympathetic Pre-and Postganglionic fibers and neuroreceptors" by Dominic Slausen at Chippewa Valley Technical College is licensed under CC BY 4.0
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Interactive Activity

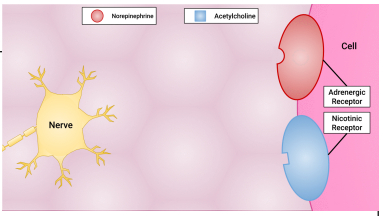

Figure 4.2f Sympathetic and Parasympathetic Pre-and Postganglionic Fibers and Neuroreceptors (Chippewa Valley Technical College/BCcampus, 2023) CC BY 4.0

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ANS Neuroreceptors and Effects

The effects of stimulating each type of neuroreceptor are outlined in this section and sample uses of medications are provided.

Sympathetic Nervous System

SNS receptors include Alpha-1, Alpha-2, Beta-1, and Beta-2 receptors. Epinephrine and norepinephrine stimulate these

receptors, causing the overall fight-or-flight response in various target organs. Medications causing similar effects are called **adrenergic agonists**, or **sympathomimetics**, because they mimic the effects of the body's natural SNS stimulation. On the other hand, **adrenergic antagonists** block the effects of the SNS receptors. Dopamine also stimulates these receptors, but it is dosage-based. Dopamine causes vasodilation of arteries in the kidney, heart, and brain, depending on the dosage. See Table 4.2 for a comparison of stimulation and inhibition of these SNS receptors.

Receptor	Effects of Stimulation	Effects of Inhibition
Alpha-1	• Contract smooth muscle • CNS stimulation • Blood vessels: vasoconstriction to nonessential organs • GI: relax smooth muscle and decrease motility • Liver: glyconeogenesis • Bladder: contraction • Uterus: contraction • Pupils: dilation • Medication example: Pseudoephedrine to treat nasal congestion by vasoconstriction	• Relax smooth muscle • Vasodilation • Bladder: increase urine flow • Medication example: Tamsulosin to improve urine flow
Alpha-2	• Primarily inhibits norepinephrine release, reducing sympathetic flow • Medication Example: Clonidine to treat hypertension	• Not used clinically

Beta-1	• Primarily stimulates heart with increased heart rate and contractility • Also causes kidneys to release renin • Medication example: Dobutamine to treat acute heart failure, to increase cardiac output	• "Selective beta-blocker" used to decrease heart rate and blood pressure • Medication example: Metoprolol to decrease heart rate and blood pressure
Beta-2	• Primarily relax smooth muscle • Blood vessels: vasodilation • Lungs: bronchodilation • GI: decreased motility • Liver: gluconeogenesis • Uterus: relaxation • Medication example: Albuterol for bronchodilation	• "Nonselective beta-blockers" block Beta-1 and Beta-2 receptors so also cause bronchoconstriction • Medication example: Propranolol blocks Beta-1 and Beta-2 receptors so lowers blood pressure but inadvertently causes bronchoconstriction

Interactive Activities

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An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=120#h5p-49*

Adrenergic Agonists

Adrenergic agonists stimulate Alpha-1, Alpha-2, Beta-1, or Beta-2 receptors. Stimulation of each type of receptor has different effects and are further explained below.

Alpha-1 receptor agonists: Stimulation of Alpha-1 receptors

causes vasoconstriction in the periphery, which increases blood pressure. Vasoconstriction also occurs in mucus membranes, which decreases swelling and secretions for patients experiencing upper respiratory infections. Examples of Alpha-1 agonist medications are pseudoephedrine or phenylephrine, used to treat nasal congestion.

Alpha-2 receptor agonists: Stimulation of Alpha-2 receptors reduces CNS stimulation and is primarily used as an antihypertensive or a sedative. An example of an Alpha-2 agonist medication is clonidine, which is used to treat hypertension and is also used to treat attention deficit hyperactivity disorder.

Beta-1 receptor agonists: Stimulation of Beta-1 receptors primarily affects the heart by increasing heart rate and contractility. It also causes the kidneys to release renin. Effects on the heart are described as having a positive **chronotropic** (increases heart rate), positive **inotropic** (increases force of contraction), and positive **dromotropic** (increases speed of conduction between SA and AV node) properties. Medications that stimulate Beta-1 receptors are primarily used during cardiac arrest, acute heart failure, or shock. An example of a Beta-1 receptor agonist medication is dobutamine, which is used to increase cardiac output in someone experiencing acute heart failure or shock. See Figure 4.2g[13] illustrating dromotropic properties of stimulating Beta-1 receptors.

13. "2018 Conduction System of Heart.jpg" by OpenStax College is licensed under CC BY 3.0

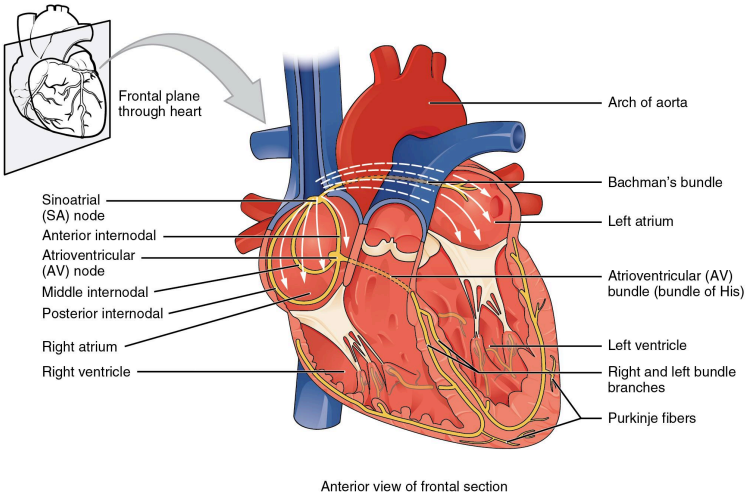

Figure 4.2g Dromotropic Properties Affect the Speed of Conduction Between SA and AV Nodes (OpenStax, 2013) CC BY 4.0

Beta-2 receptor agonists: Stimulation of Beta-2 receptors causes relaxation in smooth muscle in the lungs, GI, uterus, and liver. Medications that stimulate Beta-2 receptors are primarily used to promote bronchodilation, which opens the airway, and are often used to treat patients with asthma or chronic obstructive pulmonary disease (COPD). An example of a Beta-2 receptor agonist medication used in asthma is salbutamol. See Figure 4.2h[14] for an illustration of the effects of stimulating Beta-2 receptors in the lungs.

Side effects of Beta-2 receptor agonists are related to stimulation of Beta-2 receptors in other locations in the body. For example, salbutamol can cause tachycardia by stimulating Beta-2 receptors in the heart. Stimulation of Beta-2 receptors can also inadvertently

14. "Bronchodilators" by BruceBlaus is licensed under CC BY 4.0

cause **hyperglycemia** in patients with diabetes because of activation of Beta-2 receptors in the liver, causing **glyconeogenesis**.

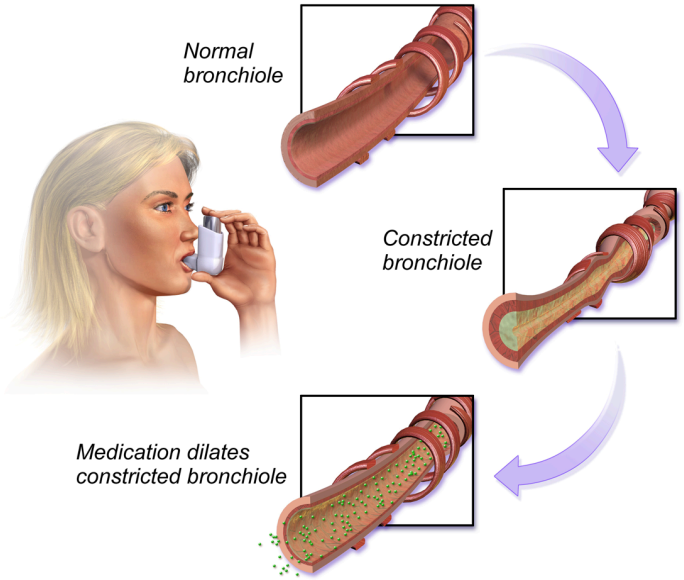

Figure 4.2h Effects of Medications Stimulating Beta 2 Receptors in the Lungs (BruceBlaus/*Wikimedia Commons*) CC BY-SA 4.0

Adrenergic Antagonists

Adrenergic antagonist medications inhibit the Alpha-1, Alpha-2, Beta-1, and Beta-2 receptors. The effects of inhibition of each receptor are explained further below.

Alpha-1 antagonists: Alpha-1 antagonists are primarily used to relax smooth muscle in the bladder and cause vasodilation.

Examples include:

- Tamsulosin is used to decrease resistance of an enlarged prostate gland and improve urine flow.

- Prazosin is used to cause vasodilation and decrease blood pressure in patients with hypertension.

Alpha-2 antagonists: This classification is used in research, but has limited clinical application.

Beta Antagonists: There are two types of beta antagonists: **selective beta blockers**, which inhibit Beta-1 receptors and affect the heart only, and **nonselective beta blockers,** that block both Beta-1 and Beta-2 receptors, thus affecting both the heart and lungs. Beta-blockers are also referred to as having negative chronotropic (decreased heart rate), negative inotropic (decreased force of contraction), and negative dromotropic (decreased speed of conduction between SA and AV nodes) properties. It is also important for a nurse to remember that beta-blockers can mask the usual hypoglycemic symptoms of tremor, tachycardia, and nervousness in patients with diabetes.

Beta-1 antagonists: Beta-1 antagonists primarily block receptors in the heart, causing decreased heart rate and decreased blood pressure. An example is metoprolol, a selective beta-blocker used to treat high blood pressure, chest pain due to poor blood flow to the heart, and several conditions involving an abnormally fast heart rate.

Beta-2 antagonists: Nonselective beta-blockers block Beta-1 receptors and Beta-2 receptors in the lungs. An example is propranolol, which is used to lower blood pressure by decreasing the heart rate and cardiac output. However, it can also cause bronchoconstriction by inadvertently blocking Beta-2 receptors, so it must be used cautiously in patients with asthma or COPD.

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=120#h5p-89*

Parasympathetic Nervous System

Acetylcholine (ACh) stimulates nicotinic and muscarinic receptors. Drugs that stimulate nicotinic and muscarinic receptors are called cholinergics. Medications are primarily designed to stimulate muscarinic receptors located mostly at target organs. Nicotinic receptors are primarily located at ganglia and neuromuscular junctions. Nicotine stimulates pre- and post-ganglionic nicotinic receptors, causing muscle relaxation and other CNS effects. An example of a medication designed to stimulate nicotinic receptors is the nicotine patch, used to assist with smoking cessation.

Muscarinic agonists are also called **parasympathomimetics** and primarily cause smooth muscle contraction, resulting in decreased heart rate, bronchoconstriction, increased gastrointestinal/genitourinary tone, and pupillary constriction. There are two types of muscarinic agonists: direct-acting and indirect-acting. Direct-acting agonists bind to the muscarinic receptor. Indirect-acting muscarinic agonists work by preventing the breakdown of ACh, thus increasing the amount of acetylcholine available to bind receptors.

Examples of direct-acting muscarinic agonist medications include:

- Pilocarpine: Used to treat glaucoma by causing the ciliary muscle to contract and allow for the drainage of aqueous humor
- Bethanechol: Used for urinary retention by stimulating the bladder causing urine output

Examples of indirect-acting muscarinic agonist medications include:

- Pyridostigmine: Used to reverse muscle weakness in patients with myasthenia gravis
- Physostigmine: Used to treat organophosphate insecticide poisoning
- Donepezil: Enhances memory in some patients with early Alzheimer's disease

Muscarinic antagonists are referred to as **anticholinergics** or "parasympatholytics." Anticholinergics inhibit ACh and allow the SNS to dominate, creating similar effects as adrenergics. Their overall use is to relax smooth muscle. "SLUDGE" is a mnemonic commonly used to recall the effects of anticholinergics and was initially associated with cholinergic excess. SLUDGE: **S**alivation decreased, **L**acrimation decreased, **U**rinary retention, **D**rowsiness/dizziness, **G**I upset, **E**yes (blurred vision/dry eyes). Anticholinergics may also cause confusion and constipation and must be used cautiously in the elderly. See Figure 4.2i[15] for an illustration of the **"SLUDGE"** effects of anticholinergics.

Examples of anticholinergic medications include:

15. ""SLUDGE" effects of Anticholinergics" by Dominic Slausen at Chippewa Valley Technical College is licensed under CC BY 4.0

- Atropine: Specific anticholinergic responses are dose-related. Small doses of atropine inhibit salivary and bronchial secretions and sweating; moderate doses dilate the pupil, inhibit accommodation, and increase the heart rate (vagolytic effect); larger doses will decrease motility of the gastrointestinal (GI) and urinary tracts; very large doses will inhibit gastric acid secretion
- Oxybutynin: Relaxes overactive bladder
- Benztropine: Reduces tremor and muscle rigidity in Parkinson's disease or in treatment of extrapyramidal reactions from antipsychotic medications
- Scopolamine: Decreases GI motility and GI secretions; used for motion sickness and post-operative nausea and vomiting [16] [17] [18] [19]

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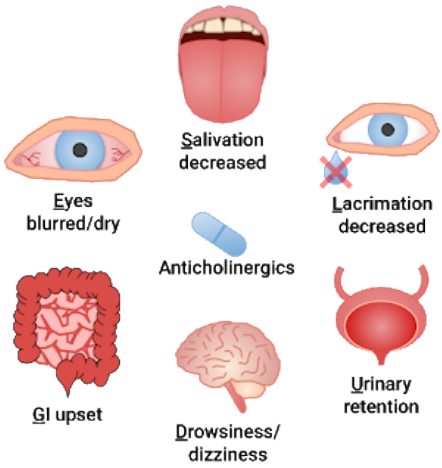

Fig 4.2i "SLUDGE" Effects of Anticholinergics: Salivation decreased, Lacrimation decreased, Urinary retention, Drowsiness/Dizziness, GI upset, Eyes (blurred vision/dry eyes). Also may cause confusion and constipation (Chippewa Valley Technical College, Egert, Lee, & Gill, 2023./BCcampus) CC BY 4.0

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- **Figure 4.2h** Effects of Medications Stimulating Beta-2 Receptors in the Lungs by BruceBlaus on Wikimedia Commons is used under the CC BY-SA 4.0 license.
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4.2 Conditions and Disease of the ANS

As you have just learned, the autonomic nervous system regulates vital functions of our internal organs, such as heart rate, blood pressure, digestion, water balance, urinary excretion, and body temperature. Individuals with an autonomic disorder have trouble regulating one or more of these systems, which can result in fainting, lightheadedness, fluctuating blood pressure, and other symptoms (Karch & Morrison, 2017).

Autonomic nervous system disorders can occur alone or as the result of another disease, such as Parkinson's disease, cancer, autoimmune diseases, alcohol abuse, or diabetes.

A common autonomic nervous system condition you may see in practice is orthostatic hypotension.

Orthostatic Hypotension

Orthostatic hypotension refers to a drop in blood pressure upon standing (after a prolonged period of sitting or lying). It is defined as a drop in systolic BP equal to or greater than 20 mmHg or diastolic BP greater than 10 mmHg within three minutes of standing. This can occur when autonomic reflexes are impaired or intravascular volume is markedly depleted. Failure of autonomic reflexes leading to hypotension is specifically knowns as baroreflex dysfunction. In baroreflex dysfunction, there is an impaired sympathetic response where there is not an appropriate level of the hormone norepinephrine, causing poor vasoconstriction. In these clients, blood pressure drops after standing because the pooling of blood

in the legs cannot be compensated by vasoconstriction (UpToDate, 2021).

Orthostatic hypotension can be asymptomatic or symptomatic. Symptoms can include dizziness, lightheadedness, syncope, muscle ache in the neck and shoulders, and even angina (UpToDate, 2021).

Other ANS Conditions and Disorders

Due to the limited scope of this textbook, we will not be discussing other ANS disorders as they are less commonly encountered in nursing practice. If you are interested in ANS dysfunction, consider reviewing resources on the following disorders:

- postprandial hypotension
- multiple system atrophy
- pure autonomic failure
- familial dysautonomia

ANS regulation is also closely linked to other concepts, such as Perfusion, Cognition and Central Nervous System Regulation. These concepts and their related medications are discussed in later chapters.

References:

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- UpToDate. (2021). Mechanisms, causes, and evaluation of orthostatic hypotension. https://www.uptodate.com/contents/search ↵

4.3 Clinical Reasoning and Decision-Making for ANS Regulation

The next sections will focus on medications related to regulating the autonomic nervous system. Before we do that, it is important to re-examine the nursing process in guiding the nurse who administers ANS medications. The nursing process consists of assessment, diagnosis, outcome identification, planning, implementation of interventions, and evaluation. Because diagnosis, outcome identification, and planning are specifically tailored to the individual client, we will broadly discuss considerations related to assessment, implementation of interventions, and evaluation with medication administration.

Assessment

Recognizing cues...

Recall that assessment is all about recognizing and analyzing "cues" from your conversations and physical assessment of your clients.

Many types of medications stimulate or inhibit specific ANS receptors. By knowing the effects, it becomes easy for the nurse to recognize side effects resulting from the stimulation or inhibition of ANS neuroreceptors. Medications that stimulate ANS receptors often impact the heart, lungs, and blood vessels.

Sympathetic (adrenergic) effects (fight or flight) lead to increased heart rate, bronchodilation, pupil dilation, increased blood sugar,

and diaphoresis. As such, nurses must monitor a client's blood pressure, heart rate, lung sounds etc for expected therapeutic effects and side effects.

Parasympathetic (cholinergic) effects (rest and digest) lead to increased urination, increased peristalsis and diarrhea, bronchoconstriction, bradycardia and hypotension. As many medications can cause *anti-cholinergic* effects, the nurse should assess for such effects as urinary retention, constipation, blurred vision, tachycardia and dry mouth.

As part of a comprehensive assessment, obtain a baseline before administering medications. This includes vital signs to detect bradycardia or hypotension, lung sounds (crackles, wheezes) and GU/GI system (bowel sounds, bowel movements, urine output).

Planning

Next, plan (refine your hypothesis), and take action.

When planning your care, this includes cue recognition and prioritization, refining your hypotheses based on your client assessment.

Common goals include:

- Client will understand the effects of their medication, and the importance of adhering to the medication regimen.
- Client's vital signs will be within the desired range.

Implementation of Interventions

A nurse should be aware of parameters to administer or withhold medications affecting the autonomic nervous system. If the ordered parameters are unclear, the nurse should withhold the medication following safe administration guidelines and notify the prescriber. For example, when no parameters are provided, blood pressure medications should not be administered if the client's apical heart rate is less than 60 beats per minute and/or the systolic blood pressure is less than 100 mmHg. As with all parameters, they are context-dependent and medication specific. For example, a client who is physically fit may have a resting heart rate of 50 bpm, thereby the 60-bpm guideline would not be appropriate.

Report any marked change in vital signs or suspected adverse effects.

Implement fall precautions, when needed, based on anticipated side effects of ANS medications.

Evaluation

Finally, evaluate the outcomes of your action.

It is always important for nurses to know the reason why a medication is ordered for a specific client, so evaluation of therapeutic effectiveness can be documented. For example, if the purpose of medication is to improve urine flow, then improvement should be seen and documented. Otherwise, the side effects may not warrant the use of the medication.

4.4 ANS Medication Classes and Nursing Considerations

Classes of medication, categorized according to neuroreceptor, are further discussed in more detail below. Figure 4.4 summarizes how ANS drugs are classified.

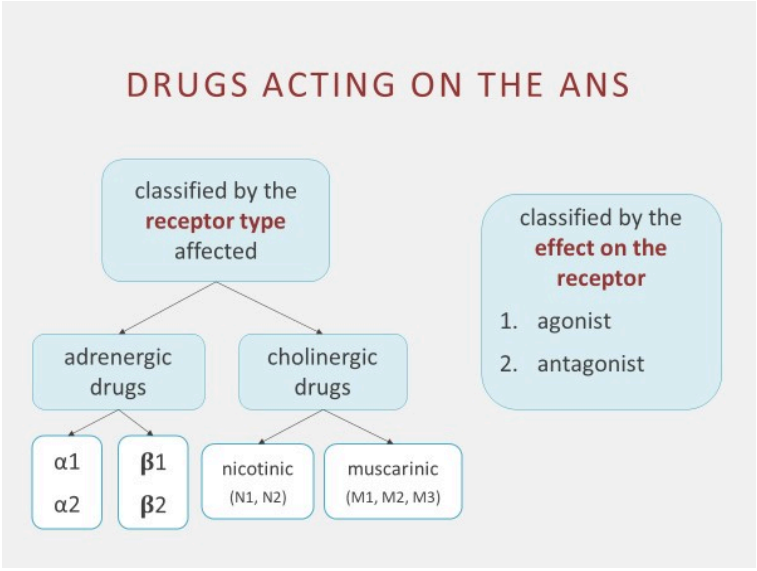

Figure 4.5 Classification of drugs acting on the ANS *Public Domain*

Table 4.4[1] further contrasts agonist and antagonist medications for each ANS neuroreceptor.

1. This work is a derivative of Daily Med by U.S. National Library of Medicine in the public domain

Receptor	Stimulation (Agonist)	Inhibition (Antagonist)
Nicotinic	• Nicotine is a nicotinic receptor agonist with stimulatory effects (CNS effects, neuromuscular activation). • Nicotine patch is used for nicotine addiction by slowly reducing dose and avoiding withdrawal effects	• Not clinically applicable
Muscarinic	• Pilocarpine causes muscle contraction; assists with glaucoma by contracting ciliary muscle and draining fluid	• Atropine in small doses inhibits secretions; in moderate doses increases heart rate; in large doses decreases gastrointestinal motility
Alpha-1 (found in smooth muscles)	• Pseudoephedrine and Phenylephrine cause vasoconstriction, decreased swelling of mucus membranes, and decreased secretions	• Tamsulosin relaxes smooth muscle in bladder/prostate to improve urine flow.
Alpha-2 (found in brain and periphery)	• Clonidine decreases CNS outflow to treat ADHD and also reduces sympathetic outflow (reducing blood pressure and heart rate).	• Mirtazapine, yohimbine

Beta-1 (found on heart and kidneys)	• Dobutamine increases heart rate, force of heart contraction, and speed of conduction between SA to AV nodes	• Selective beta-blocker: Metoprolol works on Beta-1 receptors to decrease blood pressure and heart rate
Beta-2 (found on the lungs)	• Albuterol used for bronchodilation	• Nonselective beta-blocker: Propranolol works on Beta-2 and Beta-1 receptors; decreases blood pressure but can also cause bronchoconstriction
Catecholamines stimulate multiple adrenergic receptors	• Epinephrine and Norepinephrine: stimulate alpha- and beta-receptors on target organs, causing a redistribution of blood flow with increased heart rate and vasoconstriction with decrease to other areas depending on receptor activation and dose. • Dopamine has dose-dependent effects that target arteries in the kidneys, heart, and brain	• Not clinically applicable

Supplementary Videos: See the supplementary videos below related to sympathetic and parasympathetic nervous system medications.

Sympathetic Nervous System Drugs

2

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=124#oembed-1

2. Forciea, B. (2018, January 12). Sympathetic nervous system drugs. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/-e_s-jTPtm4

Parasympathetic Nervous System Drugs

3

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Autonomic Nervous System Medication Cards

The Autonomic Nervous System med cards are all compiled in one document for easy use and reference. Go to the following link which will take you to Chapter 4 ANS-Regulation Medication Cards 2026.

3. Forciea, B. (2018, February 2). Parasympathetic nervous system drugs. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/ZSRk_NkbBPg

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4.5 Nicotine Receptor Agonists

Smoking tobacco is the leading preventable cause of disease and premature death worldwide. In Canada, tobacco use kills one in two long-term users and causes many chronic illnesses such as cancer, respiratory ailments and heart disease. Approximately 37,000 Canadians die from tobacco use each year (Government of Canada, 2023). The percentage of Canadians smoking has decreased considerably over the years, from approximately 50% of adults smoking in 1965, to approximately 13% in 2022 (School of Public Health Services n.d.). This decrease can be attributed to a number of initiatives by the Canadian Tobacco Strategy that includes improving services and resources to assist in quitting smoking and public education.

Nicotine replacement therapy (NRT) is part of a comprehensive behavioral smoking cessation program for those clients who wish to quit smoking without going through the withdrawal symptoms associated with quitting abruptly. Withdrawal symptoms usually peak in 2-3 days after quitting and include restlessness, increased appetite, depression or irritability, and intense cravings for another cigarette (Sandhu, Hosseini & Saadabadi, 2024). NRT offers a safer alternative to using tobacco, as NRT has none of the harmful chemicals such as carbon monoxide.

Indications for Use

Nicotine Replacement Therapy (NRT) is an aid to smoking cessation and for the relief of nicotine withdrawal. It offers a controlled way

to reduce nicotine dependence and provides a safer way to provide the body with nicotine while being gradually weaned off.

Mechanism of Action

Nicotine inhalation diffuses across lung tissue, into the systemic circulation and then to the different parts of the body. Nicotine binds to and activates nicotinic acetylcholine receptors, mimicking the effect of acetylcholine at these receptors. These receptors are located in the brain, neuromuscular junctions, adrenal medulla, and ganglia. Nicotine also influences the reward center in the limbic system and stimulates dopamine release leading to a pleasurable and rewarding experience. NRT is designed to mimic these effects and with progressively lower doses, it can decrease the cravings and withdrawal symptoms (Sandhu, Hosseini & Saadabadi, 2024).

Nursing Considerations

Administration: It is available in patches, lozenges, inhalers, sprays and gum. They deliver a controlled amount of nicotine to the body and can increase the chance of quitting by 50-70%. The client will start on NRT and keep the same dose for 4 weeks, then gradually taper their dose of NRT.

- Dosing: Dosing depends on the number of cigarettes smoked each day. Depending on the route, there is a wide range of mg delivered.

- Transdermal patch: 5-52.5 mg once daily application. Higher dosages are for heavy smokers. May be worn 24 hours/day, or if vivid dreams or unable to sleep, remove patch before

bedtime.
- Nicotine gum: Can be used alone or with the patch. If used with a patch, it is on a PRN basis to manage withdrawal symptoms.

Children, Pregnancy and Breastfeeding

Nicotine is not recommended for children or pregnant women. Based on available data, it is generally safer to nicotine replacement therapy (NRT) when compared to cigarette smoking, although not risk-free. Although NRT does not contain carbon monoxide or hydrogen cyanide, two toxic compounds that can harm fetal development (UpToDate, 2021), it should only be used with clinical guidance.

Hospitalized Clients

For clients who smoke and are admitted to the hospital, Nicotine Replacement Therapy will be ordered and should be initiated as soon as possible after admission. Withholding or delaying therapy will precipitate withdrawal symptoms. See the preprinted orders in your facility. The amount of milligrams /patch ordered will be based on the usual amount of tobacco use per day.

Example in Practice:

A client is admitted to the hospital with heart failure. The nurse completes their medical history and med

profile. The nurse learns they smoke cigarettes. The Nicotine Replacement Therapy orders are initiated.

If they smoke _____cig/day, the concentration of the patch will be:

7 cigarettes/day – 7 mg/day

10-20 cigarettes/day – 14 mg/day

21-30 cigarettes/day – 21 mg/day

Along with the patch, they may also be offered Nicotine gum for managing withdrawal symptoms. Nicotine gum: 2 mg one-piece q 1-2h prn (max: 15 pieces/day)

The nurse recalls that NRT should be cautiously used with cardiac clients. She confirms with the prescriber that it should not be ordered if the client has had a myocardial infarction in the last 2 weeks, those with serious arrhythmias or with unstable angina pectoris. The nurse will assess the client for nicotine withdrawal symptoms and offer nicotine gum PRN.

Adverse/Side Effects:

- **Allergic reaction:** Discontinue use and call provider if an allergic reaction occurs, such as difficulty breathing or rash, or symptoms of nicotine overdose occur, such as nausea, vomiting, dizziness, weakness, and rapid heartbeat.
- **Skin reaction:** local skin reaction occurs with 50% of users.

Usually mild and self-limiting. Can treat with hydrocortisone cream (1%). Ensure to rotate patch sites
- May also cause vivid dreams or sleep disturbances. If these occurrences occur, clients should be counselled to remove the patch at bedtime and apply a new one in the morning.

Province of British Columbia, 2012; Sandhu, Hosseini, & Saadabadi, 2023.

Client Teaching

The client should stop smoking completely while on nicotine replacement therapy to avoid additive nicotine levels higher than smoking alone. Advise clients that participating in a comprehensive smoking cessation program improves success.

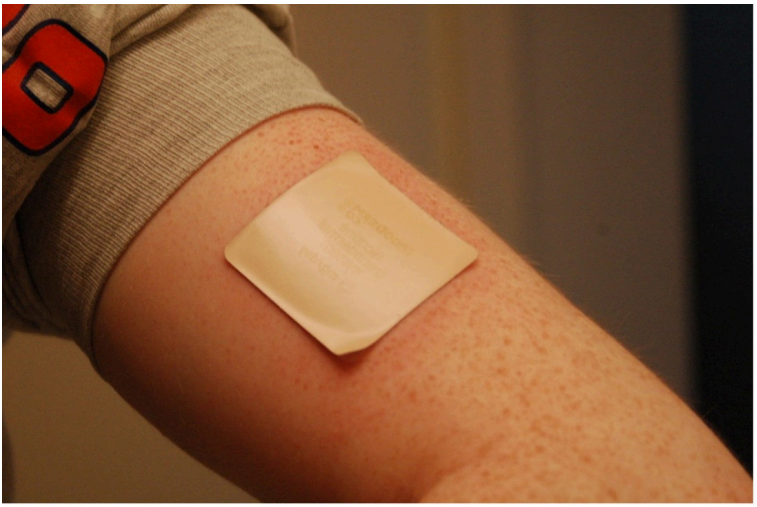
Application:

- Wash hands after applying or removing the patch.
- Apply one new patch every 24 hours on skin that is dry, clean, and hairless.
- Remove backing from patch and immediately press onto skin. Hold for 10 seconds.
- Apply to clean, hairless and dry area of upper body or arm.
- Dispose of the used patches by folding sticky ends together and putting in pouch.
- The used patch should be removed and a new one applied to a different skin site at the same time each day. Do not apply more than one patch at a time.

If using a nicotine patch, client should be aware that skin sensitivity

at the site of patch placement typically resolves within one hour (uCentral, n.d.).

Alert: Advise client to keep all nicotine products, including used inhaler cartridges, nasal spray bottles, and patches out of the reach of children and pets.



4.5a Person wearing a transdermal patch used in nicotine replacement therapy. (RegBarc/*Wikimedia Commons*) CC BY-SA 3.0

Nicotine Patch Medication Card

Now let's take a closer look at the medication card on nicotine patch (UpToDate, 2021). Medication cards assist students to learn key points about each medication class. Basic information related to a common generic medication in this class is outlined, including administration considerations, therapeutic effects, and side effects/adverse effects. Because information about medication is constantly changing, nurses should always consult evidence-based

resources to review current recommendations before administering specific medication.

Nicotine Patch Medication Card

Class: Nicotinic Agonist **Prototype:** Nicotine patch		**Indications:** Smoking aid cessation. Relief of nicotine withdrawal **Therapeutic use:** For nicotine addiction by slowly reducing dose and avoiding withdrawal effects.	
Mechanism of Action: Nicotine binds to and activates nicotinic Ach receptors, mimicking the effect of Ach.			
Administration: Apply patch to hairless, dry area on upper body or arm. Rotate sites. Remove patch and replace daily at same time. Dosing tapered q 4 weeks. Check for allergy to adhesives.	**Side Effects:** rash at site of application irregular heart rate/palpitations vivid dreams or inability to sleep nicotine overdose (see nursing considerations)	**Contraindications:** Lower dosage if taking monoamine oxidase inhibitors (MAOIs) Use cautiously in patients with recent myocardial infarction, serious arrhythmias, coronary artery disease, severe or worsening angina, hypertension, vasospastic diseases, or peripheral vascular disease Not recommended if pregnant, may cause fetal harm	**Nursing Considerations:** Discontinue use and call provider if: • Allergic reaction (difficulty breathing, rash) • Irregular heartbeat or palpitations Overdose symptoms: nausea, vomiting, dizziness, weakness, and rapid heartbeat Ensure client is not smoking while on patch (risk for nicotine overdose)

Downloadable file (.docx): Nicotine Patch Medication Card

Interactive Activity

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4.6 Muscarinic Receptor Agonists

Pilocarpine is a muscarinic receptor agonist.

Indications for Use:

Pilocarpine is used to treat ophthalmic conditions such as elevated intraocular pressure and glaucoma.

It is also used to treat dry mouth due to salivary gland hypofunction to help alleviate symptoms and prevent complications such as dental caries, gingivitis, and halitosis. Hypoactive salivary gland function can be due to radiation therapy for head and neck cancer or to treat dry mouth related to Sjogren's syndrome. Pilocarpine will stimulate residual salivary flow and provide lubrication (Medline Plus, 2025).

Mechanism of Action:

Pilocarpine causes the ciliary muscle to contract, allowing for the drainage of aqueous humor from the anterior chamber of the eye and reducing intraocular pressure related to glaucoma and ocular hypertension.

Nursing Considerations:

Muscarinic receptor agonists, such as pilocarpine, can be used in

children and older adults. There are no necessary dose adjustments for kidney or liver dysfunction in older adults but still may be required based on clinical status.

Used as a treatment to manage symptoms of dry mouth or elevated ocular pressures. Due to frequency of dosing and side effects, it is often not first line treatment for glaucoma. It is also used for xerostomia.

Ophthalmic: 1 drop into affected eye 3-4 times/ day. Remove contact lens before administration. Apply light finger pressure on lacrimal sac for 2 minutes after instilling to minimize systemic absorption (Adams et al, 2018).

Oral: 1 tablet 3-4 times/day

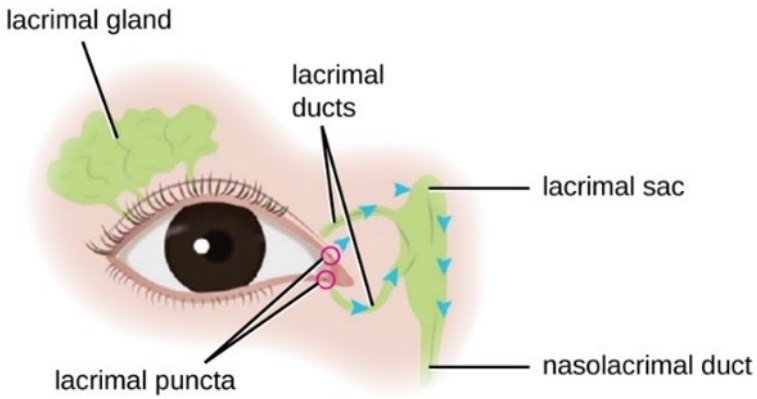

Figure 4.6a Lacrimal Sac (OpenStax Microbiology – modification of work by "Evidence Based Medical Educator Inc."/YouTube) CC BY 2.0 licence.

Adverse/Side Effects:

Common side effects include:

- Headache or brow ache
- Temporary blurred vision or difficulty seeing in dim light
- Eye irritation, stinging, or redness
- Increased sweating and salivation (more common with oral tablets)

Adverse effects include bradycardia, hypotension and vision changes (light flashes, floaters). See the prescriber for any adverse effect.

Client Teaching:

- Advise the client to use caution with night driving.
- This medication can cause hypotension (Medline Plus, 2025).
- Inform prescriber if pregnant
- If scheduled for surgery, may interact with anesthesia or increased secretions.

Pilocarpine Medication Card

Now let's take a closer look at the medication card on pilocarpine.[2] Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Pilocarpine Medication Card

Class: Muscarinic Agonist **Prototypes:** pilocarpine		**Indications:** Management of intraocular pressure in glaucoma. Management of dry mouth related to salivary gland hypoperfusion	
Mechanism of Action: causes ciliary muscle to contract, allowing for the drainage of aqueous humor form the anterior chamber of the eye and reducing intraocular pressure related to glaucoma.			
Administration: Remove contact lens before administration. Apply light finger pressure on lacrimal sac for 2 minutes after instilling to minimize systemic absorption	**Side Effects:** Diaphoresis, headache, temporary blurred vision, eye irritation. May cause hypotension May cause floaters	**Contraindications:** Caution client about night driving as medication can decrease visual acuity	**Nursing Considerations**: Apply light pressure to lacrimal sac for 2 min after application to minimize systemic absorption. Safe with peds and older adult.

Downloadable file (.docx): Pilocarpine Medication Card

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=127#h5p-53

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Media Attributions

- Figure 4.6a: Lacrimal Sac is by OpenStax Microbiology, originally adapted from work by "Evidence Based Medical Educator Inc."/YouTube: https://www.youtube.com/watch?v=d2CWgLPfTPA. used under a CC BY 2.0 licence by OpenStax.

4.7 Muscarinic Antagonists

Atropine is a competitive reversable muscarinic antagonist (anticholinergic) used for anti-vagal or bradycardic conditions. It is also used to treat asthma and gastrointestinal conditions.

Indications for Use

Due to its anticholinergic properties, there is a variety of uses for atropine. Therapeutic uses are dose dependent (Adams et al, 2018; Vallerand & Sanoski, 2025).

- Bradycardia: give 0.5-1.0 mg IV q 3-5 minutes. Do not exceed 3 mg.
- Respiratory – relaxes the bronchi, used for bronchospasm: inhalation – give 0.025- 0.05 mg/kg/dose q 4-6 hours as needed. Maximum 2.5 mg/dose. Not routinely used for this purpose.
- Decrease excess salivation: used pre-anesthesia or palliative clients. Can be given IM, IV.
- Ophthalmic: will dilate pupils for eye examinations. 1% solution
- GI: Decrease secretion of gastric acid in peptic ulcer disease and decrease GI motility with conditions causing severe diarrhea and cramping.
- Organophosphate Poisoning: to treat muscarinic symptoms of insecticide (organophosphorus or carbamate) poisoning or mushroom poisoning.

Mechanism of Action

Atropine is an anticholinergic drug that inhibits parasympathetic impulses, thereby blocking muscarinic activity. It inhibits acetylcholine at the postganglionic sites located in smooth muscle, secretory glands and the CNS. It has a direct vagolytic action, allowing the preexisting sympathetic stimulation to predominate, resulting in increased heart rate, relaxation of the bronchi, drying of secretions and dilated pupils.

Vagolytic effect: For cardiac life support with bradycardic conditions usually related to sinus or AV nodal conduction issues, 0.5 mg IV every 3-5 minutes (adult), up to 3 mg total.

Nursing Considerations

Administration: Atropine can be administered by intravenous (IV), subcutaneous, intramuscular, or endotracheal (ET) methods; IV is preferred.

- IV administration: IV push or infusion. Assess vital signs and ECG frequently during IV administration. Report any paradoxical bradycardia, ventricular ectopy or hypotension.
- Endotracheal administration: Dilute 1 to 2 mg in 10 mL of sterile water or normal saline before administration.
- Once administered, it easily absorbed and widely distributed. Half life is 4-5 hours.

Heat stroke may occur in the presence of high temperatures.

Immediately report symptoms of overdose: urine retention, abnormal heart rhythm, dizziness, loss of consciousness, difficulty breathing, weakness, or tremors.

Antidote: Physostigmine has been used to reverse anticholinergic effects.

Pediatrics: Atropine can be given to pediatric clients, with doses adjusted according to the child weight.

Older adult: As with all anticholinergics, use with caution with the elderly, because elderly clients may react with agitation or drowsiness.

Drug interactions:

- Atropine will increase the effects of antihistamines, tricyclic antidepressants, procainamide.
- Atropine will decrease the therapeutic effects of levodopa-carbidopa.

(Adams et al, 2018, Patel, McLendon, Preuss, 2025; Vallerand & Sanoski, 2024)

Adverse/side effects

Anticipate the following common side effects: Dry mouth, dry eyes, blurred vision, constipation, urinary retention and increased heart rate.

May be contraindicated with narrow-angle glaucoma.

May cause urinary retention so caution with benign prostrate hypertrophy

Client Teaching

- Advise clients that use of these medications may cause dizziness and drowsiness, so clients should be aware of potential impact on their level of alertness.

- Inform client of side effects.
    - For dry mouth, oral hygiene is important.
    - Constipation: Increase fluids and fiber in the diet.

- Inform client to not take any herbal supplements without discussing first with the prescriber.

(Adams et al, 2018, Patel, McLendon, Preuss, 2025; Vallerand & Sanoski, 2024)

Example in Practice

A client with irritable bowel disease is experiencing considerable abdominal cramping and diarrhea. There is a concern with fluid and electrolyte losses and the considerable discomfort that the client is experiencing. The client is ordered Diphenoxylate with atropine po (trade name: Lomotil). Diphenoxylate (centrally acting opioid) with the anticholinergic effects of atropine will slow the gastrointestinal motility. The subtherapeutic amounts of atropine is included in the dosage form to discourage diphenoxylate abuse.

Critical Thinking Out Loud

A 48-year-old male goes to the emergency department with issues of dizziness and fatigue for the last two days. The client appears pale. Vital signs are HR 42 bpm BP 105/62 T 36.7 C RR 20 breaths/min with oxygen sats of 97%. No shortness of breath noted.

A 12 lead ECG is ordered and shows sinus bradycardia with HR 40 bpm, regular. No ectopy. Assess for other causes of bradycardia

Atropine is ordered as the heart rate is less than 60 bpm *and* the client is symptomatic. Order reads: atropine 0.5 mg IV q 3-5 minutes to a maximum of 3 mg.

Atropine is ordered as it will block the parasympathetic actions of acetylcholine, resulting in an increased heart rate.

Prior to first dose: HR, BP, RR, oxygen sats, and T. Assess client for poor perfusion such as pallor, fatigue, dizziness and altered mental status such as confusion.

Give atropine 0.5 mg IV over one minute.

After first dose and subsequent doses, monitor:

- Vital signs
    - Anti-cholinergic effects can cause tachycardia, fluctuations in BP.
- Continuous telemetry monitored to observe for any changes.
- Assess for signs of adverse anti-cholinergic effects:
    - Flushing, hot skin
    - Neuro status: anxiety, delirium, hyperactivity

- Urinary retention
- Constipation
- Blurred vision, dry eyes, light sensitivity, pupil dilation

The goal is to increase the heart rate to over 60 bpm or whatever the HR the physician has ordered. Anticipate adverse effects and treat accordingly. Anticipate diagnostic tests to determine underlying cause of bradycardia.

Note: Answers to the Clinical Reasoning and Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Atropine Medication Card

Now let's take a closer look at the medication card on atropine in Table 4.8 (Vallerand & Sanoski, 2025; UptoDate, 2025). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medications.

Atropine Medication Card

Class: Muscarinic Antagonist **Prototype:** atropine		**Indications**: Dose dependent – symptomatic bradycardia to increase heart rate, inhibits saliva and secretions. Larger doses for decreasing GI motility	
Mechanism of Action: an anticholinergic drug that inhibits parasympathetic impulses, thereby inducing sympathetic stimulation. It inhibits acetylcholine at the postganglionic sites located in smooth muscle, secretory glands and the CNS. It has direct vagolytic action, resulting in increased heart rate, relaxation of the bronchi, drying of secretions and dilated pupils. Small doses inhibit salivation. Moderate doses cause vagolytic action, resulting in dilating the pupils, inhibit accommodation, increases HR. Large doses decrease GI motility and inhibit gastric acid secretions.			
Administration: IM, SQ, ET and IV Use with caution in older adults	**Side Effects:** xerostomia, blurred vision, flushing, hot skin, constipation, urinary retention, CV: tachycardia (most common) Adverse effects: CNS: anxiety, dizziness, vertigo, delirium CV: Short term paradoxical bradycardia.	**Contraindications:** Caution with elderly, may react as agitation or drowsiness. Caution in males with benign prostrate hypertrophy May cause urinary retention. Contraindicated with glaucoma	**Nursing Considerations:** Monitor for overdose: urine retention, abnormal heartbeat, dizziness, passing out, difficulty breathing, weakness, or tremors. Antidote: Physostigmine Heat stroke may occur if high temperature Advise client risk of dizziness and drowsiness. Oral hygiene due to dry mouth.

Downloadable file (.docx): Atropine Medication Card

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=128#h5p-54*

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4.8 Alpha-1 Agonists

Phenylephrine is an alpha-1 agonist. It has a variety of uses, depending on the route of application. Pseudoephedrine is another med in this class but is used less in practice and is tightly regulated.

Mechanism of Action

It is a direct-acting sympathomimetic that selectively stimulates alpha-1 adrenergic receptors.

Nasal congestion: Alpha-1 agonists stimulate alpha receptors in the respiratory tract, causing constriction of blood vessels and shrinkage of swollen nasal mucous membranes, thus increasing airway patency and reducing nasal congestion.

For ophthalmic uses, ointment used to facilitate mydriasis and to vasoconstrict conjunctival blood vessels.

Indications for Use

Numerous uses depending on the route. It elevates blood pressure due to vasoconstriction of veins and arteries resulting in raised arterial pressure, thereby used for septic shock and anesthesia. It may also be used as a decongestant for sympathomimetic relief in upper respiratory infections. For ophthalmic application, it is used for mydriasis and to vasoconstrict conjunctival blood vessels. Used in topical application for hemorrhoid relief.

Nursing Considerations

Pseudoephedrine has had recent limitations placed on its use because it is a common ingredient in the illicit manufacturing of the drug methamphetamine. Pharmacies now require individuals to provide identification to purchase pseudoephedrine and must track the number of purchases. As a result, most over-the-counter decongestants now contain phenylephrine.

Monitor for elevated blood pressure, urinary retention, nervousness, or difficulty sleeping.

Do not administer within 2 hours of bedtime due to risk of insomnia.

Pediatrics: There is limited data on whether pseudoephedrine can be used in children under the age of 4 years old, so it should be avoided.

Older adult: It is safe to use in older adult populations, and typically no dosage adjustments are required for renal or liver dysfunction, depending on comorbidities and cardiovascular effects.

Cautions: Phenylephrine and pseudoephedrine both should be used cautiously in clients with glaucoma, hypertension, or an enlarged prostate gland.

Drug interactions:

- contraindicated in clients taking monoamine oxidase inhibitors (MAOIs), an antidepressant, due to hypertensive effects.

Client Teaching

- Clients should be instructed to take medication as prescribed

and be careful not to double-dose.
- If they experience nervousness, breathing difficulties, or heart rate changes, they should notify their healthcare provider.
- This med has numerous drug Interactions, ensure to consult with your prescriber if there is any change in your medications.

Phenylephrine Medication Card

Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Phenylephrine and Pseudoephedrine Medication Card

Class: Alpha 1 Agonists **Prototype:** Phenylephrine		**Indications:** vasoconstriction in both veins and arteries. Vasopressor **Therapeutic use:** elevates blood pressure due to vasodilation (septic shock, anesthesia). Decongestant, ophthalmic application for mydriasis & to vasoconstrict conjunctival blood vessels. Hemorrhoid relief.	
Mechanism of Action: direct acting sympathomimetic acts as an alpha-1 adrenergic receptor agonist. For hypotension, vasoconstrictor of veins and arteries to raise mean arterial pressure. For ophthalmic uses, ointment used to facilitate mydriasis and to vasoconstrict conjunctival blood vessels.			
Administration: Depending on use: IV phenylephrine HCl (infusion). Ophthalmic ointment, nasal spray Rectal Fast absorption regardless of route. Renally excreted, unchanged in urine.	**Side Effects:** Nausea, vomiting, headache, nervousness May cause bradycardia Safe with pregnancy Caution with breastfeeding.	**Contraindications:** Caution with renal or liver disease. Safety not established in peds. Drug interactions include: Propranolol, MAOIs, prednisone – will enhance vasoconstrictive effects Caution with bradycardia, severe cardiac dysfunction, may worsen heart failure.	**Nursing Considerations:** Topical and opthal. Applications well-tolerated. IV admin: - Central line preferred. - Critical care, OR L&D areas.

Downloadable file (.docx): Phenylephrine and Pseudoephedrine Medication Card

Interactive Activity

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https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=129#h5p-55

4.9 Alpha-1 Antagonists

Tamsulosin is an Alpha-1 antagonist.

Indications for Use

Tamsulosin is used to treat benign prostate hypertrophy (BPH).

Benign Prostate Hypertrophy (BPH) is an abnormal enlargement of the prostate that decreases the outflow of urine by obstructing the urethra. It occurs in some men over the age of 40, with the incidence increasing to 70% of men over 60 years of age (Adams et al, 2018).

Factors that increase the risk for family history, smoking, heavy alcohol consumption, hypertension, diet high in protein and diabetes.

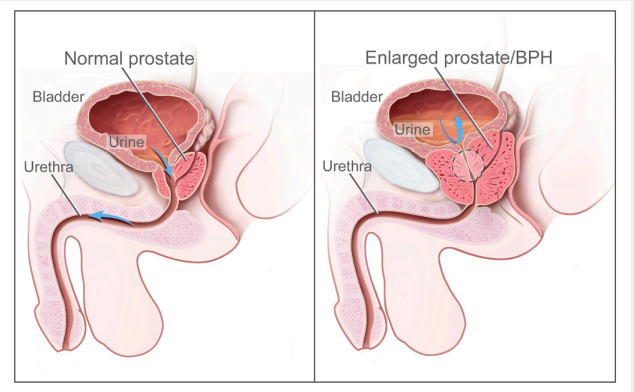

Image 4.9a Two-panel drawing shows normal male reproductive and urinary anatomy and benign prostatic hyperplasia (BPH). Panel on the left shows the normal prostate and flow of urine from the bladder through the urethra. Panel on the right shows an enlarged prostate pressing on the bladder and urethra, blocking the flow of urine. (National Cancer Institute, AV Number: CDR462221/Wikimedia Commons) *Public Domain*

Treatment includes lifestyle changes and most often men are prescribed Tamsulosin or a 5-alpha reductase inhibitor Dutasteride. If medications are ineffective, transurethral resection of the prostate is considered.

Mechanism of Action

Tamsulosin selectively blocks alpha-1 receptors in the prostate and bladder neck, leading to the relaxation of smooth muscles in the

bladder neck, and prostate, thus improving urine flow and reducing symptoms of benign prostatic hypertrophy (BPH).

Nursing Considerations

Assess urinary elimination including urinary retention, nocturia, dribbling, difficulty starting stream, frequency, urgency and sexual dysfunction.

Monitor:

- Blood pressure especially with first time using tamsulosin, as orthostatic hypotension can occur.
- Improvement in urinary elimination
- Sexual function changes including impotence, decreased ejaculation volume and decreased libido.

Cautious use with hepatic dysfunction.

Alpha-1 antagonists are not recommended for children under the age of 2 years old. They are safe to use in older adults, with no renal dose adjustments required. There is limited information about whether alpha-1 antagonists, such as tamsulosin, can be used in pregnancy.

Avoid using with other alpha-blockers. Using tamsulosin with CYP3A4 inhibitors such as ketoconazole requires caution due to increased drug levels.

Adverse/Side Effects

- Orthostatic hypotension (first dose effect), but low risk compared with non-selective alpha-1 blockers.
- Sexual function changes – decreased libido, impotence,

decreased ejaculation volume
- Dizziness

Client Teaching

- Advise clients to change positions slowly because the drug may cause orthostatic blood pressure changes.
- Take the medication at the same time each day, 30 minutes after a meal.
- The client should follow up with their healthcare provider to assess the effectiveness of the medication (Vallerand & Sanoski, 2024).

Tamsulosin Medication Card

Now let's take a closer look at the medication grid on tamsulosin (UpToDate, 2021, Vallerand & Sanoski, 2024). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Tamsulosin Medication Card

Class: Alpha-1 Antagonist **Prototype:** Tamsulosin		**Indications:** Benign prostrate hypertrophy. Off label use in chronic prostatitis/chronic pelvic pain in males, urethral calculi expulsion, ureteral stent-related urinary symptoms. **Therapeutic Effects:** Relaxes smooth muscle in bladder/prostate to improve urine flow	
Mechanism of Action: selectively blocks alpha receptors in the prostrate, leading to relaxation of smooth muscles in the bladder neck and prostrate; thus improving urine flow and reducing symptoms (nocturia, hesitancy, inability to empty bladder)			
Administration: Oral Take 30 minutes before the same meal each day.	**Side Effects:** Orthostatic hypotension Ejaculation failure Infection, dizziness, headache, rhinitis	**Contraindications:** Not for children under 2 years Avoid using with other alpha 1 blockers Contraindicated with CYP3A4 inhibitors (Ketoconazole)	**Nursing Considerations:** Monitor blood pressure, especially after first dose Advise client to change positions slowly

Downloadable file (.docx): Tamsulosin Medication Card CH 4.9

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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Media Attributions

- Image 4.9a Benign Prostatic Hyperplasia nci-vol-7137-300 is from National Cancer Institute, AV Number: CDR462221 on Wikimedia Commons is in the public domain.

4.10 Alpha-2 Agonist

Clonidine is an Alpha-2 agonist.

Mechanism of Action

As an alpha-2 adrenergic agonist, it reduces sympathetic outflow from the central nervous system, resulting in decreased peripheral resistance, heart rate, blood pressure, and renal vascular resistance.

Indications for Use

Clonidine is used to treat hypertension (HTN) and attention deficit hyperactivity disorder (ADHD).

Nursing Considerations

Monitor blood pressure and pulse rate frequently when giving these medications. Risk of hypotension, bradycardia and sedation.

Dosage is usually adjusted to the client's blood pressure and can cause hypotension, bradycardia, and sedation. Rebound hypertension may occur if stopped abruptly.

Alpha-2 agonists can be used safely in pediatric and older adult populations with appropriate dosing and monitoring. For pediatrics, dose adjustments need to be made based on the child's weight and titrated slowly. In older adult populations, dose adjustments are necessary when there is underlying kidney dysfunction.

Client Teaching

- Clients should be taught the importance of adhering to the same dosing schedule each day.
- Clients may experience orthostatic blood pressure changes so change positions carefully.
- Caution with using alcohol while taking this medication.
- May experience increased susceptibility to blood pressure changes when exercising and exposed to hot environments.
- Risk of depression as a side effect of the medication, inform client to monitor for mood changes and report changes to their prescriber. A different medication therapy may be needed (uCentral, n.d.).

Clonidine Medication Card

Now let's take a closer look at the medication grid on clonidine. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Clonidine Medication Card

Class: Alpha-2 Antagonist **Prototype:** Clonidine		**Indications:** to treat hypertension and attention deficit hyperactivity disorder	
Mechanism of Action: reduces sympathetic outflow from the CNS and decreases peripheral resistance and renal vascular resistance.			
Administration: Oral (IR and SR) Transdermal Dosage adjusted to client's BP and tolerance	**Side Effects**: Hypotension Bradycardia Sedation Rebound hypertension – do not stop abruptly	**Contraindications:** Avoid alcohol – may cause orthostatic hypotension. Caution with exercise or hot climates due to risk of hypotension.	**Nursing Considerations:** Monitor BP and pulse regularly Do not stop abruptly, taper. Adhere to same dosing schedule May cause depression, discontinue med.

Downloadable file (.docx): Clonidine Medication Card CH4.10

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=131#h5p-58*

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4.11 Beta-1 Agonists

Dobutamine is a Beta-1 agonist.

Indications for Use

Dobutamine is used to treat cardiogenic shock and severe heart failure to increase contractility and cardiac output. It is used for short term treatment with clients with severe systolic dysfunction who have low blood pressure and significantly reduced cardiac output. It is only used in critical care units.

Mechanism of Action

Dobutamine stimulates Beta-1 receptors to increase the force of contraction and conduction velocity. Beta 1 receptors are mostly in the cardiac muscle, so stimulation of these receptors will result in primarily inotropic effects (increased contractility and increased velocity of impulse contraction) with minimal chronotropic effects. The result is an improved cardiac output without a possible mild increased heart rate.

Nursing Considerations

Administration: IV infusion only, dilute concentration before administering. Large vein or central line infusion and only with infusion device.

Onset of action is 1-2 minutes and peak effect 10 minutes. The

duration of action will cease shortly after stopping the infusion, so dobutamine is administered by continuous infusion.

Assessment and Monitoring

- Continuously monitor electrocardiogram (ECG). Assess for premature ventricular contractions (PVCs), increased heart rate
- Blood pressure q 15 minutes
- Cardiac output, PCWP (pulmonary capillary wedge pressure), CVP (central venous pressure)
- Monitor urine output to assess renal perfusion
- Titrate the med based on ordered parameters (BP, HR, Cardiac Index, CVP, PCWP), infusions typically range from 2 to 20 mcg/kg/min.
- Assess peripheral pulses routinely and report any decrease in peripheral perfusion.
- Labs: monitor potassium levels; anticipate hypokalemia. Other labs: renal panel, electrolytes, lactate and blood glucose.
- Correct hypovolemia before initiating therapy.

Lifespan considerations

- Beta-1 agonists can safely be administered to pediatric clients, but doses must be adjusted according to weight.
- Generally safe to use with the older adult population, with no special dose adjustments for renal or liver insufficiency. But close monitoring due to comorbidities in this population.
- Beta-1 agonists should not be given in pregnancy, unless benefits outweigh the risks.

(Ashkar, et al, 2024; Vallerand & Sanoski, 2024).

Drug interactions

- Beta blockers may negate the effect of dobutamine, decreasing the inotropic effects.
- Nitroprusside may cause synergistic effect on increasing cardiac output.
- Dobutamine with anesthetic agents can lead to arrhythmias (Vallerand & Sanoski, 2024).

Adverse/Side effects

- Can cause a marked increase in heart rate and blood pressure.
- Risk of ectopy and arrythmias
- Report all adverse reactions promptly, especially laboured breathing, angina, palpitations, and dizziness.

Client Teaching

The client should be instructed to inform the nurse immediately if they notice chest pain, shortness of breath, or numbness or tingling in the extremities (Vallerand & Sanoski, 2024).

Dobutamine Medication Card

Now let's take a closer look at the medication card for dobutamine (UpToDate, 2021, Vallerand & Sanoski, 2024). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Dobutamine Medication Card

Class: Beta-1 Agonist **Prototype**: Dobutamine		**Indications**: used to treat cardiogenic shock and severe heart failure to increase contractility and cardiac output.	
Mechanism of Action: Stimulates Beta-1 receptors to increase the force of contraction and conduction velocity. The result is an improved cardiac output without an increased heart rate.			
Administration: IV only Must be administered with infusion device through large peripheral vein or central line. Onset of action occurs within 2 minutes. Peak plasma concentrations of the drug and peak effects occur within 10 minutes after initiation of an IV infusion.	**Side Effects**: marked increase in HR and blood pressure headache nausea dyspnea	**Contraindications**: Beta blockers may negate the effect of dobutamine, decreasing the inotropic effects. Nitroprusside may cause synergistic effect on increasing cardiac output. Dobutamine with anesthetic agents can lead to arrythmias	**Nursing Considerations**: Continuously monitor ECG, blood pressure, cardiac output, Monitor urine output to assess renal perfusion If administered through a large peripheral vein, assess for extravasation Report all adverse reactions promptly, especially labored breathing, angina, palpitations, and dizziness

Downloadable file (.docx): Dobutamine Medication Card

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=132#h5p-59

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4.12 Beta-1 Antagonists

Metoprolol is a selective Beta-1 antagonist, with a therapeutic classification of an antianginal and antihypertensive. It is commonly referred to as a beta blocker. Metoprolol is one of many beta blockers, such as atenolol, bisoprolol, acebutolol.

Indications for Use

Metoprolol is commonly used to treat high blood pressure, chest pain due to poor blood flow to the heart, as an early intervention during a myocardial infarction (MI), and in several heart conditions involving an abnormally fast heart rate.

Off label, it can sometimes be used for migraine therapy and the treatment of tremors.

Mechanism of Action

Metoprolol primarily blocks Beta-1 receptors in the heart, causing decreased heart rate, reduced myocardial contractility (negative inotropic effect) and decreased blood pressure. However, higher doses can also block Beta-2 receptors in the lungs, causing bronchoconstriction.

Nursing Considerations

Administration: Can be given oral or IV routes. Do not crush extended-release (ER) formulations.

- Orally, it works within 60 minutes with a duration of action of 6-12 hours.
- IV: monitor BP and HR, with telemetry, q 5-15 minutes when therapy initiated.

Assessment and Monitoring

- Prior to dose: Always check client's apical pulse rate x one minute. Withhold the drug and call the prescriber if the heart rate is slower than 60 beats/minute, unless other parameters are provided.
- During therapy: Assess for signs of heart failure (SOB, rales or crackles, weight gain, peripheral edema).
- Discontinuing Metoprolol: dosages are tapered over 1-2 weeks because abrupt discontinuation may cause chest pain or myocardial infarction (MI).

It crosses the blood brain barrier. It crosses the placenta and only used if maternal benefit justifies potential risk to fetus.

Cautious use with hepatic and renal failure.

Contraindicated with acute decompensated heart failure, pulmonary edema and bradycardia.

Beta-1 antagonists can be given to pediatric and older adult clients, but doses should be individualized based on client response.

Diabetic clients: monitor glucose level closely because the drug masks common signs and symptoms of hypoglycemia.

Adverse / Side Effects

- Serious potential adverse effects: pulmonary edema, bradycardia, and worsening heart failure. Report immediately to physician.
- Other adverse effects:
    - CNS: fatigue, dizziness, depression, insomnia, nightmares,
    - Resp: dyspnea, and wheezing.
    - GI/GU: gastrointestinal upset, diarrhea
    - Erectile dysfunction

Client Teaching

- Take the med only as prescribed. Do not abruptly stop medication therapy or life-threatening arrhythmias may occur.
- Teach client how to self-check pulse and blood pressure to assess the effectiveness of medication therapy.
- Avoid sudden changes in position due to the possibility of orthostatic blood pressure changes.
- May experience increase sensitivity to cold.
- Limit stimulants such as caffeinated beverages, as they may exacerbate symptoms (palpitations).
- Tell HCP if starting on any new OTC or prescription medication, including herbal remedies. Ie. cold remedies.

UpToDate, 2021; Vallerand & Sanoski, 2024;

Metoprolol Medication Card

Now let's take a closer look at the medication card for metoprolol. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Metoprolol Medication Card

<table>
<tr><td colspan="2">Class: Beta-1 Antagonist

Prototype: Metoprolol</td><td colspan="2">Indications:
Selective beta-1 blocker
Decreases blood pressure or controls rapid heart rate
Therapeutic Uses:
Angina: Long-term treatment of angina pectoris.
Heart failure with reduced ejection fraction (ER oral formulation): Treatment of stable, symptomatic heart failure
Hypertension: Management of hypertension.
Myocardial infarction: Treatment of hemodynamically stable acute myocardial infarction to reduce cardiovascular mortality</td></tr>
<tr><td colspan="4">Mechanism of Action: primarily blocks Beta-1 receptors in the heart, causing decreased heart rate and decreased blood pressure. However, higher doses can also block Beta-2 receptors in the lungs, causing bronchoconstriction.</td></tr>
<tr><td>Administration:
IV and PO
always assess apical HR and BP prior to administration.</td><td>Side Effects:
bradycardia
hypotension
worsening heart failure
CNS: fatigue, dizziness, depression, insomnia, nightmares
GI upset
GU: erectile dysfunction
Resp: dyspnea & wheezing</td><td>Contraindications:
It crosses the placenta and only used if maternal benefit justifies potential risk to fetus.
Cautious use with hepatic and renal failure.
Contraindicated with uncompensated heart failure, pulmonary edema and bradycardia.

Safe with peds and older adult with lower doses.</td><td>Nursing Considerations:
Withhold if HR < 60 or SBP <100 or as per prescriber orders

Monitor blood sugar in diabetic patients because drug can mask symptoms of hypoglycemia

Taper dose down over 1-2 weeks if d/c</td></tr>
</table>

Downloadable file (.docx): Metoprolol Medication Card CH4.12

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=133#h5p-60*

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4.13 Beta-2 Agonists

Salbutamol is a bronchodilator that is a Beta-2 agonist. It is used for the treatment and prevention of bronchospasm. It is also called Albuterol, but that name is more commonly used in the US. For further information on this med class, go to chapter 8 Respiratory Medications.

Indications for Use

Salbutamol is commonly used to treat asthma and chronic obstructive pulmonary disease (COPD) to relieve bronchospasm. It can be used via inhalation to prevent exercise induced bronchospasm or used orally for long term treatment of bronchospasm.

Figure 4.13a Ventolin HFA (Albuterol Sulfate) Asthma Inhaler used for treating asthma as a rescue inhaler

Mechanism of Action

Salbutamol selectively binds to beta-2 adrenergic receptors in airway smooth muscle. This binding increases the formation of intracellular cAMP via stimulation of adenylyl cyclase which then leads to relaxing airway smooth muscle, inhibits the release of

bronchoconstricting mediators from mast cells, and increases mucociliary transport. It also has a minor effect on Beta-1 receptors at higher doses, contributing to cardiovascular side effects.

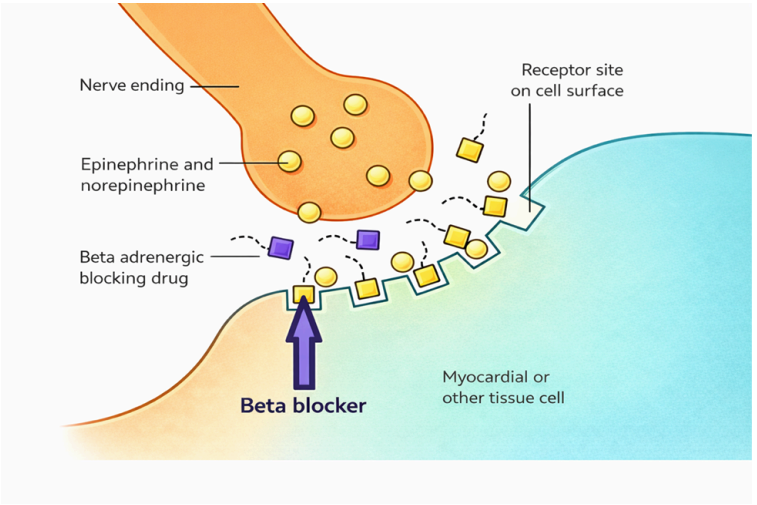

Figure 4.14b Beta adrenergic blocker mechanism of action (Sheila Odubote/ TRU Open Press).

Nursing Considerations

Administration: primarily inhalation and oral routes. Rarely given SQ, IM or IV.

- Inhalation: onset of action is 5-15 minutes, with a peak of 60-90 minutes. Duration of action is 3-6 hours. "Rescue" medication for acute bronchospasm. It has few side effects and no first pass metabolism.
- Oral: onset of action of 15-30 minutes with a peak of 2-3 hours. It has a long half-life, and easy to administer. Give with meals. Note that oral administration is less commonly prescribed.

Before and after administration:

- Monitor respiratory rate, oxygen saturation, and lungs sounds. If more than one inhalation is ordered, wait at least 1-2 minutes between inhalations. Use a spacer device to improve drug delivery, if appropriate.

Beta-2 agonists are safe for administration in pediatric and older adult populations, with appropriate dosing and scheduling.

Adverse/Side Effects

Adverse effects relate to stimulation of beta-2 receptors, which are located in skeletal vascular and bronchial smooth muscle, the liver, and on cell membranes

- paradoxical bronchospasm (with excess use). If wheezing develops, notify prescriber.
- May cause transient tachycardia/palpitations (direct stimulation of atrial beta-1 crossover effects) and tremors (beta-2 stimulation in skeletal muscle).
- Other CV: hypertension, chest pain, palpitations and arrhythmias.
- Risk of hyperglycemia. Monitor blood glucose more closely if diabetic.
- Hypokalemia (due to potassium entry into skeletal muscle)

May cause hypersensitivity reactions.

Client Teaching

- Follow instructions such as consistent dosing regimen. Do not double doses if a dose is missed.
- Use salbutamol first, then other inhalers.
- If symptoms not relieved by med or if they develop increased shortness of breath, contact prescriber.
- If using an inhaler:
    - Prime the inhaler with 4 test sprays prior to administering the dose of medication or as per manufacturer's instructions.
    - Use a spacer to deliver medication
    - May cause an unusual taste in the mouth, so rinsing mouth after use may reduce taste.

Salbutamol Medication Card

Now let's take a closer look at the medication card on albuterol (UpToDate, 2021). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Salbutamol Medication Card

Class: Beta-2 Agonist **Prototype**: Salbutamol		**Indications:** bronchodilation **Therapeutic Uses:** Bronchodilation in asthma or COPD **Off-label:** treatment of hyperkalemia	
Mechanism of Action: selectively binds to beta-2 adrenergic receptors in airway smooth muscle. This binding increases the formation of intracellular cAMP via stimulation of adenylyl cyclase which then leads to relaxing airway smooth muscle, inhibits the release of bronchoconstricting mediators from mast cells, and increases mucociliary transport.			
Administration: oral inhalation can be given IV, SC, IM and PO wait at least 1-2 minutes between inhalations oral: give with meals. Peak effect 2-3 hours.	**Side Effects**: Hypersensitivity Can cause paradoxical bronchospasm if overused Transient tachycardia, palpitations and tremors if higher dose Risk of hyperglycemia, monitor BG more often if diabetic. Hypokalemia	**Contraindications**: Hypersensitivity reactions If hypokalemia, use with caution and correct electrolytes.	**Nursing Considerations**: Report significantly increased heart rate and blood pressure, which may require the drug to be discontinued. Use spacer to improve drug delivery Rinse mouth after inhalation dose.

Downloadable file (.docx): Salbutamol Medication Card

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=134#h5p-62

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Media Attributions

- Figure 4.13a Ventolin HFA (Albuterol Sulfate) Asthma Inhaler used for treating asthma as a rescue inhaler Creative Commons Attribution-Share Alike 4.0 International https://commons.wikimedia.org/wiki/File:Ventolin%C2%AE_HFA_(Albuterol_Sulfate)_Inhaler.jpg

4.14 Beta-1 and Beta-2 Antagonists

Propranolol is a nonselective Beta-1 and Beta-2 antagonist (Beta blocker), used for cardiac conditions as an antianginal, antiarrhythmic, or antihypertensive. It is also used for non-cardiac purposes such as migraines and tremors.

Indications for Use

Propranolol is used to treat cardiovascular conditions such as high blood pressure and various cardiac conditions or dysrhythmias. For chronic stable angina, it will decrease the frequency and increase exercise tolerance. It will control supraventricular arrhythmias (eg, atrial fibrillation and flutter, atrioventricular nodal re-entrant tachycardia) and ventricular tachycardias, resulting in lower heart rate and slower contractility.

It is also used after a myocardial infarction to reduce mortality by decreasing heart workload. Beta-blockers prevent remodeling of the heart after an ischemic event by reducing the effects of catecholamines on cardiac tissue (Chen, Galuska & Hamilton, 2023).

For non-cardiovascular uses, propranolol is used for migraine prophylaxis, restless leg syndrome and essential tremor. Propranolol is also used off label for performance anxiety with symptoms of tachycardia, sweating and flushing secondary to the activation of the sympathetic nervous system (Shahrokhi & Gupta, 2023).

Essential Tremor

An isolated tremor syndrome of bilateral upper extremities, with a duration of at least three years. May also involve the head, voice and lower extremities. Treatment options can include propranolol, primidone or topiramate (anticonvulsant) all with varying degrees of effectiveness (Frei & Truong, 2022).

Mechanism of Action

Propranolol is a nonselective competitive beta-adrenergic receptor antagonist resulting in the inhibition of both Beta-1 receptors in the heart and Beta-2 receptors in the pulmonary and vascular smooth muscle.

Beta-1 receptors are located on the cardiac myocytes, including sinoatrial and atrioventricular (AV) nodes. When beta-1 is blocked, there is a slowing of the heart rate (negative chronotropic effect), a decreased conduction through AV node and a decreased myocardial contractility. Beta-2 receptors are located in the pulmonary and vascular smooth muscle. When beta-2 is blocked, blood pressure is lowered through reduced renin release from the kidneys, reduced sympathetic nervous system outflow and decreased cardiac output.

For migraine suppression, the mechanism of action is less clear. Its use for migraine treatment was discovered accidently. It is possibly due to reducing trigeminal nerve stimulation in the brain, and suppressing cortical spreading depression to lower the migraine attack threshold (Versijpt, Deligianni, Hussain, et al., 2024).

For tremor management, the proposed mechanism of action is by blocking peripheral noncardiac beta-2 receptors located in muscles (Frei & Truong, 2022).

Nursing Considerations

Administration: Oral (immediate release and extended release) available, take on an empty stomach. Do not crush extended-release formulations.

- Propranolol is readily absorbed with oral administration. For immediate release tablets, peak effects is within one to two hours.
- IV: slow infusion with continuous telemetry. Monitor blood pressure and heart rate during infusion.

Assessment and Monitoring

- Check blood pressure and apical pulse before giving drug; withhold and notify prescriber if apical pulse is less than 60 beats per minute or systolic blood pressure is less than 100 mm Hg, unless other parameters are provided.
- Can mask symptoms of hypoglycemia in diabetics.

Use with caution with clients who have co-existing asthma or chronic obstructive pulmonary disease (COPD) because of the effects on Beta-2 receptors that could potentially cause bronchoconstriction.

Use with caution in clients with impaired renal function, dosages likely lowered. As med is hepatically metabolized, may see dose reduction.

Drug Interactions

Propranolol can interact with many medications, so a thorough medication profile is warranted. There are numerous drug interactions, including aluminum- based antacid, cholestyramine, warfarin, corticosteroids, and NSAIDs.

- Aluminum based antacids and cholestyramine or colestipol (lipid lowering medications) can decrease propranolol's absorption. Do not take these meds at the same time as propranolol.
- NSAIDs can decrease effectiveness of propranolol in lowering blood pressure. Monitor BP more frequently.
- Propranolol inhibits P450 enzymes (CYP2C9) in the liver. Meds that are metabolized with CYP2C9, may be impacted. For example, warfarin is metabolized by CYP2C9 enzyme, so if inhibited, warfarin clearance is reduced, leading to increased warfarin levels in the blood, and higher risk of bleeding. Check INR more frequently.
- Corticosteroids, such as prednisone, can decrease the blood pressure lowering effects of propranolol. This is due to the sodium and water retention effects of prednisone, primarily seen if taking for more than a week. Monitor BP and weight.

Cautious use or avoid taking propranolol with other meds that lower heart rate, including calcium channel blockers.

Adverse/Side Effects

With IV administration, the most serious adverse effects include bronchoconstriction, hypotension, bradycardia, and signs of worsening heart failure.

Side effects include:

- CNS: drowsiness, fatigue, and cold extremities.
- CVS/ Resp: bradycardia, wheezing/bronchospasms
- Other: gastrointestinal issues, abdominal pain, nausea, erectile dysfunction,

Propranolol is safe to give to pediatric clients, with dose adjustments made according to response to medication.

Safety Warning: Abrupt withdrawal of this drug may cause exacerbation of angina or a myocardial infarction. To discontinue this drug, gradually reduce dosage over 1 to 2 weeks.

Propranolol is highly lipophilic, so if overdosed, can lead to seizures. Glucagon can be administered to reverse beta-blocker overdose effects, increasing heart rate, and myocardial contractility (Shahrokhi, M & Gupta, V. 2023).

Client Teaching

- Clients should be instructed to follow the medication dosing regimen.
- Stopping medication therapy abruptly may cause life-threatening arrhythmias. Dosages will be tapered.
- Monitor pulse and blood pressure to evaluate medication effectiveness.
- May cause orthostatic blood pressure changes and increased sensitivity to cold.

(Shahrokhi & Gupta, 2023).

Propranolol Medication Card

Now let's take a closer look at the medication Card for propranolol (Shahrokhi & Gupta, 2023). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Propranolol Medication Card

<table>
<tr><td colspan="2">Class: Beta-1 and Beta-2 receptor antagonist
Prototype: propranolol</td><td colspan="2">Indications: antianginal, antiarrhythmic, antihypertensive, post-MI treatment.
Non-CV uses: migraines, restless leg syndrome, essential tremors.</td></tr>
<tr><td colspan="4">Mechanism of Action: non-selective blocking of beta-1 and beta-2 receptors. Beta-1 receptors on cardiac myocytes, when blocked, leads to decreased contractility and heart rate. Beta-2 receptors are located in the pulmonary and vascular smooth muscle. When beta-2 is blocked, blood pressure is lowered through inhibiting sympathetic nervous system stimulation.</td></tr>
<tr><td>Administration:
Oral (IR, SR), on empty stomach. Do not crush
IV
Onset 1-2 hours,
Liver metabolism – caution with liver disease.</td><td>Side Effects:
Fatigue, hypotension, Bradycardia
May decrease libido
GI: abdominal pain, nausea
May cause wheezes/ bronchospasms</td><td>Contraindications:
May worsen heart failure.
Drug interactions including NSAIDs, corticosteroids, warfarin, cholestyramine, aluminum antacids.

Caution/avoid with asthma or COPD. Avoid with bradycardia.
Caution with diabetes clients – may mask hypoglycemia.</td><td>Nursing Considerations:
Monitor BP and HR. hold is HR less than 50 or BP less than 100. Check agency policy.
Monitor ECG & BP if IV admin.
Do not abruptly stop taking, taper over 1-2 weeks.
Do not take if pregnant
Glucagon for overdose.</td></tr>
</table>

Downloadable file (.docx): Propranolol Medication Card

Interactive Activity

An interactive H5P element has been excluded from this

version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=135#h5p-63*

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4.15 Adrenergic Receptor Agonists (Catecholamines)

This unit will review the three primary adrenergic receptor agonists. We will start with a brief overview of the endogenous role in the body under stress and to maintain homeostasis. Note that this is only a brief introduction to adrenergic agonists.

The autonomic nervous system is made up of the parasympathetic nervous system and the sympathetic nervous system. Together, they help maintain the homeostasis of the autonomic functions of the body.

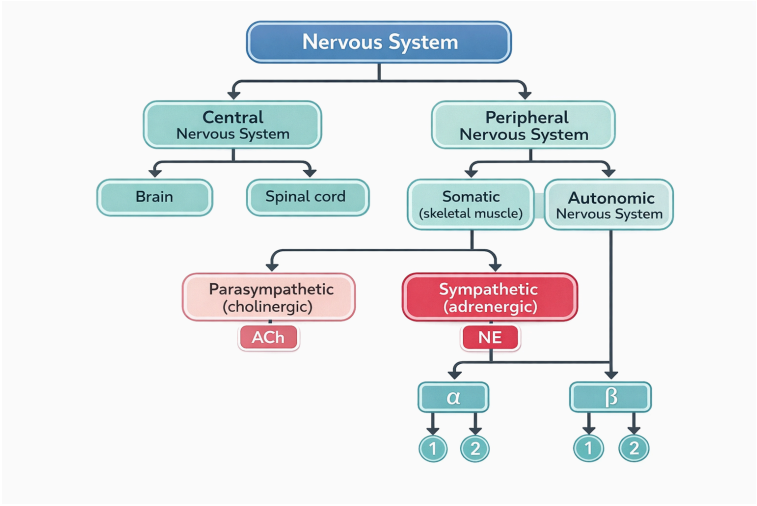

Figure 4.15a Nervous system (Sheila Obudote/ TRU Open Press) CC BY NC SA

Catecholamines are a group of similar hormones released into the bloodstream in response to physical or emotional stress. They act as neurotransmitters (NT) and hormones and regulate various physiological processes, including stress responses, cardiovascular

function, and mood regulation. The primary catecholamines are dopamine, epinephrine (adrenaline) and norepinephrine (noradrenaline).

Norepinephrine and epinephrine, released by the sympathetic nervous system and adrenal medulla, have similar actions but are released under different circumstances. Epinephrine is responsible for the fight or flight response. Under stress, the body prepares for action by releasing epinephrine resulting in an increased heart rate, increased blood pressure, dilated bronchioles and increased blood glucose levels so the body has enhanced physical abilities, energy and alertness which would be vital for survival if a threat is upon us (Khalil, Rosani, & Warrington, 2024). Norepinephrine has similar actions but it helps maintain normal functioning such as increasing alertness and arousal, constricts blood vessels, pupil dilation and affects the sleep-wake cycle.

Dopamine is both a neurotransmitter and hormone and regulates many bodily functions. It regulates mood, motivation and reward, it is essential for motor control, influences gastrointestinal motility, and acts as a vasodilator mostly in the kidneys regulating blood flow and sodium excretion (Khalil, Rosani, & Warrington, 2024).

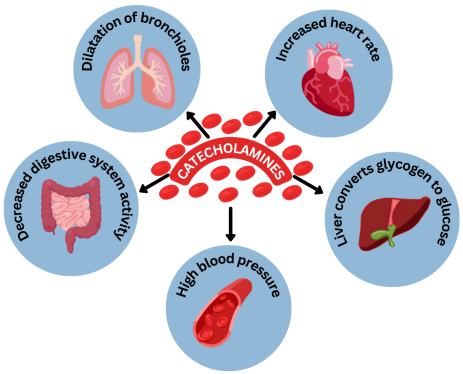

Figure 4.15b Physiological effects of catecholamines on major body systems. (TRU Open Press (2025)/Canva AI; modified from) CC BY NC SA

Adrenergic Receptors: Adrenergic receptors are located throughout the body, and when activated, they produce a wide variety of physiological responses. In the diagram below, you can see how the activation of any of the four adrenergic receptors will result in different responses. When these receptors are stimulated or blocked, they provide a balance with physiological responses, for example between vasoconstriction or vasodilation.

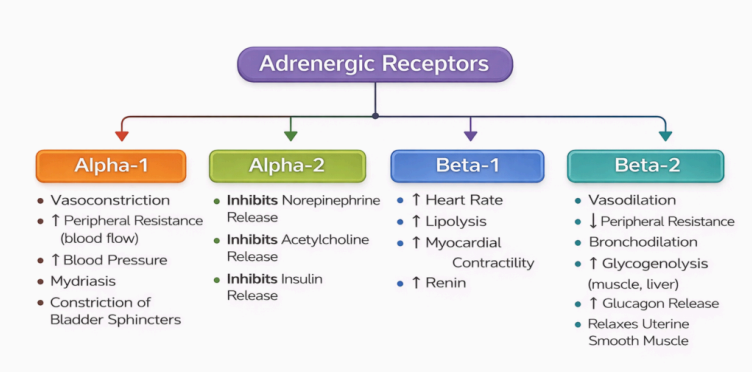

Figure 4.15c Adrenergic receptors (TRU Open Press/2025) CC-BY-NC-SA

Watch the video *Sympathetic Nervous System: Crash Course Anatomy & Physiology #14* [10:43] by CrashCourse (2015), for an overview of the sympathetic nervous system.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=136#oembed-1

When we think about adrenergic agonist medications, they have similar functions to endogenous catecholamines. When

administered, they bathe the synaptic cleft, activating the adrenergic receptor. Depending on the drug, they can activate the receptor directly, indirectly or a direct-indirect response. For example, epinephrine directly activates the adrenergic receptors. Amphetamines work indirectly by releasing the catecholamines from the vesicles within the synapse which then produces a response. Ephedrine does a mixed action, so it directly and indirectly releases the catecholamines to produce an effect (Rosenjack Burcham & Rosenthal, 2019). Recall that adrenergic antagonist medications, would block the receptor action, producing the opposite effect. For example, the beta-1 antagonistic action of Metoprolol would lead to a decrease in heart rate among other actions.

Catecholamines are often called sympathomimetics due to their effects on the sympathetic nervous system. This unit will only focus on epinephrine, norepinephrine and dopamine, but other adrenergic drugs exist. Adrenergic drugs are used for a wide variety of conditions, depending on the receptors they activate and their affinity for certain tissues. Each adrenergic drug will be examined separately due to their specific effects on the body and their uses in practice.

Did you know?

Catecholamines are named for their chemical structure. Catechol group and an amine group. Due to their chemical structure, they cannot be taken orally, have a short half-life

(so short duration of action) and cannot cross the blood brain barrier. What does this mean in a stressful situation? Endogenous epinephrine or norepinephrine are released due to a stress response, so the person can think quickly and have the energy and increased heart rate and BP to run away. But, once the stress is over, the neurotransmitters are quickly eliminated through the kidneys. Endogenous catecholamines can act within the CNS, while exogenous forms have limited CNS penetration (Rosenjack Burcham & Rosenthal, 2019). In practice, we administer these drugs to increase the heart rate or increase the BP in situations such as sepsis. They are given parenterally and depending on the use, by infusion.

Epinephrine (Adrenalin)

Epinephrine, a sympathomimetic catecholamine, is a widely used medication to manage a variety of medical conditions due to its agonist effect on both alpha (α-1 and α-2) and beta (β-1 and β-2) receptors. It works both centrally and peripherally, thereby producing a range of sympathomimetic effects. The effects are dose dependent, with lower doses activating beta receptors enhancing bronchodilation and cardiac activity (increasing heart rate and improving cardiac output). At higher doses, epinephrine activates α-receptors, inhibiting norepinephrine release and reducing sympathetic outflow. This results in vasoconstriction and increases vascular tone (Dalal & Grujic, 2024). Other effects include increasing blood glucose levels by stimulating glycogenolysis and lipolysis. This catecholamine also dilates the airways to improve oxygen intake.

Indications for Use

Epinephrine is used to treat type 1 hypersensitivity reactions (including anaphylaxis), acute bronchospasm during asthma attacks, cardiac resuscitation (treatment for ventricular fibrillation, pulseless ventricular tachycardia, asystole, pulseless electrical activity), hypotension in severe shock, or for local injection to control superficial bleeding.

Mechanism of Action

Let's take a look at how epinephrine exerts its effects, by reviewing how each receptor activation has a different function within the body.

- Alpha-1 adrenergic effects: vasoconstriction. Used for delaying absorption of local anesthetics, to control superficial bleeding and increase blood pressure.
- Alpha-2 adrenergic effects: inhibits the release of norepinephrine (which causes vasoconstriction) and increases vascular permeability. Alpha-2-receptors are also found on the pancreatic β-cells and when stimulated, insulin secretion is inhibited leading to elevated blood glucose levels.
- Beta-1 adrenergic effects: Beta-1 receptors are found mostly in the heart, and used in cardiac resuscitation to improve cardiac output, stroke volume and heart rate.
- Beta-2 adrenergic effects: Beta-2 receptors are located in the lungs, skeletal muscle and blood vessels, leading to bronchial smooth muscle relaxation and helps alleviate bronchospasm, wheezing, and dyspnea that may occur during anaphylaxis. It is also used for asthma and bronchitis (Khalil, Rosani, & Warrington, 2024; Rosenjack Burcham & Rosenthal, 2019).

Pharmacokinetics

Epinephrine is not given orally due to the rapid inactivation by two enzymes (monoamine oxidase and catechol-O-methyltransferase) in the liver before the drug can reach systemic circulation.

It is administered parenterally (intravenously (IV), subcutaneously, intramuscularly) and inhalation. If IV, it can be given IV push or by infusion depending on the rationale. Following IV administration, it is rapidly absorbed into the bloodstream and distributed throughout the body. Its half-life is very short, less than 5 minutes, so if given IV push, repeated doses are required every 3-5 minutes. It is eliminated through metabolic pathways with the liver having a primary role in clearing epinephrine from the bloodstream and from the body. Elimination, to a lesser extent, comes from the kidneys, skeletal muscles and mesenteric organs (Dalal & Grujic, 2024).

Nursing Considerations

Administration: parenteral (IV, SQ, IM) and inhalation.

Dosing and route will depend on the medical condition. For example:

- Anaphylaxis: epinephrine 0.3-0.5 mg IM or SQ into the anterolateral aspect of the thigh every 5 to 10 minutes as needed. Do not exceed 0.5 mg.

Autoinjector (Epipen): concentrations vary.

- Anaphylactic shock: IV in a 0.1 mg/mL solution or via IV infusion of 5 to 15 mcg/min, with adjustments based on clinical response. Intraosseous can be used if IV access is not available. Onset of action less than 2 minutes for IV route with duration

of action up to 30 minutes. Intranasal epinephrine 2 mg spray if IV access is not readily available. Intranasal spray with a single 2 mg spray can also be used (Dalal & Grujic, 2024).
- Cardiac resuscitation:for cardiac arrest due to asystole, ventricular fibrillation, pulseless electrical activity, or pulseless ventricular tachycardia, Epinephrine (1:10,000)1 mg IV or IO q 3-5 minutes. If no IV or IO access, inhaled dose through endotracheal tube until IV access established.

High alert med: Epinephrine is available in different concentrations and strengths. Always check the orders carefully and have a second verifier to check concentration, dosage, route and infusion pump settings (Vallerand & Sanoski, 2021). Consult a pharmacist or product monograph.

- Extravasation risk: due to the vasoconstrictive action, the administration of epinephrine should be closely monitored to prevent extravasation into surrounding tissues, as it may result in local tissue necrosis and other complications. It is contraindicated for use in fingers, toes, ears, nose, or genitalia when used with local anesthetic due to the vasoconstrictive action.
- Contraindicated in clients with narrow-angle glaucoma.
- Administer with caution to the elderly and those with pre-existing cardiovascular disease.
- When administering IV, monitor vitals (blood pressure, heart rate and respiratory rate) and cardiovascular and respiratory systems closely; if blood pressure increases sharply, give rapid-acting vasodilators. Monitor IV site for extravasation. Discard IV solution if discoloured.
- Renal impairment: epinephrine can constrict renal blood vessels and decrease urine output. Close monitoring for clients with renal disease.
- If used for bronchodilation, assess respiratory status pre and post dosages. Assess for paradoxical bronchospasm.

- Pediatric Clients: For infants and pediatric clients, dosages will be adjusted.
- Pregnancy: in the case of anaphylaxis or cardiac arrest, the use of epinephrine may be needed. Due to its effect on β2-adrenergic receptors, which causes tocolysis, epinephrine opposes oxytocin's actions on the uterus and may delay labor. It may also cause anaphylaxis-induced hypotension in pregnancy, as it may cause uterine vasoconstriction, reducing oxygen delivery to the fetus (Dalal & Grujic, 2024; Rosenjack Burchum & Rosenthal, 2019).

Adverse/Side Effects

Depending on the dose, alpha or beta receptors are activated, potentially producing different adverse effects.

- Hypertensive crisis:
    - excessive alpha-1 activation can lead to a dramatic increase in blood pressure. Cerebral hemorrhage could occur. Monitor blood pressure and heart rate closely.
- Dysrhythmias:
    - overstimulation of beta-1 receptors in the heart can lead to dysrhythmias or tachycardia. Obtain a baseline ECG and ongoing ECG monitoring for changes.
- Bronchospasm:
    - rebound bronchospasm can occur with more than three inhaled dosages. Monitor respiratory status pre and post administration.
- Hyperglycemia:
    - activation of beta-2 receptors in the liver and skeletal muscle can cause the breakdown of glycogen, leading to hyperglycemia in diabetic clients. Monitor blood glucose

more closely and anti-diabetic meds may need to be adjusted. For non-diabetic clients, the pancreas will release more insulin to maintain normal blood glucose readings.

- Tremors:
    - Due to beta-2 stimulation of the skeletal muscles, tremors is a common side effect. Tremors will decrease over time. Start with low doses to minimize the effect.

(Rosenjack Burchum & Rosenthal, 2019; Dalal & Grujic, 2024; Vallerand & Sanoski, 2021).

Example in Practice

A hospitalized client has been found unresponsive. He is pulseless and CPR is initiated. A code blue is called. The ECG shows pulseless ventricular tachycardia. Following the cardiac arrest protocol, defibrillation is provided, with continual CPR and other measures such as airway management. Epinephrine (1:10,000) 1 mg IV/IO every 3-5 minutes is ordered. Give over one minute, followed by saline flush. Epinephrine is given to increase blood pressure and stimulate heart function.

Client Teaching

For asthma or bronchodilation purposes – inhalation:

- Use correct administration technique
- Rinse mouth after treatment with warm water
- Maintain adequate hydration to avoid thick secretions.
- Notify health care provider if pregnant

For anaphylactic reactions – EpiPen use:

- Epinephrine formulated in a pen for injection is known as EpiPen. EpiPen is used for severe allergic reactions after exposure to an allergen like a bee sting. It will increase blood pressure, suppress glottal edema and counteract bronchoconstriction.
- Teach client correct EpiPen technique and usage.
- Check expiration date, store at room temperature, and protect from light.
- Effects fade after 15-20 minutes, so seek medical care immediately.

Epinephrine Medication Card

Now let's take a closer look at the medication card for epinephrine (UptoDate, 2025). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Epinephrine Medication Card

Class: Catecholamine **Prototype**: Epinephrine	**Indications:** Treatment of anaphylaxis: reversal of severe allergic reaction, bronchodilation, increased blood pressure, cardiac resuscitation, or control of superficial bleeding.		
Mechanism of Action: agonist effect on both alpha (α-1 and α-2) and beta (β-1 and β-2) receptors, producing a range of sympathomimetic effects. Effects are dose dependent, with lower doses activating beta receptors (bronchodilation and cardiac activity such as increasing heart rate and improving cardiac output). At high doses, epinephrine activates α-receptors to induce vasoconstriction and increase vascular tone			
Administration: IV, IM, SC, inhalation Discard IV solution if discolored EpiPen: SQ or IM. Inhalation: rinse mouth after treatment.	**Side Effects:** Dose dependent: Hypertension Tachycardia, tremors, hyperglycemia, Rebound bronchospasm	**Contraindications:** Caution with older adult, renal impairment Avoid with narrow-angle glaucoma. If used with local anesthetic – contraindicated for use with fingers, toes, nose or genitalia	**Nursing Considerations:** Monitor BP, HR, and respiratory status Assess peripheral site for extravasation – stop infusion and flush with NS.

Downloadable file (.docx): Epinephrine Medication Card

Norepinephrine (Noradrenaline)

Endogenous epinephrine and norepinephrine (NE) work together to prepare the body to respond to acute stress by enhancing physical performance and alertness, ensuring that energy and oxygen are efficiently delivered to vital organs and muscles (UptoDate, 2021). When norepinephrine is given as a medication, it is used as a potent vasoconstrictor or vasopressor, increasing blood pressure by narrowing blood vessels. It is also used in low doses to improve cardiac output. It is only used in critical care areas with close hemodynamic monitoring.

The trade name is levophed.

Mechanism of Action

Norepinephrine is used as a peripheral vasoconstrictor due to its activation of alpha-1 receptors. It also has an inotropic effect on the heart and dilator of coronary arteries due to beta-1 adrenergic action. It has limited beta-2 activity.

Indications for Use

- The use of norepinephrine is limited and is it is only given in critical care areas for clients with critically low blood pressure due to distributive shock or rarely, in cardiac arrest.
- At low doses, less than 2 mcg/min, the beta-1 effects are more pronounced with improved cardiac output. At higher doses of greater than 3 mcg/min, alpha-1 predominates, with vasoconstriction and increased systemic vascular resistance. NE can also increase cerebral blood flow with traumatic head injury that have impaired autoregulation (Smith & Maani, 2024).

Pharmacokinetics

Norepinephrine has a rapid onset of action with steady state obtained within five minutes. With a half life of approximately 2.5 minutes, it is administered by IV infusion. It is metabolized by the same enzymes in the liver as epinephrine, namely catechol-O-methyltransferase (COMT) and monoamine oxidase (MAO). It is excreted through the kidneys.

Nursing Considerations

High alert medication: norepinephrine is a potent vasopressor. Always have a second verifier for orders, drug calculations and infusion rates. Refer to pharmacist or drug monograph.

- Norepinephrine is only given by IV infusion due to its very short half-life and it is preferred to administer through a central line. It can be administered through a large bore peripheral line such as an antecubital fossa but very careful monitoring is required to avoid the risk of extravasation at the site. Adequate fluid resuscitation is required before and during therapy.

IV infusion

- NE is titrated to the desired arterial blood pressure or mean arterial pressure. A typical rate is 2 to 12 μg/min with close monitoring q 5-15 minutes to the set parameters in the orders. Infusions can go up to 30 μg/min depending on response. ECG monitoring is also required. Norepinephrine is only administered in critical care areas (Vallerand & Sanoski, 2021).
- Monitor urine output hourly, to ensure at least 30 mls/hr.
- Upon discontinuation, taper down slowly.

Lifespan considerations: Norepinephrine can be used for pediatric clients in septic shock. It can also be used in pregnancy, but reserved for profound hypotensive states or cardiac arrest. In the older adult, start the infusion at a low rate due to potential for renal and hepatic insufficiency with age.

Drug Interactions

- Drug interactions are similar to epinephrine. MAO inhibitors, tricyclic antidepressants and beta blockers can result in severe hypertension.
- Alpha adrenergic drugs can prevent norepinephrine's hypertensive effects (Vallerand & Sanoski, 2021).

Adverse Effects

- Many of the adverse effects are the same as with epinephrine, and related to the alpha-1 effects, and are tachydysrhythmias, angina, and hypertension.
- There is a risk of end-organ hypoperfusion, and as such, the client should be hydrated appropriately. Reflex bradycardia via the baroreceptor reflex can occur, with cardiac output remaining unchanged despite the beta-1 action (Smith & Maani, 2024).
- Extravasation: This is a potential risk with peripheral IV administration, with the med leaking into local tissue and causing significant ischemia and subsequent necrosis. If it occurs, stop the infusion, draw back any injected medication if possible, and then treat the infiltrated area with phentolamine (non-selective alpha-adrenergic antagonist). Do not continue to use that site, and preferably reestablish the infusion with a different extremity or a central line (Smith & Maani, 2024).

Dopamine

Dopamine is a versatile catecholamine that functions as both a neurotransmitter and a hormone. In the central nervous

system, dopamine is crucial for regulating mood, motivation, and reward, playing a significant role in the brain's pleasure and reward pathways. This chemical messenger is also essential for motor control and acts as a vasodilator, particularly in the kidneys, where it helps regulate blood flow and sodium excretion. Additionally, dopamine influences gastrointestinal motility and modulates the release of various hormones, making it integral to multiple physiological processes.

Indications for use

As a medication, dopamine is used to treat hypotension, bradycardia and cardiac arrest. It has dose dependent effects on targeted arteries in the kidneys, heart and brain. It is administered through an infusion.

- Low doses: 0.5-3 µg /kg/min, stimulates dopaminergic (D1) receptors on the visceral vasculature, producing vasodilation, particularly in the kidneys, which increases urinary flow. Although it can increase urine output, it does not equate to improved renal function, so its use may be limited.
- Moderate doses: 2-10 µg /kg/min, stimulates dopaminergic and beta-1 receptors, increasing cardiac output by improving contractility and also renal vasodilation.
- High doses: >10 µg /kg/min, stimulates alpha-1 receptors, resulting in peripheral vasoconstriction improving blood pressure but can cause renal vasoconstriction (Vallerand & Sanoski, 2021).

Mechanism of Action

Dopamine is derived from tyrosine and is a precursor to norepinephrine and epinephrine and is also a neurotransmitter in certain areas of the central nervous system. It is a major transmitter in the extrapyramidal system of the brain and important in regulating movement. Dopamine exerts an agonist action on beta-adrenergic receptors and indirectly by causing release of NE from storage sites in sympathetic nerve endings resulting in positive chronotropic (increased heart rate) and inotropic effects (increased cardiac contractility) on the myocardium. In the brain, dopamine acts as an agonist to the five dopamine receptor subtypes (D1, D2, D3, D4, D5) (DrugBank, 2025; Sonne, Goyal & Patel, 2025).

Pharmacokinetics

Dopamine is administered by IV infusion, with onset of action within 1-2 minutes. It has a short half life of 2 minutes, with a duration of action of 10 minutes. It is not given orally as it would undergo extensive first pass effect. Dopamine is rapidly metabolized in the liver by MAO and catechol-O-methyltransferase, with excretion primarily through the kidney.

Nursing Considerations

- **High alert medication:** As a potent vasoactive medication, always have a second verifier for orders, drug calculations and infusion rates. Refer to pharmacist or drug monograph.
- Administration: Dopamine is administered into a large peripheral vein (antecubital fossa) or central line via infusion pump. It comes prepared in premixed 250- or 500-mL bags (ie.

400 mg/500 mL), or for dilution.

- Monitoring:
  - Dopamine is given in critical care areas. Monitor BP, heart rate, ECG, central venous pressure (CVP) and urine output continuously.
  - Report any changes such as low urine output or arrythmias. If low urine output decreases without hypotension, notify prescriber as dosage may need to be reduced.
  - Monitor peripheral pulses and report any mottling or cool extremities.
  - Close monitoring of blood pressure; adjust infusion if hypotensive and report changes.
- Ensure client is well perfused and correct hypovolemia.
- Extravasation risk: careful monitoring of site for skin irritation, necrosis and sloughing of tissue. If it occurs, flush with NS and phentolamine.
- Taper dose down for discontinuation.
- Dopamine is safe to administer to pediatric and older adults, with dosages adjusted.
- Pregnancy: there is no current data on safety during pregnancy, but should not be withheld due to life-threatening risk of untreated maternal shock. (Soone, Goyal & Patel, 2025; Vallerand & Sanoski, 2021)

Adverse/Side Effects

- Adverse effects include: Arrythmias, hypotension, angina, palpitations and decreased blood flow to the extremities.
- Side effects may include nausea, headache and dyspnea.

Client Teaching

Clients should contact their health care provider immediately if experiencing unusual sweating, dizziness, heart palpitations, or chest pain.

Dopamine Medication Card

Now let's take a closer look at the medication card for dopamine (Sonne, Goyal & Patel, 2025; UptoDate, 2021; Vallerand & Sanoski, 2021). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Dopamine Medication Card

<table>
<tr><td colspan="2">Class: Catecholamine

Prototype: Dopamine</td><td colspan="2">Indications:
•Hypotension or shock: Treatment of severe hypotension or shock (e.g. septic shock and other vasodilatory shock states, cardiogenic shock, decompensated heart failure, post–cardiac arrest) that persists during and after adequate fluid volume replacement.
•Increased blood flow to kidneys causing increased urine output
•Increased cardiac output and elevated blood pressure</td></tr>
<tr><td colspan="4">Mechanism of Action: exerts an agonist action on beta-adrenergic receptors and indirectly by causing release of NE from storage sites in sympathetic nerve endings resulting in positive chronotropic (increased heart rate) and inotropic effects (increased cardiac contractility) on the myocardium. With low doses, renal vasodilation due stimulating dopaminergic receptors.</td></tr>
<tr><td>Administration:
IV infusion only
Administer with a pump.
Low doses: 0.5-3 µg renal vasodilation
Moderate doses: 2-10 µg/kg/min: increases CO, renal vasodilation
High doses >10 µg/kg/min: Vasoconstrictor with increased BP.</td><td>Side Effects:
Hypotension, Tachycardia, Palpitations, Dyspnea
Decreased blood flow to extremities
If urine flow decreases without hypotension, notify prescriber because dosage may need to be reduced</td><td>Contraindications:
Tachydysrhythmias
Pheochromocytoma

Safety not established with pregnancy
Lower doses with older adult

Drug interactions: MAO inhibitors, anti-depressants, general anesthetics, beta blockers</td><td>Nursing Considerations:
Monitor BP, HR, ECG, CVP
Monitor urine output.
Avoid hypovolemia

Assess peripheral site for extravasation – stop infusion and flush with NS with phentolamine.</td></tr>
</table>

Downloadable file (.docx): Dopamine Medication Card

Interactive Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=136#h5p-64*

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=136#h5p-65*

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=136#h5p-66*

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*]:pointer-events-auto scroll-mt-[calc(var(--header-height)+min(200px,max(70px,20svh)))]" dir="auto" data-turn-id="request-WEB:27cfa88c-f002-485f-b113-249fa0f3b17d-11" data-testid="conversation-turn-24" data-scroll-anchor="true" data-turn="assistant">

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Note. Illustration generated using Canva AI (Premium) by TRU Open Press (2025). The image is original to this work and licensed under the same Creative Commons CC BY-NC-SA licence as the text unless otherwise noted.

4.16 Clinical Reasoning and Decision Making Activities

Clinical Reasoning and Decision Making Learning Activities

Test your knowledge and application.

Practice applying your knowledge regarding ANS neuroreceptors to the following client scenarios:

1. A client begins a nicotine patch in an attempt to stop smoking. The client reports feelings of nausea, weakness, and a rapid heartbeat. What is the likely cause of these symptoms, and what is the nurse's best response?
2. A client with benign prostatic hyperplasia (BPH) has a new order for tamsulosin. He asks, "How will tamsulosin help me? I already take so many pills.
    a. What is the nurse's best response?
    b. What does the nurse plan to monitor carefully, especially after administering the first dose of tamsulosin?
3. A client with asthma is taking albuterol to help when she feels increased shortness of breath.
    a. How will albuterol assist in her breathing? The client states, "After I take albuterol, it feels

like my heart is racing."

b. What is the likely cause of this symptom?

c. What is the nurse's best response to the client's concern?

4. A client with high blood pressure is prescribed propranolol.

   a. How will propranolol help to lower his blood pressure?

   b. What will the nurse assess before administering the propranolol? The nurse listens to the client's lungs a few hours after administering propranolol and notices new wheezing.

   c. What could be a potential cause of this new finding?

   d. What is the nurse's next best response?

5. A client is prescribed metoprolol to help control his atrial fibrillation, an irregular heart rhythm.

   a. What will the nurse assess before administering the metoprolol?

   b. What findings would cause the nurse to call the provider before administering the metoprolol? Upon reassessment the next day, the nurse notices a new finding of edema in the client's feet and lower legs.

   c. What could be a potential cause of this new finding?

   d. What is the nurse's next best response?

6. A client with an acute episode of heart failure is

admitted and is prescribed dobutamine.

a. How will dobutamine improve the client's condition?
b. What will the nurse monitor carefully during administration?

Note: Answers to the Clinical Reasoning Activity questions can be found in the "Answer Key" sections at the end of the book.

CHAPTER 5: NEUROLOGICAL SYSTEM: MEDICATIONS FOR MOOD AND COGNITION

5.0 CNS Regulation, Mood, and Cognition Introduction

Learning Objectives

1. Review the structure and function of the central nervous system, including the role of neurotransmitters.
2. Understand the classifications and actions of drugs related to the central nervous system (CNS), mood, and cognition.
3. For each drug classification, describe the mechanism of action, therapeutic effects, side and adverse effects and nursing considerations.
4. Identify considerations and implications of using CNS, mood, and cognitive medications across the lifespan.
5. Apply these concepts to application questions and clinical scenarios.

Key Terms

- **action potential**
- **acute dystonia**
- **affect**
- **akathisia**

- **anxiety**
- **blood-brain barrier**
- **bradykinesia**
- **central nervous system**
- **chemical synapse**
- **cognition**
- **"DRESS"**
- **dystonia**
- **electrical synapse**
- **extrapyramidal symptoms**
- **gait disturbance**
- **hypertensive crisis**
- **mania**
- **mood**
- **nerve**
- **neuroleptic malignant syndrome**
- **neurons**
- **mechanism of action**
- **methicillin-resistant S. aureus**
- **narrow-spectrum antimicrobial**
- **pathogen**
- **prototype**
- **resistance**
- **sensitivity analysis**
- **superinfection**
- **synergistic interaction**
- **time dependent**
- **trough**
- **vancomycin-resistant S. aureus**

In Canada, more than 3.6 million people or 10% of the population are experiencing a neurological condition or disorder, according to a nationwide study conducted in 2014, the National Population Health Study of Neurological Conditions. It is projected that this number will only increase over the next 20 years due to the aging population (Government of Canada, 2017). "Those with chronic neurological conditions experience higher stress levels and a higher prevalence of self-diagnosed mood or anxiety disorders. Many suffer functional impairments with regard to cognition, mobility, dexterity, bowel, and bladder control." The impact on quality of life, supportive care and health resources is significant. Medications to manage or treat the wide variety of neurological conditions is considerable, with meds used to improve cognition and mood, alleviate pain, and improve mobility issues (Appireddy et al, 2020).

To effectively treat these conditions, an understanding of the disorder is required for the researchers to develop effective treatments. The challenge is that the central nervous system (CNS) is a complex organ system involving the brain and spinal cord. Together, they are collectively responsible for collecting, interpreting and processing sensory information. The complexity

of the CNS comes from the anatomic structure and neurochemical intricacies that researchers are still trying to fully understand. Typically, research is initially carried out on animal subjects. Due to the uniqueness of the human brain in comparison to other species, as well as the inability to fully assess the therapeutic response of treatments on animal subjects, understanding the brain and implementing effective treatments is difficult. The other challenge is the complexity of neurological disorders. For example, there are many types of depression, with a variety of symptoms and the response to medications can vary considerably. As such, although CNS drugs are used extensively to treat or manage many neurological conditions, there is still much unknown. The complexity of the nervous system and understanding of the brain can make treating and preventing diseases that affect this system complicated (OpenStax, 2025).

Due to the extensive nature of central nervous system conditions, the next three chapters will focus on different CNS medication classifications. In this chapter, it will begin with a review of the CNS, its structures, functions and neurotransmitters, followed by Unit 5.2 will review more common neurological conditions. The rest of the units in this chapter will focus on the different categories of CNS medications.

References:

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5.1 CNS Regulation, Mood, and Cognition Concepts

Concepts Related to the CNS, Mood, and Cognition

This resource provides a basic introduction to the concepts related to the central nervous system and cognition in connection with pharmacology. For a more detailed exploration of the central nervous system, refer to an anatomy and physiology resource.

The concept of **cognition** is defined as "the process of thought that embodies perception, attention, visuospatial cognition, language, learning, memory, and executive function with the higher-order thinking skills of comprehension, insight, problem-solving, reasoning, decision making, creativity, and metacognition" (Giddens, 2017).

This chapter also addresses **mood**, **affect and anxiety** (Giddens, 2017).

The concept map in Figure 8.2a summarizes information related to the concept of mood, affect, and the CNS. You are encouraged to revisit this map after you have completed the chapter. You may also wish to develop your own concept map related to other CNS concepts in this chapter.

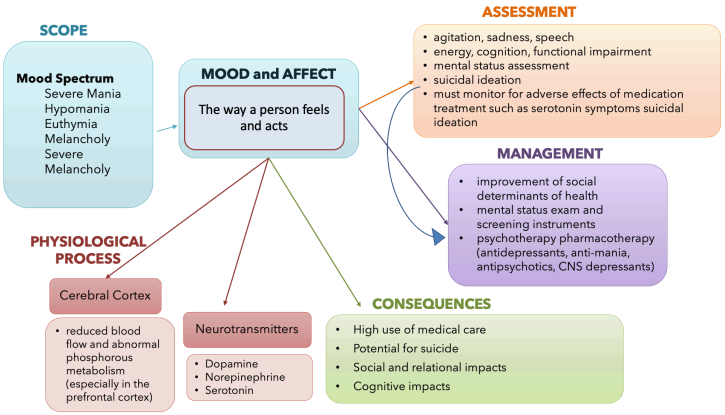

Figure 5.1a Mood and Affect Concept Map [Image description]

Overview of the Central Nervous System and Processes

Before we can begin to understand how different medications influence the brain, we need to review the central nervous system. The nervous system can be divided into two major regions: the central and peripheral nervous systems. The **central nervous system (CNS)** is the brain and spinal cord, and the **peripheral nervous system (PNS)** is everything else. The brain is contained within the cranial cavity of the skull, and the spinal cord is contained within the vertebral cavity of the vertebral column.

It is a bit of an oversimplification to say that the CNS is what is inside these two cavities and the peripheral nervous system is outside of them, but that is one way to start to think about it. In actuality, there are some elements of the peripheral nervous system that are within the cranial or vertebral cavities. The peripheral nervous system is so named because it is on the periphery—meaning beyond the brain and spinal cord. Depending

on different aspects of the nervous system, the dividing line between central and peripheral is not necessarily universal.

Brain

The brain is a highly complex organ with over 86 billion neurons that communicate between each other and to other parts of the body. The brain acts as a command center with numerous functions including processing sensory information, regulating body functions, controlling movement and overseeing cognition (The Society of Neuroscience, nd).

The brain is divided into different regions with each region designed to do special tasks or abilities. Basic brain structures and their functions are listed below (The Society of Neuroscience, nd; Adams et al, 2018).

Table 1.1

Anatomy of the Brain	**Function**
Cerebrum: two large hemispheres containing cerebral cortex and corpus callosum.	Carry information from one side of the brain to the other parts. "thinking" part of the brain, responsible for perception, speech, motor movements, memory and smell.
Cerebral Cortex: within the cerebrum, divided into lobes	Frontal lobe: coordinate voluntary movements and speech, memory and emotion, complex thought (ie. planning and problem-solving), and many aspects of personality (moral and ethical behaviour). Parietal: integrate sensory signals from the skin, process taste, and process some types of visual information. Occipital: process visual information Temporal: hearing, equilibrium, emotion and memory (amygdala), visual processing.
Thalamus	integrates sensory information and relays it to other parts of the brain,
Hypothalamus	which sends hormonal signals to the rest of the body through the pituitary gland.
Cerebellum	coordinates voluntary movements and helps the brain learn new motor skills. It also has roles in spatial and temporal perception
Brainstem: includes midbrain, pons and medulla oblongata.	Pons: influences breathing and posture Midbrain: motor control (especially eye movement), auditory and visual processing, and regulating alertness, sleep, and pain; it is a key relay center, connecting sensory and motor pathways between the forebrain and the rest of the brainstem. medulla: carries nerve pathways connecting the brain to the spinal cord and contains neural networks that help control basic functions like swallowing, heart rate, and breathing.

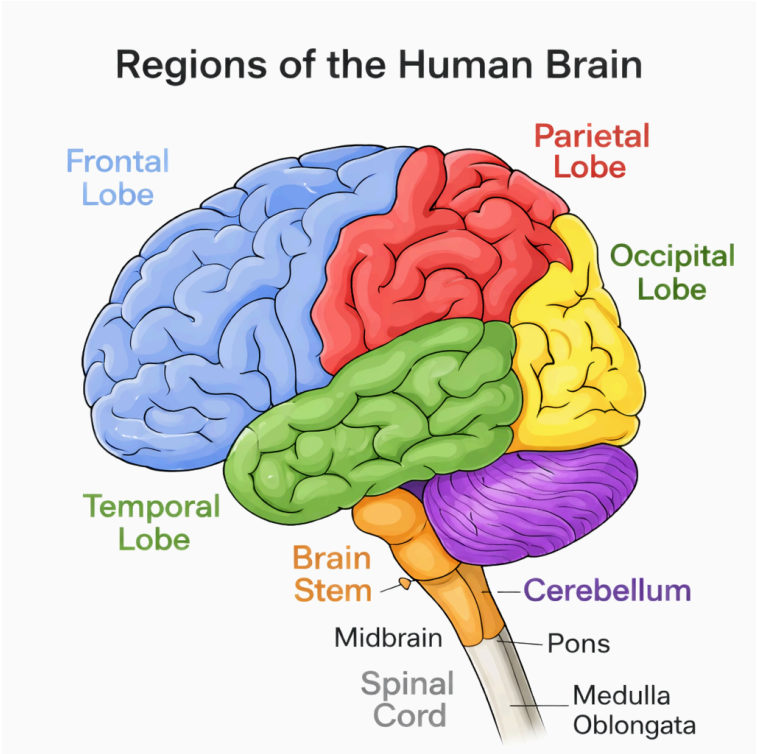

Figure 5.1b Regions of the Brain

Watch the supplementary video explaining the brain and its function.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=260#oembed-1

Video 5.1c. Neuroscientifically Challenged (April 4, 2025). Major Brain Structures and their Functions. Major Brain Structures and Their Functions

The Peripheral Nervous System

The peripheral nervous system is further divided into the autonomic nervous system and the somatic nervous system, which are further discussed in the Autonomic Nervous System chapter in this book. (See Figures 5.1d and 5.1e for illustrations of the central and peripheral nervous systems).

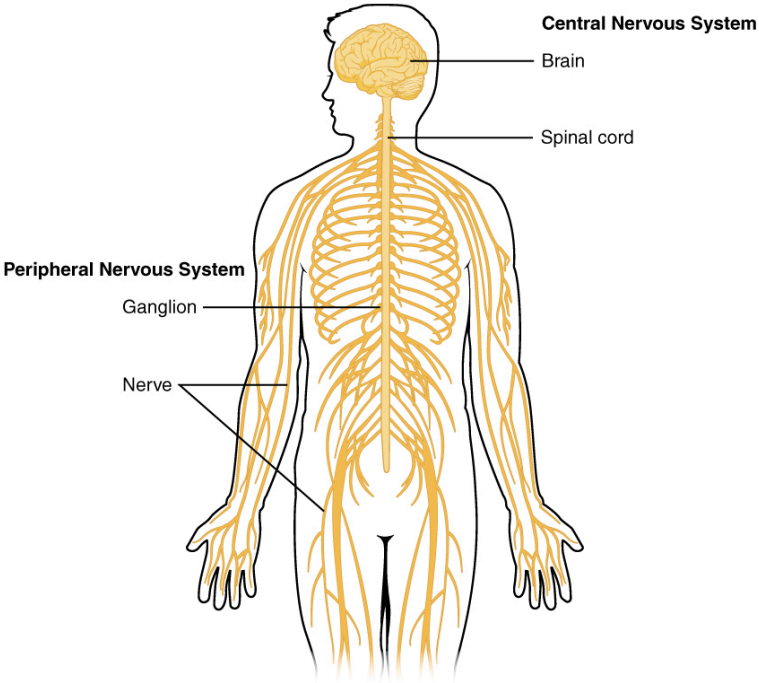

Figure 5.1d The Central and Peripheral Nervous System

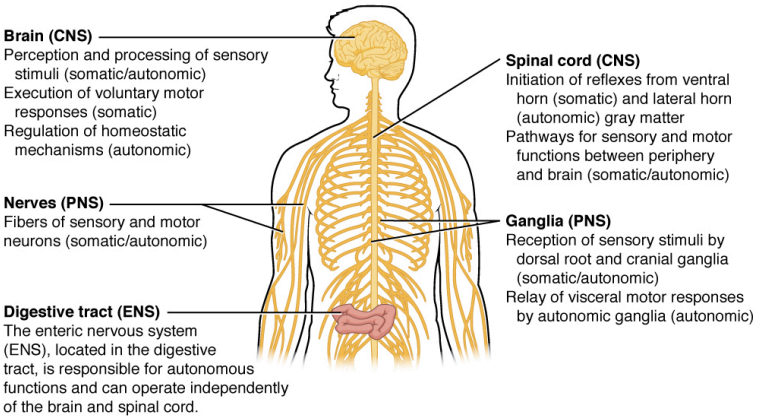

Figure 5.1e Somatic, Autonomic, and Enteric Structures of the Nervous System *[Image description]*

Review more detailed information about the nervous system function using this OpenStax link: Basic structure and function of the nervous system

Communication in the Nervous System

Neurons are the primary cells involved in processing information. There are thousands of individual cell types based on morphology, location, connectivity and chemistry (Hyman, 2005). Neurotransmitters (NTs) are chemical substances that carry information between the neurons and they play a central role in brain function and are involved in receiving, processing and transmitting information. Your brain communicates with electrical impulses that signal a release of a neurotransmitter, which then binds to the targeted cell.

Understanding this communication will help you put the pieces

together when you are trying to understand the mechanism of action of a medication that works by influencing neurotransmitters.

See Figure 5.1e for an illustration of the major elements in **neuron** communication.

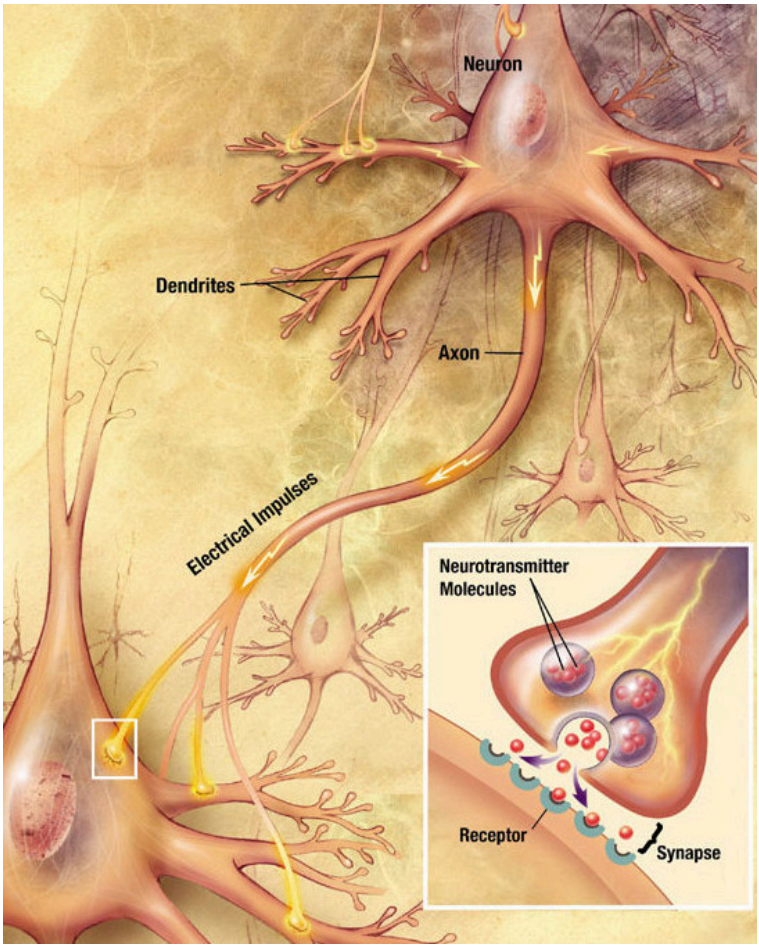

Figure 5.1f Major Elements in Neuron Communication

There are two types of connections between electrically active cells: chemical synapses and electrical synapses. A **chemical synapse**, a

chemical signal—namely, a neurotransmitter—is released from one cell and affects another cell. In comparison, in an **electrical synapse**, there is a direct connection between the two cells so that ions can pass directly from one cell to the next. In this unit, we will be focusing on the communication of a neurotransmitter in a chemicalsynapse. Once in the synaptic cleft, the neurotransmitter diffuses the short distance to the postsynaptic membrane and can interact with neurotransmitter receptors. Receptors are specific for the neurotransmitter, and the two fit together like a key and lock. One neurotransmitter binds to its receptor and will not bind to receptors for other neurotransmitters, making the binding a specific chemical event (OpenStax, 2025). (See Figure 5.2e for an illustration of a synapse).

When the neurotransmitter binds to the receptor, the cell membrane of the target neuron changes its electrical state, and a new graded potential begins. If that graded potential is strong enough to reach **threshold**, the second neuron generates an **action potential**. The target of this neuron is another neuron in the **thalamus** of the brain, the part of the CNS that acts as a relay for sensory information. The thalamus then sends the sensory information to the cerebral cortex, the outermost layer of gray matter in the brain, where conscious perception of that stimulus begins (OpenStax, 2025).

Neurotransmitters simplified

A signal is sent: an electrical impulse (action potential) travels down a neuron.
Neurotransmitters released: this triggers chemical messengers to be released into the synapse.
Message received: these messengers bind to receptors

on the next neuron.
The signal is passed on or stopped: the receiving neuron is either activated (excited), calmed (inhibited), or influenced in other ways.
Enzyme clean up: any leftover neurotransmitters are either broken down by enzymes or taken back up by the original neuron (reuptake).
Guy-Evans, 2025.

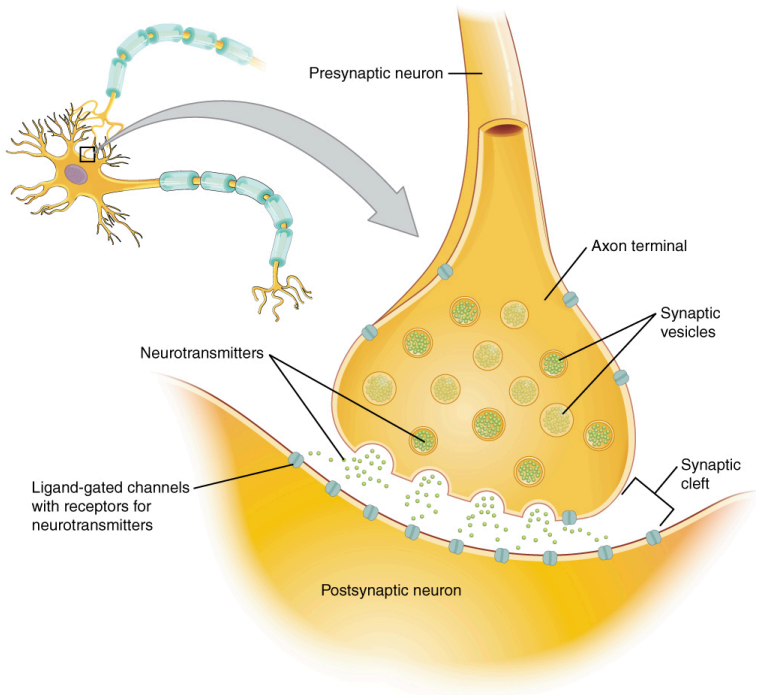

Figure 5.1g Major Elements in Neuron Communication

Chemical Synapse.jpg by Young et al., 2018 under OpenStax Anatomy and Physiology the Creative Commons Attribution 4.0 International license.

A supplementary video explaining neuron communication via action potentials is provided below.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=260#oembed-2

Neuron Communication via Action Potentials

YouTube: Anatomy and Physiology: Nervous System: Action Potential Generation V2.0. [Video].

Types of Neurotransmitters

There a number of different types of neurotransmitters. In the CNS, there are at least 21 neurotransmitters and likely more that have yet to be fully discovered. Some NTs are exclusive to the CNS, and others are in both the peripheral nervous system, autonomic nervous system or both. The response of the NT when released from the presynaptic cleft, crosses the synapse, and then either activates or inhibits the receptor on the postsynaptic neuron.

There are six groups of neurotransmitters. Biogenic Amines, amino acids, purines (ie. Adenosine), opioid peptides (ie. Endorphins, encephalins), and nonopioid peptides (ie. Oxytocin, substance P, vasopressin). Acetylcholine is part of the cholinergic

system. Biogenic amines and amino acids are explained in more detail below (Rosenjack Burchum & Rosenthal, 2019).

Amino Acids

One group of neurotransmitters is amino acids. GABA (gamma-aminobutyric acid) is an example of an amino acid neurotransmitter. They each have their own receptors and do not interact with each other. Amino acid neurotransmitters are eliminated from the synapse by re-uptake. A pump in the cell membrane of the presynaptic element, or sometimes a neighbouring glial cell, will clear the amino acid from the synaptic cleft so that it can be recycled, repackaged in vesicles, and released again.

Biogenic Amine (also known as monoamine)

Another class of neurotransmitters is the biogenic amine, a group of neurotransmitters that are enzymatically made from amino acids. This category includes catecholamines, serotonin, and histamine. Serotonin is derived from tryptophan and is the basis of the serotonergic system, which has its own specific receptors. It regulates mood, appetite and gut motility.

Other biogenic amines are made from tyrosine and include the catecholamines dopamine, norepinephrine, and epinephrine. They act as neurotransmitters and hormones regulating cardiovascular, neural and metabolic functions. Dopamine is part of its own system, the dopaminergic system, which has dopamine receptors. Some biogenic amines have mixed effects. For example, dopamine receptors that are classified as D1 receptors are excitatory, whereas D2-type receptors are inhibitory.

Norepinephrine and epinephrine belong to the adrenergic neurotransmitter system. The two molecules are very similar and

bind to the same receptors, which are referred to as alpha- and beta-receptors. Histamine is also a biogenic amine and has an important role in immune responses, allergic responses and gastric acid secretion.

Functions of Neurotransmitters

There are three main functions of neurotransmitters:

- Excitatory: Increases the chance of the neuron firing.
- Inhibitory: Calming effect, reduces the chance of firing.
- Modulatory: Adjust the activity of other neurotransmitters. Ie. Dopamine.

Excitatory Neurotransmitters	
Acetylcholine (in CNS) Role in learning, memory Regulates mood, mania, sexual aggression Activates muscle action **Decreased:** Alzheimer's Disease, Parkinson's Disease **Increased:** schizophrenia	**Norepinephrine (noradrenaline)** Role in mood, attention, arousal Fight or flight response to stress (stimulates SNS) Contracts blood vessels, increases blood flow **Decreased:** depression, loss of interest **Increased**: mania, anxiety, schizophrenia, addiction
Adrenaline Similar to norepinephrine, but more hormone-like. Heightens alertness and prepares the body for action. **Increased:** high blood pressure, stress	**Glutamate** Main excitatory neurotransmitter in the brain Crucial for learning and memory Works with GABA to control many brain function including level of excitation & regulates action potential of cells. **Decreased** (NMDA): psychosis **Increased** (NMDA): neurotoxic, Alzheimer's, stroke
Inhibitory Neurotransmitters	
Gamma-aminobutyric acid (GABA) Main calming neurotransmitter Helps regulate anxiety, motor control, and sleep **Decreased**: anxiety, seizures, mood disorders **Increased:** sedation, reduction of anxiety	**Dopamine** Acts as both excitatory and inhibitory, depending on receptor. Modulates affective states and emotions Involved in pleasure, motivation, movement, and learning Stimulates hypothalamus to release hormones **Decreased**: Parkinson's, depression **Increased**: schizophrenia, mania, ADHD

Glycine (in CNS) Slows nerve signals, controls motor coordination, in brainstem and spinal cord Controls vision and pain perception	**Serotonin** Has mixed modulatory effects Regulates mood, sleep, appetite, and digestion **Decreased:** depression, anxiety, insomnia **Increased:** anxiety, insomnia

Guy-Evans, 2025; Halter et al, 2019

Neurotransmitters play such a central role in brain function, that an imbalance of NTs can lead to many psychiatric, neurologic, and physiological conditions. Treatment with medications for many conditions target neurotransmitter receptors and other proteins involved in neurotransmitter synthesis and inactivation. The medications that are used to treat CNS disorders mimic or block the neurotransmitter based on the imbalance caused by the condition. Medications are used to either stimulate or depress the effect of the neurotransmitter. For example, CNS depressants alter the brain by decreasing the excitability of neurotransmitters, blocking their receptor site, or increasing the inhibitory neurotransmitter. On the other hand, CNS stimulants increase brain activity by increasing the excitability of neurotransmitters, decreasing the inhibitory neurotransmitters, or blocking their receptor sites (Velarde, 2018).

Norepinephrine is often associated with the fight-or-flight response. Abnormal levels of this neurotransmitter are also associated with depression, decreased alertness and interest, along with possible palpitations, anxiety, and panic attacks. Dopamine is strongly linked to motor and cognition. This neurotransmitter influences movement and can be associated with ADHD, paranoia, and schizophrenia. Serotonin is heavily involved in many bodily processes. Abnormal levels of serotonin can affect sleep, libido, mood, and temperature regulation. Alterations of this neurotransmitter have been linked to many mental health issues such as depression, bipolar disorder, anxiety, and body disorders. GABA (gamma-aminobutyric acid) can act as an inhibitory neurotransmitter. GABA assists with communication in the brain,

and if this neurotransmitter is low, it has been linked to issues such as anxiety, seizures, mania, and impulse control. The neurotransmitter glutamate works as an excitatory neurotransmitter and works with GABA to control other functions of the brain (Velarde, 2018).

Image Descriptions

Figure 5.2a Mood and Affect Concept Map

Mood and affect – the way a person feels and acts.
Scope – mood spectrum:

- severe mania
- hypomania
- euthymia
- melancholy
- severe melancholy

Physiological process

- Cerebral cortex
  - reduced blood flow and abnormal phosphorous metabolism (especially in the prefrontal cortex)
- Neurotransmitters
  - dopamine
  - norepinephrine
  - serotonin

Assessment

- agitation, sadness, speech
- energy, cognition, functional impairment
- mental status assessment

- suicidal ideation
- must monitor for adverse effects of medication treatment such as serotonin symptoms and suicidal ideation

Management

- improvement of social determinants of health
- mental status exam and screening instruments
- psychotherapy pharmacotherapy (anti-depressants, anti-mania, antipsychotics, CNS depressants).

Consequences

- high use of medical care
- potential for suicide
- social and relational impacts
- cognitive impacts

[Return to Figure 8.2a]

Figure 8.2c Somatic, Autonomic, and Enteric Structures of the Nervous System

Brain (CNS)

- perception and processing of sensory stimuli (somatic/autonomic)
- execution of voluntary motor responses (somatic)
- regulation of homeostatic mechanisms (autonomic)

Spinal cord (CNS)

- initiation of reflexes from ventral horn (somatic) and lateral horn (autonomic) gray matter
- pathways for sensory and motor functions between periphery and brain (somatic/autonomic)

Nerve (PNS)

- fibers of sensory and motor neurons (somatic/autonomic)

Ganglia (PNS)

- reception of sensory stimuli by dorsal root and cranial ganglia (somatic/autonomic)
- relay of visceral motor responses by autonomic ganglia (autonomic)

Digestive tract (ENS)

- the enteric nervous system (ENS), located in the digestive tract, is responsible for autonomous functions and can operate independently of the brain and spinal cord.

Images:

- 5.1a Mood and Affect Concept Map [Image description]
- 5.1b Lobes of the brain identified (Sheila Odubote/ TRU Open Press)
- 5.1c "1201 Overview of Nervous System.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/12-1-basic-structure-and-function-of-the-nervous-system ↵
- 5.1d "1205 Somatic Autonomic Enteric StructuresN.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/12-1-basic-structure-and-function-of-the-nervous-system ↵
- 5.1e "Chemical synapse schema cropped.jpg" by Looie496 is licensed under public domain. Access for free at https://med.libretexts.org/Bookshelves/Anatomy_and_Physiology/

Book%3A_Anatomy_and_Physiology_(Boundless)/10%3A_Overview_of_the_Nervous_System/10.1%3A_Introduction_to_the_Nervous_System/10.1A%3A_Organization_of_the_Nervous_System ↵

- "1225 Chemical Synapse.jpg" by Young, KA., Wise, JA., DeSaix, P., Kruse, DH., Poe, B., Johnson, E., Johnson, JE., Korol, O., Betts, JG., & Womble, M. is licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/12-5-communication-between-neurons ↵
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5.2 Diseases and Disorders of the CNS, Mood, and Cognition

Now that we have reviewed basic concepts of neurotransmitters and their function, let's review common conditions and disorders related to the central nervous system. Conditions that affect the central nervous system can be categorized into neurological or cognitive and mood disorders.

Although neurological disorders are more prevalent in Canadians over the age of 65, many conditions are not exclusive to the older population. Some conditions impact clients in their 20s or 30s such as brain or spinal tumours, dystonia, epilepsy, multiple sclerosis, or migraines. Some disorders first appear more in childhood, such as muscular dystrophy. Other conditions only appear in the mid to older adult, such as amyotrophic lateral sclerosis (Lou Gehrig's disease), Alzheimer's disease and other dementias (Government of Canada, 2025).

Mood disorders involve dysfunction in the areas of behaviour and personality and can have a significant impact on the person's ability to function. The causative factors of many conditions are multifaceted including biochemical, structural, genetic or traumatic events and stressors. Mood disorders are an umbrella term that includes anxiety and panic disorders, psychoses and depressive disorders, all of which have subsets of conditions that can be mildly disruptive to debilitating (Varcarolis, E. M., 2017). Mood disorders such as depression and anxiety are prevalent among our young adult population but can occur at any age.

Due to the extensive list of neurological disorders and mental health conditions, only the more common conditions will be reviewed.

- Mental health conditions: anxiety, depression, bipolar, schizophrenia and attention deficit hyperactivity disorder (ADHD).
- Seizure disorders,
- Neurodegenerative diseases:
    - Parkinson's disease
    - Alzheimer's disease and dementia

Additional supplementary videos about CNS disorders are available at Khan Academy

Cognition and Mood Disorders

Mental health challenges are common for most people at some point in their lives. Some people experience more persistent or severe symptoms that last longer and have an impact on their daily lives. Mood disorders are characterized by a disruption in thinking, mood, or behaviour and are associated with distress and impaired functioning (World Health Organization, 2026).

In 2022, the Mental Health and Access to Care Survey was conducted to learn about the prevalence of mental health disorders in Canada and access to mental health services (Statistics Canada, 2025). Mental health disorders, particularly mood or anxiety disorders, have been increasing over the last 10 years in Canada. In 2022, more than 5 million people in Canada have been diagnosed with a mood, anxiety or substance use disorder (Statistics Canada, 2025). Generalized anxiety disorder for Canadians over 15 years of age has doubled from 2012 to 2022 to 5.2%, with similar increases in those diagnosed with major depressive episodes and bipolar disorders. Globally, there is a general decline in mental health, with an increase in depression and anxiety particularly more prevalent with the onset of COVID-19 pandemic in 2020 (Stephenson, 2023). In Canada, women are more effected with mood or anxiety

disorders than men. From 2012 to 2022, there was an increase from 9.0% to 18.4% in women experiencing a major depressive episode. Substantive increases were also shown for other conditions such as generalized anxiety disorder and social phobias (Stephenson, 2023). These statistics help health care providers understand the health care needs of the population and to help ensure supports and access to treatment are in place such as community mental health counselling.

Psychiatric and mental health disorders are often due to an imbalance of neurotransmitters. There are many reasons for this imbalance, but can have genetic, environmental, hormonal changes, and exposure to toxins as some factors. The overall goal of treatment is to relieve or reduce dysfunctional thoughts and improve overall functioning. This is accomplished with modulating neurotransmitters, which is the basis of CNS drugs.

This unit will provide only a general overview on the more common mental health disorders as a precursor to understanding medications to treat some of these conditions.

Anxiety

Anxiety disorders are a group of conditions marked by pathological or extreme anxiety or dread. Types of anxiety include separation anxiety, generalized anxiety, social phobias, social anxiety, panic disorders and selective mutism. People with anxiety experience disturbances of mood, behavior, and most systems in the body, making them unable to continue with everyday activities. Many feel anxious most of the time for no apparent reason (Melrose, n.d.).

Anxiety is different from fear. Fear is a person's response to an event or object. The psychiatric disorder of anxiety occurs when the intensity and duration of anxiety do not match the potential for harm or threat to the affected person. Anxiety can be expressed with physical symptoms or behaviorally (Melrose, n.d.). This list is

not exhaustive but demonstrates the wide range of symptoms the client may experience and that the nurse needs to consider as part of their assessment (Chand, Marwaha, & Bender, 2023).

Signs and Symptoms of Anxiety

Cognitive symptoms: fear of losing control, fear of negative evaluation by others; frightening thoughts, mental images, or memories; perception of unreality or detachment; poor concentration, confusion, narrowing of attention, hypervigilance for threat; poor memory; and difficulty speaking.

Physiological symptoms: headache, increased heart rate, palpitations; shortness of breath, rapid breathing; chest pain or pressure; light-headed; sweaty, hot flashes, nausea, upset stomach, diarrhea; trembling, unsteadiness.

Behavioral symptoms: avoidance of threat cues or situations; escape, flight; pursuit of safety, reassurance; restlessness, agitation, pacing; hyperventilation; freezing, and difficulty speaking.

Affective symptoms: nervous, tense, fearful, edgy, and impatient.

Figure 8.3a Many clients with anxiety experience difficulty concentrating

Treatment consists of psychotherapy, pharmacotherapy, or a combination of both. Medications to treat the anxiety can include anti-depressants, anxiolytics, and even beta blockers (propranolol for social phobias). These medications will be explored later on in this chapter.

Psychotherapy is almost always recommended. Cognitive-behavioural therapy is one of the most effective therapies that focuses on the client identifying and modifying characteristic maladaptive thinking patterns and beliefs that trigger and maintain symptoms (Chand, Marwaha, & Bender, 2023). The client learns better ways to react and adapt to anxiety-producing situations. Other non-pharmacological interventions to decrease anxiety include relaxation techniques such as deep breathing, exercise, and support groups.

Learn more about anxiety from the Canadian Mental Health Association.

Attention-Deficit/Hyperactivity Disorder

Attention-deficit/hyperactivity disorder (ADHD) is one of the

most common neurodevelopmental disorders. It is characterized by hyperactivity, lack of impulse control, and/or lack of attention that interferes with how a person functions. ADHD is often diagnosed during childhood, and affects about 5% of the school age population. Boys are three times more likely to develop ADHD than girls. Symptoms develop in childhood and these traits can lead to poor performance in school (difficult with focusing, sitting still), difficulty with peer and family relationships and increased motor activity that may be inappropriate (Statistics Canada, 2015; Varcarolis, 2017). Approximately 50% of cases continue into adulthood, and can impact work performance and personal relationships.

Presenting Symptoms of ADHD

- Hyperactivity (fidgets, talks excessively, can't sit still)
- Impulsivity (interrupts, difficulty waiting for turn, impatience)
- Lack of attention (difficulty paying attention, easily distracted, does not pay attention to social cues)

For a diagnosis of ADHD or ADD, symptoms must be present in at least two settings, such as at home and at school. ADHD in adults may present with an associated symptom such as procrastination, lack of motivation, labile moods or disorganization (Halter, Pollard & Jakubec, 2019).

Treatment includes medication such as CNS stimulants and non-stimulants, behaviour management, psychotherapy and family support.

Figure 8.3b Clients with ADHD may have difficulty in focusing on details

Depression

Depression is defined as a persistent feeling of sadness and loss of interest (Chand & Arif, 2023). It can be characterized by episodes of depressed mood, that includes reduction in energy, lower mood, and decrease in activity. Furthermore, the capacity for enjoyment, interest and concentration is reduced, as well as sleep disturbances, fatigue and appetite issues (World Health Organization, 2021). A depressive disorder is diagnosed when the symptoms reach a threshold and lasts at least two weeks. If these problems become chronic or recurrent it can lead to impairment in an individual's ability to care for themselves and in severe cases, it can lead to suicide.

Depression is a broad term to identify a number of depressive disorders such as seasonal affective disorder, major depressive

disorder, persistent depressive disorder (dysthymia), premenstrual dysphoric disorder, and depressive disorder due to another medical condition.

In Canada, 1% of men and 2% of Canadian women are clinically depressed at any point in time and about 5% of men and 10% of women will experience clinical depression at some point in their life (Canadian Psychological Association, 2021). It is anticipated that major depressive disorders will be the second leading cause of disability globally (World Health Organization, 2021). Regardless of where a nurse works, they will care for someone with depression or the primary condition is complicated by depression (Halter, Pollard & Jacubec, 2019, pg. 245). The causative factors include both genetic and environmental factors (traumatic events, life events).

To be diagnosed with Major Depressive Disorder (MDD), the most severe form of depression, five of the following symptoms must be present within a two-week period (Chand & Arif, 2023; Mayo Clinic, 2018).

Signs and Symptoms of Depression

- Depressed mood
- Diminished interest in activities or social withdrawal
- Weight loss when not dieting or weight gain
- Insomnia or hypersomnia
- Agitation
- Fatigue or loss of energy
- Feeling of worthlessness
- Inappropriate guilt
- Diminished ability to concentrate
- Recurrent thoughts of death, suicidal ideation, or suicide attempt

Symptoms can vary in severity and duration. All clients should be

asked about suicidal thoughts or attempts and risk of harm to others. Clients who are depressed may not report symptoms unless specifically asked, so using appropriate assessment techniques is important.

At the time of initial assessment, a thorough health history that includes:

- past and current medical history,
- family history,
- social history with emphasis on stressors or triggering events.
- support system

Physical examination and lab work may also be required to rule out medical causes of symptoms (Varcarolis, 2017).

Treatment of depression typically includes some form of therapy such as psychotherapy, cognitive therapy, electroconvulsive therapy (ECT), or group therapy. Non-pharmacological interventions may be used alone or along with medications. There are a number of anti-depressants which can be prescribed which will be explored in the Anti-depressant Medication unit.

Although only 35% of individuals receive treatment for depression, it is estimated that nearly 40% of those treated for depression with antidepressants achieve full remission, while up to 30% achieve at least a 50% reduction in symptom severity (Rosenjack Burchum & Rosenthal, 2019).

Learn more about depression from the Canadian Mental Health Association.

Bipolar Disorder

Bipolar affective disorder (formerly manic-depressive disorder) is a mood disorder marked by clear shifts in energy, mood, activity levels and concentration. Typically, clients experience extreme

highs (called mania or hypomania) alternating with extreme lows (depression). See the "Depression" section for signs and symptoms of depression. People feel normal only in the periods between the highs and lows. For some people, the cycles occur so rapidly that they hardly ever feel a sense of control over their mood swings (Melrose, n.d.). It is a lifelong condition that the person needs to learn how to manage it with effective strategies and medications.

Signs and Symptoms of a Manic Episode

- Rapid speech
- Hyperactivity
- Reduced need for sleep
- Flight of ideas
- Grandiosity
- Poor judgment
- Aggression/hostility
- Risky sexual behavior
- Neglect basic self-care
- Decreased impulse control

Treatment for a client diagnosed with bipolar may include medications, safety initiatives during acute mania, electroconvulsive therapy (ECT), psychotherapy, and support groups. The severity of manic and depressive episodes varies for each client. Assessing if a client is a danger to others or themselves is the priority. People with bipolar may need assistance with impulse control during times when they are in a manic state (Varcarolis, 2017).

Learn more about bipolar disorder from the Canadian Mental Health Association

Watch the video *Mental Health Minute: bipolar disorder* [1:00] by National Institute of Mental Health (NIMH) (2021).

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=3344#oembed-1

Schizophrenia

Severe mental health illnesses such as schizophrenia can be very debilitating and can impact the persons ability to function in society. Schizophrenia refers to a group of severe, disabling psychiatric disorders marked by hallucinations, delusions, disorganized speech, grossly disorganized behavior, and negative signs and symptoms such as reduced emotional expression, avolition (significant lack of motivation), and cognitive impairment (Haney & Risvi, 2024). Schizophrenia affects people from all walks of life and usually first appears in between the ages of 15 and 30 and is more common in men. Not everyone will experience the same psychotic symptoms. Psychoses are defined as a loss of reality characterized by:

- Delusions (fixed false beliefs that cannot be changed through reasoning),
- Hallucinations (hearing, seeing, smelling, tasting, or feeling touched by things that are not there)
- Lack of insight and judgment (withdrawal from reality, illogical thinking)
- Mood and affect (lack of observable expressions of emotions, monotone voice, expressionless face, immobile body)

(Adams et al, 2019; Melrose, n.d.)

The cause of schizophrenia is multifaceted, with both genetic, neurobiological and environmental factors considered. It is a polygenic disorder thereby there is not one gene responsible, but many genetic mutations contributing to the condition. Structural and functional brain abnormalities are also a factor, with less gray matter in the frontal, temporal and hippocampus regions. Another possible factor is environmental such as complications at birth and early life challenges. Lastly, cannabis or its psychoactive ingredient, tetrahydrocannabinol (THC) can be a contributing factor to psychoses, especially for those using cannabis at an early age and in large amounts. Cannabis can induce psychotic episodes or may exacerbate preexisting psychotic conditions. There is a 6 times greater risk of schizophrenia for people who begin using large amounts of cannabis at an early age, compared to nonusers (Casadio et al, 2011). As such, cannabis use during adolescence can pose a risk for those more vulnerable. In summary, the mix of genetic and environmental factors during early brain development increases the potential for schizophrenia.

Diagnosing Schizophrenia

A comprehensive health history, a mental status examination (MSE), and a physical examination must be completed to rule out other conditions and to make a diagnosis (Hany & Rizvi, 2024).

Health history: presenting symptoms, past psychiatric history, substance use, medical conditions, medications (current and past, adherence), family history, personal and social factors and developmental history (childbirth complications, early development).

Mental Status Examination – the MSE is a standard tool to assess the client's current cognitive, affective and behavioural functioning. MSE will be done as part of initial assessment, and then repeated at different times to evaluate clinical progress. There are 10

components to the exam: appearance, behaviour, motor activity, speech, mood and affect, thought process, thought content, perception, cognition, insight and judgment.

Click on the link to watch a clinician completing a MSE on a client: Psychosis (Schizophrenia) Mental Status Examination (MSE) [12:02] by Geeky Medics (2023).

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=3344#oembed-2

There is no lab work that can help diagnose schizophrenia, but the addition of blood work can help rule out co-concurrent conditions.

Signs and Symptoms of Schizophrenia

There are three types of symptoms related to schizophrenia: positive, negative, and cognitive.

Positive Symptoms

Note that in this context, the word positive is not the same as good. Rather, positive symptoms are psychotic and demonstrate how the individual has lost touch with reality. Positive symptoms include:

- Delusions
- Hallucinations
- Disorganized thinking and behavior

Delusions fall into several categories. Individuals with a persecutory delusion may believe they are being tormented, followed, tricked, or spied on. Individuals with a grandiose delusion may believe they have special powers. Individuals with a reference delusion may believe that passages in books, newspapers, television shows, song lyrics, or other environmental cues are directed toward them. In delusions of thought withdrawal or thought insertion, individuals believe others are reading their mind, their thoughts are being transmitted to others, or outside forces are imposing their thoughts or impulses on them (Melrose, n.d.).

Hallucinations may include hearing, seeing, smelling, tasting, or feeling as if they have been touched by things that are not there (Melrose, n.d.).

Negative Symptoms

Negative symptoms are those characteristics that should be there but are lacking. Negative symptoms include:

- Apathy (lack of interest in people, things, activities)
- Lack of motivation
- Blunted affect
- Poverty of speech (brief replies)
- Anhedonia (lack of interest in activities once enjoyed)
- Avoidance of relationships

Keep in mind that the inability to show emotion associated with a blunted affect does not reflect an inability to feel emotion. Similarly, it is helpful to understand that withdrawing from others is a coping mechanism for an individual with schizophrenia and not a rejection of those who initiate contact (Melrose, n.d.).

Cognitive

Cognitive symptoms are a change in thought pattern and include:

- Poor decision making
- Loss of memory
- Distracted
- Difficulty focusing

Treatment for a client diagnosed with schizophrenia is lifelong and is aimed at relieving symptoms and enhancing client functioning. Treatment adherence is a challenge as once the client begins to feel better, they stop taking their medications, and symptoms resume. Also, many of the medications have undesirable side effects which can make adhering to the meds difficult. Non-pharmacological interventions include limit setting, addressing barriers to adherence, supported employment services, therapeutic communication, ECT, and psychotherapy. Antipsychotic medications are prescribed to control positive and/or negative signs and symptoms and require close monitoring for effect and client adherence.

Key assessments for a client with schizophrenia include examination for hallucinations and delusions, use of additional substances (alcohol or drugs), safety, their support system, and a medication review with a focus on compliance with their therapeutic regimen (Mayo Clinic, 2018; Varcarolis, 2017).

Learn more about schizophrenia from the Canadian Mental Health Association.

Seizures

The official definition of a seizure is "a transient occurrence of signs and/or symptoms due to an abnormal excessive or synchronous

neuronal activity in the brain." This means that during a seizure, large numbers of brain cells are activated abnormally at the same time. It is like an electrical storm in the brain. They may alter consciousness, alter sensation and produce abnormal motor activity.

Seizures are considered a symptom rather than a disorder in itself. Some causes of seizures can be from acute conditions such as infections, electrolyte disturbances, tumours, or trauma. Seizures can also occur on a chronic or ongoing basis. In some circumstances, the cause of seizures cannot be found. Seizures can have an impact of a person's life, such as risk of injury, restrictions on the type of activities or work, and driving restrictions (Epilepsy Foundation, 2017). There are different classifications of seizures based on severity of symptoms.

Epilepsy

Is a chronic neurological disorder characterized by recurrent, unprovoked seizures caused by sudden, abnormal electrical bursts in the brain. Symptoms vary from absence seizures (staring blankly) to tonic seizures (repeated jerky movements) and even atonic seizures (sudden loss of muscle control). It can affect clients at any age and sometimes there is a family history. Most clients will be on medications that can manage or eliminate seizure activity.

Signs and Symptoms of Seizures

Motor Symptoms

- Jerking (clonic)
- Muscles becoming limp or weak (atonic)
- Tense or rigid muscles (tonic)
- Brief muscle twitching (myoclonus)
- Epileptic spasms

Non-motor Symptoms

- Changes in sensation, emotions, thinking, or autonomic functions
- Lack of movement

Classification of Seizures

Seizures are classified in many ways, beginning with whether they are focal or generalized seizures.

Focal Seizures (focal onset or partial seizures)

Focal onset seizures have focal onset on one side of the brain. They are further classified into simple, complex, or secondarily generalized:

- Simple partial seizures are most common. They may also affect sensory and autonomic systems.

- Complex partial seizures include impairment of consciousness, with or without motor activity or other signs.
- Simple or complex partial seizures may become secondarily generalized, producing a tonic-clonic seizure. Tonic-clonic seizures are usually preceded by an aura and are the most common type.

Generalized Seizures

Generalized seizures have bilateral onset on both sides of the brain and are typified by absence (formerly petit mal) seizures, atonic seizures (short, lasting minutes), or tonic-clonic seizures. Most often there is a loss of awareness (Epilepsy Foundation, 2019; Mayo Clinic Staff, 2019; Velarde, 2019).

Common terms to describe a seizure:

These muscular changes are often associated with generalized seizures, but can occur with partial seizures as well.

- Tonic: muscles become stiff
- Atonic: sudden unexpected loss of muscle strength or tone
- Myoclonic: short, lightening-quick, jerk movements
- Clonic: periods of rhythmic or jerking movements

Canadian Epilepsy Alliance, n.d.

Status Epilepticus

Status epilepticus is a state of repeated or continuous seizures. It is often defined operationally as a single seizure lasting greater than 5 minutes or repeated seizures without recovery of consciousness. Prolonged status epilepticus impacts breathing due to prolonged muscle contractions, resulting in hypoxia, hypoglycemia, hypothermia due to increased metabolic needs and lactic acid production. If left untreated, can lead to irreversible brain injury and has a very high rate of mortality. The goal of therapy should be to achieve control of a seizure within 60 minutes or less. Pharmacological treatment of seizures is very successful in the majority of cases, but it requires accurate diagnosis and classification of seizures. Medication management of seizures may include CNS depressants, benzodiazepines or barbiturates, or anticonvulsants such as phenytoin (Velarde, 2019).

Learn more about seizures: Canadian Epilepsy Alliance https://www.canadianepilepsyalliance.org/about-epilepsy/types-of-seizures/

Neurodegenerative Diseases

Neurodegenerative diseases involve the progressive destruction of nerve cells. This includes Parkinson's disease, Alzheimer's disease and other dementias, and amyotrophic lateral sclerosis. These diseases typically begin in mid to late life and are progressive in nature. Each disease presents differently with a range of symptoms that could lead to cognitive, physical, emotional and behavioural decline.

The causes of neurodegenerative diseases are considered multifactorial, with genetic, environmental and lifestyle factors having a role. For example, toxin or chemical exposure, traumatic

brain injury, poor diet, and aging may all contribute to the onset of disease. Unfortunately, there is much we do not know about many of these diseases. There is considerable research currently underway for Parkinson's and other neurodegenerative diseases to find not only causative factors but improved treatments.

Exciting Research to change the future of neurodegenerative diseases

Current research is exploring how prions (misfolded proteins) contribute to some of these diseases such as Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis. The prions can alter the normal structure of proteins in the brain, so it no longer functions properly. It also causes proteins to clump that leads to further damage to cells and eventual cell death (Society of Neuroscience, 2018).

Research by Zhittya Genesis Medicine exploring the use of angiogenesis to treat ALS and Parkinson's. Currently in the human trial stage with Parkinson's clients, this treatment uses fibroblast growth factor 1 (FGF-1) to grow new blood vessels in ischemic tissue in the brain, resulting in the reestablishment of blood flow in dopamine-producing parts of the brain. Early trials show improved motor function and cognition.

ALS Disease: Is Angiogenesis a Possible Treatment or Even a Cure?

Zhittya Genesis Medicine ALS Disease: Is Angiogenesis a Possible Treatment or Even a Cure?

Parkinson's Disease

Parkinson's disease (PD) is a chronic progressive disease of the nervous system that impairs one's ability to move. The incidence increases with age, with the average age of onset around 60. Men are more susceptible than women. In 2022-2023, 110,000 people are living with the disease, and with the aging population in Canada, the incidence of Parkinsons is expected to increase (Government of Canada, 2025).

Parkinson's results from a combination of genetic, environmental, lifestyle and other factors, contributing to a loss of dopamine-producing cells in the substantia nigra which is part of the midbrain. This brain region affects movement, reward, and addiction (Society of Neuroscience, 2018). Non-motor symptoms are attributed to loss of serotonergic, norepinephrine and cholinergic neurons in the cerebral cortex, brainstem, spinal cord and peripheral autonomic nervous system (Parkinson Canada, n.d.). The disease worsens over time and has no cure.

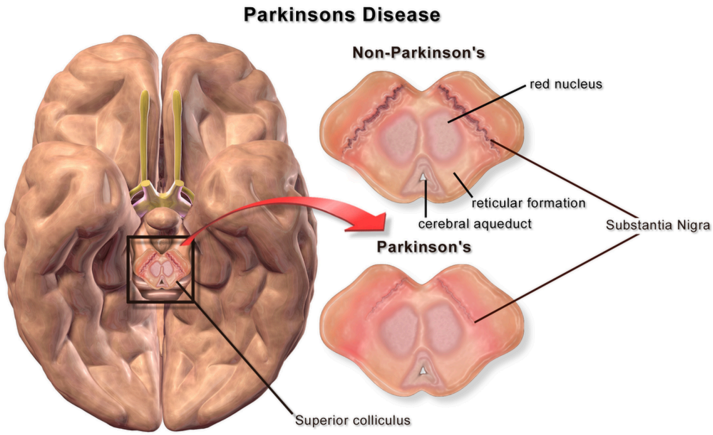

Figure: 8.3c Substantia Nigra changes in the brain with Parkinson's disease. The degeneration of nerve cells in this area lead to lack of dopamine production.

The early stage of the disease is characterized by motor problems, such as bradykinesia (slow movement), muscular rigidity, and unilateral or asymmetric resting tremor. A client who presents with two of the three symptoms likely has PD (Parkinson Canada, n.d.). Poor coordination and instability are also early symptoms. These symptoms progressively worsen. Along with motor issues, hyposmia, fatigue, depression, constipation and rapid eye movement sleep behaviour can also be present and may occur before motor symptoms develop. Cognitive decline often occurs in the later stages, with some people developing depression, memory loss and dementia. Other issues include problems with chewing and swallowing, constipation, urinary dysfunction and sleeping problems. The rate and extent of symptoms vary with some persons severely disabled and others with only minor symptoms (Government of Canada, 2025; Society of Neuroscience, 2018).

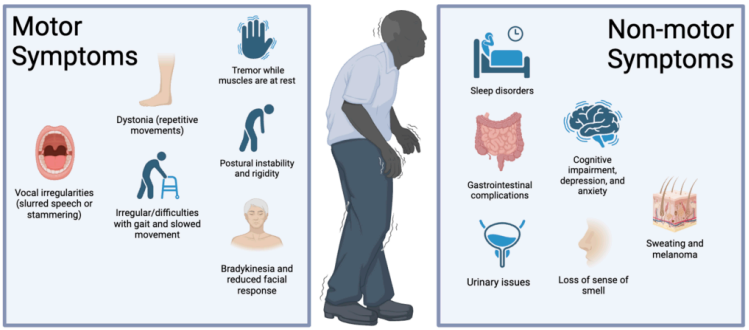

Figure 8.3d Common Symptoms of Parkinson's Disease

File:PD Symptoms.png File:PD Symptoms.png – Wikimedia Commons Creative Commons Attribution-Share Alike 4.0 International licens

Treatment

Treatment for a client with Parkinson's disease will include medications to increase dopamine in the brain to improve symptoms but will not slow the progression of neurodegenerative changes in the brain. Levodopa is typically prescribed to temporarily relieve motor symptoms but it does not slow the disease progression. Other medications that can be tried include dopamine agonists, MAO-B inhibitors, anticholinergics and NMDA antagonists. Other strategies include gene therapy and deep brain stimulation to treat clients who are not responsive to medications. Medications for Parkinson's will be explored further in unit 5.10.

Watch the following video to learn more about the impact of Parkinson's Disease

Michael J. Fox emerges from the darkness of Parkinson's
YouTube·CBC News: The National·May 25, 2023

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=3344#oembed-3

Alzheimer's Disease

Alzheimer's disease (AD) is a progressive, irreversible brain disorder that develops over years. It begins with memory loss and confusion, and progresses to a decline in cognitive abilities, behaviour and personality changes, and a loss of ability to recognize family or friends. In the very late stages, some Alzheimer's clients lose the ability to speak, walk and have difficulty eating. Alzheimer's disease

is the leading cause of dementia in the older population (National Institute of Neurological Disorders and Stroke, 2026).

Early onset AD can begin as early as the 30s or 40s and is attributed to an inherited gene mutation. Most AD is not genetic and begins with people older than 65. For late onset cases, genetic, environmental and lifestyle may be factors. Besides age of onset, the physiological changes and disease progression are the same.

AD is characterized by the accumulation of abnormal protein aggregates in the brain. These comprise beta-amyloid plaques and tau tangles. Amyloid plaques, which are made up of fragments of a protein called beta-amyloid peptide mixed with a collection of additional proteins, remnants of neurons, and bits and pieces of other nerve cells. Tau, which is required for healthy neurons, clump together in the neuron becoming neurofibrillary tangles (NFTs).

These deposits hinder the normal passage of impulses among nerve cells, leading to a loss of connections between neurons which are responsible for memory and learning. Without the connections, neurons die throughout the brain, and the affected regions atrophy. In the latter stages of the disease, the damage is widespread, leading to cell death and gradual deterioration of brain tissue (Gadhave et al, 2024).

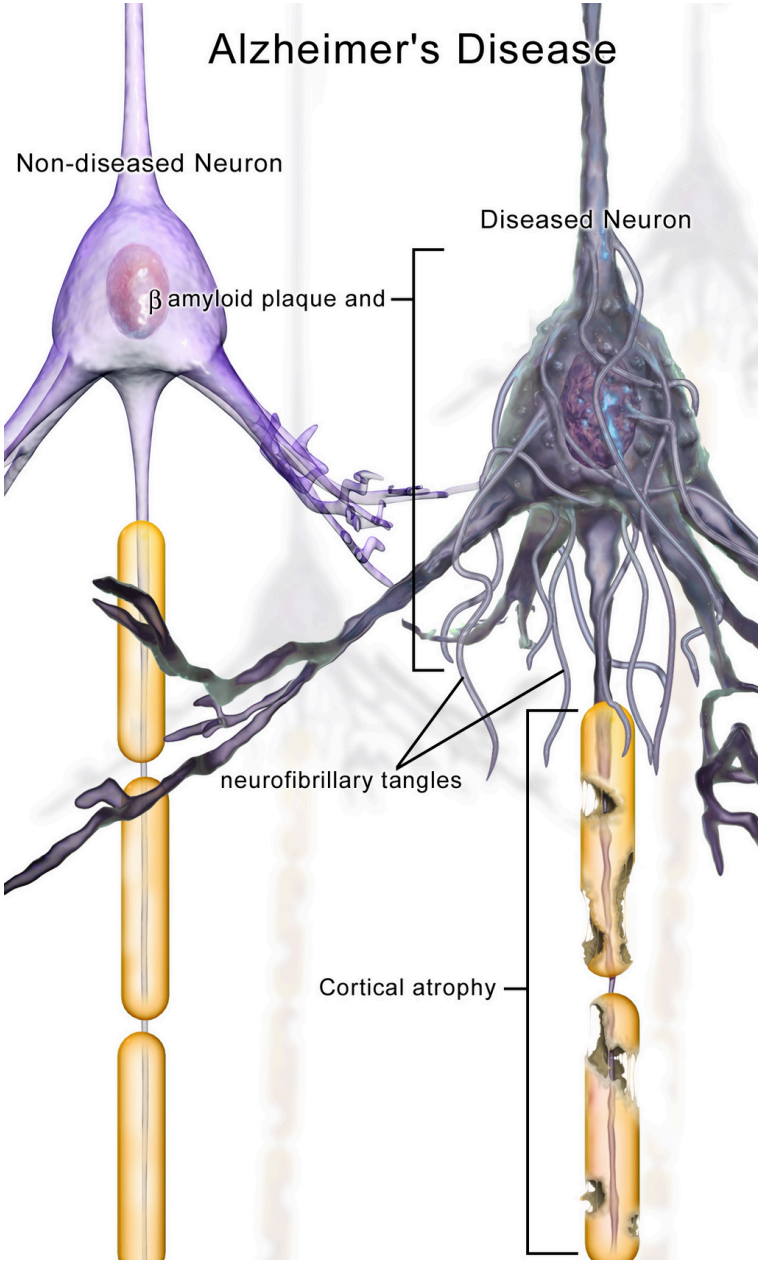

Figure 8.3d comparison between normal neuron and diseased neuron with Alzheimer's disease. Image shows neurofibrillary tangles and cortical atrophy.

There are other dementias with the most common one, besides Alzheimer's, is Lewy Body dementia. Lewy Body has a close relationship with Parkinson's disease with motor movement issues such as muscle rigidity, trouble walking and tremors, along with other symptoms such as visual hallucinations and inattention (Mayo Clinic Staff, 2025). Other dementias include vascular dementia, frontotemporal dementia, and Huntington's disease.

Treatment

There is no treatment to prevent Alzheimer's disease, only medications to modestly slow cognitive decline or improve symptoms temporarily. These medications are only effective for a few years but can help improve the ability to carry out activities of daily living, memory and manage behavioural changes.

For mild to moderate AD symptoms, cholinesterase inhibitors: donepezil (Aricept), rivastigmine (Exelon), and galantamine are prescribed to boost brain acetylcholine levels, leading to improved memory and thinking. Immunotherapy has also been prescribed for early-stage clients that work to remove amyloid plaques. Lecanemab and donanemab are two immunotherapy drugs.

For moderate-severe AD symptoms, memantine, a N-methyl-D-aspartate (NMDA) antagonist, helps regulate glutamate and can improve functioning for a short time (National Institute of Aging, 2023). There is currently considerable research on preventing the onset or treating the symptoms of Alzheimer's Disease.

Potential new treatment of proteins in Alzheimer's and Parkinson's disease

For proteins to function correctly, they are dependent on their three-dimensional shape. The linear sequence of amino acids folds into a three-dimensional shape that is based on the interactions between and among those amino acids. When the folding is disturbed and proteins take on a different shape, they stop functioning correctly. But the disease is not necessarily the result of functional loss of these proteins; rather, these altered proteins start to accumulate and may become toxic. For example, in Alzheimer's the hallmark of the disease is the accumulation of these amyloid plaques in the cerebral cortex. The term coined to describe this sort of disease is "proteopathy" and it includes other diseases. Creutzfeld-Jacob disease, the human variant of the disease known as mad cow disease, also involves the accumulation of amyloid plaques, similar to Alzheimer's. Diseases of other organ systems can fall into this group as well, such as cystic fibrosis or type 2 diabetes. Recognizing the relationship between these diseases has suggested new therapeutic possibilities. Interfering with the accumulation of the proteins, and possibly as early as their original production within the cell, may unlock new ways to alleviate these devastating diseases (OpenStax, 2025).

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5.3 Clinical Reasoning and Decision Making

Clinical reasoning is a way that nurses think and process our knowledge, including what we have read or learned in the past and apply it to the current practice context of what we are seeing right now (NCSBN, n.d.). Nurses make decisions all the time, but making decisions requires a complex thinking process. There are many tools that are useful and found online that can support your thinking through to clinical judgments. This book uses the nursing process and clinical judgment language to help you understand the application of medication to your clinical practice.

Now that we have reviewed various CNS disorders and the anatomy and physiology underlying them, let's review the importance of the nursing process and clinical judgment in guiding the nurse who administers CNS medication to treat these disorders.

Assessment

Although there are numerous details to consider prior to administering medications, we begin with an assessment. It is always important to first think about what is the health condition, con-current conditions, present and past assessments, overall goal of therapy, and medications or other treatments. Nurses must know what the medication is, how it works in the body, and the purpose of giving it.

First, let's think of why? Recognizing Cues

When thinking about administering CNS medication, there are many things to consider. Each medication is given for a specific purpose for your client, and it is your job as a nurse to assess

your clients and collect important data before safely administering medications. As a nurse, not only will you perform the skill of administering medications, but you will be expected to think critically about your client and the safety of any medication at any particular time.

A nursing assessment completed prior to administering CNS medications will likely look different than an assessment for other types of medications, as subjective assessment is paramount and in some circumstances, more important than objective data. For example, prior to administering a cardiac medication, a nurse will obtain objective data such as blood pressure and an apical heart rate. However, prior to administering CNS medication, a nurse will use therapeutic communication to ask questions to gather subjective data about how the client is feeling but may also use an objective rating scale. For example, the Patient Health Questionnaire-9 (PHQ-9) or the Patient Health Questionnaire Somatic Symptom scale.

After reviewing the possible CNS diseases, you probably noticed that there is usually an associated imbalance of a neurotransmitter. As a nurse, you cannot directly measure a neurotransmitter to determine the effects of the medication, but you can ask questions to determine how your client is feeling emotionally and perceiving the world, conditions which are influenced by neurotransmitter levels. An example of a nurse using therapeutic communication to perform subjective assessment is asking a question such as, "Tell me more about how you are feeling today?" The nurse may also use general survey techniques such as simply observing the client to assess for cues of behavior. Examples of data collected by a general survey could be assessing the client's mood, hygiene, appearance, or movement.

General Assessment Questions

Assessment will include:

- What symptoms are they experiencing? What is going on in your life that may be contributing to how you are feeling?
- How long? (acute or chronic)
- Impact on ADLs, social functioning, impacting QOL?
- What are their supports? (family, friends, support groups)
- Any Substance use +/- (prescription, non-prescription, alcohol use, nicotine, caffeine)
- Potential for self-harm and suicide (ask specifically, see box below)
- Other physical symptoms
- Other health issues (may be related to the mental health issue or unrelated)
- Medications (past and present medications, prescription, OTC and herbal supplements)

Rating Scales

Mental health professionals use a number of different rating scales as part of the initial assessment, diagnosis of a mental health condition and for ongoing monitoring that assesses for symptom improvement or decline. They are only one part of a comprehensive assessment (Halter et al., 2018).

Mental Status Examination (MSE): is the equivalent of a physical exam to assess the client's mental health needs. Mental Status Examination (MSE) : Interior, BC : eMentalHealth.ca

Mini Mental State Examination (MMSE): is a brief, structured screening tool, used to systematically assess mental status. It is an 11-question measure that tests five areas of cognitive function: orientation, registration, attention and calculation, recall and language.

Patient Health Questionnaire-9 (PHQ-9): used for assessing depression risk. Highlights predominant depression symptoms.

Hamilton Anxiety Rating Scale: measures anxiety behaviours.

Interventions

Next, plan (refine your hypothesis), and take action.

Hypothesis: Are we concerned? What is the impact on functioning, severity of symptoms, safety.

Planning and Intervention:

Almost all mental health conditions, require non-pharmacological interventions for maximum effect. Interventions may include: Psychotherapy, Cognitive Behavioural Therapy, support groups, social and family support, spiritual supports
Other interventions include healthy behaviour strategies, such as sleep, exercise, nutrition, and relaxation.

Pharmacological Interventions:

Clients will often be on one or more medications to manage their moods and behaviour.

- With the administration of any medications, it is important to always perform the seven rights (right client, medication, dose, route, reason, documentation and time) and to check for allergies prior to administration.
- Anticipate any common side effects and the expected outcome of the medication.
- When you administer CNS medication, it is key to perform

assessments before administering medication because many clients may have changing behaviors and habits that influence the way they think and feel about taking their medication.
- Some medications require an assessment of lab values before administration. For example, lithium levels may need to be drawn prior to the dose due to the narrow therapeutic range.
- Monitor for cumulative effects when CNS meds are used in conjunction with other medications, so careful assessment of the impact of the medications on one another is needed.

Evaluation

Regular monitoring and evaluation of effectiveness of meds:

CNS medications which modulate or change (inhibit/excite) a neurotransmitter, the therapeutic effect can take up to four weeks. Close monitoring for the therapeutic effect and side effects is important.

- Nurses should assess for mood, behavior, and movement improvement. If medications are effective, then clients should report fewer negative thoughts, worry, and symptomatic behaviors, as well as demonstrate fewer abnormal movements.
- Nurses also need to continually monitor for adverse effects, some of which can be life-threatening and require prompt notification to the prescribing provider.
- If symptoms are not improving or the client's condition is worsening, the nurse should promptly notify the prescribing provider for further orders. For example, a symptom and/or adverse reaction of several CNS medications is increased thoughts of suicide. If a client is experiencing thoughts of suicide, immediate assistance should be obtained to keep them safe. For more information about suicide prevention refer to the Canadian Association for Suicide Prevention site.

- Monitor for compliance with taking the meds. Some meds have undesirable side effects that can be short term or long term. Educate clients in advance that side effects are common and provide help with managing them.

In the upcoming units, we will take a closer look at specific classes of CNS medications. We will review classes and specific administration considerations, therapeutic effects, adverse/side effects, and teaching needed for each class of medications.

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5.4 CNS Depressants

CNS depressants slow down brain activity, resulting in muscles to relax and an overall calming and soothing effect for that person. CNS depressants are used to treat anxiety, seizures, insomnia and panic attacks. Medications in this category include barbiturates, benzodiazepines, inhalants, and sleep aids. Even alcohol is considered a CNS depressant.

Depressants can be considered either an anxiolytic (anti-anxiety agents) or a hypnotic, but the difference is often only the dosage. As such depressants can also be called sedative-hypnotics. Anxiolytics are used to relieve anxiety and have a lower prescribed dosage. Conversely, hypnotics are used to promote sleep and have a higher dosage.

Along with benzodiazepines, there are a variety of sleep aids or hypnotics available. This unit will briefly discuss benzodiazepine-type medications (zolpidem, eszopiclone). Other hypnotics include antidepressants (trazadone or doxepin), antihistamines (diphenhydramine) and melatonin.

Other depressants not covered in this unit include inhalants. Nitrous oxide, an inhalant, is used for medical or dental procedures for its anxiolytic and analgesic effects. Nitric oxide (NO) is mixed with oxygen and delivered via face mask in controlled settings such as clinics or a hospital.

In this unit, we will cover barbiturates and benzodiazepines.

Barbiturates

Barbiturates have a long history, first developed in 1864 by Dr. von Baeyer, but it took until 1904 where it was used for psychiatric and neurological disorders. During the earlier half of the 20th century, it was used to induce sleep in psychotic patients, prescribed to

treat insomnia and anxiety, and to reduce the number and intensity of seizures. By the 1960s and 1970s, barbiturate use declined due to serious adverse effects of dependence and risk of overdose, ultimately leading to more regulation with restricted prescriptions. At the same time, the development of benzodiazepines occurred and are now widely used (López-Muñoz, Ucha-Udabe, Alamo, 2005). Although the use is more limited, barbiturates are still used to treat seizure disorders, neonatal withdrawal, preoperative anxiety, anesthesia induction, and the induction of coma to address increased intracranial pressure (ICP) (Skibiski, Patel & Abdijadid. 2024).

Our prototype med will be Phenobarbital, which is primarily used as a sedative and to treat seizure disorders (raises the seizure threshold). In high doses, it can be used to induce anesthesia, and overdosage can cause death. Barbiturates are controlled substances under the Pharmacy Operations and Drug Scheduling Act. However, the misuse of barbiturates continues to occur with street use as a "downer" to counteract the effect of cocaine and methamphetamine.

Mechanism of Action

Normally, GABA inhibits activity in the brain leading to a calming effect. GABA is the primary inhibitory NT that reduces neuronal excitability, thereby it monitors and controls the amount of stimuli getting into the brain. If there is a disorder in GABA signaling, more impulses can lead to overstimulation, disordered thinking etc. and is the basis of some psychiatric conditions.

GABA's role in the Brain: An analogy is a security guard at a night club. The security guard allows only so many people into the nightclub so it is more controlled and calmer. GABA has a similar effect on the brain. Not all stimuli or signals get through. A disorder in GABA signalling is basis of many psychiatric conditions.

Barbiturates bind to GABA receptor-chloride channel complex keeping the chloride channel open, resulting in both enhancing the inhibitory actions of GABA and also directly mimicking the action of GABA. They depress the whole CNS by potentiating the effects of GABA.

Barbiturates have a greater effect on the chloride channel than benzodiazepines as they work to open the chloride channel even in the absence of GABA. Along with the GABA effects, barbiturates also block AMPA and NMDA receptors, a subtype of glutamate receptor. Recall that glutamate is an excitatory neurotransmitter (DrugBank, 2026). When glutamate receptors are blocked, this further reduces CNS activity. Barbiturates not only enhance the inhibition of GABA but also block excitation, resulting in a strong overall effect compared to other sedative-hypnotic meds.

[Policeman](#) *by* [Clker-Free-Vector-Images](#) *from* [Pixabay](#)

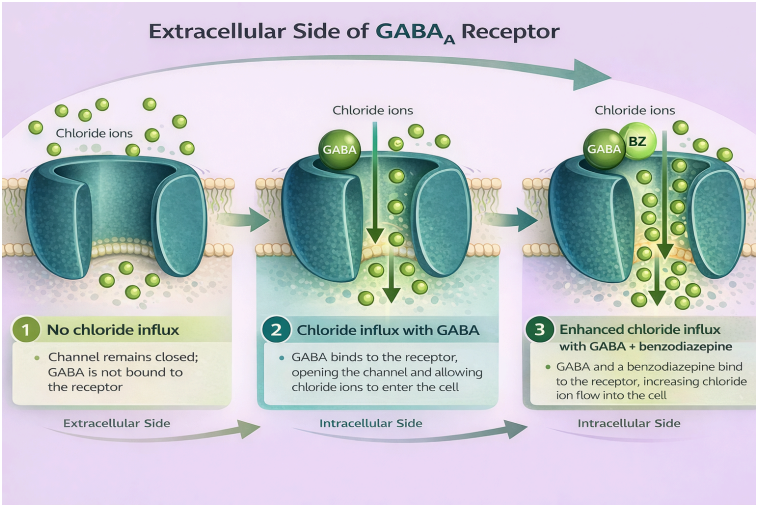

Figure 5.4a: Extracellular view of GABAa receptor (Sheila Odubote/ TRU Open Press)

The first image shows Chloride channel with GABA not bound to the receptor. The second image the chloride channel opening with the binding of GABA to the receptor and the influx of chloride cells.

The third image shows the chloride channel opening with GABA and BZ binding to receptors, allowing a greater influx of chloride cells.

Indications for Use

There are three different groups of barbiturates which are based on the duration of action. We will focus our discussion on phenobarbital, but the other meds are used for comparison.

- Methohexital, thiopental: ultra short acting (30 seconds, duration 20 minutes). Used for anesthesia induction. Could also be used for procedural sedation, but less used for this purpose.
- Secobarbital: short-intermediate acting (onset 10 minutes with duration 3-4 hours). Used for insomnia or to induce sedation with medical assistance in dying (MAID).
- Phenobarbital: long acting (onset 30 minutes, duration up to 10-12 hours). Muscle relaxant, anticonvulsant. Can be used for alcohol withdrawal if other meds not effective.

The drug absorption depends on the lipid solubility of the drug and route of administration. The more lipid soluble, the faster onset and shorter the duration of action. It makes sense that methohexital is used for the induction of anesthesia, as it works very quickly and has a short duration of action. Whereas phenobarbital has a longer duration of action which would be beneficial in seizure management (Skibiski, Patel & Abdijadid. 2024; Vallerand & Sanoski, 2024).

Pharmacokinetics

Phenobarbital is rapidly absorbed orally or intravenously. It is

distributed to all tissues including the brain, liver, skeletal muscles and kidneys. It crosses the blood brain barrier rapidly. It is metabolized by the liver through the P450 enzymes, and advanced age, chronic liver disease or drug interactions may decrease metabolism (Skibiski, Patel & Abdijadid. 2024). With repeated administration, tolerance develops due to the self-induced increase in barbiturate metabolism. Due to the high lipid solubility and subsequent distribution to fatty tissues, the sedative effects can take a long time as they are slowly released from the tissues.

Nursing Considerations

- Administered oral, IV, IM. If the oral dose is taken with food, absorption may be delayed. A loading dose may be given due to long t ½ to reach steady state.
- Nursing assessment: monitor vital signs (RR, oxygen sats, HR, BP) and respiratory status.
    - For seizure management: assess location, duration and characteristics of seizure activity
    - Assess level of consciousness, sedation levels and pain.
- Fall risk: supervise ambulation and use fall precautions.
- Pregnancy: readily crosses the placental barrier and can lead to fetal malformations. If methohexital is used for the induction prior to a caesarean delivery, the infant may have respiratory depressions (Skibiski, Patel & Abdijadid. 2024).
- Older Adult: avoid use with the older adult due to the likelihood of more pronounced depressive effects. Lower dosage and monitor closely for CNS changes, respiratory depression and fall risk.
- Contraindicated for use in clients with severe renal and hepatic disorders, severe respiratory depression, dyspnea or airway obstruction, and porphyria.

Drug Interactions:

Barbituates interact with many other drugs.

- Vitamin D: absorption interfered, so need to supplement to avoid osteomalacia.
- Vitamin K: enzyme induction leading to increased metabolism of vitamin K dependent clotting factors, resulting in an increased risk of bleeding.
- Barbiturates are enzyme inducers within the liver, so some drugs will be metabolized faster. Increased dosages and closer monitoring for meds such as warfarin, oral contraceptives, glucocorticoids.
- Synergistic effect with alcohol, antihistamines, opioids.

(Rosenjack Burchum & Rosenthal, 2019; Vallerand & Sanoski, 2024)

Side and Adverse Effects:

Side effects: similar to benzodiazepines and include:

- Drowsiness is common, especially with initiating therapy.
- Cognition: Mild impairment of concentration, judgment, memory may occur. Other: sleep disturbances, dizziness, headache, depression, poorly controlled pain, slowed reflexes, slurred speech.
- Paradoxical effects include euphoria, confusion, delirium, increased pain intensity
- GI upset (nausea, vomiting, diarrhea) and rashes, urticaria.

High Alert Med: Barbiturates is a high alert med, as there is no ceiling effect. Overdoses can cause unconsciousness, coma and

death (Rosenjack Burchum & Rosenthal, 2019; Vallerand & Sanoski, 2024)

- CNS effects: drowsiness, CNS depression, **coma**
- CV effects: lowers heart rate, hypotension. If given in higher doses, can lead to depressed myocardium and vascular smooth muscle, resulting in **shock**.
- Resp effects: decrease in respiratory rate. It depresses the brain stem respiratory drive and depresses the chemoreceptors that control respirations, leading to **respiratory depression.**

Paradoxical responses can occur. In children, may see hyperactivity, behavioural and cognitive impairment. In the older adult, may see confusion, excitation or depression. Reduced dosages required.

There is no antidote, supportive measures only in overdose.

Client Teaching

- Take the prescribed medication as directed.
- Clients who undergo prolonged therapy should not discontinue treatment abruptly as this may cause the onset of seizure activity.
- These medications may cause drowsiness and should not be taken with alcohol or other CNS depressants.
- Female clients using oral contraceptives should also use non-hormonal-based contraceptives during therapy involving barbiturate use.
- Habit forming: High risk of tolerance and dependence. Overdose can cause respiratory depression and can be fatal.
- **Overdose**: the onset of symptoms following a toxic oral exposure to phenobarbital may not occur until several hours following ingestion. If an overdose occurs, consult with

a Poison Information Center (1-800-567-8911).

Phenobarbital Medication Card

Now let's take a closer look at the medication grid for phenobarbital in Table 8.5a (Rosenjack Burchum & Rosenthal, 2019; Vallerand & Sanoski, 2024). Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Phenobarbital Medication Card

Class: CNS Depressant **Prototype**: Phenobarbital		**Indications**: sedation or seizure treatment **Therapeutic uses**: raises the seizure threshold resulting in seizure management. Can be used for sedation.	
Mechanism of Action: Alters cerebellar function and depresses actions of the brain and sensory cortex. Binds to GABA receptor-chloride channel complex keeping the chloride channel open, resulting in both enhancing the inhibitory actions of GABA and also directly mimicking the action of GABA. Depresses the whole CNS by potentiating the effects of GABA. Also inhibits glutamate, leading to further CNS calming effect.			
Administration: Orally, IM, or IV Taper dose, do not stop abruptly	**Side Effects**: Drowsiness common when initiating therapy. CNS: cognitive changes such as impaired memory, thinking, concentration. Sleep disturbances. CV: ↓BP and ↓HR. Respiratory depression Rash, GI effects (N&V, diarrhea). Adverse effects: CNS depression; overdosage can be fatal. May cause suicidal thoughts or behavior	**Contraindications**: Severe renal and hepatic disorders. Severe respiratory depression, dyspnea, or airway obstruction; porphyria. Not for use in pregnancy. Avoid in geriatric clients (lower dose, monitor for falls) High abuse potential – tolerance and dependence develop.	**Nursing Considerations**: Take as directed. May be habit forming Do not take with other CNS depressants or alcohol Assess: CV, RESP and CNS status. Fall precautions in place Many drug interactions – check with prescriber or pharmacist.

Downloadable file (.docx): Phenobarbital Medication Card

Benzodiazepines

Benzodiazepines (BZD) were first produced in the 1950s and are still widely used today. They are the drug of first choice for anxiety and sedation, along with benzodiazepine-like medications. BZD are considered safer than many of the alternative CNS depressants.

Benzodiazepines are widely used for a variety of health conditions including anxiety disorders, panic disorders, seizures, procedural sedation and alcohol withdrawal.

Indications for Use

All beneficial effects of benzodiazepines are the result of depressant actions in the CNS. It is used for sedation, anti-anxiety, and anticonvulsant effects. Lorazepam injection is indicated for the treatment of status epilepticus. It may also be used in adult clients for pre-anesthetic medication to produce sedation (sleepiness or drowsiness), relieve anxiety, and decrease the ability to recall events related to the day of surgery. Lorazepam, either oral or IV, is used as a first line treatment for alcohol withdrawal.

Off label, BZD are also used for Tourette syndrome, delirium, sleep disorders and adverse movement effects (tics, tardive dyskinesia, tremors) caused by some meds (Bounds & Patel, 2024).

There are numerous benzodiazepines and they are used for slightly different purposes. Each medication differs in potency, onset of action and duration. Some of the conditions and type of BZD are listed below.

Anxiety disorders (anxiolytic)

- Alprazolam
- Diazepam
- Lorazepam

Insomnia

- Lorazepam
- Triazolam

Seizures (anticonvulsant)

- Diazepam
- Lorazepam
- Clonazepam

Alcohol Withdrawal

- Diazepam
- Lorazepam

Conscious sedation

- Midazolam
- Diazepam

Our prototype med will be lorazepam.

Mechanism of Action

Benzodiazepines bind to specific GABA receptors to potentiate the effects of GABA, an inhibitory neurotransmitter within the CNS. These receptors (GABA-A) are proteins that collectively shape a chloride channel in the centre. When BZD bind to and activate the BZD receptor, it increases the frequency of the GABA-A receptor chloride channel opening in the presence of GABA (allosteric effect), leading to neuron hyperpolarization and reducing nerve firing for the calming and sedative effects. If there is no GABA present, the

Cl- channel would not open, and the sedative effects would not occur (Bounds & Patel, 2024; Rosenjack Burchum & Rosenthal, 2019).

Watch the short video to learn more about the MOA of benzodiazepines.

Neuroscientifically Challenged (n.d.). 2-Minute Neuroscience: Benzodiazepines. Youtube: 2-Minute Neuroscience: Benzodiazepines

Pharmacokinetics

Benzodiazepines are well absorbed after administration. They easily cross the blood brain barrier due to their high lipid solubility and are distributed rapidly. Most BZD undergo extensive metabolic alterations and are metabolized by hepatic enzymes CYP3A4 and CYP2C19. Although there are some differences between each BZD drug, most metabolites are pharmacologically active. This results in the BZD effects persisting much longer than the parent drugs half-life. For example, flurazepam whose plasma half life is 2-3 hours, its active metabolite half-life is 50 hours. Therefore, the effects of flurazepam lasts much longer. All are eliminated by the kidney (Bounds & Patel, 2024).

Nursing Considerations

Administration: mostly oral or IV routes, but can also be given IM, rectal or nasally.

- Should be prescribed for short periods only (e.g., 2 to 4 weeks). Treatment period should not be extended without re-evaluation of the need for continued therapy.
- Taper dosages to avoid withdrawal symptoms. May need to

taper over weeks or months for long-term therapy.
- IV administration: risk of adverse effects is higher than with oral dosing, especially respiratory depression. In the event of respiratory depression, maintain a patent airway and ventilatory support as needed. The additive central nervous system effects of other drugs, such as phenothiazines, narcotic analgesics, barbiturates, antidepressants, scopolamine, and monoamine-oxidase inhibitors should be considered when these other drugs are used concomitantly with, or during the period of recovery from lorazepam injection.

Pregnancy: Benzodiazepines may cause fetal harm when administered to pregnant women. Children and the elderly are more likely to experience paradoxical reactions to benzodiazepines such as tremors, agitation, or visual hallucinations.

Elderly or debilitated clients may be more susceptible to the sedative and respiratory depressive effects of lorazepam. Therefore, these clients should be monitored frequently and have their dosage adjusted carefully according to the client's response; the initial dosage should not exceed 2 mg.

Hepatic insufficiency: Dosage for clients with severe hepatic insufficiency should be adjusted carefully according to client response.

Adverse/Side Effects

Most benzodiazepines are relatively safe and well tolerated. The side effects are usually mild, and not noticed if the drug is used in low doses. Clients may experience drowsiness, dizziness, headache, nausea or vomiting, diarrhea and loss of balance.

Adverse effects are dose dependent and more likely with IV administration.

CNS:

- Low doses: drowsiness, sedation, dizziness, hang over effects, loss of balance
- High doses: confusion, disorientation, anterograde amnesia, hypotension

RESP: Low risk of respiratory depression. If given IV, can cause respiratory depression by inhibiting respiratory drive.

Adverse effects: visual disturbances such as diplopia, cyclic eyelid movement, loss of balance, and difficulty focusing eyes can occur.

High Alert Med: concomitant use of benzodiazepines and opioids may result in profound sedation, respiratory depression, coma, and death.

Paradoxical effects: when used for anxiety, can cause paradoxical effects such as insomnia, excitation, euphoria and heightened anxiety (Rosenjack Burchum & Rosenthal, 2019). This response is seen more often in children and older adults.

> Benzodiazepines are on the Beer's Criteria due to the higher risk of adverse effects and higher incidence of falls in the older population. It is recommended to avoid BZD in the older adult for insomnia or anxiety. It is acceptable to use BZD for alcohol withdrawal or severe generalized anxiety disorder unresponsive to other therapies (Canadian Geriatrics Society, 2025).

Physical and Psychological Dependence:

- Tolerance can develop if used for antiseizure, sedative or anxiolytic effects. Physical and psychological dependence may occur with long-term use. When discontinuing, may see mild

withdrawal symptoms (anxiety, sweating, tremors, dizziness).
- Withdrawal from long term high-dose therapy or abrupt cessation can cause more significant symptoms such as panic, paranoia, hypertension, muscles twitches or convulsions.

Overdose

- Overdosage of benzodiazepines is usually manifested by varying degrees of central nervous system depression, ranging from drowsiness to coma.
- Treatment of overdose:
    - It is mainly supportive until the drug is eliminated from the body.
    - Vital signs and fluid balance should be carefully monitored in conjunction with close observation of the client.
    - An adequate airway should be maintained and assisted respiration used as needed.
    - Flumazenil, a benzodiazepine antagonist, may be used for hospitalized clients. There is a risk of seizure in association with flumazenil treatment, particularly in long-term benzodiazepine users (Bounds & Patel, 2024, Vallerand & Sanoski, 2024).

Antidote Flumazenil

Flumazenil is a competitive benzodiazepine receptor antagonist. It will reverse sedation but has variable effects on respiratory depression. It also carries a

seizure risk. Administered IV, and given in incremental doses, repeated every minute, up to a total dose of 3 mg. duration of action is one hour, and may be repeated.

Client Teaching

- Clients who receive lorazepam should be cautioned that driving a motor vehicle, operating machinery, or engaging in hazardous or other activities requiring attention and coordination should be delayed for 24 to 48 hours following administration or until the effects of the drug, such as drowsiness, have subsided.
- Clients should be advised that if they get out of bed unassisted within 8 hours of receiving lorazepam, they risk falling and potentially sustaining injury.
- Alcoholic beverages should not be consumed for at least 24 to 48 hours after receiving lorazepam injectable due to the additive effects on central nervous system depression seen with benzodiazepines in general.
- Often prescribed for short term use, and if taking long term, do not abruptly stop taking the med.
- Elderly clients should be instructed that lorazepam injection may make them very sleepy for a period longer than 6 to 8 hours following surgery.
- Due to high risk of falls and injury, fall prevention strategies should be discussed.

Critical Thinking Out Loud

A 45-year-old client is being discharged home from the hospital following an appendectomy. They are usually independent and very active, with no health issues except insomnia. They tell the prescriber they would like a prescription to help them sleep at night. They are ordered: Lorazepam 0.5 – 1.0 mg oral before bedtime as needed. Other medications for discharge include an antibiotic and tramadol for pain control. The nurse reviews the order and considers this prescription for this client.

Lorazepam is an effective sedative, often used for insomnia. The dose that is ordered is low. The client is relatively young, has no mobility or cognitive concerns. He is on an analgesic that can also cause sedation and dizziness and these effects can be exacerbated with lorazepam. The nurse discusses with the client their insomnia and the use of other medications and interventions to promote sleep that have been tried in the past. They inform the client of the additive effect of taking both an analgesic and CNS depressant and the concern with being overly sedated and a risk for falls. The client understands that lorazepam should be used only if needed, right before bedtime and start with the lowest dose. They plan to try to not use lorazepam if they are also taking tramadol before bed. They understand the side effects and other considerations such as avoiding alcohol while taking lorazepam, not to drive after taking a dose, and if taking regularly, not to stop immediately.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

The Effects of Alcohol on GABA Receptors

Did you know that long term use of alcohol affects brain receptors, which undergo adaptive change in an attempt to maintain normal function. Alcohol enhances GABA activity acutely, with adaptive changes over time leading to decreased receptor sensitivity and decreased GABA levels. Therefore, a person needs more alcohol to get the same effect. GABA receptors become less responsive, leading to an imbalance of excitatory and inhibitory NTs. Alcohol also affects NMDA and dopamine receptors. For those with chronic alcohol consumption, if they stop drinking, leads to nervous system hyperactivity. Alcohol withdrawal protocols include benzodiazepines as part of the treatment to help reduce the neuron excitability.

Lorazepam Medication Card

Now let's take a closer look at the medication card for lorazepam. Because information about medication is constantly changing, nurses should always consult evidence-based resources

to review current recommendations before administering specific medication.

Lorazepam Medication Card

Class: CNS Depressants **Prototype:** Lorazepam (Ativan)		**Indications:** reduces anxiety (anxiolytic) Reduces seizure activity; treat insomnia, treatment for alcohol withdrawal	
Mechanism of Action: Binds to specific GABA receptors to potentiate the effects of GABA resulting in the frequency of the chloride channel opening. GABA also needs to be bound to a receptor on the chloride channel. This leads to neuron hyperpolarization and reducing nerve firing for calming and sedative effects.			
Administration: SL, PO, IV Use cautiously in elderly and (may have paradoxical impacts) Consider smaller dose for liver dysfunction Taper dose when D/cing if long term use	**Side Effects:** Usually mild, very safe SE: dizziness, headache, N&V, diarrhea, loss of balance Risk of oversedation Respiratory depression risk with IV admin	**Contraindications:** Avoid during breastfeeding Contraindicated with glaucoma, concurrent use of other CND depressants (alcohol, analgesics). Can lead to resp depression, oversedation, coma Tolerance can develop Peds – avoid under 12 years of age.	**Nursing Considerations:** Very safe med, but monitor BP, HR, sedation levels Take only as prescribed, short term (2-4 weeks) preferred. Avoid driving after dose Monitor for fall risk Antidote: flumazenil

Downloadable file (.docx): Lorazepam Medication Card

Clinical Reasoning and Decision-Making Activity 5.4

1. A client who has been experiencing panic attacks is prescribed lorazepam. Upon further discussion with the client, the nurse discovers that the client is planning to go on a cruise with her husband next week and plans to use a scopolamine patch to control

nausea. The client states, "I can't wait to relax on the cruise ship and have a margarita as we leave port!"

What important client education should the nurse provide to the client about the new prescription for lorazepam?

2. A client is brought in by ambulance to the ED and he are very drowsy and difficult to awaken. The client's family say that he takes lorazepam for occasional anxiety and insomnia but lately he has been taking a higher amount to cope. This morning he was found unable to easily awaken. The family suspect he took too many lorazepam pills. Following an assessment, what medication will likely be given for this client? What will be interventions to support this clients suspected overdose?

3. A client is given phenobarbital for seizure activity in the hospital. What are important nursing interventions following administrering the med? Consider immediate actions and ongoing monitoring.

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

Benzodiazepine-like Drugs

Sometimes referred to as Z-Drugs or non-benzodiazepine drugs, this category of drugs are only used for treating insomnia. Examples

are Zolpidem (trade name Ambien), Zaleplon (Sonata) and Eszopiclone (Lunesta).

They are all structurally different than benzodiazepines, and act as a GABA receptor agonist. They enhance the depressant effects of endogenous GABA. They do not have the anxiolytic or anticonvulsant effects that BZD have, and all have slightly different side effects and risk for tolerance. All are prescription medications and taken orally. Some comparisons between the meds:

Zolpidem: For short term use only, but long term use may cause tolerance and dependence. Respiratory depression may occur if used with other CNS depressants. Side effects include daytime drowsiness and dizziness.

Zaleplon: For short term use only for management of insomnia. Well tolerated with side effects including headache, nausea, drowsiness, myalgia and abdominal pain. It is less likely to cause anterograde amnesia (Bhandari & Sapra, 2023).

Eszopiclone: For short term use only (less than 4 weeks) for issues with sleep latency, sleep duration or nocturnal wakening. There is a risk of tolerance and dependence, leading to withdrawal and rebound insomnia if stopped suddenly. It is well-tolerated with minimal side effects which can include a bitter taste, headache, dizziness, and dry mouth. It can lead to psychological addiction. Adverse effect of sleep walking can occur.

(Drugs.com, 2026; Rosenjack Burchum & Rosenthal, 2019)

As with all CNS depressants, caution or avoidance for the older adult due to risk of falls and an exaggerated effect of CNS effects. They are contraindicated with severe hepatic disease, with dose reductions for those with mild-moderate hepatic disease.

To support your learning, you can access the Chapter 5 CNS Mood and Cogniton Medication Cards. This is a downloadable and editable document to allow you to update and add content.

Interactive Activities

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5.5 CNS Stimulants

CNS stimulants are a broad class of drugs that increase the activity of the central nervous system. They are mostly used for the treatment of attention-deficit hyperactivity disorders (ADHD) and as a second line treatment for narcolepsy in adults.
Other stimulants include amphetamines, caffeine, ephedrine, cocaine and khat which will not be covered (Farzam, Faizy & Saadabadi, 2023).

In this unit we will look at the use of one stimulant, methylphenidate, for the treatment of ADHD. ADHD can also be treated with non-stimulants such as atomoxetine (selective norepinephrine reuptake inhibitor (SNRI), clonidine (Alpha-2 adrenergic agonists) and guanfacine (alpha-2 agonist), which are used if stimulants are not effective.

Methylphenidate

Methylphenidate is an example of a CNS stimulant that is often used to treat ADHD. It is a first line treatment, along with amphetamine-based medications (ie. Adderall). Common methylphenidate meds are Ritalin and Concerta.

Mechanism of Action

Methylphenidate stimulates the brain and acts similar to amphetamines. This medication blocks the reuptake of the neurotransmitters norepinephrine (NE) and dopamine (DA) in presynaptic neurons, increasing the concentration of dopamine and NE in the synaptic cleft. This creates the classic stimulant effect

within the central nervous system (CNS), primarily in the prefrontal cortex (Farzam, Faizy & Saadabadi, 2023).

Methylphenidate works well with many children, as it appears children with ADHD have an abnormality in the dopamine transporter gene (DAT-1), the D4 receptor gene and/or the D2 receptor gene. The dopaminergic effects of methylphenidate will partly overcome these alterations (DrugBank, 2026).

Indications for Use

Methylphenidate is used for ADHD and narcolepsy. Off-label uses of methylphenidate include treating fatigue in patients with cancer, refractory depression in older adults, apathy in Alzheimer disease, and enhancing cognitive performance (Verghese, Patel & Abdijadid, 2024).

Nursing Considerations

Oral administration, available in immediate release, sustained release and once-daily doses. IR and SR are taken BID or TID. The absorption is slow and peaks approximately 2 hours after ingestion. Do not crush, chew or divide extended-release capsules.

Transdermal patch (Daytrana): patches are different concentrations, and typically prescribed with the lowest concentration first. Apply on the hip and remove 9 hours later. Alternate hips each day. Following application, blood levels slowly rise and peak in 9 hours, which at this point the client removes the patch. Side effects are the same as oral formulations, with two exceptions. Erythema and pruritic at the site, and hypersensitivity reaction. If a hypersensitivity reaction occurs, then any

methylphenidate product can never be used again (Rosenjack Burchum & Rosenthal, 2019; Verghese, Patel & Abdijadid, 2024).

Assessment and Monitoring:

- Blood pressure and heart rate at initial meeting and each visit.
- Weight, and self-report of anorexia or weight loss
- Growth and height in children. If child outside of normal growth curve expectations, possible discontinuation of med.
- Assess for depression, agitation, suicidality
- Monitor for signs of misuse and dependence while in therapy.

Safe with children over the age of 6. Limited safety data for use during pregnancy or breastfeeding.

Caution with cardiac clients: avoid with known structural cardiac abnormalities, cardiomyopathy, serious heart rhythm arrhythmias, or coronary artery disease as sudden death can occur. Blood pressure and heart rate should be monitored in all clients.

Do not give if client has glaucoma or severe hypertension. Clients with agitation, motor tics, Tourette syndrome, or a family history of Tourette syndrome, this med should be used cautiously as symptoms may be exaggerated.

Drug Interactions

- Contraindicated in clients using a monoamine oxidase inhibitor (MAOI), or use of an MAOI within the preceding 14 days.
- Additionally, a patient who is concurrently on warfarin, phenytoin, tricyclic antidepressants, or selective serotonin reuptake inhibitors should have their drug levels monitored and adjust doses as needed.

Side/Adverse Effects

The most common side effects include insomnia, headache, nervousness, weight loss and anorexia.

- CNS (dizziness, headache, tics, restlessness/akathisia),
- GI: nausea/vomiting, dry mouth, decreased appetite, weight loss, abdominal pain
- CV: tachycardia, palpitations, hypertension
- Growth inhibition (reduced height, weight, and bone marrow density) may be observed when prescribed to children long-term.
- Integ: excess sweating, digit ulcerations
- Decreased libido

Most side effects can be minimized with dose adjustments.

Adverse Effects:

- Serious cardiovascular events have occurred, with sudden death reported in association with CNS-stimulant treatment in pediatric clients with structural cardiac abnormalities or other serious heart problems. Sudden death, stroke, and myocardial infarction have also been reported in adults with CNS-stimulant treatment at recommended doses.
- May cause psychotic or manic symptoms in clients with no prior history
- Priapism (painful or prolonged penile erections). This is a medical emergency that requires immediate attention.
- Increases the risk of peripheral vasculopathy, such as Raynaud's phenomenon, with signs and symptoms of fingers or toes feeling numb, cool, painful, and/or changing color from pale, to blue, to red.

Client Teaching

There are several important topics to address with clients and/or parents of minor children who will be taking Methylphenidate.

- **Misuse and Dependence:** Advise clients that methylphenidate is a controlled substance, and it can be misused and lead to dependence.
    - Do not give methylphenidate to anyone else.
    - Store methylphenidate in a safe, preferably locked, place to prevent misuse.
    - Comply with laws and regulations on drug disposal. Advise clients to dispose of remaining, unused, or expired methylphenidate through a medicine take-back program if available.
- Serious Cardiovascular Risks: Advise clients that there is a serious potential cardiovascular risk, including sudden death, myocardial infarction, stroke, and hypertension. Instruct clients to contact a healthcare provider immediately if they develop symptoms such as exertional chest pain or unexplained syncope.
- Blood Pressure and Heart Rate Increases: potential increased blood pressure and heart rate with extended-release capsules. Monitor pulse and BP periodically.
- Psychiatric Risks: May cause psychotic or manic symptoms, even in clients without prior history of psychotic symptoms or mania.
- Priapism: Advise clients of the possibility of painful or prolonged penile erections and to seek immediate medical attention if this occurs.
- Circulation Problems in Fingers and Toes: Instruct clients beginning treatment with methylphenidate about the risk of peripheral vasculopathy and associated signs and symptoms: fingers or toes may feel numb, cool, painful, and/or may

change color from pale, to blue, to red. Report to your prescriber any new numbness, pain, skin color change, or sensitivity to temperature in fingers or toes or any signs of unexplained wounds appearing on fingers or toes.
- Suppression of Growth: Advise parents that methylphenidate may cause slowing of growth and weight loss.
- Alcohol Effect: Advise clients to avoid alcohol while taking extended-release capsules as it can cause a rapid release of the drug.

Methylphenidate Medication Card

Now let's take a closer look at the medication card for methylphenidate (Rosenjack Burchum & Rosenthal, 2019;Verghese, Patel & Abdijadid, 2024). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Methylphenidate Medication Card

Class: CNS stimulants **Prototype:** Methylphenidate **Trade name:** Ritalin, Concerta		**Indications:** Attention Deficit Disorder, Narcolepsy **Therapeutic Effect:** Increased mental focus and attention	
Mechanism of Action: Blocks the reuptake of norepinephrine and dopamine into the presynaptic neuron. Also inhibits the transport of these neurotransmitters, increasing the concentration of dopamine and NE in the synaptic cleft. This creates the classic stimulant effect within the central nervous system (CNS), primarily in the prefrontal cortex.			
Administration: Administer in the morning IR, SR and Extended release Do not crush or chew Transdermal patch: apply on hip each morning, remove after 9 hours. Alternate hips each day Safe for use over the age of 6	**Side Effects**: Common side effects: headache, insomnia, upper abdominal pain, decreased appetite, and anorexia. May slow growth in pediatric clients Serious side effects: Cardiac and perfusion. Priapism: seek medical care immed. Mania/ psychosis	**Contraindications**: Do not take if MAOI within 14 days. Caution with warfarin, phenytoin, antidepressants Pregnancy and lactation Avoid with CVS disease or abnormalities	**Nursing Considerations**: Controlled substance Parent teaching Clients should avoid alcohol Monitor growth/wt in children High misuse potential: monitor Monitor BP and HR

Downloadable file (.docx): Methylphenidate Medication Card CH5.5

To support your learning, you can access the Chapter 5 CNS Mood and Cognition Medication Cards. This is a downloadable and editable document to allow you to update and add content.

Clinical Reasoning and Decision-Making Activity 5.5

A 12-year-old male child has been diagnosed with ADHD

after his parents and teachers became concerned with his inability to concentrate and his poor impulse control in the classroom. The physician has prescribed methylphenidate. What topics should the nurse reinforce while educating the child and his parents about this medication?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

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5.6 Antidepressants

Antidepressants are used to treat depression and other mood disorders, as well as other medical conditions such as migraine headaches, chronic pain, and premenstrual syndrome. Antidepressants modulate neurotransmitter activity, often increasing NT levels in the CNS. The primary NTs include serotonin (5-HT), dopamine, and norepinephrine. Treatment is based on the belief that alterations in the levels of these neurotransmitters are responsible for causing depression (Lilley et al, 2014).

This unit will discuss four classes of antidepressants: tricyclic antidepressants (TCAs), selective serotonin reuptake inhibitors (SSRIs), serotonin-norepinephrine reuptake inhibitors (SNRIs), and monoamine oxidase inhibitors (MAOIs). These medications are compared in Table 5.6 at the end of this unit.

Other antidepressants not covered, but warrant a brief mention are:

Norepinephrine Dopamine Reuptake Inhibitor: bupropion

- Used for major depressive disorder, seasonal affective disorder, smoking cessation.
- Well tolerated with common side effects of headache, agitation, dry mouth and weight loss.

Serotonin-antagonist-and-reuptake-inhibitor: trazodone

- Used monotherapy or in combination with other psychotherapeutics to treat depression.
- Also blocks the histamine and α-1-adrenergic receptors although MOA not completely understood.
- Used for insomnia at low doses. Also used off label for Alzheimer's, anxiety, bulimia, and fibromyalgia.

TCAs and MAOIs are referred to as first-generation antidepressants

because they were first marketed in the 1950s. SSRIs, SNRIs, and other miscellaneous medications such as bupropion are called second-generation antidepressants and are popular because of fewer side effects like sedation, hypotension, anticholinergic effects, or cardiotoxicity (McCuistion et al, 2018).

For more information on different types of anti-depressants, watch this video.

Pharmacology – Antidepressants, SSRI, MAIO, TCA, SNRIs by Simple Nursing, is licensed under a Standard YouTube license

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Principles of Pharmacotherapy

All antidepressants (AD) work to increase the availability of one or more of the neurotransmitters, serotonin, norepinephrine and dopamine. They work slightly different in targeting these neurotransmitters to alter mood and cognition. There are also many off label uses.

They all target certain symptoms with the aim of improving self-concept, sleep disturbances, appetite disturbance, fatigue, psychomotor retardation or agitation (Halter, Pollard & Jacubec, 2019). The overall goal of AD is complete remission of symptoms.

They all work equally well and all have side effects. Usually a client will trial a few different ADs before the most effective one is found. Considerations include tolerability, safety, drug interactions, history of past response and adverse effects, client preference and

cost (Rosenjack Burchum & Rosenthal, 2019). Some side effects are beneficial. For example, for a client with fatigue, a drug that causes CNS stimulation would be chosen such as fluoxetine or bupropion. For a client with insomnia, a drug that causes sedation would be chosen, such as mirtazapine or trazadone.

To modulate the neurotransmitters effect on receptors, this takes time. They block or inhibit the NT within hours, but the therapeutic effects can take a few weeks. Symptoms resolve slowly, with initial responses in 1 to 3 weeks. Maximum responses can be 12 weeks. Clients are typically on an AD at least a month to see if any therapeutic benefit is observed. An adequate trial is 3 months and if an improvement in symptoms, then 4-8 weeks. Most clients are on the AD for 6 to 9 months after depressive symptoms improve. When antidepressants are discontinued, they are usually tapered over several weeks to avoid withdrawal (Halter, Pollard & Jacubec, 2019).

Treatment starts with a low dose to minimize side effects and then gradually increased. Depending on the client response, they are either switched to a different AD in the same class or another one is added from a different class. As mentioned, there are four main classes of antidepressants as well as atypical antidepressants. Each class has many types of medications. For example, tricyclic antidepressants have 9 different meds, although some are less used due to side effects or are used to target certain symptoms.

Two safety risks with most antidepressants are suicidal ideation and serotonin syndrome.

Suicide Risk

Safety warnings are in place for all classes of antidepressants used with children, adolescents, and young adults for a higher risk of suicide. All clients receiving antidepressants should be monitored for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed.

Antidepressants can increase the risk of suicide in the early stages of treatment before the full effects of the meds occur. Prior to starting on any AD, a person may feel very depressed, hopeless and even suicidal, and also have no energy or motivation. After starting on the med, the person's depressive feelings start to improve and they get more energy, they may still feel very hopeless. They may consider suicide as a way out and now have more energy to carry through with their plan.

Close monitoring by health care providers, one week prescription of antidepressants at a time, and close monitoring and support by family and friends to ensure a safety plan is in place.

Serotonin Syndrome

Also known as serotonin toxicity, this potentially fatal condition

arises from excessive serotonergic activity in the CNS, related to the therapeutic use of medications, drug interactions or from an intentional overdose. It is most common with SSRIs, SNRIs or MAOIs in combination of another serotonergic med, such as tramadol (analgesic), dextromethorphan (cough reliever), or illicit drugs (cocaine, MDMA).

Clients may experience mild to fatal symptoms, such as altered mental status (agitation, anxiety, confusion), autonomic dysfunction (sweating, fever, high blood pressure, tachycardia), neuromuscular excitation (tremor, rigidity, hyperreflexia, clonus) and /or gastrointestinal symptoms (nausea, vomiting, diarrhea).

In its most severe form, it can resemble **neuroleptic malignant syndrome** (NMS), which includes hyperthermia, muscle rigidity, autonomic instability with possible rapid fluctuation of vital signs, and mental status changes.

Symptoms can occur within one hour of ingestion of the excess medications, and depending on the dose, can begin with diarrhea, insomnia, tremor and shivering. Once recognized, treatment is often supportive and discontinuation of the implicated medications (Simon, Torrico, & Keenaghan, 2024).

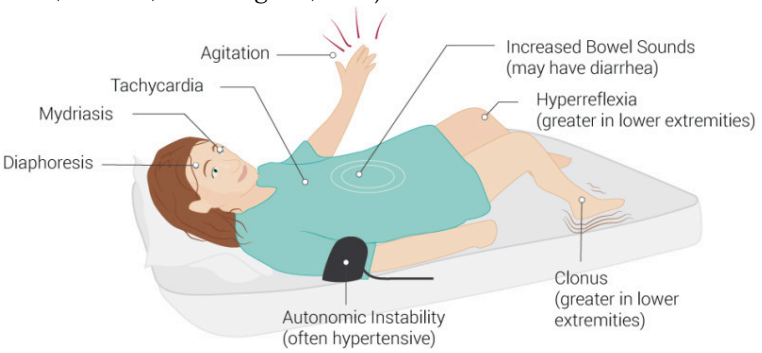

Image 5.6a: Symptoms of serotonin syndrome

Palmer, B. (2021). File:SerotoninSyndrome.jpg – Wikimedia Commons This file is licensed under the Creative Commons Attribution 4.0 International license.

Watch the video to learn more: Rhesus Medicine (2022). Serotonin Syndrome Explained. Serotonin Syndrome Explained (Serotonin Toxicity)

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Tricyclic Antidepressants

Tricyclic antidepressants (TCAs) were one of the original first-generation antidepressants. Due to the safer profile of SSRIs and SNRIs, TCAs are now used second-line for treating depression but are used more commonly to treat neuropathic pain and insomnia.

Indications for Use

TCAs are used to treat major depressive disorder but only as a second line option. Although TCAs are very effective at treating depression, the safety concern of a higher risk of suicide and fatality with overdose, makes it a second-line treatment option.

There are many off-label uses including chronic neuropathic pain conditions (myofascial pain, diabetic neuropathy, postherpetic neuralgia), fibromyalgia, bipolar disorder, ADHD and insomnia. The TCA Imipramine is used as a second line treatment for nocturnal

enuresis in children when the first-line therapy with desmopressin is ineffective (Moraczewski, Awosika & Aedma, 2023).

Mechanism of Action

Tricyclic antidepressants are so named due to the three rings in their chemical structure. They inhibit the reuptake of norepinephrine and serotonin at the presynaptic neuronal membrane resulting an increase of these NTs in the CNS synapses, intensifying their effects. Some TCAs such as amitriptyline, also has an affinity for muscarinic M1 receptors and histamine H1 receptors. TCA thus can cause sedation and anticholinergic side effects.

Watch the video for Mechanism of Action: Antidepressant Mechanism of Action: TCA

https://www.youtube.com/watch?v=AxsYh-ptasM

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Pharmacokinetics

TCAs are rapidly absorbed and highly lipophilic thereby able to cross the blood brain barrier easily. Half-live is 24 hours, therefore once a day dosing. TCAs are lipophilic but each med in this class

have different levels of lipophilicity. They all distribute widely throughout the tissues, including the CNS. They have moderate to high protein binding. Most have hepatic metabolism through P450 system. Renally excreted.

TCAs have a variable half life between 10-50 hours, depending on the drug. Dosages are always started at the lowest dose and titrated depending on the response (Moraczewski, Awosika & Aedma, 2023).

Nursing Considerations

Administration: oral form, readily absorbed. Peak levels obtained in 2-8 hours.

- If taken with food, absorption can be decreased and onset of action delayed.
- Usually administered at bedtime due to sedating effects. Night time dosing also reduces the intensity of side effects.
- Once a day dosing due to the long half-lives.
- Dosing is very individualized due to variable client response and risk of adverse effects.

Hepatic and renal insufficiency may warrant lower dosages and more frequent monitoring.

Tapering of Doses: After prolonged administration, abrupt cessation of treatment may produce nausea, headache, and malaise. The dose should be gradually tapered, but transient symptoms may still occur.

Lifespan considerations:

- TCAs should not be used in children for depression due to safety concerns.
- Pregnancy: There is a risk of congenital malformations (eye, ear, face defects). In addition, TCAs have been linked to

preterm delivery, low birth weight, neonatal withdrawal syndrome, and persistent pulmonary hypertension in newborns. Overall, TCAs are not typically considered safe medication during pregnancy and should be avoided.

- Older Adult: Geriatric clients are particularly sensitive to the anticholinergic side effects of tricyclic antidepressants. Peripheral anticholinergic effects include tachycardia, urinary retention, constipation, dry mouth, blurred vision, and exacerbation of narrow-angle glaucoma. Central nervous system anticholinergic effects include cognitive impairment, psychomotor slowing, confusion, sedation, and delirium. Elderly clients taking amitriptyline may be at increased risk for falls. Elderly clients should be started on low doses of amitriptyline and observed closely.

Drug Interactions

TCAs can interact with many drugs. Ensure to complete a thorough medication profile. If both meds are needed, more frequent monitoring is required.

- Antidepressants: TCAs should be used cautiously with other antidepressants, if required, due to the risk of increasing serotonin levels, such as SSRIs, SNRIs and MAOIs. Serotonin Syndrome is a life-threatening condition if not recognized early (see box below).
- MAOIs: concurrent use can cause hypertensive crisis.
- Anticholinergic drugs: taking an anticholinergic drug such as antihistamines, can increase adverse effects of dry mouth, urinary retention, constipation, blurred vision and confusion.
- Anticoagulants: Concurrent use of warfarin or heparin, may increase the risk of bleeding. This might result from either the inhibition of platelet aggregation by certain TCAs or the displacement of warfarin from plasma proteins by specific

TCAs.
- Anti-hypertensives: TCAs may cause additive or antagonistic effects with beta-blockers, calcium channel blockers, or clonidine. Monitor BP and HR closely.

(Sheffler; Patel & Abdijadid, 2023; Moraczewski, Awosika & Aedma, 2023).

Adverse/Side Effects

Side effects: most common are orthostatic hypotension, sedation and anticholinergic effects:

- Anticholinergic adverse effects such as constipation, urinary retention, photophobia, blurred vision, tachycardia, and drowsiness. This is due to TCAs blocking the muscarinic cholinergic receptors.
- Orthostatic hypotension: Blockage of alpha adrenergic and dopaminergic receptors can cause cardiac conduction disturbances and hypotension. Instruct clients to get up slowly, and lie down if symptoms of dizziness occur. For clients in the hospital, take BP and HR regularly, lying/sitting/standing positions to assess for low BP or high HR.
- Sedation: Histaminergic blockage can cause sedation.
- Seizure risk: serotonergic blockade can alter the seizure threshold for clients with seizure disorders.
- Higher risk of suicide: monitor closely the first 6 months for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed.

TCAs are contraindicated in the following conditions:

- Myocardial infarction
- Pregnancy, lactation

- Preexisting cardiovascular disorders, especially with preexisting bundle-branch block (may lead to heart block). TCAs decrease vagal influence on the heart and slow conduction in the bundle of His leading to higher risk of dysrhythmias. Monitor ECG before and periodically after the start of treatment for any clients at risk.
- Angle-closure glaucoma
- Prostate hypertrophy
- History of seizures.
- Hepatorenal diseases.

Overdosage

Death may occur from overdosage with this class of drugs. Multiple drug ingestion (including alcohol) is common in deliberate tricyclic antidepressant overdose. If an overdose occurs, consult with a Poison Information Center (1-800-567-8911).

TCA overdose – high risk of fatality.

TCA is unique among the ADs due to the lethal outcome in overdose situations. This is due to a number of reasons: TCAs are readily absorbed within a few hours and have a high volume of distribution in the body due to being highly lipophilic. TCAs have a narrow therapeutic index so overdosing on less than 10x the usual dose can be toxic. TCAs normally effect many receptors, not just SE and NE, but also histamine, alpha-adrenergic, and muscarinic receptors. In an overdose, the typical effects of blocking these receptors are amplified, but also sodium and potassium is also blocked in the cells leading to cardiac dysrhythmias from widening QRS, and eventual torsade's de pointes. Sodium bicarbonate is an antidote to correct the metabolic acidosis and improve dysrhythmias, along with other supportive measures to manage the hypotension and seizures (Khalid & Waseem, 2023).

Watch the video to help remember key points of TCA Toxicity:

TCA Toxicity MADE EASY! [TCA Toxicity MADE EASY! (with a FUN visual MNEMONIC)](#) by AJmonics on Youtube.

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=267#oembed-4*

Client Teaching:

- Due to the increased risk of suicidality with antidepressants, clients and their family members or caregivers should be instructed to immediately report any sudden changes in mood, behaviors, thoughts, or feelings. Mood elevation may take 7-28 days with 6-8 weeks for full effect (McCuistion et al, 2018; Lilley, Collins & Snyder, 2014).
- Inform of common side effects such as drowsiness, dizziness and hypotension and these will subside after a few weeks.
- Refrain from alcohol use as this may increase CNS depression and reduce the effectiveness of ADs.
- Take full dose at bedtime to minimize side effects. If dose is missed, take within 3 hours or wait until next scheduled dose. Do not double up dosages.
- Do not suddenly stop the med, as may experience nausea, nightmares, cold sweats within 2-4 days.

Halter, Pollard & Jacubec, 2019

Tricyclic Antidepressants Medication Card

Tricyclic Antidepressants Medication Card

Class: Tricyclic Antidepressants **Prototype:** Amitriptyline, Desipramine		**Indications:** depression. Off-label uses including chronic neuropathic pain conditions, fibromyalgia, bipolar disorder, ADHD and insomnia	
Mechanism of Action: inhibit the reuptake of norepinephrine and serotonin at the presynaptic neuronal membrane resulting an increase of these NTs in the CNS synapses, intensifying their effects.			
Administration: Oral admin at bedtime. If taken with food, decreased absorption. Taper dose when discontinuing.	**Side Effects:** orthostatic hypotension, sedation and anticholinergic effects Risk of serotonin syndrome if taken with serotonergic meds or high doses. Seizure risk Risk of suicidality Toxic if overdose: can be lethal due to cardiac dysrhythmias	**Contraindications:** Hepatic and renal insufficiency may warrant lower dosages. Lower doses for older adult. Higher risk for anticholinergic effects. Many drug interactions Not for pregnancy Caution with CV disease, BPH, hepatorenal dis., glaucoma	**Nursing Considerations:** Bedtime dosing due to sedative effects. Client teaching: Take as prescribed Refrain from alcohol Do not suddenly stop med, taper dosing required.

Downloadable file (.docx): Tricyclic Antidepressants Medication Card

Selective Serotonin Reuptake Inhibitor (SSRI)

Selective Serotonin Reuptake Inhibitors (SSRIs) are second-generation antidepressants first introduced in 1987. They are the

most prescribed antidepressant. Two common SSRIs are fluoxetine and citalopram. Fluoxetine will be our prototype med.

Indications for Use

SSRIs are primarily used to treat depression but are also used to treat obsessive-compulsive disorder, bulimia, panic disorder, posttraumatic stress disorder, other forms of anxiety, premenstrual syndrome, and migraines.

Mechanism of Action

SSRIs selectively block the reuptake of serotonin (5-HT) resulting in the increased concentration of serotonin in the synapse and increased activation of postsynaptic 5-HT receptors. The therapeutic effects are due to the adaptive cellular changes that occur with a prolonged reuptake blockage, not just the actual biochemical effect.

SSRIs have little effect on other neurotransmitters, such as dopamine, norepinephrine, acetylcholine or histamine, leading to fewer side effects.

Nursing Considerations

- Oral administration only, may take up to 6 weeks before the patients feel the effects of treatment.
- Caution if client has hepatic disease, anticipate dose reduction.
- Caution if taking other CNS medications; may cause additive sedative effects.

- Risk of serotonin syndrome with drug interactions or overdose. Monitor for symptoms.
- Monitor for increased risk of suicidal ideation, especially when therapy is initiated.
- SSRIs also have the potential to prolong the QT interval, which can lead to fatal arrhythmia, and torsade de pointes.
- Fatal overdose is rare compared to other antidepressants.
- Monitor weight before and during therapy.

Drug Interactions

Increased bleeding risk: concomitant use of fluoxetine and NSAIDs, aspirin, warfarin, or other drugs that affect coagulation. Monitor for signs of bleeding. Monitor INR more closely if client on warfarin, possible dosage reduction.

Adverse/Side Effects

SSRI's are considered relatively safe and better tolerated than TCAs or MAOIs. Common side effects include nausea, agitation, insomnia, and sexual dysfunction (anorgasmia, impotence, delayed or absent ejaculation).

Other side effects include rash, mania, seizures, and weight gain.

High Alert Med:

- Higher risk of suicide, as with all classes of antidepressants used with children, adolescents, and young adults. Clients receiving antidepressants should be monitored for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed.
- Serotonin Syndrome: The development of a potentially life-threatening serotonin syndrome or neuroleptic malignant

syndrome (NMS)-like reactions has been reported with SNRIs and SSRIs, particularly with concomitant use of serotonergic drugs, drugs that impair the metabolism of serotonin (including MAOIs), or with antipsychotics or other dopamine antagonists. See Serotonin Syndrome at the beginning of this unit for details of presenting symptoms.

Tapering of med for discontinuation: Abrupt discontinuation may discontinuation syndrome (dizziness, insomnia, nausea, agitation), so a gradual reduction in the dose rather than abrupt cessation is recommended whenever possible (Lilley et al, 2014; McCuistion et al, 2018).

Client Teaching

- Clients should be careful to take medications as directed. Abrupt discontinuation may cause anxiety, insomnia, and increased nervousness.
- Take the medication in the morning as they may cause insomnia if taken in the evening.
- Orthostatic blood pressure changes are possible during medication therapy. Advise client to change positions slowly.
- Anticipate increased drowsiness and dizziness at beginning of therapy.
- Avoid alcohol or other CNS depressant drugs.
- Clients, family, and caregivers should monitor clients carefully for suicidality.
- Inform client of side effects and monitor.
    - Sexual dysfunction: sexual problems are underreported. Inform client of the probability and encourage reporting any issues. Depending on the severity, solutions can include a drug holiday for a few days or the addition of another medication such as bupropion or nefazadone.

    - Weight gain is common, advise client to monitor weight.
- Some SSRIs should not be taken with grapefruit juice due to its effect on the CYP3A4 enzyme that affects the bioavailability of the medication. Consult with prescriber or pharmacist for drug specific guidance.
- Due to the risk of insomnia, recommend to the client to use a sleep diary to track their sleep. Also, to practice good sleep hygiene such as going to bed at a set time, avoiding stimulating activities/substances such as caffeine, nicotine or screen time and having a dark quiet room.

Example in Practice:

A 30-year-old client has been diagnosed with depression following a month of persistent depressive symptoms including hopelessness, anorexia, fatigue. She has started psychotherapy and the prescriber has started her on the SSRI: citalopram 20 mg po once a day in the morning. The nurse has provided some health teaching. The client understands this medication when she states that it may take a few weeks to start to feel a bit better, but knows it can take up to a few months. She knows to take the med in the morning, and not to double up if she misses a dose. She doesn't like the idea about gaining weight but she will weigh herself every few weeks to see if she is affected. She knows not to stop taking the med if she doesn't like the side effects and will see the prescriber first so she can be slowly taken off the med. She plans to keep her next appointment in a week and will let her mother know the plan, who is her primary support person.

Serotonin Selective Reuptake Inhibitors Medication Card

Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Serotonin Selective Reuptake Inhibitors Medication Card

<table>
<tr><td colspan="2">Class: Serotonin Selective Reuptake Inhibitors

Prototype: Fluoxetine</td><td colspan="2">Indications: treatment of depression
Also used to treat obsessive-compulsive disorder, bulimia, panic disorder, posttraumatic stress disorder, other forms of anxiety, premenstrual syndrome, and migraines.</td></tr>
<tr><td colspan="4">Mechanism of Action: SSRIs selectively block the reuptake of serotonin (5-HT) resulting in the increased concentration of serotonin in the synapse and increased activation of postsynaptic 5-HT receptors. The therapeutic effects are due to the adaptive cellular changes that occur with a prolonged reuptake blockage, not just the actual biochemical effect.</td></tr>
<tr><td>Administration:
Take up to 6 weeks before full effects

Oral admin

Grapefruit can interfere with absorption

Tapering of med for discontinuation</td><td>Side Effects:
nausea, agitation, insomnia, oorthostatic hypotension, drowsiness and dizziness at beginning of therapy

Sexual dysfunction (decreased libido)

Weight gain

Risk of suicidality - monitor

Risk of serotonin syndrome</td><td>Contraindications:
Less risk than other ADs

Drug interactions: Increased bleeding risk: concomitant use of fluoxetine and NSAIDs, anticoagulation drugs

Monitor for signs of bleeding. Monitor INR more closely if client on warfarin, possible dosage reduction</td><td>Nursing Considerations:
Client teaching:

Do not abruptly discontinue

Avoid alcohol</td></tr>
</table>

Downloadable file (.docx): Serotonin Selective Reuptake Inhibitors Medication Card

Serotonin Norepinephrine Reuptake Inhibitor (SNRI)

The two most common SNRIs are venlafaxine and duloxetine. They are structurally different although both block the NE and SE receptors. Both are used for major depression, but venlafaxine is also approved for other conditions such as anxiety disorders.

Mechanism of Action

SNRI's inhibit the reuptake of serotonin and norepinephrine, with weak inhibition of dopamine reuptake. It has minimal effects on other neurotransmitters, such as histamine or cholinergic receptors.

Indications for Use

Both SNRIs are indicated for the treatment of a major depressive disorder. Venlafaxine is also used for generalized anxiety disorder, social phobias and panic disorders. Duloxetine has also been approved for non-psychiatric conditions such as diabetic neuropathy and fibromyalgia.

Nursing Considerations

- Oral administration with immediate release and extended-release formulations. Take with food
- SNRIs are contraindicated with MAOIs or within 14 days of use

of an MAOI.
- Dosage adjustment is required for use in clients with renal and/or liver disease. Do to hepatotoxicity risk, do not give to clients with liver disease or those who consume large amounts of alcohol.
- Elderly clients are at greater risk for developing hyponatremia.
- Use with caution with other serotonin medications to avoid serotonin syndrome.
- Do not abruptly discontinue med, as can lead to withdrawal syndrome. Symptoms include anxiety, agitation, tremors, headache, vertigo, nausea, tachycardia and tinnitus. Taper dose when discontinuing.
- Pregnancy: late pregnancy use of Venlafaxine may result in neonatal abstinence syndrome characterized by irritability, abnormal crying, tremor, respiratory distress and seizures.

(Halter, Pollard & Jacubec, 2019; Rosenjack Burchum & Rosenthal, 2019)

Adverse/Side Effects

Common side effects include nausea, dry mouth, insomnia, constipation, reduced appetite, fatigue, increased sweating.

May cause increase in blood pressure. Monitor BP before treatment starts and periodically throughout treatment.

High Alert Med: As with all classes of antidepressants, there is a high risk of suicide if used with children, adolescents, and young adults.

Monitor for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed. Dose is started low, and tapered up depending on the effect.

Drug Interactions: increased risk of serotonergic and anticoagulant effects, especially with the concomitant use of

fluoxetine and NSAIDs, aspirin, warfarin, or other drugs that affect coagulation. Monitor for bleeding. If client on warfarin, increase frequency of INR monitoring, and possible dose reduction.

Client Teaching

- Clients should be careful to take medications as directed.
- If discontinuing the med, must be tapered prior to discontinuation.
- Inform client of possible side effects, such as increased drowsiness or dizziness.
- Use of SNRI medications with alcohol or other CNS depressant drugs should be avoided.
- Suicide risk: at the start of therapy and throughout, family and caregivers should monitor clients carefully for suicidality.

(McCuistion et al, 2018: Lilley et al, 2014)

Serotonin Norepinephrine Reuptake Inhibitor: Venlafaxine Medication Card

Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Serotonin Norepinephrine Reuptake Inhibitor: Venlafaxine Medication Card

Class: Serotonin Norepinephrine Reuptake Inhibitors **Prototype:** Venlafaxine		**Indications:** major depressive disorder. Also, for generalized anxiety disorder, social phobias and panic disorders. Duloxetine has also been approved for non-psychiatric conditions such as diabetic neuropathy and fibromyalgia.	
Mechanism of Action: SNRI's inhibit the reuptake of serotonin and norepinephrine, with weak inhibition of dopamine reuptake. It has minimal effects on other neurotransmitters, such as histamine or cholinergic receptors.			
Administration: Oral admin; take with food Dose adjustment if renal or liver disease Do not abruptly d/d; taper med	**Side Effects:** Nausea, dry mouth, insomnia, constipation, reduced appetite, fatigue, increased sweating Drowsiness & dizziness at beginning of therapy may increase BP Sexual dysfunction (decreased libido) Weight gain Risk of suicidality - monitor Risk of serotonin syndrome	**Contraindications:** Drug interactions: risk of bleeding if also taking NSAIDs, coagulation modifiers (ie. Warfarin) Increased bleeding risk: concomitant use of fluoxetine and NSAIDs, anticoagulation drugs Monitor for signs of bleeding. Monitor INR more closely if client on warfarin, possible dosage reduction.	**Nursing Considerations:** Monitor BP before and during treatment. Monitor mood and assess other symptoms. Client teaching: Do not abruptly discontinue. Avoid alcohol and other CNS meds

Downloadable file (.docx): Serotonin Norepinephrine Reuptake Inhibitor – Venlafaxine Medication Card

Monoamine Oxidase inhibitors (MAOI)

Monoamine oxidase inhibitors (MAOIs) have been used since the 1950s and are a first-generation antidepressant. They were used successfully to treat severe melancholic depression but fell out of favour due to adverse effects and the discovery of new antidepressants. A significant disadvantage to MAOIs is their

potential to cause a hypertensive crisis when taken with stimulant medications or foods containing tyramine. Today, nonselective MAOIs have fallen out of use due to the dietary and drug restrictions, but can be for atypical depression as a second or third choice after other antidepressants have been tried.

Mechanism of Action

The mechanism of action of MAOIs is not fully understood but is presumed to be linked to the potentiation of monoamine neurotransmitter activity in the central nervous system resulting from its inhibition of the enzyme monoamine oxidase (MAO). MAOIs prevent the breakdown of monoamine neurotransmitters, NE, dopamine, and serotonin, resulting in increased concentrations of these NTs in the brain and subsequent improved mood. But they also prevent the breakdown of tyramine, resulting in tyramine being absorbed and taken up by adrenergic neurons which causes a massive release of NE leading to hypertension (McCuistion et al, 2018).

MAOIs (tranylcypromine) have originally been non-selective and irreversible, meaning they prevent the breakdown of both MAO-A and MAO-B. Irreversible binding to the receptor means that the effect will last until the enzyme is eventually replaced. This formulation causes the most adverse effects of hypertensive crisis. New formulations have created reversible and selective MAOIs (moclobemide) or selective to MAO-B (selegiline).

Monoamine Oxidase Enzyme

Is a mitochondrial enzyme that is found in most tissues. MAO enzymes degrade monoamines which are located in the liver and in nerve endings that release the neurotransmitters NE, 5-HT and dopamine. They exist in two forms: MAO-A responsible for the catabolism of NE and 5-HT in the brain. In the intestine, MAO-A metabolizes tyramine of ingested food. MAO-B which is selective for dopamine metabolism.

Indications for Use

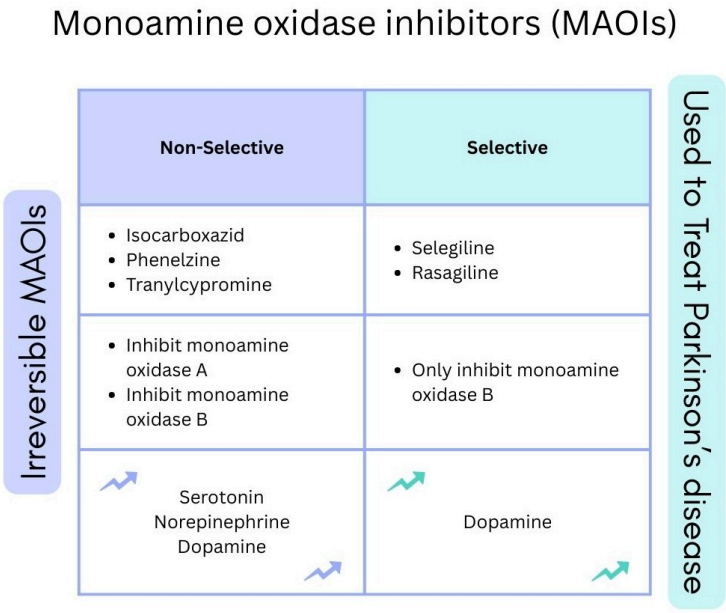
MAOIs are indicated for the treatment of major depressive disorder or atypical depression in adult clients who have not responded adequately to other antidepressants. Depending on the med, they are also used off label to treat Parkinson's disease, mood disorders such as anxiety or obsessive-compulsive disorder.

Selegiline at low doses – MAOI-B selective: treats Parkinsons Disease

Selegiline at high doses – MAOI-A and B non-selective: treats depression

Phenelzine – MAOI A and B non-selective: treats depression

To learn more about MAO inhibitors, watch the following YouTube video by Osmosis: Video: Monoamine oxidase inhibitors | Osmosis



5.6b Monoamine Oxidase Inhibitors: comparison between selective and non-selective MAOIs (created by TRU Open Press using Canva)

Comparison between non-selective and selective MAOIs. Non-selective MAOIs, irreversibly inhibit MAOI-A and MAOI-B, leading to an increase in serotonin, norepinephrine and dopamine. Selective MAOI's, that only inhibit MAOI-B, and only increase dopamine, making it a good option for the treatment of Parkinson's disease.

Nursing Considerations

Administration: oral or transdermal patch (Selegiline)

- Selegiline transdermal patch: apply q 24 hours to upper arm, upper torso or upper thigh. Common reaction is a localized rash, may apply a topical glucocorticoid as needed.
- may take up to 4 weeks to see effect. Energy may increase before mood, therefore caution with suicidal risk.
- Wash out period of 2 weeks is required if the antidepressant is changed to another med.

Risk of Hypertensive Crisis with foods containing tyramine. Many foods contain the monoamine tyramine (see list below) so these foods should be avoided for non-selective MAOIs.

Lifespan considerations:

- Safety has not been established with the pediatric population.
- The elderly population is at increased risk for postural hypotension and serious adverse effects.

Misuse and dependence have been reported.

Should not be used for clients with hepatic or renal disease.

Drug Interactions

There are many drug interactions so a thorough medication profile and health teaching is important.

- Antidepressants: most antidepressants inhibit the reuptake serotonin, so if taken with MAOI, there is a risk of serotonin syndrome. If a switch to a different AD is required, a washout period of 2 weeks is required.
- Sympathomimetics: Cold remedies containing amphetamines (phenylephrine, ephedrine) or other adrenergic meds can lead to a hypertensive crisis as they add to the pro-noradrenergic actions of MAO inhibition. Inform clients that taking any OTC meds for decongestants or cough suppression should be

discussed with the physician or pharmacist.

- Antibiotic Linezolid: Patients taking MAOIs or other serotonergic psychiatric medications should avoid taking the antibacterial drug linezolid. This antibiotic has MAOI activity as it selectively prevents bacterial protein synthesis through the inhibition of monoamine oxidase. There may be increased risk of serotonin syndrome.
- Other drugs that should be avoided are H2 Receptor Antagonist Cimetidine and synthetic opioids such as tramadol or methadone.

(Edinoff et al, 2022)

Tyramine rich foods

Many foods contain tyramine and usually this monoamine is metabolized by the liver and gut and therefore never reaches a high concentration. But, if the client is on a non-selective MAOI, tyramine is not metabolized, leading to high levels and high blood pressure.

Many foods contain tyramine and include old cheese, yeast products, pickled foods, red beans, red wine, yogurt, and smoked meats.

Although a very effective antidepressant, MAOI meds have been mostly replaced with other antidepressants due to the strict diet that would be required while on this med.

Figure 5.6e Tyramine rich foods include smoked meats, old cheese and pickled foods.

Image by BobPetUK https://www.flickr.com/photos/22179048@N05/5947451320

Adverse/Side Effects

Early in treatment, side effects are common and include orthostatic hypotension, daytime fatigue, insomnia, nausea, constipation and dry mouth.

Long term effects include weight gain and sexual dysfunction.

High Alert Med: The risk of suicide are in place for all classes of antidepressants used with children, adolescents, and young adults. Clients receiving antidepressants should be monitored for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed.

Risk of hypertensive crisis: This is defined by severe hypertension (blood pressure greater than 180/120 mm Hg) with evidence of organ dysfunction. Symptoms may include occipital headache (which may radiate frontally), palpitations, neck stiffness or soreness, nausea or vomiting, sweating, dilated pupils, photophobia, shortness of breath, or confusion. Either tachycardia or bradycardia may be present and may be associated with constricting chest pain.

Risk of serotonin syndrome: Risk if higher doses or concurrent use of other serotonergic medications. Monitor for symptoms including neuromuscular, autonomic, gastrointestinal or altered mental status.

Client Teaching

- Clients should be careful to take medications as directed. It may take up to 4 weeks to see the effects of the drug. They should avoid abrupt cessation of therapy to avoid withdrawal symptoms.
- Inform client of diet restrictions if taking a non-selective MAOI. Dietician consult may be required.
- Inform client to not take any OTC medications (cough and cold remedies) unless first consulting the prescriber or pharmacist.
- Clients should avoid alcohol, other CNS depressants, and tyramine-containing products for two weeks after therapy is discontinued.
- Clients should be advised regarding the signs of hypertensive crisis and to immediately report headache, chest or throat tightness, and palpitations to the provider.

Monoamine Oxidase Inhibitors Medication Card

Now let's take a closer look at a medication grid that compares these classifications of anti-depressants (Lilley et al, 2014; McCuistion et al, 2018).

Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Monoamine Oxidase Inhibitors Medication Card

<table>
<tr><td colspan="2">Class: Monoamine Oxidase Inhibitors

Prototype: Phenelzine (MAOI A and B (non-selective) for treatment of depression.</td><td colspan="2">Indications: major depressive disorder or atypical depression in adults who have not responded adequately to other antidepressants.
Used off label to treat Parkinson's disease, mood disorders such as anxiety or obsessive-compulsive disorder.</td></tr>
<tr><td colspan="4">Mechanism of Action: not fully understood, but presumed to be linked to the potentiation of monoamine neurotransmitter activity in the central nervous system resulting from its inhibition of the enzyme monoamine oxidase (MAO). MAOIs prevent the breakdown of monoamine neurotransmitters, NE, dopamine, and serotonin, resulting in increased concentrations of these NTs in the brain and subsequent improved mood. MAO-A enzyme in the gut and liver also breakdown tyramine, so when inhibited, leads to increased adrenergic effect and ++ hypertension.</td></tr>
<tr><td>Administration:
Oral

May take up to 4 weeks to see effect

If switching between AD, need a 2 week wash out period</td><td>Side Effects:
Risk of suicidality - monitor

Risk of hypertensive crisis- avoid tyramine (aged cheese, pickled foods, etc). occipital HA, SOB, N&V

orthostatic hypotension, daytime fatigue, insomnia, nausea, constipation and dry mouth

Long term effects include weight gain and sexual dysfunction</td><td>Contraindications:
Not for peds
Avoid with renal or liver disease

Drug interactions:
Risk of serotonin syndrome if use other ADs. Wash out period

Caution with decongestants

Avoid antibiotic linezolid</td><td>Nursing Considerations:
Monitor BP before and during treatment

Monitor mood and assess other symptoms

Client teaching:
Do not abruptly discontinue

Avoid alcohol and other CNS meds

Risk of hypertensive crisis if eating foods containing tyramine</td></tr>
</table>

Downloadable file (.docx): Monoamine Oxidase Inhibitors Medication Card

Herbal Preparation: St. John's Wort Benefits and Dangers

St. John's Wort is a plant with yellow flowers that has been used for a long time for traditional medicinal purposes. It is currently available OTC as a herbal supplement. It can be taken for mild depression and other ailments. But it comes with a warning, as it interacts with many drugs. Clients on serotonergic antidepressants should not take St John's Wort as it can increase serotonin levels leading to serotonin syndrome. It also interacts with oral contraceptives, warfarin, statins and digoxin. For nurses, ensuring to ask about herbal supplements or any OTC medications will help ensure client safety with any med.

5.6e *Image: Common St. John's Wort*

File:Common St. John's-Wort (Hypericum perforatum) – London, Ontario.jpg – Wikimedia Commons CC BY-SA 4.0

To support your learning, you can access the Chapter 5 Comparing Antidepressant Medications Table. This is a

downloadable and editable document to allow you to update and add content.

Clinical Reasoning and Decision-Making Activity 5.6

1.A 32-year-old female visits the nurse practitioner with concerns about "feeling tired all the time," "having difficulty concentrating," "problems sleeping," and "just generally feeling down." The nurse practitioner prescribed fluoxetine.

The client tells the nurse, "One of my friends told me I have to be careful or I might get serotonin syndrome if I take medication."

a. What places a client at risk for serotonin syndrome, and what symptoms should the nurse teach the client about this condition?

b. The nurse knows that anyone starting an antidepressant is at risk for suicidal thoughts. How should the nurse therapeutically discuss this potential adverse effect with the client?

c. What potential common side effects should the nurse discuss with the client?
The client states, "I can't wait to feel better again. How soon will this medication work?"

d. What is the nurse's best response?

2. You are working with a client who is being treated for treatment resistant depression. Their mood has been very

low with anhedonia, decreased ability to function, fatigue and hopelessness. They wish that they will go to sleep and not wake up. They do not have any active plans to harm themselves. They do not have any symptoms of psychosis. They report watching TV throughout the day and have difficulties sleeping at night. They average 5 hours of interrupted sleep at night and a 45 min nap in the day time.

They have been prescribed venlafaxine ER 300 mg OD and have been taking the medication at bedtime.

What education can you provide for the client?

3.On your next appointment the client tells you that their family physician has prescribed aripiprazole. They noticed on the handouts from the pharmacist that it is an antipsychotic medication and are concerned because they do not have symptoms of psychosis.

What information can you provide the client.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

Interactive Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=267#h5p-106

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Media

- **Pharmacology – Antidepressants, SSRI, MAIO, TCA, SNRIs by Simple Nursing, is licensed under a Standard YouTube license**
- Watch the video to learn more: Rhesus Medicine (2022). Serotonin Syndrome Explained. Serotonin Syndrome Explained (Serotonin Toxicity)
- Image 5.6a: Symptoms of serotonin syndrome
- Palmer, B. (2021). File:SerotoninSyndrome.jpg – Wikimedia Commons This file is licensed under the Creative Commons Attribution 4.0 International license.
- Watch the video for Mechanism of Action: Antidepressant Mechanism of Action: TCA
- https://www.youtube.com/watch?v=AxsYh-ptasM

- 5.6b: comparison between selective and non-selective MAOIs (TRU Open Press)
- BobPetUK at https://www.flickr.com/photos/22179048@N05/5947451320
- File:Common St. John's-Wort (Hypericum perforatum) – London, Ontario.jpg – Wikimedia Commons CC BY-SA 4.0

5.7 Mood Stabilizers

Mood stabilizers or anti-mania drugs are used to treat bipolar affective disorder. There are three different types of bipolar disorder but generally, it is a condition that is marked by shifts in mood, energy and ability to function. Periods of normal functioning are interrupted with periods with highs (manic) and lows (depression) (Halter, Pollard & Jacubec, 2019, pg. 277).

Lithium carbonate was the first medication used to stabilize clients with bipolar disorder in the manic phase. Lithium can be a monotherapy or used along with other medications such as anticonvulsants (valproic acid, carbamazepine, lamotrigine) and atypical antipsychotics (quetiapine). Lithium is still regarded as the gold standard for mania and maintenance. Although lithium is very effective, it has a low therapeutic range and unfavourable side effects. It is still considered the gold standard for mania maintenance. Other medications such as divalproex sodium and valproic acid may be used instead.

The treatment of mania for acute and maintenance therapy often includes more than one medication. Medications currently used:

- Lithium carbonate
- Anticonvulsants: valproic acid, carbamazepine, lamotrigine, gabapentin
- Atypical antipsychotics: quetiapine, olanzapine, risperidone, aripiprazole

Antianxiety drugs are also sometimes used to control agitation or if resistant to other meds and include diazepam, clonazepam, and lorazepam (Halter, Pollard & Jacubec, 2019, pg. 290).

In this unit, we will review lithium carbonate. Nurses need to be knowledgeable of the risks of toxicity and important monitoring and client teaching of this medication.

Lithium

Lithium is a very effective medication for the treatment of manic episodes in bipolar disorder and as maintenance treatment. It was the first medication used for mood stabilization. It is also used off-label for other conditions once typical therapies have proven ineffective.

Indications for Use

Lithium is often the drug of first choice or acute manic episodes. It is effective at treating a number of symptoms including: elation, flight of ideas, irritability, and anxiety. It helps control insomnia, agitation, distractibility, hypersexuality and paranoia (Halter, Pollard & Jacubec, 2019). It can be used as adjunct therapy for treating major depressive disorder, vascular headaches and alleviating neutropenia (Chokhawala; Lee & Saadabadi, 2024).

Mechanism of Action

Lithium alters sodium transport in nerve and muscle cells and causes a shift toward intraneuronal metabolism of catecholamines and serotonin, but the specific biochemical mechanism of lithium action in mania is unknown (Chokhawala; Lee & Saadabadi, 2024).

Pharmacokinetics

Lithium is readily absorbed following oral administration. For immediate release formulations, peak plasma concentration is

0.25-3 hours. It is not metabolized and is excreted by the kidney unchanged. About 80% of the excreted lithium undergoes reabsorption in the proximal tubule of the nephron. Renal excretion of lithium is affected by blood levels of sodium, so maintaining normal sodium levels is important (Rosenjack Burchum & Rosenthal, 2019). The half-life of lithium ranges from 18-36 hours.

Nursing Considerations

Pretreatment: a thorough medical examination is required to ensure lithium is the best choice for a client. This includes: physical examination, list of medical or psychiatric conditions and treatments, lab work (renal panel, electrolytes, thyroxine, TSH).

Administration: Oral administration only, immediate release, slow release or extended-release tablets.

- It is often prescribed BID or TID depending on clinic response and lithium levels. Due to its short half life as it is rapidly excreted renally, it is prescribed in divided daily doses.
- At the beginning of treatment, lithium dosages are low and gradually increased every few days until lithium therapeutic levels have been reached. This typically takes 7-14 days. The ideal lithium levels are between 0.6-1.2 mEq/L, but slightly higher may be more effective. Lithium levels should be lower than 1.5 mEq/L to avoid toxicity, and clinical assessment is essential.

Treatment is effective if it results in symptom alleviation and remission. Some clients will not achieve this and alternate or additional meds may be required (Chokhawala; Lee & Saadabadi, 2024).

Normalization of symptoms during a manic episode can be 1-3 weeks. During this time, an antipsychotic or benzodiazepine is given

until lithium levels become therapeutic. Those meds are then tapered off. In the maintenance phase of bipolar, lithium is prescribed 9-12 months, and for some clients they may be on it lifetime.

Therapeutic and Toxic Levels: Lithium must be closely monitored with a narrow therapeutic serum range of 0.6 to 1.2 mmol/L (Medical Council of Canada, 2021). Below 0.6 and the med is ineffective, and above 1.2 and they risk toxicity. Monitor lithium levels daily to every 2-3 days, then every 3-6 months once stabilized. Lithium levels are drawn in the morning, 10-12 hours following the last dose.

Serum sodium levels should also be monitored for potential hyponatremia (McCuiston et al, 2018).

Contraindicated or used with caution for clients with renal or cardiovascular disease, severe dehydration or sodium depletion, and to clients receiving diuretics because the risk of lithium toxicity is very high in such clients.

Pregnancy: Lithium can cause fetal harm in pregnant women. Safety has not been established for children under 12 and is not recommended.

Caution with the older adult due to declining kidney function.

Adverse/Side Effects

Side effects: many clients experience nausea, vertigo and diarrhea, but resolve in a few days. Other side effects include weight gain, fine hand tremor, polyuria, metallic taste and mild thirst that may also persist throughout treatment (McCuistion et al, 2018).

Longterm effects include hypothyroidism which can be treated with levothyroxine. Lithium may also lead to a decline in GFR (Godden, 2024).

High Alert Med: Lithium toxicity is closely related to serum lithium levels and can occur at doses close to therapeutic levels at

1.5 mEq/L and even with lithium levels within a therapeutic range. Mild symptoms such as diarrhea, drowsiness, lack of coordination are experienced with mild toxicity, progressing to severe symptoms if not corrected. This includes seizures, abnormal electrocardiographic (ECG) findings and risk of sudden death.

Lithium toxicity is also classified as acute (intentional single overdose), acute-on-chronic (acute overdose with long term use), and chronic (complication of long-term therapy such as dehydration or deteriorating renal function). Treatment will vary slightly

Clients should be advised to seek immediate emergency assistance if they experience fainting, light-headedness, abnormal heartbeats, or shortness of breath. Clients need to be attuned to any change in how they feel physically, follow the treatment plan (taking meds as prescribed, routine lithium levels) and eating a normal diet.

Lithium Toxicity Symptoms and Interventions

Note: references vary with onset of possible symptoms and corresponding lab values. Use these values as a guide only. Clinical presentation is most important.

Lithium Level	Symptoms	Interventions
Potential Side Effects (at therapeutic levels) 0.4-1.5 mEq/L	GI effects (nausea, diarrhea, anorexia), fine hand tremor, polyuria, mild thirst, weight gain	GI effects usually subside. Tremor can be treated with propranolol if it interferes with motor skills. Polyuria (up to 3L/day) leading to nocturia and excess thirst. Can be treated with amiloride (K-sparing diuretic). Encourage fluids 8-12 glasses/day.
Mild lithium toxicity 1.5- 2.5 mEq/L	Nausea & vomiting, diarrhea, fatigue, weakness and confusion, Other symptoms: course hand tremor, hyperirritability of muscles, tachycardia, ECG changes, light-headed	Next dose of lithium held. Lithium levels and electrolytes, LFTs, FBG, Ca. Vital signs, 12 lead ECG Hydration to increase urine output Correct any electrolyte abnormalities Hospitalization Possible gastric lavage if overdose with IR tablets
Moderate lithium toxicity 2.5 mEq/L to 3.5 mEq/L):	Ataxia, agitation, polyuria, serious ECG changes, tinnitus, blurred vision, stupor, severe hypertension	As above Hasten drug excretion with hemodialysis.
Severe lithium toxicity (>3.5 mEq/L):	Increased disorientation, coma, seizures, hyperthermia, hypotension, oliguria, death	As above Hasten drug excretion with hemodialysis.

(Godden, 2024; Hedya, Avula & Swoboda, 2023)

Treatment of lithium toxicity focuses on hydration and discontinuation of the drug. There is no specific antidote, but treatment of symptoms and supportive measures (Chokhawala; Lee & Saadabadi, 2024).

Causes of lithium toxicity: If clients are taking their meds as prescribed, they can still develop lithium toxicity. Clients need to be informed of potential causes and consult with their prescriber if any changes to their health. Causes of toxicity are often related to hyponatremia and include:

- dehydration (excess sweating, fever, illness such as vomiting or diarrhea),
- dietary changes (change to a low sodium diet may cause kidneys to retain lithium in place of salt),
- drug interactions – drugs that can increase lithium levels (drugs that promote sodium clearance) are NSAIDs, thiazides, metronidazole, ACE inhibitors/ARBs.

The relationship between sodium and lithium

Sodium and lithium are monovalent positive ions, so one affects the other. Lithium is handled by the kidneys the same way as sodium. Any condition affecting sodium levels or fluid volume will impact the reabsorption of lithium in the kidney. Lithium decreases sodium reabsorption in renal tubules, resulting in sodium depletion.
If low sodium levels – less lithium excreted by the kidney resulting in more reabsorbed back into the body, elevating lithium levels. Conditions that can decrease sodium levels are dehydration, vomiting, diarrhea, febrile illness, low sodium diet.
If high sodium levels – more lithium is excreted and lithium will be at subtherapeutic levels.

Client Teaching

- Clients should take medication as directed, even if feeling well.
- Monitor weight, weight gain may occur.
- Inform client of causes of toxicity and to consult prescriber if they develop a febrile illness, dehydration, or any change to sodium in their diet.
- It is important to eat a normal diet with typical fluid intake 1500-3000 mL/day and a consistent and moderate sodium intake. Avoid a low sodium diet as it may predispose you to toxicity. Avoid excess coffee, tea or cola due to diuretic effect.
- Educate client on cues of lithium toxicity, including early signs of nausea, tremors, lethargy, irregular heart rate, or confusion.
- Do not miss lab work to monitor lithium and sodium levels.
- Do not take any OTC medications without consulting with the prescriber first.
- Do not suddenly stop taking lithium, consult with your prescriber.

(Halter, Pollard & Jacubec, 2019; Vallerand & Sanoski, 2024)

Lithium Medication Card

Now let's take a closer look at the medication grid for lithium. Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information is outlined below.

Lithium Medication Card

Class: Mood Stabilizer **Prototype:** Generic Name: lithium		**Indications:** •Reduce symptoms of manic episode •Reduced frequency and intensity of manic episodes Indications •Treatment of manic episodes of bipolar disorder •Maintenance for individuals with a bipolar disorder Off label for depression, anxiety not responsive to other treatment.	
Mechanism of Action: alters sodium transport in nerve and muscle cells to shift toward intraneuronal metabolism of catecholamines, but specific biochemical mechanism in mania is unknown.			
Administration: Oral: IR, SR, CR Bedtime Rapidly absorbed, not metabolized, excreted unchanged via urine. 80% reabsorbed in proximal tubule Long t ½ 20-27 hr. Thorough assessment prior to therapy. Takes 7-14 days to achieve effect, monitor lithium levels and mood Monitor serum lithium and sodium levels	**Side Effects:** SE: nausea, diarrhea Weight gain Lithium toxicity (can cause sudden death) Hyponatremia leads to less lithium excreted -- toxicity Toxicity: lethargy, tremor, confusion, tachy, cardiac arrhythmia, hypotension SAFETY: S&S of lithium toxicity requires emergency assistance Longterm effects: renal insufficiency and hypothyroidism	**Contraindications:** Avoid with renal and CV disease Risk of toxicity if dehydrated, febrile illness, older adult, diet changes (low Na), drug interactions Caution with diuretics... lead to dehydration. Not for children under 12 Contraindicated in pregnancy (cardiac abn) and lactation (hypotonic baby, lethargy)	**Nursing Considerations:** Monitor for signs of lithium toxicity When given during a manic episode, symptoms may resolve in 1-3 weeks Close monitoring with a narrow therapeutic serum range of 0.6 to 1.2 mmol/L Monitor Se sodium levels for hyponatremia Avoid abrupt discontinuation Client education including signs of toxicity, lab work, diet consistency with fluid and sodium intake, risk of dehydration

Downloadable file (.docx): Lithium Medication Card

Clinical Reasoning and Decision-Making Activity 5.7

A 42-year-old male was recently diagnosed with bipolar

disorder after his partner became concerned about his extreme highs and lows in moods. His high mood swings were often associated with grandiose ideas, gambling, risky sexual behavior, and shopping sprees that were causing the couple to go bankrupt. The physician prescribed lithium.

1. The client states, "The doctor told me I am having manic episodes. What does that mean?" What is the nurse's best response?
2. The nurse knows that there is a risk of lithium toxicity. What are the symptoms of lithium toxicity, and how will it be prevented?
3. The client's partner asks, "How quickly will the lithium work?" What is the nurse's best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

Interactive Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=268#h5p-107*

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5.8 Antipsychotics

Antipsychotic drugs are used to treat drug-induced psychosis, schizophrenia, extreme mania, depression that is resistant to other therapy, and other CNS conditions. Antipsychotics used to be called tranquilizers because they produce a state of tranquility. First-generation antipsychotics, also called conventional antipsychotics, have similar mechanisms of action. An example of a conventional antipsychotic is haloperidol. Conventional antipsychotics have several potential adverse effects, and the selection of a medication is based on the client's ability to tolerate the adverse effects.

Second-generation antipsychotics, also referred to as atypical antipsychotics, have the benefit of fewer adverse effects and are used for many neurological conditions such as depression, anxiety, and psychosis. There are many atypical antipsychotics used in Canada, including risperidone, clozapine, olanzapine, quetiapine and aripiprazole (McCuistion et al, 2018). Due to the limitations of this unit, we will focus only on three medications, haloperidol and two atypical meds, quetiapine and clozapine. Links to some useful resources are available at the end of this unit.

1st and 2nd Generation Antipsychotics

Mechanism of Action

All antipsychotics primarily affect dopamine receptors in the brain. First generation or conventional antipsychotics, such as haloperidol, are dopamine-2 receptor antagonists in certain areas of the CNS, such as the limbic system and the basal ganglia. These areas are associated with emotions, cognitive function, and motor function,

and blockage thus produces a tranquilizing effect. They also have noradrenergic, cholinergic, and histaminergic blocking action. This class includes many meds including phenothiazines (prochlorperazine) and butyrophenones (haloperidol), among others (Chokhawala & Stevens, 2023).

Second-generation, or atypical antipsychotics are serotonin-dopamine antagonists. They block specific dopamine 2 receptors and specific serotonin 2 receptors. There are 12 different medications in this class and they all work very similar. We will focus mostly on clozapine and aripiprazole as our prototype meds, with a brief overview of quetiapine.

To learn more about the mechanism of action of antipsychotics, click on the link:

Neuroscientifically Challenged (2025). 2-minute Neuroscience: Antipsychotics.

Youtube: https://www.youtube.com/watch?v=RSJlCdOba7w

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Indications for Use

Antipsychotics are primarily used to manage psychosis and to also treat acute agitation, bipolar mania, and other psychiatric conditions.

Conventional Antipsychotics

Conventional antipsychotics (first generation), such as haloperidol or chlorpromazine, both work similarly with the same antipsychotic effects. They are used to treat the positive symptoms of schizophrenia or other psychotic disorders (mania, agitation, acute psychosis).

The difference between both meds is potency (size of dose to produce a given response). Chlorpromazine is a low-potency drug whereas haloperidol is high-potency drug (small dose needed to produce desired effect). Where they differ mostly is in the side effects, which is based on the anticholinergic effects.

Low potency (Chlorpromazine) = high sedation + high Ach + low extrapyramidal effects.

High potency (haloperidol) = low sedation + low Ach + high extrapyramidal effects.

Atypical antipsychotics

Atypical antipsychotics (second generation or SGA) treat both the positive and negative symptoms of schizophrenia or other psychotic disorders. They are often used first as they treat a wider range of symptoms. Some atypical antipsychotics are also used as an adjunct therapy for depression or nausea. Due to the sedative effects, Quetiapine (Seroquel) is used for insomnia.

The benefit of SGAs is they have less extrapyramidal symptoms, leading to better adherence, but have other adverse effects that may be less desirable. These will be discussed in the adverse effects section (Burchum Rosenjack & Rosenthal, 2019; Halter, Pollard & Jacubec, 2019).

Positive Symptoms of Schizophrenia: hallucinations (auditory such as hearing voices, or command hallucinations such as telling them to hurt themselves) and delusions.
Negative Symptoms of Schizophrenia: withdrawn, guilty feelings, low energy, lack of motivation for activities or ADLs.

Nursing Considerations for Antipsychotics

Older adult: anticholinergic effects is a concern, due to risk of falls for dizziness or confusion. On Beers List for potentially inappropriate drugs for the older adult. If required, start at the lowest possible dose and titrate.

Elderly clients with dementia-related psychosis treated with antipsychotic drugs should be closely monitored for signs and symptoms of cardiovascular events or infections such as pneumonia.

Caution with concurrent use with other CNS medications. Avoid with other CNS depressants such as barbiturates, benzothiazines or opioids.

Clients who are concurrently taking lithium and antipsychotics should be monitored closely for neurotoxicity (weakness, lethargy, fever, tremulousness, confusion, and extrapyramidal symptoms) and symptoms should be immediately reported.

Specific nursing considerations for conventional: haloperidol and Atypical: clozapine:

Haloperidol

- Highly lipophilic, wide distribution, metabolized in the liver. Partially excreted in the kidney. Dosage reductions are not required if renal or hepatic disease.
- Oral, IM, IV, nasal spray. IM either short acting immediate release or depot preparation. Depending on the reason, can be given in different dosages and routes. For example, acute psychosis give 0.5-2 mg orally TID or 2-5 mg IM q 4-8 hours. 20mg /day is the maximum dosage.
- Oral (PO): Give with food, milk, or a full glass of water to minimize GI upset. Do not mix the concentrate with coffee or tea.
- Haloperidol is contraindicated or generally avoided in clients with Parkinson's disease, Lewy Body dementia, or comatose clients due to the dopaminergic effects.
- Pretreatment:
    - Assess mental health status prior to and throughout treatment
    - ECG due to risk of QT prolongation
    - Most common side effects: anticholinergic effects (dry mouth, weight gain, erectile dysfunction in males, oligomenorrhea or amenorrhea in females.
    - Less common adverse effects: photosensitivity, pruritus, diarrhea, orthostatic hypotension
    - Extrapyramidal adverse effects are due to dopamine blockade in the nigrostriatal pathway in the brain.
        - Acute dystonia, akathisia, neuroleptic malignant syndrome, parkinsonism, tardive dyskinesia
- Monitoring:
    - Monitor for orthostatic hypotension (dizziness, falls); advise slow position changes, adequate hydration, and leg exercises. Monitor HR and BP with change in positions.

    - CV: Monitor for change in ECG such as prolongation of QT. Ensure electrolytes within normal range.
    - Monitor for Extrapyramidal Symptoms (EPS): Watch for tremors, rigidity, restlessness (akathisia), or involuntary movements (dystonia, tardive dyskinesia)
    - Watch for Neuroleptic Malignant Syndrome (NMS): assess for fever, muscle rigidity, altered mental status, and autonomic instability (tachycardia, labile blood pressure).

(Burchum Rosenjack & Rosenthal, 2019; Halter, Pollard & Jacubec, 2019; Rahman & Marwaha, 2023)

Clozapine

- oral administration, can be taken with or without food. Dose reductions if significant hepatic or renal disease.
- Pretreatment:
    - Assess mental health status prior to and throughout treatment
    - Labs include complete blood count (CBC), absolute neutrophil count (due to risk of agranulocytosis, electrolytes, A1C, lipid panel
    - Baseline weight, waist circumference and BMI. Monitor q 6 months.
    - ECG due to risk of QT prolongation
    - Most common side effects: sedation and weight gain. Adrenergic effects include orthostatic hypotension. Anticholinergic effects: dry mouth, constipation, tachycardia
    - Rare adverse effects include: seizures (dose dependent) and myocarditis, agranulocytosis, cardiomyopathy, neutropenia, paralytic ileus and pneumonia. Close monitoring required especially early in treatment.

    - There is less of a risk for extrapyramidal effects than with conventional antipsychotics.

- Monitoring
    - Monitor for improved mental health status, including therapeutic drug monitoring early in treatment with dosage adjustments expected.
    - Risk of agranulocytosis (severe form of neutropenia), so mandatory neutrophil count. Risk appears greater in first 6 months of therapy. Assess for fever, sore throat or signs of infection. Can be fatal if not detected early and treated.
    - Risk of metabolic syndrome: diabetes, obesity and dyslipidemia all a risk with atypical antipsychotics. Weight gain can be substantial. Monitor q 6 months.
    - Monitor for orthostatic hypotension (dizziness, falls); advise slow position changes, adequate hydration, and leg exercises.

- Seizure Prevention & Management: Be alert for new or increased seizure activity. Document and report, and ensure safety. Lowers seizure threshold in clients with epilepsy.
- Enquire about constipation: common side effect. Minor risk of paralytic ileus. Ask regarding bowel habits and diet. Assess for any nausea/vomiting, abdominal pain or distension.

(Correll et al, 2022; Halter, Pollard & Jacubec, 2019)

Aripiprazole

Aripiprazole is an atypical antipsychotic that is used to treat schizophrenia, bipolar disorder and as a secondary medication for major depression. It has partial dopamine agonist effects. It has similar side effects as other SGAs with headache, drowsiness,

nausea, insomnia and dizziness. It is administered orally, with or without food. Pretreatment assessment is the same as clonidine. Monitoring also includes blood glucose levels due to the risk of hyperglycemia, weight due to risk of weight gain and impulse control (Gettu & Saadabadi, 2023).

Adverse/Side Effects

Adverse effects and common side effects are identified above in the nursing considerations for each medication but are also summarized below. You might notice that the conventional medications have more adverse effects that can be undesirable and even life-threatening.

Potential Adverse Effects of Antipsychotic Medications (Halter, Pollard & Jacubec, 2019; McCuistion et al, 2018)

Adverse Effects	**Conventional Antipsychotics (Haloperidol)**	**Atypical Antipsychotics (Clozapine, Risperidone, Aripiprazole)**
Most common effects:	Anticholinergic effects (dry mouth, dry eyes etc) Weight gain, orthostatic hypotension, diarrhea	Sedation Weight gain can be substantial. Adrenergic effects include orthostatic hypotension. Anticholinergic effects: dry mouth, constipation, tachycardia
Less common effects:	photosensitivity, pruritus, Prolongation of QT interval Erectile dysfunction in males, oligomenorrhea or amenorrhea in females.	metabolic changes: diabetes and hyperlipidemia. Monitor blood glucose levels and lipid panel.
Adverse Effects	Extrapyramidal Symptoms*: Parkinsonism, tardive dyskinesia, Neuroleptic Malignant Syndrome (NMS) (rare)	Rare, but can be life-threatening: Seizures (dose dependent) myocarditis, agranulocytosis, cardiomyopathy, neutropenia, paralytic ileus pneumonia.

* These adverse effects are due to the blockage of alpha-adrenergic, dopamine, endocrine, histamine, and muscarinic receptors. For additional details about these types of receptors, see the Autonomic Nervous System chapter.

Adverse Effect	Definition
Tardive Dyskinesia	Involuntary contraction of the oral and facial muscles (such as tongue thrusting) and wavelike movements of the extremities.
Neuroleptic Malignant Syndrome (NMS)	Potentially life-threatening adverse effects, including reduced consciousness, muscle rigidity, and autonomic symptoms (high fever, unstable BP, tachycardia, diaphoresis) and myoglobinemia. Immediate emergency care required.
Extrapyramidal Symptoms	Involuntary motor symptoms, similar to those associated with Parkinson's disease. Includes symptoms such as akathisia (distressing motor restlessness) and acute dystonia (painful muscle spasms.). Also includes tardive dyskinesia. Often treated with anticholinergic medications such as benztropine and trihexyphenidyl. EPS is due to blockage of certain receptor in the brain. Higher risk with conventional meds.

Client Teaching

- Advise client to take medication as directed. Medication doses should be evenly spaced throughout the day.
- This drug may take several weeks to manifest desired effects.
- Clients should be advised regarding the possibility of extrapyramidal symptoms and that abrupt withdrawal may cause dizziness, nausea and vomiting, or uncontrolled movements of mouth, tongue, or jaw.
- The client should be careful to avoid alcohol or other CNS depressants while using the medication.
- There is a fall risk due to sedative, motor instability or dizziness.

Additional Client Teaching for clozapine

Inform client of potential adverse effects and symptoms. They should report any physical or mental health concerns to their prescriber (Correll et al, 2022).

- Encourage them to weigh themselves regularly due to the potential for weight gain. Encourage diet, exercise and a healthy lifestyle. May start on metformin as a treatment option.
- Inform client of the potential for constipation. Encourage adequate fluid and fiber intake. Report any abdominal pain or nausea & vomiting.
- Inform client of rare risk of myocarditis. Report any shortness of breath, fatigue, fever or rapid heart rate immediately.
- Inform client that blood work will be ordered periodically to check their white blood cell count.

Quetiapine

Quetiapine (Seroquel) is an atypical antipsychotic that is widely used. Like most meds in this class, it is used to treat schizophrenia, acute manic episodes, and adjunctive treatment for major depressive disorder. It is used off label for insomnia due to its sedating properties. Although it is sometimes used for insomnia on a prn basis, there is safety concerns.

Many of the side effects are the same, such as metabolic issues with weight gain, dyslipidemia and elevated blood sugars. There is also concern with clients with a history of cardiac issues such as arrythmias as it has a risk of prolonging the QT interval. The most common side effects are somnolence, orthostatic hypotension, and dizziness. The assessment and monitoring of quetiapine is the same as with other anti-psychotic medications (Maan, et al, 2023).

To learn more about these and other medications to treat mental health disorders, a helpful resource is the eMentalHealth.ca. Click on the links:

Quetiapine (Seroquel) https://www.ementalhealth.ca/Canada/Quetiapine/index.php?m=article&ID=20700

Risperidone https://www.ementalhealth.ca/Canada/Risperidone/index.php?m=article&ID=20509

Medication Table: Antipsychotic Medications https://www.ementalhealth.ca/Canada/Medication-Table-Antipsychotic-Medications/index.php?m=article&ID=71688

Comparing Antipsychotics

Now let's take a closer look at the medication grid for haloperidol and risperidone (McCuistion et al, 2018). This table is intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Comparing Types of Antipsychotics

Class	Generic Prototype (Brand)	Mechanism	Indication & Therapeutic Effect	Contraindications	Side Effects	Administration and Nursing Considerations
1st Generation (Conventional)	haloperidol (Halidol)	Block dopamine receptors in certain areas of the CNS, such as the limbic system and the basal ganglia.	Schizophrenia and Tourette's disorder. Delirium, acute psychosis.	Parkinson's disease or dementia with lewy bodies. High risk for neurotoxicity with concurrent other antipsychotics	CVS and Respiratory effects Severe: **Tardive dyskinesia, neuroleptic malignant syndrome (NMS), and extrapyramidal symptoms**	• Monitor for CVS and Respiratory event • Monitor for neurotoxicity • Avoid alcohol and CNS depressants • Caution with driving • Several weeks to take effect ***SAFETY:*** Falls related to sedation, motor instability, and postural hypotension
2nd Generation (Atypical)	risperidone (Risperidol)	Block specific dopamine 2 receptors and specific serotonin 2 receptors,	Acute manic episodes and for irritability caused by autism	High risk for neurotoxicity with concurrent other antipsychotics	Fewer adverse effects than conventional antipsychotics. Metabolic changes such as hyperglycemia, hyperlipidemia, and wt gain.	Same as 1st Generation.

Downloadable file (.docx): Comparing Types of Antipsychotics

To support your learning, you can access the Chapter 5 CNS Mood and Cogniton Medication Cards. This is a downloadable and editable document to allow you to update and add content.

Interactive Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here: *https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=269#h5p-109*

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Critical Thinking and Decision Making Activities

1.A community health nurse is working with a patient who was started on clozapine while in the hospital. When

the patient asks why frequent lab work is necessary, the nurse explains:

a. One uncommon but serious side effect of clozapine is a decrease in neutrophils, which are white blood cells that help fight infection. Regular blood tests allow us to detect this early and intervene if needed to keep you safe.

b. We need to monitor the medication to ensure the level of the medication in the blood is within safe parameters.

c. A side effect of clozapine is electrolyte changes, and it is important for us to know if this is happening to avoid issues with your heart and muscles.

d. The blood test can help us to understand if the medication is helpful by looking at impacts on neurotransmitters.

2. One month later, the patient calls to cancel their appointment, stating that they have developed fever and chills. What is the most appropriate next step?

a. Counsel the patient on managing flu-like symptoms and agree to reschedule the appointment for next week.
b. Advise the patient to seek immediate medical attention to rule out agranulocytosis.
c. Advise the patient to have blood work done tomorrow to assess for neutropenia.
d. Advise the patient to stop taking clozapine and reschedule the appointment for next week.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

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5.9 Anticonvulsants

Medications used for seizures are called anticonvulsants or antiseizure drugs. Antiseizure drugs stabilize cell membranes and suppress the abnormal electric impulses in the cerebral cortex. These drugs prevent seizures but do not provide a cure. Most antiseizure drugs are classified as CNS depressants. There are many types of medications used to treat seizures such as phenytoin, phenobarbital, benzodiazepines, carbamazepine, valproate, and levetiracetam (McCuistion et al, 2018).

There are three main pharmacological effects of antiseizure medications. First, they increase the threshold of activity in the motor cortex, thus making it more difficult for a nerve to become excited. Second, they limit the spread of a seizure discharge from its origin by suppressing the transmission of impulses from one nerve to the next. Third, they decrease the speed of the nerve impulse conduction within a given neuron.

There are over 16 different types of anticonvulsants, all working slightly different to control abnormal electrical activity and to calm excessive firing in the brain. Many work on blocking sodium/calcium channels, enhance GABAs effects or inhibit the release of excitatory neurotransmitters such as glutamate or aspartate.

Some examples of anticonvulsants are:

- Fatty acid derivative: valproic acid
- Hydantoin: phenytoin sodium
- Triazine: lamotrigine
- Dibenzoazepine: carbamazepine
- Depressants: benzodiazepines and barbiturates

Most anticonvulsants are used for other purposes, not just for managing seizures. Gabapentin, although structurally similar to GABA and classified as an anticonvulsant, is commonly used to control chronic neuropathic pain. Valproic Acid, lamotrigine, and

carbamazepine are all used as mood stabilizers to suppress mania and to treat depression in clients with bipolar disorder.

In this unit, we will present six anticonvulsants that are commonly used.

- Anti-seizure treatment: phenytoin, levetiracetam, and gabapentin
- Anti-mania treatment: valproic Acid, lamotrigine, and carbamazepine

Phenytoin

Phenytoin, which was discovered in 1938, was the first anti-seizure medication and is still being used to control seizures (McCuistion et al, 2018).

Mechanism of Action

Phenytoin is in the hydantoin class of anticonvulsants. They are structurally similar to barbiturates. Hydantoins slow the synaptic transmission by blocking sodium channels from recovering from the inactivated state, and inhibits neurons from firing. This stops the repeated excitation of cells that results in seizures (Drugs.com, 2026). As an antiarrhythmic, it shortens the action potential and decreases automaticity.

Indications for Use

Phenytoin is indicated for the treatment of tonic-clonic (grand mal)

and psychomotor (temporal lobe) seizures and for the prevention and treatment of seizures occurring during or following neurosurgery. It is also used as an antiarrhythmic, particularly for ventricular dysrhythmias from digoxin toxicity or treatment of prolonged QT interval (Vallerand % Sanoski, 2024).

Nursing Considerations

Administration: oral, IV, IM.

- Oral route should be used primarily due to pain on injection.
- IV: do not exceed 50 mg per minute in adults and 1 to 3 mg/kg/min (or 50 mg per minute, whichever is slower) in pediatric clients. Risk of severe hypotension and cardiac arrhythmias. Careful cardiac monitoring is needed during and after administering intravenous phenytoin.
- Loading dose, followed by divided doses of 2-3 times/day.

Pregnancy: do not administer if pregnant due to risk of harm to fetus.

Phenytoin has a narrow therapeutic drug level, usually between 10-20 mcg/mL, so serum drug monitoring is required (London Health Science Center, 2021). Serum levels of phenytoin sustained above the therapeutic range may produce confusional states referred to as delirium, psychosis, or encephalopathy. Accordingly, at the first sign of acute toxicity, serum levels should be immediately checked.

Abrupt discontinuation can cause status epilepticus, so in the event of an allergic or hypersensitivity reaction, rapid substitution of alternative therapy may be necessary.

Use with caution in clients with renal or hepatic impairment. Elderly clients may require dosage adjustment.

Drug interactions: There are many potential drug interactions

with phenytoin. Read drug label information before administering. Phenytoin is extensively bound to plasma proteins and is prone to competitive displacement. Phenytoin is metabolized by hepatic cytochrome P450 enzymes, so it is susceptible to inhibitory drug interactions, which may produce significant increases in circulating phenytoin concentrations and enhance the risk of drug toxicity.

Adverse/Side Effects

Most common side effects include hypotension, diplopia, nystagmus and a rash. Many common effects are nervous system reactions and are dose-related. Reactions include ataxia, slurred speech, decreased coordination, somnolence, and mental confusion (Vallerand & Sanoski, 2024).

Serious and sometimes fatal dermatologic reactions, including toxic epidermal necrolysis (TEN) and Stevens-Johnson syndrome (SJS), have been reported with phenytoin treatment. The onset of symptoms is usually within 28 days but can occur later. Phenytoin should be discontinued at the first sign of a rash.

Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS) has been reported in clients taking antiepileptic drugs, including phenytoin. Some of these events have been fatal or life-threatening. DRESS typically presents with fever, rash, lymphadenopathy, and/or facial swelling, in association with other organ system involvement. These findings should be immediately reported to the provider. Acute hepatotoxicity has been reported with phenytoin. These events may be part of the spectrum of DRESS or may occur in isolation.

Hematopoietic complications, some fatal, have occasionally been reported in association with the administration of phenytoin. These have included thrombocytopenia, leukopenia, granulocytopenia, agranulocytosis, and pancytopenia with or without bone marrow suppression.

Client Teaching

- Clients should be advised to take medications as directed and that doses should be evenly spaced throughout the day. It may take several weeks to obtain the desired medication effect.
- Abrupt withdrawal of medication may cause status epilepticus.
- Clients should avoid alcohol and other CNS depressants while taking anticonvulsant drug therapy.
- Diabetic clients should monitor their blood glucose levels carefully.
- Gingival hyperplasia – encourage client to perform good oral hygiene.

Phenytoin Medication Card

Now let's take a closer look at the medication card for phenytoin. Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Phenytoin Medication Card

Class: anticonvulsant **Prototype/ Brand Name:** phenytoin (Dilantin)		**Indications:** Reduced seizure activities Antiarrhythmic	
Mechanism of Action: interfering with sodium channels in the brain, resulting in a reduction of sustained high-frequency neuronal discharges. As an antiarrhythmic, it shortens the action potential and decreases automaticity.			
Administration: IV, IM, PO IV: Must be administered slowly IV: cardiac monitoring and in-line filter Caution in clients with renal or hepatic impairment. Elderly clients may require dosage adjustment	**Side Effects:** Common reactions: nystagmus, ataxia, slurred speech, decreased coordination, somnolence, and mental confusion SAFETY: Serious/fatal effects: dermatologic reactions, TEN, SJS, DRESS, Hematopoietic complications, Acute hepatotoxicity	**Contraindications:** Pregnancy Heart block Many drug interactions, check drug monograph on consult pharmacist to ensure safety.	**Nursing Considerations:** Requires serum drug monitoring Taper dose; do not stop abruptly Monitor blood glucose closely Avoid alcohol and CNS depressants Must administer slowly. Discontinue at first sign of a rash

Downloadable file (.docx): Phenytoin Medication Card

Levetiracetam

Levetiracetam is a relatively new anticonvulsant and indicated as adjunctive therapy in the treatment of seizures. It is generally well-tolerated with a good safety profile.

Mechanism of Action

Levetiracetam mechanism of action is not clearly defined but it appears to work primarily by binding to synaptic vesical protein 2A (SV2A), a protein involved in neurotransmitter release, which reduces the release of excitatory neurotransmitters in the brain (Kumar, Maini & Kadian, 2023).

Indications for Use

Levetiracetam is indicated as adjunctive therapy in the treatment of partial-onset, myoclonic and tonic-clonic seizures in clients 12 years of age and older with epilepsy.

Nursing Considerations

It is generally well-tolerated. Oral or intravenous administration with rapid absorption. Peak plasma concentration is one hour post oral administration.

It is safe with children over five years of age, with dosing based on weight.

Monitor:

- Monitor for mood changes
- Assess for suicidal thoughts
- Assess for rash; may cause Stevens-Johnson Syndrome. Discontinue if severe or if fever, malaise and joint aches occur.
- Monitor for DRESS 9fever, rash, lymphadenopathy or facial swelling.

Pregnancy: Plasma levels can gradually decrease during pregnancy

and should be monitored closely. Safety not established with breastfeeding.

Risk of withdrawal: Levetiracetam should not be stopped abruptly or withdrawal seizures may occur.

Use with caution in clients with renal impairment. No dosage adjustment for hepatic impairment (Kumar, Maini, & Kadian, 2024; Vallerand & Sanoski, 2024).

Adverse/Side Effects

Most common effects are neurobehavioral and are typically mild: sedation, fatigue, mood swings, headache, agitation, irritability, depression, memory loss, confusion, paresthesia, a decline in cognition, and increased suicide risk. Hypertension can also occur.

Adverse effects are rare and include: psychosis, aggression, hallucinations, and suicidal thoughts. Monitor clients for psychiatric signs and symptoms.

Advise clients not to drive or operate machinery until they have gained sufficient experience on levetiracetam.

This drug can cause anaphylaxis or angioedema after the first dose or at any time during treatment.

Serious dermatological reactions, including Stevens-Johnson syndrome (SJS) and toxic epidermal necrolysis (TEN), have been reported, as well as coordination difficulties and hematologic abnormalities (Vallerand & Sanoski, 2024).

Client Teaching

- Medications should be taken as directed and may cause increased dizziness and somnolence.
- Clients, family, and caregivers should also monitor carefully for

suicidality during medication therapy.
- Inform prescriber if they plan to take any OTC or herbal remedies.

Levetiracetam Medication Card

Now let's take a closer look at the medication card for levetiracetam (DailyMed, n.d.). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Levetiracetam Medication Card

<table>
<tr><td colspan="2">Class: Anticonvulsants

Prototype: Levetiracetam</td><td colspan="2">Indications: adjunctive therapy in the treatment of seizures, including partial-onset, myoclonic and tonic-clonic seizures.</td></tr>
<tr><td colspan="4">Mechanism of Action: The exact mechanism of action is unknown. This medication may interfere with sodium, calcium, potassium, or GABA transmission.</td></tr>
<tr><td>Administration:
Oral, IV

Taper dose: do not stop abruptly or seizures may occur</td><td>Side Effects:
Behavioral/mood changes
Somnolence, fatigue, and irritability
Coordination difficulties

SAFETY: Serious/fatal effects Anaphylaxis or angioedema, dermatologic reactions, TEN, SJS, Hematopoietic complications</td><td>Contraindications:
Clients who are suicidal

Clients with altered hematology</td><td>Nursing Considerations:
Monitor plasma levels for pregnant women
Use cautiously if renal impairment
Safe for children 12 and older

monitor carefully for suicidality during medication therapy.

Monitor for safety mobility and falls risk</td></tr>
</table>

Downloadable file (.docx): Levetiracetam Medication Card

Gabapentin

Gabapentin has been used since the 1970's as an anti-spasmodic. Currently it is used as a muscle relaxant, an antispasmodic and indicated as an adjunct treatment for partial seizures. It is most commonly used to treat neuropathic pain (Lilley et al, 2020). More recently, it is used as part of a multi-modal treatment for post-operative pain to reduce the opioid requirements.

Mechanism of Action

The exact mechanism of action is unknown. It is structurally similar to GABA, but does not act on GABA receptors or influence GABA. It does freely pass through the blood-brain barrier and modulates calcium channels and reduces excitory neurotransmitter release.

Indications for Use

Gabapentin is used for partial seizures in adults and children over 3 years of age. It is effective for neuropathic pain, including diabetic neuropathy, postherpetic neuralgia and restless leg syndrome (Yasaei, Katta, Patel, & Saadabadi, 2024). Neuropathic pain is defined by the International Association for the Study of Pain as "pain caused by a lesion or disease of the somatosensory nervous system" (Murnion, 2018). An example of neuropathic pain is tingling or burning in the lower extremities that often occurs in clients with diabetes. For post-operative pain, it can be used to decrease the amount of opioid use to control pain, along with using acetaminophen.

Off label, it has many uses including bipolar disorder, anxiety disorders, resistant depressants, mood disorders, irritable bowel

syndrome, alcohol withdrawal, postoperative analgesia, migraine prophylaxis, and postmenopausal vasomotor symptoms (Yasaei, Katta, Patel, & Saadabadi, 2024).

Nursing Considerations

Oral administration, well absorbed orally. Widely distributed and crosses blood brain barrier. Renal excretion, with t ½ life of 5-7 hours, with complete elimination 2 days.

Pregnancy: Potential harm to fetus such as cardiac defects if multiple doses received. Late pregnancy exposure can lead to small for gestational age and preterm birth.

Pediatrics: Gabapentin use in pediatric clients with epilepsy 3 to 12 years of age is associated with the occurrence of central nervous system-related adverse events. The most significant of these can be classified into the following categories: 1) emotional lability (primarily behavioral problems); 2) hostility, including aggressive behaviors; 3) thought disorder, including concentration problems and change in school performance; and 4) hyperkinesia (primarily restlessness and hyperactivity).

Older adult: peripheral edema and ataxia tend to increase with age. Fall precautions should be considered.

Antiepileptic drugs should not be abruptly discontinued because of the possibility of increasing seizure frequency.

Adverse/Side Effects

More common reactions ataxia, dizziness, fatigue, and fever.

In children, hyperkinesia, concentration difficulties and emotional liability.

Severe reactions: Stevens-Johnson syndrome, anaphylaxis,

angioedema, erythema multiforme, rhabdomyolysis, and withdrawal seizure or withdrawal symptoms if the drug is discontinued abruptly.

Depression and suicidality: There is an increased risk of depression, suicidal thoughts or behavior. Clients should be monitored for the emergence of worsening thoughts or behavior, and/or any unusual changes.

Eosinophilia and Systemic Symptoms (DRESS): also known as multiorgan hypersensitivity, has been reported in clients taking antiepileptic drugs. DRESS usually presents with fever, rash, and/or lymphadenopathy, in association with other organ system involvement. If these symptoms occur, they should be immediately reported to the provider.

DRESS (drug reaction with eosinophilia and systemic symptoms)

DRESS is an immunological hypersensitivity reaction that is most frequently seen with anticonvulsant drugs, allopurinol, and antibiotics. The incidence is 1/1000 to 1/10,000 of clients using these meds. The pathogenesis is not clear. It may be due to a genetic predisposition of the person not able to detoxify certain toxic metabolites of these meds. It usually starts one to eight weeks after the client starts on the med, with fever and rash. The rash (erythematous and maculopapular lesions) first appears on the trunk, face and upper extremities, and can progress to blisters, vesicles and pustules. Enlarged lymph nodes, hematologic and visceral organ involvement are common. In severe cases, it can progress to multiorgan failure with

death reported in 10% of those cases. (Greef, Mennie & Muise, 2010).

Client Teaching

- Clients receiving gabapentin therapy should take medication as directed and be careful not to exceed dosage recommendations.
- Can cause dizziness, somnolence, and other signs of CNS depression. Clients should be advised neither to drive a car nor to operate other complex machinery until they have gained sufficient experience on gabapentin to gauge whether or not it affects their mental and/or motor performance adversely.
- Clients should not take gabapentin within 2 hours of antacid medications.
- Additionally, gabapentin may cause increased drowsiness and dizziness.
- Clients, family, and caregivers should also monitor for suicidality.
- Risk of respiratory depression if taken with CNS depressants.

Gabapentin Medication Card

Now let's take a closer look at the medication card for gabapentin. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Gabapentin Medication Card

Class: anticonvulsant **Prototype:** gabapentin		**Indications:** Adjunct treatment for partial seizures. Most often used to treat neuropathic pain, antispasmodic and muscle relaxant.	
Mechanism of Action: The exact mechanism of action is unknown. It is structurally like GABA but does not act on GABA receptors or influence GABA.			
Administration: Oral administration Taper dose; do not stop abruptly	**Side Effects:** More common reactions: ataxia, dizziness, fatigue, and fever. Increased suicidal ideation SAFETY: Consider fall precautions for elderly. Monitor closely for suicidal ideation and DRESS syndrome. Peds: hyperkinesia, concentration difficulties and emotional liability.	**Contraindications:** Pregnancy risk: cardiac defects in fetus. Older adult – caution due to fall risk and incidence of peripheral edema	**Nursing Considerations:** Do not take within 2 hours of antacid medication. Monitor for worsening depression, suicidal thoughts, or behavior, and/or any unusual changes in mood or behavior Avoid CNS depressants due to increased risk of respiratory depression.

Downloadable file (.docx): Gabapentin Medication Card

The three anticonvulsants used for treatment of mania that will be reviewed are divalproex sodium, carbamazepine and lamotrigine. They are also used for the treatment of seizures.

Divalproex Sodium (Valproate)

Valproate is the first anticonvulsant approved for bipolar disorder. It can help control acute manic episodes. It is equally effective as lithium but it works faster and has a different side effect profile that may be better tolerated. Lithium has the benefit of reducing suicide risk and preventing relapses, which valproate does not offer.

Adverse/Side Effects

Common side effects include GI distress (nausea, vomiting, diarrhea, dyspepsia, indigestion) and also weight gain. Serious adverse effects include thrombocytopenia, pancreatitis and liver failure.

Monitoring:

Monitor liver enzymes and platelet count periodically. It can also increase the risk of suicide so monitoring mood and behaviour is vital. CNS toxicity can also occur leading to confusion, dizziness, fatigue, hallucinations and headache (Halter, Pollard & Jacubec, 2019).

Carbamazepine

Carbamazepine is approved for the treatment and prevention of mania in bipolar disorder, although it is less effective in treating depression. It seems to work best for those experiencing anger or are severely paranoid. It is sometimes prescribed for those who are treatment resistant. Carbamazepine is often used in combinations with lithium or with an antipsychotic (Halter, Pollard & Jacubec, 2019; Burchum Rosenjack & Rosenthal, 2019).

Adverse/Side Effects

Adverse effects include elevating liver enzymes, so close monitoring with weekly LFTs for the first 8 weeks of treatment is often required.

Neurologic side effects such as visual disturbances, ataxia, vertigo, unsteadiness are all common early in treatment.

Rarely, it can cause hematologic symptoms such as leukopenia and aplastic anemia, so periodic complete blood count and platelet count is required.

Drug Interactions: carbamazepine induces P450 enzymes and accelerates its own and other medications metabolism, therefore higher doses may be required. Meds affected are oral contraceptives, warfarin and tricyclic antidepressants (Burchum Rosenjack & Rosenthal, 2019).

Lamotrigine

Lamotrigine is an anticonvulsant to treat seizures and is used as a mood stabilizer for bipolar disorders. It is one of the most prescribed mood stabilizers in the US.

Indications for use:

Lamotrigine is prescribed to treat partial seizures in adults and children with epilepsy and as an adjunct therapy for tonic-clonic seizures. It is also used for maintenance therapy with bipolar disorder (Vallerand & Sanoski, 2024).

Mechanism of Action:

Lamotrigine is a triazine anticonvulsant so structurally different than other anticonvulsants. It acts to stabilize neuronal membranes by inhibiting sodium transport. It acts on the sodium channels and

inhibits release of excitatory neurotransmitters, glutamate and aspartate (Vallerand & Sanoski, 2024).

Adverse /Side Effects

Lamotrigine is well tolerated, but serious, rare adverse effects can occur. As with many anticonvulsants, Steven Johnson Syndrome and DRESS can occur. Clients are encouraged to seek medical advice if a rash develops after starting on any anticonvulsant.

Common side effects include ataxia, somnolence, headache, diplopia, blurred vison, nausea, vomiting, rash.

Serious side effects include blood dyscrasias (excess breakdown of red blood cells), increased risk of suicide and serious skin reactions (Stevens-Johnson Syndrome and DRESS) can occur (Drugs.com, n.d.).

Nursing Considerations

Oral administration, immediate release, extended release and oral disintegrating tablets. Doses are often gradually increased depending on response. Food does not affect bioavailability.

Often used as an adjunct with other meds.

Do not discontinue abruptly, to minimize risk of a seizure, taper doses over two weeks.

Closely monitor for change in mood or behaviour due to risk of suicidality.

Lactation: consult with prescriber if plan to breastfeed as the medication is distributed in breast milk.

Client Teaching

- Take medication as prescribed and do not immediately stop the med.
- Inform clients that a rash may develop that can be a serious medical event. Instruct client to seek medical advice immediately.
- The risk of suicidality: may increase the risk of suicidal thoughts or actions so any change in mood, behaviour or actions need to be followed up immediately.
- They may experience side effects such as dizziness, drowsiness so driving or performing hazardous activities should be avoided.
- Pregnancy: If there are plans to get pregnant or are pregnant, consult with prescriber.

Clinical Reasoning and Decision-Making Activity

A 70-year-client in a long-term care center has diabetes and has been prescribed gabapentin for neuropathic pain.

1. The client states, "I have never had a seizure. Why has the doctor prescribed an antiseizure medication for me?" What is the nurse's best response?
2. The nurse plans to implement additional fall precautions for this client. Why are additional fall precautions needed?
3. What potential adverse effects should the nurse plan to monitor? What adverse effects would require

immediate notification of the provider?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

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5.10 Antiparkinson Medications

Parkinson's disease is believed to be related to an imbalance of dopamine and acetylcholine and a deficiency of dopamine in certain areas of the brain, particularly the substantia nigra. Drug therapies are aimed at increasing levels of dopamine and/or antagonizing the effects of acetylcholine. Drug therapy does not cure the disease but does improve symptoms. It does not slow the progression of the disease (Lilley, Collins & Snyder, 2021).

There are six different pharmacological classes of medications that are commonly used to treat the motor symptoms of Parkinson's Disease (PD). The choice of which medications will depend on factors such as the client's age, comorbidities, functional impairment, severity of symptoms, client employment and client preference (Parkinson Canada, n.d.). Many are used as adjunct therapy in conjunction with levodopa.

Class and generic name	Action	Comments
Anticholinergic agents: Benztropine mesylate	↓ cholinergic tone (esp. for tremor/rigidity) in CNS.	Not drug of first choice. Controls problematic tremor in younger clients.
Catecholamine-O-methyl transferase (COMT) inhibitors: entacapone	Inhibits or prevent breakdown of levodopa in peripheral tissues.	Useful to prolong duration of action of levodopa and prevent wearing off sooner.
Dopamine agonists: bromocriptine	Stimulate dopamine's actions in the brain	Not drug of first choice. Used with levodopa to reduce off time by 1.5-2 hours. May allow dose reduction of levodopa.
Dopamine precursors: Levodopa + Carbidopa	Dopamine precursor + peripheral decarboxylase	See information below
Monoamine oxidase B inhibitors: selegiline	MAO-B inhibitors (prevent dopamine breakdown by preventing the action of MAO-B enzyme, leading to increased concentration of dopamine in nerve cells)	See information below
N-methyl-D-aspartate (NMDA) antagonists: amantadine	↑ dopamine release + ↓ reuptake but not fully understood.	See information below

Click on the link to learn more about Parkinson's Disease, including the mechanism of action of many of the drugs. Pharmacology – Drugs for Parkinson's Disease (made easy). https://www.youtube.com/watch?v=Z84iypHdftQ

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=271#oembed-1

Improving Outcomes with Parkinson's Disease Medications:

- Any of the medications need to be taken on time, every time. This is crucial for effectively managing the symptoms. For example, by taking meds on time will avoid motor fluctuations and will help maintain dopamine levels throughout the day. Further, early and regular medication supports the remaining dopaminergic receptors in the brain.
- Have client keep a medication/mobility diary tor record when they take their meds and when they experience adverse effects to best know if dosage and med is right for the client.
- Encourage blister packs, pill boxes or pill dispensers to ensure medications are taken on time.
- For dopaminergic meds, take 30-60 minutes before a meal high in protein to avoid delayed onset of action.
- Avoid alcohol or other CNS meds (anticholinergic agents, antidepressants, benzodiazepines) to avoid combined effects of dizziness, fatigue and drowsiness.

Common non-motor symptoms of PD and treatment:

- Constipation: can develop years before motor symptoms are evident. Slow transit time can impact intestinal absorption of dopaminergic meds. Treat with high fiber diet, more fluids, physical activity and meds such as polyethylene glycol or psyllium.
- Depression and anxiety: up to 50% of persons with PD;

antidepressants such as SSRIs, SNRIs or other agents such as Bupropion.
- Pain: PD reduces pain thresholds as well as morning dystonia and muscle pain/stiffness. Treat with acetaminophen, duloxetine or gabapentin along with non-pharmacological interventions.
- Sialorrhea (drooling): PD clients have difficulty swallowing saliva in up to 78% of cases. Glycopyrrolate and atropine are two meds that may provide relief.
- Nausea: domperidone is effective.

(Parkinsons Canada (n.d.); Parkinson's Australia, 2026).
https://www.parkinsons.org.au/information-hub/parkinsons-medications/

In this unit, we will explore the common medications used to treat Parkinson's Disease: carbidopa/levodopa, selegiline, and amantadine

Carbidopa/Levodopa

Carbidopa/levodopa is the most common drug used to treat Parkinson's disease and is usually started as soon as the client becomes functionally impaired.

Mechanism of Action

Administration of dopamine is ineffective in the treatment of Parkinson's disease because it does not cross the blood brain barrier. But levodopa, the metabolic precursor of dopamine, does cross the blood-brain barrier and is converted to dopamine in the brain. Dopa decarboxylase inhibitor or DDI (Carbidopa) is combined

with levodopa to help stop the breakdown of levodopa before it is able to cross the blood-brain barrier. Carbidopa serves another purpose, it decreases levodopa-induced nausea and vomiting that is common with levodopa alone.

Indications for Use

Carbidopa/levodopa is indicated for Parkinson's disease. It improves muscle rigidity, bradydyskinesia and tremor in clients. It is also used to treat restless leg syndrome, to treat Parkinson-like symptoms that can develop after encephalitis or injury to the nervous system due to carbon monoxide poisoning or manganese poisoning (MedlinePlus, 2026).

Nursing Considerations

Administration:

- Oral administration, immediate release, disintegrating tablets, and extended-release. Taken 3-4 times per day. Do not crush or chew extended-release tablets. Suspension formula available for continuous administration via nasogastric or PEG tube.
- Example of dose: levodopa/carbidopa controlled-release 200/50 mg. Gradual absorption over 4-5 hours, but majority within 2-3 hours (PharmScience, 2020).
- Inhalation formulas are available and used as an adjunct therapy with oral dosages.
- Take oral form with meals to decrease GI upset. To improve absorption, avoid high-protein meals near dosing. High fat, high protein meals will delay absorption by 2 hours and overall

decrease amount absorbed (competes with amino acid transporters) (Gandhi & Saadabadi, 2023).

Dosages gradually increased depending on effect. 5 days to reach steady state, and a few months to see full benefit.

Avoid in clients with peptic ulcer disease (risk of GI bleed). Extra caution with client with cardiac conditions(atrial nodal or ventricular arrhythmias). Caution with clients with peripheral neuropathy or history of psychosis.

Pregnancy: levodopa does cross the placenta and can potentially harm the fetus, although insufficient information is available. Caution with breastfeeding as it is excreted in breast milk.

Carbidopa/Levodopa is recommended for use in clients older than age 18.

Monitoring:

- Assess for a change in motor symptoms.
- Assess for change in mental health such as hallucinations, psychotic behaviour, confusion or excessive dreaming.
- Assess for depression and risk of suicidality.
- Monitor BUN, creatinine levels and hepatic function regularly.
- Clients with glaucoma, test intraocular pressure as it can increase intraocular pressure.
- Assess peripheral neuropathy before treatment and periodically while on med.
- Monitor for melanoma – increased incidence but not clear if from meds or PD itself.

Drug Interactions:

- Contraindicated for use with non-selective MAOIs (risk of

hypertensive crisis). Ensure a 14-day washout period when switching from levodopa to an MAOI or vice versa.
- Antipsychotics, antihypertensives, iron, isoniazid and metoclopramide
- Patients taking D2 antagonists may see a reduction in the effects of levodopa, and as a result, it may reduce the beneficial effects of the drug.

Clients taking carbidopa and levodopa have reported suddenly falling asleep without prior warning of sleepiness while engaged in activities of daily living (including operation of motor vehicles). Clients should be advised to exercise caution while driving or operating machines during treatment with carbidopa and levodopa (McCuistion et al, 2019).

Surgery: if going for surgery, hold the dose on the day of surgery and resume once client able to swallow. Check orders and consult with physician.

Do not abruptly discontinue med: risk of symptoms of neuroleptic malignant syndrome (NMS) have been reported with dose reductions or withdrawal of certain antiparkinsonian agents. Observe clients carefully when the dosage of levodopa is reduced abruptly or discontinued.

(Gandhi & Saadabadi, 2023; Lilley et al, 2020).

Adverse/Side Effects

Most common side effects:

- nausea, dizziness, headache, and somnolence. To relieve nausea, a higher dose of carbidopa may help. Or, adding domperidone can be helpful if additional carbidopa is ineffective.
- Dyskinesia is common, which may require dosage reduction.

- CV: dizziness and postural hypotension; thus, reducing or discontinuing antihypertensive medications is required for some clients.

Older adults: higher risk of confusion, hallucinations, delusions, psychosis and agitation. Higher risk of hip fractures due to mild increase in homocysteine levels.

Adverse Effects:

Hallucinations and psychotic-like behavior have been reported with dopaminergic medications. Clients taking dopaminergic medications may experience intense gambling urges, increased sexual urges, intense urges to spend money or indulge in binge eating, and/or other intense urges, and the inability to control these urges. These urges stop when the dosage is decreased or the medication is discontinued.

Melanoma: A higher risk for melanoma has been reported. Assess skin regularly.

Occasionally, dark red, brown, or black color may appear in saliva, urine, or sweat after ingestion of carbidopa and levodopa. Although the color appears to be clinically insignificant, garments may become discolored (Lilley et al, 2020; McCuistion et al, 2018).

Client Teaching

- See Improving Outcomes with Parkinson's Disease Medications at the beginning of this unit.
- Clients should take their medications at regular intervals as directed. If gastric irritation is experienced, clients may eat food shortly after taking medications but high-protein foods may impair drug action.

- Clients should be instructed to plan their meal times around medication times to improve their ability to use their utensils.
- Medications may cause increased drowsiness, dizziness, and orthostatic changes. To prevent falls, ambulate slowly and use assistance as needed (cane, walker).
- Clients should carefully assess their skin to monitor for new lesions and any abnormality should be reported to the healthcare provider.

Carbidopa/levodopa Medication Card

Now let's take a closer look at the medication card for carbidopa-levodopa. Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Carbidopa/levodopa Medication Card

Class: Anti-Parkinson medications: dopamine precursor **Prototype:** carbidopa/levodopa (Sinemet)		**Indications:** Reduced progression of symptoms of Parkinson's disease To treat Parkinson's and is usually started as soon as the client becomes functionally impaired. Also used to treat restless leg syndrome.	
Mechanism of Action: levodopa is presumably converted to dopamine in the brain. Carbidopa is combined with levodopa to help stop the breakdown of levodopa before it can cross the blood-brain barrier.			
Administration: Oral admin: IR, SR, ER. Suspension for J-tube continuous infusion May cause GI upset, eat food right before dose. Avoid high-protein diets Monitor hepatic, renal, and hematopoietic functions Use in clients over 18	**Side Effects:** Nausea, dizziness, headache, and somnolence Dyskinesia hypotension and dizziness Depression, suicidal ideation, hallucinations, and intense urges NMS symptoms if suddenly d/c Discolored body fluids Hypomobility with long-term use Higher risk for melanoma	**Contraindications:** Contraindicated for use with MAOIs Caution with other CNS drugs (antipsychotics, antidepressants) Avoid in pregnancy and breastfeeding SAFETY: observe carefully for depression with suicidal ideation	**Nursing Considerations:** Monitor change in motor symptoms Monitor change in mental health: hallucinations, somnolence, depression Can take several weeks to see effects Taper dose when stopping Plan mealtimes around med times Monitor for new lesions (melanoma)

Downloadable file (.docx): Carbidopa:levodopa Medication Card

Selegiline

Selegiline is often used in conjunction with carbidopa-levodopa when clients demonstrate a deteriorating response to this treatment. It is helpful to control symptom fluctuations (Lilley et al, 2020). The other MAO inhibitor, rasagiline, is also prescribed.

Mechanism of Action

Selegiline acts as a selective, irreversible MAO inhibitor, blocking the breakdown of dopamine. This leads to an increased concentration of dopamine that is ready to use in the nerve cells (Parkinsons Canada, n.d.). The MAO enzymes are responsible for catabolizing neurotransmitters such as norepinephrine, serotonin and dopamine. The blocking of these enzymes will inhibit reuptake these neurotransmitters in the CNS and elevate monoamines at the synaptic cleft.

Use for Parkinson's Disease: at lower doses, selegiline selectively inhibits monoamine oxidase-B (MAO-B).

Use for major depressive disorder: at higher doses, selegiline inhibits both MAO-A and MAO-B.

The mechanism of action of this med is not entirely understood. There is evidence selegiline may slow the progression of Parkinson disease by promoting the production of neurotrophins such as brain-derived neurotrophic factor, nerve growth factor, and glial cell line-derived neurotrophic factor (Moore & Saadabadi, 2023). For PD, the benefits of selegiline is it can prolong the effects of levodopa and decrease the fluctuations in motor control. These benefits are usually only for 12 to 24 months, before it is no longer effective (Rosenjack Burchum & Rosenthal, 2019).

Indications for Use

Selegiline is indicated as an adjunct in the management of Parkinsonian clients being treated with levodopa/carbidopa who exhibit deterioration in the quality of their response to this therapy. It is usually used as adjunct therapy but it can be used for early PD to control motor symptoms. It is also used as adjunct therapy for major

depression disorder and off label for attention-deficit hyperactivity disorder (Moore & Saadabadi, 2023).

Nursing Considerations

Administration: oral or transdermal. Both available in different dosages and titrated to effect.

- Oral route given by capsule or oral disintegrating tablet BID.
- Transdermal route: higher plasma concentration resulting in the desired nonselective MAO inhibition and anti-depressive effect to treat MDDs. Apply patch every 24 hours to clean dry skin to outer surface of the upper arm, upper torso or upper thighs. Do not cut the patch (Moore & Saadabadi, 2023).

Caution with renal insufficiency or hepatic disease. Not recommended for severe hepatic disease or end-stage renal disease.

Pregnancy and Lactation: There is a lack of data regarding the potential fetal harm with maternal use during pregnancy or breastfeeding. Safety has not been established in children.

Large doses of selegiline may inhibit MAO-A that promotes the metabolism of tyramine in the GI tract, which can cause a hypertensive crisis. At lower doses, selegiline is selective to MAO-B, but caution is still advised.

Sudden discontinuation can lead to parkinsonism and antidepressant discontinuation syndromes. Dosing needs be tapered before discontinuation.

Prior to elective surgery: Selegiline use within 14 days before elective surgery is contraindicated due to its adverse effects on blood pressure.

Adverse/Side Effects

High Alert Med: Side effects are dose-dependent, with larger doses posing a hypertensive crisis risk in conjunction with the consumption of food or beverages with tyramine. Higher doses can increase the risk for hypertensive crises. For lower doses, no specific restrictions except to avoid aged cheese over 150mg/day (Parkinsons Canada, n.d.).

Foods high in tyramine include: aged cheese, pickled foods, cured meat, smoked or processed meat, soybeans, dried fruits, soy sauce, homebrewed beer and red wine.

Common side effects:

This med is usually well tolerated.

- Anticholinergic effects: dry mouth and constipation.
- Insomnia is very common. Minimize insomnia by taking last dose at noon.
- Headaches, dizziness, insomnia, nausea and weight loss.
- Dyskinesia

Adverse effects:

- Orthostatic hypotension: encourage client to ambulate slowly. Report symptoms of dizziness.
- Mental health changes: hallucinations, any change in mental status.

Client Teaching

- See Improving Outcomes with Parkinson's Disease Medications

at the beginning of this unit.

- Depending on the dose, clients should be advised to avoid foods high in tyramine. If on a low dose and as advised by their prescriber, avoid only aged cheese >150 mg/day. Monitor blood pressure if eating tyramine rich foods.
- Inform client that they may experience drowsiness, dizziness, and blood pressure changes when ambulating. Caution with changing positions, and ambulating.
- Monitor blood pressure regularly to reduce risk of falls from hypotension and to be aware of high blood pressure leading to hypertensive crisis.
- May experience abnormal behaviors such as hallucination, sexual urges, gambling, etc., this should be reported promptly to the healthcare provider.
- Monitor for any change in motor symptoms and other effects of PD. Notify prescriber of these changes.
- Transdermal application: change patch every 24 hours. Do not cut the patch. Skin irritation may occur.

(Moore & Saadabadi, 2023; Parkinsons Canada, n.d.)

Selegiline Medication Card

Now let's take a closer look at the medication card for selegiline.

Selegiline Medication Card

Class: Anti-Parkinson: MAO-B inhibitor **Prototype:** Selegiline		**Indications:** Reduction in progression of Parkinson's disease symptoms. Adjunct therapy for major depressive disorder or attention hyperactivity disorder.	
Mechanism of Action: irreversibly and selectively Inhibits MAO-B, blocking the breakdown of dopamine. This leads to an increased concentration of dopamine that is ready to use in the nerve cells.			
Administration: Oral: IR, ER Transdermal patch: apply q 24hr to clean, dry skin Low doses: MAO-B inhibitor, for PD. High doses: MAO-A & B, for MDD Large dose: risk of hypertensive crisis if tyramine rich food consumed Low dose: limit tyramine rich food (aged cheese)	**Side Effects:** Side effects are dose-dependent Insomnia common Orthostatic hypotension, Constipation, dry mouth Dyskinesia	**Contraindications:** Caution with renal insufficiency or hepatic disease. Not recommended for severe hepatic disease or end-stage renal disease Do not d/c suddenly, risk of parkinsonism symptoms Risk during pregnancy, breastfeeding or for children not established, avoid	**Nursing Considerations:** Before and during therapy: Monitor mental health status, monitor motor symptoms Monitor BP Fall risk, assess for orthostatic hypotension, dizziness and drowsiness

Downloadable file (.docx): Selegiline Medication Card

Amantadine

Amantadine is used in the early stages of Parkinson's disease but can be effective in moderate or advanced stages in reducing tremor and muscle rigidity (Lilley et al, 2020). It was developed as an anti-viral for influenza A, but found to be effective in treating the motor symptoms of Parkinson's disease. It is no longer used as an antiviral against influenza A due to resistance

Mechanism of Action

The exact mechanism of action is unknown. Amantadine has an effect on many receptors. It inhibits dopamine uptake, stimulates dopamine release, weakly antagonizes N-methyl-D-aspartate receptors and may have an effect on cholinergic receptors (Chang & Ramphul, 2023; Rosenjack Burchum & Rosenthal, 2019). As an antiviral, it interferes with viral replication.

Indications for Use

Amantadine is used for Parkinson's disease, to reduce the bradykinesia, rigidity and tremor symptoms. It is used as adjunct therapy with levodopa to create a synergistic effect (Chang & Ramphul, 2023). Amantadine is also used for other purposes, including first-line treatment for fatigue in multiple sclerosis. There is also some benefit for clients with restless leg syndrome and to improve function in traumatic brain injuries.

Nursing Considerations

Oral administration. Either once daily or BID, with tapering up the dose based on effect.

Monitor: prior to starting on the medication and during treatment:

- Labs: renal function and liver function tests. Assess for elevated creatinine and BUN. Assess for increase in AST and ALT.
- Mental status: assess mental status before therapy and then during therapy for a change in status. Risk for hallucinations,

delusions, depression, suicidality.

- Blood pressure: baseline BP prior to therapy, assess for orthostatic hypotension (lying, sitting and standing BP).

Renal impairment or older adult: cautious use, anticipate a reduced dose. Monitor creatine clearance as amantadine is excreted via the kidney.

Caution with cardiac disease, glaucoma and prostate hypertrophy.

Do not abruptly discontinue: risk of Neuroleptic Malignant Syndrome (NMS) with dose reduction or withdrawal of amantadine therapy. Symptoms include high fever, tachycardia, muscle rigidity, and altered mental status. When discontinuing, dose will be reduced by half for one week, then discontinued (Chang & Ramphul, 2023).

Older adult: dose should be decreased if renal insufficiency. The older adult is more at risk for anti-cholinergic effects, so monitor for dizziness to avoid falls. Higher risk of hallucinations so assess mental health status. Higher risk of edema in lower extremities (Parkinsons Canada, n.d.).

Pregnancy: contraindicated due to risk of teratogenic effects on the fetus.

Adverse/Side Effects

Common side effects:

- Anticholinergic effects: dry mouth, constipation, urinary retention, confusion, blurred vision.
- CV: orthostatic hypotension, syncope, peripheral edema, dizziness. Insomnia if taken later in the day.
- Neuro: confusion, hallucinations

- Livedo reticularis is a less common side effect, causing red-purple discoloration of the skin. May occur after being on the medication for over one month. This is reversible when the medication is discontinued.

Adverse Effects:

- Neuroleptic malignant syndrome if abruptly discontinued.
- Risk of psychosis: This drug can cause intense gambling urges, increased sexual urges, intense urges to spend money uncontrollably, and other intense urges with an inability to control them.
- Risk of suicidal ideation and CNS depression. Monitor mental health and assess for suicidality.

(Chang & Ramphul, 2023; Parkinsons Canada, n.d.

Client Teaching

- Clients should take medications as directed and ensure they do not skip or double doses.
- Medications may cause drowsiness, dizziness, and orthostatic blood pressure changes. Monitor blood pressure and to care with ambulation or position changes.
- Clients should avoid using this medication with OTC cold medications or alcoholic beverages due to potential increased risk of dizziness or confusion.
- If clients, family, or caregivers note worsening depression or suicidality, this should be reported immediately to the healthcare provider.

Amantadine Medication Card

Now let's take a closer look at the medication card for amantadine. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Amantadine Medication Card

Class: Anti Parkinson: N-methyl-D-aspartate (NMDA) antagonists **Prototype:** Amantadine		**Indications:** Reduction in progression of Parkinson's disease symptoms. Used as adjunct with levodopa to reduce tremor and muscle rigidity Anti-viral, interferes with viral replication.	
Mechanism of Action: The exact mechanism of action is unknown. Antagonizes N-methyl-D-aspartate (NMDA) receptors, inhibits dopamine uptake, stimulates dopamine release, and may have an effect on cholinergic receptors.			
Administration: Oral once a day or BID. Take before noon is insomnia issue	**Side Effects:** Anticholinergic effects Orthostatic hypotension, dizziness, insomnia, nausea Increased suicidality and urges CHF and peripheral edema Neuroleptic Malignant Syndrome (NMS) risk if abruptly d/cd	**Contraindications:** Caution with renal insufficiency and older adult, reduced doses Not for pregnancy or breastfeeding Caution with cardiac disease, glaucoma and prostrate hypertrophy	**Nursing Considerations:** Monitor renal function and LFTs Monitor mental state Assess blood pressure Taper dose carefully Monitor BP Monitor for suicidal thoughts or behavior, and/or any unusual changes in mood or behavior

Downloadable file (.docx): Amantadine Medication Card

Clinical Reasoning and Decision-Making Activity 5.10

A 76-year-old client in a long-term care center has developed a shuffling gait with a stooped posture, along with a hand tremor at rest. The nurse practitioner prescribed carbidopa/levodopa.

1. The nurse knows that Parkinson's disease is related to dopamine, but dopamine can't cross the blood-brain barrier. How will carbidopa/levodopa assist with dopamine levels?
2. The client states, "I am looking forward to spending next weekend with my grandson. He even said he would let me drive his new Mustang!" What teaching should the nurse provide the client and his grandson (with the client's permission) regarding the new medication and his weekend plans?
3. The nurse reads that the most common side effect of carbidopa-levodopa is dyskinesia. What is dyskinesia? If it occurs, what is the likely treatment?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

Interactive Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=271#h5p-111

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=271#h5p-112

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CHAPTER 6: NEUROLOGICAL SYSTEM: PAIN AND MOBILITY

6.0 Pain and Mobility Introduction

Learning Objectives

- Identify the classifications and actions of medications related to pain and mobility
- Consider examples of when, how, and to whom pain and mobility medications may be administered
- Describe classifications, actions, side effects and nursing considerations associated with pain and mobility medication therapy
- Identify considerations and implications of using pain and mobility-related medications across the lifespan
- Consider evidence-based concepts when using the nursing process, clinical reasoning, and decision-making related to medications for pain and mobility
- Consider the impact of opioid analgesics on the overdose crisis and the responsibility of the nurse for client education, naloxone administration, and pain management advocacy

Key Terms

- **acute pain**
- **adjuvant analgesics**
- **chronic pain**
- **immune-mediated disease**
- **misuse**
- **mobility**
- **muscle spasticity**
- **nociceptors**
- **non-pharmacologic therapy**
- **opioid withdrawal**
- **opioid naïve**
- **opioid tolerance**
- **physiologic dependence**
- **pain**
- **patient controlled analgesia**
- **prostaglandins**
- **steady state**
- **tolerance**
- **Total Daily Dose (TDD)**
- **vertigo**

Complaints of pain are one of the most common reasons individuals seek out medical care. The pain signal indicates that something in the body is not quite right. Whether it be a headache, a broken bone, labor pain, chest pain, or other condition, pain assessment and treatment is an important part of nurse's care for their clients.

Definition of Pain:

In 1979, the International Association for the Study of Pain defined pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage (International Association for the Study of Pain [IASP], 2020). They have recently expanded this definition to include the following six notes:

- Pain is always a subjective experience that is influenced to varying degrees by biological, psychological, and social factors.
- Pain and nociception are different phenomena. Pain cannot be inferred solely from activity in sensory neurons.
- Through their life experiences, individuals learn the concept of pain.
- A person's report of an experience as pain should be respected.
- Although pain usually serves an adaptive role, it may have adverse effects on function and social and psychological well-

being.
- Verbal description is only one of several behaviors to express pain; inability to communicate does not negate the possibility that a human or a nonhuman animal experiences pain.

From this definition, pain is more than a neural or chemical mechanism but is modulated by many factors that include emotional, psychosocial, behavioural, and past and current experiences. Pain is complex and multifactorial. Every client's response to pain will be different and nurse's must be able to adapt their treatment by taking into account these differences. In unit 10.2, we will explore this concept further.

Pain impacts all demographics in Canada. For many people, pain is temporary or acute and serves as a warning sign something is wrong. Acute pain, such as pain experienced following an injury or surgery, typically is short term (resolves within 4 weeks), and resolves with tissue healing (Province of BC, 2023).

Chronic pain persists greater than 3 months, and can be due to many medical conditions. According to the Canadian Pain Task Force Report, October 2020, it is estimated that 7.63 million Canadians over 15 years of age, or one in four persons, live with chronic pain. One in five children report pain and mostly report headaches, although all forms can lead to a negative impact on life by contributing to depression, and an impact on mood and sleep. It is reported that 50% of clients with chronic pain have suffered with this pain for over 10 years. The prevalence of pain seems to increase with age, with reports ranging from 65-80% depending on age over 65 (Registered Nurses Association of Ontario [RNAO], 2025). Pain is often hidden and interwoven with other chronic conditions. As such, chronic pain has significant impacts on physical and mental health, family and community life, society and the economy. Pain is often misunderstood, underdiagnosed and poorly treated.

Health Canada released a report in 2021, titled 'An Action Plan for Pain in Canada' that lays out particular strategies to improve pain management in Canada. Some of these strategies we will address in

this chapter. To effectively assess, manage and prevent pain, nurses should work collaboratively with the health care team, their clients and caregivers.

In this chapter:

- Pain and mobility concepts including the physiology of pain and contributing factors.
- Conditions and diseases of pain
- Medication classifications: non-opioids, opioids, adjuvant, anti-gout and anesthetics.
- Clinical Thinking and Clinical Judgment Learning Activities to consolidate your understanding.

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6.1 Pain and Mobility Concepts

Concepts Related to Pain

This resource provides a basic introduction to the concept of pain as it relates to pharmacology. The perception of pain tells us that there is an actual or potential tissue damage and may occur without clear injury, and we need to do something to alleviate that pain. Pain is subjective, so one person may experience the same pain stimulus differently than another, based on the complex interactions including past and present pain experiences, emotions, behaviours, social and physical factors.

The example concept map in figure 6.1a provides a summary of the key information necessary to understand pain informed by several resources (Giddens, 2014)

You are encouraged to revisit this map after you have completed the chapter.

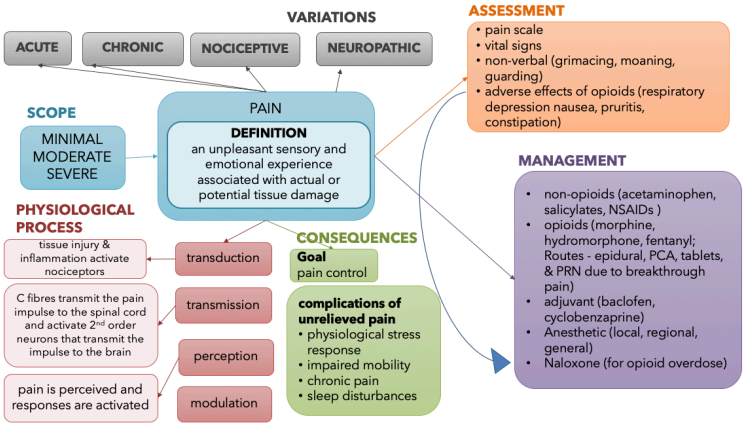

Figure 6.1a Pain Concept Map [Image Description]

Before addressing the medications that are used to treat analgesic and musculoskeletal conditions in our clients, it is important to review the physiology of pain and the anatomy of the musculoskeletal system.

Physiology of Pain

Pain occurs when there is tissue damage in the body in response to a noxious stimuli. The noxious stimuli can be from thermal, mechanical, or chemical sources which then activates pain receptors of peripheral nerves. **Nociceptors**, the nerve endings that respond to painful stimuli, are located in arterial walls, joint surfaces, muscle fascia, periosteum, skin, and soft tissue. Nociceptors are less densely distributed in many internal organs (Frandsen, & Pennington, 2018).

The cause of tissue damage may be thermal (e.g. heat, cold), physical (e.g., pressure, stretch, spasm, and ischemia) or chemical (pain-producing substances are released into the extracellular fluid

surrounding the nerve fibers that carry the pain signal). These pain-producing substances activate pain receptors, increase the sensitivity of pain receptors, or stimulate the release of inflammatory substances. Inflammatory substances include **prostaglandins**, substance P., histamine, globulin, protein kinases, arachidonic acid, and others. Pain can also activate the physiological stress response (Finnerty, 2017; Frandsen & Pennington, 2018).

Two important inflammatory substances in response to a painful stimulus

Substance P – an inflammatory neuropeptide has an important role in the perception of pain. It is released by sensory nerve fibers in response to tissue damage and activates neurokinin-1 receptors on neurons in the spinal cord, leading to increased pain signals and pain sensitivity. It has a role in inflammation, vasodilation, and immune cell activation.

Prostaglandin – is a hormone like substance produced at sites of tissue damage or infection and have a key role in the inflammatory response and pain. There are a number of types of PG, and have different effects including BP control and blood clotting.

For a person to feel pain, the signal from the nociceptors in peripheral tissues must be transmitted to the spinal cord and then to the hypothalamus and cerebral cortex of the brain. The signal is transmitted to the brain by two types of nerve cells. The two types of nerve fibers, A and C, have different speed of conduction and type of pain.

The activation of A fibers (large, myelinated: transmit touch, pressure, temp quickly) send pain response quickly and is a sharp defined pain. The activation of C fibers (small diameter, slow, unmyelinated; carry pain and temp signals) is perceived as a dull, achy or burning sensation.

The dorsal horn of the spinal cord is the relay station for information from these fibers. In the brain, the thalamus is the relay station for incoming sensory stimuli, including pain. From the thalamus, the pain messages are relayed to the cerebral cortex where they are perceived (Chen et al, 2024; Frandsen, & Pennington, 2018). In general, modulation occurs at multiple levels (spinal and central).

See Figure 10.2b for an illustration of how the pain signal is transmitted from peripheral tissues to the spinal cord and then to the brain (Guebeli, 2015)

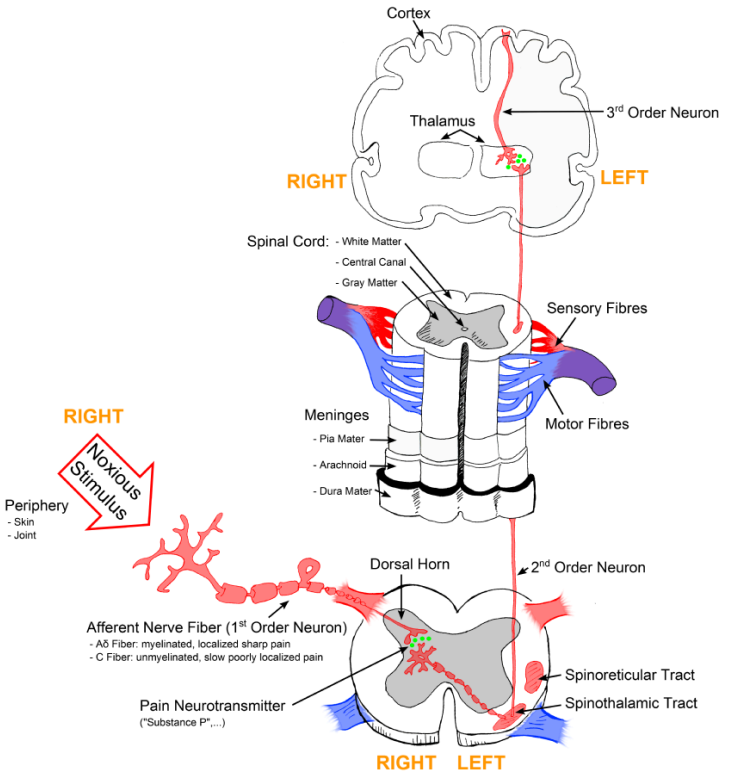

Figure 6.1 The Transmission of Pain from Peripheral Tissues to the Brain

Perception of Pain

How do people feel pain differently, despite the same pain stimulus? To help explain this phenomenon, the concept of a gated system that allows some pain signals to reach the brain while others do not was theorized by two researchers in 1965. The Gate Control Theory introduced by Ronald Melzack and Patrick Wall explains how the pain response travels to the brain to elicit a response (as outlined above), and also explains how non-pain sensations such as touch,

temperature or pressure or even emotions can also travel to or from the brain along different nerve fibers to quickly inhibit the response.

***Open and closed Gates*:**

'Gates' opened when injury occurs …. Signal to cerebral cortex…. pain is felt.

'Gates' are closed – inhibition of impulse transmission to the brain or from emotional/cognitive processes … decrease in pain perception.

For example, pain can be minimized through touch or pressure. By rubbing an area, this sends a stimuli through the DCML into the dorsal gray horn, up the same side (as the injury) of the spinal cord to the medulla, to the thalamus and signals a decrease in sensation.

Understanding the Gate Control Theory and pain management

Two clients are on a medical unit following a fall that resulted in the same injuries: a fractured left femur, rib fractures and generalized soft tissue injury.

Client A: first time in the hospital and he has not had any significant injury before. No other health issues, does meditation to manage stress and listens to music to take his mind off of his injury. For this client, the pain stimulus is the same, but the gates will 'close' due to natural endorphin release, positive emotions and ability to focus on something other than the pain. He will still feel pain, but it might be better managed.

Client B: this client has had numerous injuries and hospitalizations before, they have been in the hospital in the past, and did not have a good experience with pain control. They are also bored in the hospital, and can only think about their bad luck with this fall. For this client, the pain stimulus is the same, but the gates will stay 'open' due to negative emotions, boredom, focusing on their pain and past negative experience. They will feel pain, and likely more than client A, and potentially more difficult to manage.

Endogenous Analgesia

The CNS has its own endogenous analgesia system for relieving

pain. Endogenous opioids are primarily produced in the brain and have multiple actions throughout the body. These opioid peptides are endorphins, enkephalins and dynorphins, and bind to opioid receptors to modulate the perception and transmission of pain signals, resulting in pain relief, relaxation (slow HR) and euphoria (Sprouse-Blum et al, 2010).

So why is the pain transmission process important to know? It helps us understand how clients can express the same pain experience differently. It also helps us understand how different pain treatment modalities work and why choosing the right modality can contribute to pain relief.

See the video below for more information about how pain relievers work.

How Do Pain Relievers Work? by George Zaidan[1]

The Concept of Mobility and the Musculoskeletal System

The concept of **mobility** is defined as "purposeful physical movement, including gross simple movements, fine complex movements, and coordination; State or quality of being mobile or movable"(Giddens, 2017).

In the musculoskeletal system, the muscular and skeletal systems work together to support and move the body. The bones of the skeletal system serve to protect the body's organs, support the weight of the body, and give the body shape. The muscles of the muscular system attach to these bones, pulling on them to allow for movement of the body (Khan Acaemy, n.d.). See Figure 10.2c for an illustration of the musculoskeletal system (Open Stax, 2015).

1. Ted-Ed. (2012, June 26). How Do Pain Relievers Work? - George Zaidan [Video]. YouTube. https://youtu.be/9mcuIc5O-DE

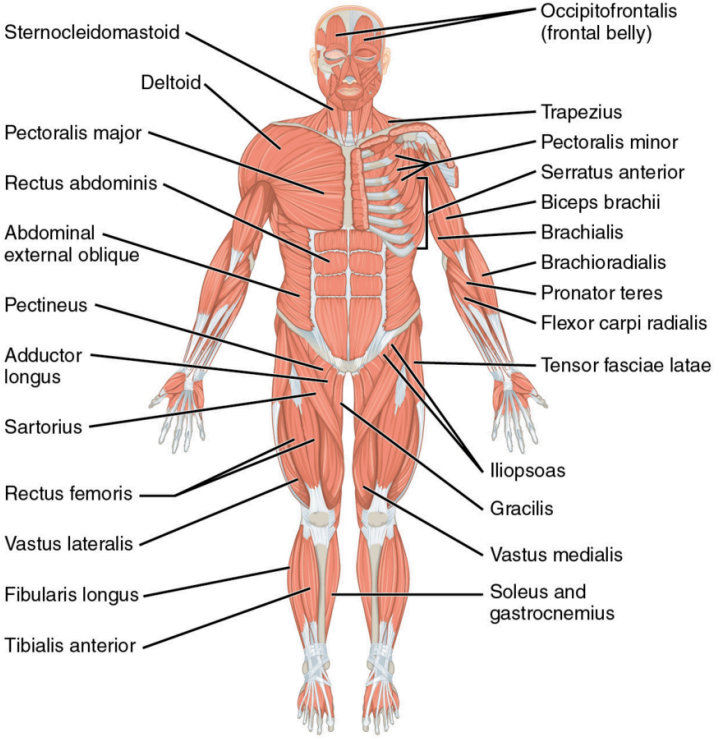

Figure 6.1c The Musculoskeletal System

Muscles

The body contains three types of muscle tissue: skeletal muscle, smooth muscle, and cardiac muscle. See Figure 6.1d for images of different types of muscle (Open Stax, 2013)

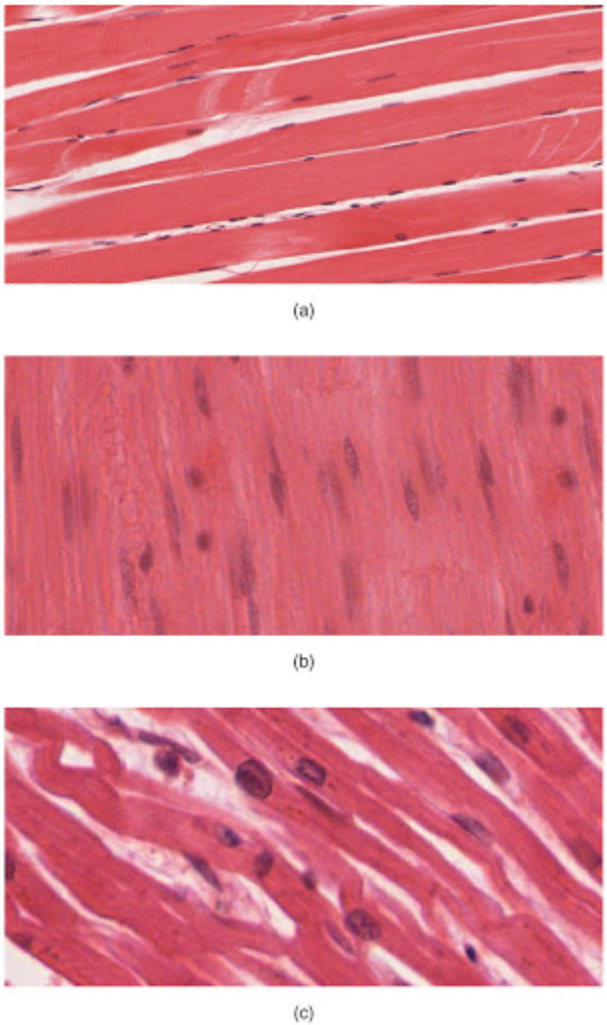

Figure 6.1d (a) Skeletal muscle; (b) Smooth muscle; (c) Cardiac muscle

Skeletal muscle is voluntary and striated. These are the muscles that attach to bones and control conscious movement. Smooth muscle is involuntary and non-striated. It is found in the hollow organs of

the body, such as the stomach, intestines, and around blood vessels. Cardiac muscle is involuntary and striated. It is found only in the heart and is specialized to help pump blood throughout the body (Khan Academy, n.d.)

When a muscle fiber receives a signal from the nervous system, myosin filaments are stimulated, pulling actin filaments closer together. This shortens sarcomeres within a fiber, causing it to contract (Khan Academy, n.d.)

Image Description

Figure 10.2a Pain Concept Map image description: This is a concept map that shows the components of pain. It starts with the definition for pain: an unpleasant sensory and emotional experience associated with actual or potential tissue damage. Then, the concept map continues through the following categories:

Scope

- Minimal
- Moderate
- Severe

Variations

- Acute
- Chronic
- Nociceptive
- Neuropathic

Assessment

- pain scale
- vital signs

- non-verbal (grimacing, moaning, guarding)
- adverse effects of opioids (respiratory depression nausea, pruritis, constipation)

Management

- non-opioids (acetaminophen, salicylates, NSAIDs)
- opioids (morphine, hydromorphone, fentanyl; Routes – epidural, PCA, tablets, & PRN due to breakthrough pain)
- adjuvant (baclofen, cyclobenzaprine)
- Anesthetic (local, regional, general)
- Naloxone (for opioid overdose)

Consequences

- Goal
  - pain control
- complications of unrelieved pain
  - physiological stress response
  - impaired mobility
  - chronic pain
  - sleep disturbances

Physiological Process

- Transduction
  - tissue injury & inflammation activate nociceptors
- Transmission
  - C fibres transmit the pain impulse to the spinal cord and activate 2nd order neurons that transmit the impulse to the brain
- Perception
  - pain is perceived and responses are activated
- Modulation [Return to Figure 10.2a]

Interactive Activities

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Images:

Gate Image: https://pixabay.com/photos/moselle-gate-iron-gate-2635914/

"Sketch colored final.png" by Bettina Guebeli is licensed under CC BY-SA 4.0 ↵

Ted-Ed. (2012, June 26). How Do Pain Relievers Work? – George Zaidan [Video]. YouTube. https://youtu.be/9mcuIc5O-DE ↵

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"414 Skeletal Smooth Cardiac.jpg" by OpenStax College is licensed under CC BY 4.0 ↵

6.2 Conditions and Diseases of Pain and Mobility

Pain is a complex experience with biological, psychological and social/ environmental factors. It can range from mild and self-limiting, to debilitating effects that impact a client's quality of life and functionality. Everyone experiences pain and it is listed as one of the top five reasons why people visit a primary care provider in Canada (Health Canada, 2019). In Canada, an estimated 7.6 million people across the lifespan live with chronic pain, and this number is expected to increase, partially due to our aging population (RNAO, 2024). Health Canada predicts that the number of Canadians living with chronic pain will rise by 17.5 per cent from 2019 to 2030 due to population growth (RNAO, 2024).

Nurses have a central role in pain assessment and management. Assessing pain is a component of every assessment and often has an impact on unrelated health conditions. As such, nurses need to have a good understanding of the types of pain, and common conditions that can exhibit unique pain experiences. In this unit, we will provide a brief overview of several conditions that cause pain or inflammation that require the use of analgesics or musculoskeletal medication. Common disorders are briefly reviewed below.

Types of Pain

A number of terms are often used to describe the pain a client is experiencing. Pain is commonly categorized by duration (acute, subacute, chronic) and by mechanism such as nociceptive, neuropathic, nociplastic (National Institute of Neurological

Disorders and Stroke, n.d.). The more common terms will be explained below.

Acute pain

Acute pain usually comes on suddenly and is caused by something specific. It is sharp in quality. Acute pain is short term (does not last longer than four weeks) and resolves with tissue healing (Province of BC, 2022). It goes away when there is no longer an underlying cause for the pain. Causes of acute pain are typically due to injuries, illnesses, surgeries or other medical procedures, and resolve with tissue healing. After acute pain goes away, a person can go on with life as usual (Cleveland Clinic, 2017).

Subacute pain

Subacute pain is defined as pain in the transition between acute and chronic. It does not resolve or diminish as expected within a 4–12-week period after the initial onset. During this time, health care practitioners should be reviewing the treatment strategies and take steps to minimize the transition to chronic pain (Province of BC, 2022).

Chronic pain

Chronic pain is pain that is ongoing and usually lasts longer than three months. This type of pain can continue even after the injury or illness that caused it has healed or gone away. Pain signals remain active in the nervous system for weeks, months, or years. Some

people suffer chronic pain even when there is no past injury or apparent body damage. Chronic pain is linked to conditions including:

- Headache
- Arthritis
- Cancer
- Nerve pain
- Back pain
- Fibromyalgia pain
- Phantom pain

People who have chronic pain can experience physical effects that are stressful on the body. These include tense muscles, limited ability to move around, a lack of energy, and appetite changes. Emotional effects of chronic pain include depression, anger, anxiety, and fear of reinjury. Such a fear might limit a person's ability to return to their regular work or leisure activities (Cleveland Clinic, 2017).

Chronic pain is a significant health issue in Canada. It is estimated that one in five (across their lifespan) or 7.6 million Canadians live with chronic pain (Province of BC, 2022). Managing chronic pain requires an individualized treatment plan that applies a trauma informed approach with the goal of improving functionality and addressing pain, disability and suffering (Province of BC, 2022).

Neuropathic Pain:

Neuropathic pain is caused by nerve damage from a lesion, injury or disease. This type of pain are often described as burning, tingling, shooting, or like electric shocks. Examples of conditions that cause neuropathic pain are diabetic neuropathy, shingles, and sciatica (RNAO, 2024).

Nociceptive Pain:

Nociceptive pain describes pain that is caused by tissue damage and/or inflammation to non-neural tissue and is due to activation of nociceptors. The sensation can be sharp, pricking, dull, or aching, depending on what caused the damage or inflammation. Examples of nociceptive pain are pain from a physical injuries such as a paper cut, an infection, a broken bone, or osteoarthritis. It can also be from chemical agents such as a burn (National Institute of Neurological Disorders and Stroke, n.d.).

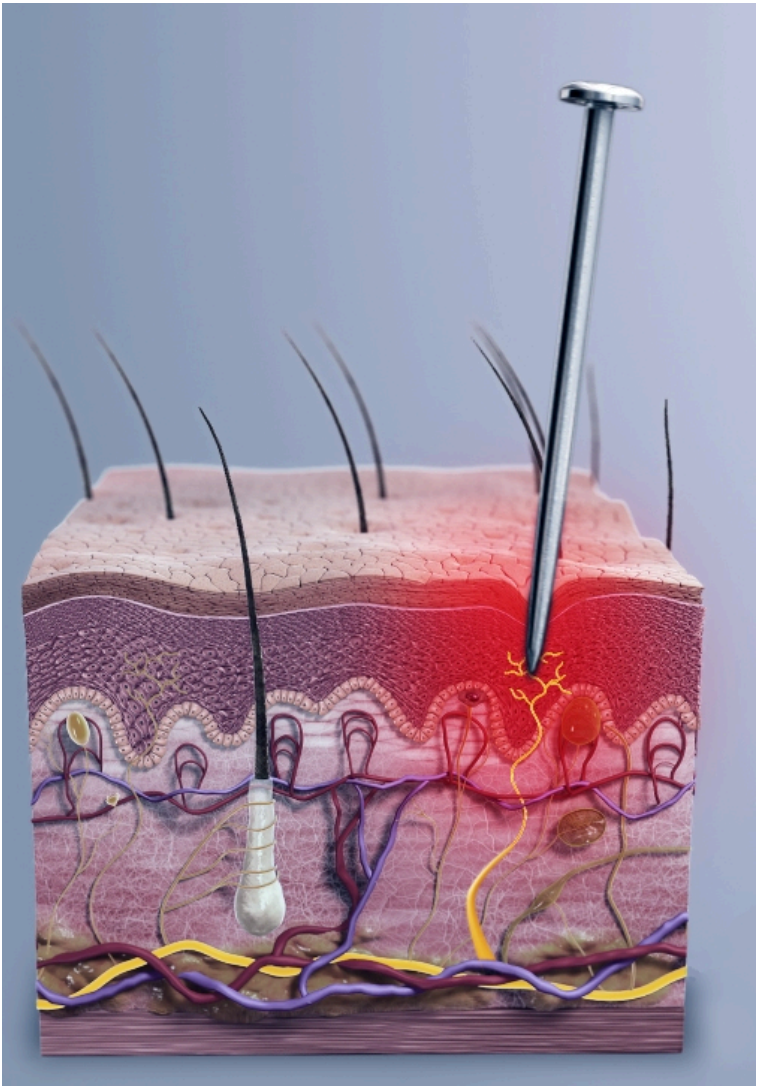

Figure 6.2a nociceptive pain

File:Nociceptive pain 2.jpg . This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license.

Original file (504 × 724 pixels, file size: 234 KB, MIME type: image/jpeg)

Nociceptive pain is caused by the activation of pain receptors, called nociceptors, in response to actual or threatened tissue damage from events like cuts, burns, or sprains. Nociceptors are stimulated when the nail pierces the skin and tissue, sending pain signals to the brain.

Other Conditions of Pain and Mobility

Fibromyalgia is a condition that causes pain all over the body (widespread pain), sleep problems, fatigue, and often emotional and mental distress. People with fibromyalgia may be more sensitive to pain than people without fibromyalgia. This is called abnormal pain perception processing. Fibromyalgia affects about 4 million US adults, about 2% of the adult population. The cause of fibromyalgia is not known, but it can be effectively treated and managed (Centers for Disease Control and Prevention, 2017).

The most common symptoms of fibromyalgia are the following:

- Pain and stiffness all over the body
- Fatigue and tiredness
- Depression and anxiety
- Sleep problems
- Problems with thinking, memory, and concentration
- Headaches, including migraines

Other symptoms may include:

- Tingling or numbness in hands and feet
- Pain in the face or jaw, including disorders of the jaw known as temporomandibular joint syndrome (TMJ)
- Digestive problems, such as abdominal pain, bloating,

constipation, and even irritable bowel syndrome (IBS)

Known risk factors include:

- Age. Fibromyalgia can affect people of all ages, including children. However, most people are diagnosed during middle age
- Lupus or Rheumatoid Arthritis. Clients diagnosed with lupus or rheumatoid arthritis (RA) are more likely to develop fibromyalgia

Other factors that have been weakly associated with the onset of fibromyalgia include:

- Sex. Women are twice as likely to have fibromyalgia as men
- Stressful or traumatic events, such as car accidents or post-traumatic stress disorder (PTSD)
- Repetitive injuries. Injury from repetitive stress on a joint, such as frequent knee bending
- Illness (such as viral infections)
- Family history
- Obesity

Doctors usually diagnose fibromyalgia using the client's history, physical examination, X-rays, and blood work (Centers for Disease Control and Prevention, 2017).

Gout

Gout is a common form of inflammatory arthritis that is very painful. It usually affects one joint at a time (often the big toe joint). There are times when symptoms get worse, known as flares, and times when there are no symptoms, known as remission. Repeated

bouts of gout can lead to gouty arthritis, a worsening form of arthritis.

There is no cure for gout, but you can effectively treat and manage the condition with medication and self-management strategies.

Gout flares start suddenly and can last days or weeks. These flares are followed by long periods of remission (weeks, months, or years) without symptoms before another flare begins. Along with the big toe, joints commonly affected are the lesser toe joints, the ankle, and the knee (Centers for Disease Control and Prevention, 2019, January 28).

Symptoms in the affected joint(s) may include:

- Pain, usually intense
- Swelling
- Redness
- Heat

Figure 6.1 b Gout: signs and symptoms. Image showing foot affected by gout Retrieved from Wikipedia Commons File: Gout Signs and Symptoms.jpg www.scientificanimations.com 2019. http://www.scientificanimations.com/wiki-images/

Gout is caused by a condition known as hyperuricemia, where there is too much uric acid in the body. The body makes uric acid when it breaks down purines, which are found in your body and the foods you eat. When there is too much uric acid in the body, uric acid crystals (monosodium urate) can build up in joints, fluids, and tissues within the body. Hyperuricemia does not always cause gout, and hyperuricemia without gout symptoms does not need to be treated. There is a higher incidence of gout in males.

Having certain health conditions can also increase your chances of developing hyperuricemia. These conditions include the following:

- Congestive heart failure
- Hypertension (high blood pressure)
- Insulin resistance
- Metabolic syndrome
- Diabetes
- Poor kidney function
- Obesity

Additional diet or medication factors may increase your chances of developing hyperuricemia:

- Using certain medications, such as diuretics (water pills)
- Drinking alcohol. The risk of gout is greater as alcohol intake increases
- Eating or drinking food and drinks high in fructose (a type of sugar)
- Having a diet high in purines, which the body breaks down into uric acid. Purine-rich foods include red meat, organ meat, and some kinds of seafood, such as anchovies, sardines, mussels, scallops, trout, and tuna.

Gout is diagnosed by assessing the symptoms and the results of the physical examination, X-rays, and lab tests. Gout is typically

diagnosed during a flare when a joint is hot, swollen, and painful and when a lab test finds uric acid crystals in the affected joint (Centers for Disease Control and Prevention, 2019, January 28).

Muscle spasm

Muscle spasms are involuntary contractions of a muscle or group of muscles (Adams et al, 2019). Spasms of skeletal muscles are most common and are often due to overuse leading to muscle fatigue, but can also be attributed to dehydration, and electrolyte abnormalities. Some medications can lead to muscle spasms such as corticosteroids and anti-lipid medication such as statins. Diseases such as multiple sclerosis can also lead to chronic muscle spasms.

The spasm often occurs abruptly, is painful, and is usually short-lived (Wedro, 2019). Other symptoms may include inflammation, edema, loss of coordination or decreased mobility (Adams et al, 2019). If there is persistent or moderate to severe discomfort, both non-pharmacological and pharmacological interventions can be tried. Non-pharmacological interventions may include gentle stretching of the muscle, application of heat or cold, rest, massage or acupuncture. Medications can include centrally acting skeletal muscle relaxants such as baclofen or cyclobenzaprine.

Multiple Sclerosis

Multiple sclerosis (MS) involves an **immune-mediated disease process** in which an abnormal response of the body's immune system is directed against the central nervous system (CNS). The CNS is made up of the brain, spinal cord, and optic nerves.

Within the CNS, the immune system causes inflammation that damages myelin (the fatty substance that surrounds and insulates

the nerve fibers), as well as the nerve fibers themselves and the specialized cells that make myelin. When myelin or nerve fibers are damaged or destroyed in MS, messages within the CNS are altered or stopped completely. Damage to areas of the CNS may produce a variety of neurological symptoms that will vary among people with MS in type and severity. The damaged areas develop scar tissue that gives the disease its name – multiple areas of scarring or multiple sclerosis. The cause of MS is not known, but it is believed to involve genetic susceptibility, abnormalities in the immune system, and environmental factors that combine to make MS symptoms variable and unpredictable. No two people have exactly the same symptoms, and each person's symptoms can change or fluctuate over time. One person might experience only one or two of the possible symptoms, while another person might experience several symptoms of the disease.

Symptoms include:

- Fatigue
- Numbness or tingling
- Weakness
- Dizziness or **vertigo**
- Walking difficulties
- **Muscle spasticity**
- Blurred vision

At this time, there are no symptoms, physical findings, or laboratory tests that can, by themselves, determine if a person has MS. Several strategies are used to determine if a person meets the long-established criteria for a diagnosis of MS and to rule out other possible causes of whatever symptoms they are experiencing. These strategies include a careful medical history, a neurologic exam, and various tests including magnetic resonance imaging (MRI), spinal fluid analysis, and blood tests (National Multiple Sclerosis Society, 2018).

Myasthenia Gravis

Myasthenia Gravis (MG) is an autoimmune disease that occurs when the immune system attacks the body's own tissues. In MG, the attack interrupts the connection between nerve and muscle called the neuromuscular junction. Myasthenia gravis is characterized by autoantibodies against the acetylcholine receptor or against a receptor-associated protein called muscle-specific tyrosine kinase. You can read more details about acetylcholine receptors in the "Autonomic Nervous System" chapter.

MG causes weakness in muscles that control the eyes, face, neck, and limbs. Symptoms include partial paralysis of eye movements, double vision, and droopy eyelids, as well as weakness and fatigue in the neck and jaws and problems, chewing, swallowing, and holding up the head. MG is treatable with drugs that suppress the immune system or boost the signals between nerve and muscle (Muscular Dystrophy Association, n.d.). The group of drugs used to control MG is called acetylcholinesterase inhibitors. They inhibit the action of the enzyme acetylcholinesterase so that more acetylcholine (ACh) is available to activate cholinergic receptors and promote muscle contraction. ACh inhibitors are classified as parasympathomimetics. Pyridostigmine is an example of an ACh inhibitor.

Cholinergic Crisis: Overdosing with ACh inhibitors can cause a complication called cholinergic crisis which is an overstimulation of cholinergic receptors. Symptoms of cholinergic crisis include severe muscle weakness and the potential for respiratory compromise. It can occur 30-60 minutes after taking a cholinergic medication and in severe cases, can lead to respiratory paralysis and death (McCuistion, 2018). It can be avoided by strictly following dosing regimen, and paying attention to early muscarinic symptoms of diarrhea, cramps, excess salivation and pupil constriction.

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6.3 Clinical Reasoning and Decision-Making for Pain and Mobility

Clinical reasoning is a way that nurses think and process our knowledge, including what we have read or learned in the past, and apply it to the current practice context of what we are seeing right now (NCSBN, n.d). Nurses make decisions all the time but making decisions requires a complex thinking process. There are many tools that are useful and found online that can support your thinking through to clinical judgments. This book uses the nursing process and clinical judgment language to help you understand the application of medication to your clinical practice.

After reviewing basic concepts related to pain and several disorders requiring analgesic or musculoskeletal medication, it is time to consider how to make decisions about these types of medications.

Assessment

Although there are numerous details to consider when administering medications, it is always important to first think about what you are giving and why.

First, let's think of why? Recognizing Cues

Prior to administration of any medication, nurses should perform an assessment and gather cues to analyze and prioritize a hypothesis (Tanner, 2006).

For instance, if considering a pain medication, you will want to complete a full pain assessment such as determining a pain scale and acceptable pain level for your client. See Figure 6.3a[1] for common nursing mnemonics for pain assessment.

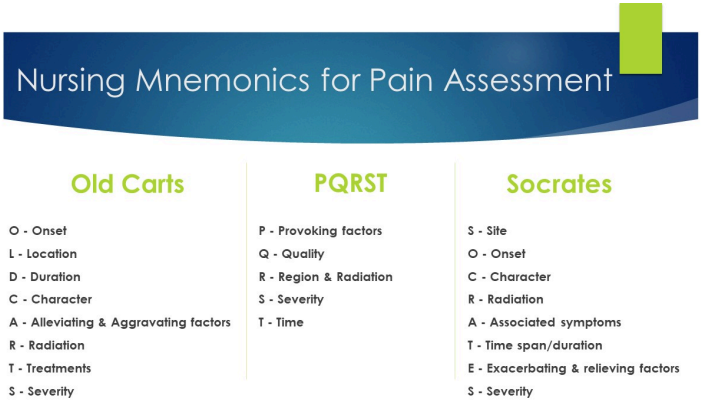

Figure 6.3a Mnemonics for Pain Assessment

If administering a medication related to mobility or the musculoskeletal system, you will first want to collect data such as strength and stability.

https://wtcs.pressbooks.pub/nursingskills/chapter/13-4-musculoskeletal-assessment/

1. "Mnemonics for Pain Assessment" by Julie Teeter is licensed under CC BY-SA 4.0

Additional baseline information to collect prior to administration of any analgesic or musculoskeletal medication includes health history, history of similar pain and treatments, history of allergies to medications or a previous adverse response.

Other cues:

Clients with pain will often have other cues that alert us to the intensity of pain. For acute pain, it can be mild to severe. Some cues during acute pain can include:

- Vital signs: tachycardia, tachypnea, elevated blood pressure, and shallow breathing. If the rate of breathing is elevated and compromised, this may lead to lower oxygen saturations. Diaphoresis and elevated temperature may also be seen.
- Gastrointestinal: nausea, vomiting and constipation may occur. This is due to changes to digestion and GI upset.
- other: increased blood glucose levels due to the stress response

For chronic pain, that is long term in nature, some of the physical symptoms are no longer present. But clients may experience disrupted sleep, fatigue, and depression.

Understanding types of pain

To be able to adequately assess and treat a client's pain, nurses need to understand the type of pain a client may be experiencing. Different types of pain will present differently and will be treated differently. For example, neuropathic pain versus acute post op pain. The types of pain include neuropathic, acute, and chronic. A

client with neuropathic pain which is caused by nerve damage may feel a burning or tingling sensation. Post-operative pain will be a sharp pain but with a short duration.

Lifespan Considerations

A majority of medications are calculated specifically based on the client's size, weight, and renal function. Client age and size are especially vital in pediatric clients. A child's stage of development and the size of their internal organs will greatly impact how the body absorbs, digests, metabolizes and eliminates medications.

Visual pain scales have been developed as a tool of communication about pain with children and adults. The Wong-Baker pain scale was the first developed to provide a visual representation of a client's pain level. The one that is presented below, figure 6.3b for the FACES Pain Rating Scale, can be used for clients over the age of 3. To use this scale, use the following evidence-based instructions.

1. Explain to the client that each face represents a person who has no pain (hurt), some, or a lot of pain.
2. Explain, "Face 0 doesn't hurt at all. Face 2 hurts just a little. Face 4 hurts a little more. Face 6 hurts even more. Face 8 hurts a whole lot. Face 10 hurts as much as you can imagine, although you don't have to be crying to have this worst pain."
3. Ask the client to choose the face that best represents the pain they are feeling.

Figure 6.3b The Wong-Baker FACES Pain Rating Scale. Used with permission from [http://www.WongBakerFACES.org.](http://www.WongBakerFACES.org)

Determinants of Health and Cultural Safety

There are several considerations for nurses when working with clients who have conditions related to pain and mobility. It is important that you engage in client care that is culturally safe, remember that pain is what the client says it is, and not further marginalize clients (Craig et al, 2020).

Interventions

Next, plan (refine your hypothesis), and take action.

Once you have gathered your assessment data and cues, you'll begin to generate solutions to the concern that your client has. Prior to administration, it is important to consider the best route of administration

for this client at this particular time. For example, if the client is nauseated and vomiting, then an oral route may not be effective.

There are also legal and ethical considerations when administering some analgesics such as opioids. When administering opioid medications, it is important to remember that these medications are controlled substances with special regulations regarding storage, auditing counts, and disposal or wasting of medication. Read more information about controlled substances in Chapter 2.

In general, when administering analgesics, we often will use the least invasive medication that is anticipated to treat the level of pain reported by the client. The World Health Organization (WHO) pain ladder was originally developed for the selection of analgesics for clients with cancer but illustrates the step-wise approach to pain control based on the level of pain indicated by the client. See Figure 6.3c for an image of the WHO ladder. For example, if a client reports a pain level of "2," then it is appropriate to start at the lowest rung of the ladder and administer a non-opioid. However, it may be clinically indicated to start at "Level 3" on the WHO ladder for clients who present with severe, difficult pain. This model is very simplistic and does not take into account clinical context or client factors. But, it is still relevant today with the step up-step down approach to pain management.

Figure 6.3c The WHO Pain Ladder. The diagram shows the step-wise approach to cancer pain management recommended by the World Health Organization (WHO)

It is important to anticipate any common side effects and the expected outcome of the medication, as well as considerations regarding what to teach the client and their family regarding the

medications. This information will be dependent upon the medication.

Evaluation

Finally, evaluate the outcomes of your action.

It is important to always evaluate the client's response to a medication. In most circumstances, the nurse should assess for a decrease in pain 30 minutes after intravenous (IV) administration and 60 minutes after oral medication. If the client's pain level is not acceptable, the nurse should investigate alternate treatment modalities or repeated or increased dosage depending on client factors and type of analgesia. Alternative treatment modalities may include, but are not limited to aromatherapy, repositioning the client, hot or cold treatments, and listening to music.

As the nurse is the client's advocate, the healthcare provider may have to be informed if the client's pain is not being controlled by analgesics. Nurses should also evaluate for any adverse effects. For instance, one adverse effect of opioid analgesics is respiratory depression. The nurse should evaluate the respiratory rate and pulse oximetry after administration of the medication. The nurse may need to consider administering other medications that treat the side effects of analgesic medication.

Pain Management Take-Aways

- use oral analgesics whenever possible.

- give analgesics at regular intervals and breakthrough analgesia as needed.
- give analgesics based on the level of intensity of pain.
- the dosage of pain is individualized to that client
- manage and anticipate adverse effects. For example, anticipate constipation from opioids and have a plan for prevention.

Vargas-Schaffer, 2010

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=316#h5p-80

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- Figure 6.3b The Wong-Baker FACES Pain Rating Scale. Used with permission from http://www.WongBakerFACES.org
- Figure 6.3c. World Health Organization (1996). Cancer pain relief. 2nd ed. Geneva: WHO. for an image of the WHO ladder.

2.

6.4 Pain and Mobility Medications Overview

The next sections will introduce different classes of analgesics and musculoskeletal medications with specific administration considerations, therapeutic effects, adverse/side effects, and teaching needed for each class of medications.

Analgesics used to treat pain are categorized as non-opioid, opioid, and adjuvant medications.

- Non-opioid medications include acetaminophen and non-steroidal anti-inflammatory drugs (NSAIDs).
- Opioid medications include natural, semi-synthetic, and synthetic drugs both prescription and non-prescription illicit drugs.
- **Adjuvant analgesics** are defined as drugs with a primary indication other than pain that have analgesic properties in some painful conditions. This group includes numerous drugs in diverse classes such as gabapentin (an anticonvulsant), amitriptyline (a tricyclic antidepressant), or muscle relaxants (Lussier et al, 2004).

Each of these classes will be discussed in more detail along with antigout and anesthetic medications.

To support your learning, you can access the Chapter 6 Comparing Opioid and Non-opioid Analgesic Medications table. This is a downloadable and editable document to support medication comparison and note-taking.

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6.5 Non-Steroidal Anti-Inflammatory Medication

Learning Objectives

- Describe the cyclooxygenase pathway and the mechanism of action of NSAIDs.
- Describe the mechanism of action, common side and adverse effects and nursing considerations of acetaminophen, ASA and Ibuprofen.
- Compare and contrast the NSAIDs: Ibuprofen, diclofenac, ketorolac and COX-2 inhibitor, celecoxib.
- Apply your understanding of these medications to clinical application questions.

Non-Steroidal Anti-Inflammatory Medication (NSAIDs)

Non-steroidal anti-inflammatory medications are widely used for their analgesic, antipyretic and anti-inflammatory actions. They are used to treat mild to moderate pain for many conditions including

headaches, general aches, dysmenorrhea, arthritis, and sprains. They are considered safe if used correctly and well-tolerated. As an OTC medication they are used extensively.

Although there are over twenty types of NSAIDs available in Canada, they all work similarly, and that is blocking the group of enzymes called cyclooxygenase (COX). The categories of NSAIDs we will examine are:

- Non-selective NSAIDs (COX 1 and 2 inhibitor):
  - Acetylsalicylic acid (ASA)
  - Ibuprofen, diclofenac, naproxen, ketorolac
- Selective NSAIDs (COX 2 inhibitor) – Celebrex

Acetaminophen is often discussed with NSAIDs as it has an effect on the cyclooxygenase pathway, but it is not an NSAID due to some notable differences and lacks anti-inflammatory properties. Acetaminophen will be covered in this unit.

We will begin this unit with examining the cyclooxygenase inhibition.

What is cyclooxygenase?

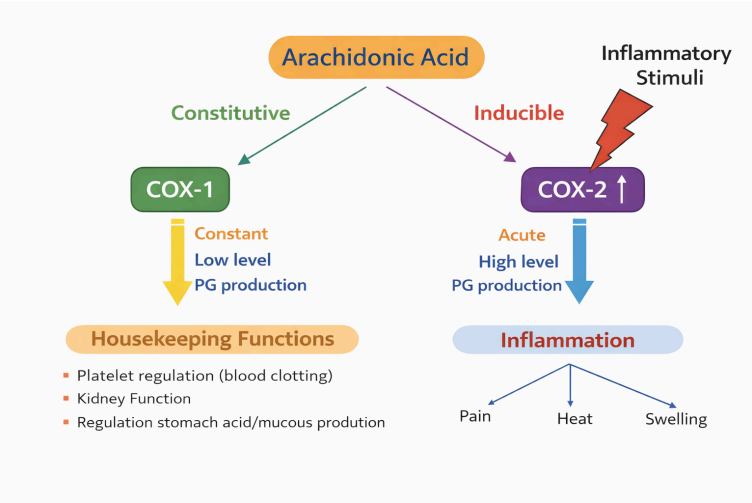
Cyclooxygenase (COX) is responsible for the synthesis of prostaglandins and other related compounds (prostacyclin, thromboxane A2) of the inflammatory process. The immediate precursor of prostaglandins (PG), arachidonic acid, is derived from membrane phospholipids and is catalyzed by two COX enzymes, COX 1 and COX 2.

COX 1 is found in all tissues and is considered the housekeeping enzyme. It has constitutive functions, meaning it is continuously produced to maintain homeostasis of organs. For example, it maintains gastric mucosa (increases bicarbonate, increases cytoprotective mucous in the stomach to provide a protective

barrier and promotes submucosal blood flow), stimulates platelet aggregation (COX promotes synthesis of TXA2) and maintains renal blood flow through vasodilation.

COX-2 is the inflammatory enzyme and is considered inducible, meaning it is produced when there is tissue injury. When tissue is injured, it has a role in inflammation by promoting fibroblasts, leukocytes and macrophages to the injured area. COX 2 enzyme is more specific to the synthesis of PGs that cause pain and inflammation. It sensitizes receptors to painful stimuli. It is also present in the brain and mediates fever.

COX-2 also has a compensatory role. In health conditions where there is a compromised renal perfusion (heart failure, renal failure), COX-2 produces vasodilatory prostaglandins that increase blood flow and helps to preserve kidney function. In health conditions with compromised circulation, COX-2 also regulates renin release from the juxtaglomerular cells in the kidneys, helping to maintain blood pressure and sodium balance. Other non-inflammatory roles are it regulates female reproduction and bone formation (Rosenjack Burchum & Rosenthal, 2019; Qureshi, O. & Dua, A., 2024).



6.5a Cyclooxygenase Pathway. (Sheila Odubote/ TRU Open Press)

COX 1, the housekeeping enzyme, has a role in promoting renal blood flow, gastric mucosa acid protection, and platelet aggregation. COX 2, increases prostaglandins during an inflammatory process, leading to pain, heat and swelling.

So, what happens when COX 1 or COX 2 are inhibited by NSAIDs?

COX 1 and 2: function and effect of inhibition

Location	*Type*	*COX Function*	*Effect of Inhibition by NSAIDs*
Stomach	1	Gastric protection ↑bicarbonate, ↑mucous, ↓HCl	Gastric irritation, ulcer formation
Platelets	1	Platelet aggregation	Risk of bleeding, ASA: protection against MI & TIA
Kidney	1 & 2	Maintains renal function: ↑renal vasodilation ↑renal perfusion	Renal impairment (vasoconstriction, ↓blood flow to kidney)
Injured tissue	2	Inflammation and pain	↓inflammation, analgesia
Brain/ CNS	2	Fever and pain	↓fever, analgesia

ASA and other NSAIDs relieve pain by inhibiting the biosynthesis of prostaglandin by different forms of the COX enzyme. As a result of the inhibition of COX-1 by an NSAID, there is decreased protection of the stomach lining, resulting in gastric irritation and bleeding. Further, there is an anti-platelet effect, particularly with ASA.

When COX-2 is inhibited, it results in the desired effects of decreased pain, swelling and fever. It can also decrease renal blood flow, along with COX 1 inhibition. This is only a risk if there is renal impairment, older adults or volume depletion.

You can watch this video about the mechanism of NSAIDs.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=318#oembed-1

Acetaminophen

Acetaminophen is a widely used analgesic and antipyretic medication, effective for treating mild-moderate pain and fever. It is available over the counter or it can be provided through prescription if combined with an opioid medication. It is referred to as paracetamol in many countries. As mentioned earlier, it is not an NSAID.

Mechanism of Action

The mechanism of Acetaminophen is still somewhat unknown. It inhibits the cyclooxygenase pathways and the synthesis of prostaglandins that serve as mediators of pain and fever primarily in the CNS (Frandsen & Pennington, 2018). Acetaminophen does not inhibit COX by binding to an active site of COX 1 or COX 2 (as with other NSAIDs), instead it appears to reduce the activity of COX through a pathway still not known. It also appears to inhibit the COX pathway in the central nervous system but not in peripheral tissues, thereby lacking any anti-inflammatory properties. For anti-pyretic effects, it acts directly on the hypothalamic heat-regulating center to cause vasodilation and sweating, to help dissipate the

heat (RNpedia, 2025). Due to acetaminophen's inhibitory action on COX, it is categorized as a non-steroidal anti-inflammatory drug that lacks anti-inflammatory properties (Gerriets et al, 2024).

Indications

Acetaminophen is used to treat mild pain and fever. It is also indicated for pain related to arthritis and rheumatic disorders however, it does not have anti-inflammatory properties.

It can be administered orally, rectally or intravenously. For the oral route, it comes in many formulations such as tablets, capsules or liquid form (syrup, suspension). IV route is rarely used and has not shown superior efficacy compared to oral or rectal routes (Gerriets et al, 2024).

It is safe for all ages, but dosing considerations are important to avoid the risk of hepatotoxicity.

Nursing Considerations

Taken as recommended, acetaminophen is a safe, well-tolerated medication. If dosage amounts are exceeded, or if the client has liver impairment or drinks alcohol in excess, then the risk of hepatotoxicity is a possibility.

Administration: oral or rectal.

- Oral route: rapidly absorbed orally, achieving peak plasma concentration in 30-60 minutes. Give drug with food if GI upset occurs.
- Rectal route: it bypasses first pass effect and is a good choice for clients NPO, dysphagia, or children who cannot manage oral administration.

- Metabolism: It is metabolized in the liver and excreted by the kidney, with 90% eliminated within 24 hours (Gerriets et al, 2024).

Health history prior to administration:

- Assess for chronic health issues: caution or contraindication for any client with impaired hepatic function, chronic alcoholism or renal insufficiency.
- Check allergy status for an allergy to the medication.

Monitor for effectiveness in lowering pain and fever.

If an overdose or toxicity occurs, N-acetylcysteine is the antidote.

Pediatric clients:

The recommended dosage for children aged 2-12 is 12.5 mg/kg every 4 hours or 15 mg/kg every 6 hours. The maximum daily dose should not exceed 75 mg/kg. Weigh the child before administering to ensure accurate weight. Use a second nurse verifier for drug calculations.

Adults or adolescents over 50kg

The recommended dosage is 4000 mg /day. Do not exceed 1000 mg per dose with minimum dosing interval of 4 hours. For example, 1000 mg q 6 hours prn OR 650 mg q 4 hours prn.

Clients with hepatic impairment

If mild, dosage will be reduced. If severe liver impairment, it is

contraindicated. Consult a health care prescriber with any client with liver impairment.

Clients with renal impairment

If creatinine clearance is less than 30mLs/min, then dosing intervals may be lengthened. Consult a health care prescriber.

Pregnancy

Acetaminophen is safe for pregnant clients. There have been some observational studies associated with prenatal acetaminophen exposure and the risk of neurobehavioural effects, but the current recommendations from the Government of Canada (2025) is that there is "no conclusive evidence that using acetaminophen as directed during pregnancy causes autism or other neurodevelopmental disorders." Advise pregnant clients to take only as prescribed and if pain or fever last longer than five days, seek out health care provider advice. Acetaminophen is safe with breastfeeding.

Drug Interactions

For clients receiving warfarin for anticoagulant therapy, taking acetaminophen for a prolonged time at the maximum dosing, can lead to an elevated international normalized ratio (INR), resulting in increased risk of bleeding. Advise all clients on warfarin to check with their prescriber before taking acetaminophen for a prolonged period of time (Gerriets et al, 2024).

Overdose or Toxicity of Acetaminophen

N-acetylcysteine (NAC) is the only antidote.

In the early stages of overdose or toxicity, symptoms are often mild, with abdominal pain and nausea that can last 12-24 hours. If labs are drawn, AST/ALT will be elevated. After 24 hours, the client will become quite unwell with nausea, vomiting, jaundice, abdominal pain and hypotension. Management will include administering IV or oral N-acetylcysteine, but likely IV as vomiting is common. Other treatments will include airway management, IV fluids and vasopressors. Administering N-acetylcysteine within 24 hours of overdose is highly effective. NAC will prevent the hepatic metabolites from forming,

Acetylcysteine is also used as a mucolytic agent to thin viscous secretions.

(Ershad, Naji, Patel, & Vearrier, 2024)

Adverse Effects

As discussed, acetaminophen is a safe medication if used as recommended and if the client has no renal or liver dysfunction. Some clients experience a headache, rash, nausea or constipation. Hypersensitivity reactions may occur and include rash, fever or reddened skin.

Example in Practice: Safety with Acetaminophen

Some medications are combined with acetaminophen and are prescribed "as needed," so the nurse must calculate the cumulative dose of acetaminophen over the previous 24-hour period.

Example 1:

Percocet 5/325 contains a combination of oxycodone 5 mg and acetaminophen 325 mg and could be ordered 1-2 tablets every 4-6 hours as needed for pain. If 2 tablets are truly administered every 4 hours over a 24-hour period, this would add up to 3900 mg of acetaminophen, which would be within limits for most adults but would exceed the recommended guidelines for a geriatric client, resulting in toxicity.

Example 2:

A client had surgery and is discharged home with a prescription:

Tylenol #3 1-2 tabs q 4-6 hours as needed.

(Tylenol #3: Codeine 30 mg and acetaminophen 300 mg and caffeine 15 mg)

This client typically takes acetaminophen 975 mg three times a day for arthritic pain. They continue with this dose as well as take the Tylenol #3. If the client takes the Tylenol #3 to the maximum amount, this will be over the maximum dosing of 4000 mg /day and put the client at risk for overdose.

Client Teaching

Acetaminophen is well-tolerated and typically has few side effects if used as directed. Important considerations for clients include:

- Medications should be taken as directed and the dosing schedule should be adhered to appropriately. This is particularly important for pediatric and older adult populations.
    - Pediatrics: available in rectal and oral formulation. Dosages are based on weight so ensure an accurate weight before dose. Follow the instructions on the package insert and ask for advice from a health care provider.
    - Older adult: do not exceed 3200 mg /day, due to possibility of renal insufficiency, which may prolong the drug's effects.
    - Adults: recommended daily dose is 1000mg every 6 hours or 650 mg every 4 hours. Do not exceed 4000 mg/day.
- Avoid using other over-the-counter medications that include acetaminophen as overdosage will occur.
- Report a rash, unusual bleeding or bruising, yellowing of skin or eyes or a change in urination.
- Avoid drinking more than 3 or more alcoholic drinks every day while on this med. Risk of liver damage can occur (Vallerand & Sanoski, 2019).
- If you take acetaminophen for fever, if the fever lasts longer than three days or exceeds 39.5C, see your health care provider.

6.6a: Open bottles of Extra Strength Tylenol and Extra Strength Tylenol PM, pain relievers with the active ingredient acetaminophen/paracetamol. Tylenol PM (the white-and-blue tablets) also contains diphenhydramine, a sleep aid.

To prevent an unexpected overdose of acetaminophen, teach clients to not take Tylenol tablets along with any combined formulations that include acetaminophen. For example, cough and cold remedies often have acetaminophen as one of the ingredients.

Acetaminophen Medication Card

Now let's take a closer look at the medication card for acetaminophen (McCuiston, Vuljoin-DiMaggio, Winton, & Yeager, J., 2018; Vallerand & Sanoski, 2021). Medication cards like this are

intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Acetaminophen Medication Card

<table>
<tr><td colspan="2">Drug classification: Cyclo-oxygenase Inhibitors (no anti-inflammatory properties)</td><td colspan="2">Therapeutic Effect: antipyretic, analgesic

Use: arthritis and rheumatic disorders involving musculoskeletal pain.
Common cold, flu, viral and bacterial infections with pain and fever</td></tr>
<tr><td colspan="2">Generic name:
Acetaminophen
Brand Name: Tylenol</td><td colspan="2">Mechanism of action:
Not completely understood
Inhibits prostaglandin synthesis through alternate pathway instead of blocking COX.
May inhibit COX in the CNS
Acts on hypothalamus → lowers fever
Vasodilation → heat dissipated</td></tr>
<tr><td>Administration:
Oral or rectal

Assess pain prior to and after admin

Administer with full glass of water

Maximum dose over 24-hour period:
• 4000 mg adults,
• 3200 mg geriatric
• 2000 mg clients with chronic alcoholism</td><td>Side effects:

Headache, nausea
Skin reddening

Hypersensitivity:
Rash, fever</td><td>Contraindication/ caution:

Allergy to acetaminophen

Use cautiously with impaired hepatic function, chronic alcoholism, pregnancy, lactation

Hepatotoxicity (liver damage) if dose exceeded or toxicity
Renal damage</td><td>Nursing considerations:

SAFETY: Do not exceed recommended dose.
Report rash, bleeding, or yellowing of skin. If overdose, monitor serum levels, life threatening if not treated.
Antidote is acetylcysteine

Avoid using multiple preparations with acetaminophen to avoid OD</td></tr>
</table>

Downloadable file (.docx): Acetaminophen Medication Card

Clinical Reasoning and Decision-Making Activity 1

Your client is admitted to the hospital with acute liver failure due to acetaminophen toxicity. Your client reveals that they have had a cold for several days and have been taking over-the-counter cold medications and acetaminophen for a headache. They also mention that every night after work they drink a "few" beers.

What client education about acetaminophen should be provided?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 6: Pain and Mobility Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

NSAIDs: Acetylsalicylic Acid

Acetylsalicylic acid (ASA) is a non-opioid NSAID analgesic and anti-pyretic. It is commonly known as aspirin. It is also used for its cardioprotective anti-platelet effects. ASA provides excellent pain relief especially for clients with conditions such as rheumatoid arthritis or other inflammatory health conditions.

Mechanism of Action

ASA irreversibly inhibits the blocking of COX-1 and COX-2 which

results in redcuing the synthesis of thromboxane 2 (TXA2). Thromboxane induces platelet aggregation leading to clot formation, constriction of blood vessels and plaque deposition. By blocking TXA2, platelets won't clump together and vasodilation occurs leading to improved blood flow. Both these actions are beneficial for atherosclerotic vessels (Rosenjack Burcham & Rosenthal, 2019).

The irreversible inhibition is what sets ASA apart from other NSAIDs. Although it takes one hour post ingestion to block platelets, due to irreversible inhibition of COX, it is inhibited for the life of the platelet which is about eight days. This provides the sustained effect of inhibiting platelet aggregation after one dose. Other NSAIDs do not have this sustained effect and are not used for cardiac prevention.

Other ASA effects are inhibiting COX-2 and PG in the hypothalamus thereby decreasing fever. Inhibiting PG will have the anti-inflammatory and analgesic effects. ASA is a good choice for mild inflammation.

Indications for Use

ASA is used for the treatment of mild to moderate pain, fever, inflammatory conditions. The analgesic effects of ASA are mostly in the peripheries, and is ideal for joint and muscle pain and headaches. It does not treat visceral pain. ASA does well in lowering fever in adults by lowering the set point of the hypothalamus by inhibiting COX-2.

For clients with inflammatory conditions, ASA is a drug of choice. To suppress inflammation, larger doses are often prescribed than if treating pain or fever. For clients impacted with dysmenorrhea, ASA inhibits prostaglandins in the uterine smooth muscle.

Cardioprotective Effects

One of the beneficial effects of ASA is the anti-platelet effects and is routinely recommended for clients at greater risk of myocardial infarction (MI) or stroke. This includes clients with ischemic stroke, transient ischemic attacks, acute MI and previous MI. It is also prescribed for higher risk clients as a primary prevention of MI (Rosenjack Burcham & Rosenthal, 2019). For anti-platelet effects, the dose of 81 mg once a day is sufficient, as higher doses will increase the risk of GI bleeding without more cardioprotective effects.

Colorectal and other Cancer Protection

The use of low dose ASA to decrease the risk of colorectal cancer has shown beneficial effects although the exact mechanism of action is still unclear. Some studies have found that "aspirin may prevent certain types of cancer through its immunomodulatory effects, regulating cellular metabolism, affecting DNA repair, reducing inflammation and preventing platelet activation" (Sun et al, 2025). In simpler terms, aspirin suppresses COX-1 formation of prostaglandins and also COX-2 suppression of tumorigenesis. COX-2 promotes tumour growth and metastases, so inhibiting this enzyme slows tumour growth. It has been shown that daily ASA reduces the risk of colorectal cancer (CRC) by 24% and CRC-associated mortality by 35% over an 8–10-year period (Garcia-Albeniz & Chan, 2012). For other cancers, low dose ASA has shown to reduce the risk of death in solid tumour cancers, 50% reduction in prostate cancer in men over 60, and in women, reduced the risk of breast cancer especially those with hormone receptor positive cancers (Rosenjack Burcham & Rosenthal, 2019). ASA is showing promise as an adjunct to other existing therapies such as

immunotherapy and cytotoxic chemotherapy for the treatment of cancer progression and metastasis (Sun et al, 2025).

Dosages

- 81 mg po once a day – for cardioprotective effects. A larger dose is not needed to inhibit platelet aggregation.
- 325-650 mg po q 4-6 hour (2600 mg/day) for pain and fever.
- 3000-4000 mg per day for inflammatory conditions such as rheumatoid arthritis.

Nursing Considerations

ASA is rapidly absorbed in the small intestine after oral administration. ASA has a short life, converted to salicylic acid within 15-20 minutes. It is highly bound to albumin, and rapidly distributed to all body tissues. It is renally excreted (Rosenjack Burchem & Rosenthal, 2019).

Children

ASA is safe for most adults and children older than 14 years of age. It is contraindicated with children due to the risk of Reye's syndrome. If a child needs analgesic or pain relief, then acetaminophen or ibuprofen can be used safely.

Reye's Syndrome

Reye Syndrome is a rare but life-threatening illness that occurs almost exclusively in children, mostly in the age range 2-14 years of age. It usually begins after the child recovers from a viral infection, such as influenza or chickenpox, and is then characterized by symptoms of encephalopathy and fatty liver degeneration. The child rapidly worsens with symptoms of nausea and vomiting, confusion, seizures and loss of consciousness. It has been linked to the child taking ASA (salicylate) following a viral infection. Symptoms start 1-2 weeks after the child has recovered from the viral infection. Death occurs in 20-40% of the cases with children who survive are left with significant brain damage (Nemours KidsHealth, 2023).

Pregnancy and Breastfeeding

ASA is not considered safe for pregnant women, especially after 20 weeks of pregnancy. It crosses the placenta, and can potentially cause low birth weight, still birth, and renal issues on the fetus. For the mother, it can suppress contractions, so need to avoid in the third trimester. It can also be found in breast milk and not recommended.

Older Adult

Older adults are more susceptible to negative GI and CNS effects of

anti-inflammatories. If the client has renal insufficiency, then ASA will not be readily excreted, prolonging the duration of action.

Adverse/Side Effects

ASA is typically well tolerated but may cause toxicity, intolerance or hypersensitivity.

The most common adverse effects for gastric distress, heartburn and nausea. If taken with food or if the client uses enteric coated ASA, these effects can be minimized.

GI bleeding

GI bleeding is common and the client may experience dark, tarry stools. Typically the amount of bleeding is very minimal, but if on ASA for a long period of time, it may produce anemia. If the client is on ASA for a long period of time, even if low doses, the risk of gastric ulceration, perforation and bleeding is a possibility. The chance for bleeding is higher if a client:

- takes a higher dose or takes it for a longer time than directed
- takes other drugs containing prescription or nonprescription NSAIDs (aspirin, ibuprofen, naproxen, or others)
- has had stomach ulcers or bleeding problems
- takes a blood-thinning (anticoagulant) or steroid drug
- is age 60 or older
- smokes cigarettes
- has 3 or more alcoholic drinks every day while using this product

To minimize the risk of gastric ulcers, clients can take a proton pump inhibitor to reduce the hydrochloric acid in the stomach.

Other meds such as histamine receptor antagonists or misoprostol are beneficial.

Contraindications

ASA is contraindicated if the client has a bleeding disorder such as hemophilia, vitamin K deficiency, or a recent history of bleeding in the stomach or intestine. High doses of ASA should be held prior to surgery for one week. It does not need to be held for minor procedures such as dental procedures (Rosenjack Burchem & Rosenthal, 2019).

Renal Impairment

Extra caution should be advised for clients at higher risk of impaired renal function from ASA use. ASA can cause irreversible renal impairment resulting in salt and water retention and edema. Clients most at risk are advanced age, history of renal insufficiency or liver impairment or heart failure.

Hypersensitivity reactions

Hypersensitivity reactions are less common, but are more likely with clients with a history of asthma, rhinitis and nasal polyps (Rosenjack Burchem & Rosenthal, 2019). This NSAID-induced respiratory disease begins within one hour of ingestion. Symptoms begin with diffuse watery rhinorrhea and can eventually lead to urticaria, bronchospasm and shock. This is not the same as an allergic reaction but due to the inhibition of COX-1 which triggers the production of leukotrienes. Clients who are allergic to any NSAID should not take aspirin as there is cross-reactivity.

Toxicity

If ASA levels climb above therapeutic levels, salicylism can occur. Cues can include tinnitus (ringing in the ears), sweating, headache, nausea and dizziness. If a mild case, then withhold ASA, and once symptoms reside, then ASA can resume but with a smaller dose. For any client at risk or is presumed to have salicylism, consult the prescriber.

If severe, the client can experience hyperthermia, tachypnea, high anion gap metabolic acidosis, hypokalemia, seizures and cerebral edema. If these cases, salicylate toxicity is treated based on salicylate concentration, acid-base and electrolyte status (Arrif & Aggarwal, 2023).

Client Teaching

Clients should be made aware of the potential risks to avoid gastric distress, GI bleeding and other adverse effects.

- Use only the recommended dosage depending on the reason for use.
- Monitor for side effects such as nausea, gastric irritation, and occasional blood in stools. Report persistent symptoms such as ongoing bleeding or fever longer than 3 days.
- Monitor for adverse effects such as tinnitus and hold ASA until seen by their prescriber.
- If the client has asthma or rhinitis, be aware of hypersensitivity reaction cues such as diffuse watery rhinorrhea, itching and bronchospasm.
- Do not give ASA to children.
- If going for surgery, discuss with health care provider for the need to hold ASA one week prior to surgery.
- Avoid consuming alcohol greater than 3 drinks a day while on

ASA

- Do not take ASA while pregnant. If taking ASA for inflammatory conditions, and under the supervision on their prescriber, ASA may be taken up to the third trimester.

ASA Medication Card

<table>
<tr><td colspan="2">Class: Acetylsalicylic Acid (ASA)

Prototype: Aspirin

Therapeutic Effects:
Analgesic: treatment of mild-moderate pain
Antipyretic, Anti-platelet</td><td colspan="2">Indications:
• Mild to moderate pain
• Fever
• Anti-inflammatory for rheumatic fever, rheumatoid arthritis, osteoarthritis
• MI prophylaxis</td></tr>
<tr><td colspan="4">Mechanism of Action: irreversible inhibition of COX 1 and COX 2, inhibits synthesis of prostaglandins. Inhibition of platelet aggregation</td></tr>
<tr><td>Administration:

Orally, rectal
Take with a full glass of water and food. Sit upright for 15-30 min

Do not crush, chew, break, or open an EC pill.</td><td>Side/Adverse Effects:
Nausea, gastric upset, occasional blood in stool.

Acute aspirin toxicity: hemorrhage, seizures, tetany, CV, renal and respiratory failure
Aspirin intolerance /hypersensitivity: bronchospasm, rhinitis

Salicylism (Dizzy, tinnitus)

SAFETY: Emergency procedures if overdose (i.e., Gastric lavage, activated charcoal, etc.)</td><td>Contraindications:
Do not give to children due to risk of Reye Syndrome

Allergy to salicylates, NSAIDs

Conditions that increase risk of bleeding, or clotting deficiencies. Caution with impaired renal function.
Avoid in pregnancy & breastfeeding

Advise to refrain from consuming more than 3 alcoholic drinks/day</td><td>Nursing Considerations:
Assess pain before and after administration.

Stop 7 days prior to surgery

Assess history, allergies, and physical condition related to liver, kidneys, hemostasis, viral infection, pregnancy, and lactation

Keep out of the reach of children

Report tinnitus, dizziness, abdominal pain; rapid or difficult breathing; nausea, vomiting, bloody stools.</td></tr>
</table>

Downloadable file (.docx): ASA Medication Card

Clinical Reasoning and Decision-Making Activity 2

A client asks why aspirin is given to prevent a heart attack or stroke. What is the nurse's response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

NSAIDs: Ibuprofen

Ibuprofen is one of the most widely used pain reliever, anti-pyretic, and anti-inflammatory medications. Ibuprofen works by inhibiting COX-1 and COX-2 enzymes, leading to an inhibition of prostaglandin synthesis. See above for details about the mechanism of action. Other similar NSAIDs include naproxen, ketorolac, and indomethacin, which will be briefly discussed.

Indications for Use

Ibuprofen is used to treat mild to moderate pain and fever, inflammatory disorders including rheumatoid arthritis and osteoarthritis, and pain associated with dysmenorrhea. The route is oral, although it can be given intravenously in a hospital setting for clients who cannot take anything by mouth.

Nursing Considerations

Ibuprofen is a widely used, relatively safe medication if taken as

instructed. It is used for all ages. Although a relatively safe medication, it has the potential for adverse effects. A thorough med profile, assessment and monitoring should be completed. For long term use, completing renal and hepatic panel, along with a CBC is recommended (Adams et al, 2019). Health conditions that may warrant further review before starting on NSAIDs include a history of alcoholism, congestive heart failure, peptic ulcer disease and renal disease.

Infants 6 months or older

Pregnancy

During pregnancy, women should consult with their health care provider to ensure the safety of taking NSAIDs during this time. If the benefit outweighs the risk, the lowest dose for the shortest period of time is recommended.

- Avoid first trimester due to increased risk of miscarriage and malformations
- Avoid after 20 weeks gestation as associated with fetal renal problems, low amniotic fluid, impaired lung maturation and limb contractures (Government of Canada, 2020).
- After 28 weeks gestation, there is an increased risk of premature closure of the fetal ductus arteriosus. Fetal and neonatal adverse effects affecting the brain, kidney, lung, skeleton, gastrointestinal tract and cardiovascular system have also been reported after prenatal exposure to NSAIDs (Antonucci et al, 2012).

Breastfeeding

Ibuprofen is safe for breastfeeding with negligible amount excreted in breast milk (NGO & Bajaj, 2024).

Older adult

Due to possible renal insufficiency in the older adult, Ibuprofen should be used at the lowest dose and for short periods. Monitor the client for indications of further renal impairment such as reduced urine output and elevation in serum creatinine and blood urea nitrogen (Rosenjack Burchum & Rosenthal, 2019).

Directions for use

NSAIDs are typically very well tolerated, especially if used as directed and for short term use. If taken on an empty stomach, it can cause gastric irritation. Take with food, although food will delay absorption and maximum effect (Ngo & Bajaj, 2024).

Drug Interactions

NSAIDs can interact with many drugs (Ngo & Bajaj, 2024; Rosenjack Burchum & Rosenthal, 2019).

- Anticoagulants: it can increase the risk of bleeding if taking warfarin, heparin or other anticoagulants
- ACE inhibitors: Ibuprofen may reduce the antihypertensive effects of ACE inhibitors.
- Lithium: it can increase the plasma levels of lithium by inhibiting renal PG synthesis, leading to lithium toxicity.
- Herbal supplements: taking certain supplements can increase

the risk of bleeding, including garlic, ginger and gingko biloba. Ensure to ask about any supplements the client may be taking.

Adverse/Side Effects

Side effects: Although well tolerated, possible side effects include headache, constipation, dyspepsia, and nausea.

Adverse effects: For clients who take Ibuprofen on a regular basis or larger doses, the risk of adverse effects can occur.

- Gastric irritation, abdominal discomfort and the risk of GI bleed due to the decrease in prostaglandins role in maintaining a healthy gastric mucosa.
- Hypersensitivity reactions: clients with a history of asthma or rhinitis are more at risk for a reaction. Monitor for a rash. In severe reactions, anaphylaxis and reactions with eosinophilia and systemic symptoms (DRESS) can occur and often in relation to clients on other meds such as sulfa derivatives, antimicrobials or anticonvulsants (Ngo & Bajaj, 2024).
- Renal failure: NSAIDs decrease renal perfusion impacting renal function. If a client takes larger doses, uses Ibuprofen regularly, or takes one of the stronger forms of NSAIDs, a higher risk of renal failure can occur.

Box Warnings

- **Cardiovascular thrombotic events:** Ibuprofen increases the risk of serious cardiovascular events such as myocardial infarction and stroke. The risk is higher is the client takes more than is directed or takes it for longer than directed.
- **Coronary artery bypass:** Ibuprofen administration is not

advised during the perioperative period for patients undergoing coronary artery bypass graft (CABG) surgery.

Stomach bleeding warning: The chance for bleeding is higher if the client:

- is age 60 or older
- has had a history of stomach ulcers
- takes an anticoagulant or steroid med
- takes other drugs containing prescription or nonprescription NSAIDs (aspirin, ibuprofen, naproxen, or others)
- has 3 or more alcoholic drinks every day while using this product
- takes a higher dose or for a longer time than directed

Client Teaching

- Consume the medication with a full glass of water and remain upright for 30 minutes following medication administration.
- Avoid the use of alcohol while taking this medication.
- Avoid using the medication for longer than 10 days on a regular basis.
- Monitor for a rash, visual changes, tinnitus, weight gain, or influenza-like symptoms, these should be reported to the healthcare provider immediately.[8]

NSAIDs: Ketorolac and Diclofenac

Other NSAIDs are often taken for inflammatory or analgesic purposes. Ketorolac and Diclofenac will be reviewed. Both have the same mechanism of action as already discussed.

Ketorolac

Ketorolac is an NSAID that is commonly used to treat "breakthrough" pain that occurs during the treatment of severe acute pain being treated with opioids. It is a potent analgesic with limited anti-inflammatory properties due to toxicity risk. Its analgesic effects are similar to opioids but without the adverse effects of respiratory depression or abuse potential.

Indications for Use

Ketorolac is indicated for the short-term (up to 5 days in adults) management of moderate to severe acute pain that requires analgesia at the opioid level. There is a higher risk of cardiac thrombotic events, renal failure, peptic ulcers and risk of bleeding if taken longer than 5 days. Give orally following IV or IM ketorolac.

Dosage

It can be give orally, nasal spray, IM or IV routes.

- Oral dosing: 10 mg q 4-6 hours prin
- IV/IM dosing: 60 mg x 1 or 30 mg q 6 hour prn

(Rosenjack Burchum & Rosenthal, 2019)

Example in Practice

A client comes to emergency department for severe lower back pain following over-exerting themselves doing physical work. After an assessment is completed, the physician writes the following order: Ketorolac 60 mg IM now. The RN administers the Ketorolac and the client is to be sent home with a prescription of Ketorolac 10 mg po q 4-6 hours prn x 5 days.

The client asks why they are given the IM dose first. The nurse explains that it is given to raise the blood levels of ketorolac quickly to achieve faster pain relief. The additional oral doses at home maintains the blood levels.

The nurse will be providing some instructions for the client. The nurse tells the client to use the medication only as prescribed and not to take more than indicated. They should avoid using other NSAIDs such as ibuprofen to avoid adverse effects. They are to avoid drinking alcohol. If they develop a rash, blood in their stool, or abdominal pain, they need to return to the ED or see their health care prescriber.

File:Ketorolac 2.jpg https://commons.wikimedia.org/wiki/File:Ketorolac_2.jpg This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. 2020

Nursing Considerations

Ketorolac is safe for most adults. It is not considered safe for pregnant or breastfeeding women. In general, ketorolac should be avoided by older adults due to high risk of toxicity. If necessary for use in older adults, the dosage should be reduced. It can be given to children, with weight adjusted dosing.

Adverse/Side Effects

As Ketorolac is a stronger formulation than Ibuprofen, the adverse effects are more of a concern, and as such, this med is for short term use only. Adverse effects listed for Ibuprofen also pertain to

ketorolac. Adverse effects include drowsiness, headache, GI bleed, abnormal taste, dyspepsia, nausea, Stevens-Johnson syndrome, edema, and renal failure.

It is contraindicated if active peptic ulcer disease. Older adults are at greater risk of adverse effects.

Client Teaching

- Along with the previously discussed side/adverse effects, ketorolac may cause dizziness or drowsiness.
- Avoid alcohol or other aspirin-containing products unless directed by their healthcare provider.
- If the client notices rash, visual changes, tinnitus, weight gain, or influenza-like symptoms, these should be reported to the healthcare provider immediately.

Mahmoodi, Patel & Kim, 2024; Rosenjack Burchum & Rosenthal, 2019)

Diclofenac

Diclofenac is used to treat pain and inflammation related to inflammatory disorders such as rheumatoid arthritis and ankylosing spondylitis. It also is used to treat dysmenorrhea, migraines and mild-moderate pain related to sprains.

Dosing: Diclofenac can be taken orally, topical ointment, transdermal or suppository.

- Acute pain: 18-35 mg TID
- Inflammatory conditions: 35 mg TID
- Dysmenorrhea or post-partum: suppository route is an option for localized effect.
- Pain due to sprains/strain: Topical ointment for localized effect. Potential risk for dry skin or contact dermatitis.

All side and adverse effects, contraindications and drug interactions for NSAIDs apply to diclofenac.

NSAID: Celecoxib

Celecoxib is a COX-2 inhibitor and the only drug in this class available in Canada. It was developed under the premise that inhibiting COX-2 only to achieve the analgesic, anti-inflammatory effects would be more beneficial than also inhibiting COX-1 which causes the gastric irritation and anti-platelet effects. Unfortunately, other versions of COX-2 inhibitors caused a double-fold increase in the risk for myocardial infarction and stroke, especially if taken for a long duration of action. As of 2004, only celecoxib is available.

Mechanism of Action

Celecoxib specifically inhibits the enzyme COX-2 that is required for the synthesis of prostaglandins.

Indications for Use

Celecoxib is used to treat the pain associated with osteoarthritis, rheumatoid arthritis (including juvenile), and ankylosing spondylitis. It also relieves the pain associated with dysmenorrhea.

Nursing Considerations

- Celecoxib is considered safe for children 2 years or older.
- Dosage adjustment is required for clients with hepatic impairment (see Box Warning). Monitor AST and ALT levels.

- Labs: may cause hypophosphatemia, hyperkalemia and increased BUN.
- Contraindicated for use during pregnancy, especially after 20 weeks due to risk of fetal renal impairment.
- Older adults are more susceptible to negative side-effects of anti-inflammatories.
- Use cautiously with clients with cardiovascular disease, as risk of MI or stroke increases.

Adverse/Side Effects

Adverse effects are similar for all NSAIDs. Adverse effects include hypertension, peripheral edema, increased liver enzymes, abdominal pain, dyspepsia, gastroesophageal reflux disease, vomiting, and diarrhea.

Gastrointestinal Bleeding, Ulceration, and Perforation: NSAIDs cause an increased risk of serious gastrointestinal (GI) adverse events including bleeding, ulceration, and perforation of the stomach or intestines, which can be fatal. These events can occur at any time during use and without warning symptoms.

High Alert Med: Increased risk of cardiovascular (CV) events and gastrointestinal bleeding, ulceration, and perforation. Health Canada has also issued a safety review of celecoxib (Health Canada, 2016). Celecoxib can cause an increased risk of serious cardiovascular thrombotic events, including myocardial infarction and stroke, which can be fatal. This risk may occur early in the treatment and may increase with duration of use. Celecoxib capsules are contraindicated in clients who have recently received coronary artery bypass graft (CABG) surgery.

Client Teaching

Clients should take medication as directed and use the lowest effective dose for the shortest period of time. If signs of GI toxicity occur, these should be reported immediately to the healthcare provider.

Advise client to not take other NSAIDs while on celecoxib, as increased risk of GI effects.

NSAID Medication Card

Class: Non-Steroidal Anti-Inflammatory Medications **Prototype:** Ibuprofen, ketorolac (Tordal), diclofenac (Voltaren), celecoxib (Celebrex)		**Indications:** anti-inflammatory, analgesic, anti-pyretic **Therapeutic Effects:** decreases mild-moderate pain. Treats inflammatory conditions such as osteoarthritis, rheumatoid arthritis, spondylitis as well as inflammation from injury. Pain from primary dysmenorrhea. Fever reduction	
Mechanism of Action: Blocks cyclooxygenase (COX-1 and COX-2), resulting in Inhibition of prostaglandin synthesis. Celebrex inhibits COX-2 only.			
Administration: PO or IV/IM (ketorolac). Assess pain before and after. Take with food or milk if upset stomach. Stay well hydrated • Absorption: GI • Metabolism: Liver • Excretion: Kidneys	**Side Effects:** CNS: headache, dizziness, fatigue CV: HTN, CVS events, heart failure, edema (Celecoxib) GI: nausea, dyspepsia, GI pain, constipation, diarrhea Hema: bleeding (GI, gums), platelet inhibition Steven Johnson syndrome Ketorolac: Abnormal taste SAFETY: If overdose, implement gastric lavage.	**Contraindications:** Allergy to NSAIDs or salicylate; or sulfonamides (celecoxib) CV, renal, or liver dysfunction Peptic ulcer or known GI bleed Thrombotic events Pregnancy or lactation Drug-drug Interactions: • Loop diuretics • Beta-blockers • Lithium toxicity (ibuprofen) • anticoagulants • ethanol ingestion	**Nursing Considerations:** Assess for allergies, S&S of GI bleed, skin rash, renal function, Liver function Use drug only as suggested; avoid overdose Report sore throat, fever, rash, itching, weight gain, swelling in ankles or fingers, changes in vision, black or tarry stools.

Downloadable file (.docx): NSAID Medication Card – CH 6.5

Interactive Learning Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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Clinical Reasoning and Decision Making Learning Activities 3

1. A client who is a chronic alcoholic asks if it is okay to take ibuprofen for knee pain. What is the nurse's best response?
2. Ketorolac IV was administered to a client for severe pain (rated as "8") due to a back injury. When should the effectiveness of the medication be evaluated?
3. A client has been prescribed celecoxib for their arthritic pain. What client teaching does the nurse plan to provide?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

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Images

6.5a Cyclooxygenase Pathway. (Sheila Odubote/ TRU Open Press)

6.6b Extra Strength Tylenol and Tylenol PM.jpg/ *Wikimedia Commons*). CC BY-SA 3.0 https://commons.wikimedia.org/wiki/File:Extra_Strength_Tylenol_and_Tylenol_PM.jpg

6.6c Ketorolac 2.jpg https://commons.wikimedia.org/wiki/File:Ketorolac_2.jpg This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. 2020

6.6 Opioid Analgesics and Antagonists

Learning Outcomes

- Describe the mechanism of action of opioid agonist and opioid antagonist medications.
- Discuss the primary effects, indications and nursing considerations for the different opioid medications, including, morphine, fentanyl, hydromorphone, codeine, and methadone.
- Understand how tramadol's mechanism of action differs from opioid medications and articulate uses and important nursing considerations.
- Discuss the mechanisms of action, indications and nursing considerations for opioid antagonists, Naloxone and Suboxone.
- Apply this understanding when considering the nursing care of clients receiving these medications through critical thinking and application questions.

In this unit, we will look generally at opioid analgesics as they all have very similar effects.

Opioid Analgesics

There are several types of opioid analgesics, most are used to treat moderate-severe pain. They are used for many types of pain, often for acute (post-operative, post-injury), chronic pain conditions, chemotherapy and palliative pain. The type and dose of opioids that are ordered will differ depending on the use. All have the potential of addictive properties and misuse, and as such are a controlled drug and require a prescription. In Canada, they are placed in drug schedule 1A (prescription only, controlled substance). Clients who are on opioids for palliative purposes rarely leads to drug abuse or addiction (Fraser Health, 2006).

Most opioids that are prescribed are used along with non-opioid or adjunctive medications to improve pain control and lower the amount of opioids used.

Assessment of Pain

Prior to any administration of analgesics, a thorough assessment is required to best meet the needs of the client. Included in the assessment:

- Physical and psychosocial assessment
- Medication profile of all medications; prescribed, OTC and herbal supplements.
- Assessment of the pain including PQRST questioning
- Impact of pain on quality of life, ability to complete ADLs (activities of daily living) and functionality.

Mechanism of Action

Opioid receptors are located throughout central nervous system and in other locations in the body. Opioid receptors are proteins that respond to both natural opioids (enkephalins, endorphins) and opioid drugs. There are 3 types of opioid receptors: μ [mu], κ [kappa] and δ [delta]. Of these, two are primary receptors for pain: mu (morphine), kappa (butorphanol). Each receptor-drug complex results in pain relief, although some pairings have more sedative or euphoria effects than others.

The primary effect, pain relief, is achieved when opioids bind to receptors on neuronal cell membranes –> slows or stops the pain message to the brain.

Opioid receptors are located throughout the body. In the brain, they are located in the cerebral cortex, brain stem, and thalamus. In the respiratory system, they are located in the mechanoreceptors in the lungs and airways. They are located throughout the autonomic nervous system, and as such have an effect in the gastrointestinal tract and the urinary system. So, when opioid receptors are occupied by an opioid med, they occupy receptors in many parts of the body, not just the CNS to decrease pain. This helps explain the many adverse effects.

The following table provides a general overview:

Table 6.6a Mechanism of Action and Effects

Receptor	Other effects	Pain relief effects
Mu (μ)	Respiratory depression	All have a role in pain relief
Kappa (κ)	Dysphoria, sedation	All have a role in pain relief
Delta (δ)	Mood	All have a role in pain relief

Full agonists

Most opioid medications have agonist effects on opioid receptors. (refer to chapter 1 for an overview of agonist actions). Examples of agonist opioids including morphine, codeine, fentanyl, oxycodone, hydromorphone, and methadone.

Partial agonists

A few opioid analgesics have a partial agonist response. For example, **Buprenorphine** is a partial agonist that is considered a safe alternative to opioid use disorder and with managing severe pain not responsive to other alternative treatments. It is a partial agonist on the mu-opiate receptor, along with weak kappa receptor antagonist and delta receptor agonist. It is unique as it has a ceiling effect at higher doses, where it would then transition into an antagonist mode. This action decreases the respiratory depression risk (Kumar, Viswanath & Saadabadi, 2024).

Indications for use

For mild pain, non-opioid medications are effective. For more moderate to severe pain, opioid analgesics are prescribed and in conjunction with non-opioid options. In the hospital setting for acute pain, opioids that are frequently prescribed are morphine sulfate, fentanyl, or hydromorphone and all three can be given IV or oral. For pain control with more of a sustained effect or if the client can swallow, then oral formulas of morphine (MS Contin) or hydromorphone (oral, rectal formulas) can be ordered.

Unique Pain Situations

Palliative or long-term chronic pain: some clients will be prescribed a transdermal patch of fentanyl (Duragesic) along with possibly an oral opioid for breakthrough pain. Another alternative is to use adjunct medications, which can include non-opioid (NSAIDs, muscle relaxants, cannabinoids) options. Refer to the unit 6.7 for more information on adjunct med pain meds.

Break through dose (BTD)

Some clients are on a regular dose of analgesic but need extra pain relief for painful dressing changes, repositioning or other painful situations. In these cases, the physician will prescribe a PRN med to use along with the regularly scheduled analgesic. There are a few ways that are used to calculate BTD. One option is 10-20% of the daily opioid dose, depending on client context. Another option is to start with a breakthrough dose 50% of the every 4-hour dose. With any BTD, reassessing the effectiveness daily is important. If the background dose is increased, then the breakthrough dose is also increased (Doulton, 2014). For example, the order reads:

Morphine 2 – 5 mg IV q 4 hours

Morphine 1 – 2.5 mg IV q 4 hours prn for breakthrough pain

Often, the background dose and breakthrough dose are the same opioid. Sometimes they are different. For example, if the client is on a fentanyl transdermal patch, the BTD will be an alternate medication such as a short-acting morphine, oxycodone, or hydromorphone (Doulton, 2014).

Managing Pain in Acute Care Settings: Patient-controlled analgesia

To provide more effective pain control in clients who are cognitively capable to follow the instructions, patient-controlled analgesia (PCA) is a good option. Opioids are commonly used in PCA include morphine, hydromorphone and fentanyl. To receive the opioid using a PCA device, the client pushes a button, which releases a specific dose but also has a lockout mechanism to prevent an overdose (McCuistion et al, 2018).

Read more about opioid usage in Canada at this Health Canada website.

Figure 6.6a Patient Controlled Pump (DiverDave; PCA-01.JPG/ Wikimedia Commons) CC BY-SA 3.0

Treatment with Opioids: general principles

- Opioids are a drug of choice for moderate to severe pain.
- Long lasting or continuous pain should be treated with sustained release opioids.
- Use the oral route when able; there is no perfect route so the plan should be individualized for each client.
- Think about the 3 B's when reviewing the physician's orders: bowels, barfing and breakthrough. Is there a med or treatment plan for each?
- Ceiling effect: most opiates do not have a ceiling effect (Tramadol and Codeine are exceptions). Therefore, if the client is experiencing more pain (end of life, cancer pain, severe pain), then a higher dose of opiate can be given without achieving a maximum concentration.
- Allergies: most 'allergies' to opioids are not true allergies, but an adverse effect. Pruritis is a common adverse effect, and is sometimes mistaken for an allergy. If a true allergy exists for morphine or codeine, they might not be allergic to a different classification, such as synthetic fentanyl or semi-synthetic hydromorphone.

(Fraser Health, 2008; Adams et al, 2019)

Classification of Opioid medications

- Natural opiates are morphine and codeine, as they are derived from the unripe seeds of the poppy plant.
- Synthetic opioid meds are fentanyl, methadone
- Semi-synthetic opioid meds are oxycodone, hydromorphone

Why it matters? Pruritis occurs more with natural opiates instead of

synthetic opioids. If a client has a true allergic reaction in one drug classification, they might be fine in a different classification.

Morphine

Is a natural opioid, derived from the unripe seeds of the poppy plant. Morphine is typically used as the standard which other opioids are measured against.

Fentanyl

Fentanyl is a synthetic opioid. It is 80-100 times more potent than morphine. It is used for moderate to severe pain from intra-op, post op pain, chronic pain, breakthrough pain, and emergency pain control. It is highly lipophilic, with a rapid onset of action when given IV (one minute) and a short duration of action (one hour) making it ideal for procedural or emergency pain relief. For ongoing severe pain, transdermal patches are often prescribed.

Hydromorphone

Hydromorphone is a semi-synthetic opioid used for moderate to severe pain. It is 5-8 times more potent than morphine. Ie. Morphine 10 mg IV = Hydromorphone 2 mg IV. For clients with renal insufficiency, it is a good option over morphine. It has a faster onset than morphine, so faster analgesic effect. It can be given in many routes, and often seen used for palliative clients using the SQ butterfly administration.

Codeine

Codeine is a natural opioid that is used for moderate pain relief. It is often used in combination with acetaminophen or ibuprofen to provide a convenient non-opioid/opioid option. Besides pain relief, it has a unique use as a cough suppressant (anti-tussive) and the only opioid with this effect. It is not used with children less than 12 years due to the risk of respiratory depression and minimal cough suppression abilities. Codeine does have a ceiling effect which is different than the other opioid choices.

Methadone

Methadone is a synthetic opioid that is used for chronic pain management, opioid maintenance therapy or for neuropathic pain. The opioid dependent treatment is for maintenance or for detoxification. The principal goal is to relieve cravings, suppress abstinence syndrome and block the euphoric effects associated with opioids. it is given orally once a day by a clinic or pharmacy, and has a long duration of action of 24-36 hours. For clients with a cardiac history, there is a possible adverse effect of prolonging the QT interval and leading to torsade de pointe if left untreated. Clients that are a good candidate for methadone therapy and have a cardiac risk, a baseline ECG prior to starting methadone and then one month after is recommended. Methadone is for long term management and some clients are on methadone for months to years.

Tramadol

Tramadol is a dual mechanism of action analgesic. It has a weak agonist effect on the mu receptor, and also inhibits norepinephrine

and serotonin reuptake in the pre-synaptic neurons. It is used for a wide variety of pain situations including neuropathic pain, post-operative pain, lower back pain, as well as pain associated with labour, osteoarthritis, fibromyalgia, and cancer. It is also used off-label for premature ejaculation and restless leg syndrome that are refractory to other medications.

It is a relatively safe analgesic, with 1/10th the potency of morphine. Ie. Morphine 1 mg oral = Tramadol 10 mg oral. Benefits to tramadol include a low incidence of constipation, nausea and dizziness compared to other opioids as well as no hypotension risk. It has a lower risk of respiratory depression compared to other opioids. It should be used with caution with clients with epilepsy or head trauma as it may cause seizures. Other cautions include avoid using with other CNS depressants, especially antidepressants with serotonin inhibition such as SSRIs or TCA's. Tramadol does have a ceiling effect due to the risk of seizures at higher doses (Fraser Health, 2008).

Dosing and Routes of Administration

Depending on the opioid, it can be available in many formulations including oral, PR, IM, SQ, IV and transdermal.

Oral routes: it can also be available in immediate release (IR), sustained release (SR) or controlled release (CR). It is important for nurses to be alert for oral meds that are SR or CR, as the dose, frequency and duration of action will be different.

Example:

- Immediate release: t1/2 is 2-4 hours with duration of action 4-5 hours.
- Sustained release: duration of action is 8-12 hours.

Differences between immediate release, controlled release and sustained release:

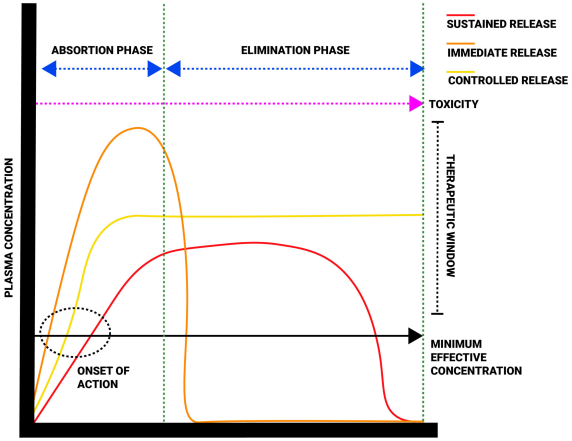

Figure 6.6b Differences between immediate release, controlled release and sustained release medications. (TRU Open Press [adapted] from 1.3 Pharmacokinetics)

A client with complex or chronic pain issues will often be prescribed a SR or CR formula so they have consistent pain control.

Table 6.6b Common Opioid Analgesics displays several common opioid medications and their trade names, routes and dosages (Vallerand & Sanoski, 2019).

Generic/trade name	Route	Adult Dosage Formulation
morphine MS Contin, Statex, M.O.S.	PO & Rectal SQ, IM, & IV Immed. release, extended release, sustained release	Oral: 5, 10, 30 mg IR tab 12 hr and 24 hr SR formulations Rectal: 5-30 mg PR IV: 2mg/ml – 50 mg/ml Relative potency: 10 mg IV = 30 mg po
fentanyl Duragesic, abstral	Transdermal IM IV	Oral: 100-800 mcg tabs 12 mcg-100mcg patch IV: 50 mcq/ml Relative potency: 100x more potent than Morphine
hydromorphone Dilaudid	PO Rectal SQ, IM & IV	Oral: 1-8 mg SR: 12 and 24 hr formulations PR: 3 mg IV/SQ/IM: 2- 50 mg/ml
oxycodone Oxycontin Percocet	PO	Oral: 5 mg-20 mg IR 5-80 mg SR No IV or supp Percocet: 5 mg/325 mg

Combination Formulations: opioids are often combined with a non-opioid medication such as acetaminophen or ibuprofen. This gives the added benefit addressing the pain utilizing different pain pathways and using less opioids that can cause dependency and more adverse effects.

Tylenol #3: Acetaminophen 325-650 mg + codeine phosphate 30 mg + caffeine 15 mg

Drug manufacturers also make Tylenol #2 (acetaminophen 300 mg, codeine phosphate 15 mg, caffeine 15 mg) as an option for those

clients needing less pain control such as for dental procedures or from minor injuries.

Did you know… the purpose of caffeine is to improve the absorption of codeine and acetaminophen.

Safety Considerations with Opioids: potency matters

It is important to consider that the type of opioid and their route have different effects on the client. How potent the opioid is will have an effect on the dose we give. For instance, hydromorphone is five times more potent than morphine. Fentanyl is 80-100 times more potent than morphine (UptoDate, 2021). What does this mean in practice? Nurses need to pay attention to the dose to avoid under or over medicating a client.

- Morphine is given in milligrams(mg). The typical dose would be 2-5 mg IV.
- Fentanyl is given in micrograms (mcg). The typical dose would be 50-100 mcg IV. In comparison to morphine, it is 100x more potent.
- Hydromorphone is also given in mg. A dose may be 1.5 mg IV. In comparison to morphine, it is 5 times more potent.

Side/Adverse Effects

Most clients will experience some side effects from taking an opioid. Mild effects can include dizziness, sedation, nausea, and constipation. The most serious effect is respiration depression. Nurses play an important tole in minimizing these effects. To begin, nurses need to anticipate that adverse effects will occur, completing

a thorough assessment before and after administration, close monitoring, and being proactive with interventions.

Adverse effects of Opioids

Many unwanted effects of opioid meds are due to the activation of receptors in other parts of the body. The following table lists adverse effects, physiological causes and nursing considerations.

Table 6.6c Adverse Effects of Opioids

Adverse effects:	Cause	Nursing considerations
Pruritis	Due to histamine release. More with epidurally administered opioids	Give Antihistamine prn (mostly with non-synthetic opioids, morphine or codeine)
Constipation	Due to slowed peristalsis and relaxation of smooth muscle and inhibiting secretions of fluids into the intestinal lumen when opioids bind to opioid receptors in the bowel.	Strategies to manage constipation: Assess GI system, especially LBM. Give Laxative/ stool softener/ fiber – Encourage hydrate/ mobilize/bowel routine
Nausea & Vomiting	Increased sensitivity of the vestibular system and stimulation of the chemoreceptor trigger zone in the medulla. Note: N&V associated with opioid administration lessens with subsequent doses.	Anti-emetic prn. Anticipate nausea, can give anti-emetic prophylactically Post op – often ondansetron. Dimenhydrinate often prescribed.
Respiratory depression	Decreased sensitivity of respiratory centers in the brain to CO2 when opioids bind to areas in the medulla. This is compounded with concurrent use of other CNS depressants (alcohol, barbiturates, benzodiazepines)	Most serious of SE. Can last 4-5 hours ALWAYS assess RR/depth pre/ post opioid Anticipate issues Fentanyl highly apenogenic

CNS	drowsiness, sedation, euphoria via activation of different receptors dysphoria activation of Mu receptors	Altered LOC – safety concern … assess dizziness, stuporous Caution with head injury (can mask neuro changes) Codeine causes least CNS changes
Urinary retention / hesitancy	due to increased tone of bladder sphincter	Assess in/outs. Palpate bladder, bladder scan post-void Promote voiding – void q 4hr, measure ↑concern with BPH or if also on anti-cholinergic meds.
Cough suppression (anti tussive)	Often codeine is given because of this side effect. Only analgesic with anti-tussive properties. Codeine is often an ingredient in prescription cough medicines.	Caution/avoid with peds d/t respiratory depression.
Increased ICP	By suppressing respirations, CO2concentrations of the blood ↑, this causes vasodilation of cerebral vessels causing ICP to ↑	Caution with head injury (mask neuro changes). Keep RR within normal range
Hypotension	Blunt baroreceptors reflex and vasodilation resulting in ↓SVR. Release of histamine – causes peripheral vasodilation→ orthostatic hypotension.	Assess BP pre/ post analgesic Assess for orthostatic hypotension Teach client about lightheadedness, dizzy. Fall risk caution

High Alert Med: The risk of serious adverse reactions, including

slowed or difficulty breathing and death, have been reported with the combined effects of morphine with other CNS depressants. Long-term usage of morphine may result in drug tolerance, dependence, and/or misuse. Naloxone is used to reverse opioid overdose.

Respiratory Depression

Respiratory depression is the primary risk of opioids. Respiratory depression occurs more frequently in the elderly or those suffering from conditions accompanied by hypoxia, hypercapnia, or upper airway obstruction, for whom even moderate therapeutic doses may significantly decrease pulmonary ventilation.

Use morphine with extreme caution in clients with chronic obstructive pulmonary disease or cor pulmonale and in clients having a substantially decreased respiratory reserve, hypoxia, hypercapnia, or pre-existing respiratory depression. In such clients, even usual therapeutic doses of morphine sulfate may increase airway resistance and decrease respiratory drive to the point of apnea. Consider alternative non-opioid analgesics, and use morphine sulfate or other opioids only under careful medical supervision at the lowest effective dose in such patients.

Use In Head Injury and Increased Intracranial Pressure

In the presence of head injury, intracranial lesions, or a preexisting increase in intracranial pressure, the possible respiratory depressant effects of morphine and its potential to elevate cerebrospinal fluid pressure may be markedly exaggerated. Furthermore, morphine can produce effects on pupillary response and consciousness, which may obscure neurologic signs of increased intracranial pressure in clients with head injuries.

Hypotensive Effect

Morphine may cause severe hypotension in individuals unable to maintain blood pressure who have already been compromised by a depleted blood volume or drug administration of phenothiazines or general anesthetics. Administer morphine sulfate with caution to clients in circulatory shock, as vasodilation produced by the drug may further reduce cardiac output and blood pressure. Blood pressure is always taken as part of the pre-opioid assessment, then at least 15 minutes after administration, along with pain assessment, heart rate and respiratory status.

Gastrointestinal Effects

Do not administer morphine to clients with gastrointestinal obstruction, especially paralytic ileus because opioids diminish propulsive peristaltic waves in the gastrointestinal tract and may prolong the obstruction. The administration of morphine sulfate may obscure the diagnosis or clinical course in clients with an acute abdominal condition.

Use in Pancreatic/Biliary Tract Disease

Use opioids with caution in clients with biliary tract disease, including acute pancreatitis, as morphine sulfate may cause spasming and diminished biliary and pancreatic secretions.

Nursing Considerations

Opioids can be used for all ages. It should be used cautiously with:

- Pregnancy: Some clients with opioid dependency or with medical conditions that require pain management (myalgia, joint pain), will require opioids during pregnancy. It is not well understood all the harms opioids may cause to the fetus due to lack of research for ethical reasons. There have been a few large studies that suggest opioid use during pregnancy has been associated with birth defects such as congenital heart defects and neural tube defects. There does not appear to be evidence of low birth weight as previously determined (Yazdy, Desia & Brogly, 2015). Some opiates also appear to have less adverse effect on the fetus than others. For clients who are taking opiates at the time of delivery, the newborn is at risk for neonatal opioid withdrawal syndrome (NOWS). These newborns experience withdrawal symptoms and often need supportive care until stable. For clients who need to be on opiates while pregnant, oversight by a physician is needed to weigh the benefits vs risk of both the mother and fetus.
- Breastfeeding: Opioids are found in breastmilk. If opioid use is required, the smallest dose for the shortest time is advised. Some opioids appear to have more effect such as codeine and tramadol, but all opioids can potentially cause adverse effects of sedation, poor feeding and respiratory depression. It is advised to limit opioid use to 2-3 days post-partum and under health care provider monitoring (Ito, 2018).
- Clients with liver and renal impairment: For clients with renal impairment, a lower dose adjustment is required. As opiates are metabolized in the liver, and can be prescribed with liver disease but in lower doses and close monitoring.
- Older adult: Due to pharmacodynamic changes that occur with aging, the older adult is more susceptible to the adverse effects of opiates, which can increase negative effects on the central nervous system, cardiovascular system, and gastrointestinal system. For example, due to the sedative effects, the risk of falls is high so ensure precautions are in place.

- Other health conditions that require caution, closer monitoring and lower dosages:
    - Addison's disease, hypothyroidism
    - Prostatic hypertrophy, or urethral stricture
    - CNS depression, toxic psychosis
    - Acute alcoholism, and delirium tremens
    - May aggravate convulsions in clients with convulsive disorders
    - May induce or aggravate seizures.

Neonatal Opioid Withdrawal Syndrome

Newborns that have been exposed to opioids in utero have a higher risk of health issues post delivery. Neonatal Opioid Withdrawal Syndrome or Neonatal Abstinence Syndrome is a combination of gastrointestinal, respiratory, autonomic and central nervous system disturbances that affect postnatal life adaptation in critical areas of sleep, feeding and autonomic function. Neonates with severe NOW symptoms require prolonged hospitalization and pharmacotherapy, with unknown long-term effects (Yazdy, Desia & Brogly, 2015).

Client Assessment for IV Opioid Administration:

A nurse is preparing to give a client Morphine IV following a pain assessment. The client has 7/10 sharp pain to the right abdominal

area, non-radiating, increases with movement. Before the nurse administers the morphine, what else should be assessed?

Always assess vital signs prior to giving an analgesic and especially parenteral route due to the faster onset of action.

- Blood pressure, heart rate (due to hypotensive effects of opioids)
- Respiratory rate and oxygen saturations (due to the risk of respiratory depression)

Once the dose has been given, stay with the client for the first 5 minutes and reassess pain, RR and oxygen sats, as well as BP and HR, particularly if first time dose.

In 15 minutes, reassess pain level and vital signs. The nurse will be anticipating a slight drop in BP and respiratory rate. For some clients, they have a more profound effect and a significant drop in BP or RR occurs. Ensure not to administer the opioid faster than the drug monograph advises, due to a risk a hypotension.

Client Education

It is important to provide accurate information to clients about how to safely use opiates. This is especially true if clients are opiate naive. Additionally, clients might be worried about becoming addicted to opioids even with short-term usage. You can teach your client that most patients who use opioids do not become addicted, but advise using the opioid as directed and for the shortest period of time.

- Do not use alcohol or other CNS depressants: Morphine has addictive effects when used in conjunction with alcohol, other opioids, or illicit drugs that cause central nervous system depression because respiratory depression, hypotension,

profound sedation, coma, or death may result. Avoid the use of other opiates, phenothiazines, and sedative/hypnotics and antidepressants.
- Ensure to store in a safe place away from children or pets.
- Driving and Operating Machinery: Opioids can impair the mental and/or physical abilities needed to perform potentially hazardous activities such as driving a car or operating machinery.
- Advise clients about using short-term opiates versus long-term opiates so they know the differences in dose and scheduling.
- Fentanyl Transdermal patch: If using a fentanyl transdermal patch, the client needs specific instructions to ensure safe use. This includes:
    - Never apply heat to the patch or surrounding area.
    - Never cut or tamper with the patch.
    - Use gloves when applying to a clean, hairless area.
    - Do not abruptly stop using the patch, consult prescriber.

- Anticipate adverse effects:
    - Constipation: advise to start a laxative such as sennakot when starting to take opiate at home. Monitor bowel movements, and if loose stools, use laxatives less often. Ensure client drinks more water and increases fiber intake.
    - Sedation and dizziness: opiates are sedating and can lower BP; so do not undertake any activity that can increase risk of falls without precautions in place.
    - Nausea: Many opiates will cause some nausea; this will subside over time. Take an anti-nausea medication to minimize the nausea.
    - Instruct client to monitor for symptoms of an allergic reaction such as shortness of breath, tight feeling in the throat, hives, nausea or vomiting.

Figure 6.6c Fentanyl Patch (DanielTahar /Wikimedia Commons) CC BY-SA 4.0

Critical Thinking Out Loud

40-year-old client is admitted to the hospital following a motor vehicle incident. They have multiple injuries that

require constant pain relief to give them a manageable level of pain control. Their underlying pain score is 4/10, with pain 8/10 when the physiotherapist completes the therapy sessions. The order might read:

- Hydromorphone po q 4-6 hours PRN
- Morphine 2-5 mg IV q 1 hour PRN for breakthrough pain.
- Acetaminophen 325-650 mg po q 4 hours.

Following an assessment of their pain, the nurse will give the acetaminophen regularly as ordered. They should also give hydromorphone on a regular basis, so the client has sustained pain relief. For the physiotherapy sessions, giving the client Morphine IV prior to the session so they are more comfortable. How much Morphine to give? Factors to consider are: is the client opioid naive? When was the last morphine dose? How much morphine have they been given before and was it effective? What side effects occurred and is it safe to give another dose? Good effective analgesia is an individualized approach.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 6: Pain and Mobility Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

An interactive H5P element has been excluded from this version of the text. You can view it online here:

https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=320#h5p-13

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Safety Considerations for Opioid Use

The Opioid Crisis in Canada

Almost 25% of Canadians experience chronic pain and opioids have been commonly used for chronic pain management. Opioid prescriptions are also used for treating opioid dependence. However, there is debate about the effectiveness of treating chronic

non-cancer pain with opioids based on concerns related to the safe usage of these medications.

The past 30 years have seen waves of opioid-related deaths starting in the 1990s when overdose deaths were linked to a dramatic increase in prescription opioids for chronic pain. The wave increased again in 2010 when overdose deaths were more commonly related to illicit drug use.[4] Currently, most of the harm related to opioid use is due to the synthetic opioid, fentanyl, which is extremely potent and significantly increases the risk of overdose even in trace amounts. Figure 10.7a depicts the waves of opioid-related deaths in the United States, which closely mirrors the trend in Canada (CDC, 2016).

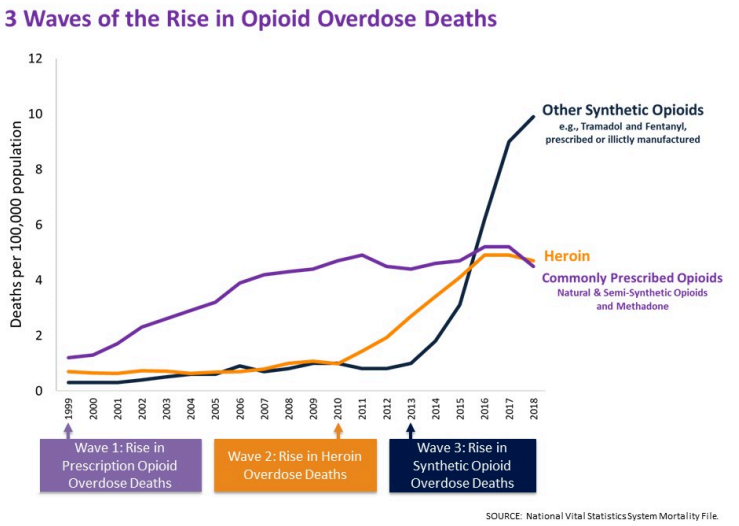

Figure 6.6d Three Waves of Opioid Overdose Deaths [Image Description] (National Vital Statistics System, CDC) CC0

From 2016 to 2019, there were more than 14,700 opioid-related

deaths in Canada (Government of Canada, 2021). In 2016 in British Columbia, the provincial health officer declared a public health emergency under the Public Health Act due to the rise in opioid-related overdose deaths (Government of Canada, 2021).

In response to the public health emergency, the College of Physicians and Surgeons of British Columbia developed Professional Standards and Guidelines: Safe Prescribing of Drugs with Potential for Misuse/Diversion, based on the 2016 CDC Guideline for Prescribing Opioids for Chronic Pain (CDC, 2016). Improving the prescription of opioids through clinical practice guidelines is intended to ensure clients have access to safer, effective pain treatment while also reducing the number of people who misuse or overdose from these drugs. In light of the overdose crises, is important for nurses to provide safe and equitable care for clients experiencing pain.

To learn more about substance use, refer to the British Columbia Center on Substance Use and the Canadian Center on Substance Use and Addiction.

Opioid Analgesic Medication Card

Now let's take a closer look at the medication card for opioid analgesics (Rosenjack Burchum & Rosenthal, 2016;Vallerand & Sanoski, 2019). Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Opioid Analgesic Medication Card

Class: Opioid analgesic **Prototype/Brand Name**: morphine sulfate (M-ESlon, MS Contin) hydromorphone (Dilaudid) fentanyl (Duragesic) codeine		**Indications:** analgesia Anti-tussive (Cough suppressant) **Therapeutic Effect:** Treatment of moderate to severe pain Analgesia during anesthesia Pulmonary edema Cough suppressant (Codeine)	
Mechanism of Action: Binds to opioid receptors (mu, kappa) in the CNS and alters the perception of and response to painful stimuli while producing generalized CNS depression.			
Administration: IR and SR oral preparations IV, SC, IM, rectal, epidural, or transdermal. No ceiling effect Used in all ages. Caution in pregnant and breastfeeding women, liver and renal impairment, and elderly clients. If nausea, take with food and lay quietly	**Side Effects:** CNS depression (respiratory, CVS, sedation, N/V, sweating) respiratory depression Sweating, Pruritus Potentially Fatal: Respiratory depression; circulatory failure; hypotension; deepening coma; anaphylactic reactions. SAFETY Assess resp and sedation, naloxone for reversal. Consider a bowel regime for risk of constipation.	**Contraindications:** Acute pancreatitis Renal impairment Liver impairment Respiratory depression Paralytic ileus Obstructive airway disease Increased intracranial pressure Acute alcoholism	**Nursing Considerations**: Assess for allergies, S&S of respiratory & CNS depression, GI obstruction, head injury etc. Do not perform hazardous activities No other CNS depressants. Do not cut, crush, or chew controlled release Dilute and administer IV slowly

Downloadable file (.docx): Opioid Analgesic Medication Card

Clinical Reasoning and Decision-Making Activity 1

A client with metastatic lung cancer is experiencing 6/10 rib pain. The nurse completes their assessment and plans to give the regularly scheduled oral morphine for pain relief.

1. What should be included in the assessment prior to

giving the analgesic?
2. When should the effectiveness of the medication be evaluated?
3. What adverse effects would the nurse want to assess for that may put the client at risk?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 6: Pain and Mobility Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Opioid Antagonists

Naloxone

Naloxone is a reversal agent used to mitigate risk for opioid-induced respiratory depression by displacing the full opioid agonists. It is safe medication and used to temporarily reduce the effects of overdose from opioids leading to life saving measures of improved breathing. It is only effective if someone has opioids in their system.

Mechanism of Action

Naloxone is an antagonist opioid medication that has a high affinity for μ-opioid receptors, rapidly displacing opioids bound to these

receptors. This leads to a reversal of effects — particularly respiratory depression, sedation, and euphoria, but also reverses analgesia. It does not produce opioid-like effects and has no abuse potential.

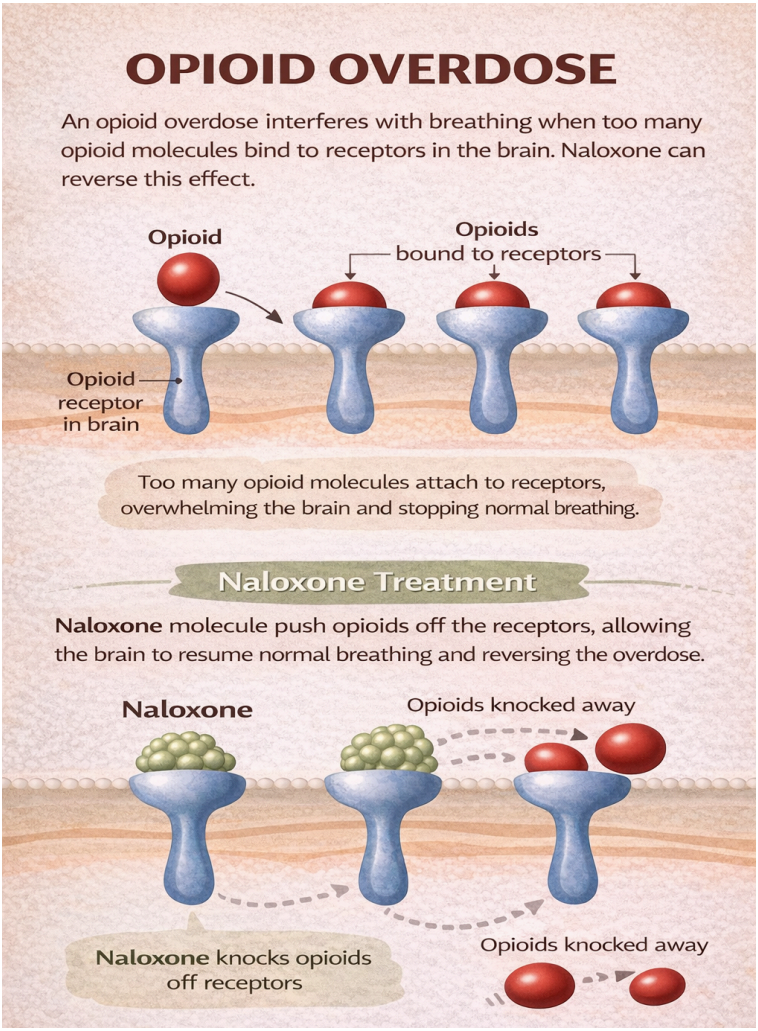

Figure 6.6e Opioid overdose. The action of naloxone in reversing the effects of opioid medications. Naloxone has a high affinity for the mu receptors, and in the presence of an opioid, will bind to

available receptors as well as bump off opioid medications. This effect leads to an immediate effect of reversing respiratory depression. (Sheila O./TRU Open Press adapted from harmreduction.org)

Indications for Use

Naloxone is indicated for the complete or partial reversal of opioid depression, including respiratory depression induced by natural and synthetic opioids. It is used as a life-saving measure in the community and hospital settings.

When opioids are taken in large quantities they can cause life-threatening symptoms such as respiratory depression, bradycardia, hypotension along with slurred speech, drowsiness and constricted pupils (Adams et al, 2019). If untreated, symptoms can progress to vomiting, absent pulse and breathing, loss of consciousness and death. Naloxone will rapidly reverse these symptoms of central nervous system depression (Drugbank, 2025). Due to its relatively short duration of action of 30-60 minutes, repeated doses of naloxone are often required. Some people need more than one dose of naloxone at a time if the first dose is ineffective.

Naloxone is available in subcutaneous, intramuscular, nasal spray or intravenous routes. In the community, kits can be obtained with IM injections or nasal spray along with all the other supplies needed to treat an overdose. Obtaining a naloxone kit is relatively easy from pharmacies or mental health clinics with minimal training. First responders all carry naloxone as a first line overdose treatment plan.

Dosage:

- IM or IV: 0.4 mg
- IV infusion: 0.2- 0.4 mg/hr

Watch the following video on how to use naloxone: How to Use a Naloxone Kit on Someone Who Overdosed [1:36] by CBC News (2022) on YouTube.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=320#oembed-1

Nursing Considerations

Assess:

- Respiratory rate less than 10 breaths per min.
- Other: bradycardia, drowsiness or decreased level of consciousness, hypotension, pupil constriction

Administer:

- IM: onset of action is 3-5 minutes, with t1/2 life 60-90 minutes. Since naloxone rapidly reverses opioid effects, the client will immediately experience withdrawal symptoms and no pain relief (Adams et al, 2019).
- Clients who arrive in emergency after receiving naloxone in the community need close monitoring as the effects of Naloxone wear off. The effects of naloxone are about 30-60 minutes, so depending on the amount of opioid they used, they may begin to show signs of overdose again with respiratory depression, slow heart rate and drowsiness.
- Anticipate the need for repeated doses of naloxone, often IV

push and sometimes IV infusion depending on how the client is doing.
- Naloxone is widely distributed and crosses the blood brain barrier and placenta.
- Children: Naloxone can be given safely to children over the age of 12, the safety and effectiveness of naloxone have not been established in younger children. In emergencies, including pregnancy and young children, naloxone may be given when benefits outweigh risks.

Monitor:

- After naloxone is given, assess every 3-5 minutes: sedation score, blood pressure and heart rate, respiratory assessment including respiratory rate and oxygen saturations. Airway management and IV fluids are often part of the treatment plan (Drugbank, 2025). Additional assessment may include ECG.

Adverse/Side Effects

- Adverse effects include tremors, drowsiness, sweating, hypertension, nausea, and vomiting.
- Clients may also experience acute narcotic abstinence syndrome or withdrawal symptoms for those who are opioid dependent.
- Neonates: opioid withdrawal may also include convulsions, excessive crying, and hyperactive reflexes.
- Naloxone reverses an opioid that was indicated for pain, so the pain may return.
- Abrupt reversal of opioid depression or excessive dosages of naloxone is not without risk. Abrupt reversal can lead to ventricular tachycardia or fibrillation, pulmonary edema, coma, encephalopathy and cardiac arrest.

Opioid withdrawal symptoms can be mild to severe and all clients require close monitoring.

- Increased thirst, chills, fever, muscle pain
- CNS: drowsiness, stimulation, confusion, headache, seizures
- GI: nausea, vomiting, diarrhea
- CVS/Resp: tachycardia, tachypnea, hypertension, wheezing, pulmonary edema

Once in an acute care setting, the Clinical Opiate Withdrawal Scale (COWS) will likely be implemented. Go to the link to learn more about COWS. Emergency Care BC: Clinical Opiate Withdrawal Scale—Treatment : Emergency Care BC

Client Teaching

Clients should be advised regarding the risks associated with opioid analgesic use. Clients and their families should be provided information about how to use opioid antagonists. Refer to the College of Pharmacists of BC for information on naloxone and how to use in an overdose: BC Pharmacists. Clients can obtain a naloxone kit free of charge from many mental health clinics or pharmacists.

Naloxone Medication Card

Class: Opioid Antagonist **Generic Name:** naloxone **Prototype:** Narcan		**Indications:** complete or partial reversal of opioid effects **Therapeutic Effect:** Reversal of analgesia and CNS and respiratory depression caused by opioid agonists.	
Mechanism of Action: competes with opioid receptor sites in the brain and, thereby, prevents binding with receptors or displaces opioids already occupying receptor sites.			
Administration: IV, nasal, IM IV onset: 2 mins IM onset: 3-5 mins T1/2 60 minutes repeated doses PRN Safety and effectiveness have not been established in children. Caution for pregnant and lactating women Metabolism: Liver Excretion: Kidney	**Side Effects:** CNS: agitation, reversal of analgesia CV: tachycardia, blood pressure changes, dysrhythmias, pulmonary edema Acute narcotic abstinence syndrome SAFETY: If providing naloxone for an overdose consider CPR as needed to support the client.	**Contraindications:** Allergy to narcotic antagonists. Pregnancy, lactation.	**Nursing Considerations:** Assess for allergies, and S&S of MI Conduct baseline pain assessment Excessive doses in postop clients may result in significant reversal of analgesia and may cause cardiovascular events Provide comfort measures to help client cope with pain and withdrawal symptoms.

Downloadable file (.docx): Naloxone Medication Card

Clinical Reasoning and Decision-Making Activity 2

A post-operative client just received naloxone for respiratory depression. When should the client's respiratory status be reassessed?

Note: Answers to the Clinical Reasoning Activities and

Critical Thinking questions can be found in the Chapter 6: Pain and Mobility Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Image Description

Figure 6.6d Three Waves of Opioid Overdose Deaths

A line graph that depicts deaths per 100,000 population due to different types of opioids between 1999 and 2018.

- Commonly prescribed opioids (natural and semi-synthetic opiods and methadone): From 1999 to 2011, the death rate per 100,000 population steadily rises from 1 to 5. There is a slight dip after that but it rises again by 2016.
- Heroin: From 1999 to 2010, the death rate per 100,000 remains quite steady at around 1. From 2010 to 2016, the death rate rises steadily to just under 5 per 100,000., then it levels out.
- Other synthetic opioids (e.g., Tramadol and Fentanyl, prescribed or illicitly manufactured): From 1999 to 2013, the death rate per 100,000 remains quite steady at around 1. From 2013 to 2018, the death rate rises steeply to 10 per 100,000.

Below the graph, three waves are identified:

- Wave 1: Rise in prescription opioid overdose deaths started in 1999.

- Wave 2: Rise in heroin overdose deaths started in 2010.
- Wave 3: Rise in synthetic opioid overdose deaths started in 2013.

[Return to Figure 6.6d]

Interactive Activities

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Media Attributions

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6.7 Adjuvant Analgesics

Learning Outcomes

- Describe the purpose of adjuvant medications in treating pain.
- Articulate the common adjuvant medications and how they promote pain relief.
- Understand the mechanism of action, indications for use, adverse effects and nursing considerations for muscle relaxants.
- Understand the mechanism of action, indications for use, adverse effects and nursing considerations for NMDA antagonist ketamine.

There are numerous adjunct medications and all have a place in providing pain relief for certain health issues. Medications used as adjuvant analgesics were developed for other purposes but were later found to be effective to treat pain. They are used to enhance analgesia and need to be used properly to provide effective pain management.

Many drug classifications have been found to be effective for pain management. Some classifications are:

- Antidepressants
- Antiepileptics
- Alpha 2-adrenergic agonists
- Botox

- Corticosteroids (dexamethasone, prednisone)
- Local anesthetics (lidocaine, bupivacaine)
- Muscle relaxants
- NMDA antagonists (Ketamine)
- Cannabinoids

The prescribing of adjuvant medications is often for clients with complex or chronic pain situations. For example, pain from cancer, fibromyalgia, multiple sclerosis, palliative or chronic pain post-injury that is not easily managed with typical analgesics or when avoiding or minimizing the use of opiates is desired. Often these pain syndromes are a result of a mixture of pain mechanisms, and therefore there is no simple formula available to manage the chronic complex pain state.

Before adjuvant medications are prescribed, the health care team completes a detailed health history including learning about the client's other health issues, a thorough medication profile, the goal of care and the stage of disease.

Example in Practice

A client has breast cancer with metastases and is experiencing significant bony pain. They have been initially prescribed non-opioid and opioid pain medications with suboptimal results. After a detailed assessment, this client will continue with a opioid: Duragesic fentanyl patch, hydromorphone oral for breakthrough pain, and also be prescribed an adjuvant medication for persistent cancer pain syndrome. There

are many options that can be used effectively and an individualized plan will be needed. Options could include the corticosteroid dexamethasone, bisphosphonates or an antidepressant (Mitra & Jones, 2011).

In this unit, we will start with a brief overview of some of the common adjuvant medications. A more detailed discussion of muscle relaxants and NMDA antagonists will be provided.

Antidepressants

Although antidepressants (AD) have been used as an adjuvant to treat pain caused by arthritis, migraines, neuropathic pain and fibromyalgia, the research on the efficacy is not consistent and evidence varies across drug class and condition. A meta-analysis has shown inconclusive evidence of the efficacy of AD to treat pain (Ferriera et al, 2023). Of the antidepressants, TCAs and SNRIs show the most benefit. Tricyclics have been reported to show moderate efficacy in treating cancer and neuropathic pain (Birkinshaw et al, 2023). Marks, Choi and Turpen (2024) prescribe serotonin and norepinephrine reuptake inhibitors (SNRIs): duloxetine for chronic pain with moderate effect across all outcomes measured. For clients with difficult to manage chronic pain or palliative clients, AD may provide some relief and worth trying.

Antiepileptics (anticonvulsants)

Antiepileptic drugs have shown some efficacy in treating neuropathic pain. Neuropathic pain is a result of damaged nerve fibers, so pain from causes such as post-op, would be generally less effective for acute nociceptive pain. Chronic nerve pain from diabetic neuropathy, postherpetic neuralgia, or central neuropathic pain post-stroke are some conditions that antiepileptics may be beneficial. Gabapentin and pregabalin are two medications that provide some relief. Gabapentin may also be prescribed for migraine headaches (Sealock & Seneviratne, 2021: Wiffen et al, 2013).

Local Anesthetics

Local anesthetics work by blocking nerve impulses and provide effective pain relief to a localized area, often for a brief period of time. They can be applied topically prior to doing a painful procedure. They can be given via SQ injection to the injured area, for example prior to inserting stitches. Or they can be injected directly into the tissues for a nerve block to a joint or extremity. Local anesthetics will be reviewed in unit 6.8.

Corticosteroids

Dexamethasone is the main corticosteroid that is often prescribed for chronic pain issues, especially related to cancer or palliative pain control. Corticosteroids reduce inflammation through inhibiting prostaglandin synthesis and reduce vascular permeability that results in tissue edema. They also reduce neuropathic pain through reducing spontaneous discharges in damaged nerve cells (Vyvey, 2010). Corticosteroids will be reviewed in chapter 9, endocrine unit.

Bisphosphonates

This class of drugs is used to treat osteoporosis and can slow down bone breakdown and reduce inflammation. Alendronate, one med in this classification, is also used for pain from bone metastases. The mechanism of action is less clear, but likely related to the inhibition of osteoclast-medicated bone reabsorption. It would be a secondary medication for pain relief.

Medical Cannabis

Cannabis has been used for its psychoactive effects for a long time in Canada, and it was not until 1999 that it was approved for medicinal purposes. In Canada, 17.7% of those over the age of 15 used cannabis for medical reasons (Health Canada 2013b). In the last few decades, there has been considerable research exploring the beneficial effects of cannabis. Δ9-tetrahydrocannabinol (THC) is well-known for its psychotropic effects (feelings of euphoria, mood altering). Cannabinoids (CBD) does not have this mood altering effect and has been used to treat many health issues, such as nausea, appetite stimulation, pain relief and seizure prevention (Kallant & Porath-Waller, 2016).

With the more recent research and interest in the medicinal use of cannabis, as well as prompted by the unreliability of effects from smoking or ingesting cannabis, synthetic versions have been developed. Nabilone, Dronabinol, and Sativex are a few synthetic products available. For pain control, medicinal cannabis is approved for neuropathic pain, relief from muscle spasticity and for treating cancer pain. Adverse effects can include impaired cognitive functioning such as memory, coordination and judgment issues, and chronic bronchitis (Kallant & Porath-Waller, 2016; Schrot & Hubbard, 2016).

Historical use of Cannabis

The cultivation of cannabis started in Neolithic China more than 6000 years ago. Research of the medical use of cannabis started in 1838 by Sir William B. O'Shaughnessy, who treated individuals in India with muscle spasms and convulsions. Medical use of cannabis mostly subsided after that time, due to the unpredictability of effects and variable potency found with ingesting or smoking cannabis (Kallant & Porath-Waller, 2016). In the 1960's research increased again, and cannabidiol (CBD) and the most psychoactive cannabinoid delta-9-tetrahydrocannabinol (THC) were identified. Since then, more than 100 different cannabinoids have been discovered. Current studies are uncovering how cannabis has a role in modulating inflammatory and neuroprotective properties as well as other effects such as mood and daily functioning. The discovery of the endocannabinoid system (ECS) has also shown promise in understanding its central role in the regulation of many key functions to maintain homeostasis (Lanz et al, 2016).

Muscle Relaxants

Movement disorders are difficult to treat as the underlying cause of the pain or movement limitations can be due to skeletal, muscular, endocrine or nervous systems. A comprehensive assessment is ideal to best determine a treatment plan that may include drug therapy with antispasmodics, antispastics or benzodiazepines (covered in chapter 8). The utilization of muscle relaxants varies for treatment

of acute and chronic pain. Choosing which drug to prescribe can be difficult as some of the drug's mechanism of action are poorly understood as well as determining the underlying reason for pain (Chang, 2020).

Skeletal muscle relaxants can be divided into two categories:

Centrally acting skeletal muscle relaxants:

- Baclofen – used for spasticity
- Cyclobenzaprine – used for spasms (localized muscle spasm)

Direct-acting muscle relaxants:

- Dantrolene – used for spasticity

Defining the Terms: Spasticity and Spasms

Spasticity originates in the central nervous system. Spasticity disorders are characterized by increased muscle tone, spasm or loss of dexterity. Ie. Cerebral palsy, multiple sclerosis or stroke are examples. These conditions are treated with physical therapy and a combination of drugs.

Muscle Spasms are an involuntary contraction of a muscle or muscle group. The muscle becomes tightened, leading to a decreased ability to function. Causes can include localized muscle injury, acute or chronic pain syndromes and epilepsy. These conditions

are treated with a combination of NSAIDs and centrally acting muscle relaxants, along with physiotherapy and non-pharmacological interventions (ie. massage, acupuncture, rest).

Anti-spastic medications are used for conditions such as cerebral palsy and multiple sclerosis. For ex., baclofen, dantrolene, tizanidine and diazepam (Benzodiazepine).

Anti-spasmodic medications are used for musculoskeletal conditions include cyclobenzaprine metaxalone, and methocarbamol (Robaxin).

In this section, we will review baclofen and cyclobenzaprine.

Baclofen

Indications for Use

Baclofen is used to treat muscle spasticity caused by multiple sclerosis, spinal cord injuries, or other spinal cord disorders. It helps reduce the frequency and severity of painful spasms in quadriplegic or paraplegic clients. Off label, Baclofen has also been used to treat clients with alcoholic liver disease, and reduce alcohol cravings and anxiety. It is also sometimes used for intractable hiccups.

Mechanism of Action

Baclofen is a centrally-acting skeletal muscle relaxant. It acts within the spinal cord to suppress hyperactive reflexes involved in the regulation of muscle movements. It also is structurally similar to gamma-aminobutyric acid (GABA), an inhibitory neurotransmitter, leading to an inhibitory action of neuronal activity in the brain and spinal cord (Adams, 2019). By reducing the release of excitatory neurotransmitters in the presynaptic neurons and stimulating the inhibitory neuronal signals in the postsynaptic neurons, this results in spasticity relief (Ghanavatian & Derian, 2024).

Nursing Considerations

Administration:

- Baclofen is taken orally, with peak effect one-hour post-administration. The t1/2 is 4-5 hours, requiring multiple dosing throughout the day.
- Dose: 15-20 mg TID or QID. Maximum dosing 80mg/day.
- Doses are titrated up every 3 days.
- Take with or without food.

Intrathecal administration: may be injected into the lumbar region to reduce generalized spastic hypertonia post-stroke, or other cerebral or spinal spasticity.

Metabolism and Excretion: baclofen is metabolized in the liver, and 70% is eliminated in an unchanged form through the kidneys, with a small amount excreted in the feces. Doses are reduced for clients with renal insufficiency of a GFR 30-60 mL/min/1.73 m^2.

Baclofen is safe for clients 12 years and older. It is not advised for pregnancy due to risk of birth defects, so benefit vs risk needs to be

considered. Very small amount of baclofen is found in breast milk, with the only caution is sedation in the infant.

Adverse/Side Effects

Baclofen is well tolerated, safe medication with rare adverse effects. It has a wide safety margin. Most adverse effects are on the CNS or GI systems.

- As a CNS depressant, drowsiness, dizziness, vertigo or light-headedness are common. These effects subside with continued use and they are minimized with titrated doses.
- GI effects can include nausea, vomiting and constipation.
- Urinary retention risk especially if the client has benign prostrate hypertrophy or is taking anti-cholinergic meds.
- Muscle weakness

Other adverse effects have been reported but rare, and include hypotension, peripheral edema, hypoventilation, insomnia, depression and impotence.

Abrupt Drug Withdrawal

Hallucinations, paranoid ideation and seizures have occurred on abrupt withdrawal of oral baclofen. Therefore, except for serious adverse reactions, the dose should be reduced slowly over 1 to 2 weeks when the drug is discontinued. Abrupt withdrawal of intrathecal baclofen can result in hyperpyrexia, altered mental state, rebound spasticity and muscle rigidity. Slow titration and close monitoring of the pump is required.

Overdose

Signs and symptoms of overdose include vomiting, muscular hypotonia, drowsiness, accommodation disorders of the eye, coma, respiratory depression, and seizures. There is no antidote, so supportive measures only.

Client Teaching

- Advise clients of the potential adverse effects. They should not drive if they experience confusion or drowsiness until those symptoms subside.
- Clients should be advised to change positions slowly because of the potential orthostatic changes that may occur.
- They should avoid concurrent use with alcohol or other CNS depressants as they will potentiate sedation and dizziness.
- Do not abruptly stop taking baclofen and see their prescriber for instructions to taper their dosages.

Ghanavatian and Derian, 2024; Rosenjack Burchaum and Rosenthal, 2019.

Baclofen Medication Card

Now let's take a closer look at the medication card for baclofen. Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Baclofen Medication Card

Class: Centrally Acting Muscle Relaxant **Prototype(s):** Baclofen	**Indications:** Muscle symptoms (such as spasm, pain, and stiffness, caused by multiple sclerosis, spinal cord injuries, or other spinal cord disorders).		
Mechanism of Action: Suppresses hyperactive reflexes in the spinal cord involved in the regulation of muscle movements. It also is structurally like GABA, an inhibitory neurotransmitter, leading to an inhibitory action of neuronal activity in the brain and spinal cord.			
Administration: Baclofen is safe for clients 12 years and older. Do not take this drug during pregnancy. PO and intrathecal routes. Dosages are titrated up over 1–2 weeks. Take with or without food. Excretion: Kidneys, lower dosages if renal insufficiency.	**Side Effects:** Drowsiness, dizziness or light-headedness, and confusion. GI/GU: nausea, constipation, sedation, and urinary retention. Potentially Fatal: Respiratory or CV depression, seizures. No antidote. SAFETY WARNING: Abrupt discontinuation can cause serious reactions.	**Contraindications:** Hypersensitivity. Active peptic ulcer disease. Caution for use with renal impairment; dosage should be lowered.	**Nursing Considerations:** Assess for allergies. Avoid abrupt withdrawal. Avoid use with alcohol or other CNS depressants. Report frequent or painful urination, constipation, nausea, headache, insomnia, or confusion that persists or is severe. Potential for orthostatic hypotension; change positions slowly.

Downloadable file (.docx): Baclofen Medication Table

Clinical Reasoning and Decision-Making Learning Activity 1

A client just started taking baclofen for muscle spasticity due to multiple sclerosis.

What teaching should the nurse provide?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 6: Pain and Mobility Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Cyclobenzaprine

Indications for Use

For clients with acute muscle spasm, treatment can include non-pharmacological measures, non-steroidal anti-inflammatories, and the use of a centrally acting muscle relaxant. Cyclobenzaprine is used to treat acute muscle spasms. It relieves muscle spasm locally, without interfering with the overall muscle function. It is commonly used for acute muscle spasm.

Mechanism of Action

Cyclobenzaprine reduces tonic somatic muscle activity (depresses motor activity) at the level of the brainstem. It is structurally similar to tricyclic antidepressants.

Nursing Considerations

Administration: oral formula, well-absorbed from the GI tract.

- Immediate release: Onset of action: one hour, with peak in 4 hours.
- Also available in extended release.
- T1/2 is 1-3 days, with maximum effect may take 1-2 weeks.

Caution with hepatic impairment as the drug undergoes considerable enterohepatic recirculation. Lower dosages are required with liver disease.

Contraindicated or used with caution if taking antidepressants while on this med due to risk of serotonin syndrome.

Lifespan considerations:

- Children: safe for clients 15 years and older.
- Older adult: Use cautiously with older adults, as the frequency and severity of adverse events are increased, especially if also taking concomitant medications. Dosing for the older adult should begin with 5 mg dose and titrated slowly upward.
- Pregnancy and Breastfeeding: avoid with pregnancy as safety has not been established. Should not be used by breastfeeding women.

Adverse/Side Effects

Cyclobenzaprine is well tolerated. Most adverse effects are on the CNS and CV system and anticholinergic effects.

CNS: drowsiness, dizziness and fatigue.

CV: similar to tricyclic anti-depressants, it can cause sinus tachycardia and conduction delays. Caution with clients with a cardiac history.

Anti-cholinergic effects: dry mouth, blurred vision, photophobia, urinary retention and constipation. Use with caution with clients with benign prostrate hypertrophy, narrow-angle glaucoma and increased intra-ocular pressure.

Serotonin Syndrome:

The development of a potentially life-threatening serotonin syndrome has been reported with cyclobenzaprine hydrochloride when used in combination with other drugs, such as selective serotonin reuptake inhibitors (SSRIs), serotonin-norepinephrine reuptake inhibitors (SNRIs), tricyclic antidepressants (TCAs), tramadol, bupropion, meperidine, verapamil, or MAO inhibitors (MAOIs). The concomitant use of cyclobenzaprine hydrochloride with MAO inhibitors is contraindicated.

Serotonin Syndrome (Serotonin Toxicity)

Serotonin is a neurotransmitter that regulates mood, behaviour and other physiological functions. Serotonin syndrome occurs from an excessive serotonergic activity throughout the central nervous system that can be potentially life-threatening. Excess serotonin can be

caused by therapeutic medication use (taking a large dose of a prescribed med), accidental medication interactions (taking more than one med that increases serotonin levels), using recreational drugs or an intentional overdose.

Serotonin syndrome symptoms may include:

- mental status changes (e.g., confusion, agitation, hallucinations),
- autonomic instability (e.g., diaphoresis, tachycardia, labile blood pressure, hyperthermia),
- neuromuscular abnormalities (e.g., tremor, ataxia, hyperreflexia, clonus, muscle rigidity),
- and/or gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea).

The client typically feels unwell and seek help before life-threatening symptoms appear.

Treatment includes discontinuing any concomitant serotonergic agents if the above reactions occur, and supportive symptomatic treatment should be initiated. If concomitant treatment with cyclobenzaprine hydrochloride and other serotonergic drugs is clinically warranted, careful observation is advised, particularly during treatment initiation or dose increases.

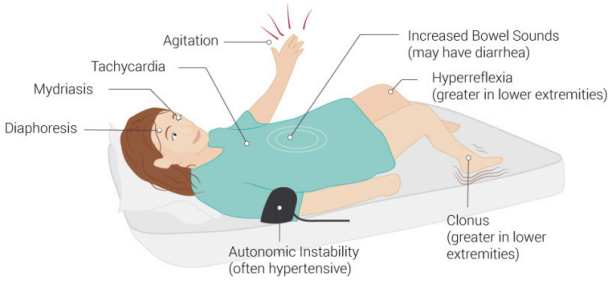

Figure 6.7 a SerotoninSyndrome.jpg (800 × 363 pixels, file size: 51 KB, MIME type: image/jpeg) This file is licensed under the Creative Commons Attribution 4.0 International license. (Beckie Palmer/ Wikimedia Commons) CC BY 4.0

Client Teaching

- Take as directed and inform prescriber of any change or additions of other medications including herbal supplements or recreational substances.
- Advise client of potential adverse effects of the medication.
- Change positions slowly because of the potential orthostatic changes that may occur.
- If taking more than one serotonergic medication, report any symptoms of toxicity.
- Avoid concurrent use with alcohol or other CNS depressants.
- Caution with driving as risk of sedation and dizziness
- Report any change in heart rate or rhythm.
- May cause constipation; increase fluids and fiber intake.

Cyclobenzaprine Medication Card

Now let's take a closer look at the medication card for cyclobenzaprine (Opentextbc, n.d.)

Cyclobenzaprine Medication Card

Class: Centrally Acting Muscle Relaxant **Prototype:** Cyclobenzaprine (Flexeril)	**Indications:** Used to treat acute muscle spasms.		
Mechanism of Action: Reduces tonic somatic muscle activity at the level of the brainstem. It is structurally like tricyclic antidepressants. The precise mechanism of action is not known.			
Administration: Use cautiously with older adults and those taking antidepressants or other CNS depressants. Safety and efficacy in clients under 15 years are not established.	**Side Effects:** Antimuscarinic effects. Neurological adverse effects. GI disorders. Orthostatic hypotension. Tachycardia. Hypersensitivity reactions. Increased sedation with other CNS depressants. Orthostatic hypotension: caution with changing position. SAFETY WARNING: Serotonin Syndrome.	**Contraindications:** Hypersensitivity to cyclobenzaprine. Acute recovery phase of MI. Arrhythmias, heart block or conduction disturbances. Congestive heart failure (CHF). Hyperthyroidism.	**Nursing Considerations:** Assess for allergies. Monitor heart rate and rhythm. Caution with urinary retention, glaucoma, lactation, and mild hepatic impairment. Inform clients about serious side effects. Avoid concurrent use with alcohol or other CNS depressants. Report urinary retention or difficulty voiding, pale stools, or yellow skin/eyes. Do not use within 2 weeks of a monoamine oxidase inhibitor (MAOI) or other antidepressants such as SSRIs, SNRIs, and TCAs.

Downloadable file (.docx): Cyclobenzaprine Medication Card

Clinical Reasoning and Decision-Making Learning Activity 2

A client asks if they can drive their car while taking cyclobenzaprine.

What is the nurse's best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 6: Pain and Mobility Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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6.8 Anesthetics

Learning Outcomes

- Describe the purpose of local and general anesthetic agents.
- Understand the mechanism of action, indications for use, adverse effects and nursing considerations for local anesthetics.
- Understand the indications for use and nursing considerations for general anesthetics.
- Understand the mechanism of action, indications for use, adverse effects and nursing considerations for NMDA agents: Ketamine.

For many clients, the treatment of pain is often managed with taking a non-steroidal anti-inflammatory and depending on the severity, they may also be treated with an opioid medication. Opioids provide excellent pain relief but have significant side effects such as sedation, nausea, constipation and the risk of tolerance. Adjunct pain medications are often used for chronic pain, including neuropathic pain syndromes but have some limitations with the degree of pain relief provided. Local anesthetic agents provide an option for pain relief for situations that more localized relief is needed, which can be for both acute and chronic pain.

Anesthetic agents are categorized into local and general anesthesia. For very localized pain situations, such as dental work or a painful joint, local anesthetics provide total or partial loss of

sensation targeting just the painful site. General anesthetics produce a general loss of consciousness and sensation and is used for most surgical procedures that require the client to be without pain and be unconscious for a long period of time.

As a nurse, you may care for a client prior to preoperative, perioperative, or postoperative. It is important that you are aware of the type of anesthetic that your client has received or been prescribed, which will direct your assessment, monitoring for adverse side effects and other interventions.

In this unit, we will focus mostly on local anesthetic agents and ketamine with an emphasis on nursing considerations.

Local Anesthesia

Local anesthetics produce a rapid loss of sensation to a localized part of the body. These agents produce a total or partial loss of sensation, particularly tactile sensation and pain (Drugbank, 2025).

Indications for Use:

Local anesthetics are used for many different purposes. Most are effective for short term pain relief such as for procedures or acute pain situations. For some clients with chronic myofascial pain syndromes, local anesthetics can be injected to a number of tissues, including nerve, joint and muscle. For example, post-herpetic pain or fibromyalgia (Bagshaw et al, 2015).

There are different routes of local anesthesia which are outlined in the table 6.8a. The route selected depends on the purpose of anesthesia. For example, epidural injection for labour, direct injection into tissue for dental work, or topical application for painful hemorrhoids (Bagshaw et al, 2015; Adams et al, 2019).

Types of local anesthetics:

There are two types of local anesthetics: ester-type such as procaine and amide-type agents such as lidocaine. Ester and amide refer to their chemical structure. Typically, amides have replaced ester anesthetics due to less side effect and longer duration of action.

Ester: procaine, cocaine

Amide: bupivacaine, lidocaine, ropivacaine

The physician chooses the type of agent and the route based on client specific factors such as allergies and the purpose of the procedure (acute vs chronic pain) and the extent of loss of sensation required. Lidocaine has moderate potency and duration of action. Bupivacaine has high potency and duration of action. Both agents also come in different concentrations, such as lidocaine 1% or 2% or bupivacaine 0.25 or 0.50%. This will increase potency but also increase systemic effects (Bagshaw et al, 2015).

Figure 6.8a Vial of lidocaine 1% for local anesthesia Lidocaine hci.jpg https://commons.wikimedia.org/wiki/File:Lidocaine_hci.jpg

Mechanism of Action

The mode of action is the same for all commonly used local anesthetics. Local anesthetics reversibly block conduction of neural

impulses along nerve fibers by binding to sodium channels in the nerve. When the sodium channel is blocked, this prevents depolarization and transmission of nerve impulses.

Adverse/Side Effects

For each route, there are benefits and risks. Refer to the chart for a brief overview of each anesthetic route.

Table 6.8a Local Anesthetics

Route	Example in practice	Additional comments
Topical	Applied to mucous membranes, eyes, throat. Lidocaine is widely used. · ointment for painful hemorrhoids · patch or ointment for sore muscles, · applied to skin before painful procedure (IV insertion for peds).	Very little systemic effects if applied in small amounts. Risk of toxicity if large amount applied or to broken skin. Low skin penetration
Infiltration	Injected directed into tissue to block specific group of nerves at the surgical site. Lidocaine or bupivacaine. Epinephrine can be added to prolong effect.	
Nerve block	Injected near or distant to surgical field/target site. Lidocaine or bupivacaine. · Blocks sensation to limb for 12-24 hours.	Benefit of early ambulation but risk with infection, nerve injury or hematoma.
Spinal (subarachnoid)	Injected into cerebral spinal fluid (CSF) at lumbar region.	Autonomic blockade can cause urinary or fecal incontinence depending on the level and extent of blockade. Spinal headache (posture dependent).
Epidural	Injected into epidural space within spinal column but outside dura mater. Blocks conduction of nerve roots in that area. Lidocaine or bupivacaine. Continuous infusion or one time dose. · During delivery · Painful bowel surgeries	

Adams et al, 2019; Drugbank, 2025; Professional Practice Network of Ontario, 2021, March; Urban, & Bleckwenn, 2002.

Local Anesthetic Toxicity

For all routes there is a risk of the anesthetic entering the bloodstream. Epidural injections have a higher risk of puncture due to the location near thin-walled arteries/veins, compared to a nerve block which is injected near thick-walled veins. Topical application can pose a risk if ointment is applied to broken skin.

Client presentation includes:

- CNS: dizziness, drowsiness, disorientation, tinnitus, twitching, apneic, LOC
- CVS: arrythmias (prolonged PR interval, bundle branch blocks, ectopy), hypotension, cardiac collapse
- GI: nausea, vomiting, diarrhea

Monitoring includes BP, HR, RR and oxygen saturations, and level of consciousness.

Hypersensitivity:

Pruritic rash may develop at site within 72 hours. Actual allergic reaction is rare.

Respiratory symptoms:

Diaphragm paralysis. Due to phrenic nerve is blocked (C3, C4, C5). Assess for decreased breath sounds potentially only on one side, elevated hemidiaphragm on chest X-ray.

Pneumothorax – if supraclavicular nerve block, risk of pneumothorax.

Hematoma formation:

Inadvertent puncture of nearby vascular structures can lead to perineural hematoma with regional nerve block. Apply pressure to the site to stop the bleeding and hematoma..

Neonatal Depression:

For epidurals during labour and delivery, there is a risk of neonatal bradycardia and CNS depression if there is systemic absorption or concurrent opioid use. Monitor cardiac and respiratory status.

Nursing Considerations

Depending on the route of delivery, the nurse's role will be to prepare the client for the procedure, and provide monitoring afterwards. For each route of administration, different assessments and monitoring are required. Below are nursing considerations for a few of the routes.

Topical application: this includes any ointments, patches, creams.

- Assess: pain assessment, assess area for broken skin or infection.
- Wear gloves for application
- Avoid broken skin
- Apply smallest amount needed and only to the affected area
- Avoid wrapping the site or applying heat, unless directed, as this will accelerate absorption.

- Adverse effects: Very little systemic effects if applied in small amounts. Risk of toxicity if large amount applied.

Epidural: For clients with an epidural catheter for pain management post-operatively or during delivery, refer to the hospital policy and procedures. Close assessment and monitoring are important to avoid risk of respiratory depression or cardiovascular effects (hypotension, bradycardia).

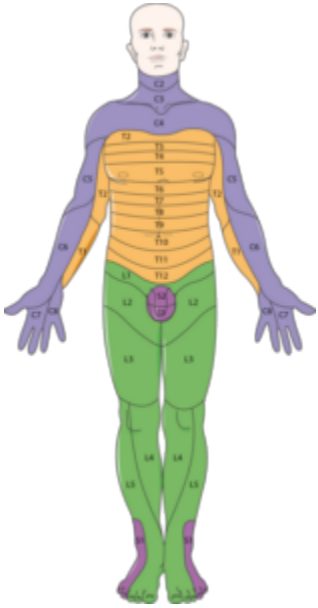
The Epidural solution is often ordered as a combination of an opioid and anesthetic agent in normal saline. The bag is specially prepared in the pharmacy and is labelled for epidural infusion. It is always preservative free.

For example: Bupivacaine 0.25% with Fentanyl 2 mcq/mL in 0.9% sodium chloride 100 mL.

Post-insertion and after client is stable, monitor client q 4 hours and PRN.

- Sedation score
- Pain score
- Motor block (Bromage scale): flex ankles and knees. Potential for motor nerves affected. Score can be 0 block, 1 (just able to move knees), 2 (able to move feet only), 3 (unable to move feet or knees). Can be unilateral or both sides.
- Sensory block (Dermatome level): ice test to determine the upper and lower levels of dermatome involvement. Numbness should only be within a few dermatomes above and below the site of insertion.
- Vital signs: blood pressure, heart rate, resp rate and oxygen saturations.

Adams et al, 2019; Professional Practice Network of Ontario (2021, March).



6.8b image: dermatomes

Figure 6.8b File:Nervous system – Dermatomes 1 — Smart-Servier.png This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license. https://commons.wikimedia.org/wiki/File:Nervous_system_-_Dermatomes_1_-_Smart-Servier.png

General Anesthesia

General anesthesia is a medication-induced reversible unconsciousness with loss of protective reflexes. All sensation including loss of consciousness is lost. In comparison to local anesthetics, the loss of sensation is throughout the whole body.

General anesthesia is usually accomplished with more than one

drug to achieve a balanced anesthesia with rapid induction of unconsciousness, muscle relaxation and to maintain a deep anesthesia (Adams et al, 2019). Due to the generalized effect, general anesthesia requires the establishment and maintenance of airway control (Frandsen & Pennington, 2018).

General anesthetics are administered by the anesthesiologist prior and during surgery either intravenously or by inhalation. In the post-anesthetic recovery room, nurses will closely monitor the client for CNS depression, respirations and oxygen saturations, and any vital sign changes, along with assessing for nausea and vomiting and any post-op bleeding (Adams et al, 2019).

Alternative to Anesthetics for Painful Procedures: Conscious Sedation

For some clients, a short duration procedure is required, such as resetting a dislocated shoulder or for a scheduled colonoscopy. In these cases, physicians will do a conscious sedation. Conscious sedation is an approach that provides sedation, dissociation and analgesia for non-invasive or minimally invasive procedures outside the operating room A combination of medications are injected through a intravenous that allows the client to be relaxed (benzodiazepine: midazolam) and free of pain (opioid: fentanyl) during the medical procedure. This allows the client to remain responsive but sedated with reduced awareness, without feeling discomfort (Frandsen & Pennington, 2018). The client may or may not be able to speak or respond in this state and will be drowsy. Midazolam is a short acting benzodiazepine. Fentanyl has a rapid onset of action, within a minute, and also a short duration action. Both meds work well together for short procedures. Sometimes, propofol is given in place of midazolam. Ketamine can also be used, in particular for children. Nurses assist in the procedure with completing the pre-procedural vital signs, ongoing assessment and

airway monitoring during the procedure and then post-procedure monitoring for airway management, cardiovascular status and pain.

There are a number of other drugs used for anesthetic purposes that is beyond the scope of this textbook. In specialized areas such as the operating room and critical care areas, nurses will receive additional training to assess and monitor clients receiving those medications.

NMDA antagonists: Ketamine

Ketamine is a N-Methyl-D asparate receptor antagonist, producing a dissociative state anesthesia. It provides sedation, amnesia, and analgesia with a lower risk of respiratory depression. It is used effectively for anesthesia induction, procedural sedation, pain management and psychiatry. It produces a dissociative anesthesia where the person feels dissociated from their environment (Rosenbach Burchum & Rosenthal, 2019).

Indications for use:

Ketamine is used for anesthesia either on its own or in combination with other medications. It is also highly effective for brief surgical procedures that does not require skeletal muscle relaxation. For example, for emergencies that require short-term procedural sedation and rapid sequence intubation (Rosenbaum et al, 2024).

It is also used for pain management in the hospital following surgery, in particular for clients with opiate use disorder when the plan is to use opiates sparingly but with there is a need for strong analgesics. Other off label uses are fortreatment-resistant depression, managing suicidal ideation, and treating refractory status epilepticus (Rosenbaum, Gupta, Patel & Palacios, 2024).

Dosing:

Ketamine can be given IV or IM, dosing depends on the use(Benzoni, Agarwal & Cascella, 2025).

Procedural sedation and anesthesia induction:

IV: initial dose of 1-2 mg/kg with additional doses of 0.5 -1.0 mg/kg q 5-10 minutes. IV onset of action is less than 30 seconds, with duration of action 5-10 minutes

IM: dosing is 5 mg/kg with duration of action 10-25 minutes.

Low-dose ketamine infusion:

For clients with chronic pain issues that have become opiate dependent or where the risk factors using opiates are best avoided (Ead, 2022). Low-dose ketamine infusion or intermittent prn administration is used either alone or along with other adjunct pain-relieving medications. The dosing is much lower than for anesthetic purposes. For example, 10 mg IV given over 30 minutes (compared to anesthetic doses of 1-2 mg/kg). This low dose avoids many of the adverse effects, but may cause brief elevated blood pressure and transient tachycardia (Ead, 2022).

Mechanism of action

Ketamine is a noncompetitive N-methyl-D-aspartate (NMDA) and glutamate receptor antagonist that blocks HCN1 receptors. It also inhibits glutamate, an excitatory neurotransmitter involved in pain transmission. Further, cholinergic, aminergic, and opioid systems

appear to play both a positive and negative modulatory role in both the sedative and analgesic effects (Rosenbaum et al, 2024). It desensitizes central pain pathways and modulates opioid receptors.

Adverse effects

CNS: during the recovery period following ketamine, some clients will experience vivid dreams and delirium, even hallucinations. These are usually short lived but can last 24 hours. To minimize these effects, co-administer a benzodiazepine, such as midazolam or lorazepam.

CVS: May increase heart rate and blood pressure due to sympathetic stimulation.

GI: can cause nausea and vomiting. Pretreat with ondansetron.

Nursing Considerations

Ketamine is contraindicated with clients with poorly controlled hypertensions or elevated intracranial pressure. It is typically not recommended for pregnant clients.

Following ketamine administration for procedural sedation, it is important to monitor cardiovascular and respiratory status. Anticipate the client may experience a dissociative state with short term delirium or confusion.

For intermittent ketamine for pain management: monitor BP and HR. anticipate hypertension and possible transient tachycardia. Other adverse effects include nausea, increased salivation, blurred vison and dizziness (Ead, 2022).

Ketamine with propofol:

For emergency or procedural sedation, ketamine can be administered with propofol. This combination mitigates some of the adverse effects of each med. Propofol reduces ketamine induced vomiting. Ketamine reduces the hypotensive effects of propofol.

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Images

Figure 6.8a Vial of lidocaine 1% for local anesthesia Lidocaine hci.jpg https://commons.wikimedia.org/wiki/File:Lidocaine_hci.jpg

Figure 6.8b File:Nervous system – Dermatomes 1 — Smart-Servier.png. Creative Commons Attribution-Share Alike 3.0 Unported license. https://commons.wikimedia.org/wiki/File:Nervous_system_-_Dermatomes_1_–_Smart-Servier.png

6.9 Antigout

Gout is a chronic inflammatory arthritis characterized by episodes of severe joint pain, typically in the great toe. Hyperuricemia (high blood levels of uric acid) is defined as serum levels above 7mg/dL in men and 6 mg/dL in women (Rosenjack Burchum & Rosenthal, 2019). Men are more likely to get gout than women. It is due to either an excess production of uric acid or impaired renal excretion of uric acid. The deposit of sodium urate (sodium salt of uric acid) in the synovial joint precipitates a series of events leading to inflammation, deposition of large, gritty deposits called tophi in the joint and also in the kidney leading to renal damage. The cause of gout is multifactorial, including a genetic predisposition, dietary influences (purine rich diet, alcohol) and health conditions such as obesity, hypertension and diabetes.

Two different classes of medications are used to treat gout. The first involves short term relieve of symptoms such as non-steroidal anti-inflammatories, such as Indomethacin or COX-2 inhibitor, Celebrex. If NSAIDs are not decreasing the inflammation, corticosteroids may be ordered.

The second part of treatment is for prevention or management of chronic gout by lowering serum uric acid levels. Allopurinol is widely used. Other medications include Colchicine (anti-inflammatory by limited leukocyte infiltration) for acute flare-ups and prophylaxis during the initiation of urate-lowering therapy. Probenecid may also be ordered to increase uric acid excretion.

Xanthine Oxidase Inhibitor: Allopurinol

Indications for Use

Allopurinol is used for the prevention and treatment of gouty arthritis and nephropathy and for the treatment of secondary hyperuricemia.

Mechanism of Action

Allopurinol blocks the production of uric acid by inhibiting the action of xanthine oxidase (Vallerand & Sanoski, 2024). This reduction in uric acid production inhibits phagocyte infiltration inside the synovial cavity. This then prevents new tophus formation and allopurinol can also regress tophi that have already formed. It also prevents nephropathy or urate nephrolithiasis.

Nursing Considerations

Allopurinol is safe for all ages. It is well tolerated and absorbed well after oral administration. It should be taken after meals to avoid GI upset. It is also important to ensure the client is well-hydrated, with the potential of 3000 mls of water a day, to avoid renal calculi.

The drug must be taken consistently to have any long-term benefit.

For clients with renal impairment, the dose will be reduced.

Initial therapy: may precipitate a gouty attack. If this occurs, take colchicine or NSAIDs.

Monitoring: clients should return for bloodwork every 2-5 weeks

while titrating the dose to achieve a target serum uric acid level. Follow up labs are every 6 months (Qurie, Preuss & Musa, 2023).

Adverse/Side Effects

Allopurinol is well tolerated. Common side effects include nausea, diarrhea and abdominal discomfort. A maculopapular pruritic rash can also occur.

CNS effects include drowsiness, headache or a metallic taste.

Hypersensitivity syndrome or DRESS syndrome – this is characterized by a rash, fever, eosinophilia, and eventual liver and renal dysfunction (Cleveland Clinic, 2017).

Client Teaching

- Advice clients to take as directed. Take after meals.
- Ensure to stay hydrated, drink 3000 mls of water a day to avoid renal calculi.
- Alkaline diet: eat more alkaline-rich foods, such as plant-based proteins, low-fat diary, certain fruits (cherries, citrus), most vegetables and molasses. This will decrease the chance of stone formation.
- Reduce eating purine-rich foods such as meat, seafood and alcohol. These may contribute to uric acid production.
- Report any rash or unusual bleeding.

Allopurinol Medication Card

Now let's take a closer look at the medication card for

allopurinol. Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below (Rosenjack Burchum & Rosenthal, 2019; Vallerand, A., & Sanoski, 2024)

Allopurinol Medication Card

Class: Xanthine Oxidase Inhibitors **Prototype(s):** Allopurinol (Purinol)	**Indications:** • Treatment of gouty arthritis and nephropathy. • Treatment of secondary hyperuricemia.		
Mechanism of Action: Blocks production of uric acid by inhibiting the action of xanthine oxidase.			
Administration: Safe for all ages. Reduce dose for renal impairment. Drink 2.5–3 L/day to decrease the risk of renal stone development. Take after meals.	**Side Effects:** GI effects common: GI upset, diarrhea, nausea. Hypotension, flushing, drowsiness may occur. Risk of liver and renal dysfunction, or a drug rash with eosinophilia and systemic symptoms (DRESS) syndrome or drug hypersensitivity syndrome. SAFETY: Discontinue drug at first sign of skin rash.	**Contraindications:** Allergy to allopurinol. Blood dyscrasias. Use cautiously with liver disease, renal failure, lactation, or pregnancy.	**Nursing Considerations:** Assess for allergies. Monitor for improvement: decreased pain, swelling, and redness in affected joints. Take as directed. Reduce alcohol consumption. Regular serum uric acid blood work: initially 2–5 weeks after initiation, then every 5 months. Alkaline diet; increase water intake to 2.5–3 L/day to prevent renal calculi. Report unusual bleeding, bruising, or rash to a health care provider immediately.

Downloadable file (.docx): Allopurinol Medication Card CH6.9BySheila

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Vallerand, A., & Sanoski, C. A. (2024). Davis's Drug Guide for Nurses (19th ed.). F.A. Davis Company.

6.10 Clinical Reasoning and Decision Making Consolidation Activities

Now let's apply what you have learned! Complete the following case study and interactive learning activities.

Your 82-year-old postoperative client is hard to rouse 30 minutes after you administered IV morphine. Their BP is 102/72, respirations are 8 and shallow and SpO2 is 88% on room air.

Which of the following (with health care provider orders) are priority nursing actions? Select all that apply.

a. Administer oxygen
b. Administer naloxone
c. Insert a foley catheter
d. Increase IV fluid rate
e. Raise the head of the bed

What is your rationale for choosing that answer?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 6: Pain and Mobility Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=3871#h5p-117

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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An interactive H5P element has been excluded from this version of the text. You can view it online here:
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6.11 Pain Management Consolidation Virtual Simulation

This simulation is a consolidation of the pain management concepts. This virtual simulation will take about 15-20 minutes to complete. It is an opportunity to apply pain management principles in a postoperative context, including making clinical decisions, assessment of pain and prioritize interventions.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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CHAPTER 7: CARDIOVASCULAR SYSTEM

7.0 Cardiovascular System Medications Introduction

Learning Objectives

- Understand common health conditions that can contribute to cardiovascular disorders.
- Describe the classifications and actions of cardiovascular drugs and renal system drugs.
- Explain your understanding of when, how, and to whom cardiovascular system drugs may be administered
- Identify the mechanism of action, side and adverse effects and nursing considerations associated with cardiovascular drug therapy
- Identify considerations and implications of using cardiovascular and renal system medications across the life span
- Articulate key client teaching for each med class to promote health and client safety while taking these medications.
- Apply evidence-based concepts when using the nursing process

Key Terms

- **afterload**
- **anticoagulant**
- **arrhythmia**
- **arteriosclerosis**
- **artery**
- **atherosclerosis**
- **blood pressure**
- **capillaries**
- **cardiac output (CO)**
- **cerebrovascular accident**
- **coagulation**
- **vascular compliance**
- **contractility**
- **diastole**
- **edema**
- **embolus**
- **fibrillation**
- **fibrinolysis**
- **hemostasis**
- **hyperlipidemia**
- **hypertension**
- **hypervolemia**
- **hypovolemia**
- **international normalized ratio**
- **ischemia**
- **loop of henle**
- **myocardial infarction**
- **negative inotropic factors**
- **partial thromboplastin time**
- **perfusion**
- **positive inotropic factors**
- **preload**
- **prothrombin time**
- **renin-angiotensin-aldosterone system**
- **sinoatrial (SA) node**
- **sinus rhythm**
- **stroke volume (SV)**
- **systole**
- **thrombus**
- **transient ischemic attack**
- **veins**
- **venous reserve**

The cardiovascular system (CV) supplies blood throughout the body. It is composed of the heart, arteries, veins and capillaries that all work together to provide oxygenated blood and other nutrients to all parts of the body, as well as remove cellular wastes and by-products. Perfusion is the term to describe this process that is regulated by the nervous system, autoregulated by different organs and tissues as well as hormones, blood volume, electrolytes and much more. (Chaundry, Miao, & Rehman, 2022).

This chapter will begin with a review of the body systems that work to maintain adequate perfusion to the body to maintain physiological function and survival, including the cardiovascular and renal system. In unit 7.2 Conditions and Disorders related to Perfusion, a review of some important conditions that can impact perfusion will be examined. The rest of the units will cover the many medication classifications related to the CV system. The final unit is diuretics and although they work on the renal system, they are used primarily to improve cardiovascular health by lowering

fluid volume. At the end of most units will be some interactive questions to test your understanding. You will also notice that there are medication cards for some of the medications. These were developed as a guide for you to use in your own practice and to edit as needed.

Reference

Chaundry, R. & Miao, J. & Rehman, A. (2022). Physiology, Cardiovascular. National Library of Medicine. StatPearls [Internet]. https://www.ncbi.nlm.nih.gov/books/NBK493197/

7.1 Perfusion: Introduction to the Circulatory System

Basic Concepts of Perfusion and Renal Elimination

To understand the effects of various cardiovascular medications, it is important to first understand the basic anatomy and physiology of the cardiovascular and renal system.

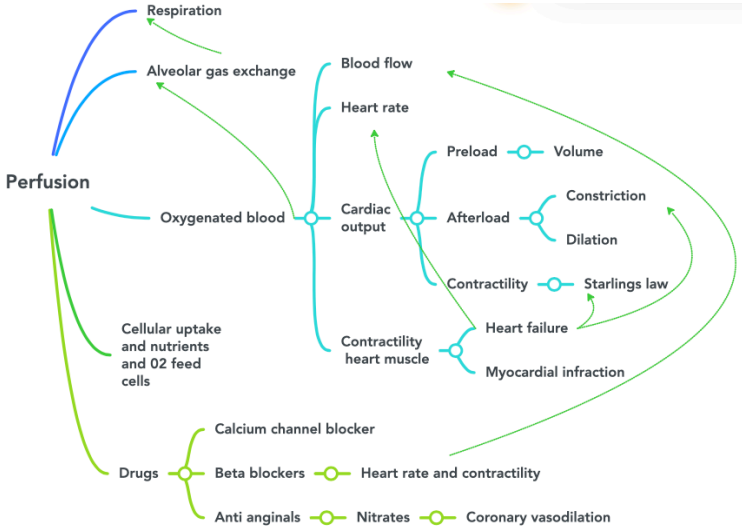

Figure 7.1a Perfusion concept map [Image Description]

The Heart

Did you know that the average adult human heart contracts approximately 108,000 times in one day, more than 39 million times in one year, and nearly 3 billion times during a 75-year lifespan? Each heartbeat ejects approximately 70 mL of blood, resulting in 5.25 liters of fluid per minute and approximately 14,000 liters per day. Over one year, that means over 2.6 million gallons of blood are sent through roughly 60,000 miles of vessels in the adult body (OpenStax, n.d.). It is no wonder that the heart is the most important muscle of the body! This chapter will review important concepts and disorders related to the heart and cardiovascular system before discussing common medication classes. It is vital for nurses to understand how these cardiovascular medications work to provide safe, effective care to the clients who take them.

The heart is the muscular powerhouse of the body that provides two main functions, including;

1. **Oxygenates and provides nutrients to organs and tissues**

The heart works to move oxygenated blood, nutrients, and hormones to organs and tissues so that they can conduct the vital processes needed to keep the body functioning. Without a properly functioning heart to ensure blood flow, cells are in jeopardy of cellular hypoxia, impairment, and subsequent death.

2. **Removes waste products from organs and tissues**

The second function of the heart is to move deoxygenated blood and unwanted metabolic wastes from the body to be excreted out of the system, and to provide the blood with an opportunity to re-oxygenate and begin the cyclical process again.

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Location of the Heart

The human heart is located within the thoracic cavity, medially between the lungs in the space known as the mediastinum. The great veins, the superior and inferior venae cavae, and the great arteries, the aorta and pulmonary trunk, are attached to the superior surface of the heart, called the base. The base of the heart is located at the level of the third costal cartilage, as seen in Figure 6.1.[1] The inferior tip of the heart, the apex, lies just to the left of the sternum between the junction of the fourth and fifth ribs. It is important to remember the position of the heart when placing a stethoscope on the chest of a client and listening for heart sounds.[2]

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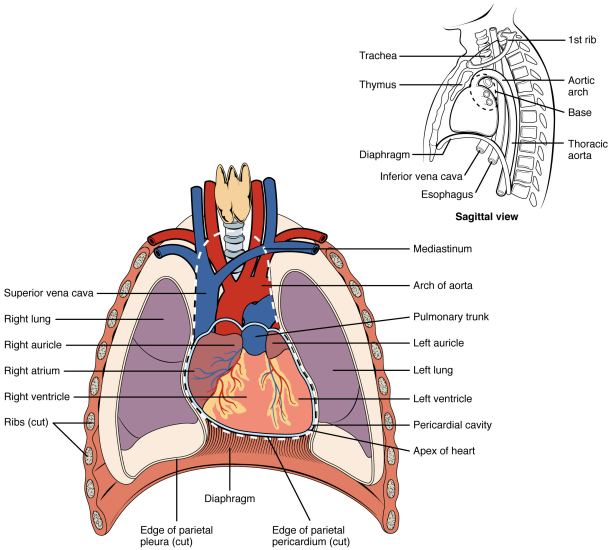

Figure 6.1 Position of the heart in the thoracic cavity

Chambers and Circulation through the Heart

The heart consists of four chambers: two atria and two ventricles. The right atrium receives deoxygenated blood from the systemic circulation, and the left atrium receives oxygenated blood from the lungs. The atria contract to push blood into the lower chambers, the right ventricle and the left ventricle. The right ventricle contracts to push blood into the lungs, and the left ventricle is the primary pump that propels blood to the rest of the body.

There are two distinct but linked circuits in the human circulation called the pulmonary and systemic circuits. The pulmonary circuit transports blood to and from the lungs, where it picks up oxygen and delivers carbon dioxide for exhalation. The systemic circuit transports oxygenated blood to virtually all of the tissues of the body and returns deoxygenated blood and carbon dioxide to the

heart to be sent back to the pulmonary circulation. See Figure 6.2[3] for an illustration of blood flow through the heart and blood circulation throughout the body.[4]

3. "Dual System of the Human Blood Circulation" by OpenStax College is licensed under CC By 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/19-1-heart-anatomy
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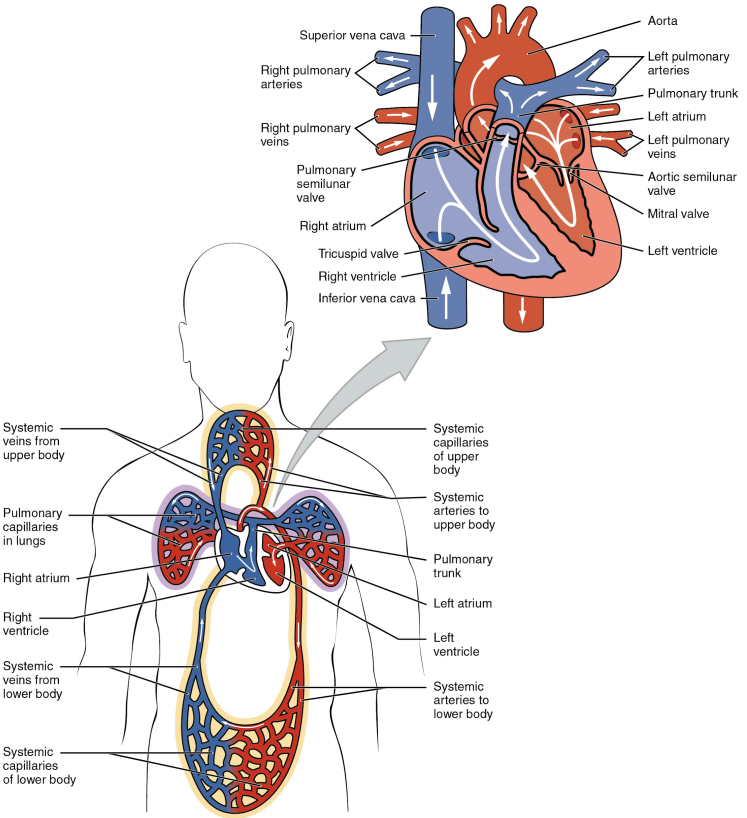

Figure 6.2 Chambers of the heart and blood circulation to the lungs and throughout the body

Blood also circulates through the coronary arteries with each beat of the heart. The left coronary artery distributes blood to the left side of the heart, and the right coronary distributes blood to the right atrium, portions of both ventricles, and the heart conduction system. See Figure 6.3[5] for an illustration of the coronary arteries.

5. "Surface Anatomy of the Heart" by OpenStax College is licensed

When a client has a myocardial infarction, a blood clot lodges in one of these coronary arteries that perfuse the heart tissue. If a significant area of muscle tissue dies from lack of perfusion, the heart is no longer able to pump.

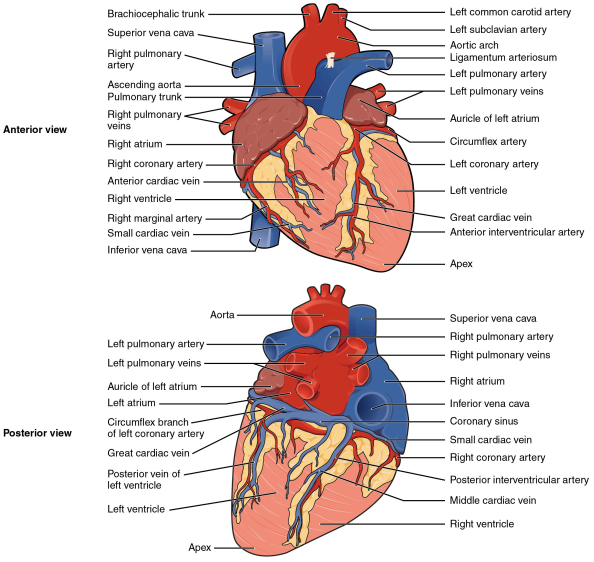

Figure 6.3 Coronary arteries of the heart

Conduction System of the Heart

Contractions of the heart are stimulated by the electrical conduction system. The components of the cardiac conduction system include the sinoatrial (SA) node, the atrioventricular (AV) node, the left and right bundle branches, and the Purkinje fibers. (See Figure 6.4 for an image of the conduction system of the heart.[6])

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6. "2018 Conduction System of the Heart" by OpenStax College is

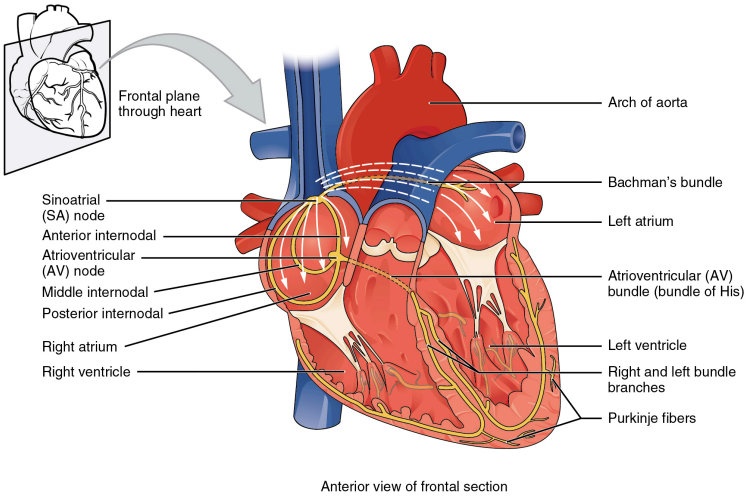

Figure 6.4 Components of the cardiac conduction system

Normal cardiac rhythm is established by the **sinoatrial (SA) node**. The SA node has the highest rate of depolarization and is known as the pacemaker of the heart. Your SA node generates spontaneous electrical impulses between 60-100 beats per minute, causing the atria to contract. If there is damage to the SA node The AV node can take over pacing the heart but this is at a substantially lower rate 40-60 beats per minute. Now if there is damage to both of these areas, the heart does have capacity to support itself with a rate of 20-40 beats per minute but this impacts our cardiac output and appropriate functioning of the heart. We really want the SA node to function as it initiates the **sinus rhythm** or normal electrical pattern followed by contraction of the heart. The SA node initiates

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the action potential, which sweeps across the atria through the AV node to the bundle branches and Purkinje fibers, and then spreads to the contractile fibers of the ventricle to stimulate the contraction of the ventricle.[7]

Cardiac Conductive Cells

Sodium (Na), potassium (K) and calcium (Ca2) ions play critical roles in cardiac conducting cells in the conduction system of the heart. Unlike skeletal muscles and neurons, cardiac conductive cells do not have a stable resting potential. Conductive cells contain a series of sodium ion channels that allow influx of sodium ions that cause the membrane potential to rise slowly and eventually cause spontaneous depolarization. At this point, calcium ion channels open and Ca2 enters the cell, further depolarizing it. As the calcium ion channels then close, the K channels open, resulting in repolarization. When the membrane potential reaches approximately −60 mV, the K channels close and Na channels open, and the prepotential phase begins again. This phenomenon explains the autorhythmicity properties of cardiac muscle. Calcium ions play two critical roles in the physiology of cardiac muscle. In addition to depolarization, calcium ions also cause myosin to form cross bridges with the muscle cells that then provide the power stroke of contraction. Medications called calcium channel blockers thus affect both the conduction and contraction roles of calcium in the heart.

The autorhythmicity inherent in cardiac cells keeps the heart beating at a regular pace. However, the heart is regulated by other

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neural and endocrine controls, and it is sensitive to other factors, including electrolytes. These factors are further discussed in the homeostatic section below.[8]

Focus on Clinical Practice: The ECG

Surface electrodes placed on specific anatomical sites on the body can record the heart's electrical signals. This tracing of the electrical signal is called an electrocardiogram (ECG), also historically abbreviated EKG. Careful analysis of the ECG reveals a detailed picture of both normal and abnormal heart function and is an indispensable clinical diagnostic tool. A normal ECG tracing is presented in Figure 6.5[9]. Each component, segment, and the interval is labeled and corresponds to important electrical events.

There are five prominent components of the ECG: the P wave, the Q, R, and S components, and the T wave.

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9. "Electrocardiogram Depolarization.jpg" by OpenStax College is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/19-2-cardiac-muscle-and-electrical-activity

The small P wave represents the depolarization of the atria. The large QRS complex represents the depolarization of the ventricles, which requires a much stronger impulse because of the larger size of the ventricular cardiac muscle. The ventricles begin to contract as the QRS reaches the peak of the R wave. Lastly, the T wave represents the repolarization of the ventricle. Several cardiac disorders can cause abnormal ECG readings called "dysrhythmias," also called "arrhythmias," and there are several types of antidysrhythmic medications used to treat these disorders that will be discussed later in this chapter.[10]

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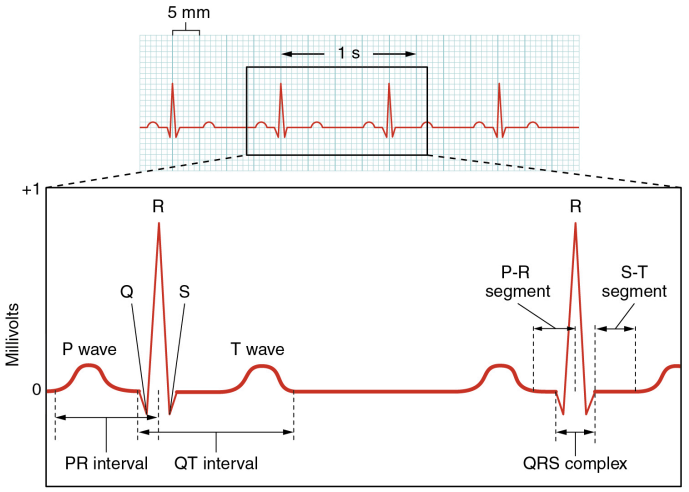

Figure 6.5 Components of an ECG reading

Cardiac Cycle

The period of time that begins with contraction of the atria and ends with ventricular relaxation is known as the cardiac cycle. The period of contraction that the heart undergoes while it pumps blood into circulation is called **systole**. The period of relaxation that occurs as the chambers fill with blood is called **diastole**.

Phases of the Cardiac Cycle

At the beginning of the cardiac cycle, both the atria and ventricles are relaxed (diastole). Blood is flowing into the right atrium from the superior and inferior venae cavae and into the left atrium from the four pulmonary veins. Contraction of the atria follows depolarization, which is represented by the P wave of the ECG.

Just prior to atrial contraction, the ventricles contain approximately 130 mL blood in a resting adult. This volume is known as the end diastolic volume or **preload**. As the atrial muscles contract, pressure rises within the atria and blood is pumped into the ventricles.

Ventricular systole follows the depolarization of the ventricles and is represented by the QRS complex in the ECG. During the ventricular ejection phase, the contraction of the ventricular muscle causes blood to be pumped out of the heart. This quantity of blood is referred to as **stroke volume (SV)**. Ventricular relaxation, or diastole, follows repolarization of the ventricles and is represented by the T wave of the ECG.[11]

Cardiac Output

Cardiac output (CO) is a measurement of the amount of blood pumped by each ventricle in one minute. To calculate this value, multiply stroke volume (SV), the amount of blood pumped by each ventricle, by the heart rate (HR) in beats per minute. It can be represented mathematically by the following equation: CO = HR × SV. Factors influencing CO are summarized in Figure 6.6[12] and include autonomic innervation by the sympathetic and parasympathetic nervous system, hormones such as epinephrine, preload, contractility, and afterload. Each of these factors is further discussed below.[13] SV is also used to calculate ejection fraction,

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12. "2031 Factors in Cardiac Output.jpg" by OpenStax College is licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/19-4-cardiac-physiology
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which is the portion of the blood that is pumped or ejected from the heart with each contraction.

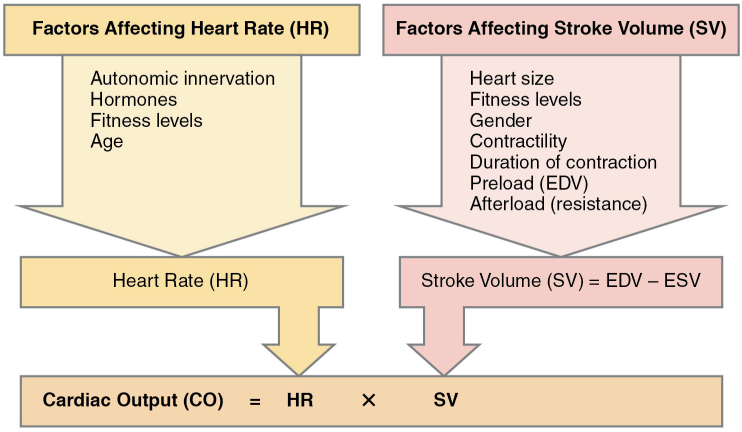

Figure 6.6 Factors affecting cardiac output

Heart Rate

Heart rate (HR) can vary considerably, not only with exercise and fitness levels, but also with age. Newborn resting HRs may be 120 -160 bpm. HR gradually decreases until young adulthood and then gradually increases again with age. For an adult, normal resting HR will be in the range of 60–100 bpm. Bradycardia is the condition in which resting rate drops below 60 bpm, and tachycardia is the condition in which the resting rate is above 100 bpm.

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Correlation Between Heart Rates and Cardiac Output

Conditions that cause increased HR also trigger an initial increase in SV. However, as the HR rises, there is less time spent in diastole and, consequently, less time for the ventricles to fill with blood. As HR continues to increase, SV gradually decreases due to less filling time. In this manner, tachycardia will eventually cause decreased cardiac output.

Cardiovascular Centers

Sympathetic stimulation increases the heart rate and contractility, whereas parasympathetic stimulation decreases the heart rate. (See Figure 6.7 for an illustration of the ANS stimulation of the heart.[14]) Sympathetic stimulation causes the release of the neurotransmitter norepinephrine (NE), which shortens the repolarization period, thus speeding the rate of depolarization and contraction and increasing the HR. It also opens sodium and calcium ion channels, allowing an influx of positively charged ions.

NE binds to the Beta-1 receptor. Some cardiac medications (for example, beta blockers) work by blocking these receptors, thereby slowing HR and lowering blood pressure. However, an overdose of beta blockers can lead to bradycardia and even stop the heart.[15]

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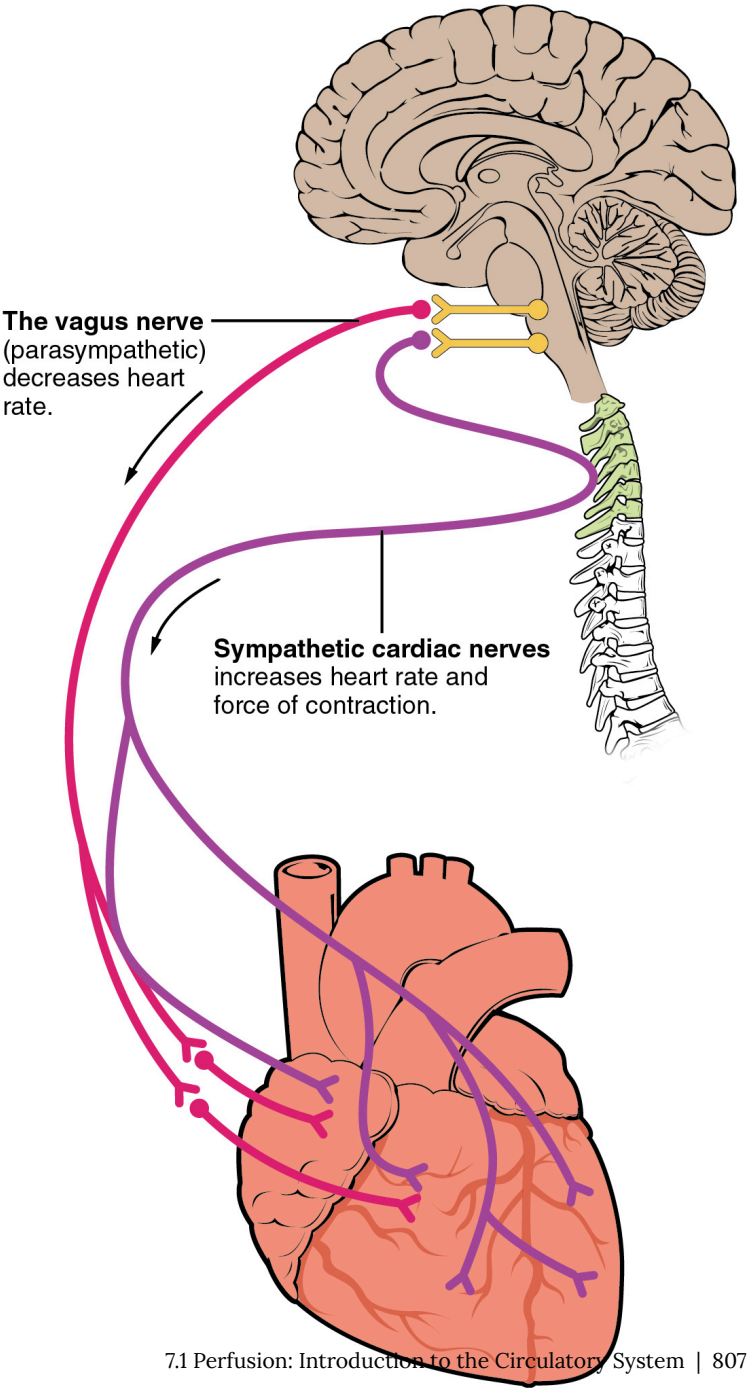
The vagus nerve (parasympathetic) decreases heart rate.
Sympathetic cardiac nerves increases heart rate and force of contraction.

Figure 6.7 ANS stimulation of the heart includes sympathetic and parasympathetic stimulation

Stroke Volume

Many of the same factors that regulate HR also impact cardiac function by altering SV. Three primary factors that affect stroke volume are: preload, or the stretch on the ventricles prior to contraction; **contractility**, or the force or strength of the contraction itself; and **afterload**, the force the ventricles must generate to pump blood against the resistance in the vessels. Many cardiovascular medications affect cardiac output by affecting preload, contractility, or afterload.[16]

Preload

Preload is another way of expressing end diastolic volume (EDV). Therefore, the greater the EDV is, the greater the preload is. One of the primary factors to consider is filling time, the duration of ventricular diastole during which filling occurs. Any sympathetic stimulation to the venous system will also increase venous return to the heart, which contributes to ventricular filling and preload. Medications such as diuretics decrease preload by causing the kidneys to excrete more water, thus decreasing blood volume.

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Contractility

Contractility refers to the force of the contraction of the heart muscle, which controls SV. Factors that increase contractility are described as **positive inotropic factors,** and those that decrease contractility are described as **negative inotropic factors**.

Not surprisingly, sympathetic stimulation is a positive inotrope, whereas parasympathetic stimulation is a negative inotrope. The drug digoxin is used to lower HR and increase the strength of the contraction. It works by inhibiting the activity of an enzyme (ATPase) that controls movement of calcium, sodium, and potassium into heart muscle. Inhibiting ATPase increases calcium in heart muscle and, therefore, increases the force of heart contractions.

Negative inotropic agents include hypoxia, acidosis, hyperkalemia, and a variety of medications such as beta blockers and calcium channel blockers.

Afterload

Afterload refers to the force that the ventricles must develop to pump blood effectively against the resistance in the vascular system. Any condition that increases resistance requires a greater afterload to force open the semilunar valves and pump the blood, which decreases cardiac output. On the other hand, any decrease in resistance reduces the afterload and thus increases cardiac output. Figure 6.8[17] summarizes the major factors influencing cardiac

17. "2036 Summary of Factors in Cardiac Output.jpg" by OpenStax College is licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/19-4-cardiac-physiology

output. Calcium channel blockers such as amlodipine, verapamil, nifedipine, and diltiazem can be used to reduce afterload and thus increase cardiac output.[18]

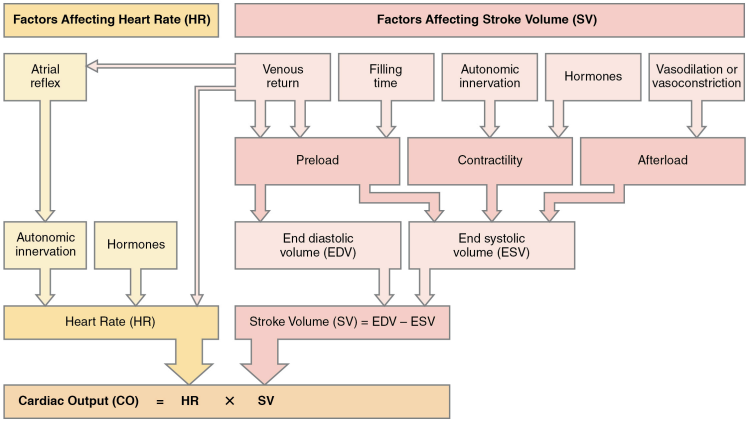

Figure 6.8 Factors affecting cardiac output

Systemic Circulation: Blood Vessels

After blood is pumped out of the ventricles, it is carried through the body via blood vessels. An **artery** is a blood vessel that carries blood away from the heart, where it branches into ever-smaller vessels and eventually into tiny **capillaries** where nutrients and wastes are exchanged at the cellular level. Capillaries then combine with other small blood vessels that carry blood to a **vein**, a larger blood vessel that returns blood to the heart. Compared to arteries, veins are thin-walled, low-pressure vessels. Larger veins are also equipped

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with valves that promote the unidirectional flow of blood toward the heart and prevent backflow caused by the inherent low blood pressure in veins as well as the pull of gravity.

In addition to their primary function of returning blood to the heart, veins may be considered blood reservoirs because systemic veins contain approximately 64 percent of the blood volume at any given time. Approximately 21 percent of the venous blood is located in venous networks within the liver, bone marrow, and integument. This volume of blood is referred to as **venous reserve**. Through venoconstriction, this reserve volume of blood can get back to the heart more quickly for redistribution to other parts of the circulation.

Nitroglycerin is an example of a medication that causes arterial and venous vasodilation. It is used for clients with angina to decrease cardiac workload and increase the amount of oxygen available to the heart. By causing vasodilation of the veins, nitroglycerin decreases the amount of blood returned to the heart, and thus decreases preload. It also reduces afterload by causing vasodilation of the arteries and reducing peripheral vascular resistance.[19]

Edema

Despite the presence of valves within larger veins, over the course of a day, some blood will inevitably pool in the lower limbs, due to the pull of gravity. Any blood that accumulates in a vein will increase the pressure within it. Increased pressure will promote the flow of fluids out of the capillaries and into the interstitial fluid. The

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presence of excess tissue fluid around the cells leads to a condition called **edema**. See Figure 6.9[20] for an image of a client with pitting edema.

Figure 6.9 Pitting edema

Most people experience a daily accumulation of fluid in their tissues, especially if they spend much of their time on their feet (like most health professionals). However, clinical edema goes beyond normal swelling and requires medical treatment. Edema has many potential causes, including hypertension and heart failure, severe protein deficiency, and renal failure. Diuretics such as furosemide are used to treat edema by causing the kidneys to eliminate sodium and water.[21]

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Blood Flow and Blood Pressure

Blood flow refers to the movement of blood through a vessel, tissue, or organ. **Blood pressure** is the force exerted by blood on the walls of the blood vessels. In clinical practice, this pressure is measured in mm Hg and is typically obtained using a sphygmomanometer (a blood pressure cuff) on the brachial artery of the arm. When systemic arterial blood pressure is measured, it is recorded as a ratio of two numbers expressed as systolic pressure over diastolic pressure (e.g., 120/80 is a normal adult blood pressure). The systolic pressure is the higher value (typically around 120 mm Hg) and reflects the arterial pressure resulting from the ejection of blood during ventricular contraction or systole. The diastolic pressure is the lower value (usually about 80 mm Hg) and represents the arterial pressure of blood during ventricular relaxation or diastole.

Three primary variables influence blood flow and blood pressure:

- Cardiac output
- Compliance
- Volume of the blood

Any factor that causes cardiac output to increase will elevate blood pressure and promote blood flow. Conversely, any factor that decreases cardiac output will decrease blood flow and blood pressure. See the previous section on cardiac output for more information about factors that affect cardiac output.

Compliance is the ability of any compartment to expand to accommodate increased content. A metal pipe, for example, is not compliant, whereas a balloon is. The greater the compliance of an artery, the more effectively it is able to expand to accommodate surges in blood flow without increased resistance or blood pressure. When vascular disease causes stiffening of arteries, called **arteriosclerosis**, compliance is reduced and resistance to blood flow is increased. The result is higher blood pressure within the vessel and reduced blood flow. Arteriosclerosis is a common

cardiovascular disorder that is a leading cause of hypertension and coronary heart disease because it causes the heart to work harder to generate a pressure great enough to overcome the resistance.

There is a relationship between blood volume, blood pressure, and blood flow. As an example, water may merely trickle along a creek bed in a dry season, but rush quickly and under great pressure after a heavy rain. Similarly, as blood volume decreases, blood pressure and flow decrease, but when blood volume increases, blood pressure and flow increase.

Low blood volume, called **hypovolemia**, may be caused by bleeding, dehydration, vomiting, severe burns, or by diuretics used to treat hypertension. Treatment typically includes intravenous fluid replacement. Excessive fluid volume, called **hypervolemia**, is caused by retention of water and sodium, as seen in clients with heart failure, liver cirrhosis, and some forms of kidney disease. Treatment may include the use of diuretics that cause the kidneys to eliminate sodium and water.[22]

Homeostatic Regulation of the Cardiovascular System

To maintain homeostasis in the cardiovascular system and provide adequate blood to the tissues, blood flow must be redirected continually to the tissues as they become more active. For example, when an individual is exercising, more blood will be directed to skeletal muscles, the heart, and the lungs. On the other hand, following a meal, more blood is directed to the digestive system. Only the brain receives a constant supply of blood regardless of

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rest or activity. Three homeostatic mechanisms ensure adequate blood flow and ultimately perfusion of tissues: neural, endocrine, and autoregulatory mechanisms.

Neural Regulation

The nervous system plays a critical role in the regulation of vascular homeostasis based on baroreceptors and chemoreceptors. Baroreceptors are specialized stretch receptors located within the aorta and carotid arteries that respond to the degree of stretch caused by the presence of blood and then send impulses to the cardiovascular center to regulate blood pressure. In addition to the baroreceptors, chemoreceptors monitor levels of oxygen, carbon dioxide, and hydrogen ions (pH). When the cardiovascular center in the brain receives this input, it triggers a reflex that maintains homeostasis.

Endocrine Regulation

Endocrine control over the cardiovascular system involves catecholamines, epinephrine, and norepinephrine, as well as several hormones that interact with the kidneys in the regulation of blood volume.

Epinephrine and Norepinephrine

The catecholamines epinephrine and norepinephrine are released by the adrenal medulla and are a part of the body's sympathetic or fight-or-flight response. They increase heart rate and force of

contraction, while temporarily constricting blood vessels to organs not essential for fight-or-flight responses and redirecting blood flow to the liver, muscles, and heart.

Antidiuretic Hormone

Antidiuretic hormone (ADH), also known as vasopressin, is secreted by the hypothalamus. The primary trigger prompting the hypothalamus to release ADH is increasing osmolarity of tissue fluid, usually in response to significant loss of blood volume. ADH signals its target cells in the kidneys to reabsorb more water, thus preventing the loss of additional fluid in the urine. This will increase overall fluid levels and help restore blood volume and pressure.

Renin-Angiotensin-Aldosterone System

The **renin-angiotensin-aldosterone system** (RAAS) has a major effect on the cardiovascular system. Specialized cells in the kidneys respond to decreased blood flow by secreting renin into the blood. Renin converts the plasma protein angiotensinogen into its active form—Angiotensin I. Angiotensin I, an inactive precursor, circulates in the blood and is then converted to active Angiotensin II in the lungs. This reaction is catalyzed by the enzyme called angiotensin-converting enzyme (ACE). Medications called ACE inhibitors such as lisinopril target this step in the RAAS in an effort to decrease blood pressure.

Angiotensin II is a powerful vasoconstrictor that greatly increases blood pressure. It also stimulates the release of ADH and aldosterone, a hormone produced by the adrenal cortex. Aldosterone then increases the reabsorption of sodium into the blood by the kidneys. Because water follows sodium, there is an

increase in the reabsorption of water, which increases blood volume and blood pressure. See Figure 6.10 for an illustration of the renin-angiotensin-aldosterone system and Figure 6.11[23] for a summary of the effect of hormones involved in renal control of blood pressure.[24]

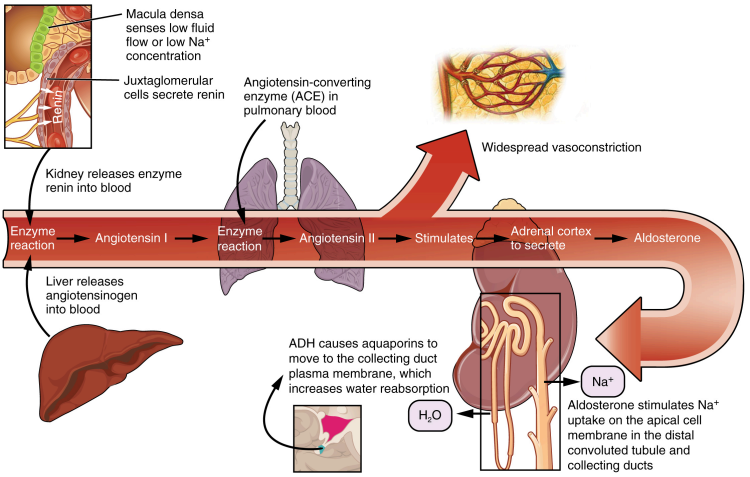

Figure 6.10 The renin-angiotensin-aldosterone system

23. "2626 Renin Aldosterone Angiotensin.jpg" by OpenStax College is licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/25-4-microscopic-anatomy-of-the-kidney
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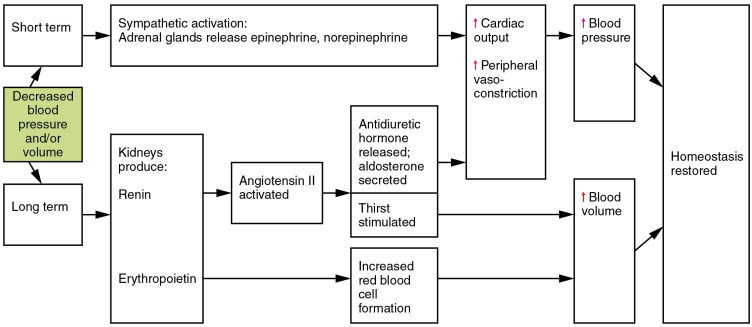

Figure 6.11 Hormones involved in renal control of blood pressure

Autoregulation of Perfusion

Local, self-regulatory mechanisms allow each region of tissue to adjust its blood flow—and thus its perfusion. These mechanisms are affected by sympathetic and parasympathetic stimulation, as well as endocrine factors. See the following tables for a summary of these factors and their effects.[25]

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Factor	Vasoconstriction	Vasodilation
Sympathetic stimulation	Arterioles within integument abdominal viscera and mucosa membrane; skeletal muscles (at high levels); varied in veins and venules	Arterioles within heart; skeletal muscles at low to moderate levels
Parasympathetic	No known innervation for most	Arterioles in external genitalia; no known innervation for most other arterioles or veins

Factor	Vasoconstruction	Vasodilation
Epinephrine	Similar to sympathetic stimulation for extended fight-or-flight responses; at high levels, binds to specialized alpha (α) receptors	Similar to sympathetic stimulation for extended fight-or-flight responses; at low to moderate levels, binds to specialized beta (β) receptors
Norepinephrine	Similar to epinephrine	Similar to epinephrine
Angiotensin II	Powerful generalized vasoconstrictor; also stimulates release of aldosterone and ADH	n/a
ANH (peptide)	n/a	Powerful generalized vasodilator; also promotes loss of fluid volume from kidneys, hence reducing blood volume, pressure, and flow
ADH	Moderately strong generalized vasoconstrictor; also causes body to retain more fluid via kidneys, increasing blood volume and pressure	n/a

Factor	Vasoconstriction	Vasodilation
Decreasing levels of oxygen	n/a	Vasodilation, also opens precapillary sphincters
Decreasing pH	n/a	Vasodilation, also opens precapillary sphincters
Increasing levels of carbon dioxide	n/a	Vasodilation, also opens precapillary sphincters
Increasing levels of potassium ion	n/a	Vasodilation, also opens precapillary sphincters
Increasing levels of prostaglandins	Vasoconstriction, closes precapillary sphincters	Vasodilation, opens precapillary sphincters
Increasing levels of adenosine	n/a	Vasodilation
Increasing levels of lactic acid and other metabolites	n/a	Vasodilation, also opens precapillary sphincters
Increasing levels of endothelins	Vasoconstriction	n/a
Increasing levels of platelet secretions	Vasoconstriction	n/a
Increasing hypothermia	Vasoconstriction	n/a
Stretching of vascular wall (myogenic)	Vasoconstriction	n/a
Increasing levels of histamines from basophils and mast cells	n/a	Vasodilation

Kidney Function Review

As discussed earlier, the kidney helps to regulate blood pressure, along with the heart and blood vessels, primarily through the Renin-Angiotensin-Aldosterone System (RAAS). In addition to

cardiovascular medications affecting the RAAS system, there are also medications called diuretics that reduce blood volume by working at the nephron level. This section will review the basic concepts of kidney function at the nephron level to promote understanding of the mechanism of action of various cardiovascular medications.

The kidney receives blood from the circulatory system via the renal artery. The renal artery branches into smaller and smaller arterioles until the smallest arteriole, the afferent arteriole, services the nephrons. There are about 1.3 million nephrons in each kidney. Nephron's role is to "clean" the blood from excessive wastes by extracting it out of the blood and forming it into urine by accomplishing three principal functions—filtration, reabsorption, and secretion. They also have additional secondary functions in regulating blood pressure (via the production of renin) and producing red blood cells (via the hormone erythropoietin).[26]

The initial filtering of the blood takes place in the glomerulus, a cluster of capillaries surrounded by the glomerular capsule. The rate at which this filtering occurs is called the glomerular filtration rate (GFR) and is used to gauge how well the kidneys are functioning. The rate at which blood flows into the glomerulus is controlled by afferent arterioles and the blood vessels flowing out of the glomerulus. These blood vessels are called called efferent

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arterioles.[27] See Figure 6.13[28] for an illustration of blood flow through the kidney and nephrons.

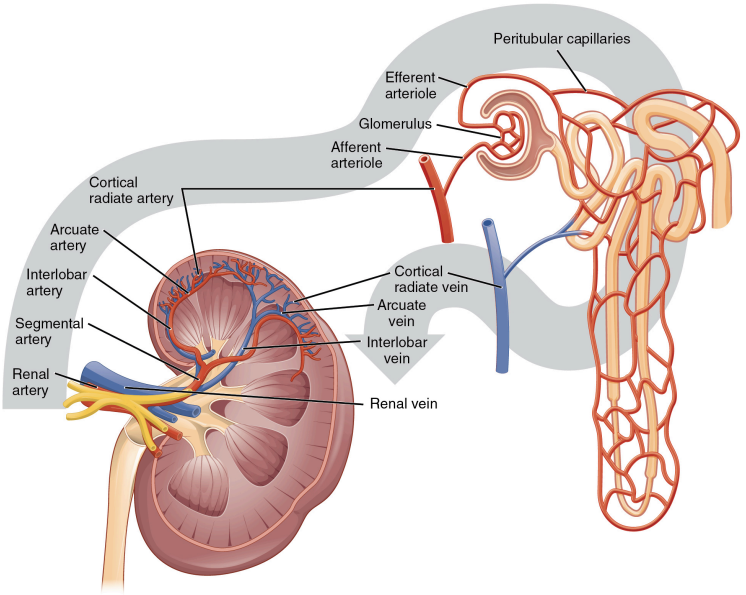

Figure 6.13 Blood flow through the kidney and nephrons

Lying just outside the glomerulus is the juxtaglomerular apparatus (JGA). One function of the JGA is to regulate renin release as part of the RAAS system discussed earlier in this chapter.

27. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M, & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 443-454. Elsevier.
28. "2612 Blood Flow in the Kidneys.jpg" by OpenStax College is licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/25-3-gross-anatomy-of-the-kidney

See Figure 6.14[29] for an illustration of nephron structure. From the glomerulus (1), the proximal tubule (2) returns 60-70% of the sodium and water back into the bloodstream. From the proximal tubule, the filtrate flows into the descending Loop of Henle (3) and then the ascending **Loop of Henle** (4). Another 20-25% of sodium is reabsorbed in the ascending loop of Henle, and this is the site of action of loop diuretics. Filtrate then enters the distal tubule (5), where sodium is actively reabsorbed in exchange for potassium or hydrogen ions, a process regulated by the hormone aldosterone. This is the site of action for thiazide diuretics. The collecting duct (6) is the final pathway; this is where antidiuretic hormone (ADH) acts to increase the absorption of water back into the bloodstream, thereby preventing it from being lost in the urine.[30]

29. "Figure 41 03 04.jpg" by CNX OpenStax is licensed under CC BY 4.0
30. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M, & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 443-454. Elsevier.

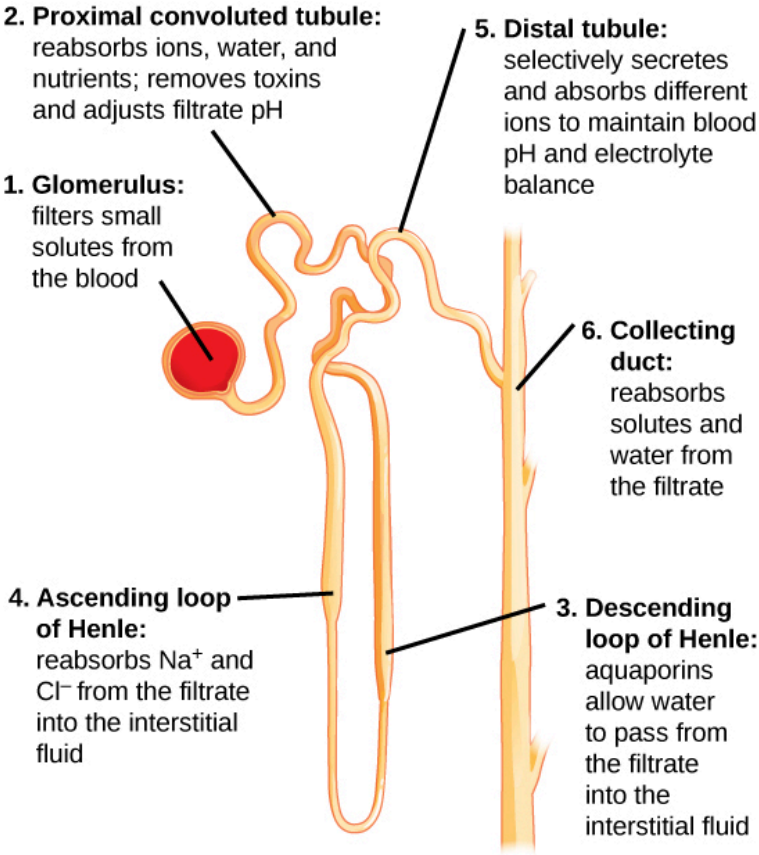

Figure 6.14 Nephron structure

Elimination of Drugs and Hormones

Water-soluble drugs may be excreted in the urine and are influenced by one or all of the following processes: glomerular filtration, tubular secretion, or tubular reabsorption. Drugs that are structurally small can be filtered by the glomerulus with the filtrate. However, large drug molecules such as heparin or those that are

bound to plasma proteins cannot be filtered and are not readily eliminated. Some drugs can be eliminated by carrier proteins that enable secretion of the drug into the tubule (such as dopamine or histamine).[31]

Blood and Coagulation

Now that we have reviewed the functions of the heart, blood vessels, and kidneys, we will review coagulation. As we discussed, the primary function of blood as it moves through the blood vessels in the body is to deliver oxygen and nutrients and remove wastes as it is filtered by the kidney, but that is only the beginning of the story. Cellular elements of blood include red blood cells (RBCs), white blood cells (WBCs), and platelets, and each element has its own function. Red blood cells carry oxygen; white blood cells assist with the immune response; and platelets are key players in **hemostasis**, the process by which the body seals a small ruptured blood vessel and prevents further loss of blood. There are three steps to the hemostasis process: vascular spasm, the formation of a platelet plug, and coagulation (blood clotting). Failure of any of these steps will result in hemorrhage (excessive bleeding). Each of these steps will be further discussed below.[32]

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Vascular Spasm

When a vessel is severed or punctured or when the wall of a vessel is damaged, vascular spasm occurs. In vascular spasm, the smooth muscle in the walls of the vessel contracts dramatically. The vascular spasm response is believed to be triggered by several chemicals called endothelins that are released by vessel-lining cells and by pain receptors in response to vessel injury. This phenomenon typically lasts for up to 30 minutes, although it can last for hours.

Formation of the Platelet Plug

In the second step, platelets, which normally float free in the plasma, encounter the area of vessel rupture with the exposed underlying connective tissue and collagenous fibers. The platelets begin to clump together, become spiked and sticky, and bind to the exposed collagen and endothelial lining. This process is assisted by a glycoprotein in the blood plasma called von Willebrand factor, which helps stabilize the growing platelet plug. As platelets collect, they simultaneously release chemicals from their granules into the plasma that further contribute to hemostasis. Among the substances released by the platelets are:

- adenosine diphosphate (ADP), which helps additional platelets to adhere to the injury site, reinforcing and expanding the platelet plug
- serotonin, which maintains vasoconstriction
- prostaglandins and phospholipids, which also maintain vasoconstriction and help to activate further clotting chemicals

A platelet plug can temporarily seal a small opening in a blood

vessel, thus buying the body more time while more sophisticated and durable repairs are being made.[33]

Coagulation

The more sophisticated and more durable repairs are called **coagulation**, or the formation of a blood clot. The process is sometimes characterized as a cascade because one event prompts the next as in a multi-level waterfall. The result is the production of a gelatinous but robust clot made up of a mesh of fibrin in which platelets and blood cells are trapped. Figure 6.15[34] summarizes the three steps of hemostasis when an injury to a blood vessel occurs. First, vascular spasm constricts the flow of blood. Next, a platelet plug forms to temporarily seal small openings in the vessel. Coagulation then enables the repair of the vessel wall once the leakage of blood has stopped. The synthesis of fibrin in blood clots involves either an intrinsic pathway or an extrinsic pathway, both of which lead to a common pathway creating a clot.[35]

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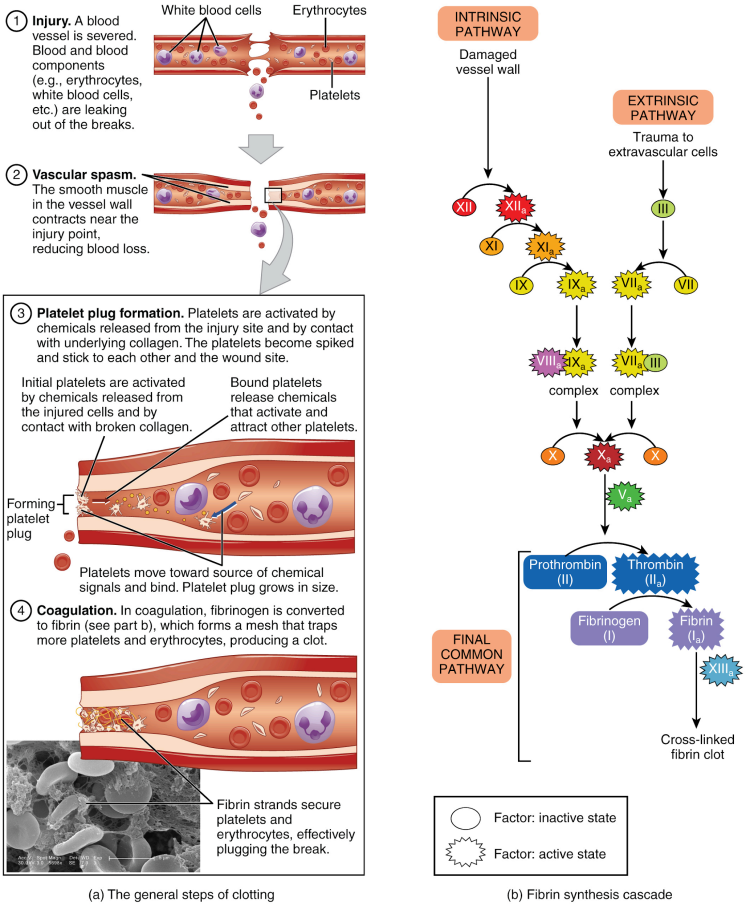

Figure 6.15 The steps of hemostasis

Extrinsic Pathway

The quicker responding and more direct extrinsic pathway (also known as the tissue factor pathway) begins when damage occurs to the surrounding tissues, such as in a traumatic injury. The events in the extrinsic pathway are completed in a matter of seconds.

Intrinsic Pathway

The intrinsic pathway is longer and more complex. In this case, the factors involved are intrinsic to (present within) the bloodstream. The pathway can be prompted by damage to the tissues or resulting from internal factors such as arterial disease. The events in the intrinsic pathway are completed in a few minutes.

Common Pathway

Both the intrinsic and extrinsic pathways lead to the common pathway, where fibrin is produced to seal off the vessel. Once Factor X has been activated by either the intrinsic or extrinsic pathway, Factor II, the inactive enzyme prothrombin, is converted into the active enzyme thrombin. Then thrombin converts Factor I, the soluble fibrinogen, into the insoluble fibrin protein strands. Factor XIII then stabilizes the fibrin clot.

Fibrinolysis

The stabilized clot is acted on by contractile proteins within the platelets. As these proteins contract, they pull on the fibrin threads, bringing the edges of the clot more tightly together, somewhat as we do when tightening loose shoelaces. This process also wrings out of the clot a small amount of fluid called serum, which is blood plasma without its clotting factors.

To restore normal blood flow as the vessel heals, the clot must eventually be removed. **Fibrinolysis** is the gradual degradation of the clot. Again, there is a fairly complicated series of reactions that involves Factor XII and protein-catabolizing enzymes. During

this process, the inactive protein plasminogen is converted into the active plasmin, which gradually breaks down the fibrin of the clot. Additionally, bradykinin, a vasodilator, is released, reversing the effects of the serotonin and prostaglandins from the platelets. This allows the smooth muscle in the walls of the vessels to relax and helps to restore the circulation.

Plasma Anticoagulants

An anticoagulant is any substance that opposes coagulation. Several circulating plasma anticoagulants play a role in limiting the coagulation process to the region of injury and restoring a normal, clot-free condition of blood. For instance, antithrombin inactivates Factor X and opposes the conversion of prothrombin (Factor II) to thrombin in the common pathway. Basophils release heparin, a short-acting anticoagulant that also opposes prothrombin. A pharmaceutical form of heparin is often administered therapeutically to prevent or treat blood clots.

A **thrombus** is an aggregation of platelets, erythrocytes, and even WBCs typically trapped within a mass of fibrin strands. While the formation of a clot is normal following the hemostatic mechanism just described, thrombi can form within an intact or only slightly damaged blood vessel. In a large vessel, a thrombus will adhere to the vessel wall and decrease the flow of blood. In a small vessel, it may actually totally block the flow of blood and is termed an occlusive thrombus.

There are several medications that impact the coagulation cascade. For example, aspirin (acetylsalicylic acid) is very effective at inhibiting the aggregation of platelets. Clients at risk for cardiovascular disease often take a low dose of aspirin on a daily basis as a preventive measure. It is also routinely administered during a heart attack or stroke to reduce the formation of the platelet plug. Anticoagulant medications such as warfarin and

heparin prevent the formation of clots by affecting the intrinsic or extrinsic pathways. Another class of drugs that are known as thrombolytic agents is used to dissolve an abnormal clot. If a thrombolytic agent is administered to a client within a few hours following a thrombotic stroke or myocardial infarction, the client's prognosis improves significantly. Tissue plasminogen activator (TPA) is an example of a medication that is released naturally by endothelial cells but is also used in clinical medicine to break down a clot.[36]

Video Review of Basic Concepts

For additional video review of the basic anatomy and physiology concepts of the cardiovascular and renal system, see the supplementary videos below.[37]

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37. Forciea, B. (2018, April 26). Structure of Arteries and Veins V2. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/HZAeua5JbrU

Blood Vessels

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Muscle Contraction[38]

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Fluids and Electrolytes: Potassium and Aldosterone[39]

38. Forciea, B. (2016, September 14). Muscle Contraction Physiology. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/TB7TypeksGk

39. Forciea, B. (2017, April 26). Fluids and Electrolytes Potassium. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/SNAiGaaYkvs

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Fluid and Electrolytes: Sodium[40]

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40. Forciea, B. (2017, April 24). Fluids and Electrolytes Sodium. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/ar-WrfC7SJs

Anatomy of the Heart[41]

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The Blood[42]

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41. Forciea, B. (2015, May 20). Anatomy of the Heart (v2.0). [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/d8RSvcc8koo
42. Forciea, B. (2015, May 19). Anatomy and Physiology: The Blood. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/bjfcOSoDSzg

Anatomy of Urinary System[43]

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Renin-Angiotensin System[44]

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43. Forciea, B. (2015, May 13). Urinary System Anatomy (v2.0) [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/2Wd45Zmq_Ck
44. Forciea, B. (2015, May 13). Renin-Angiotensin System for Anatomy and Physiology (v2.0) [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/iin4lbAKv7Q

can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=191#oembed-8

Introduction to ECG[45]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=191#oembed-9

45. Forciea, B. (2015, May 12). Introduction to the Electrocardiogram (ECG) V2.0. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/mAN0GK7O9yU

Circulatory System Anatomy[46]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=191#oembed-10

Image Description

Figure 6.1a Perfusion concept map image description:

This concept map illustrates the steps of perfusion. The flow is as follows:

Respiration

- Alveolar gas exchange

46. Forciea, B. (2015, May 12). Circulatory System Anatomy (v2.0). [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/nBSHhkOEKHA

- Oxygenated blood
    - Blood flow
    - Heart rate
    - Cardiac output (this also connects to alveolar gas exchange)
        - Preload
            - Volume
        - Afterload
            - Constriction
            - Dilation
        - Contractility
            - Starlings law
    - Contractility heart muscle
        - Heart failure (this also connects to heart rate, Starlings law and constriction)
        - Myocardial infraction
- Cellular uptake and nutrientss and 02 feed cells
- Drugs
    - Calcium channel blocker
    - Beta blockers
        - Heart rate and contractility (this also connects to blood flow)
    - Anti anginals
        - Nitrates
            - Coronary vasodilation [Return to Figure 6.1a]

7.2 Conditions and Disorders related to Perfusion

Perfusion refers to the process in which blood carries oxygen and nutrients to body tissues and organs and transports waste products of cellular metabolism away. Any disruption to the arterial blood supply through compromised cardiac output or a disruption to the vessels can lead to cardiovascular and cerebrovascular diseases. Cardiovascular disease (CVD) is a group of disorders of the heart and blood vessels and includes coronary artery disease (ischemic heart disease), cerebrovascular disease, peripheral vascular disease, deep vein thrombosis and congenital heart disease. Cardiovascular (CV) disease is a major cause of death and disability in Canada. According to 2017-2018 data from the Canadian Chronic Disease Surveillance System, about 8.5 % of Canadian adults are living with ischemic heart disease. It is the second leading cause of death, with 50,000 deaths per year (Government of Canada, 2022). Despite substantial advances in its prevention, diagnosis, and treatment, CVD remains a major cause of morbidity, mortality, and health care expenditure.

Atherosclerosis is the dominant underlying pathophysiology of CVD. There are 9 potentially modifiable risk factors that are attributed to 90% of the risk of the first myocardial infarction in both men and women. These are diabetes, hypertension, abdominal obesity, psychological stress, cigarette smoking, and dyslipidemia (ratio of apolipoprotein (apo) B (apoB) to apoA-I), physical inactivity, diet high in saturated fats or trans fats, and excessive alcohol use (Brunham, Lonn & Mehta, 2022).

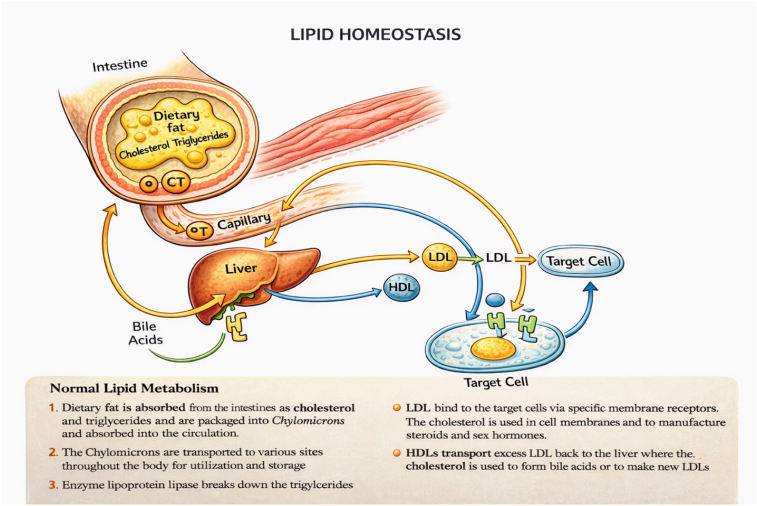
In this unit, we will begin our review of some of the risk factors including dyslipidemia, atherosclerosis and hypertension. Common cardiac disorders will then be reviewed including angina pectoris, myocardial infarction, cerebrovascular accidents, thrombi and emboli, arrhythmias and heart failure. This is a brief review, so for

more indepth understanding of each of these conditions, please refer to other resources.

Dyslipidemia

Dyslipidemia is an umbrella term to describe a high level of cholesterol and /or triglycerides or a low level of high-density lipoprotein (HDL). Hyperlipidemia refers to high cholesterol (Davidson & Altenburg, 2025). The two important lipids in the blood are cholesterol and triglycerides.

Triglycerides are a type of fat used for energy. They are produced in the intestine and liver from small fats called fatty acids.
Cholesterol is a fat (also called a lipid) that is an essential component of cell membranes, of brain and nerve cells, and of bile, which helps the body absorb fats and fat-soluble vitamins. It is also used to make vitamin D and many hormones including estrogen, testosterone and cortisol (Davidson & Altenburg, 2025).



7.2a Lipid Homeostasis: normal lipid metabolism

Conditions and Disorders Related to Perfusion

Now that we have reviewed the basic anatomical and physiological concepts of the cardiovascular and renal system, let's discuss some common cardiac disorders.

Cholesterol Facts

Cholesterol is lipophilic, transported through the blood inside lipoproteins. Cholesterol has many important functions:

- Component of cell membranes,
- synthesis of certain hormones,
- synthesis of bile salts used in digestion of dietary fats and to facilitate abs of fat-soluble vitamins,
- reduces water evaporation in skin.

Cholesterol is mostly produced in the liver, & also comes from dietary sources

An increase in dietary cholesterol produces a small increase in blood cholesterol b/c a rise in exogenous cholesterol, inhibits endogenous cholesterol production

Saturated fat intake is important… ↑ saturated fats contribute to an ↑circulating cholesterol b/c the liver uses saturated fats to make cholesterol

Hepatic cholesterol synthesis is catalyzed by 3-hydroxy-3-methylglutaryl coenzyme A reductase (HMG-CaA reductase)

Lipoproteins are round particles that carry fat (lipids) and proteins, and they travel in the bloodstream to cells throughout your body. The different types of lipoproteins are chylomicrons, high-density lipoproteins (HDL), low-density lipoproteins (LDL) and very low density lipoproteins (VLDL).

- **High density lipoprotein (HDL) cholesterol:** Often called "good" cholesterol because it promotes the excretion of cholesterol. It carries cholesterol from the peripheries back to the liver to be excreted. Exercise helps to increase HDL and remove cholesterol from the bloodstream. ↑HDL = ↓risk of CAD
- **Low density lipoprotein (LDL) cholesterol:** Often called "bad" cholesterol because it delivers cholesterol to the peripheral tissues, where it can be stored in the bloodstream, which contributes to atherosclerosis. ↑LDL=↑risk of CAD

Lipoproteins or lipids increase for a variety of reasons, and can be due to primary causes such as genetics and secondary causes related to lifestyle and other factors. Lifestyle factors include a diet high in fat, being overweight, and lack of exercise (ADAM, 2018). Low density lipoproteins (LDL) also increase slightly as people age, particularly in women after menopause (Davidson & Altenburg, 2025). Other secondary causes include diabetes mellitus, chronic kidney disease and hypothyroidism.

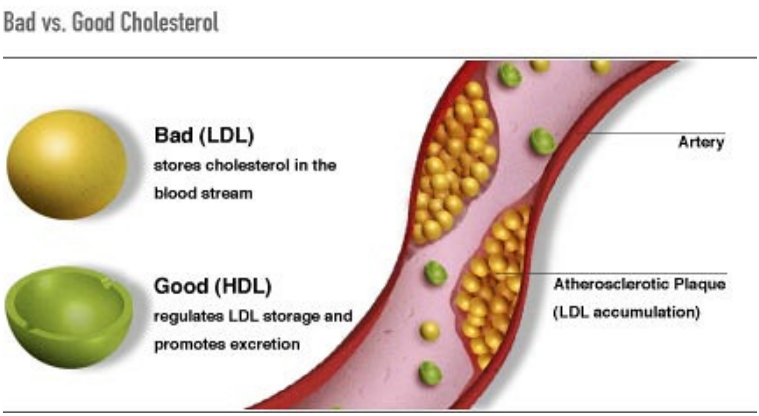


Figure 7.2b A comparison of LDL (bad cholesterol) and HDL (good cholesterol)

Pharmacological treatment for managing dyslipidemia for the prevention of cardiovascular disease begins with screening individuals that includes age, health issues, family history, lifestyle factors, and lab work (Canadian Cardiovascular Society, 2021).

Clients over the age of 40 should be automatically screened, that includes a physical exam and lab work for early prevention and to determine risk. This screening should be done every five years after the age of 20. With the client's lifestyle factors reviewed and any changes implemented to improve their health, and if the lipid profile is still elevated, treatment often begins with the use of a statin medication.

Health behaviour interventions include smoking cessation, healthy eating, managing a healthy weight, exercise, alcohol in moderation and adequate sleep. It is important for the client to adjust lifestyle to minimize their risk factors for CV disease.

Other cholesterol lowering meds will be added, depending on follow up lab work on the response to the statin or if the client's cholesterol levels dictate the addition of another medication.

To learn more about these interventions go to the 2021 Canadian Society for Managing Dyslipidemia Guidelines, go to the following

link: 2021 Canadian Cardiovascular Society Guidelines for the Management of Dyslipidemia for the Prevention of Cardiovascular Disease in Adults – Canadian Journal of Cardiology

Understanding the lab tests –

Nurses need to understand and interpret typical blood tests for a range of health issues. You do not need to memorize the values as the normal value range will always be provided in the lab reports.

A client is preparing to go for lab work in a few days. Advise the client to not drink alcohol 24 hours before the lab work. Also, do not drink anything except water the morning of the lab work (no food or drink up to 14 hours prior).

HealthLink BC: Cholesterol and Triglyceride Tests

Retrieved from: https://www.healthlinkbc.ca/tests-treatments-medications/medical-tests/cholesterol-and-triglycerides-tests

Ideal cholesterol and triglyceride numbers for adults

Table. Ideal cholesterol and triglyceride numbers for adults

Total cholesterol	Less than 5.2 mmol/L
HDL cholesterol	1.6 mmol/L or higher
LDL cholesterol	Less than 2.6 mmol/L (less than 2.0 for people at high risk for an MI)
Triglycerides	Less than 1.7 mmol/L

Atherosclerosis

Arteriosclerosis begins with injury to the endothelium of an artery, which may be caused by irritation from high blood glucose,

infection, tobacco use, excessive blood lipids, and other factors. The risk of atherosclerosis increases as the total cholesterol level (LDL, HDL and VLDL) increase, even if the levels are not high enough to be considered dyslipidemia (Davidson & Altenburg, 2025).

Injured artery walls cause inflammation. As inflammation spreads into the artery wall, it weakens and scars it, leaving it stiff. Circulating triglycerides and cholesterol can seep between the damaged lining cells and become trapped within the artery wall, where they are joined by leukocytes, calcium, and cellular debris. Eventually, this buildup, called plaque, can narrow arteries enough to impair blood flow. The term for this condition, atherosclerosis, describes the plaque deposits. Atherosclerosis can affect the arteries that supply the heart and those that supply the brain, potentially leading to a stroke.

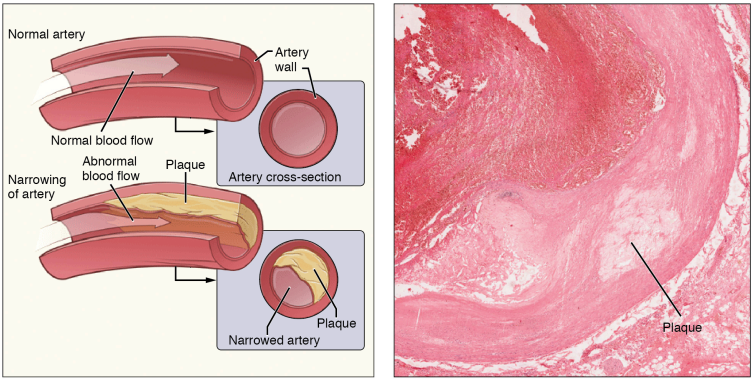


Figure 7.2c Atherosclerosis. Open Stax College.

Sometimes plaque can rupture, causing microscopic tears in the artery wall that allow blood to leak into the tissue on the other side. When this happens, platelets rush to the site to clot the blood. This clot can further obstruct the artery and—if it occurs in a coronary or cerebral artery—cause a sudden heart attack or stroke. Alternatively, plaque can also break off and travel through the

bloodstream as an embolus until it blocks a more distant, smaller artery.

Even without total blockage, narrowed vessels lead to ischemia (reduced blood flow to the tissue region "downstream" of the narrowed vessel). Ischemia can lead to hypoxia (decreased supply of oxygen to the tissues), causing a myocardial infarction or cerebrovascular accident.

Treatment of atherosclerosis includes lifestyle changes, such as weight loss, smoking cessation, regular exercise, and adoption of a diet low in sodium and saturated fats. Antilipemic drugs such as Atorvastatin are prescribed to reduce cholesterol and help prevent atherosclerosis.

Hypertension

Chronically elevated blood pressure is known clinically as hypertension. Hypertension Canada identity hypertension as blood pressure over 130/85 using an automated cuff at home. This lower systolic reading from previous recommendations is to initiate earlier screening and lifestyle changes to avoid cardiovascular disease (Goupil et al, 2025). About 6 million Canadians, or 19 % of our population, currently suffer from hypertension, many of who are unaware of their condition. Unfortunately, hypertension is often a silent disorder, meaning no symptoms occur until complications happen, so clients may fail to recognize the seriousness of their condition and fail to follow their treatment plan. The result is often a heart attack or stroke. Hypertension may also lead to an aneurysm (ballooning of a blood vessel caused by a weakening of the wall), peripheral arterial disease (obstruction of vessels in peripheral regions of the body), myocardial infarction, chronic kidney disease, or heart failure.

Unhealthy lifestyle habits play a major role in the development of hypertension and its associated cardiovascular morbidity and

mortality (Goupil et al, 2025). All clients with hypertension should be aware of lifestyle changes to lower their risk. Such changes as lowering dietary salt intake, eating more potassium rich foods, regular moderate intensity exercise (150 minutes per week), weight loss if overweight, and lowering alcohol intake if above 2 drinks/day (Hypertension Canada, 2025). Some clients are also at a higher cardiovascular risk and this includes those with established cardiovascular disease (coronary artery disease, heart failure), diabetes mellitus, chronic kidney disease and those over 75 years of age.

The addition of pharmacological therapy should be used in addition to lifestyle changes. For those with BP 130-139 with no cardiovascular disease risk, trialing lifestyle changes first for 3-6 months, and then if BP is still elevated, then initiating medications.

Figure 7.2d Health care professional taking blood pressure.

It is critical to obtain an accurate blood pressure that will be used for the development of a treatment plan for hypertension

Understanding what causes our blood pressure to increase will

help you understand the drugs we use to treat hypertension. Our RAAS system is outlined in the diagram below.

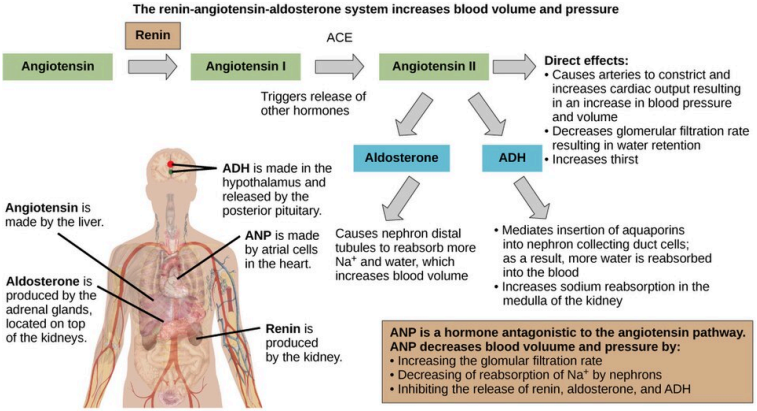


Figure 7.2e The renin-angiotensin-aldosterone system [Image Description]

Thrombi and Emboli

Thrombi are most commonly caused by vessel damage to the endothelial lining, which activates the clotting mechanism. A thrombus can seriously impede blood flow to tissue or organs. Deep vein thrombosis (DVT) can occur when blood in the veins, particularly in the legs, remains stationary for long periods, such as during and after surgery.

Figure 7.2f Typical signs of a DVT include unilateral edema and redness

When a portion of a thrombus breaks free from the vessel wall and enters the circulation, it is referred to as an embolus. An **embolus** that is carried through the bloodstream can be large enough to block a vessel critical to a major organ. When it becomes trapped, an embolus is called an embolism. In the heart, brain, or

lungs, an embolism may cause a heart attack, a cerebrovascular accident (CVA) – otherwise known as a stroke – or a pulmonary embolism. These are medical emergencies.

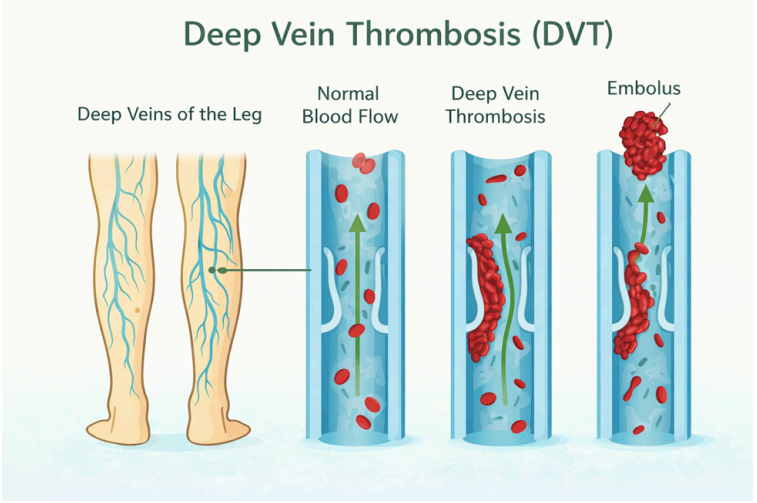


Figure 7.2g Deep vein thrombosis formation (Sheila Odubote/ TRU Open Press)

Medications such as aspirin and warfarin are used to prevent the formation of clots in people who are at risk. Heparin is a medication that can be used to prevent or treat clots, and tPA is used to dissolve severe clots causing ischemia in the brain, heart, or lungs.

Angina Pectoris

Angina pectoris, or chest pain, is a pressure, squeezing or pain in the center of the chest. It is the most common symptom of ischemic heart disease, a major cause of morbidity and mortality worldwide.

Angina results from an imbalance between myocardial oxygen

supply (decreased coronary blood flow) and the myocardial oxygen demand (increased myocardial oxygen consumption).

Factors that determine myocardial oxygen demand include the contractility of the heart, the heart rate, and the intramyocardial wall tension. Heart contractility and heart rate are influenced by exercise, stress and caffeine, for example, – which all stimulate the SNS leading to increased heart rate and contractility. The myocardial wall tension is determined by preload and afterload. Drugs that reduce these factors, reduce oxygen demand.

The factor that determines oxygen supply is the myocardial blood flow. At rest, the heart extracts nearly all the oxygen that is delivered to the heart by the coronary vessels. When oxygen demand increases, such as during exercise, the coronary arteries dilate and blood flow increases. This increase in blood flow to perfuse the myocardium occurs during diastole (heart is at rest). (Rosenjack Burchum & Rosenthal, 2019). In a healthy heart, this oxygen supply and demand is in balance. A heart with coronary artery disease will not be able to adequately deliver blood to the myocardium, resulting in an imbalance with oxygen needs and anginal pain.

Coronary artery stenosis is the most common cause of myocardial ischemia. During increased myocardial oxygen demand, the stenosis prevents adequate myocardial oxygen supply. So, when there is increased demand without increased oxygen supply, angina results (Gillen & Goyal, 2022).

Angina can be due to non-cardiac and cardiac causes, and a thorough history and physical is critical in differentiating these causes and identifying patients experiencing acute coronary syndrome (Gillen & Goyal, 2022). Angina is one of the signs of acute coronary syndrome (ACS). Along with chest pain, clients can experience nausea, shortness of breath and pain that radiates to the jaw, back, and neck.

Angina is classified in one of the three categories:

- **Stable angina** (demand ischemia) is due to chronic narrowing

(stenosis) of coronary arteries due to atherosclerosis. When the coronary artery narrows too much this results in an inadequate blood flow. Symptoms occur with exertion only and are due to increased myocardial oxygen demand from increased heart rate, increased blood pressure, and increased myocardial contractility, among other factors. This type of angina is treated with drugs that reduce oxygen demand, including beta blockers, calcium channel blockers and nitrodilators.

- **Unstable angina** (supply ischemia) is due to a transient formation and dissolution of a thrombosis within a coronary artery. When the clot forms there is a reduced coronary flow, leading to a reduction in the oxygen supply and demand ratio. Symptoms often occur at rest and is the more concerning type of angina. If symptoms don't resolve, it can lead to myocardial infarction. Treatment is with meds that reduce oxygen demand and inhibit thrombus formation (antiplatelet meds, aspirin).
- **Variant or vasospastic angina**, also known as Prinzmetal angina, also occurs at rest but is unrelated to coronary atherosclerosis. It is caused by a spasm in the heart's arteries that temporarily decreases blood flow. The spasm can be due to stress, medications, smoking or extreme cold and often occurs at rest. It is treated with meds to reverse or inhibit coronary vasospasm, such as calcium-channel blockers and nitrodilators.

Angina that is left untreated, it can lead to myocardial infarction, stroke, acute coronary syndrome and death. Treatment includes lifestyle changes such as weight loss, quit smoking and to lower cholesterol through diet and medications (i.e. statins). Medications to treat angina include nitrate therapy to improve coronary blood flow and ultimately relief the chest pain and other symptoms. Other medications are prescribed depending on the type and severity of angina, and can include antihypertensives, anticoagulants,

antilipemic (HMG-CoA reductase inhibitor), and anti-platelet medications (Tan & Yang, 2024).

Myocardial Infarction

Myocardial infarction (MI) is the medical term for what is commonly referred to as a "heart attack". It results from a lack of blood flow and oxygen to a region of the heart, due to a partial or full thickness blockage of one or more coronary arteries. Each coronary artery supplies blood to a specific area of the heart's muscular wall, so if that artery is blocked, that region of the heart will have less oxygen supply and subsequent ischemia. This blockage is often due to a buildup of atherosclerotic plaque and becomes a thrombus or when a portion of an unstable atherosclerotic plaque travels through the coronary arterial system and lodges in one of the smaller vessels. If blood supply is not restored to that area, infarction or myocardial cell death can occur.

Watch the short video on myocardial infarction:

Merck Manual (2025). Video: Myocardial Infarction-Merck Manual Consumer Version

Symptoms of myocardial infarction can vary, with some people experiencing mild symptoms such as nausea and mild chest discomfort. Other clients experience sudden, sharp retrosternal pain, dizziness and diaphoresis. Many of the symptoms are shared with other medical conditions, including anxiety attacks and simple indigestion, so accurate diagnosis is critical for survival. It is important for nurses to ask detailed questions to ensure subtle symptoms are not missed. Symptoms can include:

- Chest pain that may feel like pressure, tightness, pain, squeezing or aching.
- Heart palpitations
- Pain or discomfort that spreads to the shoulder, arm, back,

neck, jaw, teeth or sometimes the upper abdomen.
- Diaphoresis
- Fatigue
- Heartburn or indigestion. Pain can be mild or severe substernal pain.
- Light-headedness or sudden dizziness
- Nausea
- Shortness of breath

Men and women may also experience symptoms differently. For example, more common in men is left or middle moderate to severe chest pain, diaphoresis and shortness of breath. In women, symptoms may present with milder chest pain, abdominal pain and nausea/vomiting (Sella et al, 2021). Completing a detailed assessment is important to not miss subtle or less typical cues of an MI.

To diagnose a coronary artery occlusion, in the emergency department, the following examinations will be completed:

- Physical exam: BP, HR, RR and oxygen saturations, along with a physical assessment.
- 12 lead ECG: assess for changes in the ST and Q wave components of the ECG complex. ST-segment elevation in two contiguous lead (measured at J-point) or ST depression and T wave changes (Ojha & Dhamoon, 2023).
- Blood work: troponin, which is a serum cardiac marker that detects chemicals released by the damaged heart muscle.

Types of MI include ST elevation (STEMI) and non-ST elevation (non-STEMI).

- STEMI: this is a complete blockage in a coronary artery resulting in complete lack of blood flow to that area of the heart. The full thickness of the heart muscle can die if blood

(oxygen) is not returned right away.

- Non-STEMI: this is a partial blockage of blood flow in a coronary artery. As only part of the heart wall thickness is damaged, the ST segment is often not elevated.

Treatment includes aspirin, nitroglycerine, morphine and possibly supplemental oxygen if oxygen saturations are less than 94% or per agency protocol. Bedrest is also required.

Longer-term treatments depend on the extent of blocked coronary artery (partial or full blockage, one vessel or multiple vessels impacted) and may include: injections of thrombolytic agents, such as the tissue plasminogen activator also known as tPA, that dissolve the clot; the anticoagulant heparin; a balloon angioplasty with stents to open blocked vessels; or bypass surgery to allow blood to pass around the site of blockage. Please note that drugs such as tPA are used in Emergency and Intensive Care Units (Ojha & Dhamoon, 2023).

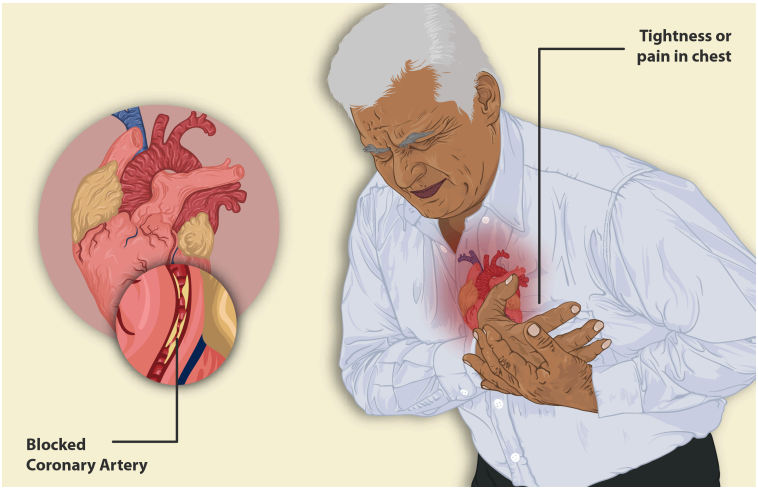


Figure 7.2i Male clients often describe chest pain associated with MI "like something is sitting on my chest" but female clients may simply have feelings of GI upset.

Cerebrovascular Accident (CVA)

The internal carotid arteries, along with the vertebral arteries, are the two primary suppliers of blood to the human brain. Given the central role and vital importance of the brain to life, it is critical that blood supply to this organ remains uninterrupted. However, blood flow may become obstructed due to atherosclerosis or an embolus that has traveled from elsewhere in the blood. For example, an arrhythmia called atrial fibrillation can cause clots to form in the heart and then move to the brain. When blood flow is interrupted, even for just a few seconds, a **transient ischemic attack (TIA)**, or mini-stroke, may occur, resulting in loss of consciousness or temporary loss of neurological function. Loss of blood flow for longer periods produces irreversible brain damage or a stroke, also called a **cerebrovascular accident (CVA)** (Open Stax, n.d.). There are two types of cerebrovascular accidents: ischemia and hemorrhagic. Ischemic strokes are caused by atherosclerosis, or a blood clot that blocks the flow of blood to the brain (see Figure 7.2i).

Eighty percent of strokes are ischemic. Hemorrhagic strokes are caused by a blood vessel that ruptures and bleeds into the brain. Risk factors for a stroke include smoking, high blood pressure, and cardiac arrhythmias. Treatment of a stroke depends on the cause (Andersen & Townsend, 2015). Ischemic strokes are treated with thrombolytic medication such as tPA to dissolve the clot, whereas hemorrhagic strokes often require surgery to stop the bleeding.

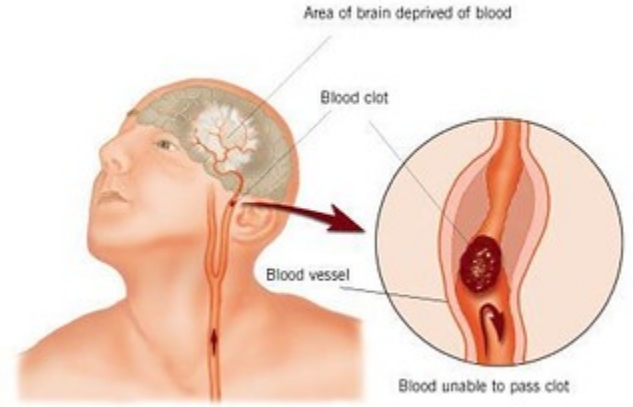
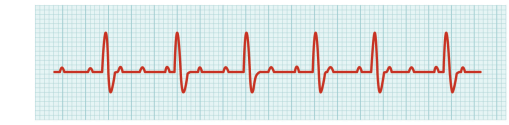


Figure 7.2j Ischemic Stroke

Arrhythmias

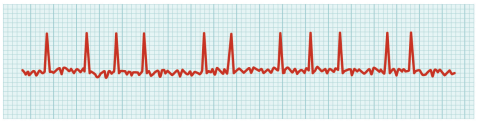
Occasionally, an area of the heart other than the SA node will initiate an impulse that will be followed by a premature contraction. Such an area is known as an ectopic focus. An ectopic focus may be stimulated by localized ischemia, exposure to certain drugs, elevated stimulation by both sympathetic or parasympathetic divisions of the autonomic nervous system, or several diseases or pathological conditions. Occasional occurrences are generally transitory and nonlife threatening, but if the condition becomes chronic, it may lead to either an **arrhythmia**, a deviation from the normal pattern of impulse conduction and contraction, or to **fibrillation**, an uncoordinated beating of the heart. Severe arrhythmias can lead to cardiac arrest, which is fatal if not treated within a few minutes.

Abnormalities that may be detected by the ECGs are shown in Figure 7.2j. Antiarrhythmic medications such as Sotalol, Diltiazem, and Amiodarone are used to treat arrhythmias.



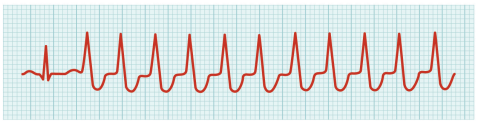
Note how half of the P waves are not followed by the QRS complex and T waves while the other half are.
Question: What would you expect to happen to heart rate (pulse)?

(a) Second-degree (partial) block



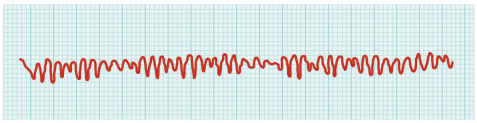
Note the abnormal electrical pattern prior to the QRS complexes. Also note how the frequency between the QRS complexes has increased.
Question: What would you expect to happen to heart rate (pulse)?

(b) Atrial fibrillation



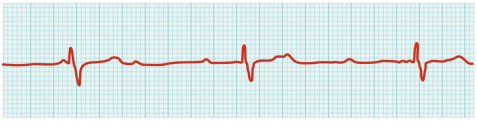
Note the unusual shape of the QRS complex, focusing on the "S" component.
Question: What would you expect to happen to heart rate (pulse)?

(c) Ventricular tachycardia



Note the total lack of normal electrical activity.
Question: What would you expect to happen to heart rate (pulse)?

(d) Ventricular fibrillation



Note that in a third-degree block some of the impulses initiated by the SA node do not reach the AV node while others do. Also note that the P waves are not followed by the QRS complex.
Question: What would you expect to happen to heart rate (pulse)?

(e) Third-degree block

Figure 7.2k Sample arrhythmias: a) In a second-degree or partial block, one-half of the P waves are not followed by the QRS complex and T waves while the other half are. (b) In atrial fibrillation, the electrical pattern is abnormal prior to the QRS complex, and the frequency between the QRS complexes has increased. (c) In ventricular tachycardia, the shape of the QRS complex is abnormal. (d) In ventricular fibrillation, there is no normal electrical activity. (e) In a third-degree block, there is no correlation between atrial activity (the P wave) and ventricular activity (the QRS complex)

Heart Failure

Heart failure (HF) "is a complex clinical syndrome characterized by the heart's inability to pump blood effectively due to structural or functional impairments." (Shams, Malik & Chhabra, 2025). In similar

terms, it is the inability of the heart to pump enough blood to meet the body's needs. It is characterized by ventricular dysfunction, reduced cardiac output, insufficient tissue perfusion and signs of fluid retention (Burchum Rosenjack & Rosenthal, 2019).

Heart failure has remained the leading cause of cardiovascular morbidity and mortality in Canada despite advances in treatment. In Canada, more than 100,000 people are diagnosed with HF each year with over 800,000 currently living with heart failure. These numbers are expected to increase due to the aging population and more people surviving from cardiac conditions such as myocardial infarctions (Almufeh et al, 2025).

Heart failure has previously been classified into two types of heart failure. Right sided heart failure or heart failure with left ventricular (LV) systolic dysfunction is when the right ventricle is too weak to pump enough blood to the lungs, leading to a build up in the veins, increased pressure and volume overload. These clients have fluid back up in the rest of the body with symptoms of fatigue, palpitations, enlarged liver, and jugular vein distention. Left sided heart failure or diastolic HF is when the LV ejection fraction is preserved. The left ventricle can't relax normally because the muscle has become stiff. These clients present with fluid back up in the lungs with symptoms of shortness of breath, cough and fatigue (Informed Health.org, n.d.). Left heart failure is more common.

HF is classified based on left ventricular ejection fraction (LVEF) and clinical staging. Treatment options have evolved and now take into account the broad spectrum of left ventricular ejection fraction from preserved, mildly reduced, reduced or improved LVEF. In this text we will generally discuss standard therapy options for heart failure. According to the Cardiovascular Society of Canada, treatment goals are to prevent further deterioration, treat symptoms and remove the underlying causes if possible (McDonald et al, 2023).

The extent of medications depends on LV dysfunction and clinical presentation. Routine treatment includes three types of drugs:

- Diuretics (thiazide, potassium-sparing, loop)
- Agents that inhibit RAAS (ACE inhibitors, angiotensin II receptor blockers, aldosterone blockers, direct renin inhibitors, angiotensin receptor neprilysin inhibitors)
- Beta blockers (carvedilol, metoprolol)

With more compromised clients with reduced LV dysfunction (EF <40%), quadruple therapy is recommended that includes the following medications:

- ACEi, ARBs or ARNIs
- Beta blockers
- MRAs (mineralocorticoid receptor antagonist)
- Sodium-glucose cotransporter-2 inhibitors (SGLT2i's)

In addition, depending on symptoms, an individualized plan that includes the addition of diuretics, digoxin and other classes of meds (McDonald et al, 2023).

Overall, the management of heart failure has become increasingly complex. Medication advancements are ongoing. Other non-pharmacological interventions to support symptom management include exercise, sodium and fluid restrictions, limiting alcohol and smoking cessation.

Image Description

The renin-angiotensin-aldosterone system image description: The renin-angiotensin-aldosterone system, illustrated in Figure 7.2e proceeds through several steps to produce angiotensin II, which acts to stabilize blood pressure and volume. Renin (secreted by a part of the juxtaglomerular complex) is produced by the granular cells of the afferent and efferent arterioles. Thus, the kidneys control blood pressure and volume directly. Renin acts on

angiotensinogen, which is made in the liver and converts it to angiotensin I. Angiotensin converting enzyme (ACE) converts angiotensin I to angiotensin II. Angiotensin II raises blood pressure by constricting blood vessels. It also triggers the release of the mineralocorticoid aldosterone from the adrenal cortex, which in turn stimulates the renal tubules to reabsorb more sodium. Angiotensin II also triggers the release of anti-diuretic hormone (ADH) from the hypothalamus, leading to water retention in the kidneys. It acts directly on the nephrons and decreases glomerular filtration rate. Medically, blood pressure can be controlled by drugs that inhibit ACE (called ACE inhibitors).

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Media Attribution

- 7.2a Lipid metabolism
- 7.2b "máu nhiễm mỡ – cholesterol" by LÊ VĂN THẢO is licensed under CC BY-SA 2.0 ↵
- 7.2c "2113ab Atherosclerosis.jpg" by OpenStax College is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/20-2-blood-flow-blood-pressure-and-resistance
- 7.2d Monthly check up." by Bryan Mason is licensed under CC BY 2.0 ↵
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- 7.2e Renin-angiotensin-aldosterone system Open Stax College Renin angiotensin found on OER Commons is licensed under a CC BY NC license.
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- 7.2g Deep vein thrombosis formation
- 7.2h Symptom differences between men and women with myocardial infarction
- Modern Heart and Vascular Cardiac Differences Between Women and Men
- 7.2i "A man having a Heart Attack.png" by https://www.myupchar.com/en is licensed under CC BY-SA 4.0 ↵
- 7.2j "Stroke Diagram" by ConstructionDealMkting is licensed under CC BY 2.0 ↵
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7.3 Clinical Reasoning and Decision-Making Related to Cardiac Medications

Assessment and Cues

For just about every health condition, perfusion assessment if a key component, particularly cardiovascular conditions. Prior to giving any cardiac medication, you need a baseline. This will always start with assessing heart rate (rate, rhythm) and blood pressure. For many conditions, you will also want to know capillary refill, skin temperature, skin colour, presence of peripheral edema and heart sounds (S1 S2). As the respiratory function is very much interrelated with the cardiovascular system, assessing respiratory function will also be done. At a minimum, respiratory rate, quality of respirations (depth, work of breathing), oxygen saturations, and chest auscultation.

Mechanism of action of meds is essential to know

Understanding the mechanism of action of a cardiac medication will help a nurse choose the proper assessments to perform on a client. It will also help with understanding therapeutic effects and any adverse effects. It is important for a nurse to complete a full cardiac assessment to fully understand the health status of the client, the safe implementation of the medication, and the expected effectiveness of the medication.

Many cardiovascular drugs alter a client's blood pressure or heart

rate, such as antiarrhythmics, cardiac glycosides, antihypertensives, and diuretics. As mentioned above, it is important for a nurse to assess a client's blood pressure and heart rate prior to administration. For some meds, ECG monitoring may be ordered before a dose, periodically to assess for changes, or continuous monitoring. Medication parameters are often included in the order by a healthcare provider.

Example in Practice

A client, 45 years old, has hypertension. They are ordered metoprolol 100 mg po once a day. The nurse recalls the MOA of beta blockers and that they lower blood pressure and heart rate through blocking beta 1 adrenergic receptors in the heart. The nurse takes the heart rate and blood pressure. The nurse also listens to the apical rate for one minute.

HR 55 bpm, regular. BP 122/68 apical rate 56 bpm, S1 S2 audible.

The nurse holds metoprolol as they recall that the order states to hold the med if HR is less than 60. The nurse completes a thorough assessment, and the prescriber is notified.

Monitoring Labs

Electrolytes can play a large role in cardiac conduction and muscle function. Medications that alter electrolytes, such as Loop diuretics, require a review of laboratory values before administration. Loop diuretics such as furosemide (Lasix) often cause a depletion of potassium. If a nurse administers a loop diuretic to a client who already has low serum potassium levels (called hypokalemia), worsening symptoms of hypokalemia will occur, which can cause life-threatening arrhythmia.

Monitoring kidney function is also important when administering many cardiovascular medications. For example, some diuretics may impact renal function, particularly in vulnerable clients. A nurse should be aware of cardiovascular medications that are affected by impaired renal function or cause renal injury. In addition, a nurse must appropriately assess and report abnormal laboratory values such as worsening serum creatinine and glomerular filtration rates (GFR). It is also important to assess for signs of dehydration, as well as intake and output in client's taking diuretics.

Anticoagulant medications cause serious risk for bleeding that can be life threatening. Prior to administering medication that alters a client's coagulation, it is important to assess for signs and symptoms of unusual bleeding or bruising. Laboratory values, such as International Normalized Ratio (INR), PTT, or platelets, may also require review prior to administering an anticoagulant medication. Any new abnormal lab values or signs of increased bleeding and internal bleeding should be immediately reported.

Implementation

Before administration of any cardiovascular drug, it is vital for the nurse to determine if this cardiac medication is safe for this client

at this time. For example, if the client's heart rate or blood pressure is below the anticipated parameters, the medication should be withheld and the prescribing provider notified.

It is also important to consider the effect of the medication before administering it at the ordered time. For example, if a diuretic is prescribed before a client is sent to a diagnostic test, the test may be disrupted by the need for the client to urinate, and the dosage should be rescheduled for a later time. A more significant safety concern arises when a client who is scheduled for surgery is prescribed aspirin or an anticoagulant. The nurse should consider these types of upcoming events before administering medications as they are ordered.

Evaluation

Evaluate therapeutic response

It is always important to evaluate the client's response to a medication compared to what is expected. Many medications require dose adjustments to produce desired effect. For example, IV heparin is administered based on a protocol that requires dose adjustment based on PTT or aPTT lab results to achieve therapeutic range (and avoid overdosage that can cause life-threatening bleeding). Also, assess for any adverse effects that may have occurred, such as nausea or dizziness, both common effects from cardiac drugs.

Monitoring:

For all cardiac meds, monitor a client's blood pressure, heart rate,

intake and output, edema, or other cardiac assessments to evaluate if the ordered cardiac agents are effective or if further treatment or dosage adjustment is required.

Continually monitor the client for potential adverse effects of the medication. For example, is the client becoming dehydrated following the diuretic furosemide? Are they developing muscle cramps and tingling in their feet, both signs of hypokalemia from diuresis? Is there labs that should be done to ensure the client is within normal limits, for example ordering electrolytes? Some adverse effects can be life threatening and require prompt notification to the prescribing provider.

Client teaching

Does the client understand the purpose of the medications? Assess for basic understanding of what the drug does or is used for, for example, "this med will lower my blood pressure." Make sure they know how to take the med correctly (with or without food, morning or bedtime), as well as common side effects. Lastly, they should know when to return for follow up appointments, and when to notify their provider of changing symptoms. Additional client education before discharge home is always required, especially if new medications are prescribed.

7.4 Perfusion and Renal Elimination Medications

If you have not done so already, be sure to read the "Review of Basic Concepts" section earlier in this chapter. To truly understand the mechanism of action of various cardiovascular and renal system medications and their potential adverse effects, it is vital to have a solid understanding of the anatomy and physiology underlying the cardiovascular system.

The remaining sections of this chapter will review classes of medications related to cardiovascular and renal systems, including administration considerations, therapeutic effects, adverse/side effects, and client education. Medication cards are intended to assist students to learn key points about each medication class. Basic information related to a common generic medication in this class is outlined, including administration considerations, therapeutic effects, and side effects/adverse effects. These med cards are editable, so download them and add information to help your understanding. They are intended as a starting point.

Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Within each unit, you will find a downloadable and editable medication cards or tables to help with your learning. These are located at the end of most of the units.

7.5 Antiarrhythmics

Antiarrhythmics

An arrhythmia is any deviation from the normal rate or pattern of a heartbeat. This includes heart rates that are too slow (bradycardia), too fast (tachycardia), or irregular. The terms dysrhythmia (disturbed heart rhythm) and arrhythmia (without rhythm) are traditionally used interchangeably in clinical practice despite their difference in meaning.

The ECG is used to identify and monitor an arrhythmia. See more information about ECGs in the "Review of Basic Concepts" section and an overview of arrhythmias in the "Common Cardiac Disorders" section.

Antiarrhythmic medications regulate heart rate and rhythm by manipulating the conduction of electrical signals to change the heart rate or to attempt to revert an arrhythmia to a normal sinus rhythm. Treating the arrhythmia depends on the symptoms the client is experiencing and the potential severity. The treatment is directed at the cause and antiarrhythmic medications is one treatment option. Depending on the rhythm and severity, other treatments include cardioversion, pacemakers, catheter ablation and implantable defibrillators.

All antiarrhythmic medications have a risk of producing an arrhythmia so careful monitoring is required. This can include continuous or intermittent ECG analysis, blood pressure, heart rate, and other physical changes such as chest pain, respiratory status (SOB, dyspnea, lung sounds, hypoxia), neurological changes (LOC, syncope, confusion) and fluid status. Some antiarrhythmic medications are used during emergency situations such as cardiac arrest, whereas others are used long-term, such as those that control atrial fibrillation.

Most antiarrhythmic drugs are grouped into 4 main classes (Vaughan Williams classification) based on their dominant cellular electrophysiologic effect or mechanism of action (Merck Manual, 2023). Some drugs have more than one mechanism of action and fit into more than one category.

Vaughan Williams Classification of Antiarrhythmic Drugs

Drs. Singh and Vaughan Williams developed the classification system in 1970. It classifies antiarrhythmic drugs based on their dominant cellular electrophysiologic effect. The four classes of drugs also have subclasses (1A, 1B etc). Due to the evolving understanding of physiology and the development of new drugs, this drug classification system has some limitations. Some drugs are not included, and many drugs could fit into more than one class due to having more than one mechanism of action. For example, amiodarone, a class III drug, also has sodium and calcium-channel blocking actions. Some revisions have occurred to reflect current research. Despite its limitations, it is the classification system that is still predominately used.

Vaughan Williams Classification of Antiarrhythmic Drugs

Class	Action/ Drug	Mechanism of Action
I	Sodium channel Blockers Ia: Quinidine, Procainamide Ib: Lidocaine, Phenytoin Ic: Propafenone, Flecainide	Sodium channel blockers (membrane-stabilizing drugs). Block fast sodium channels and slow conduction in fast-channel tissues (working atrial and ventricular myocytes, His-Purkinje system). Class I drugs are subdivided into subclasses Ia, Ib, and Ic.
II	Beta Blockers Acebutolol Propranolol Sotalol	Affect sinoatrial [SA] and atrioventricular [AV] nodes. Action: decrease rate of automaticity, slow conduction velocity, and some prolonging of refractoriness.
III	Potassium channel blockers Amiodarone, Sotalol	Prolong action potential duration and refractoriness in slow- and fast-channel tissues.
IV	Calcium channel blockers Verapamil, Diltiazem	Non-dihydropyridine calcium channel blockers. Action: depress calcium-dependent action potentials in slow-channel tissues resulting in a decrease the rate of automaticity, slow conduction velocity, & prolong refractoriness.

V	Adenosine	Diagnose and terminate SVT

Class I – Sodium Channel Blockers

Class I antidysrhythmic medications slow conduction and prolong depolarization by decreasing sodium influx into cardiac cells. There are three subgroups of sodium channel blockers: Class IA, IB, and IC. Procainamide is an example of a Class IA antidysrhythmic. Lidocaine is an example of a Class IB medication that is also used as a local anesthetic. Flecainide is an example of a class IC antidysrhythmic.

Mechanism of Action

Sodium channel blockers block fast sodium channels, by slowing the conduction and prolongs depolarization by decreasing sodium influx into cardiac cells. The conduction rate and automaticity are decreased. They work on atrial and ventricular myocytes and His-Purkinje system. On an ECG, you will see a widening of the P wave or QRS complex, prolonged PR interval or a combination (Merck Manual, 2023). The different subclasses of class I drugs, relates to the kinetics of the sodium channel effects based on the heart rate.

Class IA drugs have intermediate kinetics, so their fast-channel tissue conduction slowing effects may or may not have an effect on normal rhythm at a normal rate. Class IA drugs block repolarizing potassium channels, prolonging the refractory periods of fast-channel tissues. On the ECG, the QT-interval will be prolonged even at normal rates. This class of drugs are used for fast rhythms such as supraventricular tachyarrhythmias (atrial fibrillation, atrial

flutter, atrial tachycardia) and ventricular tachyarrhythmias (ventricular tachycardia and ventricular fibrillation)

Class IB drugs have fast kinetics, so their effects are only on fast heart rates. They have minimal effects on atrial tissue. They are used to suppress ventricular tachyarrhythmias such as ventricular tachycardia or ventricular fibrillation.

Class IC drugs have slow kinetics, and their effects are evident with all heart rates. They are more potent than class IB antiarrhythmics. They are used for both atrial and ventricular tachydysrhythmias (atrial fibrillation, atrial flutter, ventricular tachydysrhythmias).

This can help explain why physicians may choose one drug class over another when treating a dysrhythmia.

Indications for Use: Procainamide

Depending on the subclass, the use will be different as outlined above. We will examine class 1a drug Procainamide in this unit.

Procainamide is used for chemical cardioversion in treating atrial flutter and atrial fibrillation, in terminating ventricular tachycardia, supraventricular arrhythmias, and in restoring sinus rhythm in Wolf-Parkinson-White syndrome (Patel & Goyal, 2024).

Nursing Considerations

Administration:

- Procainamide is given IV or PO with the onset of action in 10 to 30 minutes.
    - IV: can be given IV direct or infusion. A loading dose of IV procainamide is 10 to 17 mg/kg and administered at a rate

of 20 to 50 mg/min (100 mg q 5 minutes). A maintenance dose would follow.
    - Oral: for supraventricular arrhythmia, based on weight and given in divided doses every 6 hours. For example: 50 mg/kg/24 hours divided into doses every 6 hours. Do not crush extended-release tablets.

Metabolized by the liver and renally excreted. Half-life is 3 hours.

Monitoring:

- Continuous ECG monitoring. Assess for heart block, PVCs, greater than 50% QRS widening.
- Monitor blood pressure. If greater than 15 mmHg drop, notify MD.
- During IV administration: client on bedrest to avoid hypotension.
- Monitor CBC, platelets, electrolytes
- Monitor urine output

(Vallerand & Sanoski, 2024)

Sodium channel blockers are contraindicated in clients who have a history of thrombocytopenia, myasthenia gravis or electrolyte imbalances (particularly hypokalemia and hypomagnesemia)

Use cautiously with clients who have a serious heart block rhythm and do not have an artificial pacemaker, such as a 2nd degree heart block.

There is an increased risk for toxicity with clients who have heart failure and renal or hepatic dysfunction due to drug accumulation. Dose reduction for renal impairment and up to 50% dose reduction with liver disease.

Children: can be given but safety not fully evaluated.

Pregnancy: crosses the placental barrier

Grapefruit juice should be avoided by clients taking this medication.

Drug Interactions:

These drugs interact with many drugs, including cardiac glycosides, cimetidine, anticonvulsants, nifedipine, and warfarin. A complete med profile is needed before initiating therapy.

Adverse/Side Effects

Side effects:

- Hypotension
- Nausea, vomiting, diarrhea
- Fever
- Premature ventricular contractions (PVCs)

Adverse Effects:

Adverse effects include cardiac toxicity, bradycardia, drug-induced lupus erythematosus-like syndrome, and blood dyscrasias.

- Cardiac side effects: QRS, QTc, and PR prolongation which can worsen when levels of procainamide rise. Can lead to torsade's de pointes. ECG monitoring is important during treatment. Procainamide infusion may also increase the number of PVCs.
- Drug-induced lupus erythematosus-like syndrome (rare): can occur with chronic use.
- Blood dyscrasias (rare): bone marrow depression, leading to

pancytopenia or agranulocytosis, thrombocytopenia.

(Pritchard & Thompson, 2023)

Client Teaching

- Instruct client to take med exactly as prescribed
- Take with food to minimize GI upset
- Monitor pulse and blood pressure as recommended
- Report any fever, joint pain or rash to their health care provider
- Report immediately any shortness of breath, signs of bleeding, bruising, persistent headache.
- May experience dizziness so take precautions to avoid falls.
- Inform prescriber if you are pregnant or plan to become pregnant
- Caution with using CNS depressants such as alcohol, may contribute to dizziness. Avoid caffeine and tobacco.

(Medline Plus, 2026)

Class II – Beta Adrenoreceptor Antagonists (Beta Blockers)

Beta blockers are used widely for cardiovascular disorders. They are commonly used as first-line antiarrhythmic therapy because of their excellent safety profile and effectiveness in treating ventricular arrhythmias. In the heart, they are used to decrease conduction velocity, automaticity, and the refractory period of the cardiac conduction cycle. Beta blockers can be used for many

cardiovascular issues such as heart failure, arrythmias, myocardial infarction, hypertension and angina.

Non-selective Beta-1 and Beta-2 include labetalol, propranolol, timolol, carvedilol, and sotalol. Selective Beta-1 drugs include acebutolol, metoprolol, bisoprolol and esmolol. Each med is used for slightly different purposes. For example, propranolol is used for many conditions such as hypertension, heart failure, MI, and arrythmias, whereas sotalol is used mostly for arrhythmias (Kabunde, 2023).

Beta-1 selective medications, such as metoprolol, that are used to treat hypertension will be reviewed in the Antihypertensive section later in this chapter.

Recall… sympathetic adrenergic nerves release norepinephrine (NE) and epinephrine. Beta receptors bind NE that is released from sympathetic adrenergic nerves and also binds to NE and epinephrine that is circulating in the blood.

- Increases heart rate and blood pressure – this increases cardiac output and workload of the heart.
- Increases strength of heart contractions – this helps increase cardiac output
- Bronchodilation – bronchioles will dilate so breathing is easier and more oxygen enters the blood. More oxygen is needed as the myocardium needs it for this nervous system response
- Increases blood sugar – for energy via glycogenolysis in the liver.

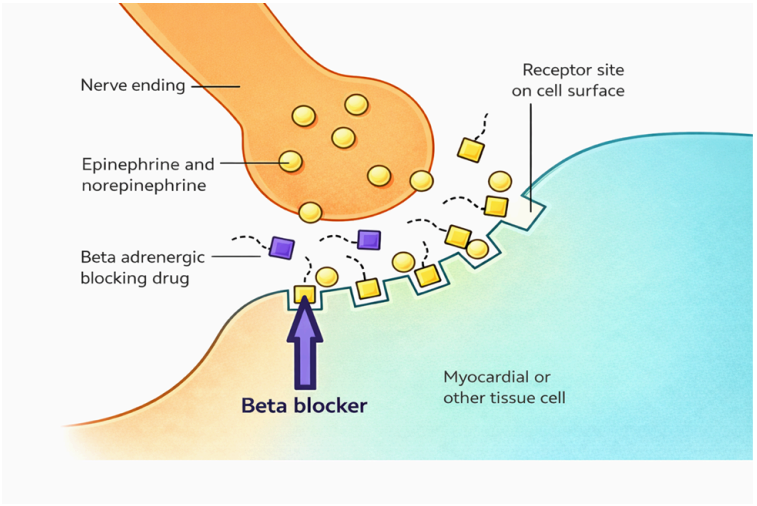
Beta blockers will block many of these actions by

competing for the binding site on beta-adrenergic nerves. This is helpful for conditions where the workload of the heart needs to be decreased or the heart is beating too fast.

Mechanism of Action

Non-selective beta-adrenergic antagonists block both beta-1 and beta-2 receptors. An example is propranolol. They will target the heart, kidneys, and lungs as well as the GI system and vascular smooth muscle. In the heart, they decrease the rate of automaticity, slow conduction velocity and prolong refractoriness. This results in a slower heart rate, PR interval lengthened, and the AV node transmits rapid atrial depolarizations at a lower frequency (Merck Manual, 2023).

Beta-1 adrenergic antagonist, as its name implies, selectively blocks only the beta-1 receptors so the effects are specific to cardiac cells. An example is metoprolol.



7.5a Beta adrenergic blocker mechanism of action (Sheila Odubote/TRU Open Press, adapted from MU Science Blog, 2010).

Our prototype medication will be sotalol. Sotalol is also a Class III antiarrhythmic with potassium channel blocking abilities and also has beta-adrenergic blocker properties.

Indications for Use

Class II drugs are used primarily to treat supraventricular tachycardias and to slow the ventricular response rates with atrial fibrillation or atrial flutter. Sotalol specifically is used for hemodynamically stable ventricular tachycardia and maintaining sinus rhythm is paroxysmal atrial fibrillation (Mubarik, Patel & Cassagnol, 2024).

Nursing Considerations

Administration: Oral or intravenous. Slow IV infusion to avoid hypotension. Peak effects for both IV and oral routes are similar, with oral route 2-3 hours and IV route 2 hours. Oral route BID dosing.

Oral administration – food or antacids will decrease absorption by up to 20%. Give on empty stomach

Pre-Treatment:

- Obtain full medical history and med profile.
- Baseline ECG, blood pressure and heart rate. If QTc is greater than 450 ms, drug will be held.
- Labs: renal (creatine clearance), electrolytes (normal se magnesium and potassium levels). If renal insufficiency, avoid using this med (Merck Manual, 2023).

Monitor:

- Monitor ECG and blood pressure. ECG assessed prior to therapy and 2-4 hours after each dose. Assess for QT prolongation.
- Apical pulse prior to dose. If less than 50 bpm, hold the med and consult with the prescriber. Check agency policy or orders for parameters with holding the med.
- Monitor electrolytes. Contraindicated with hypokalemia. Magnesium and potassium may be administered if low. May increase potassium levels and uric acid levels.
- Monitor blood glucose levels, may cause hyperglycemia.
- Anticipate client in the hospital for 2-3 days during dosage adjustments

- Monitor intake/urine output and daily weights. Assess for fluid overload (dyspnea, crackles, edema).

Contraindicated with bradycardia, 2nd or 3rd degree heart block, heart failure or conditions that lead to bronchospasm. Also, contraindicated with labile diabetes due to hypoglycemic effects.

Drug Interactions: calcium channel blockers, digoxin, clonidine.

Older adult: if renal insufficiency, dosage reduction required.

Genetic differences: some clients with Asian heritage metabolize and excrete propranolol faster and are also more sensitive to the drug. Caution with overdosage. Dose reduction of up to 50% and closer monitoring for adverse effects (Adams et al, 2019).

Adverse/Side Effects

Side effects:

- CV: Bradycardia, dizziness, fatigue, palpitations, cold hands/feet.
- Resp: Bronchospasm (contraindicated In clients with asthma)
- Other: hypoglycemia, thyroid abnormalities, erectile dysfunction

Adverse Effects:

- Bradydysrhythmias, heart failure, pulmonary edema

High Alert Med: This drug can cause arrhythmias. This medication lengthens a client's QTc interval. Initiation of this medication requires a client to be in a facility to determine baseline QT and intermittent QT interval checks. QT interval checks are done 2-4

hours after each dose. If the QT corrected interval is greater than 500 msec, the dosing must be changed. Risk of Torsade de Pointes or new ventricular tachycardia/ fibrillation (Mubarik, Patel & Cassagnol, 2024).

Client Teaching

- Clients should be instructed regarding the significance of compliance with therapeutic drug regimens and should take medications as prescribed, even if not symptomatic.
- Clients or family members may need instruction on how to take pulse rate and blood pressure. They should receive parameters regarding reporting to their healthcare provider. They should report any pulse rate less than 50 bpm and significant changes in blood pressure.
- Inform client that meds can cause dizziness and visual changes. Clients may also notice orthostatic blood pressure decrease with position changes and should be advised to change positions slowly. If the client notices irregular, fast heart rate or experiences any fainting episodes, they should notify their healthcare provider immediately.
- May also mask the signs of hypoglycemia (no tachycardia or elevated BP), so diabetic clients must use extra caution to monitor for low blood sugar.
- Inform client of potential side effects, such as increased cold sensitivity.
- Inform health care provider if plan to take any new meds including OTC or herbal supplements.
- Do not abruptly discontinue med.

Unbound Medicine, n.d.; Vallerand & Sanoski, 2024.

Metoprolol Medication Card

Now let's take a closer look at the medication card for metoprolol. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Metoprolol Medication Card

<table>
<tr><td>Class:
Antihypertensives – Beta-1 Antagonist (Beta Blocker)

Prototype:
Metoprolol</td><td colspan="3">Indications:
• Hypertension
• Chest pain related to poor coronary blood flow
• Tachycardia and rapid arrhythmias
• Early intervention in myocardial infarction to reduce cardiac workload</td></tr>
<tr><td colspan="4">Mechanism of Action:
Metoprolol selectively blocks beta-1 receptors in the heart, resulting in decreased heart rate, decreased myocardial contractility, and lowered blood pressure. At higher doses, beta-2 receptor blockade may occur, potentially causing bronchoconstriction.</td></tr>
<tr><td>Administration:
Do not crush tablets
Give on empty stomach

Assess heart rate; hold medication if HR < 60 bpm

Take at the same time every day as prescribed</td><td>Side Effects:
• Fatigue
• Dizziness
• Depression
• Insomnia
• Nightmares
• GI upset
• Erectile dysfunction
• Dyspnea
• Wheezing
• Cold sensitivity

SAFETY:
• Taper dose gradually over several weeks
• Abrupt discontinuation may cause chest pain or myocardial infarction</td><td>Contraindications:
Asthma or reactive airway disease

Higher doses may block beta-2 receptors causing bronchoconstriction and cough

Do not give if bradycardia, heart block or HF</td><td>Nursing Considerations:
Monitor BP and HR daily. Hold if HR less than 60 bpm, or SBP less than 90, notify Dr

Masks symptoms of hypoglycemia

Monitor blood glucose closely in diabetic patients

Monitor lytes, avoid hypokalemia.</td></tr>
</table>

Downloadable file (.docx): Metoprolol Medication Card

Class III – Potassium Channel Blockers

Class III medications prolong repolarization by blocking the potassium channels in cardiac cells that are responsible for repolarization. They are used for emergency treatment of tachydysrhythmias. Amiodarone is an example of an antidysrhythmic that has predominantly Class III properties. Sotalol is also considered a class III med, with class II properties.

Mechanism of Action

Class III medications prolong repolarization by blocking the potassium channels in cardiac cells that are responsible for repolarization. By prolonging the refractory period, the QT interval is prolonged and makes the cell less excitable. They suppress tachyarrhythmias caused by re-entry mechanisms resulting in stabilization of the dysrhythmia (Klabunde, 2023).

Reentry Mechanisms in the heart

In very simple terms, reentry circuits are a condition due to a change in heart signaling. It is impaired conduction in the heart that can occur in a small region of the heart (local reentry) or it can occur between the atria and ventricles (global reentry). It can lead to very fast heart rates. Antiarrhythmic drugs or electrical cardioversion are given to alter the effective refractory period or conduction velocity or to eliminate reentry mechanisms.

To help understand this concept, watch the video: Cardiology: Re-entry Circuits #cardiology #ubcmedicine [9:02] by UBC Medicine – Educational Media (2017) on YouTube.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=203#oembed-1

Our prototype medication will be amiodarone. Amiodarone also has sympatholytic, sodium and calcium antagonistic properties that decrease AV sinus node conduction (Patel & Goyal, 2024). It inhibits adrenergic stimulation.

Indications for Use

Amiodarone is used for many tachydysrhythmias that have not responded well to other antiarrhythmics. It is used for ventricular tachycardia, including ventricular fibrillation; atrial fibrillation and flutter. It is the medication most commonly used for atrial dysrhythmias in clients with heart failure. It suppresses the arrythmia by 1. slowing the sinus rate, 2. increasing the PR and QT intervals, 3. decreasing peripheral vascular resistance, leading to vasodilation.

Pharmacokinetics:

Amiodarone is absorbed in the GI tract slowly. It is highly protein bound, distributed and accumulates in body tissues. It is metabolized by the liver and almost completely excreted in the bile. It has a very long half-life of 13-107 days.

Nursing Considerations

Administration: oral, IV or intraosseous (children). Depending on the rhythm (severity and type), oral or IV administration will be initiated.

- Oral: onset of action is 2-3 days, with a slow variable onset and a peak effect of 1-3 weeks. Duration of action can be months due to its long half-life. Give with meals to minimize GI upset.
- IV: onset of action is 2 minutes, with a peak effect 20 minutes. Typically, a loading dose (150 mg IV over 10 minutes) is followed by a continuous infusion (540 mg over the next 18 hours). The continuous infusion is then followed by oral administration. Amiodarone solution mixed in a glass bottle or polyolefin bottle to prevent absorption. IV tubing needs an in-line filter.

Pre-Treatment:

- Obtain full medical history and med profile.
- Labs: electrolytes (potassium, calcium and magnesium), liver panel and thyroid function. Correct hypokalemia and hypomagnesemia before therapy initiated.
- Baseline ECG, blood pressure and heart rate.

- Continuous ECG monitoring should be initiated.

Monitor:

- Monitor ECG continuously during IV therapy or initiation of oral therapy. Assess for rate and rhythm changes such as PR interval prolongation, slight QRS widening, T wave reduction or QT prolongation.
- Report any bradycardia or increase in arrythmia immediately. Rate reduction or discontinuation of drug may be required.
- Monitor blood pressure. Hypotension may occur in the first few hours after initiating therapy.
- Monitor electrolytes. Hypomagnesemia, hypokalemia or hypocalcaemia can decrease med effectiveness.
- Monitor liver function: if AST and ALT three times above normal, dose reduction likely.
- Assess respiratory function: report dyspnea, tachypnea, or crackles
- Long term: monitor thyroid function tests, assess for pulmonary conditions (interstitial pneumonitis), vision changes.

Pregnancy: Amiodarone can cause fetal injury when administered to a pregnant client.

Older Adult: Use cautiously in clients with decreased hepatic or cardiac function.

Drug Interactions:

Read drug label information carefully due to several potential drug interactions.

- Increases risk of increased QT prolongation with macrolides,

fluoroquinolones
- Increases effects of digoxin 2-3-fold and other cardiac meds (i.e. Lidocaine)
- Increases effects of warfarin. Warfarin dosing should be decreased and INR monitored closely.
- St John's Wort: may decrease the effects of amiodarone by inducing CYP enzymes that metabolize it in the GI tract. Avoid St John's Wort.
- Grapefruit juice will inhibit metabolizing enzymes in GI tract. Avoid use while on amiodarone.

Caution use with clients with heart failure, thyroid disease, coronary refractive laser surgery, severe pulmonary or liver disease. (Adams et al, 2018; Kelly & Morgan, 2023; Vallerand & Sanoski, 2024)

Adverse/Side Effects

Side effects:

- Corneal microdeposits, photosensitivity, vision changes
- Neuro: tremor, confusion, dizziness, fatigue, peripheral neuropathy, poor coordination, gait issues.
- CV: bradycardia, hypotension
- GI: anorexia, constipation, nausea

Adverse Effects:

High Alert Med: Amiodarone has several fatal toxicities such as pulmonary toxicity, exacerbation of arrhythmia, liver injury, and

heart block. Clients who require initiation of this therapy should be hospitalized and monitored closely in a critical care area.

Acute respiratory issues such as pulmonary fibrosis and acute respiratory distress syndrome. Frequent assessment for pulmonary toxicity (crackles, decreased breath sounds, pleuritic friction rub, fatigue, cough, hypoxia). Chest Xray q 3-6 months while on long term therapy.

CV: AV heart block, Prolonged QT interval (with potential for Torsade's des Pointes)

(Adams et al, 2018; Kelly & Morgan, 2023; Vallerand & Sanoski, 2024)

Client Teaching

- Clients should be advised to closely follow the recommended dosing regimen. If one dose of medication is missed, the client should follow the normal dosing schedule and resume with the next dose. If more than one dose of medication is missed, the client should call the healthcare provider for guidance.
- Clients should be compliant with all follow-up appointments and monitoring.
- Monitor pulse daily. Report any changes.
- Clients should avoid drinking grapefruit juice during medication therapy.
- Some clients may experience photosensitivity and protective measures should be taken such as protective clothing and sunblock up to 4 months after therapy discontinues.
- Inform client of potential side effects and report to their health care provider any changes. Side effects may not appear for days, weeks or months.

Amiodarone Medication Card

Now let's take a closer look at the medication card for amiodarone. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Amiodarone Medication Card

Class: Antiarrhythmic, Class III: Potassium channel blockers **Prototype:** Amiodarone		**Indications:** tachydysrhythmias that have not responded well to other antiarrhythmics. Used for: ventricular tachycardia, including ventricular fibrillation; atrial fibrillation & flutter. Restores sinus rhythm.	
Mechanism of Action: Acts on myocardial depolarization and also repolarization. It blocks potassium, sodium and calcium channels as well as beta- and alpha-adrenergic receptors. By prolonging the refractory period, the QT interval is prolonged and makes the cell less excitable. It suppresses the arrythmia, by slowing the sinus rate, increasing the PR and QT intervals, and decreasing peripheral vascular resistance, leading to vasodilation.			
Administration: Oral: BID at regular times. Give with meals. IV: loading dose, then slow infusion for short term treatment. Long duration of action, can be months.	**Side Effects:** Neuro: tremor, confusion, dizziness, fatigue, peripheral neuropathy, poor coordination, gait issues. CV: bradycardia, hypotension GI: anorexia, constipation, nausea Corneal microdeposits, photosensitivity, vision changes (halos, blurred vision) ACUTE Respiratory issues: wheezing, SOB, fatigue, cough Thyroid issues: decreased tolerance to heat or cold SAFETY: Can have fatal toxicities and multiple drug interactions	**Contraindications:** Use cautiously with older adults with diminished hepatic, renal or cardiac function Drug interactions such as Digoxin, Warfarin, Simvastatin, Sildenafil, Cyclosporine, Quinidine, and propafenone, Quinolones and Antidepressants Avoid drinking or eating grapefruit juice as it interacts with metabolism	**Nursing Considerations:** Continuous ECG monitoring during IV admin. Monitor BP, HR Assess Lytes, LFTs Correct hypokalemia and hypo magnesia before therapy. Long term therapy: assess thyroid function Remind to use sunblock to prevent sun burns

Downloadable file (.docx): Amiodarone Medication Card

Class IV – Calcium Channel Blockers

The class IV antiarrhythmics, calcium channel blockers, are widely used for cardiovascular disorders. These medications increase the refractory period of the AV node by slowing the influx of calcium ions, thus decreasing the ventricular response and the heart rate.

Calcium channel blockers can be divided into two distinct classes: one that blocks calcium channels in the heart, called non-dihydropyridines (verapamil, diltiazem) and the other that blocks calcium channels in the vascular smooth muscle, dihydropyridines (amlodipine, nifedipine). In this unit, we will examine the class that effects the heart and is used as an antiarrhythmic to control supraventricular tachycardias.

Later in this chapter, we will examine calcium channel blockers that relax the vascular smooth muscle and is used for hypertension. See the "Anti-hypertensives" section later in this chapter for more information.

Mechanism of Action

Diltiazem and verapamil both have a greater affinity to cardiac conduction cells. They decrease conduction velocity and slow the conduction through the AV node by binding to the L-type calcium channels on cardiac myocytes and cardiac nodal tissue. These channels regulate the influx of calcium into cells which stimulates muscle contraction and has a role in pacemaker currents and phase 0 of action potentials. When these calcium channels are blocked, the results are decreased myocardial force contractility (negative inotropy), decreased heart rate (negative chronotropy), and

decreased conduction velocity (negative dromotropy), particularly at the atrioventricular node (Klabunde, 2023).

In this unit, our prototype drug will be diltiazem.

Indications for Use

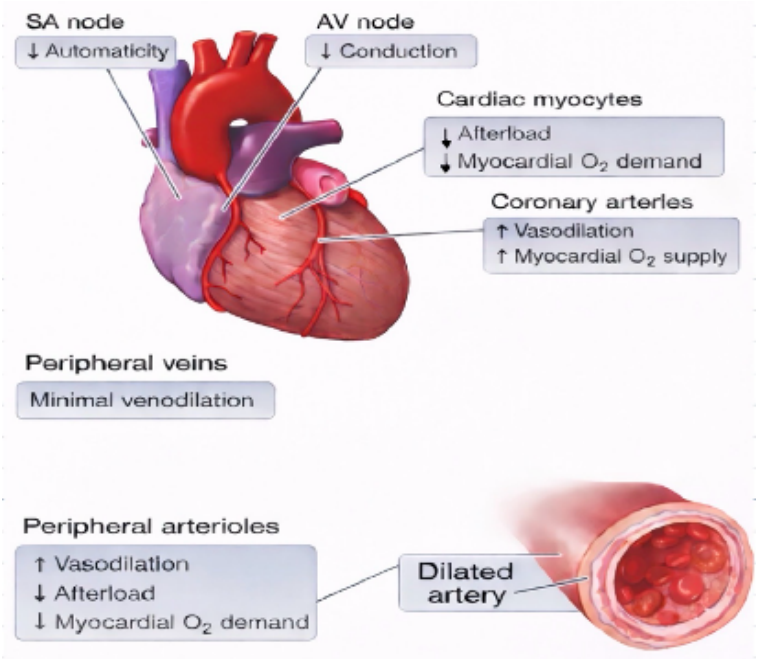
Both diltiazem and verapamil are both equally effective. Both are used to treat arrhythmias such as acute and chronic atrial fibrillation and atrial flutter, and other supraventricular tachycardias. Verapamil is more selective to the myocardium and is less effective as a systemic vasodilator drug. It is effective in treating angina (reversing coronary vasospasm and reducing myocardial oxygen demand) and treating arrythmias.

Diltiazem has more vasodilator actions, so it is also be used for hypertension (Klabunde, 2023). Other uses are to treat Raynaud's syndrome, angina pectoris prophylaxis, migraine prophylaxis and pulmonary hypertension (Talreja & Cassagnol, 2023).

Calcium Channel Blockers:

Non-dihydropyridines: diltiazem and verapamil

Cardiac Effects	**Vascular Effects**
↓contractility	Smooth muscle relaxation Vasodilation – ↓afterload, ↓myocardial oxygen demand Venodilation – minimal venous tone effects
↓heart rate	slows the heart rate
↓conduction velocity	the speed of the electrical impulses that travel through the heart will be slower.



7.5b non-dihydropyridines calcium channel blockers block the movement of calcium into heart and blood vessel muscle cells, resulting in vessel relaxation (vasodilation) and reducing heart rate and contractility (Sheila Odubote/TRU Open Press)

Nursing Considerations

Administration: oral and IV.

- Oral: Immediate release (IR), ER, CR formulas. IR onset of action 30-60 minutes.
- Metabolized by P450 enzymes and an inhibitor on CYP3A4, so drug interactions possible.

No dose adjustments for renal insufficiency. Use cautiously with hepatic disease, anticipate dose adjustment.

Avoid with clients with hypotension (<SBP 90), acute myocardial infarction, conduction defects or clients with 2nd or 3rd-degree heart block or sick sinus syndrome.

Do not give concurrently with beta blockers as both meds depress cardiac electrical and mechanical activity.

Monitor:

- blood pressure before and after dose for hypotension.
- heart rate and ECG. Hold dose if apical rate lower than 50 bpm or per orders. Assess for ECG changes.
- Assess for chest pain: precipitating factors, quality, radiation, location, duration, severity.
- Assess for adverse effects such as signs of heart failure (SOB, edema, fatigue)

Adverse/Side Effects

Side effects: peripheral edema, bradycardia, dizziness, headache, and fatigue.

Adverse Effects: congestive heart failure, myocardial infarction, and hepatotoxicity.

- It can worsen signs and symptoms of heart failure due to the negative inotropic effect. Clients may experience bradycardia, worsening 1st degree AV block, syncope, hypotension.

(Talreja & Cassagnol, 2023)

Client Teaching

- Clients should be advised to closely follow the recommended dosing regimen.

- Clients or family members may need instruction on how to take a pulse rate and should report any pulse less than 50 bpm.
- Clients should also be advised that this medication may cause dizziness and visual changes.
- Clients may also notice orthostatic blood pressure decrease with position changes and should be advised to change positions slowly.
- Clients should be advised to avoid grapefruit juice during medication therapy.
- They should also monitor for gingival sensitivity and be sure to maintain good oral hygiene.
- Clients may also notice increased photosensitivity and should take protective measures.

To help with comparing the medications and to learn important considerations for each medication, refer to the Chapter 7 CV Medications anti-arrythmics and anti-anginals

Clinical Reasoning and Decision Making Learning Activities

A client has been started on a beta blocker: metoprolol a few months ago. What will be important assessments to evaluate the effectiveness of this med?

1. A client is taking a beta blocker: propranolol for hypertension and they are now prescribed sulfonylurea as an additional diabetic treatment. Which is the best response to this treatment plan: (Choose the best answer)

    a. Propranolol will suppress the insulin release

from the pancreas, and thereby decrease the sulfonylurea effect. The dose will need to be increased.

b. Taking both meds will have a synergistic effect as they both have an effect on the pancreas, so decrease both dosages.

c. Taking both meds will have little effect, except monitor blood sugar levels more closely.

d. There is no concern with taking either of these medications except increased nausea if taken together.

2. A patient is prescribed a Calcium Channel Blocker Non-D: verapamil. The nurse completes an assessment prior to administering the medication. What assessment finding would lead the nurse to hold the med and contact the prescriber?
3. The nurse is providing some health teaching for a client taking a calcium channel blocker: Verapamil. What would be important dietary information the client should be aware of?
4. A nurse is administering amiodarone with a client in ventricular tachycardia. What is an expected finding?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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Media Attributions

- 7.5a Beta adrenergic blocker mechanism of action is adapted by Sheila Odubote, TRU Open Press, from MU Science Blog, 2010.
- 7.5b non-dihydropyridines calcium channel blockers effects on the heart and blood vessels is adapted by Sheila Odubote, TRU Open Press.

7.6 Cardiac Glycosides

Cardiac Glycosides

Digoxin is a cardiac glycoside medication that has been used for centuries to treat heart failure. It is derived from the foxglove plant Digitalis lanata. Currently it is one of the few positive inotropic drugs we see in practice. It is only used when first line treatments are not effective due to other drug's having a higher safety profile and less adverse effects. It is mostly used to treat mild-to-moderate heart conditions, such as heart failure and chronic atrial fibrillation (David & Shetty, 2024).

Mechanism of Action

Digoxin exerts its effects through two mechanisms of action.

1. Positive inotropic effect: Digoxin works by inhibiting the sodium and potassium pump, which results in an increase in intracellular sodium and an influx of calcium into cardiac cells, causing the cardiac muscle fibers to contract more efficiently and increase cardiac output (McCuistion et al, 2018).
2. AV node inhibition: Digoxin stimulates the parasympathetic nervous system, slowing the conduction through the AV node, and reducing heart rate (David & Shetty, 2024).

Watch this short video to understand the MOA of digoxin:
Dr. Matt & Dr Mike (2017). Digoxin – Mechanism of Action
https://www.youtube.com/watch?v=Xm0vsJ8IU9c

Digoxin has three effects on heart muscle:

- positive inotropic action (increases contractility, stroke volume and, thus, cardiac output),
- negative chronotropic action (decreases heart rate), and
- negative dromotropic action (decrease conduction of cardiac cells).

The inotropic effect of digoxin supports improving the heart's ability to pump with more strength, but it is important to understand that being on digoxin too long can cause more heart failure. Imagine that you have an elastic hairband; eventually, as you stretch it repeatedly over time, it either loses its elasticity, or it breaks. The heart can only take so much force of contraction for so long before the stretch becomes exacerbated. Digoxin, although groundbreaking for heart failure, should really be saved for use closer to end stage heart failure to support the heart in the final stages (McCuistion et al, 2018).

Indications for Use

This medication is used as second-line treatment for clients who have heart failure or chronic atrial fibrillation. Digoxin is beneficial with heart failure with reduced ejection fraction of less than or equal to 40%. It is used as adjunct therapy in symptomatic heart failure despite optimal treatment. It is used for rate control in atrial fibrillations when other therapies have not been successful (David & Shetty, 2024).

Due to the risk for digoxin toxicity, the clinical use of digoxin has decreased as other medications are being used that have a higher safety profile and less adverse effects.

Pharmacokinetics

When digoxin is administered orally, it has a high bioavailability of 75%. The efficacy is reduced if taken with high-fiber foods. It is extensively distributed throughout the body, with the ability to cross the blood brain barrier and placental barrier. Digoxin is eliminated by the kidneys with a half life of 36 to 48 hours. Renal failure can prolong the half life due to lower drug clearance (David & Shetty, 2024).

Nursing Considerations

Administration: oral, IV, IM

- IV is preferred for rapid digitalization. Diluted or undiluted. Refer to drug monograph.
- Oral route: avoid taking med with high fiber foods as absorption will be decreased.
- Loading (digitalizing) dose followed by maintenance doses. Digoxin levels are monitored 6-12 hours after last loading dose to confirm steady state levels.

Pre-Treatment

- ECG prior to administering the first dose.
- Labs: electrolytes. Potassium must be within normal range as low potassium levels can lead to toxicity.

Monitor:

- Apical pulse should be taken for a full minute before administration of this medication. If the apical pulse is less than 60, the dose should be withheld and the physician notified.
- Monitor ECG (may be continuous with during IV digitalizing doses) and blood pressure.
- Serum digoxin levels should be monitored, with a normal therapeutic range from 0.8 to 2 ng/mL.
- Serum potassium levels should also be closely monitored as hypokalemia increases the effect of digoxin resulting in digoxin toxicity. Normal potassium level is 3.5 to 5.0 mEq/L, and a result less than 3.5 should be immediately reported to the prescriber.
- Closely monitor for signs of digoxin toxicity.
- Monitor renal function. Digoxin clearance is closely related to renal function, as measured by creatinine clearance.
- Assess: peripheral edema, lung sounds
- Dose adjustment: older adults, clients with renal insufficiency and clients with lean body mass are more susceptible to develop digoxin toxicity. Lower dosages are required. No dose adjustment for hepatic impairment.

Pregnancy: Digoxin crosses the placental barrier. Postpartum, monitor neonate for signs of toxicity. Digoxin levels in breast milk are very low.

Digoxin has a narrow therapeutic index, with the risk of toxicity leading to lethal dysrhythmias. To prevent toxicity, close monitoring for symptoms and regular

follow up with digoxin levels, blood work (lytes, renal panel) and an ECG.

Digoxin serum levels 0.5-0.9 ng/mL (or 0.6 – 1.2 nmol/L). Monitor digoxin levels:

- at least 6-12 hours after first dose, then weekly until steady state levels are acheived.
- With each dose adjustment
- With any change in renal function
- With any change in electrolyte levels (i.e. sick with diarrhea, vomiting).

Treatment includes hydration and may include digibind.

Canadian Thoracic Society, 2023

Adverse/Side Effects

Side effects: GI symptoms, headache, weakness, dizziness, anxiety, depression, delirium, and hallucination (David & Shetty, 2024).

Digoxin toxicity can lead to fatal cardiac arrhythmias. Risk increases when digoxin levels exceed 2.0 ng/mL. May also occur with lower digoxin levels if impaired renal function, older adults, low body weight and hypokalemia.

Overdose or accumulation of digoxin can cause toxicity:

- Mild symptoms: Nausea, vomiting anorexia. Bradycardia often observed.

Neuro: lethargy, delirium, weakness.

Visual disturbances are common, such as blurry vision, halos or colour changes (Xanthopsia). Yellow-green tinted vision typically is associated with toxicity.

Hyperkalemia

- Cardiotoxic levels: increased automaticity (i.e. PVC's), AV node block, slowed ventricular response. Can lead to ventricular dysrhythmias, ectopy and atrial tachycardias.
- Toxicity of this medication typically occurs at greater than 2 ng/mL, but some clients may have signs and symptoms at lower levels. Decreased renal function, hypokalemia, hypercalcemia, and hypomagnesemia may increase risk for digoxin toxicity.

If toxicity is expected: bloodwork that includes renal panel, electrolytes, digoxin level and an ECG. Assess for symptoms of toxicity.

Management of Toxicity includes hydration, treating hyperkalemia (give glucose and insulin) and treating ventricular arrhythmias. May give digoxin immune Fab (Digibind) which binds to digoxin and prevents it from binding to active sites.

Figure 7.6a Image: a vial of Digibind (James Heilman, MD/ Wikimedia Commons) CC BY-SA 3.0

Client Teaching

- The client should be instructed to follow the prescribed dosing regimen and take medications at the same time each day. The client should be informed to not double up on medication doses. Consult the healthcare provider for follow-up instruction if two or more doses of medication are missed.
- Clients should monitor their pulse rate for one minute and report any pulse rate less than 60.
- Do not take digoxin with a high fiber meal. Avoid taking any

antacids within 2 hours of dose.
- Inform client of symptoms of digoxin toxicity including low heart rate, vision changes and nausea. If they experience any signs of digoxin toxicity, contact the provider immediately.
- The medication should be stored in its original container and care should be taken not to mix the medication with other medications (Vallerand & Sanoski, 2024).

Digoxin Medication Card

Now let's take a closer look at the medication card for digoxin in Table 6.7. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Digoxin Medication Card

Class: Cardiac Glycoside **Prototype:** Digoxin		**Indications:** To treat heart failure and chronic atrial fibrillation. Second line option if other therapy not successful.	
Mechanism of Action: Digoxin works by inhibiting the sodium and potassium pump, which results in an increase in intracellular sodium and an influx of calcium into cardiac cells, causing the cardiac muscle fibers to contract more efficiently and increase cardiac output.			
Administration: Oral: without food once a day in the morning Take within 2hrs pre or post eating high fiber foods for best absorption Do not take antacids, or metoclopramide within 2 hours	**Side Effects:** Digoxin toxicity: early signs include nausea, vomiting, and diarrhea Bradycardia and arrhythmias Headache, weakness, dizziness, and mental changes such as anxiety or hallucinations Gynecomastia (with prolonged use) SAFETY: Older adults, renal insufficiency or low body weight clients have increased risk of toxicity- Digibind is used to treat toxicity	**Contraindications:** Kidney or hyper or hypo thyroid problems Avoid alcohol or driving machinery if this drug causes dizziness for the person Pregnancy-may take while pregnant, consult MD. Minimal levels in breastmilk; consult with MD. St Johns Wort, antifungals and some antibiotics can affect the removal of digoxin in the body	**Nursing Considerations:** Apical pulse check for full 1 minute before administration Monitor serum digoxin levels for toxicity, se potassium levels Monitor BP, periodic ECG. Monitor for S & S of heart failure and overload including urine output and respiratory assessment

Downloadable file (.docx): Digoxin Medication Card

Clinical Reasoning and Decision-Making Activities

1. Why should a nurse assess the apical pulse for 1 full minute before administering digoxin?

2. How does a nurse evaluate whether digoxin is effective?
3. Why must the nurse monitor serum potassium levels as well as digoxin levels?
4. A nurse enters a patient's room and the patient complains "My vision seems strange and I feel nauseated." What is the nurse's next best action?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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Media Attributions

- Figure 7.6a A vial of Digibind, by James Heilman, MD on

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7.7 Antianginal Drugs

Antianginal drugs are used to treat angina pectoris. Angina is chest pain caused by an imbalance between the oxygen needs of the myocardium and the ability to deliver oxygen supply from inadequate blood flow. This can lead to hypoxia of the cardiac tissue. Angina can be chronic ischemic pain caused by atherosclerosis in coronary artery disease or acute ischemic pain caused by a myocardial infarction.

The overall goal is to reduce the intensity and frequency of attacks. Antianginals increase blood flow to the heart or decrease oxygen demand by the heart. Recall that there are three types of angina: stable, unstable and variant. Treatment looks a bit different for each type of angina. All drugs primarily only provide symptom relief; they do not fix the underlying issue (Burchum Rosenjack & Rosenthal, 2019).

Stable angina: exertional angina

- Nitrates: vasodilate coronary arteries and veins, decrease oxygen demand
- Beta blockers: decrease heart rate and contractility, decrease oxygen demand
- Calcium channel blockers: dilate arterioles, decrease afterload. Non-diphenhydramine's also decrease heart rate and contractility.

Unstable angina: medical emergency from severe coronary artery disease

- Anti-ischemic therapy consists of nitroglycerin, beta blockers, oxygen if hypoxia or respiratory distress, morphine IV, and ACE inhibitors.
- Anti-platelet therapy consists of aspirin, clopidogrel and ticagrelor.

    - Abciximab if angioplasty planned
    - Eptifibatide or tirofiban if no angioplasty. Both meds are antiplatelet glycoprotein IIb/IIIa inhibitors
- Anticoagulant therapy – LMWH or direct thrombin inhibitors or unfractionated heparin IV

Variant angina (vasospastic or Prinzmetal)

- Calcium channel blockers and nitrates. Both increase coronary oxygen supply by relaxing the coronary artery spasm.

In this unit, we will be focusing on Organic Nitrates.

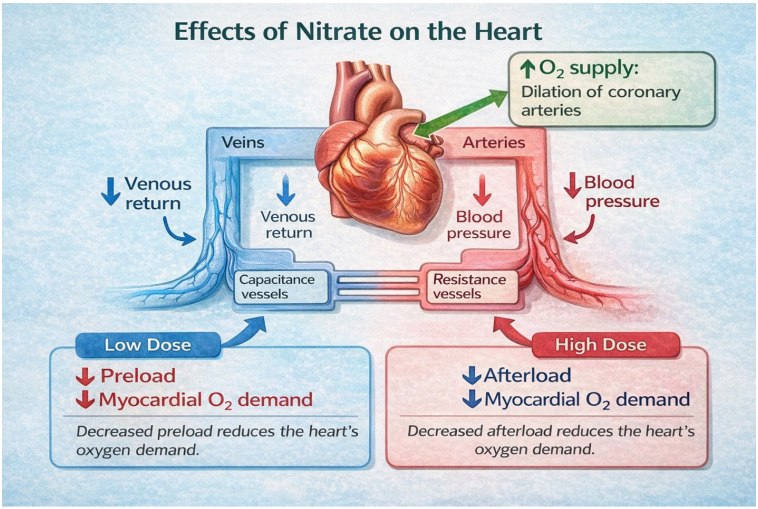
Nitrates

Nitroglycerin is the drug of choice for relieving acute angina. Since it was discovered in 1857, it has been the main drug for angina due to being fast, effective and inexpensive. It causes vasodilation of blood vessels and causes the dilation of coronary vessels. Nitroglycerin is the most common nitrate, but there is also isosorbide dinitrate and nitroprusside. Medications in this class can be used for acute anginal attacks or for long term therapy (Adams et al, 2018). It comes in various forms from oral, sublingual, intravenous, topical and transdermal.

Mechanism of Action

Nitrates work by increasing the release of nitric oxide, which then activates a series of chemical events resulting in the relaxation of the vascular smooth muscle, leading to vasodilation and angina relief. It acts primarily on the veins with minimal dilation of arterioles. With venous dilation, the amount of blood returning

to the heart (preload) is reduced. With a lower volume of blood in the chambers, cardiac output is decreased and the workload of the heart is reduced. This leads to a lower myocardial oxygen demand. To a lesser extent, nitro also dilates coronary arteries allowing more blood flow to the myocardium (Adams et al, 2018).



7.7a The mechanism of action of nitrates on the heart (Sheila Odubote/ TRU Open Press).

Indications for Use

Nitroglycerin is used to relieve angina due to coronary artery disease, during times of an acute attack, or prophylactically. They are also used for arterial hypertension and heart failure. Off label, it is used topically for anal fissures to increase blood flow to the area and promote healing.

Note: Nitroprusside is a nitric oxide donor and used for

hypertensive crisis or cardiogenic shock to rapidly lower BP, afterload and preload. It is given intravenously.

Isosorbide is used prophylactically to prevent angina pain or for heart failure with a low ejection fraction. It works more slowly than nitroglycerin so not ideal for acute anginal pain.

In this unit, our prototype drug will be nitroglycerin.

Pharmacokinetics:

Nitroglycerin is highly lipid soluble which makes it ideal for routes such as sublingual and transdermal. It undergoes rapid inactivation by hepatic enzymes so oral doses are mostly reduced to being ineffective for acute use. For acute angina, only sublingual or buccal dosing is administered due to the fast onset of action and ease of administration. The half life is 1-4 minutes (Vallerand & Sanoski, 2024).

Nursing Considerations

Administration: sublingual, extended-release tablets, creams, transdermal patches, and intravenously. All produce the same effects with differences in onset and duration of action.

- Rapid acting: sublingual tablets or spray with onset 1-3 minutes and duration 30-60 minutes. Used for acute angina attack or for anticipated angina from exertion. PRN basis. Given as soon as the pain appears for best effect.
- Long acting: SR oral capsules, transdermal patches or topical ointment. Onset is 30-60 minutes with a long duration of action. Oral route duration of action is 3-8 hours and transdermal route has a duration of 24 hours. Transdermal

patch is used for sustained protection from angina.

- Transdermal patch: constant release of nitro, with a range of patch sizes from 0.1-0.8 mg/hr. Apply daily and rotate sites. To avoid tolerance, must have a patch-free interval of 10-12 hours, usually at night. Ensure previous patch is removed before applying. Apply the patch to a hairless area, usually the upper chest.

For stable angina – **long-acting** nitrate for prophylaxis

- NTG Transdermal patch – 0.2 – 0.8 mg/h, one patch a day (remove at night for 10-12h)
- NTG Ointment – 7.5 – 40 mg a day
- NTG Oral capsules, SR 10-40mg TID
- Isosorbide: oral

For acute anginal pain – **short acting** nitrate for acute chest pain

- NTG Sublingual tablet – ie. 1 tab q 5 min x 3 rounds every 15 min (do not exceed 3 doses/per episode of chest pain)
- NTG Spray – (0.4 to 0.8 mg), 1 spray q 5 min to max of 3 sprays in 15 min. (do not exceed 3 doses/day)

For Heart Failure with acute MI, preop Hypertension++, hypertensive emergencies

- NTG IV – range from 10 to 120 micrograms/min.

Potential for tolerance to the effects of nitrates

- Allow for wash out period. For a transdermal patch – keep patch off 10-12 hours out of each day (usu overnight). prescriber will order patch-free period.

Prior to treatment, take blood pressure and heart rate. For NTG given for stable angina, reassess in one hour post-oral dose. A 10 mmHg drop is within normal limits.

Drug interactions:

- Cautious use with antihypertensives and CNS depressants due to hypotensive effects
- Clients taking sildenafil (Viagra) or similar medications for erectile dysfunction or PDE inhibitors in the previous 24 hours may not take nitroglycerin as this may result in a dangerous drop in blood pressure.

Nitroglycerin should not be used in pregnant women or those who are breastfeeding. If used, benefits should outweigh risks.

Contraindicated with severe anemia, increased intracranial pressure, hypersensitivity, or circulatory failure.

Cautious use with older adult due to fall risk from hypotension.

Adverse/Side Effects

Nitroglycerin is generally well tolerated.

Common side effects: headache, orthostatic hypotension, reflex tachycardia

- Orthostatic hypotension is due to blood pooling in the veins when sitting up. May experience light-headedness and dizziness.

- Reflex tachycardia results from a lower BP triggers baroreceptors and stimulating sympathetic stimulation of the heart. If this occurs, pretreatment with a beta blocker or CCB (verapamil) may be required (Burchum Rosenjack & Rosenthal, 2019).

Other side effects include palpitations, weakness, sweating, flushing, nausea, vomiting, or dizziness.

Client Teaching

- Instruct client to avoid eating or smoking during administration as this may alter absorption.
- Clients should sit during administration to decrease the risk for injury due to the possibility of hypotension, dizziness, and weakness.
- Refrain from alcohol as may experience flushing and weakness.
- Ensure client is informed of correct application and removal of transdermal patch
- Ensure client is informed of correct use of nitro spray or sublingual tablets for acute anginal attacks. Do not spray more than once every 5 minutes to a maximum of 3 sprays in 15 minutes to relieve chest pain. If chest pain is not relieved after the first dose, 911 should be called.
- Nitroglycerin may also be used prophylactically 5 to 10 minutes prior to engaging in activities that might precipitate an acute attack.
- Inform prescriber if there is any change to the pattern or severity of their chest pain.
- Nitroglycerin decomposes when exposed to heat or light, so it should be stored in the original, airtight glass container. See Figure 7.7b for an image of nitroglycerin containers.

(Kim, Adnan & Schaller, 2023; Vallerand & Sanoski, 2024)

Figure 7.7b Sublingual nitroglycerin should be stored in its original, air tight glass container (Intropin/Wikimedia Commons) CC BY 3.0

Example in Practice:

This case study is to show the sequence of assessment and nitro administration for acute anginal pain.

A 63-year-old client has come into the emergency department with complaints of mid-sternal chest pain 7/10, non-radiating. It started 30 minutes ago when he was doing yard work and it has not subsided. He is visibly diaphoretic with slight shortness of breath. BP 148/82 HR 86 bpm, resp rate 22 breaths/min, oxygen sats 95%. He has no cardiac history and only has acid reflux that he takes the OTC antacid. He tells the nurse his partner had him chew an aspirin on the drive to ED.

After completing the assessment, the triage nurse brings him into the department. A 12 lead ECG is done and blood work for a troponin level and lytes are taken. While those orders are occurring, the nurse prepares to give nitroglycerin to relieve the chest pain.

The order reads:

Nitroglycerin 1 spray q 5 minutes for chest pain. Give up to 3 doses, 5 minutes apart.

The sequence of assessment and medication is the same each time.

Assess: chest pain (PQRST), BP, HR, RR and oxygen sats

- Chest pain 8/10 HR 93 bpm BP 148/90 RR 22) Oxygen sats 96%

Give: nitroglycerin 1 spray under the tongue

Wait 5 minutes

Reassess chest pain and vital signs. Still has chest pain?

- Chest pain 7/10 HR 82 bpm, BP 138/88 RR 20

Give (2nd dose): nitroglycerin 1 spray under the tongue

Wait 5 minutes.

Reassess chest pain and vital signs. Still has chest pain?

- Chest pain 4/10. HR 78 bpm BP 132/77 RR 18 O2 sats 94%

Give (3rd dose): nitroglycerin 1 spray under the tongue

Wait 5 minutes.

Reassess chest pain and vital signs. Still has chest pain?

- Chest pain 4/10. HR 75 bpm BP 130/75 RR 18 O2 sats 96%

At this point, no more nitro can be given. The goal is no chest pain. The nurse checks the orders and she can give Morphine 1-5 mg IV q 5 minutes to a maximum of 20 mg in 1 hour.

Morphine 2 mg IVP is given (Pain is 4/10 and client opioid naïve. Start with a low dose)

The nurse stays with the client, reassesses chest pain and vital signs in 5 minutes.

5 minutes: At this point, the client states his chest

pain has gone away.HR 80 bpm BP 128/70 RR 14 with O2 sats of 95%. In some critical care areas, nitroglycerin infusion could be initiated instead of morphine.

Other care that is occurring during this time include:

- Bedrest
- NPO
- Intravenous access – 2 peripheral IVs, saline lock
- Complete a physical assessment (especially lung sounds, skin colour, edema)
- Provide supplemental oxygen if oxygen sats are less than 94% or per your agency policy.

Nitroglycerine Medication Card

Now let's take a closer look at the medication card for nitroglycerin. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Nitroglycerine Medication Card

Class: Antianginals **Prototype:** Nitroglycerin		**Indications:** acute anginal pain, prophylactic treatment to prevent angina. Arterial hypertension, heart failure, anal fissures (topical). Vasodilation to decrease oxygen demand and decrease cardiac workload	
Mechanism of Action: Nitrates increase the release of nitric oxide, which then activates a series of chemical events resulting in the relaxation of the vascular smooth muscle, leading to vasodilation and angina relief. It acts primarily on veins with dilation of arterioles minimal. With venous dilation, the amount of blood returning to the heart (preload) is reduced. With a lower volume of blood in the chambers, cardiac output is decreased and the workload of the heart is reduced. This leads to a lower myocardial oxygen demand.			
Administration: Oral, IV, sublingual, transdermal Oral, transdermal: long term preventative therapy SL, buccal: acute angina attack Keep nitro tablets in original container and away from light Ensure SL tablet under tongue dissolves Transdermal: rotate sites, have med-free period each day 12-14 hours to avoid tolerance	**Side Effects:** Hypotension, headache, nausea Other: tachycardia, flushing, peripheral edema, blurred vision AE: paradoxical tachy	**Contraindications:** Contraindications with hypersensitivity, increased intracranial pressure, cardiomyopathy, shock Caution with renal and liver failure, MI Drug interactions: sildenafil and other PDE inhibitors Not for pregnancy or breastfeeding	**Nursing Considerations:** Monitor BP, HR and chest pain prior to each nitrospray. Do not give more than 3 doses 5 minutes apart. Reassess between each dose Complete med profile prior to initiating therapy Can use prophylactically before exercise if needed Sit during administration in case of drop in BP

Downloadable file (.docx): Nitroglycerine Medication Card

Clinical Reasoning and Decision-Making Activity

1. A client was administered the first dose of nitroglycerin at 1305hrs for acute angina. What should the nurse evaluate after administration?
2. A client has been experiencing occasional mild substernal chest pain when he exercises. They go to the clinic and a cardiac assessment is completed. They are currently pain free. The client is prescribed Nitro spray 1 spray for chest pain. Repeat 2x if unrelieved.

    a. How does this med work to relieve chest pain?
    b. What teaching will the client need to administer this med safely? Include in your answer common side effects and correct administration of the med.

3. A 70-year-old client has a history of stable angina. He is ordered: Nitro patch 0.4mg/hr. Apply at 0900h and remove at 2000hr.

    a. What is the purpose of this type of order?
    b. Prior to applying the patch in the morning, what should the nurse assess?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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- 7.7b Sublingual nitroglycerin [Nitroglycerin (1).JPG] by Intropin on Wikimedia Commons is licensed under CC BY 3.0 license.

7.8 Anti-hypertensives

Hypertension occurs when an individual's blood pressure is above normal limits for a sustained period of time. The current hypertension guidelines by Hypertension Canada is a BP over 130/80 mmHg with automated readings, and over 140/90 in office readings. Hypertension can be either primary (essential) due to genetic and environmental factors or secondary due to other diseases such as renal disease, preeclampsia or thyroid disease. It can occur at any age, including children, although we mostly see hypertension in the middle age adult and older, or with clients with risk factors. For clients at higher risk, such as those with diabetes mellitus, cardiovascular disease, dyslipidemia, or renal disease, the target BP may be lower. Pharmacological treatment will begin when the BP is over 140/90, or if cardiovascular disease then treat if BP over 130/90 (Goupil et al, 2025).

There are over 14 different classes of drugs to treat hypertension. To understand why there is so many classes of meds, we go back to the physiological changes that contribute to high blood pressure. The mechanisms that regulate blood pressure are:

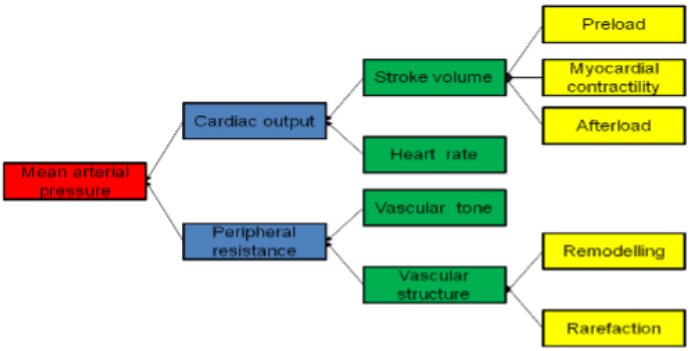
- Neural: sympathetic NS receives messages from baroreceptors and chemoreceptors to change vessel diameter in response to low BP. If BP is too low, the brainstem stimulates:
    - heart (activates B1 receptors in the heart)
    - blood vessels (activates alpha-1 receptors in the endothelial cells that line blood vessels, leading to vasoconstriction. BP can also be high due to structural remodelling that can lead to the hardening of the arteries.
- Hormonal: RAAS (renin angiotensin aldosterone system) is activated in response to low blood volume. Review the RAAS as an important determinant of blood pressure and fluid volume.
- Renal: the kidney has a central role in BP regulation. When BP

falls, the GFR also lowers, promoting the retention of Na, Chl and water. This increase in blood volume, results in an increase in venous return to the heart, increased CO, and increased BP.

To lower blood pressure, medications are chosen to reduce heart rate, myocardial contractility, blood volume, venous return and lessen the tone of the arteriolar smooth muscle. Recall that blood pressure can be defined as:

Arterial blood pressure (BP) = cardiac output (CO) x peripheral resistance.

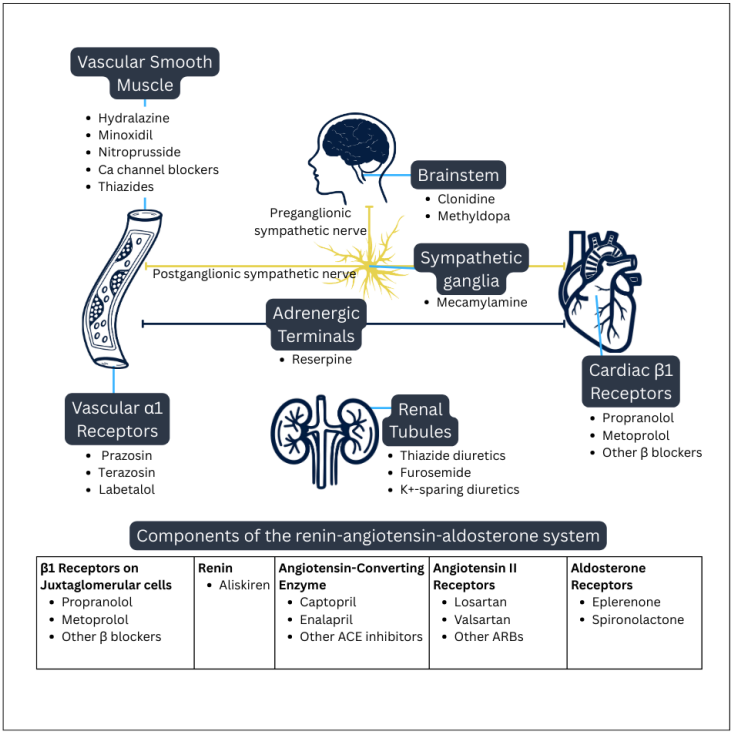
An increase in either CO or peripheral resistance, will increase BP. To take it a step further, the diagram 7.8a shows the other factors that will impact CO or peripheral resistance, and ultimately BP.



7.8a The factors that influence mean arterial pressure. (Adh30/Wikimedia Commons) CC BY-SA 4.0

As mentioned above, there are 14 different classes of meds to lower blood pressure. Refer to the diagram below for all the sites of action of antihypertensives and the medications.

Refer to the chart at the end of this unit for an overview of antihypertensives and sites of action.



7.8b Sites of action of antihypertensive drugs. Drugs for Hypertension – Clinical Gate (TRU Open Press/Canva [adapted] from Clinical Gate, 2017) CC BY-NC-SA 4.0

Depending on their blood pressure and other factors such as other health issues (i.e. renal, cardiac health issues) and cost considerations, clients may be started on one antihypertensive but the current guideline is for triple therapy with three different classes of anti-hypertensives. The benefit is the dosages will be lower and less potential side effects and they all working synergistically to manage blood pressure.

Clients need to be also implementing lifestyle changes such as diet, exercise and cessation of smoking. Client resources on

lowering blood pressure are available through HealthLinkBC – Lifestyle Steps to Lower Your Blood Pressure (www.healthlinkbc.ca).

First line treatment of blood pressure:

- Thiazide-type diuretics: hydrochlorothiazide. This med will be covered in the diuretic unit
- Calcium channel blockers: Dihydropyridines (amlodipine)
- Angiotensin-converting enzyme (ACE) inhibitors: ramipril and angiotensin II receptor blockers (ARBs): losartan

(BC Guidelines.ca, 2020)

Other medication classes that are also commonly used, but not first line, are beta blockers (Bisoprolol, Metoprolol), alpha-2 agonist (clonidine), direct-acting vasodilators (hydralazine) and thiazide-like diuretics (indapamide).

This unit will cover only a few common medications. Some of the classes of meds have been covered in other units.

In chapter 4: Autonomic Nervous System:

- Unit 4.12 beta blockers (metoprolol, propranolol),
- Unit 4.10 alpha-2 agonist (clonidine)

This unit will cover:

- Meds that alter RAAS:
    - Angiotensin Converting Enzyme Inhibitors
    - Angiotensin Receptor Blocker (ARB)
- Direct-acting vasodilators: hydralazine
- Calcium channel blocker: amlodipine

Drugs that suppress RAAS: ACE inhibitors, Angiotensin receptor blockers

ACE Inhibitor (Angiotensin Converting Enzyme)

ACE inhibitors are a widely used for as antihypertensives. There are a number of medications in this class including ramipril, captopril, enalapril, among others. They have slightly different formulations from each other, but all work similarly. ACE inhibitors have a good safety profile.

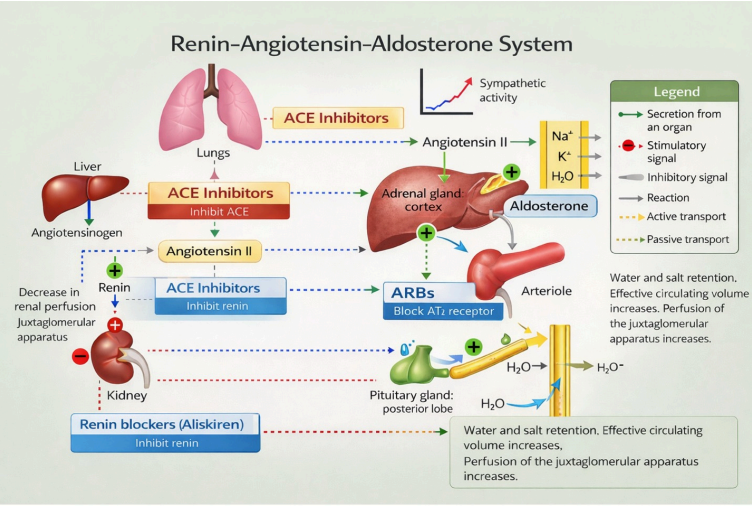
In this unit, our prototype med will be Captopril. Note that all ACE inhibitors end in 'pril'

Mechanism of Action

This medication blocks the conversion of Angiotensin I to Angiotensin II in the renin-angiotensin-aldosterone system. This action prevents vasoconstriction and aldosterone-mediated volume expansion, resulting in vasodilation and sodium and water excretion by blocking aldosterone.

Captopril improves cardiac output and reduces blood pressure by:

- Decreasing peripheral vascular resistance
- Reducing preload by causing vasodilation and natriuresis
- Reduces afterload by inhibiting the formation of angiotensin II



7.8c The effects of antihypertensive medications on RAAS (Sheila Odubote/ TRU Open Press) CC BY-NC-SA 4.0

The second effect of ACE inhibitors is they also inhibit the breakdown of bradykinin. This results in vasodilation and also bronchoconstriction from bradykinin lodging in the bronchioles. Symptoms include a cough and in rare cases, angioedema.

What is bradykinin and why is asking about a cough important?

Bradykinin is a substance involved in the inflammatory process and has a role to play in sensitizing somatosensory fibers causing hyperalgesia, and it also has a role in mediating pro-inflammatory peptides and the local release of histamine.

Bradykinin is normally broken down by an enzyme called kininase. Kininase and ACE are the same enzyme. When ACE inhibitors are taken, they inhibit the breakdown of bradykinin, thereby increasing bradykinin levels. Typically, this is of no concern, but in some clients, they develop a dry cough which is due to higher levels of bradykinin. The elevated bradykinin may result in angioedema. As such, if someone is on an ACE inhibitor and develops a cough, they are switched to an ARB which does not have any effect on bradykinin.

See more information about the renin-angiotensin-aldosterone system in the "Review of Basic Concepts" section of this chapter.

Indications for Use

Cardioprotective effects: ACE inhibitors are an antihypertensive of choice for patients with hypertension, heart failure, post-MI ventricular dysfunction or diabetic nephropathy (Marte et al, 2024). It prevents remodeling of the left ventricle and also cardiac and vascular hypertrophy. They are effective at reducing mortality with these effects.

They are indicated as first-line treatment for patients with chronic kidney disease with evidence of proteinuria.

ACE inhibitors are used for clients with a cardiac history such as heart failure, recurrent stroke prevention and post-MI.

ACE inhibitors are also used for diabetic nephropathy, which is the leading cause of end-stage kidney disease (ESKD). This condition is due to microvascular complications of diabetes in both type 1 and type 2 diabetes. Captopril decreases the rate of

progression of renal insufficiency by controlling blood pressure (Marte et al, 2024).

Nursing Considerations

Administration: oral BID or TID. Take one hour before meals as food decreases bioavailability. Enalapril can be given both oral and IV.

Monitor:

- Obtain baseline electrolytes and renal panel. Repeat these labs yearly.
- Blood pressure prior to therapy and then the following two weeks. Once stabilized, q 4 months.

Renal impairment: as it is excreted by the kidney, reduced dosage is required.

Liver impairment: avoid in clients with severe liver disease such as cirrhosis and ascites.

Pregnancy: do not give if pregnant or plan to become pregnant. Captopril will cause fetal birth defects such as skull hypoplasia, impaired renal function, hypotension, and fetal death.

Use with caution with clients who have diabetes.

Use with caution or avoid with Black people due to a slightly higher risk of angioedema. ACE inhibitors are also less effective in lowering blood pressure in this population (Nkunu et al, 2026).

Can cause hyperkalemia, monitor for ECG changes or symptoms such as nausea, palpitations, muscle pain or paresthesia (Marte et al, 2024). Clients with renal impairment, diabetes or who are on potassium supplements are more at risk.

Drug Interactions:

- Avoid use with other medications that increase potassium (i.e. potassium sparing diuretics).
- May increase risk of lithium toxicity.

Adverse/Side Effects

Side Effects include:

- First dose hypotension: profound hypotension after taking the first dose. Assess BP prior to dose and then 2 hours post. Ensure client safety to prevent falls.
- Orthostatic hypotension, dizziness, syncope
- Metallic taste
- Cough: dry, non-productive. Occurs in 20% of people. Can start within one week to 6 months after initiating therapy. If it develops, switch to an ARB.

Adverse Effects:

- Hyperkalemia aldosterone production is decreased which normally promotes K excretion in the kidney. Monitor serum potassium levels.
- Increased BUN and Creatine, decreased GFR: anticipate slight decrease. Caution with renal insufficiency
- Angioedema: rare. May experience increased facial swelling or difficulty swallowing or breathing should seek emergency medical attention. Report a persistent cough or angioedema to the health care provider (DailyMed, n.d.)
- Neutropenia

Client Teaching

- Medications should be taken as directed. Take one hour before meals on an empty stomach.
- Clients taking ACE inhibitors should be cautioned to avoid salt substitutes or foods high in potassium.
- May alter sense of taste, but this generally resolves within 2-3 months of medication therapy.
- If persistent dry cough develops, see prescriber. Will be switched to an ARB or other antihypertensive.
- Inform prescriber if plan to get pregnant or are pregnant.
- If weight gain and swelling of feet or ankles, see prescriber.
- Seek immediate medical assistance if swelling of the throat, lips or tongue.
- Change positions slowly, may become dizzy or lightheaded

Captopril Medication Card

<table>
<tr><td colspan="2">Class: Angiotensin Converting Enzyme Inhibitor (ACEi)

Prototype: Captopril</td><td colspan="2">Indications: Hypertension, chronic kidney disease, cardiac history (heart failure, recurrent stroke prevention and post-MI) and diabetic neuropathy.</td></tr>
<tr><td colspan="4">Mechanism of Action: Blocks the conversion of Angiotensin I to Angiotensin II in the renin-angiotensin-aldosterone system. This prevents vasoconstriction and aldosterone-mediated volume expansion, resulting in vasodilation and sodium & water excretion by blocking aldosterone. It improves CO & reduces BP by: decreasing PVR, reducing preload, reduces afterload.</td></tr>
<tr><td>Administration:
BID or TID. Take one hour before meals as food decreases bioavailability.</td><td>Side Effects:
Hyperkalemia, monitor for muscle pain, paresthesia, palpitations
First dose hypotension
Orthostatic hypotension, dizziness, syncope
Metallic taste
Cough: dry, non-productive</td><td>Contraindications:
Do with pregnancy
Not with liver disease
Caution with Black pple, risk of angioedema</td><td>Nursing Considerations:
Renal panel, lytes before therapy and regularly.
BP prior and 2 weeks post
Reduce dose if renal failure
Do not take K+ supplements
Monitor for wt gain or peripheral edema</td></tr>
</table>

Downloadable file (.docx): Captopril Medication Card

Angiotensin II Receptor Blocker (ARB)

ARBs are similar to ACE inhibitors in that they act on the renin-angiotensin-aldosterone system (RAAS). They are well tolerated, and often prescribed to clients unable to take ACE inhibitors due to the drug-induced cough. Both ARBs and ACE inhibitors have similar efficacy and indicated for similar conditions such as hypertension and diabetic neuropathy (Khalil & Zeltser, 2024). Losartan is an example of an Angiotensin II receptor blocker.

Mechanism of Action

ARBs act similarly to ACE inhibitors to lower blood pressure. ARBs prevent the angiotensin II mediated vasoconstriction and release of aldosterone, but do so by blocking the action of angiotensin II (ACE inhibitors block the formation of angiotensin II). The result is vasodilation and decreased peripheral resistance. It also has renoprotective effects in type 2 diabetes. It can also reduce the risk of stroke with clients with hypertension with left ventricular hypertrophy (Mulla, Patel & Siddiqui, 2024).

Indications for Use

ARBs are used to treat hypertension and to prevent nephropathy in diabetic clients. It is also beneficial for clients with hypertension and left ventricular hypertrophy to help prevent ventricular remodelling.

Nursing Considerations

Administration: well absorbed orally, with onset of action in 6 hours and duration of action 24 hours. Take the med at the same time each day. If taken with food, absorption will be slowed down.

Monitor serum potassium levels at initiation of therapy and regularly.

Do not administer to clients who are pregnant due to risk of fetal harm. It is not recommended for children under 6.

Hepatic impairment: Anticipate dosage adjustment with hepatic impairment.

May cause renal failure in clients with renovascular disease, volume depletion or taking NSAIDs.

Risk of hyperkalemia: risk increases if concurrent renal impairment, diabetes or use of potassium supplements.

Adverse/Side Effects

Side effects: hyperkalemia, fatigue, diarrhea, dizziness, nausea

Adverse effects:

- Renal insufficiency. Assess for proteinuria periodically
- Upper respiratory tract infection
- Hypotension
- Gastritis
- Urinary tract infection
- Angioedema: facial swelling or difficulty breathing, seek medical help

(BC Guidelines.ca, 2020; Mulla, Patel & Siddiqui, 2024)

Client Teaching

- Medications should be taken as directed, at the same time each day.
- Clients should not discontinue therapy unless directed to do so by their healthcare provider.
- Patients should be careful to avoid salt substitutes and foods with high levels of potassium. Do not take potassium supplements unless directed by your prescriber.
- ARBs may cause orthostatic changes and patients should be cautioned to change positions slowly.

Direct-Acting Vasodilators

Hydralazine and minoxidil are examples of direct vasodilators. They are an effective antihypertensive, but do have a number of side effects that prevents them from being a first line therapy.

Nitroprusside is another direct acting vasodilator but is reserved for life threatening hypertension. It is administered IV and works within a few minutes. This med would be given in critical care areas.

Hydralazine will be our prototype medication.

Mechanism of Action

Hydralazine's direct mechanism of action is unknown, but it causes vasodilation via direct relaxation of vascular smooth muscle. It works on the dilation of arterioles without much effect on the dilation of veins. Peripheral vasodilation results in a reduction of blood pressure and decreased vascular resistance. It also leads to a compensatory baroreceptor-medicated release of epinephrine and norepinephrine which increases venous return and cardiac output.

As the sympathetic nervous system is stimulated, this leads to tachyphylaxis and tachycardia (Herman, Bruss & Tivakaran, 2023).

Indications for Use

Hydralazine is used to treat essential hypertension not responsive to other medications. It can be used for hypertensive emergencies and acute onset hypertension during pregnancy, along with labetalol.

Nursing Considerations

Administration: oral or IV.

- For oral, it is given up to QID, with doses tapered up depending on effect.
- For IV dosages during hypertensive emergencies, effects occur within 5 to 30 minutes with a total duration of 2 to 6 hours (Herman, Bruss & Tivakaran, 2023).

Monitor:

- heart rate, blood pressure and ECG before therapy and regularly
- Risk of orthostatic hypotension. Ambulate clients slowly and take BP lying, sitting, and standing or as per orders.

Do not abruptly discontinue medication.

If reflex tachycardia occurs, may be treated with a beta-adrenergic med.

Use with caution in clients with coronary artery disease, mitral valve rheumatic heart disease, and cerebral vascular accidents.

This medication should only be used in pregnancy if the benefits outweigh the risks, due to lack of safety studies.

Adverse/Side Effects

Reflex tachycardia, monitor ECG or assess heart rate and blood pressure closely. Clients may feel palpitations.

Other: tremors, numbness, tingling, disorientation, nasal congestion, headache, nausea, vomiting, and diarrhea are effects associated with hydralazine (Medline, n.d.).

Adverse effects:

Systemic lupus erythematosus (SLE): a chronic disease that causes inflammation in the connective tissue. It affects many organs including skin, joints, kidneys, lungs, central nervous system, and blood-forming (hematopoietic) system. Although rare, this adverse effect places hydralazine in a third line therapy. Although lupus symptoms can vary, monitor for a characteristic sign of SLE, a flat, red rash across the cheeks and bridge of the nose. This rash is called a "butterfly rash" because of its shape (Medline, n.d.).

Client Teaching

- Clients should remain compliant with the therapeutic dosing regimen, even if symptoms resolve. The client should be cautious not to double up on medication doses. Additionally, the client should consult the healthcare provider for follow-up instruction if two or more doses of medication are missed.
- Clients should be instructed to monitor their weight and assess for fluid retention in the feet and ankles.
- Risk of orthostatic hypotension, advise client to mobilize slowly.

- Instruct client to report any rashes and fatigue.
- Instruct client to report any angina, faintness, dizziness, or numbness and cool extremities.
- Client or caregiver should take clients blood pressure as directed.

Calcium-Channel Blockers

There are two types of Calcium channel blockers (CCB). Non-dihydropyridines (verapamil, diltiazem) and dihydropyridines (amlodipine, nifedipine). Although both types cause dilation of arterioles, non-dihydropyridines also have effects on the heart by decreasing cardiac conduction and contractility (Rosenjack Burchum & Rosenthal, 2019).

This section will focus on dihydropyridines that have a greater affinity for peripheral smooth muscle and ultimately decrease blood pressure.

Our prototype drug will be amlodipine.

Mechanism of Action:

CCBs bind to receptors on L-type voltage-gated calcium channel. This results in the calcium channel being blocked and the inhibition of calcium influx into cardiac (myocytes, SA and AV nodes) and vascular smooth muscle cells. In the heart, this leads to a decrease in conduction and a decrease in the workload of the heart. In the blood vessels, this leads to vasodilation. Amlodipine has a greater affinity for vascular smooth muscle leading to dilation of peripheral arteries, decreased vascular resistance (afterload) and decreased blood pressure (Bulsara, Patel, & Cassagnol, 2024).

CCB also have an effect on the pancreatic islet cells. It inhibits the release of insulin. In an overdose situation, this would lead to hyperglycemia.

Indication of Use

Amlodipine is used for hypertension. It is also prescribed for stable and variant angina. With variant angina, it relaxes the coronary artery spasm. Off label, it can also be used for Raynaud's phenomena, left ventricular hypertrophy and diabetic neuropathy.

Nursing Considerations

Administration: oral, once a day dosing. It can be taken with or without food. Peak concentration is 6-8 hours, with a long half life with terminal elimination of 30-50 hours. It is extensively metabolized by P450 enzymes in the liver.

Dosage adjustment with liver impairment. No lower dosage with renal impairment.

Pregnancy: can be used safely during pregnancy.

Drug Interactions:

- NSAID use can decrease the effects of CCB
- Grapefruit can increase the effects of CCB (flavonoid and nonflavonoid components of grapefruit interferes with CYP3A4 activity)
- Clarithromycin or erythromycin can decrease metabolism of CCB, leading to hypotension.
- If taken with high doses of statins, there is an increased risk for

myopathy and rhabdomyolysis (Bulsara, Patel, & Cassagnol, 2024). Figure 7.8d Brown coloured urine that is characteristic of rhabdomyolysis.

Figure7.8d Urine from a person with rhabdomyolysis showing the characteristic brown discoloration as a result of myoglobinuria. (James Heilman, MD/ Wikimedia Commons) CC BY-SA 3.0

Monitoring:

- Labs: renal (creatinine and BUN) and hepatic panel
- Assess BP and HR prior to initiating therapy and regularly. If SBP <100 hold med, or as ordered.
- Take BP lying, sitting and standing to assess for orthostatic hypotension.
- Assess for adverse effects such as headache, constipation, lightheaded, flushing, peripheral edema.

Amlodipine is contraindicated in patients with heart failure, severe aortic stenosis, unstable angina, severe hypotension, chronic constipation, and hepatic impairment (BC Guidelines.ca, 2020; Bulsara, Patel, & Cassagnol, 2024).

Adverse/Side Effects

Side effects: headache, constipation

- Other: side effects related to vasodilation: pedal edema, flushing, headache, palpitations

Adverse Effects:

- Angina, heart failure, pulmonary edema, tachycardia, bradycardia, skin rashes

Client teaching:

- Clients should remain compliant with the therapeutic dosing regimen, even if blood pressure improves. Take med once a day. The client should be cautious not to double up on medication doses.
- Clients should be instructed to monitor blood pressure regularly during therapy.
- Assess for fluid retention in feet and ankles.
- Risk of orthostatic hypotension, advise client to mobilize slowly.
- Avoid grapefruit juice
- Can cause constipation, increase fluids and fiber.

The following tables provide an overview of Anti-hypertensive Medications effects on the body. Table 1 provides an overview of the different sites in the body and the drug effects. Table 2 provides the sites of drug action within the RAAS.

Anti-hypertensive Medication Cards

The following medication cards are to assist in your learning of the content and to use in the practice setting. They are editable med cards and are intended for you to change or add content. The med cards are not intended to replace referring to a current drug guide to ensure correct use of the medications. Chapter 7 Cardiovascular Anyhypertensive Med Cards

Overview of Sites of Drug Action and their Effects

Site of Drug Action*	**Representative Drug**	**Drug Effects**
Brainstem	Clonidine	Suppression of sympathetic outflow decreases sympathetic stimulation of the heart and blood vessels.
Sympathetic ganglia	Mecamylamine	Ganglionic blockade reduces sympathetic stimulation of the heart and blood vessels.
Adrenergic nerve terminals	Reserpine	Reduced norepinephrine release decreases sympathetic stimulation of the heart and blood vessels.
Cardiac beta1 receptors	Metoprolol	Beta1 blockade decreases heart rate and myocardial contractility.
Vascular alpha1 receptors	Prazosin	Alpha1 blockade causes vasodilation.
Vascular smooth muscle	Hydralazine	Relaxation of vascular smooth muscle causes vasodilation.
Renal tubules	Hydrochlorothiazide	Promotion of diuresis decreases blood volume.

Overview of Sites of Drug Action and the Renin-Angiotensin-Aldosterone System

Site of Drug Action*	Representative Drug	Drug Effects
Beta1 receptors on juxtaglomerular cells	Metoprolol	Beta1 blockade suppr
Renin	Aliskiren	Inhibition of renin su
Angiotensin-converting enzyme (ACE)	Captopril	Inhibition of ACE dec
Angiotensin II receptors	Losartan	Blockade of angiotens
Aldosterone receptors	Eplerenone	Blockade of aldostero

Retrieved from: Rosenthal & Rosenjack Burchum. (2025). Drugs for Hypertension – Clinical GateClinical Gate

Clinical Reasoning and Decision-Making Activity 1

A male 65-year-old client has the following medications ordered: metoprolol 100 mg daily, lisinopril 5 mg daily, verapamil ER 100 mg daily, and hydrochlorothiazide 25 mg daily. He has a history of hyperlipidemia, hypertension, and coronary artery disease. The client asks the nurse, "Why do I have to take so many medications?"

1. What is the class and mechanism of action of each of these medications?
2. What is the nurse's best response to the client's

question?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Clinical Reasoning and Decision-Making Activity 2

A client has hypertension and is started on the ACE inhibitor, enalapril. After six months, their prescriber ordered blood work, and discovered the client's serum potassium level of 5.5 meq/mL.

1. What is the rationale for the higher potassium level? Is there a concern?
2. To lower the potassium levels, what would the nurse want to include in a teaching session?
3. The clients blood pressure is still high despite starting on enalapril. The prescriber has now started amlodipine (CCB). What health teaching should the client be aware of with amlodipine?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of

Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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Rosenthal, L. & Rosenjack Burchum, J. (2025). *Lehne's*

Pharmacotherapeutics for Advanced Practice Providers. Elsevier Canada. Drugs for Hypertension – Clinical GateClinical Gate

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7.9 Antilipemic Medications

Pharmacological treatment for managing dyslipidemia for the prevention of cardiovascular disease begins with screening individuals that includes age, health issues, family history, lifestyle factors, and lab work (Canadian Cardiovascular Society, 2021). Review unit 7.2 Conditions and Disorders related to Perfusion, Dyslipidemia.

Antilipemic agents are used to treat hyperlipidemia and dyslipidemia that may lead to additional health problems such as stroke, myocardial infarction, angina, and heart failure. The risk of atherosclerosis and coronary artery disease is directly related to increased levels of low-density lipoproteins (LDLs). If LDL levels decrease, this can slow the progression of atherosclerosis.

If after lifestyle changes are not successful at improving cholesterol levels, anti-lipemic meds are initiated. This therapy is long term and should be used in adjunct with a healthy diet and exercise regime. Some of the meds are used primarily to lower low-density lipoproteins (LDLs), some for lowering triglycerides, and others can help raise high density lipoproteins (HDLs).

Statins are often the first medication to be started and depending on the response, other cholesterol lowering meds will be added.

Treatment Guidelines

- Cholesterol screening done every 5 years for adults 40-75 years of age (earlier if risk factors for

CAD). Labs include total cholesterol, LDL, HDL, triglycerides (TG).

- Identity high risk factors, including lifestyle and health issues (diabetes, family history of CAD).

Non- pharmacological interventions: diet, exercise, weight control, smoking cessation

LDL not lowered with diet, exercise, lifestyle changes → drug therapy is initiated along with ongoing lifestyle modifications

1. Drug Therapy: HMB-CoA reductase inhibitors "statins" →reduce LDLs
2. If ineffective, and depending on ongoing blood work, add on:

Bile-acid sequestrants – cholestyramine, colestipol and colesevelam (reduce LDLs)

Cholesterol absorption inhibitors – Ezetimibe (reduce LDLs)

3. Along with the above, may add on drugs to raise HDL. Ie. Fibrates (lower TG, increase HDL)

To learn more about these interventions go to the 2021 Canadian Cardiac Society Dyslipidemia Guidelines and Resources, go to the following link: https://ccs.ca/guideline/2021-lipids/

In this unit, we will cover the following classes of meds:

- HMG-CoA Reductase Inhibitors (statins),
- Bile Acid Sequestrants,
- Fibrates,

- Niacin,
- Cholesterol Absorption Inhibitors.

HMG-CoA Reductase Inhibitors (statins)

HMG-CoA reductase inhibitors, more commonly known as statins, are the first line treatment to manage dyslipidemias and prevent cardiovascular disease. There are a number of meds in this class, including atorvastatin, lovastatin and simvastatin, that all differ in potency, metabolism and potential for side effects. For example, atorvastatin is more potent with higher ability to lower LDLs, whereas rosuvastatin is more hydrophilic with fewer muscle related side effects. Based on the client profile including age, risk factors and lab values, the prescriber will determine the most appropriate statin. Statins need to be used along with dietary and lifestyle modifications.

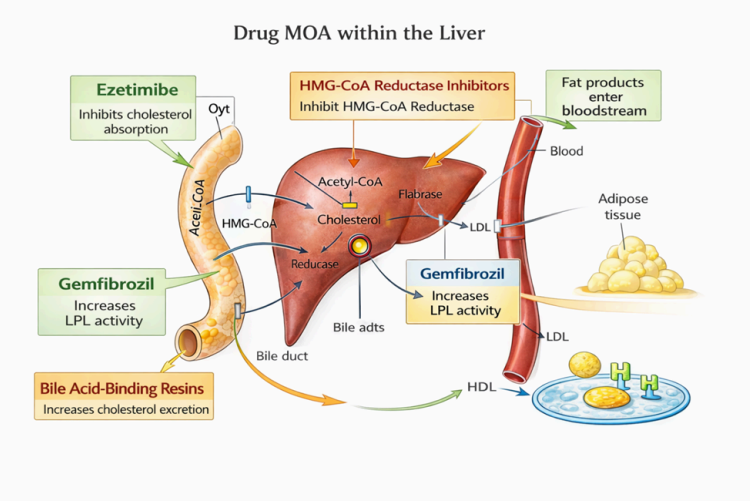
Atorvastatin will be our prototype medication.

Mechanism of Action

Atorvastatin inhibits HMG-CoA reductase and cholesterol synthesis, which reduces LDL (low density lipoprotein). Statins decrease cholesterol production in the liver by preventing HMG-CoA conversion to mevalonate. HMG-CoA is a rate limiting enzyme in cholesterol synthesis. When this enzyme is reduced, cholesterol production is decreased, resulting in hepatocytes making more HMG-CoA reductase (restoring cholesterol synthesis), increasing LDL receptor expression, and enhancing clearance of LDL from circulation. With more LDL receptors, the liver can remove more LDLs from the blood (McIver & Siddique, 2025).

Along with lowering LDL levels, statins also decrease the

production of very low density lipoproteins (VLDLs), resulting in lower VLDL levels and triglyceride levels. Statins also increase HDLs levels (Rosenjack Burchum & Rosenthal, 2019).



7.9a Mechanism of action of the different anti-lipemic medications (Sheila Odubote/TRU Open Press) CC BY-NC-SA

Indications for Use

This medication is used for hyperlipidemia and the prevention of cardiovascular disease. It primarily lowers LDLs, but also has an effect on lowering triglycerides and increasing HDLs. Statins decrease the risk of CV disease, such as myocardial infarction, stroke, revascularization procedures, and angina. It is also prescribed for type 2 diabetics who have multiple risk factors to lower their CV risk (McIver & Siddique, 2025). Other effects include anti-inflammatory, anti-oxidant (helps protect cells from damage) and anti-proliferative (inhibits growth and division of cells) effects. They also have anti-inflammatory effects and improve endothelial dysfunction and vascular remodelling, helping to stabilize

atherosclerotic plaques and reducing thrombosis. The extent of these other actions in improving CV health is less clear, and statins continue to be used for mostly for the reduction of lipid levels (Feingold, 2024).

Pharmacokinetics

Statins are rapidly absorbed after administration, with peak effect in 1-2 hours. It has extensive first pass effect. It is metabolized in the liver via CYP3A4 and CYP3A5. It is excreted in the bile.

Nursing Considerations

Administration: oral. Take at same time each day, with or without food.

For most statins, it is advised to take statins at bedtime as endogenous cholesterol synthesis occurs during fasting at night.

Atorvastatin has a long half life, so taking the med at any time of the day is acceptable, but need to be consistent with taking it at the same time.

Labs: liver enzymes (AST/ALT), creatine kinase (CK), lipid profile. Labs are drawn before therapy, 6 months after initiation and then every 5-12 months. Blood glucose levels drawn prior to therapy and regularly, depending on risk for diabetes.

Renal function: Renal function is not a concern with atorvastatin. Other statins would require a dose reduction if severe renal impairment, such as lovastatin or simvastatin.

Do not use with clients who have hepatic disease.

Pregnancy: contraindicated with clients who are pregnant or breastfeeding. If planning on becoming pregnant, stop statins three months prior to becoming pregnant.

Pediatrics: typically not given to children, but may be given in children 8-10 years of age with severe pediatric dyslipidemia.

Use caution with older adult due to increased risk for myopathy.

Drug Interactions:

Depending on the statin, drug interactions can be a concern due to effects with CYP3A4 metabolism. There are many meds that can interact with statins. If the client is on many other meds, atorvastatin may not be ideal as drugs that inhibit CYP3A4 will increase atorvastatin levels. In this case, other statins would be prescribed such as rosuvastatin. Drug interactions can occur with certain antibiotics, antifungals, calcium channel blockers, leading to higher statin levels and more risk for adverse effects.

Avoid grapefruit juice as it deactivates CYP3A4, leading to risk of serious adverse effects such as myopathies and elevated blood sugar levels.

Adverse/Side Effects

Generally well-tolerated with side effects uncommon. Most side effects are transient.

Side effects: headache, nausea, constipation, dyspepsia.

Adverse effects:

- Myopathy: injury to muscle tissue occurs in 5-10% of clients. Clients experience muscle aches, tenderness or weakness and can be diffuse or localized. Myositis (muscle inflammation) is rare, leading to elevated CK and potassium levels. Rarely, this can lead to rhabdomyolysis.
- Rhabdomyolysis is a condition in which damaged skeletal muscle breaks down rapidly, causing muscle pain and weakness. Labs show elevated myoglobin and marked elevation of CK which can cause renal impairment due to CK plugging up glomeruli. Symptoms include renal impairment and a characteristic tea-coloured urine (DailyMed, 2025). Increased risk of myopathy are the older adult, low vitamin D and

coenzyme Q levels, high doses of statins, concurrent use of fibrates and those with multiple health disorders.
- Hyperglycemia: may increase blood sugar levels due to increasing insulin resistance or impairing insulin secretion in the beta cells. Risk of developing diabetes type 2 in pre-diabetic clients. Can raise H1C and random glucose levels.

Figure 7.9b The characteristic tea-coloured urine that can been seen with rhabdomyolysis (James Heilman, MD/ Wikimedia Commons) CC BY-SA 3.0

Client Teaching

- Clients should take the prescribed medication as directed and do not double up missed doses.
- Avoid or limit consumption of grapefruit juice during drug therapy.
- Continue with dietary and lifestyle modifications.
- Inform client if they experience any muscle pain, tenderness, or weakness, these should be reported to the healthcare

provider.

- When obtaining a prescription, ensure that their prescribed statin is not substituted for a different statin.
- If you plan to become pregnant, inform your health care provider. Statins are avoided during pregnancy.
- Inform prescriber is planning on taking any OTC medications, herbal supplements or vitamins as they may interact with the med.

Vallerand & Sanoski (2024)

Atorvastatin (Lipitor) Medical Card

Class: HMG-CoA reductase **Prototype:** Atorvastatin (Lipitor)		**Indications:** Hyperlipidemia Prevention of Cardiac disease and stroke Reduce risk post revascularization procedures Decreases Lipid levels LDL's, some effect to decrease TG and increase HDLs	
Mechanism of Action: linhibits HMG-CoA reductase and cholesterol synthesis, which reduces LDL (low density lipoprotein) and improved blood flow through vessels			
Administration: Oral, daily at set time each day. Bedtime for most statins. Dose tapered Increasing doses happen every 2-4 weeks until therapeutic lipid blood levels Do not stop taking unless advised by doctor Keep away from children and moisture (avoid bathroom storage) Avoid grapefruit	**Side Effects:** Well tolerated, SE mild. Nausea and diarrhea Dyspepsia Increased blood glucose Adverse effects: Risk of Rhabdomyolysis- kidney damage (assess kidney function) Myalgia Muscle pain and weakness Tea colored urine Irregular heartbeat SAFETY: Report muscle pain, yellow skin, decrease in urine and abdominal pain	**Contraindications:** Hepatic disease Pregnant or breast feeding Children under 10 years of age Many drug interactions: Cyclosporine, antifungals, fibrates (Gemfibrozil), CCB	**Nursing Considerations:** Caution with older adult (increased risk for myopathy) Monitor liver and kidney function, BG for diabetics/prediabetics May increase Hb1AC, monitor.

Downloadable file (.docx): Atorvastatin Medical Card

Fibric Acid Derivatives (Fibrates)

Gemfibrozil, is a fibrate used to treat hypercholesterolemia and mixed dyslipidemia. It is used mostly to lower triglyceride levels, but can also raise HDL levels. It has minimal effects on lowering LDL levels. They are used less often due to higher risk of adverse effects when used with other antilipemic meds. As with all the antilipemic meds, dietary and lifestyle factors should be implemented. Other fibrates are fenofibrate and fenofibric acid.

Mechanism of Action

Fibrates work by decreasing plasma TG levels by lowering VLDL levels. They bind to PPAR-alpha, breaking down particles that make TGs in the liver. This can decrease TGs by as much as 30-60% They also breakdown cholesterol and suppress fatty acids from adipose tissue, and lastly increase the excretion of cholesterol in bile (Patel, Mathew & Singh, 2025; Vallerand & Sanoski, 2024).

Nursing Considerations

Administration: well- absorbed orally, excreted mostly unchanged in the kidney. Gemfibrozil should be taken before meals, and fenofibrate with meals to enhance absorption. Often BID dosing.

Labs: prior to therapy and regularly:

- Cholesterol levels (total cholesterol, LDL, HDL, TG), liver enzymes, CBC, Lytes and glucose

May cause hepatic dysfunction, monitor liver enzymes

Contraindicated if there is severe renal impairment.

May cause gallstones due to increased biliary cholesterol saturation. Monitor for symptoms of gall bladder disorder, such as RUQ pain, decreased tolerance to fried foods and bloating.

Pregnancy: high TGs can induce pancreatitis, so if TGs are elevated during pregnancy, then treat with omega-3 fatty acids with fenofibrate/gemfibrozil during the second trimester (Patel, Mathew & Singh, 2025).

Older adult: increased risk of myopathy if using both statins and fibrates.

Drug Interactions

- Statins: increased risk of statin-induced myopathy, leading to rhabdomyolysis. Monitor for muscle pain
- Warfarin: displaces warfarin from albumin leading to increased anticoagulant effects. Monitor INR and may need to reduce warfarin dosage.

Adverse/Side Effects:

Common side effects include abdominal pain, epigastric pain and diarrhea. Less common effects include blurred vision and muscle pain.

Client Teaching

- Take medication as directed, do not double up if dose missed.
- Take along with implementing dietary and lifestyle changes. Reduced fat, cholesterol and CHO foods, limit alcohol, exercise and quit smoking

- Inform client to report any abdominal pain, nausea, fever, muscle pain.
- Inform client to tell prescriber if they plan to become or are pregnant.

(Patel, Mathew & Singh, 2025; Vallerand & Sanoski, 2024).

Bile Acid Sequestrants

This class of meds has been around the longest and was once the mainstay in lipid-lowering therapy. They are not as potent as other med classes and are less tolerated, so they are used less today.

Mechanism of Action

Bile acid sequestrants bind to bile acids in the intestine, forming an insoluble complex that gets excreted in the feces resulting in a depletion of bile acids in the enterohepatic circulation. As bile acid concentrations decrease, more hepatic cholesterol converts to bile acids; this reduces hepatic cholesterol and increases hepatic LDL receptors to uptake LDL, resulting in a decrease in LDL blood concentrations (Lent-Schochet & Jialal, 2023).

Indications for Use

Bile acid sequestrants are used for hypercholesterolemia without hypertriglyceridemia. They are used in combination with other

meds or monotherapy. They can lower LDL-C between 15 to 30% (Lent-Schochet & Jialal, 2023).

There are three types of bile acid sequestrants.: cholestyramine, colestipol and colesevelam. Colesevelam is the newer of the three and better tolerated. It is also used for clients with diabetes mellitus type 2 (T2D) to lower LDL and hemoglobin (Hb)A1c (Lent-Schochet & Jialal, 2023).

Colesevelam will be our prototype drug.

Nursing Considerations

Administration: oral in either a tablet or granules, usually in divided doses during the day. Dosages start low and taper up.

Assess lipid profile before initiating therapy. Lipid reduction can be observed after 2 weeks of therapy. Check fasting lipid profile 4-12 weeks after initiating therapy, then q 3-12 months.

Risk of GI obstruction, monitor bowel movements and fluid intake.

Can decrease blood glucose levels. Monitor blood glucose in diabetic clients.

Drug Interactions

Bile acid sequestrants decrease the absorption of many drugs by binding and excreting in the feces if taken at the same time. Medications known to form a complex with colesevelam include warfarin, thiazide diuretics, digoxin and some antibiotics. Take these meds one hour before or 4 hours after colesevelam.

Do not take fat soluble vitamins (vitamins A, D, E, K) within 4 hours of colesevelam (Rosenjack Burchum & Rosenthal, 2019).

Adverse/Side Effects

Side effects are gastrointestinal:

- Bloating, vomiting, heartburn, loss of appetite, indigestion, and upset stomach.
- Constipation especially in larger doses and older adults.
- Exacerbate peptic ulcer disease and hemorrhoids.

Client teaching:

- Take as prescribed. Do not take the powder dry.
- To avoid constipation, monitor bowel movements. Increase fluid intake and fiber in diet.
- Decreased effect of some meds if taken at the same time, inform client to take as prescribed.
- Monitor blood glucose levels if diabetic.

Cholesterol Absorption Inhibitor

Cholesterol absorption inhibitors are used alone or along with other antilipemic drugs such as HMG-CoA inhibitors. They are used to manage hypercholesterolemia.

The prototype med will be Ezetimibe.

Mechanism of Action

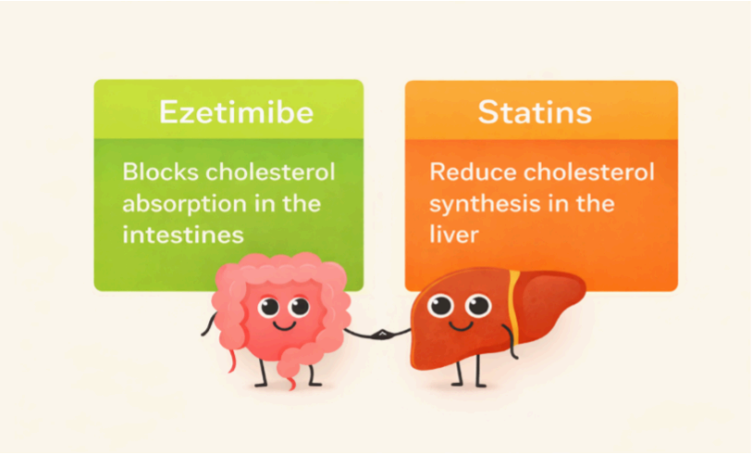
Ezetimibe blocks the absorption of cholesterol in the small intestines and reduces the delivery of intestinal cholesterol to the

liver. It also reduces the hepatic cholesterol stores and increases the clearance of cholesterol from the blood. This results in a reduction of LDLs. It is is unique in that it does not affect the absorption of fat-soluble nutrients such as fat-soluble vitamins, triglycerides, or bile acids (Drug Bank, 2026).

Indications for Use

This medication is used for treatment of hyperlipidemia and familial hypercholesterolemia. It can reduce total cholesterol and LDL levels by up to 20%. It is used as a monotherapy or in combination with statins.

Ezetimibe, when used along with statins, provides a synergistic approach to lower LDL cholesterol by inhibiting both intestinal absorption and liver production. For high risk clients, this combination is safer than doubling the dose of statins alone (Nodari et al, 2007).



7.9c Mechanism of action differences between Ezetimibe and Statins (Sheila Odubote/TRU Open Press) CC BY-NC-SA

Nursing Considerations

Administration: oral dosage, taken once a day. Can be taken with or without food.

Labs: prior to therapy, liver enzymes and lipid panel. Monitor lipid panel 2-4 weeks after initiation, and then regularly.

If medication is combined with HMG-CoA reductase inhibitors, do not give to pregnant or breastfeeding clients.

Drug interactions: risk of gallstones if given with fibrates. Slight increased risk of liver toxicity with statins.

Adverse/Side Effects

Minimal side effects with monotherapy. Usually transient.

Side effects: runny nose, sore throat, headache

Use with caution when ezetimibe is combined with additional medication. Monitor for arthralgia, rhabdomyolysis if taking statins.

Client Teaching

- Clients should take the prescribed medication as directed and avoid consuming grapefruit juice during drug therapy.
- The medication should be used with dietary and lifestyle modifications.
- Inform client if they experience muscle pain, tenderness, or weakness, this should be reported to the healthcare provider.
- If you plan to become pregnant, inform your health care provider.
- Inform prescriber is planning on taking any OTC medications, herbal supplements or vitamins as they may interact with the med.

Vallerand & Sanoski, 2024

Nicotinic Acid

We will briefly review nicotinic acid. It is not commonly used anymore but may be prescribed in certain circumstances. Although it is a vitamin, it does have significant adverse effects that requires close monitoring.

Niacin, nicotinic acid and also known as vitamin B3, has been previously used to reduce cardiovascular events in clients with previous myocardial infarctions. It reduces LDLs, reduces triglycerides, and raises HDLs. It is rarely used today due to adverse effects, and lack of additional benefit when added to statins. But, for clients with a high risk of an MI and who cannot take statins, it is an option.

The most common side effect is cutaneous flushing due to the increase in prostaglandin release in the capillary beds. This can be mitigated if the client takes aspirin 30 minutes prior to their dose.

Other adverse effects include dyspepsia and nausea, although mild. In high doses, it can lead to high levels of uric acid resulting in gout, impaired glucose tolerance resulting in diabetes, and an increase in liver toxicity. It is contraindicated with active peptic ulcer disease and liver disease (DailyMed, 2025).

Careful monitoring is important, including assessing liver function, uric acid levels, and blood glucose monitoring.

Comparing Anti-Lipemic Medications

To help with comparing the medications and to learn important considerations for each medication, refer to the Chapter 7

Comparing Anti-lipemic Medications. This is a downloadable and editable document to allow you to update and add content. In clinical practice, always refer to current drug references for administration.

Clinical Reasoning and Decision-Making Questions

1. A client is ordered a cholesterol absorption inhibitor: Ezetimibe. Which statement is true about this medication?

a. Taken once a day due to long duration of action
b. Avoid taking med with any food as absorption will be decreased.
c. Only take the med in the evening due to cholesterol synthesis occurs at night.
d. Taken TID as short duration of action. Sprinkle the granules on food.

2. The nurse has been caring for a patient admitted with dehydration. The patient has been taking Bile Sequestrant (colesevelam) regularly and complains of nausea. Which assessment finding would be of most concern for the nurse?

a. Bloating after med administration
b. Flatulence and belching
c. Hypoactive bowel sounds and abdominal distension
d. Indigestion and abdominal distention.

3. A client is started on HMG CoA inhibitor: Atorvastatin.

Based on the cholesterol lab values, why would this med be prescribed?

a. It lowers total cholesterol, HDL and LDL levels.
b. It lowers total cholesterol and triglycerides (TG) moderately.
c. It lowers LDLs minimally and raises HDL levels.
d. d. It primarily lowers LDL levels with a decrease in total cholesterol and TG. HDL's will be elevated.

4. The nurse provides some health teaching for a client starting on Atorvastatin. What will be important to include?

a. Report muscle aches and tenderness immediately

b. Report any dark stools and abdominal discomfort

c. Anticipate nausea and diarrhea which will reside after a few months.

d. Return for lab work in two weeks to see if the statin is working.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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7.10 Blood Coagulation Modifiers

Coagulation normally serves a very healthy protective function by keeping us from excessive hemorrhaging. Hemostasis is a physiologic process by which bleeding is stopped following a blood vessel injury. It is a multistep process. The first is vascular spasm or constriction at the site of injury, followed by the formation of a platelet plug (primary hemostasis) and then, the reinforcement of the platelet plug by fibrin (coagulation phase). This seals the wound.

Watch the video to review the process of blood clotting.

Blood Clotting (Hemostasis) [4:37] by Dr. Matt and Dr. Mike (2020) on YouTube.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=209#oembed-1

However, in conditions such as atrial fibrillation, deep vein thrombosis, pulmonary embolism, myocardial infarction and stroke (caused by emboli), where abnormal blood clotting has occurred, our clotting mechanisms can actually harm us. In these cases, pharmacological agents are used to alter the blood clotting mechanisms in order to preserve health and well-being.

Because blood clotting occurs via a few different pathways and processes, pharmacological agents are chosen depending on the severity of the condition and the desired anticoagulant effect. It is important to remember that there are varying levels of risk when anticoagulants are used. As such, nurses need to have knowledge

to ensure safe administration and to educate clients on how to use these meds safely.

There are a number of drugs that modify coagulation. These include anticoagulants, antiplatelet drugs, thrombolytics (lyse thrombi), and antifibrinolytics.

- Antiplatelets: cyclooxygenase inhibitors (ASA, Clopidogrel/ Ticagrelor), and glycoprotein IIb/IIIa inhibitor (tirofiban)
    - These drugs inhibit platelet aggregation
    - Used for arterial thrombus prevention
- Anticoagulants (Heparin, low molecular weight heparin, Warfarin, Rivaroxaban)
    - These drugs disrupt the coagulation cascade and suppress the production of fibrin.
    - Used for venous thrombus prevention
- Thrombolytics (Alteplase)
    - Promote the lysis of fibrin, and lead to dissolution of the thrombi.
    - Used to dissolve an ischemic stroke clot. Used only in critical care areas due to high risk and close monitoring required.
- Antifibrinolytic (tranexamic acid)
    - Promote blood coagulation by stabilizing blood clots.
    - Used for heavy menstrual bleeding. Taken orally, working within 24 hours.
- Note: desmopressin, an antidiuretic hormone medication, can also be used to control excessive bleeding, especially with hemophilia or von Willebrand's disease.

Difference between arterial and venous thrombosis

Venous thrombosis develops at sites where blood flow is stagnant in a vein, usually deep veins. The stagnant blood initiates the clotting cascade, leading to fibrin production, and red blood cells and platelets adhering to form a thrombus (clot). Embolus are venous thrombi that have a long tail and can break off the become lodged elsewhere in the body such as the pulmonary circulation. Anticoagulants prevent thrombosis in veins.

Arterial thrombosis begins with the adhesion of platelets to the arterial wall, following damage to the wall or a rupture of plaque. Platelets aggregate and can occlude the artery. This is localized and can lead to decreased perfusion to the area. Antiplatelet drugs prevent thrombosis in arteries.

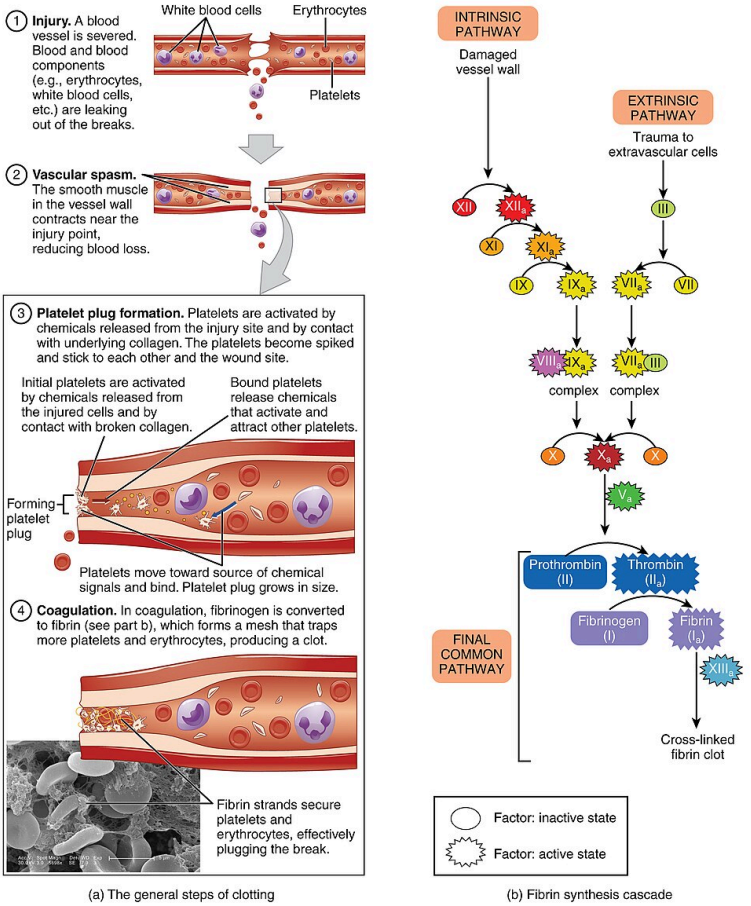


Figure 7.10a Hemostasis and the clotting cascade (OpenStax College/Anatomy and Physiology CNX/Wikimedia Commons) CC BY 3.0

In this unit, we will focus on only three categories that affect coagulation:

- Antiplatelets: cyclooxygenase inhibitors (ASA, Clopidogrel/ Ticagrelor)
- Anticoagulants (Heparin, low molecular weight heparin,

Warfarin, Rivaroxaban, Dabigatran)
- Thrombolytics (Alteplase)

Antiplatelets

Antiplatelet therapy (APT) is the foundation of treatment and prevention of atherothrombotic events in patients with atherosclerotic cardiovascular disease (Canadian Journal of Cardiology, 2023). Although aspirin was the first antiplatelet medication, today there are a number of both oral and parenteral medications. Oral APT include aspirin, clopidogrel, ticagrelor, and dipyridamole. Parenteral meds are glycoprotein IIb/IIIa inhibitors such as tirofiban and eptifibatide, which are used in the acute phases of acute coronary syndrome (Iqba, Lopez & Hai, 2022).

Acetylsalicylic acid (aspirin) and clopidogrel (Plavix) will be the prototype medications.

Figure 7.10b Chewable aspirin are used for clients experiencing a myocardial infarction due to their rapid absorption. (Mike Mozart/Flickr) CC BY 2.0

To help understand the difference between the meds, we will look at the mechanism of action of ASA, Clopidogrel and Glycoprotein platelet inhibitors.

Mechanism of Action

Antiplatelet drugs suppress platelet aggregation and prevent thrombosis in arteries. Antiplatelet drugs can be divided into categories based on their mechanism of action.

1. Platelet aggregation inhibitors:
    1. Cyclooxygenase inhibitor: Acetylsalicylic acid (ASA)
    2. P2Y12 adenosine diphosphate (ADP) receptor blockers: Clopidogrel, ticagrelor.
2. Glycoprotein platelet inhibitors: tirofiban
3. Other APT meds that are not covered in this unit are protease-activated receptor-1 antagonists (vorapaxar) and nucleoside transport inhibitor and PDE3 inhibitor (cilostazol).

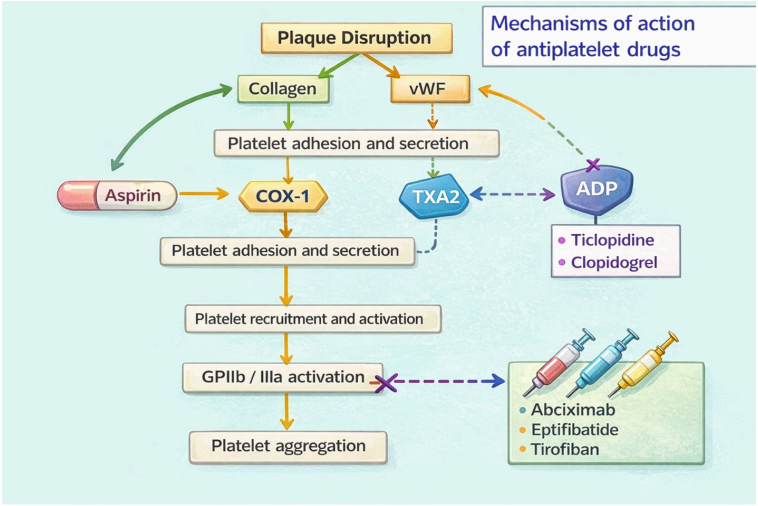


Figure 7.10c Mechanism of Action of Anti-platelet Medications. (Sheila Odubote/TRU Open Press) CC BY-NC-SA

Acetylsalicylic acid (ASA)

ASA irreversibly inhibits the cyclooxygenase enzyme (COX) activity in the prostaglandin synthesis pathway (PGH2). This contrasts with NSAIDs which reversibly binds to COX. Cyclooxygenase is needed for platelets to synthesize thromboxane A2 (TXA2) which is one of the factors to promote platelet aggregation and vasoconstriction on vascular smooth muscle. By inhibiting TXA2 mediated vasocontraction and platelet aggregation, the risk of arterial thrombosis is reduced. Low dose aspirin of 81 mg/day can result in near complete inhibition of COX-1. Low doses are often used, as higher doses can also inhibit COX-2 and lead to a higher risk of GI bleeding (Iqba, Lopez & Hai, 2022).

The irreversible inhibition is what sets ASA apart from other NSAIDs. Although it takes one hour post ingestion to block platelets, due to irreversible inhibition of COX, it is inhibited for the life of the

platelet which is about eight days. This provides the sustained effect of inhibiting platelet aggregation after one dose. Other NSAIDs do not have this sustained effect and are not used for cardiac prevention.

P2Y12 Adenosine Diphosphate (ADP) Receptor Blockers: Clopidogrel

P2Y12 ADP receptor blockers work on platelet surface, irreversibly inhibiting the platelet P2Y12 receptor thereby preventing platelet aggregation. Clopidogrel causes irreversible receptor blockage while ticagrelor causes reversible blockage. Both have similar efficacy. Since P2Y12 inhibition with ticagrelor is reversible, the antiplatelet effect dissipates more rapidly than with clopidogrel, which are irreversible P2Y12 inhibitors. Therefore, there is less procedure-related bleeding and less time to withhold the drug prior to procedures (Wallentin et al, 2009).

Glycoprotein platelet inhibitors

Glycoprotein platelet inhibitors work by irreversibly inhibiting glycoprotein IIb/IIIa (GpIIb-IIIa) receptors on platelets, thus decreasing platelet aggregation. Their action is on the final step of platelet aggregation which limits all the platelet aggregation factors. They are the most effective antiplatelet drugs and are used short term to prevent ischemic events in ACS (Rosenjack Burchum & Rosenthal, 2019).

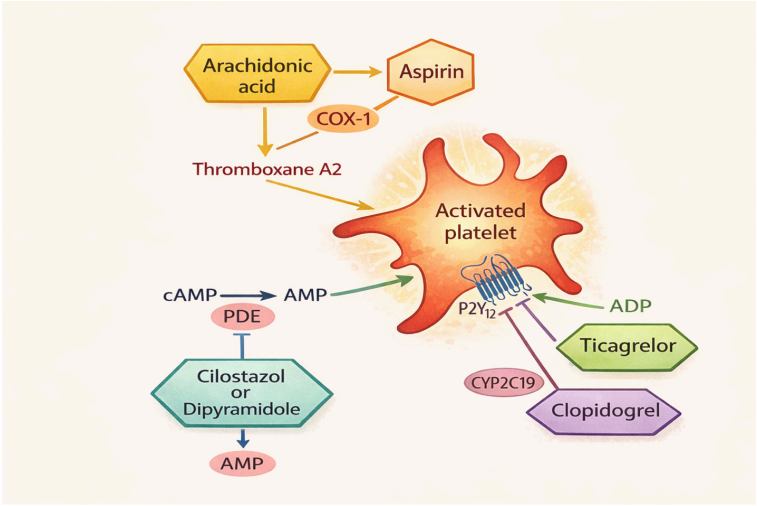


Figure 7.10d An activated platelet and the mechanism of actions of coagulation modifiers, ticagrelor, clopidogrel, and aspirin. (Sheila Odubote/ TRU Open Press) CC BY-NC-SA

Indications for Use

Anti-platelet therapy are used for a wide variety of cardiovascular conditions. It is used for the prevention of acute coronary syndrome, for the maintenance of coronary artery stents, and peripheral artery disease.

Acetylsalicylic Acid

Acetylsalicylic Acid (aspirin) is a non-opioid analgesic and anti-pyretic. It is also used for its cardioprotective anti-platelet effects. In this unit, we will focus only on the cardioprotective effects. ASA is also in **unit 6.5** with a focus on the analgesic and antipyretic effects.

Cardioprotective Effects of ASA: One of the beneficial effects of

ASA is the thrombotic effects and is routinely recommended for clients at greater risk of myocardial infarction (MI) or stroke. This includes clients with ischemic stroke, transient ischemic attacks, acute MI (both ST elevation and non-ST segment elevation) and previous MI. It is also prescribed for higher risk clients as a primary prevention of MI (Rosenjack Burcham & Rosenthal, 2019). For anti-platelet effects, the dose of 81 mg once a day is sufficient, as higher doses will increase the risk of GI bleeding without more cardio protective effects.

Clopidogrel

Clopidogrel is used to prevent stenosis of coronary stents or secondary prevention following an MI or ischemic stroke.

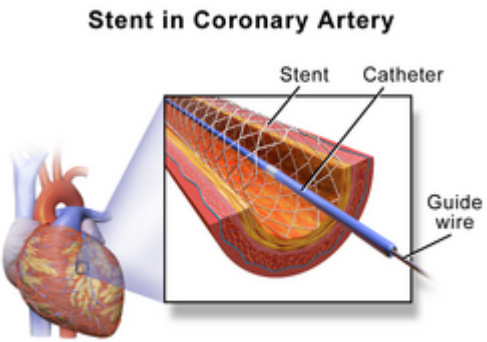


Figure 7.10e A coronary stent placed by a percutaneous coronary intervention (PCI). (BruceBlaus/ Wikimedia Commons) CC BY 3.0

Tirofiban

Tirofiban, the GP IIb/IIIa antagonist, is used short term to prevent ischemic events in clients with ACS or undergoing percutaneous coronary insertion. It is given intravenously.

Nursing Considerations for Anti-Platelet Medications

Administration:

- ASA can be given oral or rectal. It comes in tablet, liquid and enteric coated options. Different dosages are prescribed depending on the rationale for use:
    - 81 mg po once a day – for cardioprotective effects. A larger dose is not needed to inhibit platelet aggregation.
    - 325 mg po for acute cardiac events, such as suspected MI, to achieve effects quickly.
    - 325-650 mg po q 4-6 hour (2600 mg/day) for pain and fever.
    - 3000-4000mg per day for inflammatory conditions such as rheumatoid arthritis
- Clopidogrel, taken orally, and it is well tolerated. It is given with ASA in clients with ACS. It reaches steady state in 5-7 days.
- GPII-IIIa inhibitors are given intravenously and used for short term therapy during acute coronary syndrome.

ASA is rapidly absorbed in the small intestine after oral administration. ASA has a short life, converted to salicylic acid within 15-20 minutes. It is highly bound to albumin, and rapidly distributed to all body tissues. It is renally excreted (Rosenjack Burchum & Rosenthal, 2019).

Prior to surgery: ASA causes irreversible inhibition of platelet aggregation. This effect lasts the life time of a platelet which is 7-10 days. ASA is often withheld for several days prior to surgery or certain procedures to prevent excessive bleeding.

Children: ASA is contraindicated in children under the age of 14 due to the risk of Reye's syndrome. Reye's Syndrome can occur in children who have a viral or upper respiratory tract infection

and are then given ASA to treat the fever. Children develop encephalopathy and liver damage secondary to mitochondrial injury. There is a high fatality rate of 30-45%. Children under 14 years should not be given ASA. If a child needs analgesic or pain relief, then acetaminophen or ibuprofen can be used safely.

Pregnancy and Breastfeeding:

ASA is not considered safe for pregnant women, especially after 20 weeks of pregnancy. It crosses the placenta, and can potentially cause low birth weight, still birth, and renal issues on the fetus. For the mother, it can suppress contractions, so need to avoid in the third trimester. It can also be found in breast milk and not recommended.

Older Adult:

Older adults are more susceptible to negative GI and CNS effects of anti-inflammatories. If the client has renal insufficiency, then ASA will not be readily excreted, prolonging the duration of action. There is also an increased risk of bleeding with concurrent use of Clopidogrel plus ASA.

Contraindications to using antiplatelet medications include large esophageal varices, recent stroke within 2 years, ESRD, severe hypertension with BP over 200/110.

Clients with an allergy to Ibuprofen should not take ASA due to cross sensitivity.

Increased risk of GI bleeding with clients with peptic ulcer disease or gastritis, clients on warfarin, or any bleeding disorders.

Drug Interactions for Clopidogrel

Clopidogrel is metabolized to its active metabolite by CYP2C19. Concomitant use of drugs that inhibit the activity of this enzyme results in reduced plasma concentrations of the active metabolite of Clopidogrel and a reduction in platelet inhibition. Drugs interactions can occur if used with proton pump inhibitors, opioids, NSAIDs, warfarin, and antidepressants (Iqba, Lopez, & Hai, 2022).

Adverse/Side Effects

ASA is typically well tolerated but may cause toxicity, intolerance or hypersensitivity.

The most common side effect is gastric irritation. This can range from mild gastritis to gastrointestinal bleeding. To avoid this effect, clients are recommended to take enteric coated ASA (Arif & Aggarwal, 2023).

Other side effects include heartburn and nausea. Bruising easily and bleeding gums are also common.

Adverse Effects:

Bleeding: GI bleeding is relatively common and the client may experience dark, tarry stools. Typically, the amount of bleeding is very minimal, but if on ASA for a long period of time, even at low doses, it may produce anemia. Also, there is a higher risk of gastric ulceration, perforation and bleeding. The chance for bleeding is higher if a client:

- takes a higher dose or takes it for a longer time than directed
- takes other drugs containing prescription or nonprescription NSAIDs (aspirin, ibuprofen, naproxen, or others)

- has had stomach ulcers or bleeding problems
- takes a blood-thinning (anticoagulant) or steroid drug
- is age 60 or older
- smokes cigarettes
- has 3 or more alcoholic drinks every day while using this product

To minimize the risk of gastric ulcers, clients can take a proton pump inhibitor to reduce the hydrochloric acid in the stomach. Other meds such as histamine receptor antagonists or misoprostol are beneficial.

Hypersensitivity reactions

Hypersensitivity reactions are less common but are more likely with clients with a history of asthma, rhinitis and nasal polyps (Rosenjack Burchum & Rosenthal, 2019). This NSAID-induced respiratory disease begins within one hour of ingestion. Symptoms begin with diffuse watery rhinorrhea and can eventually lead to urticaria, bronchospasm and shock. This is not the same as an allergic reaction but due to the inhibition of COX-1 which triggers the production of leukotrienes. Clients who are allergic to any NSAID should not take aspirin as there is cross-reactivity.

Salicylate Toxicity

If ASA levels climb above therapeutic levels, salicylism can occur. Cues can include tinnitus (ringing in the ears), sweating, headache, nausea and dizziness. If a mild case, then withhold ASA, and once symptoms reside, then ASA can resume but with smaller doses.

If severe, the client can experience hyperthermia, tachypnea, metabolic acidosis, hypokalemia, seizures and cerebral edema. If

these cases, salicylate toxicity is treated based on salicylate concentration, acid-base and electrolyte status. Treatment is activated charcoal, treating acidosis, and supportive measures (Arrif & Aggarwal, 2023).

Contraindications

ASA is contraindicated if the client has a bleeding disorder such as hemophilia, vitamin K deficiency, or a recent history of bleeding in the stomach or intestine. High doses of ASA should be held prior to surgery for one week. It does not need to be held for minor procedures such as dental procedures (Rosenjack Burchum & Rosenthal, 2019).

Renal Impairment

Extra caution should be advised for clients at higher risk of impaired renal function from ASA use. ASA can cause irreversible renal impairment resulting in salt and water retention and edema. Clients most at risk are advanced age, history of renal insufficiency or liver impairment or heart failure.

Client Teaching

Clients should be made aware of the potential risks to avoid gastric distress, GI bleeding and other adverse effects.

- Take with a full glass of water and remain upright for 30 minutes
- Use only the recommended dosage depending on the reason for use.

- Monitor for side effects such as nausea, gastric irritation, and occasional blood in stools. Report persistent symptoms such as ongoing bleeding or fever longer than 3 days.
- Monitor for adverse effects such as tinnitus and hold ASA until seen by their prescriber.
- If the client has asthma or rhinitis, be aware of hypersensitivity reaction cues such as diffuse watery rhinorrhea, itching and bronchospasm.
- Do not give ASA to children.
- If going for surgery, discuss with health care provider for the need to hold ASA one week prior to surgery.
- Avoid consuming alcohol greater than 3 drinks a day while on ASA
- Do not take ASA while pregnant. If taking ASA for inflammatory conditions, and under the supervision on their prescriber, ASA may be taken up to the third trimester.

(Vallerand & Sanoski, 2024).

Acetylsalicylic Acid Medication Card

Now let's take a closer look at the medication card for antiplatelet meds. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Acetylsalicylic Acid (Aspirin) and Clopidogrel (Plavix) Medication Card

Class: Blood Coagulation Modifiers (Antiplatelet) **Prototypes:** Acetylsalicylic Acid (Aspirin) Clopidogrel (Plavix)	**Indications:** treatment and prevention of atherothrombotic events in patients with atherosclerotic CV disease: MI, Stroke, Acute Coronary Syndrome (ACS), Post-angioplasty and stent insertion, Unstable angina		
Mechanism of Action: Acetylsalicylic acid (ASA) irreversibly inhibits platelet activation and aggregation. Clopidogrel (Plavix) is metabolized to its active form by CYP2C19. Drugs that inhibit this enzyme reduce the active metabolite of clopidogrel, decreasing platelet inhibition.			
Administration: Oral or rectal; dose depends on client and indication ASA 80 mg once a day CV prevention Enteric coated to avoid GI upset Administer with food to reduce GI upset and bleeding risk Avoid grapefruit	**Side Effects:** Easy bruising, bleeding gums. Adverse: Tinnitus, Blood in stool SAFETY: Increased bleeding risk Dual therapy with ASA + Plavix is common in cardiac patients *Call 911 for sudden vision changes, confusion, weakness, arm pain, sweating, or trouble speaking	**Contraindications:** Children under 12 years (risk of Reye's syndrome with ASA) Avoid alcohol (↑ GI bleeding risk) Avoid concurrent NSAID use Renal insufficiency will prolong effects Salicylism risk: Monitor for tinnitus, sweating, headache, nausea. Hold med	**Nursing Considerations:** Hold 7–10 days prior to surgery (platelet lifespan) Monitor for bleeding: tachycardia, hypotension, low urine output Assess abdomen and flanks for bruising or bleeding Turn patient to assess posterior and peritoneal areas for bleeding

Downloadable file (.docx): Acetylsalicylic Acid Medication Card

Anticoagulants

Recall that anticoagulants are used to prevent venous clot formation. Clients who are more at risk for clots such as deep vein thrombosis (DVT) are those with blood flow stasis (advanced age, obesity, atrial fibrillation, bedrest), endothelial damage (major surgery or trauma) and hypercoagulable states (increased estrogen from pregnancy or oral contraceptive use) (Kushner et al, 2024).

Anticoagulants prevent the formation of a clot by greatly enhancing the activity of antithrombin, which inactivates thrombin and factor Xa, which results in reducing the formation of fibrin and the ability of the blood to clot. They are used to:

- Prevent the formation of thrombi with high-risk clients
- Prevent and treat thromboembolic events (DVT, PE)
- Prevent excess coagulation from surgery or dialysis

Anticoagulants include the following drug classes:

- heparins or unfractionated heparin and low molecular weight heparin (LMWH),
- warfarin (Coumadin),
- selective factor Xa inhibitors (Rivaroxaban), and
- direct thrombin inhibitors (dabigatran).

In this unit, we will review heparins, warfarin and selective factor Xa inhibitors.

Diagnosis for venous clot formation:

For all clients who are high risk for a DVT or pulmonary embolus (PE), nurses must assess for:

- DVT: unilateral calf pain, swelling and warmth in the calf.
- Pulmonary embolus: SOB, chest pain, fatigue, tachycardia, hypoxia

Note: clients will not present with all these symptoms or they will be very subtle. Pay attention to subtle cues and report any unusual finding.

For any client suspected of a clot, PE or DVT diagnostics may include:

- Positive D-dimer (elevated levels indicate a clot somewhere in the body, not very specific so not used for definitive diagnosis)
- Chest XR to rule out other causes
- Duplex ultrasound if DVT suspected
- CT scan chest
- VQ scan

Medication Safety with Blood Coagulation

Anticoagulants are a high alert med due to the risk of bleeding. Heparin and warfarin are both on the top 10 list of drugs most frequently reported causing harm due to a drug error (Institute for Safe Medication Practices in Canada (ISMP), 2020). In hospital settings, errors are related to administration issues including incorrect dosage calculations and infusion rates (Anderson & Townsend, 2015). ISMP (2006) found that the underuse of anticoagulants in high-risk clients that resulted in venous thromboembolism is one of the most serious complications. In the community, anticoagulants can be used incorrectly by clients and carry the risk of serious bleeding. To reduce harm, the Health Research and Educational Trust recommend that facilities:

- Educate staff based on evidence and best practices.
- Use standardized order sets and protocols. For example, standardized order sets for heparin and warfarin.
- Perform medication reconciliation at all transitions.

(Anderson & Townsend, 2015).

Heparin Sodium

Heparin sodium is an anticoagulant that is commonly used in the hospital setting to either prevent or treat thrombosis. Heparin unfractionated (IV infusion) is given in high doses to treat a DVT or PE. In lower doses, it is given SQ to prevent post-op thrombosis.

Heparin is a high alert medication due to the different concentrations and high risk of bleeding. To avoid risk, hospitals use several processes for storing and labelling to help prevent errors. As nurses, we must ensure safety by following the appropriate steps when choosing which vial to draw up the medication and follow hospital protocols during administration such as independent double checks.

We will review unfractionated heparin and also Low Molecular Weight heparin (enoxaparin)

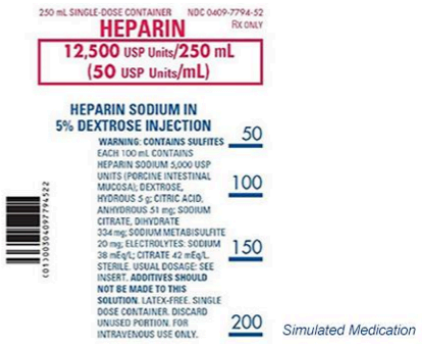


Figure 7.10f Heparin comes in many dosages, and overdose can be deadly, so it is important for the nurse to use safeguards to prevent potential medication errors. (left: LHcheM/ Wikimedia Commons) CC BY-SA 3.0 (right: DailyMed/NIH/Chippewa Valley Technical College) CC BY 4.0

Safety alert for heparin

Heparin comes in many different concentrations, depending on the rationale for prescribing heparin.

Dosages include: 1000 units/mL, 5000 units/mL, 10,000 units/mL

Take precautions to avoid a med error by following safe med practices.

Mechanism of Action

Unfractionated Heparin

Unfractionated heparin potentiates the inhibitory effect of antithrombin on factor Xa and thrombin. In the absence of both of these clotting factors, the production of fibrin is reduced and clotting is suppressed (Rosenjack Burchum & Rosenthal, 2019). Recall that fibrin forms the framework for thrombi in veins.

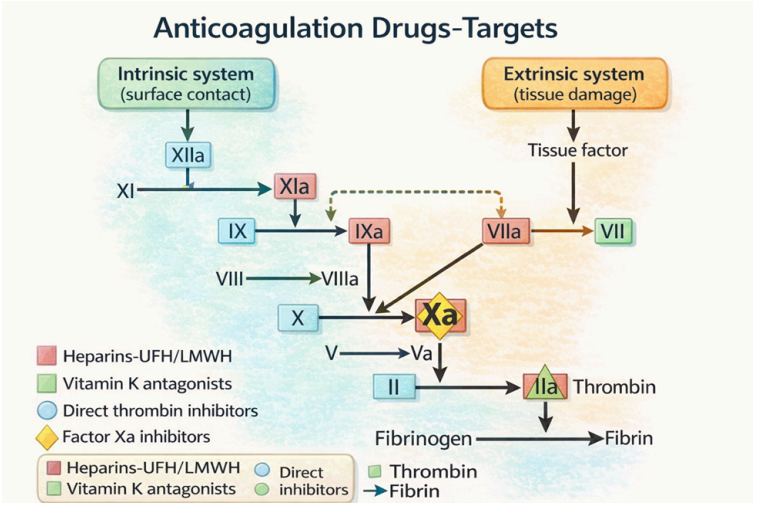
Heparin does not have fibrinolytic activity; therefore, it will not break down existing clots, only prevent venous thrombosis.

Heparin is highly polar, and as such does not readily cross membranes especially the GI tract, so it is only given parenterally. Heparin works quickly, within minutes by IV route. It has a peak effect of 5-10 minutes. It has a short half-life of 1-2 hours, which is longer in clients with renal or hepatic insufficiency, obesity or infections (Vallerand & Sanoski, 2024). For SQ route, the is 20-60 minutes.

Low Molecular Weight Heparin (dalteparin, enoxaparin)

Low Molecular Weight Heparin (LMWH) also potentiates the inhibitory effect of antithrombin. But their molecular chains are shorter than with unfractionated heparin, so they preferentially inactivate factor Xa and less able to inactivate thrombin. Heparin has a faster onset of anticoagulant action as it will inhibit Xa and thrombin, while LMWH acts only through Xa inhibition.

LMWH are equally effective at venous thrombi prevention. It has a higher bioavailability and a prolonged half-life than unfractionated heparin, resulting in more predictability. As such, they are given in a fixed dose, once a day and do not require PTT monitoring (Patel & Varacallo, 2025).



7.10g Coagulation cascade and where anticoagulants work to disrupt the clotting factors. (Sheila Odubote/TRU Open Press) CC BY-NC-SA

Indications for Use

Unfractionated Heparin

Depending on the purpose, the dose and concentration of heparin are different. It is only given IV or SQ, as the heparin molecule is too large to cross membranes in the GI tract.

- IV heparin (continuous infusion) is commonly indicated for the treatment of deep venous thromboembolism (DVT) or pulmonary embolism. It is also indicated for use during acute myocardial infarction.
- Subcutaneous heparin is commonly indicated to prevent DVT or embolization caused by atrial fibrillation.
- Heparin IV flushes ("Hep-Locks") are used to maintain the patency of central IV lines. These concentrations are very low, with between 10-100 units/mL.

Low Molecular Weight Heparin (dalteparin, enoxaparin)

Used for:

- prophylaxis of venous thromboembolic disease (VTE) on acute or elective admission to the hospital,
- treatment of deep vein thromboses (DVT) and pulmonary embolism (PE).
- DVT treatment in pregnant women.

Unlike heparin, they can also be used by clients at home. For example, high risk post-op clients that need short term anticoagulation.

Nursing Considerations

Administration:

Unfractionated heparin IV for DVT and PE treatment:

- Continuous IV infusion in peripheral or central line. IV bags are pre-mixed in pharmacy with 25,000 units heparin /D5W 500 mL for a concentration of 50 units/mL.
- Heparin Nomogram is used that includes lab work, initial heparin therapy and continuous therapy. Initial dosing is based on client weight.
- It requires close monitoring of frequent partial thromboplastin time (PTT) results to ensure dosage is in therapeutic range and to reduce the risk of overdose with associated bleeding. Dosage is considered adequate when the activated partial thromboplastin time (APTT) is 1.5 to 2 times the normal or when the whole blood clotting time is elevated approximately 2.5 to 3 times the control value. Follow institutional therapeutic monitoring for current practice guidelines and client context.
- Labs: baseline PTT, CBC and INR before therapy, then PTT every 6 hours until within therapeutic range. Monitor platelet count q 2-3 days.

Unfractionated heparin SQ for DVT prophylaxis:

- SQ syringes with 10,000 units/mL for dose of 5000 units SQ.
- BID dosing. Risk of bruising at site.
- No PTT monitoring

Heparin molecules are too large to cross membranes so only given IV or SQ. It is also too large to cross the placental barrier, so there is no risk to the fetus. It is also too large to be excreted in breastmilk.

LMWH: enoxaparin is administered SQ, usually once a day. Often

prescribed for 7-10 days post-op for clients recovering from hip or knee surgeries or abdominal surgeries.

Hepatic and renal impairment: heparin is metabolized by the liver and excreted by the kidney. The half-life is two hours so if renal or hepatic impairment, duration of action will be longer.

Do not give IV heparin with antiplatelet medications.

Older adult: A higher incidence of bleeding has been reported in clients over 60 years of age, especially women.

Reversal agent: protamine sulfate. If bleeding requires quick reversal of anticoagulation, protamine is given by slow infusion to neutralize heparin sodium and reverse the heparin action. Protamine forms a bond with the heparin molecule and neutralizes it immediately. Administer 20 mg/min. Protamine 1 mg will neutralize 100 units of heparin. It lasts about 2 hours and then dose may need to be repeated.

Contraindicated in clients with a history of Heparin-Induced Thrombocytopenia (HIT) and Heparin-Induced Thrombocytopenia and Thrombosis (HITT). HIT is a condition where platelets drop 30% or more below a client's baseline after heparin is administered and can lead to HITT where thrombi are formed.

Use with caution with medications that affect the coagulation cascade due to additive effects that increase the risk of bleeding. When a client is receiving IV heparin therapy to treat a blood clot, it may be overlapped with oral warfarin to establish anticoagulation therapy after discharge. See more information about this process under the "Warfarin" section.

Adverse/Side Effects

High Alert Med: Fatal hemorrhages have occurred due to medication errors. Carefully examine all heparin products to confirm the correct dose prior to the administration of the drug. Independent double check for infusions. Notify prescribing

provider immediately of new signs of bleeding or bruising, or sudden changes in vital signs that indicate internal bleeding, such as decreasing blood pressure with an associated increase in heart rate.

Heparin-Induced Thrombocytopenia (HIT): Some clients may develop Heparin-Induced Thrombocytopenia (HIT) or Heparin-Induced Thrombocytopenia and Thrombosis (HITT). It is a potentially fatal immune-mediated disorder that is characterized by extremely low platelet count and an increase in thrombotic events despite adequate anticoagulation. Monitor platelet count. If this develops, heparin should be discontinued immediately.

Cues of internal bleeding

The risk of internal hemorrhage is 10%. Assess for symptoms such as hypotension, tachycardia, petechiae, red or black stools, hematuria, pelvic pain and headache. Notify the MD immediately if hemorrhage is suspected. Protamine sulfate IV is the reversal agent.

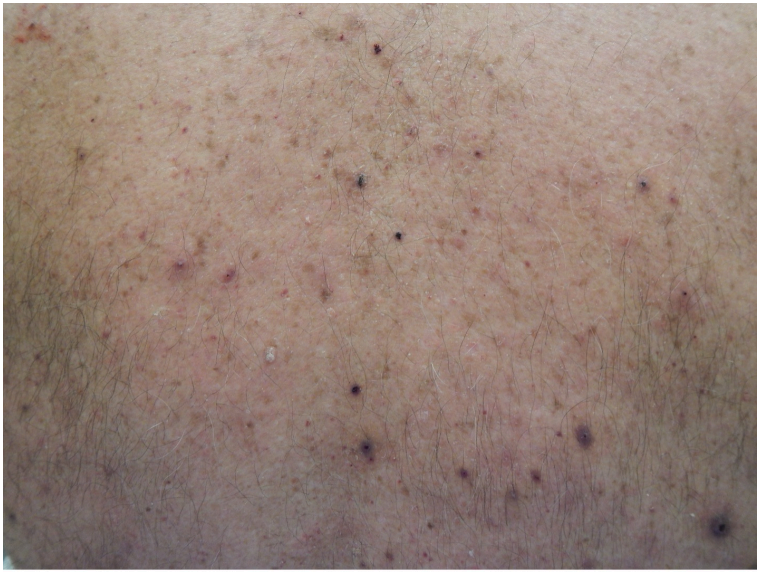


Figure 7.10h Petechia on the back of a client. (James Heilman, MD/Wikimedia Commons) CC BY-SA 4.0

Client Teaching

- Clients should notify health care staff immediately of new signs of bleeding or bruising,
- and remind physicians and dentists that they are receiving heparin before any surgery or invasive procedure is scheduled.
- Clients should avoid medications containing aspirin or NSAIDS.
- Clients should avoid IM injections, and use a soft toothbrush and electric razor, as precautions against causing bleeding (Vallerand & Sanoski, 2024).

Low Molecular Weight Heparin (LMWH)

Enoxaparin is a low molecular weight heparin (LMWH) is often prescribed instead of heparin for DVT prevention. It is very effective but with the additional benefit of not requiring aPTT monitoring.

Figure 7.10i Enoxaparin in a prefilled syringe (stux/Pixabay) Pixabay Content License.

Mechanism of Action

Enoxaparin is a low molecular weight heparin, which has antithrombotic properties with a higher ratio of anti-Factor Xa to anti-Factor IIa activity compared to heparin. It is metabolized slowly from the liver. It has a longer bioavailability and is more predictable than heparin. For this reason there is a fixed dose and no need for monitoring coagulation.

Indications for Use

It is indicated for the prevention and treatment of deep vein thrombosis (DVT), which may lead to pulmonary embolism (PE). It is also used in combination with aspirin for the treatment of acute myocardial infarction or a STEMI. It is often prescribed post op for clients who are high risk of a DVT such as orthopedic surgeries.

Nursing Considerations

Administration: SQ and preferably in the abdomen for best absorption. Given once a day or BID. It is supplied in a prefilled syringe.

Safety and effectiveness have not been established in pediatric clients.

Older adult: The risk of bleeding increases with age, especially if used concurrently with antiplatelet medications.

Renal Impairment: Use with caution in clients with renal impairment; risk of bleeding is increased. A dosage adjustment is recommended for clients with severe renal impairment.

Overdoses can be neutralized with a slow IV infusion of protamine sulfate. Not as effective as with heparin.

Adverse/Side Effects

Less bleeding risk but still monitor for bleeding. Higher risk following percutaneous coronary revascularization procedures or with concurrent medication conditions such as recent GI ulcer. It may cause Heparin-Induced Thrombocytopenia (HIT) or Heparin-Induced Thrombocytopenia with Thrombosis (HITT).

High Alert Med: Epidural or spinal hematomas may occur in

clients who are anticoagulated with low molecular weight heparins (LMWH) and are receiving neuraxial anesthesia or undergoing spinal puncture. These hematomas may result in long-term or permanent paralysis.

Client Teaching

- Notify health care staff immediately of new signs of bleeding or bruising.
- Remind physicians and dentists that they are receiving heparin before any surgery or invasive procedure is scheduled.
- Clients should avoid medications containing aspirin or NSAIDS (Vallerand & Sanoski, 2024).

Warfarin

Since 1954, warfarin has been a standard but hazardous treatment for preventing blood clots. It is a vitamin K antagonist. Warfarin requires close laboratory monitoring and individual dose adjustments based on PT and INR lab results. When the pharmaceutical industry began marketing modern replacements for warfarin, including dabigatran, rivaroxaban, and apixaban, they designed them to be easier to use than warfarin because no laboratory monitoring was required, but they were not necessarily safer. It is vital for nurses to provide thorough client and caregiver education for clients prescribed anticoagulants at home. Suggested client education topics are included for each type of medication below.

Mechanism of Action

Warfarin inhibits an enzyme that is required for the action of vitamin K. Without vitamin K, the production of clotting factors II, VII, IX and X as well as coagulation regulator proteins C and S, is diminished. These clotting factors circulate in the blood so it takes a few days for plasma levels to fall. Warfarin is also highly bound to protein, so the actual available amount of warfarin is unavailable to produce its effect. This explains why there is a delay in achieving therapeutic effect (Patel et al, 2024).

Indications for Use

Warfarin is typically given for long term prophylaxis against thrombosis. It is indicated for:

- Prophylaxis and treatment of venous thrombosis and its extension, pulmonary embolism (PE).
- Prophylaxis and treatment of thromboembolic complications associated with atrial fibrillation (AF) and/or cardiac valve replacement.
- Reduction in the risk of death, recurrent myocardial infarction (MI), and thromboembolic events such as stroke or systemic embolization after myocardial infarction.

Pharmacokinetics

Warfarin is easily absorbed following oral administration. It can take up to 72 hours to take effect, with the duration of action between 2 and 5 days. It is highly protein bound at 99%. Free or unbound warfarin readily crosses cell membranes. It crosses the placental

barrier. It is metabolized in the liver and excreted by the kidney and feces (Patel et al, 2024).

Nursing Considerations

Administration: oral, formulated in various strengths in different colors to help prevent errors when clients self-administer different dosages at home (See figure 7.10h) Close International normalized ratio (INR) monitoring is required.

Monitoring:

- Baseline INR prior to therapy.
- Warfarin initiated at 5 mg/day but may be lower in at-risk clients (see below).
- INR every 2-4 days, then weekly, and once stable q 2 weeks, then eventually q 4 weeks. The objective is for the INR to be raised to an appropriate level.

Normal INR 0.8-1.2
Target 2-3 (target for mechanical valve 3-4.5)
(Ministry of Health, 2023).
At the initiation of therapy:

- INR will rise without concomitant therapeutic anticoagulant effect during the first 5-7 days of treatment. During the maintenance phase, a dose change may not be reflected in INR for 4-5 days and so dose changes more than twice a week are not recommended.
- As therapeutic effect will not occur for the first 5 days, LMWH or unfractionated heparin SQ may be prescribed during that time.

Dosages: typical starting dose is 5 mg/day. Lower doses of 1-2

mg/day may be ordered for clients who are frail, over 70 years of age, hypoalbuminemia (i.e. malnourished, liver disorders, post-operative), heart failure, recent use of some antibiotics that would impact gut flora.

In hospitalized clients receiving heparin therapy, there is often a period of overlap where the client is prescribed both IV heparin and warfarin until the INR reaches therapeutic range. At that point, the IV heparin is discontinued.

Cultural differences: clients of Asian descent tend to require lower doses. Clients of African American descent tend to need higher doses because of the differences in genetic polymorphisms between these populations.

Contraindications:

Absolute contraindications include liver disease with baseline INR greater than 1.3, non-adherence to taking the med or with accessing INT testing, or hemorrhagic tendencies or blood dyscrasias. Also, recent surgery of the central nervous system or eye, or traumatic surgery resulting in large open surfaces.

Bleeding tendencies include conditions such as active ulceration in the GI tract, overt bleeding in the GU or respiratory systems, cerebral aneurysms, dissecting aorta, pericarditis, or bacterial endocarditis.

Pregnancy: contraindicated during pregnancy due to risk to fetus such as teratogenicity and spontaneous abortion. LMWH is safe to use. Women with mechanical valves who may need warfarin, then avoid first trimester and within 2-4 weeks of delivery.

Dietary restrictions:

Although there are no absolute dietary restrictions for patients taking warfarin, they do need to maintain a consistent and regular diet. Their vitamin K intake should be consistent amount each day or it can influence INR levels. Vitamin K rich foods include leafy greens, cabbage, fish, liver, tomatoes. Avoidance of certain herbs

such as garlic, ginger, gingko bilboa, and St John's Wort, may be recommended.

(Ministry of Health, 2023; Patel et al, 2024).

Drug Interactions

Warfarin has significant interactions with many medications; either they interact to reduce the coagulant effects (sub therapeutic) or the coagulation can be increased to the point of hemorrhage. For example, there is a higher risk of bleeding (higher INR) with many medications including anticonvulsants (phenytoin sodium), analgesics (acetaminophen, aspirin, tramadol). antibiotics (amoxicillin, macrolides, tetracycline and many others), antidepressants (SSRIs, citalopram) and anti-arrythmics (amiodarone, propafenone).

INR levels are decreased with St John's Wort, antibiotic (rifampin), antithyroid agents, trazadone and smoking. Read drug label information before administering. Consult with the prescriber or the pharmacist.

BC Guidelines.ca (2015)

Reversal Agent: Vitamin K1

Vitamin K antagonizes warfarin's actions and can reverse the inhibition of clotting factor synthesis. It is used if INR is greater than 5.

Dosage: oral or IV. For IV, dilute and infuse slowly to avoid flushing, chest pain, dyspnea and hypotension.

i.e. 2.5 mg po or 0.5- 1.0 mg IV. Only give enough vitamin K to get INR back into range. If severe bleeding, can give fresh frozen plasma or whole blood. If too much vitamin K is given, it is difficult to anticoagulate afterwards.

(Ministry of Health, 2023; Patel et al, 2024)

Figure 7.10j Warfarin is an oral pill with various strengths in different colors to help prevent errors. (Gonegonegone/Wikimedia Commons) CC BY-SA 3.0

Adverse/Side Effects

High Alert Med: Warfarin can cause major or fatal bleeding. Perform regular monitoring of INR in all treated clients. Drugs, dietary changes, and other factors affect INR levels achieved with warfarin therapy. Instruct clients about prevention measures to minimize risk of bleeding and to report signs and symptoms of bleeding. Warfarin can cause acute kidney injury and bleeding risks are increased in clients with liver disease.

Signs of bleeding can include: hypotension, tachycardia, bruises, petechiae, hematomas, red or black stools, pelvic pain, headache.

Client Teaching

Clients or their caregivers must be able to adhere to the treatment plan. Ensure they understand the treatment goals and need for strict monitoring and strategies to avoid risk. Advise clients to:

- Avoid alcohol, cranberries, and grapefruit as they increase the effect of warfarin and the risk of bleeding.
- Strictly adhere to the prescribed dosage schedule.
- Follow INR monitoring guidelines as provided by the prescriber.
- Avoid any activity or sport that may result in traumatic injury and risk of bleeding.
- Tell their provider if they experience frequent falls, since warfarin can increase their risk for bleeding in the brain.
- Eat a normal, balanced diet, including green, leafy vegetables, to maintain a consistent intake of vitamin K.
- Tell all health care professionals and dentists that they are taking warfarin, especially before surgery or dental procedures.
- Use electric razors instead of straight razors.
- Carry identification stating that they are taking warfarin.
- Do not take any medications, herbal supplements or OTC meds without consulting with their prescriber.
- Notify their provider immediately if any unusual bleeding or symptoms occur, such as pain, swelling or discomfort, prolonged bleeding from cuts, increased menstrual flow or vaginal bleeding, nosebleeds, bleeding of gums from brushing, unusual bleeding or bruising, red or dark brown urine, red or tar black stools, headache, dizziness, or weakness (DailyMed, 2025).

Example in practice:

A 72-year-old client, Jas, has experienced a syncopal episode and was brought to ED. He is diagnosed with atrial fibrillation. Following the initial treatment to lower his heart rate and improve his cardiac output, he is now stable. He is ordered the beta blocker bisoprolol to maintain his heart rate. Jas is also ordered warfarin for long term prevention of a stroke. The nurse checks his recent blood work. The INR is 2.2. Jas weighs 62 kg. The nurse checks the Warfarin nomogram in the physician's orders. Based on the client's latest INR and his weight, the nurse will give him warfarin 5 mg po. Jas will be taking 5 mg each morning for the next two days, at which time his INR will be rechecked and the dose adjusted to keep his INR between 2-3.

Warfarin Medication Card

Now let's take a closer look at the medication card for warfarin. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Warfarin Medication Card

Class: Anticoagulant **Prototype:** Warfarin		**Indications:** prevention and treatment of venous thrombosis, thrombolytic complications with AF or cardiac valve replacement, and reduction of thrombolytic events following MI	
Mechanism of Action: Warfarin inhibits an enzyme that is required for the action of vitamin K. Without vitamin K, the production of clotting factors II, VII, IX and X as well as coagulation regulator proteins C and S, is diminished. These clotting factors circulate in the blood, so it takes a few days for plasma levels to fall.			
Administration: Oral, available in many dosages. Once a day dosing, based on INR INR levels done q 2-3 days, then weekly, then q 4 weeks when stable	**Side Effects:** Risk of bleeding both minimal (pink gums, bruising) to severe (black tarry stools, extensive bruising) Antidote: vitamin K	**Contraindications:** Many drug interactions. Do not take any herbal, OTC or new prescriptions without consulting with MD. Contraindicated with hemorrhagic disorders, liver disease, pregnancy	**Nursing Considerations:** Monitor for bleeding Client teaching important: Consistent diet with vitamin rich foods Avoid alcohol Monitor bleeding Avoid use of razors

Downloadable file (.docx): Warfarin Medication Card

Clinical Reasoning and Decision-Making Activity 1

A client who was treated in the hospital for DVT in his left leg has been prescribed warfarin.

1. The client asks, "Will the warfarin dissolve the clot in my leg?" What is the nurse's best response?

The nurse plans to assess the client's lab work before administering the warfarin.

2. What blood test(s) are important to monitor for clients taking warfarin, and what is the therapeutic range?

The nurse knows that the client will need to monitor his diet when taking warfarin.

3. What dietary instructions should be provided to the client?

The nurse plans to provide client education regarding this newly prescribed medication.

4. Outline the topics to cover with this high-risk medication.
5. What is the reversal agent for warfarin?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Direct Factor Xa Inhibitor: Rivaroxaban

Rivaroxaban (Xarelto) is a selective Xa inhibitor. Rivaroxaban is a relatively newer class of anticoagulant and has some advantages over warfarin. It works quickly, has a fixed dosage, lower bleeding risk and no need for monitoring. Another med in this class is apixaban.

Mechanism of Action

Rivaroxaban is a selective inhibitor of factor Xa and indirectly inhibits platelet aggregation induced by thrombin. It binds directly with factor Xa resulting in the inhibition of thrombin.it binds to both free and clot bound factor Xa which is different than heparin.

High bioavailability following oral administration. Highly protein bound, excreted in the urine and in the liver.

Indications for Use

Rivaroxaban is indicated for prevention or treatment of DVT and PE. It is used to prevent the risk of stroke with atrial fibrillation. In combination with aspirin, it is indicated to reduce the risk of major cardiovascular events such as cardiovascular (CV) death, myocardial infarction (MI) and stroke, and in clients with chronic coronary artery disease (CAD) or peripheral artery disease (PAD).

Nursing Considerations

Administration: oral form, take with or without food. Take with water and ensure adequate hydration.

Avoid with end stage renal disease or advanced liver disease

Overdose: in the case of an overdose, treat with activated charcoal to avoid further absorption. Andexanet can be given as an antidote.

Drug Interactions: rivaroxaban levels can be altered by any drug that inhibit or induce CYP3A4 and P-glycoprotein. For example, phenytoin and St John's Wort can reduce rivaroxaban's effects. Check monographs and consult with the pharmacist.

Pregnancy: not safe with pregnancy

Food interactions: Grapefruit interferes with the metabolism of rivaroxaban, resulting in higher dosages. The furanocoumarins in grapefruit inhibit the enzyme CYP3A4, which reduces the metabolism of rivaroxaban. Avoid eating grapefruit or drinking grapefruit juice, or limit to 1-2 glasses a week. It is safe to drink or eat other fruits, such as orange juice.

Adverse/Side Effects

As with all anticoagulants, there is a risk of bleeding. Compared to warfarin, the risk of bleeding is low.

High Alert Med: Epidural or spinal hematomas may occur in clients who are anticoagulated with rivaroxaban and are receiving neuraxial anesthesia or undergoing spinal puncture. These hematomas may result in long-term or permanent paralysis.

Client Teaching

- Clients should report any signs of unusual bleeding or bruising to the healthcare provider.
- Inform the prescriber of all prescriptions, OTC medications, vitamins, and herbal products.
- Consult with the prescriber if planning on taking any new medications or supplements.
- Advise client about avoiding grapefruit or limiting to only only 1-2 glasses per week.

Direct Thrombin Inhibitors: Dabigatran

Dabigatran (Pradaxa) is a direct-acting thrombin inhibitor. It has many advantages over warfarin, such as no need for monitoring, less risk of bleeding, and predictable effects so less restrictions based on the client's age.

Mechanism of Action

Dabigatran is a competitive, direct thrombin inhibitor. Because thrombin enables the conversion of fibrinogen into fibrin during the coagulation cascade, its inhibition prevents the development of a thrombus.

It is well absorbed in the GI tract with low protein binding. It is not metabolized by the liver. Renal excretion.

Indications for Use

This drug is used to prevent or treat deep vein thromboses (DVT) or pulmonary emboli (PE). It is also used for prevention of stroke and systemic embolism with nonvalvular atrial fibrillation.

Nursing Considerations

Administration: oral form, give with or without food.

Overdose: Idarucizumab, a specific reversal agent, is available for urgent care or emergency operation client care.

Pediatrics: Safety and effectiveness have not been established.

Drug Interactions: there are fewer drug interactions than with warfarin, but caution with P-glycoprotein modulators.

Adverse/Side Effects

High Alert Med: Epidural or spinal hematomas may occur in clients who are anticoagulated with dabigatran and are receiving neuraxial anesthesia or undergoing spinal puncture. These hematomas may result in long-term or permanent paralysis.

Risk of bleeding can be fatal (DailyMed, 2025).

Client Teaching

- Clients should report any signs of unusual bleeding or bruising to the healthcare provider.
- Dispose of dabigatran bottles four months after opening.
- inform their health care provider of all prescriptions, OTC medications, vitamins, and herbal products.

Thrombolytic: Alteplase (tPA)

Alteplase (tPA) is a thrombolytic used to break up clots. It is also known as tissue plasminogen activator and it is one of three drugs that can be used to remove a clot. It has a very short half-life of 5 minutes so it can open a clogged artery rapidly. It is often given with heparin to prevent re-occlusion of the affected blood vessel.

It can also be used to unplug central lines, but at much smaller dosages (McCuistion et al, 2018).

Mechanism of Action

Alteplase binds to fibrin in a thrombus and converts the entrapped plasminogen to plasmin, which is an enzyme that digests the fibrin meshwork of clots. Plasmin also degrades fibrinogen and other clotting factors, resulting in the breakdown of the clot.

Indications for Use

Alteplase is indicated for the acute treatment of myocardial infarction (MI), stroke, or massive pulmonary embolism (PE). It is also used to clear central lines such as a peripherally inserted central line catheter (PICC).

It is important to understand that Alteplase is considered a "clot buster" whereas previous anti-platelet drugs do not clot-bust but rather make the platelets less sticky. This makes Alteplase a high risk medication. Since it cannot differentiate between what clot you want to dissolve, it basically floats through the blood destroying all clots.

Nursing Considerations

Administration: given IV, dosage is based on weight. Bolus dose of 15 mg, then 50 mg infused over 30 minutes, hen 35 mg infused over 60 minutes (Rosenjack Burchum & Rosenthal, 2019).

Alteplase should be given as soon as possible for the best outcome. The best results are within 2-4 hours of symptom onset or sooner.

Monitor:

- Vital signs before and during treatment, then at least q 4 hour.

- Assess for bleeding q 15 minutes during first hour of therapy, then every 15-30 minutes for the next 8 hours and then every 4 hours for the duration of therapy. Frank bleeding can occur from IV sites, body orifices, melena stool, joint pain and coffee ground emesis. If uncontrolled bleeding occurs, stop therapy and report immediately.
- Labs: prior to and during therapy, labs may include CBC, fibrin/fibrin degradation product, PT, thrombin time, aPTT, cross match

Occluded venous access device: 2 mg/2 mL into occluded catheter. May repeat once in 2 hours if still occluded (Vallerand & Sanoski, 2024).

The drug is contraindicated in situations in which the risk of significant bleeding is greater than the potential benefit such as:

- Active internal or intracranial bleeding
- History of recent stroke
- Recent (within 3 months) intracranial or intraspinal surgery or serious head trauma
- Presence of intracranial conditions that may increase the risk of bleeding (e.g., some neoplasms, arteriovenous malformations, or aneurysms)
- Current severe uncontrolled hypertension
- Recent major surgery

Significant post-administration monitoring is performed due to the risk of life-threatening bleeding.

Adverse/Side Effects

High Alert Med: This drug can cause significant, sometimes fatal,

internal or external bleeding, especially at arterial and venous puncture sites.

Avoid intramuscular injections for at least 24 hours and perform venipunctures carefully and only as required.

It can increase the risk of thrombo-embolic events in clients with high likelihood of left heart thrombus, such as clients with atrial fibrillation.

Client Teaching

For treating an embolus: client should be on bedrest and avoid unnecessary procedures such as shaving or vigorous tooth brushing.

Explain the purpose of the therapy and the need for close monitoring.

Inform client to report any potential signs of bleeding, such as bruising, black stools or joint or abdominal pain.

(Vallerand & Sanoski, 2024)

Comparing Medications for Blood Coagulation

To support your learning, you can access the Chapter 7 Blood Coagulation Modifiers medication table medication table. This is a downloadable and editable document to allow you to update and add content. In clinical practice, ensure to access current drug manuals and agency policy prior to administration.

Critical Thinking and Decision-Making Activity 2

Complete the following questions. Refer to the answer key for the correct answers.

Joseph, 59 years old, has sudden onset of 4/10 substernal chest pain.

1. His partner gives him two low-dose aspirins to chew while waiting for the ambulance. Is this good advice?
2. Joseph arrives at the hospital. An ECG and troponin levels are done. He is diagnosed with a non-ST-elevation MI. He is ordered nitroglycerin spray to help relief his chest pain. The nurse prepares to give the nitrospray. The nurse recalls the correct administration technique:

    a. "Shake the canister, hold it upside down, and spray onto the client's throat."
    b. "Spray the medication under their tongue and do not swallow immediately."
    c. "Inhale deeply while spraying the medication into your mouth."
    d. "Apply the spray to the skin of your chest, covering an area 2 inches wide."

3. Which side effect should the nurse anticipate with a client taking nitroglycerin?

    a. Severe hypotension
    b. A persistent, severe cough
    c. Headache
    d. Increased heart rate (bradycardia)

4. Joseph's chest pain is resolved with two sprays of

nitroglycerin. Later that day, he has had an angiogram of his heart and a stent was inserted into one of his coronary arteries. Upon returning to the ward, he is ordered Clopidogrel 300mg po, followed by 75 mg po daily. What is the purpose of this type of dosing? What does clopidogrel do?

5. After a few days, Joseph is going home. He is prescribed:

- Nitroglycerin spray for chest pain, one spray at a time up to 3 sprays. Wait 5 minutes between sprays.
- Aspirin 81 mg po once a day
- Clopidogrel 75 mg once a day

What might be important for teaching him about his antiplatelet therapy?

6. Joseph is wondering why his friend takes warfarin for his heart issues. He asks if he should also be on warfarin as well. What will the nurse tell him?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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7.11 Diuretics

Diuretics are a category of medications that are used extensively for a variety of edematous and non-edematous conditions that result in fluid-buildup in the body. Most diuretics act by targeting ion transport receptors on the luminal surface of the renal tubules. Conditions we will commonly see diuretic therapy include acute or chronic renal disease, with the goal to help the kidney work more effectively. Diuretics are used when there is a fluid or volume overload issue, often due to heart failure, which might be evident in pulmonary edema or peripheral edema. With end-stage liver disease, the client often experiences ascites, and diuretics will also be used. We also see diuretics prescribed for essential hypertension, with the goal to decrease blood volume and therefore blood pressure. Lastly, diuretics are sometimes used to eliminate toxic substances from the body through diuresis (Arumugham, & Shahin, 2023).

To understand how diuretics work, you need to have a good understanding of the renal system and Renin Angiotensin Aldosterone System. Take time now to review the components of the kidney and RAAS.

Watch: Kidney function and anatomy | Renal system physiology | NCLEX-RN | Khan Academy

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=215#oembed-1

To monitor how well the kidney is functioning, a client will be

ordered lab tests. Often referred to as a renal panel, it will include BUN, eGFR, and electrolytes:

Blood urea nitrogen (BUN):

- Measures how much nitrogen is in the blood.
- Urea, or BUN, is a nitrogen-containing waste product of protein and amino acid metabolism. The liver releases urea into blood and it is filtered by the kidneys into urine.
- ↑'d levels of urea due to dehydration, kidney disease, ↑ protein intake or ↑ protein breakdown from muscle damage or GI bleeds.

Estimated glomerular filtration rate (eGFR):

- Measures the filtration rates according to your serum creatinine or cystatin C, age and sex.
- This is the best indicator of glomerular function. GFR normally decreases with age.

Serum creatinine:

- This test looks for creatinine buildup. Creatinine is a waste product that comes from the digestion of dietary protein and the normal breakdown of muscle tissue.
- Numerous factors can affect creatinine levels including diet; muscle (weight of your muscles); malnutrition; and other chronic illnesses.

Serum Potassium:

- Therapeutic serum potassium level is 3.5-5 mEq/L.
- Potassium is often excreted with diuretic therapy, and must be closely monitored to ensure within therapeutic limits.
- Mild hypokalemia can present as mild muscle weakness. As potassium levels drop, dysrhythmias are common, with flattened T waves and depressed ST depression. Potassium

levels below 2.5 mEq/L, serious and even lethal dysrhythmias, along with muscle cramps and weakness.

Serum Sodium:

- Therapeutic serum sodium level is 136–145 mEq/L.
- Mild hyponatremia can cause nausea and fatigue, with lower sodium levels resulting in headache, lethargy and seizures.

Refer to the National Kidney Foundation website for information on monitoring lab values: How to Read Your Kidney Health Lab Results | National Kidney Foundation

Most diuretics all have similar mechanism of action in that they block sodium and chloride reabsorption, which creates an osmotic pressure within the nephron that prevents the passive reabsorption of water. This results in water and solutes retained within the nephron, and then excreted out in the urine. But, each diuretic works on a different part of the renal tubules, so their overall effects will differ with the amount of diuresis and the degree that solutes that are reabsorbed.

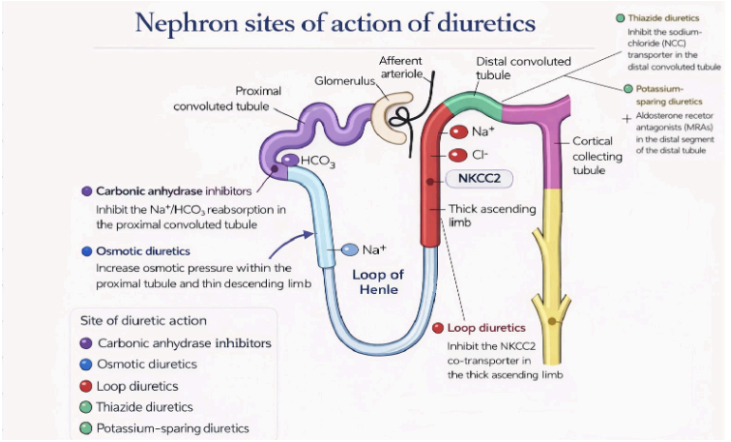

Figure 7.11a Mechanism of action of diuretics (TRU Open Press) CC BY-NC-SA

General Overview of Diuretics:

- all work in a particular area of the nephron. Those that act earlier in the nephron (where there is a higher solute concentration) has the greater diuretic effect.
- all diuretics cause diuresis but some have a greater effect. The choice of diuretic depends on kidney and other health issues.
- all have the potential to lower BP by lowering vascular volume
- most can cause hypovolemia due to excess fluid loss
- all have the potential to cause electrolyte and acid base imbalances

There are five categories of diuretics, these are loop, thiazide and thiazide-like, osmotic, carbonic anhydrase inhibitors, and potassium sparing. The choice of diuretic will depend on the health issue, lab work and the client's clinical presentation. Many clients with advanced disease will have complex medication profiles and may be on more than one diuretic.

Example in Practice 1:

A client has heart failure secondary to an incompetent aortic valve. The client is experiencing shortness of breath from pleural effusions and pulmonary edema. This client is prescribed a loop diuretic to help rid the body of the extra fluid. Depending on the client's potassium levels, they may be prescribed a second diuretic, such as a potassium-sparing diuretic or a carbonic anhydrase inhibitor.

Example in Practice 2:

Client B has essential hypertension. The client is on anti-hypertensive medications, but the prescriber feels a decrease in preload may also be helpful. To eliminate some intravascular fluid that is contributing to a higher preload, a thiazide diuretic may be ordered. Thiazides work on the distal convoluted tubule so they are not as powerful but will still decrease preload and decrease systemic vascular resistance due to their direct vasodilatory effects (Arumugham & Shahin, 2023).

Example in Practice 3:

Client C has acute kidney injury from sepsis. The acute kidney injury has caused decreased urine output. The client is ordered a loop diuretic to help with the fluid overload and reduce pulmonary edema. Loop diuretics will not help resolve the kidney injury or prevent dialysis, they will help rid the body of excess fluid (Hegde, 2020).

In this unit we will review the following three classes of meds:

- loop (furosemide)
- thiazide (hydrochlorothiazide)
- potassium sparing (spironolactone)

As we will not cover osmotic diuretics or carbonic anhydrase inhibitors in detail in this unit, so the following brief overview is provided.

Osmotic diuretics

Osmotic diuretics (Mannitol) work by increasing the osmolarity of the tubular fluid in the proximal tubule and the loop of Henle. It is given IV, and exerts its effect by creating a strong osmotic force that inhibits passive reabsorption of water, which then leads to increased urination.

Mannitol is used for elevated intracranial pressure (ICP) and

cerebral edema (head injured patients) and to prevent renal failure in urgent situations of severe hypotension, shock, and oliguric acute kidney injury. For all uses, it is mostly given in higher acuity or critical care areas due to close assessment and monitoring that is required due to the powerful nature of the med and the instability of the client's state.

Carbonic anhydrase inhibitors

Carbonic anhydrase inhibitors, Acetazolamide, is also sometimes used as an adjunct diuretic for heart disease. It is also prescribed for many non-cardiac conditions such as glaucoma, epilepsy and for altitude sickness.

Carbonic anhydrase is found in the proximal tubule and red blood cells. Acetazolamide prevents the breakdown of carbonic anhydrase, leading to sodium, bicarbonate, and chloride being excreted along with water. By causing a loss of HCO3+ in the urine, this leads to metabolic acidosis. The body then compensates for this loss of bicarbonate by decreasing CO2 levels and stimulates ventilation and ultimately higher partial pressures of O2 in the blood. For clients with altitude sickness, this effect will decrease the incidence of tissue hypoxia (Arumugham & Shahin, 2023).

Loop Diuretics

Loop diuretics are the most effective diuretic to produce the most loss of fluid and electrolytes. They are used extensively for many conditions that cause fluid overload. Within this class, Torsemide, bumetanide and furosemide are loop diuretics; with furosemide the most common med ordered in this class.

Furosemide will be our prototype med.

Mechanism of Action

Loop diuretics action is in the thick ascending loop of Henle. It inhibits the absorption of sodium and chloride by inhibiting the Na-Cl cotransporter system. By blocking the reabsorption of sodium and chloride, passive reabsorption of water occurs, with subsequent urinary excretion of water. Due to this same process, potassium is also excreted. And, to a lesser extent, the loss of calcium and magnesium (Huxel, Raja & Ollivierre-Lawrence, 2023).

Indications for Use

Loop diuretics are very potent diuretics and are used when a client has an exacerbation of fluid overload. Furosemide is used to treat clients with edema, hypertension, pulmonary edema, peripheral edema and congestive heart failure. IV furosemide is used to urgently treat pulmonary edema.

Nursing Considerations

Administration: oral, IM or IV. For acute fluid overload, such a pulmonary edema, intravenous route would be given. Prolonged effects can occur if the client has any hepatic or renal dysfunction.

- IV: The usual initial dose is 20-40 mg, repeated in 1-2 hours depending on effect. Onset of action within 5 minutes, with duration of action 2 hours. Administer by slow IV push. For high dose therapy, furosemide continuous infusions with a rate of 4mg/min may be ordered.
- Oral: the usual initial dosage is 20 mg, up to 80 mg. Onset of action within 60 minutes. The peak effect occurs within the

first or second hour. The duration of diuretic effect is 6 to 8 hours.

When possible, loop diuretics should be administered in the morning, and evening doses should be avoided (unless urgent) so that sleep is not disturbed.

Monitoring:

- Before therapy, assess intake and output, signs of fluid overload, blood pressure and heart rate and lung sounds.
- During therapy, monitor for dehydration, hypotension and electrolyte imbalances that can occur with excessive diuresis:
    - Dehydration: assess for dryness of mouth, thirst, weakness, lethargy, drowsiness,
    - Electrolyte disturbances, particularly hypokalemia: confusion, nausea, headache, muscle pains or cramps, muscular fatigue, tachycardia, arrhythmias,
- Anticipate potassium loss and the likelihood of potassium supplements. Potassium sparing diuretics such as spironolactone is often ordered to counterbalance the potassium losses from loop diuretics.

Laboratory Tests: Monitor serum electrolytes, (particularly potassium), creatinine and BUN should be done frequently during the first few months of furosemide therapy and periodically thereafter.

Risk of ototoxicity: assess for tinnitus and hearing loss. Hearing loss is more common with rapid or high dose administration or with renal dysfunction. Hearing loss may be reversible.

Older adult: Use cautiously for clients with decreased renal function. Kidney function should be monitored closely for all clients because this is a potent medication that works within the kidney tubules.

(Huxel, Raja & Ollivierre-Lawrence, 2023; Vallerand & Sanoski, 2024)

Drug Interactions

- Digoxin: Monitor the client closely for hypokalemia if furosemide is used concomitantly with digoxin. Hypokalemia may increase the risk of digoxin toxicity and subsequent risk of dysrhythmias.
- Lithium: furosemide will lower sodium levels, which can result in lithium accumulating to toxic levels. Close monitoring of lithium levels with reduction of lithium dosage may be required.
- Sulfa allergy: slight risk of allergic reaction if taking furosemide and the client has a sulfa allergy.

Contraindicated in anuria, severe cases of electrolyte depletion, and hepatic coma.

Pregnancy: Treatment during pregnancy requires monitoring of fetal growth. There are no human studies available, so use furosemide only if absolutely needed.

Tolerance: Tolerance can develop and can cause a 'breaking' phenomena where there is a rebound retention of Na^+ due to increased absorption from the distal tubules. The result is a progressive decrease in urinary output after repeated doses of furosemide. This can occur with chronic diuretic therapy. Diuretic resistance can also occur when the maximum dose of furosemide does not produce the anticipated diuresis. This can be due to hypertrophy of the distal tubule which increases sodium reabsorption. Close intake and output are required when furosemide is first administered or in acute situations of fluid overload in order to assess for the diuretic effect. With long term therapy, clients should be taught to monitor fluid changes such as edema, weight gain or respiratory changes that indicate fluid overload.

Huxel, Raja & Ollivierre-Lawrence, 2023

Adverse/Side Effects

Adverse effects include dehydration, hypotension, and electrolyte imbalances.

Excess loss of sodium, chloride, magnesium and potassium. Hypokalemia, with a serum potassium of less than 3.5 mEq/L, can lead to serious dysrhythmias.

- Close monitoring of serum electrolytes is essential during therapy. Hypokalemia can first present with muscle weakness and cramping, tingling or numbness, fatigue and heart palpitations. As the level drops lower, if not corrected, it can lead to paralysis, difficulty breathing and an irregular heart beat. The ECG complex will display a prolonged PR interval, long QT, small or absent t waves (Cleveland Clinic, 2022). See figure 7.11b
- Potassium supplements many be added as a scheduled medication to decrease risk of hypokalemia.

Dehydration can occur due to fluid loss. Monitor for signs of dehydration such as dry mouth, thirst, weakness, lethargy, oliguria.

Hypotension can occur due to excess fluid loss and the relaxation of venous smooth muscle. Monitor for signs such as light-headedness and dizziness.

The risk of ototoxicity increases with concurrent use of other drugs such as aminoglycosides and renal impairment (DailyMed, 2025).

Hyperglycemia risk is rare, and due to the inhibition of insulin release. For diabetic clients or prediabetes, this may require closer monitoring and anti-diabetic medication adjustments.

7.11b The effects of hypokalemia and hyperkalemia on the ECG complex (Sheila Odubote/ TRU Open Press). CC BY-NC-SA

Client Teaching

- Take medication as prescribed. Do not double up doses if a dose is missed
- Monitor blood pressure and pulse
- Report any rashes, muscle weakness, muscle cramps, nausea, dizziness, tingling of extremities
- Inform prescriber if planning on becoming pregnant or if pregnant.
- Advise clients to change position slowly, as they may experience orthostatic changes.
- Clients should also report weight gain of more than three pounds in a day or five pounds in a week to their healthcare provider.
- Clients should also be encouraged to enjoy potassium-rich foods during loop diuretic drug therapy. Avoid high sodium foods.

Furosemide Medication Card

Now let's take a closer look at the medication card for furosemide. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Furosemide Medication Card

Class: Loop Diuretic **Prototype:** Furosemide (Lasix)		**Indications:** used for pulmonary edema, HTN, peripheral edema, HF, kidney/liver /heart fluid overload **Decreases fluid load leading to:** - decrease BP and preload, - increase urine output -improve oxygenation-gas exchange capacity and ventilation	
Mechanism of Action: Loop diuretics inhibit absorption of sodium and chloride in the loop of Henle, thus causing fluid loss, along with sodium, potassium, calcium, and magnesium losses. Loop diuretics are very potent diuretics and are used when a patient has an exacerbation of fluid overload.			
Administration: PO/IV Administer IV slowly to prevent ototoxicity Take in morning to avoid nocturia Check BP (sitting & standing) before administering risk of orthostatic BP Weight gain of more than 3 pounds in one day needs to be reported. Track weight daily Dosage is dependent on condition and for children it is weight based. Usually starting dose is low and increased as needed.	**Side Effects:** Dehydration (Dry mouth or thirst) Hypotension (Dizziness Light headedness) Electrolyte depletion especially potassium (muscle cramps, fatigue) Ototoxicity Blurred vision Fainting Unusual tiredness Fast or irregular heartbeat SAFETY: Monitor blood glucose with diabetics-hyperglycemia may occur. If diarrhea or vomiting-increased risk for dehydration. Notify DR	**Contraindications:** Sucralfate, cholestyramine, and colestipol decrease absorption of Lasix If condition does not improve-report to prescribing MD Sensitive to sun avoid sun lamps or tanning Avoid aminoglycosides due to risk of ototoxicity	**Nursing Considerations:** Monitor Potassium serum levels, renal fcn, Assess BP before administering medication Weigh patient daily to track hydration and volume status Strict Intake and output charts of volume status Promote potassium-rich food Anticipate potassium supplements

Downloadable file (.docx): Furosemide Medication Card

Clinical Reasoning and Decision Making Learning Activity 1

Mrs. Smith is a 79-year-old widow who has lived alone for the past 5 years. Three years ago she was hospitalized for a myocardial infarction, which resulted in heart failure. She is compliant with her medications, which include digoxin (Lanoxin) 0.125 mg daily, furosemide (Lasix) 40 mg daily, and potassium (K-Dur) 20 mEq daily.

Recently Mrs. Smith ran out of her potassium and thought that because it was "just a supplement," it would be OK to go without it until the next time she went to town to fill the prescription. She has not taken her potassium for a week.

Today she is at the clinic with generalized weakness, fatigue, nausea, and diarrhea. Her BP is 104/62, pulse 98 bpm and slightly irregular, RR 20, and temp 36 C. Blood is drawn and shows serum sodium level of 150 mEq/L (normal 135-145 mEq/L), digoxin level of 2.6ng/ml (normal 0.6-1.2 nmol/L) and potassium level of 3.0 mEq/L (normal 3.5-5.0 mEq/L).

1. What assessments should a nurse do before and after administering a diuretic?
2. What are the signs and symptoms of digoxin toxicity? What can happen to a client who has toxic levels of digoxin?
3. Furosemide can cause dehydration. What might be some symptoms of dehydration?
4. What electrolyte imbalance(s) can occur in clients

taking furosemide (Lasix)?

5. What relationship exists between this client's furosemide, digoxin, and potassium levels?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Thiazide and Thiazide-like Diuretics

Thiazide diuretics are considered first line diuretic for hypertension. It has similar effects as loop diuretics as it increases the excretion of sodium, potassium and chloride as well as water. The amount of diuresis is much lower than loop diuretics making it a safer medication.

Our prototype med will be hydrochlorothiazide (HCTZ)

Mechanism of Action

Thiazide diuretics, also known as benzothiadiazides, work in the early segment of the distal convoluted tubule to directly inhibit the sodium chloride cotransporter, thereby preventing sodium reabsorption and inducing both natriuresis and diuretic effects (Akbari & Khorasani-Zadeh, 2023). In this part of the nephron, only 10% of filtered sodium and chloride is normally reabsorbed, so the diuretic effect is much lower than loop diuretics. They are not effective for immediate diuresis.

Thiazide-like diuretics, lack the benzothiadiazide backbone in the chemical properties, and is considered better at managing hypertension and less effect of electrolyte disturbances. Two meds in this category are metolazone and indapamide (Akbari & Khorasani-Zadeh, 2023).

Indications for Use

Hydrochlorothiazide diuretics are used to manage hypertension and adjunct therapy for peripheral edema with heart failure, hepatic cirrhosis, corticosteroids and estrogen therapy. HCTZ can also be used to manage edema from renal dysfunction, such as nephrotic syndrome.

What is Nephrotic Syndrome?

Nephrotic syndrome is proteinuria with a low serum albumin level and edema. It is characterized by a loss of protein in the urine of greater than 3 grams a day or the presence of 2 grams of protein per gram of urine creatinine. It can be due to a number of kidney diseases and from systemic diseases such as diabetes and lupus erythematosus (Sinnakirouchenan & Batuman, 2025).

Nursing Considerations

Administration: oral form only. Take in the morning with food. Taper dosages depending on effect.

- Onset of action within 2 hours, peaks in 4 hours, and lasts 6-12 hours.

Monitoring:

Thiazides will cause the same loss of electrolytes and water, but to a much lesser extent.

- Electrolyte imbalances including hyponatremia, hypokalemia, and hypochloremia.
    - Assess labs before and periodically during therapy.
    - Hypokalemia can occur so if lower than 3.5 mEq/L, potassium supplements may be needed. Encourage potassium rich diet.

- Fluid loss and dehydration is a moderate risk. Assess for signs of dehydration, weakness, hypotension, and light-headedness.
    - Monitor blood pressure and heart rate before dose and periodically afterwards.
    - Monitor urine output

Contraindicated with clients with anuria or sulfa hypersensitivity. Use with caution with clients with renal disease.

Avoid NSAIDs as this may blunt the effect of diuretics.

Adverse/Side Effects

Adverse effects are similar to loop diuretics, with the exception that it does not cause ototoxicity.

- Electrolyte imbalances including hyponatremia, hypokalemia, and hypochloremia.
- Metabolic alkalosis
- Hyperglycemia due to a decrease in insulin secretion.

- Hyperuricemia due to increased urate reabsorption in the proximal tubule. May precipitate gout in clients with this disorder.
- Hyperlipidemia although MOA is unclear. Monitor LDLs, total cholesterol, cholesterol and triglycerides.

Risk of acute pancreatitis: Although rare, thiazides have a toxic effect on the pancreas and can lead to increased pancreatic secretions and ischemia.

Hypersensitivity reactions can occur so monitor for reactions that include rash, hives, angioedema, wheezing, and anaphylaxis.

(Akbari & Khorasani-Zadeh, 2023; Rosenjack Burchum & Rosenthal, 2019).

Client Teaching

- Clients should be instructed to take these medications at the same time each day and do not double up doses if a dose is missed.
- Notify their healthcare provider if they experience significant change in weight, such as 5-pound weight gain in one week.
- May cause orthostatic changes so individuals should change positions slowly. Monitor blood pressure periodically.
- Some clients may note increased photosensitivity, so protective measures such as sunscreen and covering up in the sun.
- Incorporate non-pharmacological measures to lower blood pressure, such as low sodium diet and exercise.

Potassium Sparing Diuretic

Potassium-sparing diuretics are used to treat or prevent hypokalemia associated with the use of loop diuretics and thiazide diuretics. It has a very mild diuretic effect, therefore it is rarely used alone as a diuretic. It can also be used with hepatic disease for those with ascites. There are two categories of potassium-sparing diuretics: aldosterone antagonists and non-aldosterone antagonists.

Spironolactone is an aldosterone antagonist and will be our prototype medication.

Mechanism of Action

Spironolactone acts primarily through competitive binding of receptors at the aldosterone-dependent sodium-potassium exchange site in the distal convoluted renal tubule. Spironolactone causes increased amounts of sodium and water to be excreted, while potassium is retained. The amount of diuresis is minimal, as much of sodium has already been absorbed by the time the filtrate reaches the distal nephron.

Indications for Use

Spironolactone is used primarily to treat resistant hypertension and edema in clients with heart failure and liver disease. It also has a cardioprotective effect in clients with heart failure due to the aldosterone blockade in the heart and blood vessels. It can also be used for hyperaldosteronism and polycystic ovary syndrome. Also used to counterattack potassium loss caused by other diuretics such as thiazides and loop.

Nursing Considerations

Administration: oral form only. Peak effect is 2-3 days with a duration of action of 2-3 days. Administer in the morning to avoid nocturia.

Monitoring:

- Blood pressure and heart rate prior to therapy and regularly, especially if given as an adjunct to antihypertensive therapy.
- Urine output and report if significant oliguria (often less than 30 ml/hour).
- Assess for hyperkalemia such as fatigue, muscle weakness, paresthesia, confusion, dyspnea, and cardiac arrythmias.
- Labs: electrolytes, BUN, creatinine, serum magnesium

Renal impairment: Use cautiously with clients who have renal impairment due to increased risk for hyperkalemia.

Use with caution with diabetic clients as it may cause hyperglycemia.

Drug interactions:

- Risk of hypotension if used with antihypertensive drugs
- NSAIDs may decrease spironolactone's effects
- May increase the risk of lithium toxicity. Monitor sodium and lithium levels.

Adverse/Side Effects

- Electrolyte imbalances may occur including hyperkalemia, hyperglycemia, and hyperuricemia.

- Dehydration and hypotension: monitor blood pressure and signs of light-headedness or dizziness.
- Hypersensitivity reaction may occur, monitor for rash and discontinue if it develops due to risk of Steven Johnson syndrome.
- Endocrine effects such as erectile dysfunction, menstrual irregularities and gynecomastia may occur due to med being structurally similar to steroid hormones.

Client Teaching

- Clients should be instructed to take these medications at the same time each day. Take in the morning to avoid nocturia
- Notify their healthcare provider if they experience significant changes in weight.
- Diuretics may cause orthostatic changes, so individuals should change positions slowly. Avoid activities such as driving if feeling dizzy.
- Clients should be advised to avoid salt substitutes and foods that contain high levels of potassium.
- Monitor blood pressure regularly
- Inform male clients of potential for erectile dysfunction or gynecomastia. A lower dose may be required. Inform female clients of the potential for irregular menses.

Arumughan & Shahin (2023); Rosenjack Burchum & Rosenthal (2019); Vallerand & Sanoski, (2024)

Comparing Diuretic Medications

To support your learning, you can access the Chapter 7 Comparing Diuretic Medications table tables. This is a downloadable and editable document to allow you to update and add content. For clinical practice, ensure to consult current drug manuals and agency policy prior to administration.

Clinical Reasoning and Decision-Making Learning Activities 2

1. A client is prescribed a thiazide (hydrochlorothiazide) for hypertension. The nurse notices they have a number of other health issues. Which health issue does this medication may cause concern?

    a. epilepsy
    b. heart failure
    c. gout
    d. COPD

2. A client will be started on spironolactone for liver cirrhosis and ascites, as an additional diuretic. The nurse should monitor for which common side effect?

    a. tachycardia
    b. hypoglycemia
    c. hypertension
    d. gynecomastia

Note: Answers to the Clinical Reasoning Activities and

Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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7.12 Clinical Reasoning and Decision-Making Learning Activities

Clinical Reasoning and Decision Making Questions

Peter, 89 years old, lives independently and manages his own care. As the home health nurse, you are visiting Peter to assess how he is managing with the new diagnosis of atrial fibrillation. He tells you he also has gout that flares up occasionally, and he used to have hypertension. Your assessment of Peter includes: VS: 132/98 HR 86 irreg RR 14 b/min O2 sats 95% on room air. He is oriented x 3, good long-term memory, but has difficulty with remembering a few recent events. His gait is steady and uses a cane for support. His chest is clear throughout with good air entry to bases. No cough, no sputum, no SOB. Bowel sounds x 4 quadrants. Abdomen soft. Voiding independently, states nocturia x 2. Skin warm and dry, pitting edema +1 bilaterally to feet and ankles.

He shows you his pill organizer of his meds and his calendar for important events and appointments. He was recently started on Warfarin and Diltiazem.

Med profile:

- Atorvastatin 20 mg po once daily
- Warfarin 7.5 mg po once daily for the next 7 days.
- Diltiazem 180 mg po once a day
- Ramipril 5 mg po BID

Answer the following questions in relation to the case study.

The nurse reviews the med profile and considers the rationale for some of the meds.

1. How does diltiazem work to improve Peter's cardiovascular health? select all that apply

    a. Slows the conduction through the AV node
    b. Increases the conduction through the AV node
    c. Primarily causes vendilation resulting in a lower blood pressure
    d. Causes vasodilation in the coronary arteries and vascular smooth muscle

2. The nurse is doing some health teaching about the CCB: diltiazem. **True or False**: The nurse states, "This med may cause a low blood pressure resulting in dizziness. You may experience swelling in your ankles but this is a common side effect."
3. Peter has heard he will need blood work done while on the anticoagulant: Warfarin. What blood work is routinely done to ensure the client is appropriately anticoagulated and to prevent the risk of a stroke? How often will he need this blood work done?
4. What is important health teaching for a client while on the anticoagulant, warfarin?

5. Peter tells the nurse he has been on Atorvastatin for many years. The nurse notices Atorvastatin is in the morning slot of his pill organizer. **True or False:** taking atorvastatin in the morning is the best time to take this med.
6. Peter states he has also been on the ACE inhibitor: ramipril for a few years for his high blood pressure. The nurse recognizes more health teaching is needed if he states:

    a. If I get a bad productive cough it is due to ramipril. I will need to see my prescriber.
    b. If I get persistent dry cough, I should see my prescriber.
    c. I need to still watch my salt intake to prevent a higher blood pressure.
    d. I know to avoid salt substitutes as they are high in potassium.

7. Furosemide is loop diuretic commonly prescribed for a number of health issues to eliminate excess fluid. What might be some adverse effects of Furosemide? Consider some common and more serious adverse effects.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 7: Cardiovascular Medications Answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Chapter 7 Cardiac Glossary

Afterload: The tension that the ventricles must develop to pump blood effectively against the resistance in the vascular system.

Anticoagulant: Any substance that opposes coagulation.

Arrhythmia: A deviation from the normal pattern of impulse conduction and contraction of the heart, which, if serious and untreated, can lead to decreased cardiac output and death.

Arteriosclerosis: A condition when compliance in an artery is reduced, and pressure and resistance within the vessel increase. This is a leading cause of hypertension and coronary heart disease, as it causes the heart to work harder to generate a pressure great enough to overcome the resistance.

Artery: A blood vessel that carries blood away from the heart (except for pulmonary arteries that carry oxygenated blood from the lungs back to the heart).

Atherosclerosis: A buildup, called plaque, that can narrow arteries enough to impair blood flow.

Blood pressure: A type of hydrostatic pressure, or the force exerted by blood on the walls of the blood vessels or the chambers of the heart.

Capillaries: Smallest arteries where nutrients and wastes are exchanged at the cellular level.

Cardiac Output (CO): To calculate this value, multiply stroke volume (SV), the amount of blood pumped by each ventricle, by heart rate (HR), in contractions per minute (or beats per minute, bpm). It can be represented mathematically by the following equation: $CO = HR \times SV$.

Cerebrovascular Accident (CVA): Lack of blood flow to the brain that can cause irreversible brain damage, often referred to as a "stroke."

Coagulation: The formation of a blood clot.

Compliance: The ability of any compartment to expand to

accommodate increased content. The greater the compliance of an artery, the more effectively it is able to expand to accommodate surges in blood flow without increased resistance or blood pressure. Veins are more compliant than arteries and can expand to hold more blood. When vascular disease causes stiffening of arteries, compliance is reduced and resistance to blood flow is increased.

Contractility: The force of contraction of the heart.

Diastole: The period of relaxation that occurs as the chambers fill with blood.

Edema: The presence of excess tissue fluid around the cells.

Embolus: When a portion of a thrombus breaks free from the vessel wall and enters the circulation. An embolus that is carried through the bloodstream can be large enough to block a vessel critical to a major organ. When it becomes trapped, an embolus is called an embolism. In the heart, brain, or lungs, an embolism may accordingly cause a heart attack, a stroke, or a pulmonary embolism.

Fibrillation: An uncoordinated beating of the heart, which, if serious and untreated, can lead to decreased cardiac output and death.

Fibrinolysis: The gradual degradation of a clot.

Hemostasis: The process by which the body temporarily seals a ruptured blood vessel and prevents further loss of blood.

Hyperlipidemia: Elevated cholesterol levels in the blood that increase a patient's risk for heart attack and stroke.

Hypertension: Chronically elevated blood pressure.

Hypervolemia: Excessive fluid volume caused by retention of water and sodium, as seen in patients with heart failure, liver cirrhosis, and some forms of kidney disease.

Hypovolemia: Decreased blood volume that may be caused by bleeding, dehydration, vomiting, severe burns, or by diuretics used to treat hypertension. Treatment typically includes intravenous fluid replacement.

International Normalized Ratio (INR): A blood test used to

monitor the effects of warfarin and to achieve therapeutic range, generally between 2.0 and 3.5 based on the indication.

Ischemia: Reduced blood flow to the tissue region "downstream" of the narrowed vessel.

Loop of Henle: A component of the nephron where loop diuretics act to eliminate sodium and water.

Myocardial Infarction (MI): Commonly referred to as a heart attack, resulting from a lack of blood flow (ischemia) and oxygen to a region of the heart, resulting in death of the cardiac muscle cells.

Negative Inotropic factors: Factors that decrease contractility.

Partial Thromboplastin Time (PTT): A blood test used to monitor how long it takes for a patient's blood to clot. PTT is used for patients receiving IV heparin therapy to achieve therapeutic range. Dosage is considered adequate when the activated partial thromboplastin time (APTT) is 1.5 to 2 times the normal or when the whole blood clotting time is elevated approximately 2.5 to 3 times the control value.

Positive inotropic factors: Factors that increase contractility.

Preload: The amount of blood in the atria just prior to atrial contraction.

Prothrombin Time (PT): A blood test that measures how long it takes for a patient's blood to clot. PT is used to monitor the effects of warfarin in preventing clot formation.

Renin-Angiotensin-Aldosterone System (RAAS): Renin converts the plasma protein angiotensinogen into its active form—Angiotensin I. Angiotensin I circulates in the blood and is then converted into angiotensin II in the lungs. This reaction is catalyzed by the angiotensin-converting enzyme (ACE). Angiotensin II is a powerful vasoconstrictor, greatly increasing blood pressure. It also stimulates the release of ADH and aldosterone, a hormone produced by the adrenal cortex. Aldosterone increases the reabsorption of sodium into the blood by the kidneys, causing reabsorption of water and increasing blood volume and raising blood pressure.

Sinoatrial (SA) node: Normal cardiac rhythm is established by the

sinoatrial (SA) node. The SA node has the highest inherent rate of depolarization and is known as the pacemaker of the heart.

Sinus rhythm: Normal electrical pattern followed by contraction of the heart.

Stroke Volume (SV): The amount of blood that both ventricles pump during each contraction, normally in the range of 70–80 mL.

Systole: The period of contraction that the heart undergoes while it pumps blood into circulation.

Thrombus: An aggregation of platelets, erythrocytes, and WBCs trapped within a mass of fibrin strands that adhere to the vessel wall and decrease the flow of blood or totally block the flow of blood.

Transient Ischemic Attack (TIA): Occurs when blood flow is interrupted to the brain, even for just a few seconds, resulting in loss of consciousness or temporary loss of neurological function.

Veins: Blood vessels that conduct blood toward the heart (except for pulmonary veins that carry deoxygenated blood from the heart to the lungs).

Venous reserve: Volume of blood located in venous networks within the liver, bone marrow, and integument.

CHAPTER 8: RESPIRATORY SYSTEM: MEDICATIONS TO PROMOTE PERFUSION

8.0 Respiratory System

Learning Objectives

1. Identify the classifications and actions of respiratory system drugs
2. Provide examples of when, how, and to whom respiratory system drugs may be administered
3. Describe the mechanism of action, adverse and side effects, and nursing considerations associated with respiratory system drugs
4. Include considerations and implications of using respiratory system drugs across the lifespan
5. Apply your understanding to clinical application and clinical reasoning questions using evidence-based concepts.

Key Terms

- **allergies**
- **anaphylaxis**
- **clinical reasoning**
- **cyanotic**
- **gas exchange**
- **pallor**
- **paradoxical effect**
- **respiratory rate**
- **sputum**

Respiratory System Introduction

Every year, Canadians visit their health care provider for respiratory diseases such as allergies, asthma, bronchitis, common cold, chronic obstructive pulmonary disease (COPD), and pneumonia. Respiratory diseases and illnesses are a major public health concern in Canada.

Respiratory illnesses such as the common cold are the most frequently reported, and are attributed to over 100 rhinoviruses. It is usually self-limiting and can be treated with many OTC remedies to suppress cough (antitussives), to use as a decongestant or to suppress nasal inflammation (antihistamines, intranasal glucocorticoids). Note that these remedies only manage the symptoms rather than treat the underlying viral infection.

Chronic respiratory diseases (CRD) are an umbrella term to describe diseases that effect the airways and other structures of the lungs. Some of the most common are chronic obstructive pulmonary disease (COPD), asthma, occupational lung diseases and pulmonary hypertension (World Health Organization, 2026). Other respiratory conditions that have a significant and potentially debilitating affect are cystic fibrosis, pneumonia, bronchiolitis, tuberculosis, and lung cancer. Respiratory diseases affect people of all ages and many are chronic, thereby having a major impact not only on the individual with the disease, but on their family, community and the health care system (Public Health Agency of Canada, 2018). Over 3 million Canadians are affected by one of the five major respiratory diseases, COPD, asthma, tuberculosis, lung cancer and cystic fibrosis, with many more persons impacted by other diseases not tracked by the health care system (Public Health Agency of Canada, 2018).

The cost of chronic respiratory diseases has a great impact on health care costs in Canada. Currently, 3 million people in Canada, about 9.5% of Canada's population, have asthma. Interestingly, 2 million adults have been diagnosed with COPD, and approximately

1.5 million people have not yet been diagnosed. The burden of respiratory diseases affects individuals and their families, schools, workplaces, neighborhoods, and cities. Improving health surveillance efforts will help to support and design new policies and programs that will positively impact the effects of these diseases on Canadians. The Canadian Chronic Disease Surveillance System (CCDSS) researches and identifies data on chronic diseases such as asthma and COPD to seek further solutions for the improvement of health for diagnosed Canadians (Public Health Agency of Canada, 2018).

The biggest risk factor for many of the chronic conditions is tobacco smoke (Public Health Agency of Canada, 2018). In addition, other risk factors include air pollution, occupational chemicals and dusts, and frequent lower respiratory infections during childhood. CRDs are not curable; however, various forms of treatment that help open the air passages and improve shortness of breath can help control symptoms and improve daily life for people living with these conditions.

There are a variety of treatments for acute exacerbation and chronic respiratory conditions that often include inhalers that either open the airways (bronchodilators) or reduce inflammation (ie. glucocorticoids). In this unit, we will learn about some of the more common drug classifications, recognizing there are other treatments that are often used in combination therapies.

As you transition through this chapter and begin the section on medications to treat, you will notice that multiple medication classifications are discussed but there is only one medication card to be completed per chapter. These medication cards were developed as a guide for you to use in your own practice. There is a section that provides these tools in a word format for you to download and edit as needed. But before we look at the medications, let's review the anatomy and physiology.

References:

Public Health Agency of Canada. (2018). Asthma and chronic obstructive pulmonary disease (COPD) in Canada, 2018. Government of Canada. https://www.canada.ca/en/public-health/services/publications/diseases-conditions/asthma-chronic-obstructive-pulmonary-disease-canada-2018.html

World Health Organization (2026). Chronic respiratory diseases. Chronic respiratory diseases

8.1 Respiratory System and Gas Exchange Concepts

Concepts Related to Respiratory Medications

Overview of the Respiratory System

The purpose of the respiratory system is to perform gas exchange. Pulmonary ventilation moves air into and out of the alveoli for this gas exchange process. At the respiratory membrane where the alveolar and capillary walls meet, gases move across the membranes, with oxygen entering the bloodstream and carbon dioxide exiting. It is through this mechanism that blood is oxygenated and carbon dioxide, the waste product of cellular respiration, is removed from the body. See Figure 8.1a

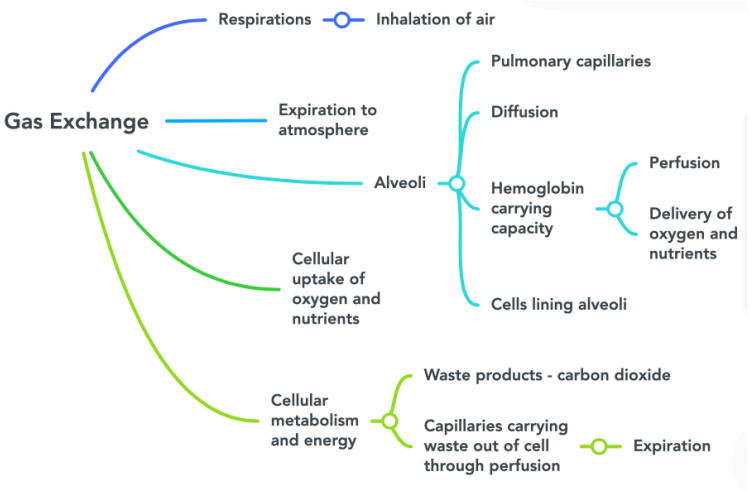

Figure 8.1a Example of Gas Exchange Concept Map [Image Description]

The major organs of the respiratory system function primarily to provide oxygen to body tissues for cellular respiration, remove the waste product carbon dioxide, and help maintain acid-base balance. Portions of the respiratory system are also used for non-vital functions, such as sensing odors, speech production, and for straining, such as during childbirth or coughing. [1]

See Figure 8.2b[2] illustrating major respiratory structures

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2. "2301 Major Respiratory Organs.jpg" by OpenStax College is licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/22-1-organs-and-structures-of-the-respiratory-system

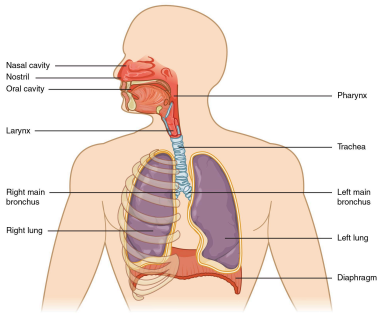

Figure 8.2b Major Respiratory Structures: The major respiratory structures span the nasal cavity to the diaphragm

Functionally, the respiratory system can be divided into a conducting zone and a respiratory zone. The conducting zone of the respiratory system includes the organs and structures not directly involved in gas exchange. The gas exchange occurs in the respiratory zone.

Conducting Zone

The major functions of the conducting zone are to provide a route for incoming and outgoing air, remove debris and pathogens from the incoming air, and warm and humidify the incoming air. Several structures within the conducting zone perform other functions as well. The epithelium of the nasal passages, for example, is essential to sensing odors, and the bronchial epithelium that lines the lungs can metabolize some airborne carcinogens.

The cilia of the respiratory epithelium help remove the mucus and debris from the nasal cavity with a constant beating motion, thus sweeping materials toward the throat to be swallowed. Interestingly, cold air slows the movement of the cilia, resulting in the accumulation of mucus that may, in turn, lead to a runny nose during cold weather. This moist epithelium functions to warm and humidify incoming air. Capillaries located just beneath the nasal epithelium warm the air by convection.

Bronchial Tree

The trachea branches into the right and left primary bronchi at the carina. A bronchial tree (or respiratory tree) is the collective term used for these multiple-branched bronchi. The main function of the bronchi, like other conducting zone structures, is to provide a passageway for air to move into and out of each lung. In addition, the mucous membrane traps debris and pathogens.

A bronchiole branches from the tertiary bronchi. Bronchioles, which are about 1 mm in diameter, further branch until they become the tiny terminal bronchioles, which lead to the structures of gas exchange. There are more than 1,000 terminal bronchioles in each lung. The muscular walls of the bronchioles do not contain cartilage like those of the bronchi. This muscular wall can change the size of the tubing to increase or decrease airflow through the tube.

Respiratory Zone

In contrast to the conducting zone, the respiratory zone includes structures that are directly involved in **gas exchange**. See Figure 5.2b[3] for an illustration of the respiratory zone. The respiratory zone begins where the terminal bronchioles join a respiratory bronchiole, the smallest type of bronchiole, which then leads to an alveolar duct, opening into a cluster of alveoli.

3. "2309 The Respiratory Zone.jpg" by OpenStax College is licensed under CC BY 3.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/22-1-organs-and-structures-of-the-respiratory-system

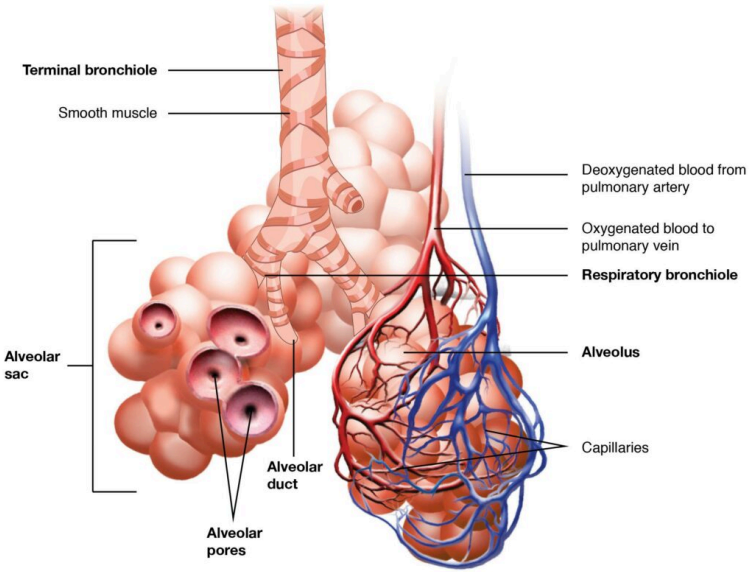

Figure 8.2c The Respiratory Zone. Bronchioles lead to alveolar sacs in the respiratory zone where gas exchange occurs

Alveoli

An alveolar duct is a tube composed of smooth muscle and connective tissue, which opens into a cluster of alveoli. An alveolus is one of the many small, grape-like sacs that are attached to the alveolar ducts.

An alveolar sac is a cluster of many individual alveoli that are

responsible for gas exchange. See Figure 8.2d[4] for an illustration of the structures of the respiratory zone.

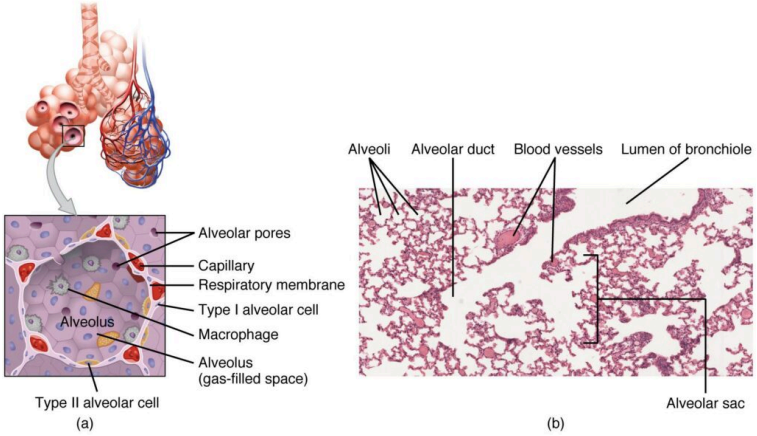

Figure 5.2c Structures of the Respiratory Zone. The alveolus is responsible for gas exchange

Respiratory Rate and Control of Ventilation

Breathing usually occurs without thought, although at times you can consciously control it, such as when you swim under water, sing a song, or blow bubbles. The **respiratory rate** is the total number of breaths, or respiratory cycles, that occur each minute. Respiratory rate can be an important indicator of disease, as the rate may increase or decrease during an illness. The respiratory rate is controlled by the respiratory center located within the medulla

4. "2310 Structures of the Respiratory Zone.jpg" by OpenStax College is licensed under CC BY 3.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/22-1-organs-and-structures-of-the-respiratory-system

oblongata in the brain, which responds primarily to changes in carbon dioxide, oxygen, and pH levels in the blood.

The normal respiratory rate of a child decreases from birth to adolescence. A child under 1 year of age has a normal respiratory rate between 30 and 60 breaths per minute, but by the time a child is about 10 years old, the normal rate is closer to 18 to 30. By adolescence, the normal respiratory rate is similar to that of adults, 12 to 18 breaths per minute.

Neurons that stimulate the muscles of the respiratory system are responsible for controlling and regulating pulmonary ventilation. The major brain centers involved in pulmonary ventilation are the medulla oblongata and the pontine respiratory group. (See Figure 8.2e[5] for an illustration of the respiratory centers of the brain.)

5. "2327 Respiratory Centers of the Brain.jpg" by OpenStax College is licensed under CC BY 3.0 .Access for free at https://openstax.org/books/anatomy-and-physiology/pages/22-3-the-process-of-breathing

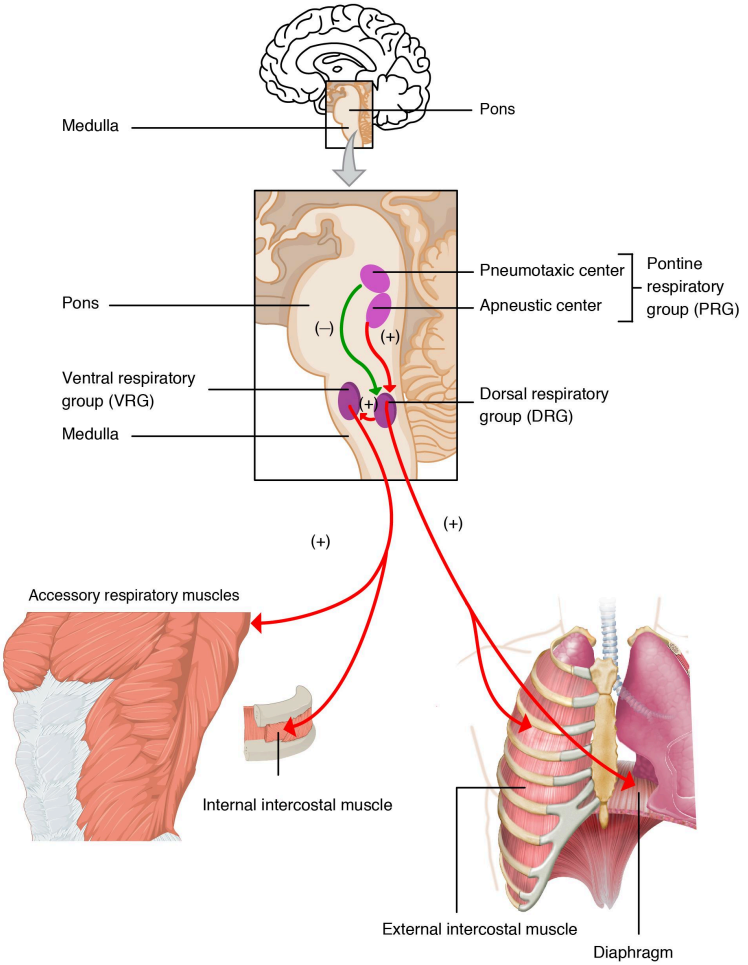

Figure 8.2e Respiratory Centers of the Brain

Supplementary Videos: See the supplementary videos below related to respiratory anatomy and physiology.

Anatomy of Respiratory System[6]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=146#oembed-4

6. Forciea, B. (2015, May 13). Repiratory System Anatomy (v2.0). [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/aqTwrdMS6CE

Inhalation and Exhalation[7]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=146#oembed-1

7. Forciea, B. (2015, May 12). Anatomy and Physiology: Respriratory System: Breathing Mechanics (v2.0). [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/X-J5Xgg3l6s

Carbon Dioxide Transport[8]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=146#oembed-2

8. Forciea, B. (2015, May 12). Repiratory System: C02 Transport (v2.0). [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/BmrvqZoxHYI

Surface Tension[9]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=146#oembed-3

9. Forciea, B. (2015, May 13). Anatomy and Physiology: Respiratory System: Surface Tension (v2.0). [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/YHTAausYA94

Image Description

Figure 8.2a Example of Gas Exchange Concept Map image description: This concept map illustrates the steps of gas exchange. The flow is as follows:

- Respirations
    - Inhalation of air
- Expiration to atmosphere
- Alveoli
    - Pulmonary capillaries
    - Diffusion
    - Hemoglobin carrying capacity
        - Perfusion
        - Delivery of oxygen and nutrients
    - Cells lining alveoli
- Cellular uptake of oxygen and nutrients
- Cellular metabolism and energy
    - Waste products – carbon dioxide
    - Capillaries carrying waste out of cell through perfusion
        - Expiration [Return to image]

8.2 Conditions and Diseases Related to the Respiratory System

The upper respiratory airways involve the nose, mouth and throat. Conditions that affect the upper respiratory system include the common cold, allergic rhinitis, and sinusitis and are usually involve an inflammatory response that affects the mucosal layer of the airways. These conditions are often self-limiting but can result in breathing difficulties and other respiratory symptoms.

The lower respiratory airways the trachea and the lungs, which includes the bronchi, bronchioles, and alveoli. Some of the most common lower respiratory conditions are asthma and chronic obstructive pulmonary disease (COPD), which includes emphysema and chronic bronchitis.

In this unit, we will review conditions that affect the upper respiratory system including allergies and the common cold. We will also review conditions that affect the lower respiratory system including asthma, bronchitis and chronic obstructive pulmonary disease (COPD).

To begin, we will discuss anaphylaxis, which is a potentially life-threatening medical emergency.

Anaphylaxis

Some types of allergies, including allergies to foods and insect stings, can trigger a severe reaction known as anaphylaxis. As a life-threatening medical emergency, anaphylaxis can cause a client to go into shock. There are a number of common triggers that

can precipitate the IgE-mediated (type 1) hypersensitivity reaction. These include food (shellfish, peanuts, eggs, wheat), latex, and insect stings or bites.

Signs and symptoms of anaphylaxis include:

- Loss of consciousness
- Drop in blood pressure
- Severe shortness of breath
- Skin rash or itching
- Light-headedness
- Rapid, weak pulse
- Nausea and vomiting

Symptoms often begin mildly, with a cough, runny nose, rash or even a lump in the throat. It can then progress quickly to more serious symptoms.

Anaphylaxis involves the release of numerous chemical mediators from the degranulation of basophils and mast cells after re-exposure to a specific antigen. IgE crosslinking and resultant aggregation of high-affinity receptors induce the rapid release of stored chemical mediators. These chemical mediators include histamine, tryptase, carboxypeptidase A, and proteoglycans. The resulting inflammatory response includes:

- Histamine release that increases vascular permeability and vasodilation, leading to tissue hypoperfusion. The body responds to these changes by increasing heart rate and cardiac contraction.
- Prostaglandin D functions as a bronchoconstrictor, simultaneously constricting cardiac and pulmonary arteries. It also potentiates peripheral vasodilation, contributing to the hypoperfusion of vital organs.
- Leukotrienes add to bronchoconstriction and vascular permeability and contribute to inflammation and bronchoconstriction. Chronic exposure may induce airway

remodeling.
- The platelet activation factor also acts as a bronchoconstrictor and increases vascular permeability.
- TNF-alpha activates neutrophils (as part of stress response leukocytosis) and increases chemokine synthesis.

(McLendon & Sternard, 2023)

Rapid treatment within the first hour of exposure is crucial. Treatment is with epinephrine intramuscular (IM) and airway management. Often only one dose of epinephrine is needed but it can be repeated. Typical dose is epinephrine 0.3 to 0.5 mg of 1:1,000 concentration intramuscular into the thigh.

Following the initial reaction, anaphylactic reactions can also occur biphasically, meaning there is a reoccurrence of symptoms 8-11 hours after the initial reaction (McLendon & Sternard, 2023). Clients who are treated in the ED are usually observed until the risk of a second reaction has passed.

Upper Respiratory System Disorders Include Allergies and the Common Cold

Allergies

Allergies occur when your immune system reacts to a foreign substance – such as pollen, bee venom, pet dander, or food – that doesn't cause a reaction in most people.

Your immune system produces substances known as antibodies. When you have allergies, your immune system makes antibodies that identify a particular allergen as harmful, even though it isn't. When you come into contact with the allergen, your immune system's reaction can inflame your skin, sinuses, airways, or digestive system.

The severity of allergies varies from person to person and can range from minor irritation to a potentially life-threatening emergency. While most allergies can't be cured, treatments can help relieve allergy symptoms.

Allergy symptoms, which depend on the substance involved, can affect airways, sinuses, and nasal passages, skin, and the digestive system (Mayo Clinic Staff, 2018a).

Hay fever, also called allergic rhinitis, is an inflammatory disorder, often triggered by an airborne allergen. It is the most common allergic disorder. It can cause:

- Sneezing
- Itching of the nose, eyes, or roof of the mouth
- Runny, stuffy nose
- Watery, red or swollen eyes (conjunctivitis)

A food allergy can cause:

- Tingling in the mouth
- Swelling of the lips, tongue, face, or throat
- Hives
- Anaphylaxis

An insect sting allergy can cause:

- Large area of swelling (edema) at the sting site
- Itching or hives all over the body
- Cough, chest tightness, wheezing, or shortness of breath
- Anaphylaxis

A drug allergy can cause:

- Hives
- Itchy skin
- Rash
- Facial swelling

- Wheezing
- Anaphylaxis

Atopic dermatitis, an allergic skin condition also called eczema, can cause skin to:

- Itch
- Redden
- Flake or peel

Treatment can include intranasal glucocorticoids, antihistamines (oral and nasal) and sympathomimetics (phenylephrine, pseudoephedrine) (Rosenjack Burchum & Rosenthal, 2019).

Common Cold

The common cold is a viral infection of the upper respiratory tract. There are over 100 types of viruses can cause a common cold. Viruses that can cause a cold include rhinoviruses, coronavirus, and enterovirus among many others(Tobin, Thomas & Bomar, 2025).

Children younger than 6 are at greatest risk of colds, but healthy adults can also expect to have two or three colds annually. Most people recover from a common cold in a week or 10 days. Symptoms might last longer in people who smoke due to impaired mucociliary function and impaired immune function.

Symptoms of a common cold usually appear one to three days after exposure to a cold-causing virus. Signs and symptoms, which can vary from person to person, might include:

- Runny or stuffy nose, sore throat, cough, congestion
- Slight body aches or a mild headache, low-grade fever, malaise
- Sneezing

(Mayo Clinic, 2019a).

Symptoms can be mild to moderate, but usually self-limiting. Treatment includes non-steroidal anti-inflammatories to treat general discomfort and fever, antihistamines, anticholinergics, and antitussives, all with the goal of symptom relief (Tobin, Thomas & Bomar, 2025).

Lower respiratory system disorders include asthma, bronchitis and chronic obstructive respiratory disease (COPD).

Asthma

Asthma is a chronic respiratory disorder affecting the lungs of both children and adults. It starts with an immune response to an allergen that leads to inflammation, edema, and bronchospasm of the airways, which inhibits air from entering the lungs. In addition, excessive mucus secretion can occur, which further contributes to airway blockage. Cells of the immune system, such as eosinophils and mononuclear cells, are also involved in infiltrating the walls of the bronchi and bronchioles. Airway inflammation is the primary issue in asthma.

In exercise-induced asthma, the release of inflammatory mediators such as histamine is initiated by the rapid dehydration of the airway surface by breathing in cold, dry air during exercise.

Bronchospasms occur periodically and lead to an "asthma attack." An attack may be triggered by environmental factors such as dust, pollen, pet hair, or dander; changes in the weather; mold; tobacco smoke; respiratory infections; exercise; and stress (Open Stax, n.d.).

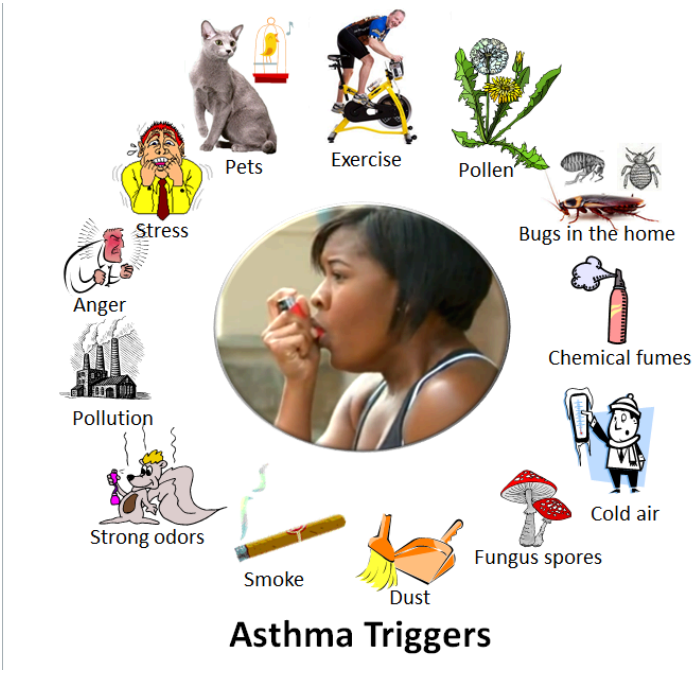

Figure 8.3a Common triggers of asthma [File:Asthma triggers 2.PNG – Wikimedia Commons]

Along with asthma, many people with asthma are more likely to have other chronic diseases or conditions such as diabetes, hypertension, and mood or anxiety disorders. These conditions can make asthma symptoms worse or impede effective treatment (Ontario Health, 2025).

Symptoms of an asthma attack involve coughing, shortness of breath, wheezing, and tightness of the chest. Symptoms of a severe asthma attack that requiring immediate medical attention include difficulty breathing that results in **cyanotic** lips or face, confusion, drowsiness, a rapid pulse, sweating, and severe anxiety.

The severity of the condition, frequency of attacks, and identified triggers influence the type of medication that an individual may require. Asthma is classified based on the severity of the disease. This includes very mild, mild, moderate, and severe which helps direct medication management.

Good asthma control is crucial. When inflammation is uncontrolled, tissues undergo remodeling which leads to permanent structural changes to the bronchi and thus permanent alteration in lung function.

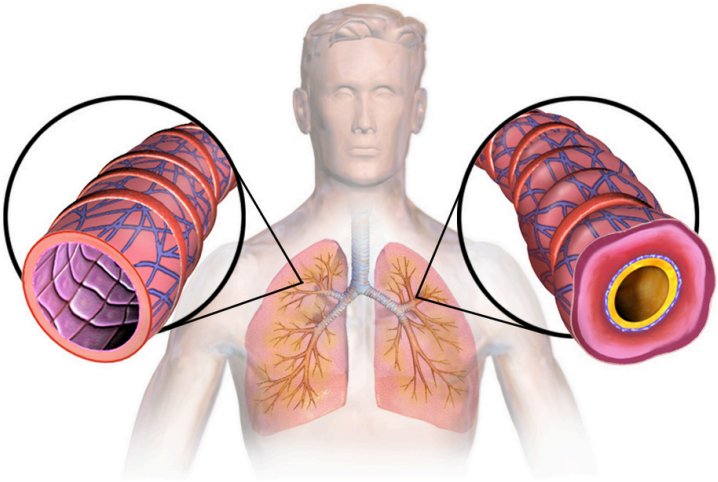

Figure 8.3b The effects of asthma on airways. This image shows an airway on the left unaffected, and an airway on the right impacted by bronchoconstriction and mucous. https://commons.wikimedia.org/wiki/File:Asthma_(Lungs).png

For more information on diagnosis, treatment and management of asthma: Government of BC (2023). Asthma Diagnosis, Education and Management. BC Guidelines.ca Asthma Diagnosis, Education and Management – Province of British Columbia

Diagnosing Asthma

Management begins with an accurate diagnosis. This includes a thorough clinical history, physical examination and lung function tests that may include spirometry, peak flow meter test (estimates peak expiratory flow rate), assessments of airway hyperresponsiveness, sputum eosinophil levels, blood eosinophil levels, and chest X-rays (Sun, Sun & Wang, 2023).

Peak Flow Monitoring:

Peak flow monitoring is the use of a peak flow monitor to estimate the ability to push air out of the lungs (PEFR).

Peak expiratory flow (PEF): measures the maximum speed of expiration using a peak expiratory flow meter. The peak airflow will decrease during expiration if airways are blocked due to airway inflammation or bronchoconstriction (Asthma Canada, 2026). The device can be used at home and is also often used in the ED as part of a respiratory assessment.

Symptoms that suggest asthma:

- Frequent episodes of breathlessness, chest tightness, wheezing or cough
- Symptoms worse at night and in the early morning
- Symptoms develop with a viral respiratory tract infection, after exercise, or exposure to aero-allergens or irritants.

- Symptoms improve with bronchodilators or corticosteroids

(Canadian Thoracic Society, 2017)

Following a diagnosis, regular reassessment of control and risk of exacerbation is important. Further, all clients with asthma should have a self-management education that includes a written action plan, environmental triggers avoidance, and inhaler technique training (Canadian Thoracic Society, 2021).

Medications are given to increase airflow by:

- Bronchodilation (beta 2 adrenergic, anticholinergics)
- Decrease mucous production (corticosteroids inhaled or oral and anticholinergics)
- Decrease immune response (corticosteroids, antileukotrienes)

Treatment is on a continuum.

If symptoms are controlled, the client will take a controller (daily inhaled corticosteroid) plus a PRN rescue med short acting beta adrenergic.

If symptoms are less controlled, the inhaled corticosteroid dose may be increased and a long acting beta adrenergic med might be added. For example, ICS/formoterol is sometimes prescribed.

View the following video for additional insight into how asthma works.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=149#oembed-1

Bronchitis

Bronchitis is an inflammation of the lining of the bronchial tubes, which carry air to and from the lungs. People who have bronchitis often cough up thickened mucus, which can be discolored. Bronchitis may be either acute or chronic.

Often developing from a cold or other respiratory infection, acute bronchitis is very common. Acute bronchitis, also called a chest cold, usually improves within a week to 10 days without lasting effects, although the cough may linger for weeks.

Chronic bronchitis, a more serious condition, is a constant irritation or inflammation of the lining of the bronchial tubes, often due to smoking. Chronic bronchitis is one of the conditions included in COPD (Mayo Clinic Staff, 2017).

Symptoms for either acute bronchitis or chronic bronchitis may include:

- Cough
- Production of mucus (sputum), which can be clear, white, yellowish-gray, or green in color — rarely, it may be streaked with blood
- Fatigue
- Shortness of breath
- Slight fever and chills
- Chest discomfort

Chronic Obstructive Pulmonary Disease

Chronic Obstructive Pulmonary Disease (COPD) is a slowly progressing, chronic inflammatory lung disease that causes obstructed airflow out of the lungs. It is an umbrella term for progressive respiratory diseases that include emphysema and bronchitis. The most common cause of COPD is tobacco smoking,

including second hand smoke or passive exposure (Government of Canada, 2018).

Symptoms include breathing difficulty, cough, mucus (sputum) production, and wheezing. It is often caused by long-term exposure to irritating gases or dust, and most often occurs due to smoking. People with COPD are at increased risk of developing heart disease, lung cancer, and a variety of other conditions.

Emphysema and chronic bronchitis are the two types of COPD. Emphysema is a condition in which the alveoli at the end of the smallest air passages (bronchioles) of the lungs are destroyed and hyperinflated. Chronic bronchitis is inflammation of the lining of the bronchial tubes, characterized by daily cough and mucus (sputum) production. See Figure 8.3c for an illustration of normal lungs compared to lungs with COPD.

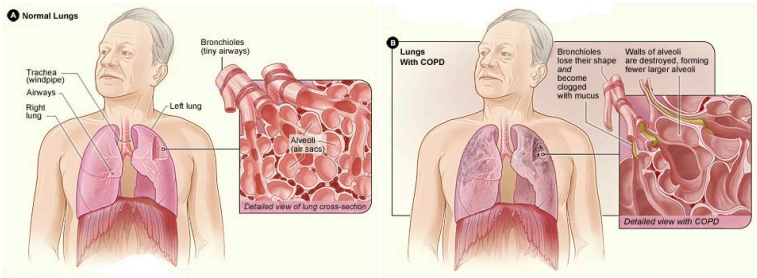

Figure 8.3c *Normal lungs compared with lungs in a person with COPD. "Copd 2010Side.JPG" by National Heart Lung and Blood Institute is licensed under CC0* ↵

COPD begins with prolonged exposure to noxious inhaled particles. Overtime, there is a progressive airflow limitation and tissue destruction due to pulmonary inflammation, increased mucous, and decreased muco-ciliary function. Persistent inflammation and chronic infections eventually lead to remodelling, permanent scarring, decreased alveoli elasticity and decreased lung recoil.

COPD is treatable but not curable. COPD symptoms often don't

appear until significant lung damage has occurred, and they usually worsen over time, particularly if smoke exposure continues.

Other signs and symptoms of COPD may include:

- Shortness of breath, especially during physical activities
- Wheezing
- Chest tightness
- Chronic cough that may produce mucus (sputum) that may be clear, white, yellow, or greenish
- Cyanosis
- Frequent respiratory infections
- Lack of energy
- Unintended weight loss (in later stages)

Persons with COPD are at risk for respiratory infections due to chronic inflammation, increased mucous production and impaired ciliary function associated with the disease. Damage to the pulmonary vasculature can also lead to other respiratory conditions including pulmonary hypertension, cor pulmonale, hypoxia and hypercapnia (Sealock & Seneviratne, 2021).

Unlike some diseases, COPD has a clear cause and a clear path of prevention. The majority of cases are directly related to cigarette smoking, and the best way to prevent COPD is to never smoke — or to teach clients to stop smoking now (Mayo Staff Clinic, 2017b).

Everyday Connection: The Effects of Second-Hand Tobacco Smoke

The burning of a tobacco cigarette creates multiple chemical compounds that are released through mainstream smoke, which is inhaled by the smoker, and through

sidestream smoke, which is the smoke that is given off by the burning cigarette. Second-hand smoke, which is a combination of side stream smoke and the mainstream smoke that is exhaled by the smoker, has been demonstrated by numerous scientific studies to cause disease. At least 40 chemicals in side stream smoke have been identified that negatively impact human health, leading to the development of cancer or other conditions, such as immune system dysfunction, liver toxicity, cardiac arrhythmias, pulmonary edema, and neurological dysfunction. Furthermore, second-hand smoke has been found to harbor at least 250 compounds that are known to be toxic, carcinogenic, or both. Some major classes of carcinogens in second-hand smoke are polyaromatic hydrocarbons (PAHs), N-nitrosamines, aromatic amines, formaldehyde, and acetaldehyde.

Tobacco and second-hand smoke are considered to be carcinogenic. Exposure to second-hand smoke can cause lung cancer in individuals who are not tobacco users themselves. It is estimated that the risk of developing lung cancer is increased by up to 30 percent in nonsmokers who live with an individual who smokes in the house, as compared to nonsmokers who are not regularly exposed to second-hand smoke. Children are especially affected by second-hand smoke. Children who live with an individual who smokes inside the home have a larger number of lower respiratory infections, which are associated with hospitalizations, and higher risk of sudden infant death syndrome (SIDS). Second-hand smoke in the home has also been linked to a greater number of ear infections in

children, as well as worsening symptoms of asthma (Open Stax, n.d.).

Medications for treatment depends on symptoms and respiratory function diagnostic results. As the disease progresses, more medications are added. Medications for symptom control and exacerbation reduction include:

- maximizing gas exchange. This includes:
  - short-acting beta-2 adrenergic (SABA) inhalers
  - long-acting beta-2 adrenergic (LABA) inhalers.
  - long-acting muscarinic antagonists (LAMA)
  - inhaled corticosteroids (ICS)
- expectorants to increase airway patency and to facilitate secretion removal

Example in practice:

A 60-year-old client, Francois, is diagnosed with COPD and is started on a LAMA medication, tiotropium bromide. They are also prescribed a SABA, salbutamol. They take their LAMA daily, and use the SABA for an onset of SOB or wheezes and can use it 1-2 times/week.

After a year, Francois finds he takes salbutamol more than 2 times/week, and has more fatigue. The prescriber will add the LABA, salmeterol, to improve the overall management. He will continue to take his LAMA and SABA as prescribed.

Over time, and as Francois's condition deteriorates, his dosages of the meds will be increased, and an inhaled corticosteroid may be added to further decrease the inflammation and mucous.

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=149#h5p-115

Image Descriptions

Figure 8.3a Common triggers of asthma. People have different

triggers to asthma that can include smoke, pet dander, pollution, stress, fungal spores, chemical fumes, dust and exercise.

Figure 8.3b How Asthma Affects the Airway – Image Description

A normal airway has relaxed smooth muscles. Asthmatic airway has relaxed smooth muscles with inside wall inflamed and thickened. During an asthma attack, air is trapped in alveoli and the smooth muscles tighten. [Return to Figure 8.3a]

Figure 8.3c Normal lungs compared with lungs in a person with COPD. Figure A shows the location of the lungs and airways in the body. The inset image shows a detailed cross-section of the bronchioles and alveoli. Figure B shows lungs damaged by COPD. The inset image shows a detailed cross-section of the damaged bronchioles and alveolar walls.

Media Attributions

Figure 8.3a Common triggers of asthma File:Asthma triggers 2.PNG – Wikimedia Commons

Figure 8.3b How Asthma Affects the Airways https://commons.wikimedia.org/wiki/File:Asthma_(Lungs).png

Figure 8.3c Normal lungs compared with lungs in a person with COPD. "Copd_2010Side.JPG" by National Heart Lung and Blood Institute is licensed under CC0 ↵

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- "Asthma and Your Airways" by unknown, is licensed under CC BY-NC-SA 3.0 Access for free at https://humannhealth.com/what-you-need-to-know-about-asthma/341/ ↵

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8.3 Clinical Reasoning and Decision-Making related to the Respiratory System

Clinical Reasoning and Decision-Making Related to Gas Exchange

Clinical reasoning is a way that we think and process our knowledge, including what we have read or learned in the past, and apply it to the current context of what we are seeing right now in practice (NCSBN, n.d). Nurses make decisions all the time, and making decisions requires a complex thinking process. There are so many useful tools to be found online that can support your thinking through to clinical judgments. In the past, and still relevant, is the nursing process. We will utilize the nursing process as well as clinical judgment tools to help you clearly understand further respiratory drugs and their application in practice.

Now that we have reviewed the respiratory system and common respiratory disorders, let's apply your knowledge to support the learning of the respiratory system and drugs related to gas exchange.

Assessment

Although there are numerous details to consider when administering medications, it is always important to first think about what you are giving and why.

Clinical Indication for the Medication: Recognizing Cues

Respiratory medications are often given to alleviate allergies or cold symptoms, or to decrease/eliminate shortness of breath (SOB). An important piece of your nursing assessment should be to assess the client's respiratory status. The respiratory assessment includes observing the respiratory rate and quality of respirations (shallow, deep), obtaining a pulse oximetry reading, and auscultating lung sounds. Other pieces of the assessment include inspecting skin color, such as observing for **pallor**, or cyanosis, and determining if there is a cough or **sputum** present. If sputum is present, it should be assessed for color, odor, consistency, and amount (COCA).

Additional baseline information to collect prior to the administration of any respiratory medication includes any history of allergy or previous adverse drug response. If the client has had an acute change in their breathing or are required to monitor their breathing at home, the use of a peak flow meter will help determine the maximum speed of expiration an if any airflow issues due to inflammation or bronchoconstriction (Asthma Canada, 2026).

Interventions

Next, plan (refine your hypothesis), and take action.

Respiratory medications are available in many different formulations, such as nasal spray, inhalations, oral tablets or liquids, injections, or intravenous route, so it is always important to verify the correct route and anticipate the associated side effects. For example, inhalations deliver the required medication directly to the lungs, which means the medicine(s) can act directly on the lung tissues, minimizing systemic side effects. On the other hand, intravenous medications are administered to act quickly, but can cause systemic side effects. Additionally, some products contain more than one medicine with different dosages (for example, inhalers that combine a long-acting bronchodilator with a glucocorticoid).

During the administration of respiratory medications, it is important to anticipate the expected outcome of the medication and any common side effects. For example, salbutamol is a short acting beta-2 agonist that is given for bronchodilation. The nurse should plan to perform a respiratory assessment before and after administration of salbutamol to document the effectiveness of the medication, as well as monitor for tachycardia, a common side effect.

Additionally, the nurse should also ensure the proper use of the inhalers by the client. Observe the client self-administering the medication, and further instruct the client in proper use. (Drugs.com, n.d.).

Evaluation

Finally, evaluate the outcomes of your action.

It is important to always evaluate the client's response to a medication.

- Complete a respiratory assessment before and after the medications have been administered. Include respirations, pulse oximetry, and lung auscultation. Compare the results.
- Symptoms: assess for symptoms not improving or worsening. Also, assess for overall clinical presentation. For example, do they experience fatigue or shortness of breath?
- Allergies: Is there a decrease in allergy symptoms (cough, runny nose, tearing eyes) and any decrease in shortness of breath?
- Monitor for adverse effects of any medications administered. For example, is there tachycardia following salbutamol inhaler?

If the symptoms are not improving or the clinical assessment is worsening, prompt intervention is required, such as notification of the health care provider for further orders, to prevent further clinical deterioration.

Utilizing tools such as this concept map helps work through thinking like a nurse. This map in figure 8.4 is an example of what a concept map could look like. Your own design may vary so do not worry. You should now take time to explore what you have read and apply it visually.

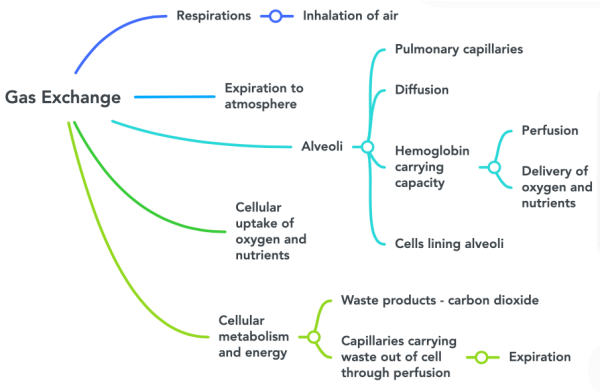

Figure 8.4 Concept Map of Gas Exchange [Image Description]

Image Description

Figure 8.4 Concept Map of Gas Exchange image description: This concept map illustrates the steps of gas exchange. The flow is as follows:

- Respirations
  - Inhalation of air
- Expiration to atmosphere
- Alveoli
  - Pulmonary capillaries
  - Diffusion
  - Hemoglobin carrying capacity
    - Perfusion
    - Delivery of oxygen and nutrients
  - Cells lining alveoli
- Cellular uptake of oxygen and nutrients
- Cellular metabolism and energy
  - Waste products – carbon dioxide
  - Capillaries carrying waste out of cell through perfusion

- Expiration [Return to image]

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8.4 Gas Exchange Administration Considerations

Now that we have reviewed basic concepts, we will take a closer look at specific respiratory classifications and specific administration considerations, therapeutic effects, adverse/side effects, and teaching needed for each class of medications.

Administration Considerations

Drugs related to gas exchange are given through multiple routes including inhalation, oral, sublingual, injectable, and nebulized. It is important to consider how these routes are impacted by your client's needs. For example, children may struggle with certain routes such as inhalation. As a nurse, you must anticipate the needs of your client and mitigate complications. In this example, the nurse can provide an aerosol chamber to support the client getting the proper medication.

Therapeutic Effects

Nurses are responsible for monitoring the effects of any medications we administer. The therapeutic effect is the result we expect to see from administering a drug. In the next few chapters, you will learn about different drugs used for clients and the

therapeutic effect of each drug. It is important to note that since we are discussing respiratory drugs, likely one of the therapeutic effects will be improved breathing.

Adverse and Side Effects

Side effects are the negative consequence of taking medications. It is important that nurses understand what side effects may occur and try to prevent these from happening. Adverse effects and side effects must be considered when deciding to take a medication. The benefit of the medication must out weigh the negative effects.

Client Teaching

Health Literacy is an important concept in medication administration and the nurse's role. We must ensure our clients are comfortable and confident in the medication process and their knowledge about the medications they are taking. Before discharging a client from care, the nurse should ensure that the client fully understands their medications, how to take them, side effects that might happen, and the therapeutic effects we expect to see.

Extra Resources

In the next chapters we will look at drug classifications related to gas exchange.

Medication cards are useful in the clinical setting and to help

with learning the meds. In this chapter, some of the drug classes have individual med cards and they are located within each unit. You have the option to download and edit as needed. The following **Comparing Respiratory Medications** is also an option to support your learning. Download and edit as needed.

Downloadable file (.docx): Chapter 8 Comparing Respiratory Medications med cards

8.5 Antihistamines

Antihistamines are used to mitigate conditions that are mediated by histamine. Histamine-1 antihistamines, such as diphenhydramine, chlorpheniramine, and dimenhydrinate are used for respiratory inflammatory conditions (allergies, angioedema, sinusitis) and motion sickness. This is not to be confused with histamine-2 receptor antagonists, such as famotidine.

Diphenhydramine and Cetirizine are two commonly-seen antihistamine drugs. Our prototype medication will be diphenhydramine.

Diphenhydramine is an example of a first-generation antihistamine. (See Figures 8.5a and 8.5b) Second-generation antihistamines were developed to have fewer side effects. An example of a second-generation antihistamine is cetirizine.

Mechanism of Action

Antihistamines have the following mechanisms of action: H1 receptor antagonism reduces the effects of histamine. Some of these effects are vasodilation (inhibiting histamine mediated vasoconstriction), respiratory tract and GI tract), decreasing capillary permeability, decreasing bronchoconstriction, decreasing salivation, and tear formation. Diphenhydramine is highly lipophilic and readily crosses the blood-brain barrier antagonizing central H1 receptors, causing sedation and anticholinergic effects. It antagonizes both central and peripheral H1 receptors resulting in decreased vascular permeability.

What is histamine?

Histamine is present within all body tissues, but has the highest concentration in the lungs, basophils, and mast cells. It also is a potent vasoactive agent through its effect on bronchial smooth muscles and nociceptive itch nerves. In response to an allergen or stimulus, activation of the H1 receptors causes pruritus, vasodilation, flushing, tachycardia and bronchoconstriction (Patel & Mohiuddin, 2023).

Indications for Use

Diphenhydramine is used for relief of allergies or cold symptoms. It provides relief from hay fever or upper respiratory allergy symptoms that include runny nose, sneezing and itchy eyes, nose or throat. It can also be used for motion sickness.

Figure 8.5a Diphenhydramine is a first-generation antihistamine that is available orally or as an IV medication

Figure 8.5b Diphenhydramine HCl preparation, single dose vial for IV administration

Nursing Considerations

Administration: oral, IM and IV; 25-50 mg (adult). Oral dosages can be given with a meal or milk to decrease GI irritation.

Use with caution in severe liver disease, angle-closure glaucoma, prostatic hypertrophy and peptic ulcer disease.

Used for many uses so understand purpose of giving the med.

Pediatrics: This medication is not safe for children under the age of 2 years without a healthcare provider's order.

Older adult: increased susceptibility to anticholinergic effects, such as delirium, dizziness, dry mouth, urinary retention, constipation. Increased risk of falls. Give a smaller dose, or avoid.

Drug Interactions:

- CNS depressants such as benzodiazepines, opioids, or alcohol. Can lead to additive CNS and respiratory depression, increasing sedation, hypoventilation, and fall risk.
- Use with other CNS medications such as tricyclic antidepressants and antipsychotics can lead to anticholinergic and sedative effects. Assess for dry mouth, constipation, urinary retention, and delirium.
- Caution with promethazine as it can contribute to prolonging QT interval and risk of torsades de pointes.

Adverse/Side Effects

- Common side effects include sedation, cognitive impairment, and anticholinergic adverse effects such as dry mouth, urinary retention, constipation, and blurred vision.
- CNS depression especially if used with other CNS depressants such as opioids, hypnotics, alcohol.
- CNS stimulation with excessive doses can occur, especially in children.
- At higher doses: dizziness, tinnitus, and delirium.

Client Teaching

- Clients should be advised that antihistamines may cause drowsiness, and concurrent use of alcohol or other CNS depressants should be avoided.
- Only take the recommended amount of medication and not exceed dosing recommendations.
- Inform client of potential anticholinergic effects such as dry eyes, constipation, urinary retention, dizziness.
- Some clients may experience side effects such as dry mouth, and frequent oral hygiene may assist in alleviating discomfort.

(Frandsen, & Pennington, 2018; Vallerand & Sanoski, 2024).

Diphenhydramine Medication Card

Now let's take a closer look at the medication card for diphenhydramine. Medication cards are intended to assist students to learn key points about each medication class. Basic information related to a common generic medication in this class is outlined, including administration considerations, therapeutic effects, and side effects/adverse effects. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Diphenhydramine Medication Card

Class: Antihistamine **Prototype:** diphenhydramine (Benadryl)		**Indications:** Relieves allergic reactions and temporarily relieves symptoms due to hay fever or other upper respiratory allergies: runny nose; sneezing; itchy, watery eyes; itching of the nose or throat. Common cold symptom management	
Mechanism of Action: Blocks histamine at H1 receptor, inhibits smooth muscle constriction in blood vessels and respiratory and GI tracts: decreases capillary permeability, salivation and tear formation.			
Administration: PO/IV/IM/Suppository Dosages for adult PO 25-50mg q4-6hrs PRN. IV 10-50mg IM or IV Common dosages for children 4 years and older 1.25mg per kg or body weight injected IM (intramuscularly) up to 4 times per day	**Side Effects:** Sedation Anticholinergic effects GI: Nausea/Vomiting Paradoxical effect: excitation in children SAFETY: Note the name is close to Dimenhydrinate (gravol) so double check you have the right medication	**Contraindications:** Avoid alcohol and CNS depressants due to risk of sedation Caution with liver disease Older adult: on Beers List – caution due to risk of falls, drowsiness	**Nursing Considerations:** Assess for sedation Consider second and third generation antihistamines since they have less sedative properties Risk of dizziness and sedation, implement fall prevention strategies

Downloadable file (.docx): Diphenhydramine Medication Card

Media Attributions

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- "diphenhydramine (1)" by Intropin is licensed under CC BY-NC 2.0 ↵

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8.6 Decongestants

Decongestant medications have been available over the counter for years. Although they are readily available, considerations are necessary when taking any drug. In this unit we will explore these drugs further.

Our prototype med is pseudoephedrine.

Pseudoephedrine

Pseudoephedrine is an over-the-counter (OTC) decongestant (see Figure 8.6a). More details regarding pseudoephedrine are described in Chapter 4.0 Autonomic Nervous System.

Figure 8.6a Sudafed is the brand name for the decongestant pseudoephedrine.

Mechanism of Action

Pseudoephedrine has agonist effects primarily on the alpha-adrenergic receptors and acts indirectly by releasing norepinephrine from its storage sites. This results in vasoconstriction of the nasal mucosa, which shrinks nasal mucosa membranes.

Indications for Use

Decongestants relieve nasal obstruction due to inflammation.

Nursing Considerations

Administration: oral, well absorbed. Onset within 15-30 minutes

Assess nasal congestion and lung sounds before and periodically after therapy. Assess blood pressure and heart rate due to side effects of potential hypertension and palpitations.

This medication is not recommended for children under the age of 4 years, seek medical advice.

Use with caution for clients who have cardiac dysrhythmias, hyperthyroidism, DM (diabetes mellitus), prostatic hypertrophy, and glaucoma (Frandsen & Pennington, 2018).

Decongestants are contraindicated in clients with severe hypertension, coronary artery disease (CAD), and narrow-angle glaucoma. Caution if client has been on the antidepressant, MAO inhibitors, within the last 14 days.

Adverse/Side Effects

Common side effects include anxiety, palpitations, anorexia

Other effects include hypertension, dysrhythmia, dizziness, headache, insomnia, and restlessness. Adverse effects: blurred vision, tinnitus, chest tightness, dry nose, and nasal congestion.

Rebound decongestion can occur with topical use.

Client Teaching

- Client must take care to follow dosing recommendations.
- If dosing standards are surpassed or if taking other cold remedies concurrently, may experience adverse stimulant effects such as palpitations, increased nervousness, breathing difficulties, heart rate changes, and hallucinations (Vallerand & Sanoski, 2024).
- Encourage fluid intake of 1500-2000 mL/day to decrease secretion viscosity

Pseudoephedrine Medication Card

Now let's take a closer look at the medication drug card on Pseudoephedrine. Medication cards are intended to assist students to learn key points about each medication class. Basic information related to a common generic medication in this class is outlined, including administration considerations, therapeutic effects, and side effects/adverse effects.

Pseudoephedrine Medication Card

Class: Decongestants **Prototype:** Pseudoephedrine (Sudafed)		**Indications:** decongestant, available OTC Relieves nasal and sinus congestion, decreases sinus pressure and decrease pain Use of nasal congestion due to common cold and hay fever, upper respiratory allergies	
Mechanism of Action: It acts on the adrenergic alpha and beta receptors by releasing norepinephrine from its storage sites. This causes vasoconstriction-shrinking nasal mucosa membranes.			
Administration: Immediate release, extended release Tablets or solution Do not crush, chew, or break an extended-release tablet Oral suspension: ensure proper measuring and dose Adult Doses: Immediate release: 30 to 60 mg orally q 4 to 6 hours PRN Maximum daily dose is 240 mg/day.	**Side Effects:** Rebound congestion with nasal route CV stimulation-tachycardia risk, dizziness or anxiety. dangerously high blood pressure Loss of appetite Fever, headache, cough, or skin rash-contact doctor SAFETY: Cautious when administering to cardiac patients due to the stimulation it can cause Caution with taking other OTC cold remedies to ensure you are not taking more drugs than indicated Do not use if breastfeeding	**Contraindications:** Avoid using prolonged-greater than 7 days Caution with heart disease: Only use if advised by prescriber as it acts as a sympathomimetic This drug is banned for professional sports by the World Anti-Doping Agency as it is a stimulant and is claimed to enhance performance DO not use in children under 4 years of age DO not take if taking MAO inhibitors within 14 days, this leads to serious side effects. DO not take if taking caffeine pills, diet pills or other stimulants such as ADHA medications	**Nursing Considerations:** Drink at least 1.5-2L/day If cardiac disease, thyroid disease or diabetes: check with prescriber if safe to take

Downloadable file (.docx):Pseudoephedrine Medication Card

Media Attributions

- 8.6a "Project 366 #165: 130612 Helping Hand?" by Pete is licensed under public domain ↵

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Frandsen, G. & Pennington, S. (2018). Abrams' clinical drug: Rationales for nursing practice (11th ed.). Wolters Kluwer. ↵

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8.7 Antitussives

A cough is one part of the respiratory defence mechanisms. It protects the lungs from inhaled particles, microorganisms and toxic gases (Tyerman & Cobbett, 2023). Other defences include the filtration of air through the nasal passages, the mucociliary clearance system within the trachea and bronchioles, reflex bronchoconstriction and alveolar macrophages. The cough reflex can be initiated by an irritant within the bronchial mucosa or from other sites not part of the respiratory tract. Coughing is important to remove foreign matter or a buildup of secretions, and in these situations, coughing should not be suppressed. But, some coughs are not beneficial, as they are non-productive, irritating and prevent rest.

When a client reports that they have a cough, a nurse completes a thorough assessment of their health conditions, medications, and other symptoms that they may be experiencing. A functional assessment is important to learn about their exercise tolerance and sleep habits, along with their self-care practices (diet, exercise, smoking, immunizations).

Subjective assessment specific to the cough:

- When did the cough start? How often do you cough? Does it wake you up at night?
- What relieves the cough? What makes it worse?
- Do you have any sputum? What colour and consistency? Do you cough up any blood?

Other respiratory assessment questions include asking about shortness of breath, other breathing issues, chest pain with breathing, and any remedies they have tried to alleviate the cough.

After completing the subjective assessment, a physical assessment is completed that includes vital signs, chest auscultation and work of breathing.

If a cough suppressant is needed, antitussives can be obtained either OTC or if the cough is severe, with a prescription. There are two types of antitussives, opioids and non-opioid antitussives. Opioid antitussives include codeine which is a very effective cough suppressant. It acts within the CNS to elevate the cough threshold. It is only used with adults due to safety concerns of respiratory depression in children (Rosenjack Burchum & Rosenthal, 2019).

Non-opioid antitussives include dextromethorphan and diphenhydramine. Dextromethorphan is the most effective OTC nonopioid to suppress cough and this medication will be the focus of this unit.

Dextromethorphan

Dextromethorphan is an effective OTC cough suppressant. It is the active ingredient in most cough medicines.

Figure 8.7a: Robitussin Cough Cold Flu Congestion decongestant Relief Medicine

Mechanism of Action

Dextromethorphan primarily acts as a noncompetitive antagonist of NMDA receptors in the brain along with other target sites. It depresses the cough center in the medulla oblongata and the cough receptors in the throat, trachea, or lungs, effectively elevating the threshold for coughing. It is a derivative of opioids but lacks typical analgesic and respiratory depression effects at therapeutic doses.

Indication for Use

Antitussives are used for a dry, hacking, nonproductive cough that interferes with rest and sleep.

Off label, it is also used for a number of other conditions such as stroke, seizure and with Parkinson's disease clients.

Nursing Considerations

Administration: it is given orally, either in syrups, lozenges or tablets.

This medication is not recommended for children under the age of 4 years, without medical consult.

Dextromethorphan and acetaminophen are often used together, along with other meds, in cough medicines. Teach clients to not take more than the recommended daily amount of acetaminophen if they are taking it alongside the cough medicine.

Risk of serotonin syndrome if taking this medication with SSRIs and MAOI antidepressants.

Adverse/Side Effects

Dextromethorphan is well tolerated with minimal side effects. Adverse effects from cough suppressants are rare. The most commonly reported reactions include nausea and gastrointestinal discomfort, with drowsiness and dizziness also occurring in some clients.

Less common adverse effects are a rash or difficulty breathing.

At high doses, there is a risk of euphoria, hallucinations and disassociation. There are reports of the drug being used as a recreational drug (Frandsen & Pennington, 2018).

Client Teaching

- Clients should take care to avoid irritants that stimulate their cough.
- Use for dry, non-productive cough. If cough is productive, only take if recommended by prescriber.
- Risk of drowsiness, so take precautions if necessary.
- Avoid taking them with other CNS depressants or alcohol
- Advise that many OTC cough medicines have multiple drugs in the formula. Ensure to avoid taking higher dosages than recommended. For example, acetaminophen is in many combination medications.
- If symptoms persist more than 3-5 days seek medical assessment again (Velarde, 2020).

Media Attribution

- "Robitussin Cough Cold Flu Congestion decongestant Relief Medicine" by Mike Mozart is licensed under CC BY 2.0 ↵

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8.8 Expectorants

Guaifenesin (Mucinex) is an example of an expectorant.

Mechanism of Action

Expectorants such as guaifenesin, reduce the viscosity of tenacious secretions by irritating the gastric vagal receptors that stimulate respiratory tract fluid and also increase the hydration of respiratory secretions. This results in decreasing the viscosity of respiratory tract secretions and facilitating mucous clearance.

Indication for Use

Expectorants are used for a productive cough and for loosening mucus from the respiratory tract. It is used as an OTC medication to loosen secretions, and also as a prescription for chronic bronchitis.

Nursing Considerations

Administration: oral dosing, elixir or tablet. Do not eat or drink 30 minutes after elixir. Immediate and extended release formulations.

The medication is well tolerated. For children, follow age-specific guidelines. Guaifenesin is only recommended for use during pregnancy and breastfeeding when the benefit outweighs the risk.

Adverse/Side Effects

Guaifenesin may cause a skin rash, headache, nausea, and vomiting (Frandsen & Pennington, 2018). These effects are generally mild and infrequent.

Client Teaching

- Clients should attempt to avoid irritants that stimulate their cough.
- Advise to increase fluid intake to enhance effectiveness.
- Inform client that this medication can cause drowsiness.
- Clients should avoid taking them with other CNS depressants or alcohol (Unbound Medicine, n.d.).

Guaifenesin Medication Card

Now let's take a closer look at the medication card for guaifenesin (Daily Med, 2025; Velarde, 2020).

Guaifenesin Medication Card

Class: Expectorants **Prototype:** Guaifenesin (Mucinex)		**Indications:** Helps loosen sputum (mucus) and thin bronchial secretions to make coughs more productive.	
Mechanism of Action: Expectorants reduce the viscosity of tenacious secretions by irritating the gastric vagal receptors that stimulate respiratory tract fluid, thus increasing the volume but decreasing the viscosity of respiratory tract secretions.			
Administration: Liquid syrup or elixir, PO pill form – 12 hr effect (1 tablet is 600 mg) Max dose is 1200 mg in 24hrs No eating or drinking for 30 minutes after syrup Encourage patient to cough and deep breath Stay hydrated (2-3 liters/day) Do not exceed 24 hr limit of two doses IF taking pill form-take with full glass of water Do not crush or break pill	**Side Effects:** skin rash, headache, nausea and vomiting diarrhea. Large doses cause drowsiness Safety: Speak with MD for use when pregnant or breast feeding Risk of drowsiness-assess respirations and wakefulness	**Contraindications:** CNS depressants Caution with pregnancy and breast feeding Do not use if: Hyperthyroid, diabetes, closed angle glaucoma, high blood pressure, Heart disease, Enlarged prostate	**Nursing Considerations:** Safe for all ages. Only recommended for use during pregnancy & breastfeeding when benefit outweighs the risk Avoid irritants that stimulate their cough. Can cause drowsiness. Patients should avoid taking them with other CNS depressants or alcohol

Downloadable file (.docx): Guaifenesin Medication Card

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8.9 Beta-2 Adrenergic Agonists

Bronchodilators are widely used for symptomatic relief of bronchospasm related to asthma or chronic obstructive respiratory disease (COPD). Beta-2 adrenergic agonists are the most commonly used bronchodilator for both quick acting relief and long-term management. Other bronchodilators are anticholinergics, methylxanthines as well as combination inhalers. These will be reviewed in the upcoming units.

Before you begin this unit and the subsequent units, take time to review asthma and COPD in unit 8.1, in particular the management of both diseases. A brief overview is provided below. This unit does not address the many non-pharmacological interventions that are necessary.

Asthma medication management

Following a diagnosis, the treatment of asthma has two goals: terminate bronchospasm during an acute attack and to reduce or prevent risk (preventing reoccurrence, preventing further airway damage). This is accomplished by using a combination of medications.

- Beta adrenergic agonists and anticholinergics: bronchodilators
- Inhaled corticosteroids: suppress inflammation

COPD medication management

COPD is a chronic, progressive disease. According to the Canadian Thoracic Society, the treatment goals are to reduce dyspnea, improve health status, prevent acute exacerbations and reduce mortality (Bourbeau et al, 2023). Treatment depends on the severity (mild, moderate, severe). This is accomplished by using a combination of medications:

- Beta adrenergic agonists and anticholinergics: bronchodilators, short and long acting
- Inhaled corticosteroids: suppress inflammation
- Phosphodiesterase type 4 inhibitors

In this unit, we will review beta adrenergic agonists: Salbutamol (short acting) and salmeterol (long acting).

See the "Autonomic Nervous System: Beta-2 Agonists" chapter for more information regarding Beta-2 agonists.

Beta Adrenergic Receptor Agonists: salbutamol and salmeterol

Salbutamol is the most widely used bronchodilator for effective relief of acute bronchospasm. It is considered a 'rescue' or 'reliever' inhaler that reverses airway narrowing. Note that in the U.S, it is called albuterol.

Salmeterol is the long-acting bronchodilator and as the name suggests, it has a long duration of action. Note that other formulations are often prescribed that are combination inhalers, for example, the ICS-formoterol inhaler.

Figure 8.9a A salbutamol inhaler

Figure 8.9b A vial of salbutamol for inhalation

Mechanism of Action

Salbutamol and salmeterol stimulate Beta 2-adrenergic receptors in the smooth muscle of bronchi and bronchioles producing bronchodilation. The lungs have a large number of beta-2 receptors. The binding increases the formation of intracellular cAMP by stimulation of adenylyl cyclase which results in relaxing airway smooth muscle, inhibits the release of histamine from mast cells, inhibits macrovascular leakage and to a small degree it increases mucociliary transport (Daily Med, 2025; Vallerand & Sanoski, 2024). In simpler terms, beta-2 receptor stimulation increases cAMP, resulting in smooth muscle relaxation and bronchodilation.

Indications for Use

Short-acting beta agonists (SABA) is used to prevent an acute attack with onset of action almost immediately. They provide rapid relief of acute bronchospasm and prevent exercise-induced bronchospasm. They treat bronchospasms to prevent wheezing, chest tightness

and difficulty breathing due to respiratory diseases such as asthma and COPD.

Long-acting beta agonists (LABA), salmeterol, is used to prevent bronchospasm. LABA are both inhaled and oral formulas. Terbutaline is an example of an oral LABA although less commonly prescribed. It is taken up to four times a day. It is also available in an inhaled form.

Salbutamol can also be used for hyperkalemia. It causes hypokalemia as a result of an influx of potassium into skeletal muscle cells.

Nursing Considerations

Administration: short acting salbutamol: inhaled route. Long-acting salmeterol is inhaled or oral route.

Short Acting Beta Agonist (SABA):

- Onset 5-15 minutes, with a duration 3-6 hours. 1-2 puffs q 20min x 3 doses for acute exacerbation.
- MDI, DPI or nebulizer
- Hydrophilic, so not stored in tissues

Long-Acting Beta Agonist (LABA):

- Fixed schedule dosing i.e. BID
- It is lipophilic so longer duration of action.
- Onset 10-15 minutes with duration up to 12 hours

Safety Alert

Do not confuse the two beta-2 adrenergic inhalers. Salbutamol is short-acting and used for acute bronchospasm or anticipated exercise-induced bronchoconstriction. It is considered a rescue medication.

Salmeterol is long-acting and used for maintenance therapy for clients with asthma or COPD.

Monitoring:

- Assess lung sounds and respiratory rate before therapy. Assess for wheezes, work of breathing, oxygen saturations and stridor.
- Assess pulse and BP
- Assess sputum for colour and consistency

Prior to dosing: prime inhaler first by releasing four test sprays into the air.

Pediatric dosing: deliver by metered dose inhaler with a spacer device.

Pregnancy: avoid with pregnancy unless benefits outweigh risks. Do not use during labour due to interfering with uterine contractions.

(Vallerand & Sanoski, 2024)

Adverse/Side Effects

Side effects are related to sympathomimetic action. Anxiety, insomnia, tachycardia and tremor. Usually transient and mild.

Long term over use can lead to hypokalemia and hyperglycemia (stimulates hepatic glucose production).

Beta-2 agonists can cause muscle tremor, excessive cardiac stimulation, and CNS stimulation (Frandsen & Pennington, 2018).

Inhalation administration

The inhalation route has many advantages over other routes. It delivers the drug directly to the lungs or site of action, systemic effects are minimized, the relief of attacks is rapid. There are four types of inhalation devices: metered dose (pressurized device that delivers a measured dose), Respimat (fine mist), dry powder inhaler (dry micronized powder) and nebulizer (converts drug solution into a mist). The most common type is the metered dose (MDI). For any of these devices, correct use is important so the medication reaches the lungs. For example, a spacer is usually recommended for a MDI inhaler so the med does not end up in the mouth instead of the lungs. For more information: Delivery Devices – Asthma Canada (Asthma.ca, 2026).

Client Teaching

- Instruct clients to take medications as directed and report to their healthcare provider any sustained or worsening symptoms.
- When first using an inhaler, clients should be instructed to prime the inhaler unit prior to administering their medication and as per manufacturers recommendations.
- Ensure client understands correct inhaler technique, use of spacing devices and to seek medical care if rescue med is not relieving symptoms.
- Use of medications like salbutamol can cause an unusual taste in the mouth, and rinsing the mouth with water after use is permitted.
- Clients should have an understanding of medication onset and use short-acting and long-acting inhalers appropriately.
- Notify the prescriber if pregnant or planning on becoming pregnant.

Salbutamol and Salmeterol Medication Card

Now let's take a closer look at the medication card for salbutamol and salmeterol (Adams et al, 2020; Frandsen & Pennington, 2018; Vallerand & Sanoski, 2024).

Salbutamol and Salmeterol Medication Card

Class: Beta- 2 adrenergic Agonists **Prototype:** Salmeterol (long acting) and Salbutamol (short acting)		**Indications:** Short-acting salbutamol is used to prevent or treat bronchospasms in people with asthma, reversible obstructive airway disease, or exercise-induced bronchospasm. Long acting is used to prevent bronchospasm	
Mechanism of Action: Salbutamol and salmeterol stimulate Beta 2-adrenergic receptors in the smooth muscle of bronchi and bronchioles producing bronchodilation. Beta-1 receptors can also be inadvertently stimulated, causing tachycardia. Short acting induces rapid bronchodilation and Long-acting salmeterol is used to prevent bronchospasms.			
Administration: Take as directed for proper dosing SABA: onset 5-15 min duration of action 4-6hrs LABA: onset 10-25 min duration of action 12 hours	**Side Effects:** Muscle Tremor, tachycardia, anxiety, insomnia Unusual taste in the mouth after use Hyperglycemia Hypokalemia if overuse May develop tolerance SAFETY: Long-acting med should never be used in an acute attack	**Contraindications:** Use with caution with Hyperthyroidism, Glaucoma, Diabetes, Hypokalemia, seizures, CV disease (e.g., heart failure, hypertension, arrhythmias, coronary artery disease) Use with pregnancy only if benefit outweighs risk	**Nursing Considerations:** Assess lung sounds, BP and HR before use. Rinse mouth after administration Patient teaching: Prime MDI before use, Proper use Can develop paradoxical Broncho spasms

Downloadable file (.docx): Salbutamol and Salmeterol Medication Card

The following Chapter 8 Comparing Respiratory Medications med cards is also an option to support your learning. Download and edit as needed.

Critical Thinking and Decision-Making Questions

Complete the following questions to test your understanding. Go to the chapter 8.9 answer key

1. A 30-year-old client presents to the ED with acute SOB and bronchospasm. She informs the nurse she has asthma and ran out of her inhaler, Salbutamol.

    a. The nurse quickly does a respiratory assessment. Besides SOB, what might be other cues of bronchospasm?
    b. The nurse prepares to give salbutamol. What is important to do prior to giving the med?
    c. The client's condition has improved. She tells the nurse she sometimes takes her salbutamol 2 puffs at a time, up to 4 times in a day. What is the concern with this administration?

2. Which statements are correct about beta 2 adrenergic agonist inhalers? Select all that apply

    a. Short acting beta 2 adrenergic agonist inhalers are used for acute bronchospasm.
    b. If a beta 2 adrenergic agonist inhaler is used prior to exercise, take the inhaler one hour prior to exercise.
    c. These meds may cause temporary tachycardia and tremor which can be severe and lead to long term effects. If this occurs, report to the prescriber.
    d. It is safe to use salbutamol if a client is pregnant.

3. True or False: Salmeterol is used for acute bronchospasm.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 8:

Respiratory Medications Answer Key V2 – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

References

"Ventolin® HFA (Albuterol Sulfate) Inhaler.jpg" by MisterNarwhal is licensed under CC BY SA 4.0 ↵

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8.10 Anticholinergics

Anticholinergics, also known as muscarinic antagonists, are used as a bronchodilator for maintenance therapy with COPD. Ipratropium bromide inhaler is a short-acting anticholinergic and tiotropium is the long-acting option. Most meds in this class end in 'ium'.

Additional information regarding anticholinergics can be found in the "Autonomic Nervous System" chapter.

In this unit, our prototype medication will be Ipratropium bromide.

Figure 8.10a Tiotropium, a long-acting anticholinergic. Spiriva HandiHaler"-brand dry powder inhaler (open).png" by RonEJ at English Wikipedia is licensed under CC0 1.0 ↵

Mechanism of Action

Acetylcholine, a neurotransmitter, is released from nerve endings in the bronchial tree resulting in bronchoconstriction. Anticholinergics block the muscarinic (M3) receptors in the bronchial smooth muscle leading to bronchodilation and a decrease in mucous secretions (Liang & Chao, 2023).

Indications for Use

Anticholinergics are used for maintenance therapy of bronchoconstriction associated with COPD primarily and as an additional therapy for moderate to severe asthma. It has slow and prolonged effects so it is not used on its own for acute episodes. It is used separately or in combination inhalers with SABA or LABA meds. It is considered a 'controller' inhaler.

For COPD, it is often the first controller the client will be prescribed, along with a short-acting bronchodilator, salbutamol. If they use their salbutamol inhaler more then 1-2 times/week, then a long-acting beta-2 adrenergic med is ordered.

Review the following YouTube video for why the different medications are ordered for both asthma and COPD.

MedCram Medical Lectures Explained Clearly: Inhalers (Asthma Treatment & COPD Treatment) Explained! Inhalers (Asthma Treatment & COPD Treatment) Explained!

Nursing Considerations

Administration: inhaled or nasal, onset 1-2 minutes, with peak effect 1-2 hours. Duration of action 4-6 hours (Vallerand & Sanoski, 2024).

Assess respiratory status before administering and post therapy. Assess lung sounds, respiratory effort, RR, and oxygen saturations.

Combivent inhaler – salbutamol with ipratropium. Meds are combined to ease the use for the client as only one inhaler to use. Taken QID or as needed.

Adverse/Side Effects

Side effects: minimal systemic effects, mostly localized such as they may experience a dry mouth and irritation of the pharynx.

Risk of drying out secretions too well, with potential with risk of dry mucosal plugs and increased risk of infections.

(Daily Med, 2026; Liang & Chao, 2023)

Client Teaching

- Client should be instructed to use the inhaler as directed and be careful not to exceed dosage recommendations.
- They should receive education regarding the onset of the medication and differences in usage for short- and long-acting anticholinergics.
- Able to verbalize that this is not a first-line reliefer inhaler if acute bronchospasm
- Rinse mouth after use and practice good oral hygiene. Can chew sugarless gum to help with dry mouth.
- Clients with certain diseases should be cautious with using anticholinergics including myasthenia gravis, hyperthyroidism, glaucoma, enlarged prostate, hypertension, urinary tract blockage, and heart failure.
- Some long-acting anticholinergics may cause signs of angioedema and the healthcare provider should be notified if

this occurs (Vallerand & Sanoski, 2024).

Ipratropium and Tiotropium Medication Card

Now let's take a closer look at the medication card for ipratropium and tiotropium (Adams et al, 2020; Daily Med, 2026; Verlande, 2020; Frandsen & Pennington, 2018).

Ipratropium and Tiotropium Medication Card

Class: Anticholinergics **Prototype:** Ipratropium (short acting anticholinergic). Tiotropium (long-acting anticholinergic)		**Indications:** Anticholinergics are used for maintenance therapy of bronchoconstriction associated with asthma, chronic bronchitis, and emphysema Rapid bronchodilation to improve air movement and gas exchange.	
Mechanism of Action: Anticholinergics block the action of acetylcholine in bronchial smooth muscle, resulting in bronchodilation and a decrease in mucous secretion.			
Administration: Inhaler, nebulizer, nasal spray: use proper technique to get appropriate dosages Dosing up to 3-4 times/ day. Give after salbutamol if ordered. Controller inhaler, not for acute relief of bronchospasm	**Side Effects:** Minimal systemic effects. Localized: Drying of nasal mucosa sore throat, nausea GI upset Headaches, Dizziness Long term use may lead to angioedema	**Contraindications:** Caution with: Myasthenia gravis, hyperthyroid, glaucoma, enlarge prostate, urinary retention, heart failure	**Nursing Considerations:** Complete respiratory assessment before administration and regularly. Assess for adverse effects Watch for angioedema Client education – ensure client aware of purpose of inhaler and adverse effects.

Downloadable file (.docx): Ipratropium and Tiotropium Medication CardCH8.10

References

- "Spiriva HandiHaler"-brand dry powder inhaler (open).png"

by RonEJ at English Wikipedia is licensed under CC0 1.0 ↵
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8.11 Corticosteroids

Corticosteroids are a widely prescribed and effective medication class for long term management of airway inflammation. To suppress airway inflammation, inhalation formulas are routinely prescribed for their localized action. Examples include fluticasone, budesonide and beclomethasone. Given regularly, these meds can reduce the frequency of asthma symptoms, bronchial hyperresponsiveness and risk of exacerbation (Liang & Chao, 2023). Most of the meds in this class all end in 'one.' For example, beclomethasone, fluticasone, and mometasone.

In more severe cases, glucocorticoids can also be given orally (prednisone) or intravenously (methylprednisolone) to get the respiratory disease under control or for long term management. The risk of adverse effects with systemic corticosteroids are high especially if used long term so they are used judiciously. For example, a client will often be on a short term treatment with prednisone to get the bronchial inflammation under control, and then go back to only using inhalers.

Additional information about corticosteroids and potential adrenal effects is located in the "Endocrine" chapter.

Our prototype drug will be fluticasone.

Figure 8.11a

Mechanism of Action

All corticosteroids act as an anti-inflammatory and immune modifier. Inhaled corticosteroids work directly at the cellular level within the bronchioles reversing capillary permeability and lysosomal stabilization to reduce inflammation (Laing & Chao, 2023). Inhaled corticosteroids do not provide immediate effect, but work gradually that can take up to a few weeks to reach maximum effect.

Fluticasone is a locally-acting anti-inflammatory and immune

modifier. The nasal spray is used for allergies, and the oral inhaler is used for long-term control of asthma. Fluticasone is also used in a combination product with salmeterol. It decreases the frequency and severity of asthma attacks and improves overall asthma symptoms.

Indications for Use

Inhaled Corticosteroids (ICS), such as fluticasone inhalers, are used as a prophylaxis of chronic asthma and to a lesser extent, COPD. It is used as preventative therapy to suppress inflammation. They are given on a fixed schedule, not PRN. They are part of the first line management of inflammation in asthma. As such, it is considered a 'controller' drug. If the client's asthma symptoms worsen, corticosteroids can be given in a stepwise fashion, with low, medium and high-dose corticosteroids being prescribed. Corticosteroids can also be used alongside other 'controller' medications, such as long-acting beta-agonists or leukotriene antagonists.

Example of asthma treatment:

A client will be on an ICS and short-acting beta-2 adrenergic inhaler, salbutamol (SABA). They are symptomatic and need the SABA more than 1-2 times/week?

ICS dosage may be increased. Still symptomatic and need the SABA more than 1-2 times/week?

Long-acting beta-2 adrenergic (LABA) is added.

Other medications that can be added are leukotriene receptor modifiers and long-acting muscarinic antagonists.

Example of COPD treatment:

Start with long-acting muscarinic antagonist (LAMA), along with a SABA. Need the SABA more than 2 times/week?

- Add a long-acting beta-2 adrenergic agonist (LABA). Often LAMA/LABA meds are in a combination inhaler.
- Other medications that can be added are inhaled corticosteroids (ICS), mucolytics, phosphodiesterase-4 (PDE4) inhibitors and biologics depending on clinical response.

Nursing Considerations

Administration: There are up to six different glucocorticoid inhalers. Fluticasone is given via MDI, twice day. Others such as budesonide are given via DPI.

Controller medications: fluticasone is always given on a fixed schedule, usually BID. If the respiratory symptoms worsen, the prescriber will determine if a higher dose is needed, even short term.

Pediatrics: Fluticasone is safe for children aged 4 years and older. Inhaled glucocorticoids can slow the growth in children, but do not prevent them from reaching full height (Liang & Chao, 2023). Watch for potential mood changes such as irritability and possible hyperactivity in children.

Long term use: risk of bone loss is minimal, contrary to the risk with using oral glucocorticoids which has significantly more systemic effects. Ensure client does weight bearing exercises, uses lowest dose possible and take calcium and vitamin D regularly. The prescriber may recommend a bone density test is done prior to therapy and periodically afterwards.

Older adult: Use with caution with the older adult with COPD as may increase risk of pneumonia.

Adverse/Side Effects

Side effects are minimal due to the localized effect of inhalation meds, mostly bypassing first-pass metabolism.

Common side effects include hoarseness, dry mouth, cough, sore throat, and oropharyngeal candidiasis. These effects are more common with high-dose inhalers. They can be minimized if a spacer is used.

Dysphonia may occur due to myopathy of laryngeal muscles and mucosal irritation.

To avoid candida infections, rinse mouth after use.

Absolute contraindications for inhaled corticosteroids are a severe hypersensitivity to milk proteins/lactose. Dry powder inhalers contain lactose as a stabilizing agent, so this form of inhaler should be avoided (Laing & Chao, 2023).

Adverse effects: although rare, may contribute to cataracts, glaucoma, hypothalamic-pituitary-adrenal axis dysfunction, and impaired glucose metabolism.

Figure 8.11b Fluticasone MDI

Figure 8.11c Fluticasone oral inhaler formulation

Client Teaching

- Advise clients to take the inhaler as prescribed. If taking a SABA as well, take first before the ICS.
- Do not use to treat an acute asthma attack, ICS are used as controller medications
- Inform client of common side effects such as hoarseness, and dry mouth.
- Risk of candidiasis infection, so ensure to rinse mouth with warm water after using inhaler.
- Use a spacer for medication to reach the lungs more effectively.

Fluticasone Medication Card

Now let's take a closer look at the medication card for fluticasone.[7][8][9]

Fluticasone Medication Card

Class: Corticosteroids **Prototype:** Fluticasone (Flovent)		**Indications:** used for management of nasal symptoms of perennial non-allergic rhinitis, control of asthma symptoms. Reduces inflammation in bronchioles.	
Mechanism of Action: Local anti-inflammatory and immune modifier. Inhaled corticosteroids work directly at the cellular level within the bronchioles reversing capillary permeability and lysosomal stabilization to reduce inflammation. The nasal spray is used for allergies, and the oral inhaler is used for long-term control of asthma.			
Administration: Inhaler, nasal spray Oral inhaler BID. Take at same time each day Rinse mouth before and after use to prevent candidiasis. Fluticasone is also used in a combination product with salmeterol.	**Side Effects:** Oral candidiasis – rinse mouth after using inhaler. Hoarseness Dry mouth Cough Sore throat May mask oral infections	**Contraindications:** Do not use if allergy to milk protein/lactose Caution with older adults. At high doses or long-term use: may cause growth suppression in children	**Nursing Considerations:** Can take up to two weeks to feel benefit. Used as a controller med, not for acute bronchospasm. Use spacer to improve delivery of med to lungs.

Downloadable file (.docx): Fluticasone Medication Card

Critical Thinking and Decision Making Questions

1. A patient has prescriptions for two inhalers. One inhaler is a bronchodilator, and the other is a corticosteroid (ICS). Which instruction should the nurse give the patient regarding these inhalers? Pick

the correct option.

a. The corticosteroid should be taken first to decrease inflammation.

b. The bronchodilator should be taken first to open up the airways.

c. Take the inhalers at least 2 hours apart. The ICS inhaler cannot be taken with other inhalers.

d. The order of the taking the inhalers does not matter with these two drugs.

2. A client will be started on fluticasone inhaler. Their friend told them that there are a lot of terrible side effects with steroid medications and they shouldn't be on it for very long. How will the nurse respond?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 8: Respiratory Medications Answer Key V2 – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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8.12 Leukotriene Receptor Antagonists

Leukotriene receptor antagonists are used to prevent and treat chronic asthma. They are only used for maintenance therapy, and often if inhaled corticosteroids (ICS) are not enough or if they are not to be used. There are two commonly used meds, zafirlukast and montelukast. Zileuton, a leukotriene synthesis inhibitor, may also be used. Montelukast is taken orally, and is generally a well-tolerated, safe med.

Our prototype med will be montelukast.

Mechanism of Action

Recall that leukotrienes are inflammatory mediators derived from arachidonic acid. When asthma is triggered, the leukotriene enzyme is released by mast cells along with other inflammatory mediators, binding to highly selective receptors on bronchial smooth muscle and other airway tissues. This leads to bronchial smooth muscle constriction, an increase in mucous gland secretion, and blood vessel permeability leading to edema in the airways. Leukotrienes are what drive allergic responses, asthma and inflammation (Watanabe, Okuno & Yokomizo, 2019).

Montelukast blocks leukotriene (CysLT1) receptors in the airways which prevents the migration of inflammatory cells and prevents smooth muscle contraction. This results in reduced inflammation, bronchodilation, decreased mucous, and decreased vascular permeability.

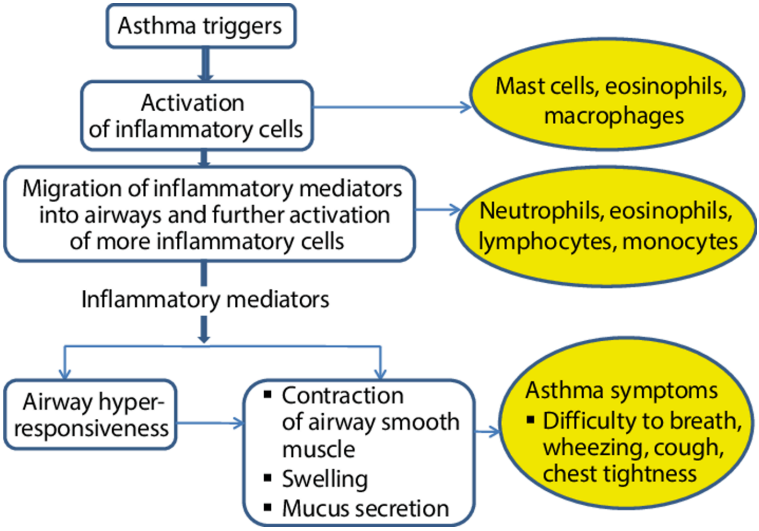

Fig. 8.12a. Various inflammatory mediators, tissues and cell interactions in the airways.
This image is distributed under the terms of the Creative Commons Attribution 3.0 Unported (CC BY 3.0) (https://creativecommons.org/licenses/by/3.0/) https://www.researchgate.net/figure/arious-inflammatory-mediators-tissues-and-cell-interactions-in-the-airways_fig2_370526518

Indications for Use

Montelukast is used for the long-term control of asthma and for decreasing the frequency of asthma attacks. It is also indicated for exercise-induced bronchospasm and allergic rhinitis. It is not used for COPD. It can be used as monotherapy or as adjunct therapy along with an inhaled corticosteroid.

Nursing Considerations

Administration: oral, available in granule packets, tablets and chewable tablets.

- Can be taken with or without food.
- For asthma, take in the evening. For allergic rhinitis, take either morning or evening. For exercise-induced bronchospasm, take two hours before exercise to prevent an attack. (Choi & Azmat, 2023).
- Slow onset of action, within 24 hours with full effect over days.
- Granule packet: Once opened, use within 15 minutes. Can be taken with soft foods, such as apple sauce.

Monitoring:

- Prior to starting montelukast, obtain a baseline respiratory assessment. Reassess periodically.
- Monitor closely for behavioural changes such as depression or suicidal thoughts.
- Assess for development of a rash, risk of Steven-Johnson syndrome. Symptoms such as fever, malaise, muscle or joint pain, blisters, oral lesions

Safe for pediatrics depending on formulation and during pregnancy based on benefit-risk.

Minimal drug interactions

Use cautiously if client has phenylketonuria, hepatic impairment (decrease dosage).

(Choi & Azmat, 2023; Vallerand & Sanoski, 2024)

Adverse/Side Effects

Minimal side effects such as nausea, diarrhea, headache, fatigue, dyspnea and sleep disturbance (Frandsen & Pennington, 2018). Children may experience diarrhea, nausea, laryngitis, sinusitis, or viral infections (Choi & Azmat, 2023).

May elevate liver function enzymes, monitor regularly.

Less common, neuropsychiatric disorders such as depression, aggression, suicidal ideation, anxiety or nightmares. Assess risk before initiating therapy, such as a history of depression. Monitor for these effects and take necessary precautions to ensure client safety.

Figure 8.12b Montelukast Tablets

Client Teaching

- Clients should be instructed to take medications at the same time each day and at least two hours prior to exercise. Do not double up doses.
- Inform client and caregiver of risk of depression, suicidal ideation or other change in behaviour. Careful monitoring and report any change in behaviour.
- Advise client montelukast is not used for acute bronchospasm.
- They should not discontinue medications without notifying the healthcare provider.

Montelukast Medication Card

Now let's take a closer look at the medication card on montelukast (Adams et al, 2020; Vallerand & Sanoski, 2024; Verarde, 2020). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Montelukast Medication Card

Class: Leukotriene Receptor Antagonists **Prototype:** Montelukast (Singulair)		**Indications:** Used for the long-term control of asthma and for decreasing the frequency of asthma attacks. It is also indicated for exercise-induced bronchospasm and allergic rhinitis	
Mechanism of Action: Montelukast blocks leukotriene receptors in the airways which prevents the migration of inflammatory cells and prevents smooth muscle contraction. This results in reduced inflammation, bronchodilation, decreased mucous, and decreased vascular permeability.			
Administration: Granule packs and chewable or regular tablets Take within 15 minutes of opening granule packet	**Side Effects:** Headache, cough, nasal congestion, nausea, diarrhea, insomnia May elevate liver enzymes, monitor periodically	**Contraindications:** Risk of neurobehavioral disorders such as depression, suicidal ideation, aggression Monitor closely for change in behaviour	**Nursing Considerations:** Assess respiratory status before treatment initiated and regularly Assess mental health and behaviour. Inform client or caregivers to report any change in behaviour Can be given to children 12 months and older Take at regular times each day and two hours before exercise. Not a rescue drug, it is for long term management of asthma

Downloadable file (.docx): Montelukast Medication Card

Critical Thinking and Decision-Making Questions

1. A client is prescribed montelukast, a leukotriene receptor antagonist. Which statement informs the nurse that the client needs further health teaching?

    a. I can use this med for an acute asthma attack.
    b. If I have a change in behaviour, such as depressed mood, I should tell my prescriber.
    c. It doesn't matter if I eat food while taking the med.
    d. If I miss a dose one day, I will not double up the dose the following day.

2. True or False: Ensure to shake the montelukast inhaler and attach a spacer prior to taking the dose.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 8: Respiratory Medications Answer Key V2 – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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Media Attributions

- Fig. 8.12a. Various inflammatory mediators, tissues and cell interactions in the airways.
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- 8.12b "Singulair 10mg" by FedEx is licenced under CC BY-NC-ND 2.0 ↵

8.13 Xanthine Derivatives

Xanthine derivatives, theophylline, is used as a bronchodilator for asthma unresponsive to inhaled corticosteroids or long-acting beta-adrenergic medications. It has proven effective in reducing the frequency and severity of symptoms, including nocturnal exacerbations and prn doses of beta-2 agonists (Daily Med, 2026). Unfortunately, it is not widely used due to its low safety margin and drug interactions. Close monitoring and client adherence is key to the safe use of this med.

Mechanism of Action

Xanthine derivative medications resemble naturally occurring xanthines such as caffeine, theobromine and methylxanthines, which are components of coffee, tea and chocolate.

Although the mechanism of action is not completely understood, theophylline inhibits tissue phosphodiesterase which increases cellular cyclic AMP levels (inhibits the breakdown and metabolism). This results in relaxation of bronchial smooth muscle and pulmonary blood vessels, as well as inhibiting IgE released chemical mediators such as histamine among other. This results in its anti-inflammatory effects (Bethesda, 2020). It is also an adenosine receptor antagonist, which can cause arrhythmias. Overall, it suppresses airway responsiveness to stimuli that cause bronchoconstriction.

Indications for Use

Theophylline is rarely used as a second line drug for the long-

term management of persistent asthma that is unresponsive to beta agonists or inhaled corticosteroids. It is given orally, and can lead to a decrease in the frequency and severity of asthma attacks. Due to its prolonged effects, it is effective for clients who have nocturnal attacks (Rosenjack Burchum & Rosenthal, 2019). It has a limited role in the treatment of COPD.

Nursing Considerations

Administration:

- oral, sustained release taken once a day. Depending on the formulation, do not take at night or within 60 minutes of a high fat meal. Follow manufacturers guidelines.
- IV: IV aminophylline can be given in acute bronchospasm. But the efficacy is similar to beta 2 agonists and glucocorticoids, and with much more safety risk due to narrow therapeutic window.

Theophylline has a low therapeutic window of 10-20 mcq/mL (Jilani, Pruess & Sharma, 2023).

As with other meds with low therapeutic window, if too low of a drug level, the effects are subtherapeutic, and if too high, there are toxic effects. Many variables can impact the therapeutic levels including consuming certain foods, smoking, and medications. For example;

- Caffeine competes with the theophylline for metabolizing liver enzymes, leading to theophylline levels to rise. Caffeine also acts as a stimulant, and along with the medication can cause palpitations and restlessness. Avoiding or limit caffeine is recommended.
- Charbroiled meats will increase theophylline metabolism.

- Tobacco induces theophylline metabolism. If the client smokes, they need to be consistent. If they plan to quit, the medication levels need to be reduced to avoid toxicity.
- Drug interactions include phenytoin, rifampicin, cimetidine, oral contraceptives.

Monitoring:

- Respiratory assessment prior to therapy and periodically.
- CNS effects such as headache, anxiety and tremors.
- Serum theophylline levels prior to therapy, with dose adjustments, signs of toxicity and yearly.

Metabolized in the liver so any liver dysfunction can lead to increased half-life and risk for toxicity.

Cautious use with hyperthyroidism, cardiac disease, peptic ulcer disease, hepatic dysfunction and seizure disorders.

Theophylline can be administered to the older adult and children but very careful monitoring must occur to prevent toxicity.

(DailyMed, 2026; Jilani, Pruess & Sharma, 2023)

Adverse/Side Effects

Theophylline is generally well-tolerated, but tolerability limited to narrow therapeutic window. Side effects include:

- CNS stimulation such as tremor, anxiety, nervousness, headache and insomnia.
- GI: nausea, vomiting, increased stomach acid secretion, and gastroesophageal reflux (Frandsen & Pennington, 2018).

Adverse effects related to toxic levels include:

- early signs: nausea, vomiting, tachycardia, insomnia, tremor

- late signs: convulsions and cardiac arrhythmias (ventricular fibrillation if severe)

Managing toxicity: close assessment for early signs of toxicity. Latter signs of toxicity or overdose, include convulsions and arrythmias. If recent overdose of med is suspected, activated charcoal can be given, beta blockers for dysrhythmias and benzodiazepines for seizures (Jilani, Pruess & Sharma, 2023).

Client Teaching

- Clients should be sure to take medications as prescribed. Do not double up a missed dose. Do not crush or break extended-release tablets.
- Close adherence to food and beverage restrictions. Avoid caffeine, chocolate, charbroiled meats and high fat meals.
- Close monitoring for any signs of toxicity, recognizing early signs and reporting to health care provider.
- If client smokes, consistent use is important. If they plan to increase or decrease the amount smoked (i.e. plan to quit), dose adjustment is needed.
- Anticipate serum theophylline levels as instructed by the prescriber, such as with any reported adverse effects, change in diet, or illness.
- Do not take any additional prescription, OTC or herbal remedies without discussing with prescriber to avoid drug interactions.

Jilani, Preuss & Sharma, 2023; Mayo Clinic, 2026

Theophylline Medication Card

Now let's take a closer look at the medication card on theophylline (Daily Med, 2026; Frandsen & Pennington, 2018). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Theophylline Medication Card

<table>
<tr><td colspan="2">Class: Xanthine Derivatives

Prototype: Theophylline</td><td colspan="2">Indications: Used for the long-term management of persistent asthma that is unresponsive to beta agonists or inhaled corticosteroids.</td></tr>
<tr><td colspan="4">Mechanism of Action: Theophylline relaxes bronchial smooth muscle by inhibition of the enzyme phosphodiesterase and suppresses airway responsiveness to stimuli that cause bronchoconstriction. It is not used extensively, due to a low therapeutic window and many drug and food interactions.</td></tr>
<tr><td>Administration:
Oral or IV

Oral sustained release, once a day.

Take in the morning.

Not a rescue med</td><td>Side Effects:
Nausea and Vomiting
CNS stimulation: Nervousness, tremor insomnia

Safety: caution with renal or hepatic dysfcn, anticipate dose adjustment.

If vomiting occurs- risk of toxicity.</td><td>Contraindications:
Contraindicated with active peptic ulcer disease, seizure disorders, cardiac arrhythmias

Abstain from smoking. If plan to quit, inform prescriber as it will affect med levels.
Numerous drug interactions.</td><td>Nursing Considerations:
Avoid respiratory irritants

Drink 2-3 L of water per day to help thin secretions

Serum blood levels q6-12 months to follow and track labs and prevent toxicity

Dietary changes: avoid caffeine, charbroiled meats

Avoid caffeine
Stop smoking
interactions occur</td></tr>
</table>

Downloadable file (.docx): Theophylline Medication Card

To support your learning, you can access the Chapter 8 Comparing Respiratory Medications med cards. This is a downloadable and editable document to allow you to update and add content.

Critical Thinking and Decision Making Questions

1. A patient is prescribed theophylline for long-term asthma management. The nurse is monitoring for potential toxicity. Which of the following symptoms would most likely indicate theophylline toxicity? Choose the correct option.

a. Tinnitus and dizziness
b. Headache and nausea.
c. Hypotension and confusion
d. Drowsiness and depression

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 8: Respiratory Medications Answer Key V2 – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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8.14 Clinical Reasoning and Decision-Making Learning Activities

Clinical Reasoning and Decision Making Learning Activities

Let's apply what you have learned in the respiratory unit.

Asthma Scenario

An adult patient presents to the emergency department with complaints of shortness of breath and increased difficulty breathing. The patient is alert and oriented x 3, skin is pink, warm and dry, BP 148/88, T 98, P92, R 24, pulse oximetry 91% on room air. Assessment of the lung reveals expiratory wheezing throughout the lung fields. The client has a medical history of asthma, hypertension, and diabetes.

1. The nurse anticipates which of the following medications will be initially administered to the client?

a. Theophylline
b. Montelukast
c. Salbutamol
d. Salmeterol

2. List the steps the nurse should take to safely administer the medication.
3. What assessments should the nurse plan to complete after administering the medication?
4. The nurse plans on teaching the client about using the salbutamol inhaler at home. What information should be included?
5. What is the best method for the nurse to use to ensure that the client is correctly using an inhaler?

Allergy Scenario

A pediatric client presents to the emergency department with complaints of shortness of breath, increased difficulty breathing, and a cough. The client is alert and responsive/appropriate for age, skin is pink, warm and dry, BP 112/68, T 99, P106, R 32, pulse oximetry 90% on room air. Assessment of the lung sounds reveals diminished lung sounds throughout all lung fields. The client has a medical history of a peanut allergy. The client's mother tells you that they were at a birthday party and after the client consumed a cupcake, the symptoms started.

6. The nurse anticipates that which of the following medication likely will be ordered for this client?

a. Diphenhydramine
b. Epinephrine
c. Cetirizine
d. Guaifenesin

Review Questions

1. Which of the following is an important client education point for someone prescribed a leukotriene modifier like montelukast?

    a. Take the medication only during periods of respiratory exacerbation.
    b. Monitor for symptoms of oral thrush and report them immediately.
    c. Take the medication regularly, even when symptoms are not present.
    d. Discontinue the medication immediately if mood changes occur.

2. What is the most appropriate nursing intervention for a patient taking a theophylline (methylxanthine) medication for long-term asthma management?

    a. Monitor for blood levels to avoid toxicity.
    b. Instruct the patient to stop the medication immediately if they experience dizziness.
    c. Increase the dosage if the patient is not feeling relief.
    d. Assess for visual disturbances related to the medication.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 8: Respiratory Medications Answer Key V2 – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

CHAPTER 9: GASTROINTESTINAL MEDICATIONS

9.1 Introduction to the Gastrointestinal System

Learning Objectives

- Review the Gastrointestinal system and processes.
- Understand the physiological changes with common alterations of the GI system, including hyperacidity, constipation, diarrhea, nausea and vomiting.
- Articulate clinical reasoning process for GI conditions including assessment, interventions and evaluation.
- Understand the medications and treatments used for anti-ulcer management, including mechanism of action, pharmacokinetic considerations, side effects and nursing considerations.
- Understand the medications used for diarrhea or constipation, including mechanism of action, pharmacokinetic considerations, side effects and nursing considerations.
- Understand the medications and treatments used to manage nausea, including mechanism of action, pharmacokinetic considerations, side effects and nursing considerations.
- Apply your understanding to clinical reasoning and decision-making activities.

9.2 Overview of the GI System

It is important to understand the GI anatomy and physiology to understand how the GI medications work to treat conditions. The GI system is complex and this unit will provide a general overview including digestive system structure, processes and regulation.

The example concept map below in figure 9.2a provides a summary of the key information necessary to understand gastrointestinal elimination informed by several resources (Giddens, 2017).

You are encouraged to revisit this map after you have completed the chapter.

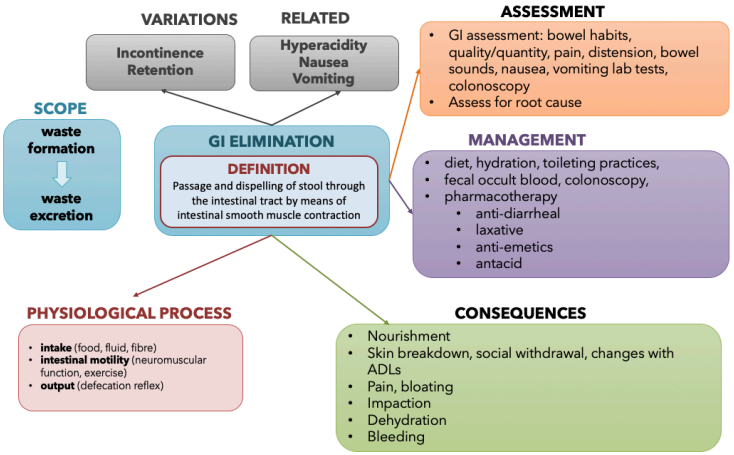

Figure 9.2a GI Elimination Concept Map

Overview of Gastrointestinal System and Processes

The digestive system has two main components, the G.I. tract and the accessory structures. The gastrointestinal tract begins with the mouth with the intake of food or fluids, continuing with the pharynx, esophagus, stomach, small and large intestines, and finally to the rectum and anus with the excretion of waste products. The accessory structures include salivary glands, mucous glands, tongue, teeth, liver, gallbladder and pancreas. All of these have important functions in the digesting of food to be used as nutrients for body functions. Once food enters the small intestine, it propelled along the length of the GI tract by peristaltic movements. Many of the accessory structures assist the tract by secreting enzymes or substances to help transform, digest, absorb or transport food as it travels along the tract (Ogobuiro et al, 2023). Once the nutrients have been broken down and absorbed, the waste material is eliminated.

Figure 9.2b illustrates the anatomical components of the gastrointestinal system as a whole. The remainder of this section will provide a review of the digestive system, digestive system processes and regulation, the stomach, the small and large intestines, and chemical digestion and absorption.

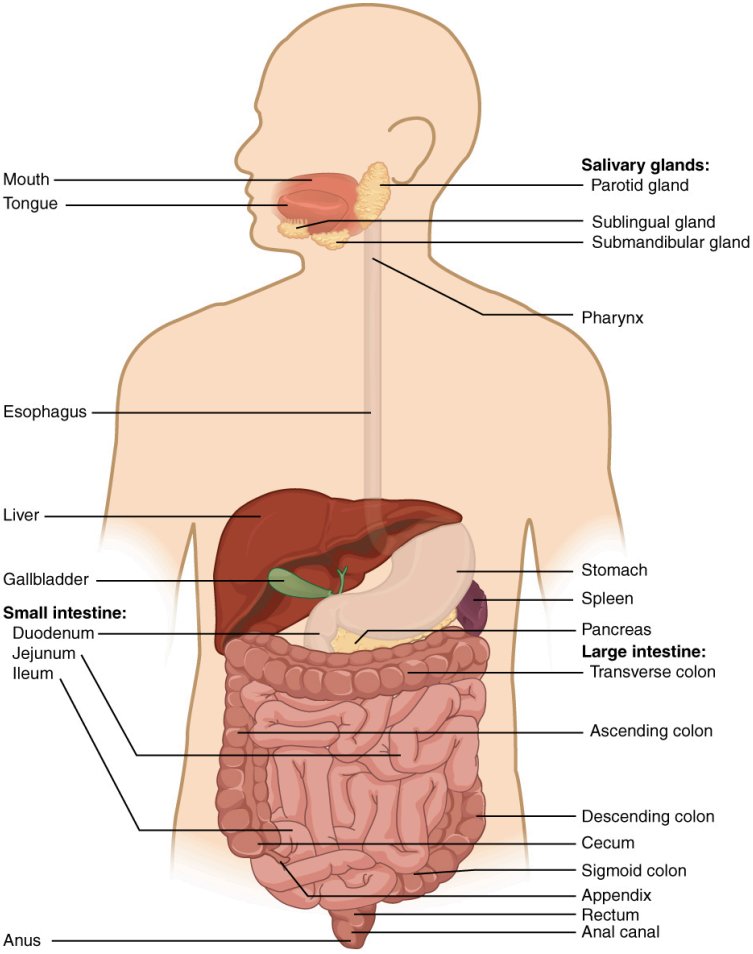

Figure 9.2b Components of GI System (CNX OpenStax/[Components of the Digestive System") CNX OpenStax CC BY 4.0

Watch the videos below for a review of the gastrointestinal system and digestive system.

Gastrointestinal System Review

Forciea, B. (2015, March 18). *Anatomy and Physiology of the Digestive System* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/1ssJV-EpfiQ.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=2463#oembed-1

Ted Ed Review of The Digestive SystemBryce, E. (2017, December 14). *How Your Digestive System Works.* [YouTube]. https://youtu.be/Og5xAdC8EUI.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=2463#oembed-2

The Stomach and Digestion

The stomach contains cells that secrete different substances as part of the digestive process: parietal cells, chief cells, and surface epithelium cells. See an image of the stomach and these cells in Figure 9.2c.

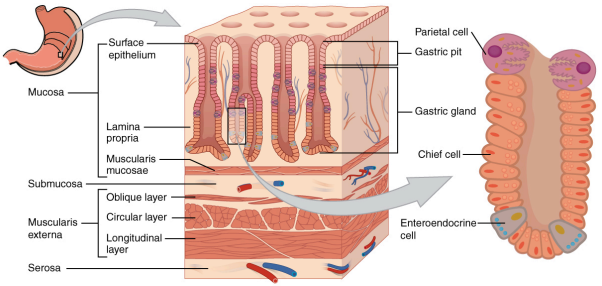

Figure 9.2c An image of the stomach with surface epithelium cells in the mucosa, and an enlarged image of the gastric gland showing chief cells and parietal cells. (CNX OpenStax/ "2415 Histology of StomachN.jpg" CC BY 3.0)

Surface epithelium cells are found within the lining of the stomach and secrete mucus as a protective coating. Parietal cells and chief cells are found within the gastric glands. **Parietal cells** produce and secrete hydrochloric acid (HCl) to maintain the acidity of the environment of a pH of 1 to 4. Parietal cells also secrete a substance called **intrinsic factor**, which is necessary for the absorption of vitamin B12 in the small intestine. Parietal cells are the primary site of action for many drugs that treat acid-related disorders. Chief cells secrete pepsinogen that becomes **pepsin**, a digestive enzyme, when exposed to acid. The stomach also contains enteroendocrine cells (ECL or enterochromaffin-like cells) located in the gastric glands that secrete substances including serotonin, histamine, and somatostatin. G cells in the stomach secrete gastrin that promotes secretions of digestive substances. Although these cells play an important role in the digestive system, acid-related diseases can occur when there is an imbalance of secretions.

Elimination and Defecation

The digestive system is continually at work, but unless something goes amiss, you don't notice your digestive system working. The final step of digestion is called **defecation**, when undigested materials are removed from the body as feces. During this final step, the large intestine absorbs water and changes the waste from a liquid into stool; then peristalsis helps move the stool into the rectum. Diarrhea and constipation occur when conditions occur that affect this final step of defection.

The process of defecation begins when mass movements force feces from the colon into the rectum, stretching the rectal wall and provoking the defecation reflex, which eliminates feces from the rectum. This parasympathetic reflex is mediated by the spinal cord. It contracts the sigmoid colon and rectum, relaxes the internal anal sphincter, and initially contracts the external anal sphincter. Figure 9.2d reviews the anatomy of the rectum and its external and internal sphincters. The presence of feces in the anal canal sends a signal to the brain, which gives the person the choice of voluntarily opening the external anal sphincter (defecating) or keeping it temporarily closed. If defecation is delayed until a more convenient time, it takes a few seconds for the reflex contractions to stop and the rectal walls to relax. The next mass movement will trigger additional defecation reflexes until defecation occurs (OpenStax, 2022).

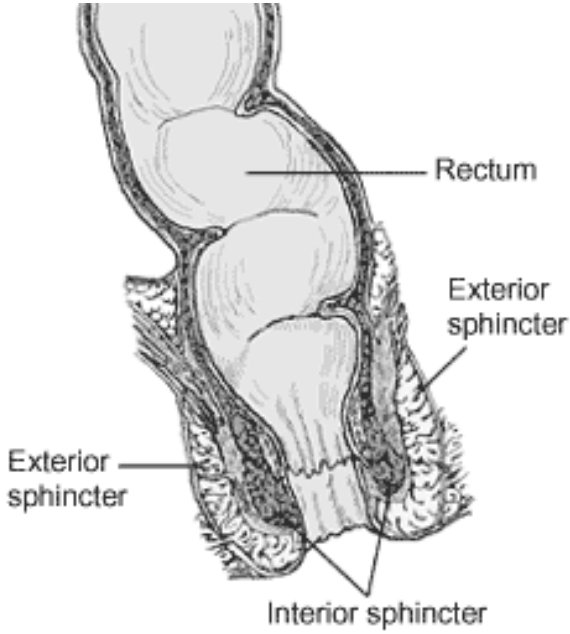

Figure 9.2d Anatomy of the Rectum (anorectum.gif" by U.S. Government National Institutes of Health is licensed under CC0

If defecation is delayed for an extended time, additional water is absorbed, making the feces firmer and potentially leading to constipation. Alternatively, if the waste matter moves too quickly through the intestines, not enough water is absorbed and diarrhea can result. The Bristol Stool Chart, developed by Cabot Health, is used to assess stool characteristics and is a useful tool in relaying stool consistency ranging from constipated to diarrhea. This tool is often used in facilities.

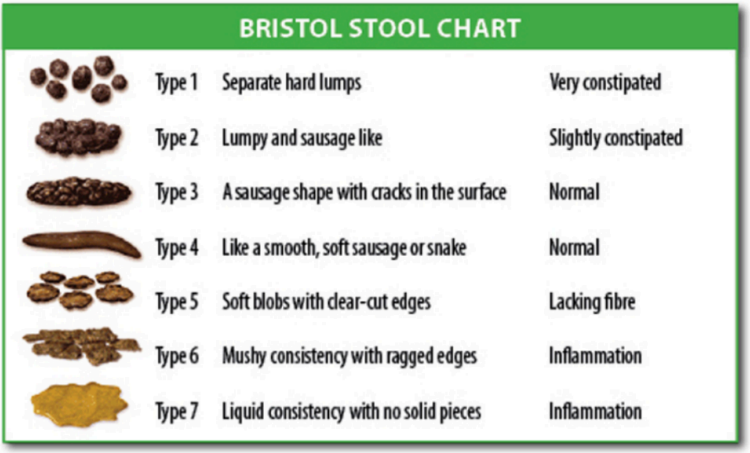

Figure 9.2e Bristol Stool Chart (Cabot Health Bristol Stool Chart/ BristolStoolChart.png" CC BY-SA 3.0

You can further review how the digestive system works at the following links:

- Your Digestive System and How it Works [1]
- Video on Digesting Food [2]
- Overview of the Digestive System [3]
- Digestive System Processes and Regulation [4]

1. National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Health. (2018). *Treatment for constipation.*https://www.niddk.nih.gov/health-information/digestive-diseases/constipation/treatment.
2. Digesting Food by Stanford School of Medicine and Khan Academy is licensed under CC BY-NC-SA 3.0.
3. This work is a derivative of Anatomy and Physiology by OpenStax licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/1-introduction

- The Stomach[5]
- The Small and Large Intestines[6]
- Chemical Digestion and Absorption: A Closer Look[7]

Image Description

Figure 9.2a GI Elimination Concept Map description: This is a concept map that shows the components of the GI elimination. It starts with the definition for GI elimination: the passage and dispelling of stool through the intestinal tract by means of intestinal smooth muscle contraction.

Variations

- Incontinence
- Retention

Related

- Hyperacidity

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- Nausea
- Vomiting

Assessment

- GI assessment: bowel habits, quality/quantity, pain, distension, bowel sounds, nausea, vomiting lab tests, colonoscopy
- Assess for root cause

Management

- diet, hydration, toileting practices,
- fecal occult blood, colonoscopy,
- pharmacotherapy
    - anti-diarrheal
    - laxative
    - anti-emetics
    - antacid

Consequences

- Nourishment
- Skin breakdown, social withdrawal, changes with ADLs
- Pain, bloating
- Impaction
- Dehydration
- Bleeding

Physiological Process

- intake (food, fluid, fibre)
- intestinal motility (neuromuscular function, exercise)
- output (defecation reflex)

Scope

- Waste formation leads to waste excretion

9.2b"Components of the Digestive System" by CNX OpenStaxis licensed under CC BY 4.0 Access for free at https://openstax.org/books/anatomy-and-physiology/pages/23-1-overview-of-the-digestive-system

9.2c "2415 Histology of StomachN.jpg" by CNX OpenStaxis licensed under CC BY 3.0 Access for free at https://cnx.org/contents/FPtK1zmh@16.7:O9dvCxUQ@8/23-4-The-Stomach ↵

9.2d "Anorectum.gif" by U.S. Government National Institutes of Health is licensed under CC0↵

9.2e "BristolStoolChart.png" by Cabot Health, Bristol Stool Chart is licensed under CC BY-SA 3.0↵

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Ogobuiro; I., Gonzales, J., Shumway; K., Tuma, F. (2023). Physiology, GI tract. National Library of Medicine. Statpearls [internet]. Physiology, Gastrointestinal – StatPearls – NCBI Bookshelf

OpenStax (2022). Anatomy and Physiology. CC BY 4.0. https://openstax.org/books/anatomy-and-physiology/pages/1-introduction

9.3 Conditions and Diseases of the Gastrointestinal System

Proper functioning of the gastrointestinal system is essential in providing the necessary nutrients to other body systems and vital organs. The ability to take in nutrients, convert them to a usable form to support body functions and then eliminate waste involves numerous processes and any alteration can significantly impact a clients physical, social and psychological functioning. For example, a client with chronic diarrhea can impact the ability to enjoy social events or work. Persistent nausea can lead to a decrease in food and fluid intake leading to dehydration and nutritional deficiencies. There are many GI disorders and it is beyond the scope of this book to explore them all. In this section, we will review common conditions and diseases related to the gastrointestinal system including conditions related to hyperacidity (Gastroesophageal reflux disease, peptic ulcer disorder and stress ulcers), alterations in the lower GI system (diarrhea, constipation), and nausea and vomiting.

Conditions related to Hyperacidity

Gastroesophageal Reflux Disease

One of the most common problems associated with the gastrointestinal system is hypersecretion of gastric acid (hyperacidity). Gastroesophageal reflux disease (GERD) is often

referred to by clients as heartburn, indigestion, or sour stomach. GERD is caused by lower esophageal sphincter dysfunction and excessive hydrochloric acid that tends to back up, or reflux, into the lower esophagus. See Figure 9.3a for an illustration of GERD (Blaus, 2015).

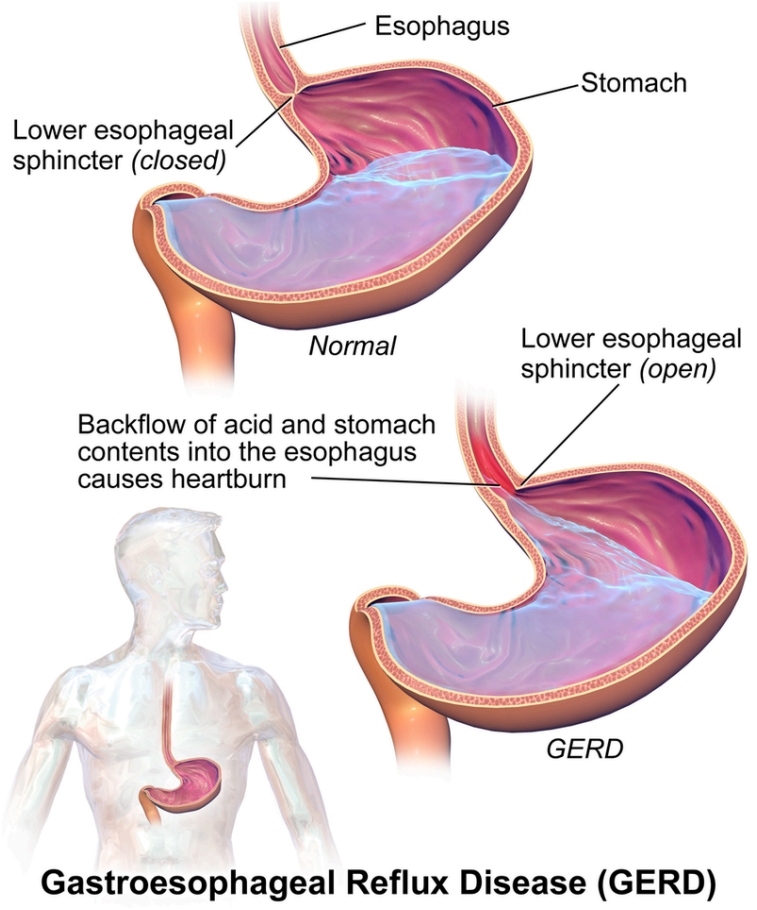


Figure 9.3a Illustration of GERD [Image Description]

GERD is often a benign condition, easily treated with over-the-

counter remedies such as antacids or other anti-ulcer medications. Many clients have persistent or chronic GERD, with daily troublesome symptoms that impact quality of life. It is estimated approximately 15% of the Canadian population has GERD (Canadian Digestive Health Foundation, 2025). The incidence of GERD is increasing globally, with precipitating factors of dietary choices, increasing obesity rates and genetic predispositions (Tanvir, Nijjar, Aulakh, et al., 2024).

For some clients, GERD is not easy to treat and can lead to inflammation in the gastric mucosa, esophagitis, and an erosion of mucosa leading to an ulcer. Rarely, clients could develop Barrett's esophagus which is the primary risk factor for cancer of the esophagus (Canadian Digestive Health Foundation, 2025). Due to the impact of abdominal discomfort and the risk of more serious complications, the early treatment of hyperacidity is important.

Risk factors for developing gastroesophageal reflux disease

The likelihood of experiencing GERD include both modifiable and non-modifiable risk factors. Some clients are more predisposed due to other underlying health conditions, but often there are factors that increase a client's risk of experiencing symptoms.

Modifiable risk factors:

- obesity,
- smoking,
- dietary choices. Many foods can trigger symptoms and include high fat/high cholesterol foods, spicy foods, citrus fruits or juices, alcohol consumption, coffee and spicey foods. Even

chocolate can be a trigger.
- emotional stress and anxiety.

To alleviate or prevent GERD, clients should know the triggers that can precipitate their symptoms.

Non-modifiable risk factors:

- Parental or family history of GERD, such as muscular or structural issues with the esophagus or stomach.
- Age is also a factor with increasing prevalence from mid-adulthood onwards. There are exceptions though, with some children and adolescents presenting with symptoms.
- Physiological conditions such as lower esophageal sphincter relaxation or abnormalities, delayed gastric emptying or impaired salivary functioning (Tanvir, Nijjar, Aulakh, et al., 2024). For example, clients with a hiatus hernia, a defect in the diaphragm that allows the stomach to pass through the diaphragmatic opening into the thorax, can experience heartburn, dysphagia and chest pain **(**Copstead & Banasik, 2010, p. 836).
- Many pregnant women also experience GERD, with an estimated 25% experience heartburn daily. Symptomatic GERD usually presents in the first trimester and progresses throughout pregnancy (Altuwaijri, 2022). The occurrence of GERD in pregnancy is related to both hormonal and structural changes and often is alleviated following birth.
- Some clients with other health conditions such as lung transplantation or cystic fibrosis are also predisposed.

Balancing Act between Defensive and Aggravating Factors

Acid-related disorders can also occur when there is an imbalance between defensive factors that protect the mucosa and aggravating factors that can lead to a reflux of acid secretions by the surface epithelium cells in the stomach.

Defensive Factors:

Our bodies have a unique way to protect the mucosa lining of the stomach.

- A thick mucous layer is secreted continuously from the epithelial cells that line the stomach. The mucous forms a protective barrier.
- Bicarbonate, secreted by the epithelial cells of the stomach and duodenum buffers acidic properties of HCL and neutralizes H ions that penetrate the mucus.
- Prostaglandins stimulate the production of mucus and bicarbonate, as well as promotes vasodilation.

A healthy blood flow to the tissues also provides a defensive mechanism, by bringing nutrients to the tissues (Sealock & Seneviratne, 2021).

Aggravating Factors:

These defensive factors can be overwhelmed by aggravating factors which can be episodic or chronic.

- Hyperacidity – some clients have hyperacidity that is either

increased with food or fluid choices, or more rarely, due to hyperacidity conditions.

- Pepsin, an enzyme in our digestive juices, can inflame the mucosa.
- Smoking blocks prostaglandins and impairs blood flow to the mucosa.
- Nonsteroidal Anti-inflammatory medications (NSAIDs), such as Ibuprofen, if taken on a regular basis also lead to a drop in prostaglandin production thereby decreasing mucous and bicarbonate production.
- Heliobacterium Pylori (H. Pylori) is a gram-negative bacterium that can colonize in our stomach. If the bacteria numbers are elevated, due to a decrease in our normal flora, H. Pylori will lead to an erosion of the gastric mucosa (National Collaborating Center for Infectious Diseases, 2023). To learn more about H. Pylori, go to https://nccid.ca/debrief/helicobacter-pylori/

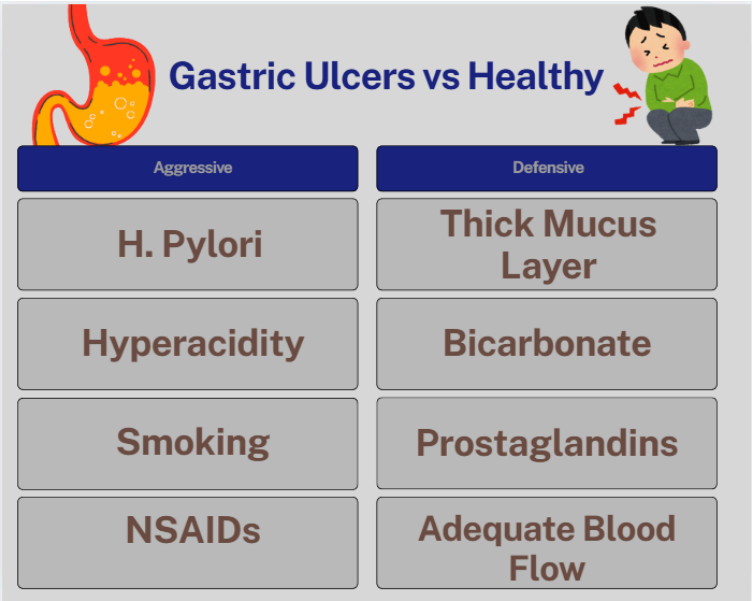


Figure 9.3b Gastroesophageal Reflux Disease: aggressive factors can overwhelm defensive factors (Sheila Odubote/TRU Open Press) CC BY-NC-SA

Peptic Ulcer Disease

Peptic ulcer disease (PUD) occurs when gastric or duodenal ulcers are caused by the breakdown of GI mucosa by pepsin, in combination with the caustic effects of hydrochloric acid. The injury to the mucosa can occur in the esophagus, stomach or duodenum and can range from irritation to severe ulceration. Hyperacidity can contribute to PUD, but major precipitating factors are NSAID use and the organism H. Pylori (Copstead & Banasik, 2010, p.839). Other factors include genetic predisposition. For example persons of African American/Hispanic ethnicity or a first degree relative with PUD have a higher incidence (Malik, Gnanapandithan & Singh, 2022).

Helicobacter Pylori-Associated PUD

*Pylorus*is a gram-negative bacillus that is found within the gastric epithelial cells. This bacterium is responsible for 90% of duodenal ulcers and 70% to 90% of gastric ulcers. Although *H. Pylori* infection can occur in anyone, it is more prevalent among those with lower socioeconomic status and is commonly acquired during childhood (Malik, Gnanapandithan & Singh, 2022). The organism has a wide spectrum of virulence factors, allowing it to adhere to and inflame the gastric mucosa, leading to gastric ulceration. Diagnosis of H. Pylori can include a urea breath test, serologic testing or stool antigen test.

The treatment for H. Pylori is triple therapy with the prescription of two antimicrobials and a proton pump inhibitor. Pantoprazole, clarithromycin, and metronidazole, or amoxicillin are used for 7 to 14 days. Sometimes, the addition of bismuth salicylate is also prescribed.

Nonsteroidal anti-inflammatory drug (NSAID) associated PUD

NSAID use is the second most common cause of PUD after *H. pylori* infection (Malik, Gnanapandithan & Singh, 2022). The secretion of prostaglandin normally protects the gastric mucosa. NSAIDs block prostaglandin synthesis by inhibiting the COX-1 enzyme, resulting in decreased gastric mucus and bicarbonate production and a decrease in mucosal blood flow. Avoiding or minimizing the use of NSAIDs is an important step in treatment. Other medications also contribute to PUD and include corticosteroids and potassium chloride.

PUD is the most harmful disease related to hyperacidity because it can result in bleeding ulcers, a life-threatening condition. As such, prompt diagnosis and treatment is essential.

Stress Ulcers

Stress-related mucosal damage is another common condition that can occur in hospitalized clients leading to PUD. Thus, many post-operative or critically ill clients receive medication to prevent the formation of a stress ulcer, which is also called **stress ulcer prophylaxis** (Sealock & Seneviratne, 2021) . See an image of a duodenal ulcer in Figure 9.3b.(Blausen Medical, 2015).

Figure 9.3b Image of a duodenal ulcer

The video *Heartburn* by MedlinePlus, Bethesda (MD)/ National Library of Medicine (2019) provides a basic illustration and understanding of heartburn.

Alterations in Bowel Patterns

There is a wide variation in bowel patterns and what may be considered normal for one individual may be considered an issue for someone else. Completing a comprehensive history of a client's bowel patterns (frequency, consistency, history of bowel patterns and conditions) along with a GI assessment and diet history will assist in determining a treatment plan.

Diarrhea

Diarrhea itself is not a disease but is a sign and symptom of other conditions and disease processes in the body.

Diarrhea is defined as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual). Frequent passing of formed stools is not considered diarrhea. Using a tool such as the Bristol Stool chart can help in identifying stool characteristics.

Diarrhea has multiple causes such as bacteria from contaminated food or water; GI viruses such as norovirus, or rotavirus; parasites found in contaminated food or water; medicines such as antibiotics, cancer drugs, and antacids that contain magnesium; food intolerances and sensitivities; and diseases that affect the colon, such as Crohn's disease or irritable bowel syndrome (National Institute of Diabetes and Digestive and Kidney Diseases, 2018). Diarrhea can also occur as a result of emotional stress or from leakage of stool around impacted feces. If diarrhea is acute in nature, it may be attributed to food sensitivities or medications, stress or ingestion of an irritant such as caffeine. Chronic diarrhea is defined as symptoms greater than 4 weeks, and can be related to many issues such as GI or endocrine disorders.

The most severe threat posed by diarrhea is dehydration caused

by the loss of water and electrolytes. This can occur with either acute or chronic diarrhea and will depend on the severity of symptoms. Diarrheal disease is a leading cause of child mortality and morbidity throughout the world due to dehydration; frail elderly are also at risk. When severe diarrhea occurs, assessment for dehydration and electrolyte imbalances receive top priority and rehydration with oral rehydration solutions or IV fluids may be required (World Heath Organization, 2017).

Constipation

Constipation is defined as "three or fewer bowel movements in a week; stools that are hard, dry or lumpy; stools that are difficult or painful to pass; or the feeling that not all stool has passed." (National Institute of Diabetes and Digestive and Kidney Diseases, 2018). If defecation is delayed for an extended time, additional water is absorbed, thus making the feces firmer and potentially leading to constipation.

There are several causes of constipation, such as lack of proper fluids or fiber in the diet, lack of ambulation, various disease processes, recovery from surgical anesthesia and opiates, and side effects of many medications. A list of these potential causes can be found in Table 9.3a (National Institute of Diabetes and Digestive and Kidney Diseases, 2018).

Because there are several potential causes of constipation, treatment should always be individualized to the client. Many times, constipation can be treated with simple changes in diet, exercise, or routine. However, when medications are also needed to resolve constipation, there are several categories of laxative medications that work in different ways. Classes of laxative medications are described below.

Table 9.3a Common Causes of Constipation

Cause	Examples
Medications	• Antacids that contain aluminum and calcium • Anticholinergics and antispasmodics • Anticonvulsants—used to prevent seizures • Calcium channel blockers • Diuretics • Iron supplements • Medicines used to treat Parkinson's disease • Narcotic pain medicines • Some medicines used to treat depression
Health and Nutrition Problems	• Not eating enough fiber • Not drinking enough liquids or dehydration • Not getting enough physical activity • Celiac disease • Disorders that affect the brain and spine, such as Parkinson's disease • Spinal cord or brain injuries • Diabetes • Hypothyroidism • Inflammation linked to diverticular disease or proctitis • Intestinal obstructions, including anorectal blockage and tumors
Daily Routine Changes	• Pregnancy • Aging • Traveling • Ignoring the urge to have a bowel movement • Medication changes • Change in diet

Nausea and Vomiting

Similar to diarrhea and constipation, nausea and vomiting are common conditions that are most often signs and symptoms of other conditions or side effects of medication.

Nausea is a commonly encountered symptom that can be

described as an unpleasant sensation of having the urge to vomit. Nausea often precedes vomiting but not always. Vomiting (emesis) is the forceful expulsion of gastric contents. Nausea and vomiting are considered a protective mechanism, against the potential of toxic ingestion. Nausea can also be attributed to many other situations including medications (ie. post-op nausea, chemotherapy) and motion sickness. It can also be attributed to many other conditions such as gastrointestinal, cardiac, labyrinthine, metabolic or endocrine disorders (Singh, Yoon, & Kuo, 2016).

Causes of Nausea

There are many causes of nausea. Some examples include:

Medications:

- analgesics,
- cardiac meds (beta blockers, digoxin),
- hormone meds (oral anti-diabetic, oral contraceptives),
- antibiotics (erythromycin, tetracycline),
- anti-Parkinson meds

Disorders or conditions:

- GI disorders (obstruction, irritable bowel syndrome, gastroenteritis),
- neuro disorders (migraines, increased

intracranial pressure),

- psychiatric conditions (depression, pian, anxiety),
- pregnancy (morning sickness due to hormonal changes)
- endocrine (diabetic ketoacidosis),
- cardiac (myocardial infarction, congestive heart failure).

Toxins:

- food poisoning
- exposure to toxic substances

Nausea is triggered by a diverse emetic stimulus through central and/or peripheral nervous systems. It is a complex process activating the Vomiting Center either directly or indirectly.

Vomiting Center

The vomiting center, located in the medulla is like a coordination center that receives input from four areas before initiating the vomiting reflex. The four principal areas are:

- chemoreceptor trigger zone (CTZ)
- gastrointestinal tract,
- cerebral cortex and thalamus,
- vestibular region

See Figure 9.3c for an illustration of the pathophysiology of nausea and vomiting.

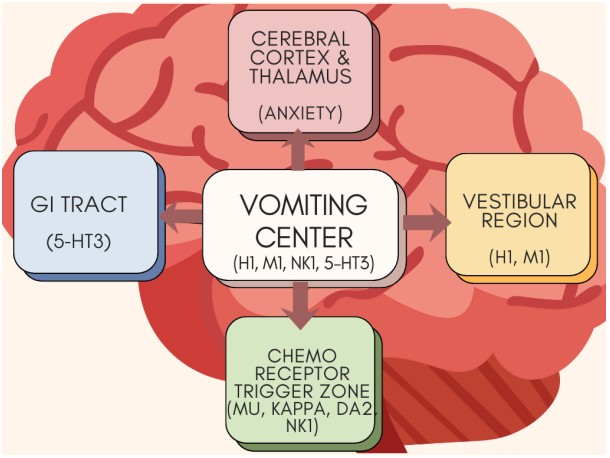


Figure 9.3c Pathophysiology of nausea and vomiting [Image Description]

Chemoreceptor Trigger Zone

<p”>An important part of the emesis circuit is the **chemoreceptor trigger zone (CTZ)**, located in the **area postrema** in the brain. The CTZ is not restricted by the blood–brain barrier, which allows it to respond directly to toxins in the bloodstream such as anesthesia and opioids. The CTZ also receives stimuli from several other locations in the body including the vestibular center; visceral organs such as the GI tract, kidneys, and liver; the thalamus; and the cerebral cortex. The CTZ contains receptors for dopamine, serotonin (5-HT3), opioids, and substance P, which, when activated, send signals to the vomiting center.

Vestibular Center

The vestibular center can stimulate the vomiting center directly or indirectly through the CTZ. The **vestibular system** is located within the inner ear and gives a sense of balance and spatial orientation for the purpose of coordinating movement with balance. The feeling of nausea associated with motion sickness often arises from stimuli from the vestibular center.

Cerebral Cortex

The cerebral cortex and other parts of the brain can also stimulate the vomiting center directly. The stimuli are often related to our senses: odors, tastes, images or sights. All these signals then can send stimuli to the CTZ, which then go to the vomiting center. Pain can also directly stimulate the vomiting center.

Gastrointestinal Tract

In the GI tract, sensory nerves via the vagus and sympathetic nerves send signals to the vomiting center. These afferent nerves are stimulated by mucosal irritation such as infection or chemotherapy, or overdistension of the stomach.

The gastrointestinal tract sends stimuli to the CTZ via cranial nerves IX and X related to obstruction, distension, inflammation, and infection.

These signals to the vomiting center initiates vomiting by inhibiting peristalsis and producing retro-peristaltic contractions beginning in the small bowel and ascending into the stomach. It also produces simultaneous contractions in the abdominal muscles and diaphragm that generate high pressures to propel the stomach

contents upwards. Additionally, autonomic stimulation of the heart, airways, salivary glands, and skin cause other symptoms associated with vomiting such as salivation, pallor, sweating, and tachycardia.

Physiology of Vomiting

The video below, *Physiology of Vomiting – Vomiting reflex* [7:42], by Armando Hasudungan (2017) reviews the vomiting reflex, with attention to the neurotransmitters involved in the nausea and vomiting process. Anti-emetic medications target the receptors of specific neurotransmitters, blocking their action and alleviating nausea (Becker, 2010).

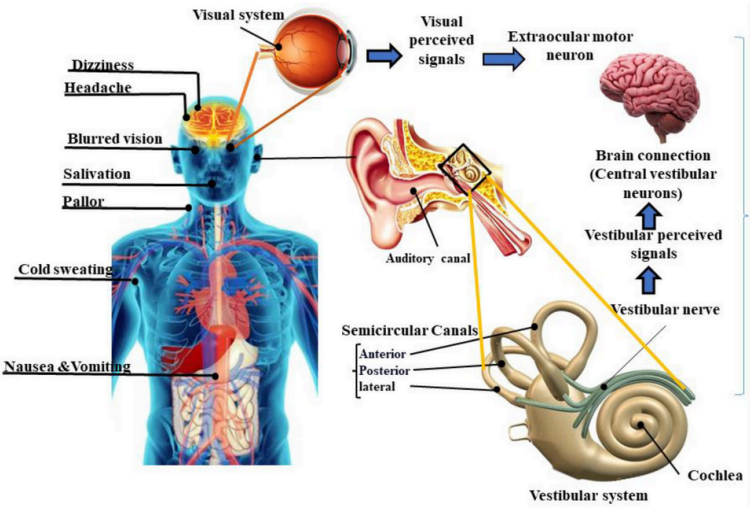
One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=2469#oembed-1

Example in Practice

A client is on a cruise and begins to feel nauseated. Her mouth begins to water, she begins to feel sweaty and her heart rate increases.

Motion sickness is a common occurrence and is initiated by signals from the vestibular system in the inner ear.

Along with the sensation of nausea, other physiological responses also occur. Autonomic stimulation leads to increased salivation. Sympathetic stimulation can lead to other sensations such as diaphoresis, dizziness and tachycardia.



File: motion sickness.png This file is licensed under the [*Creative Commons Attribution 4.0 International license.*]

https://commons.wikimedia.org/wiki/File:Motion_sickness.png

Most clients can treat their symptoms of nausea or vomiting with

OTC anti-emetics. A health care provider should be contacted immediately if the following conditions occur:

- Vomiting for longer than 24 hours
- Blood in the vomit (also called hematemesis)
- Severe abdominal pain
- Severe headache and stiff neck
- Signs of dehydration, such as dry mouth, infrequent urination, or dark urine

Image Descriptions

Figure 9.3a image description: Illustration of GERD.

The stomach is located in the upper left quadrant of the abdomen and the esophagus comes down from the throat to the stomach.

When it is normal, the lower oesophageal sphincter, which is between the esophagus and stomach, is closed. Stomach acid and stomach contents sit in the stomach.

When a person has GERD, the lower esophageal sphincter is open. This allows a back flow of acid and stomach contents into the esophagus, which causes heartburn. [Return to figure 9.3a]

Figure 9.3c image description: The pathophysiology of nausea and vomiting.

The Vomiting Center sits in the centre. The receptors illustrated in the vomiting center are:

- H1 histamine
- M1 acetylcholine
- NK1 (neurokinin), and 5-HT3 serotonin.

Four principal areas can activate the vomiting center:

- GI Tract (5-HT3 serotonin)
- Cortex Thalamus (Anxiety, Pain)

- Vestibular (H1 histamine, M1 acetylcholine)
- Chemoreceptor trigger zone (mu/kappa opioids, DA2 dopamine, and NK1 (neurokinin)) [Return to figure 9.3c]

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9.4 Clinical Reasoning and Decision-Making for Gastrointestinal Elimination

Clinical reasoning is a way that nurses think and process our knowledge, including what we have read or learned in the past, and apply it to the current practice context of what we are seeing right now (National Council of State Board for Nurses, n.d.). Nurses make decisions all the time but making decisions requires a complex thinking process. There are many tools that are useful and found online that can support your thinking through to clinical judgments. This book uses the nursing process and clinical judgment language to provide a framework to help you understand the application of medications to your clinical practice.

Now that we have reviewed the GI system, elimination, and common GI-related disorders, let's look at clinical reasoning and decision-making about related medications.

Assessment

Although there are numerous details to consider when administering medications, it is always important to first think about what you are giving and why.

First, consider the clinical indication: recognizing cues

Whenever a nurse administers medications related to the GI system and elimination, there are common assessments that should be documented, such as an abdominal assessment and documentation of bowel sounds and bowel patterns. Nausea, vomiting, diarrhea, and constipation are often symptoms of other

conditions of the body. It is important to find the underlying cause for these symptoms related to the GI symptoms.

Some GI symptoms can mimic other conditions in the body that are more serious. For instance, if a client complains of "heartburn", the nurse should perform a complete focused cardiac assessment and not assume it is GI-related because clients may erroneously attribute many cardiac conditions to "heartburn."

Dehydration can also be a serious risk in clients that have severe nausea, vomiting, and/or diarrhea. Priority assessments and documentation related to monitoring for dehydration, especially in vulnerable populations of infants, children, and the elderly, assess for symptoms of dehydration, such as decreased blood pressure associated with tachycardia, decreased skin turgor, and decreased urine output or dark concentrated urine. If lab tests are ordered, monitor hemoglobin, hematocrit, and serum sodium levels for additional signs of dehydration. If signs of dehydration occur, the provider should be immediately notified, and treatment initiated for dehydration.

Interventions

Next, plan (refine your hypothesis), and take action.

Nurses should read the drug label information and follow the recommendations for administering GI medications with other medications or the intake of food. Cultural preferences should also be accommodated when safe and feasible because the client may believe in alternative methods for treating GI discomfort.

Some OTC medications can be recommended to clients experiencing GI symptoms. For instance, **probiotics** have been found to be generally safe in all populations, and the nurse can advocate for the use of probiotics in clients with diarrhea or those at risk for diarrhea because of other medications prescribed. It

is important to teach clients not to exceed dosages of OTC medications because life-threatening adverse effects may occur.

In addition to teaching about medication therapy, nurses can also teach clients nonpharmacological interventions. For instance, for clients with nausea, vomiting, and diarrhea, replacing fluid and electrolytes by drinking water, electrolyte-containing drinks, or sodas without caffeine; and eating soft, bland food like bananas, rice, and toast (BC Cancer Agency, n.d.).

Children with severe diarrhea may also require oral rehydration solutions to replace lost fluids and electrolytes.

For clients with constipation, non-pharmacological measures include:

- Getting enough fiber in the diet
- Drinking plenty of water and other liquids
- Getting regular physical activity
- Trying to have a bowel movement at the same time every day (National Institute of Health, 2018).

Another important consideration for implementation is the route of administration. This is especially the case if a client is nauseated or vomiting.

Evaluation

Finally, evaluate the outcomes of your action.

It is important to always evaluate the client's response to a medication.

Clients should experience improvement of symptoms within the defined time; if not, the provider should be notified. Increased pain or new symptoms may need to be reported immediately. For instance, if a client begins vomiting or defecating blood, this should be immediately reported.

Because antidiarrheals treat the symptoms of diarrhea but do not eliminate the cause of it, if symptoms do not resolve within 48 hours or if symptoms get worse, the provider should be notified, and other potential causes of diarrhea investigated. Evaluation for dehydration should continuously occur until the condition resolves.

For the condition of constipation, if bowel movement does not occur within the expected timeframe, the provider should be notified, and other causes investigated for individualized treatment. It is imperative that good documentation of bowel movements and communication among staff occur when constipation is being treated with various medications. If there is a complete absence of bowel sounds, worsening distension or abdominal pain, a smearing of stool, or other findings indicating that a paralytic ileus or blockage may be occurring, the provider should be immediately notified.

Now that we have reviewed basic concepts and clinical decision making, we will next take a closer look at specific administration considerations, therapeutic effects, adverse/side effects, and teaching needed for each class of medications related to GI system and elimination.

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9.5 Anti-Ulcer Medications

Learning Objectives

By the end of this section, the learner will:

- Identify the characteristics of antacid medications to treat hyperacidity conditions.
- Identify the characteristics of H2 receptor antagonist medications, including mechanism of action, onset and duration of action and nursing considerations.
- Identify the characteristics of proton pump inhibitor medications, including mechanism of action, onset and duration of action and nursing considerations.
- Articulate important client teaching experiencing hyperacidity for health promotion and medication safety.
- Apply clinical judgment for anti-ulcer medications including key assessments, administration, interventions and evaluation.

Hyperacidity Medication Classes

The goal of drug therapy is to alleviate symptoms, promote healing, prevent complications and prevent reoccurrence. Most medications

do not alter the disease process, but create conditions to promote healing (Rosenjack Burcham & Rosenthal, 2019).

In this unit we will focus on the commonly used agents that are available over-the-counter or by prescription. The four main classes of anti-ulcer medications:

- Antacids,
- Antisecretory: H**2** antagonists, Proton pump inhibitors (PPI's),
- Mucosal protectants

Non-drug Therapy: along with taking medications to minimize symptoms or to promote healing, the client should be looking at lifestyle factors that may have contributed to their hyperacidity symptoms.

What role does diet, lifestyle, smoking and alcohol have? Refer back to the previous unit, 9.3 to check your answers.

Nursing Process and Clinical Judgment

Nursing Assessment (recognizing cues)

Self-report of symptoms (may include: epigastric pain, nausea, bitter taste in mouth, pain increases when supine, dysphagia, bloating, etc)

- What alleviates the discomfort?
- What exacerbates or triggers the symptoms?
- What remedies have you tried (OTC meds, home remedies, non-pharmacological)?

Objective cues:

- Abdominal assessment

- Vital signs
- Pain characteristics
- Nutritional history

This list is not exclusive; other assessments may be added depending on presenting symptoms.

Hypothesis

Based on reported symptoms,

Acute epigastric pain from GERD related to reflux symptoms as evidenced by:

- Burning pain in esophagus and stomach
- Pain increases when lying down
- Pain minimal when avoids certain foods such as caffeine and high-fat foods

Planning and Interventions

Three ways to promote healing/prevention of symptoms:

- Reduce gastric acidity – antisecretory agents (PPI, H2 antagonists), antacids, misoprostol
- Enhance mucosal protectants (sucralfate and misoprostol)
- Eradicate H. Pylori – antibiotics, antisecretory (PPI)

Depending on causative factors/symptom history, the treatment plan will include lifestyle changes (avoiding triggers and use non-pharmacological interventions) and start a trial of OTC anti-ulcer medications. This can be antacids, OTC PPI or H2RA.

Client teaching:

- Encourage diet modifications as prescribed
- General information about:
    - Diagnosis and treatments
    - Recognition of symptom progression
    - Diet and lifestyle changes
    - Support resources available
- Medications:
    - Take medication as directed
    - Report any medication side effects
- Call the provider if:
    - Your pain or symptoms worsen

There are questions or concerns about the condition or increasing of symptoms.

Evaluation:

Symptom management – did the meds relieve the symptoms? What changes did the client make to their diet?

If no relief from symptoms, a prescriber may plan for testing such as a H. Pylori test or endoscopy to rule out other causes. They may write a prescription for a PPI or a H2 RA, and possible further testing to rule out other causative factors (ie. H. Pylori).

Some clients will be ordered a PPI for 6-8 weeks, then reassess symptoms. Refer to the PPI section for risk of long-term use of PPIs and the process of deprescribing PPIs (Bartels, 2024; Sealock, & Seneviratne, 2021).

Antacids

The use of antacids to control acid-related discomfort spans

centuries. In ancient Greece, coral was crushed and given to those with dyspepsia: Coral is calcium carbonate.

There are many benefits to taking antacids, and these include that they are inexpensive, relatively safe and readily available. Due to their neutralizing abilities, they are widely used and available OTC for dyspepsia and acid indigestion.

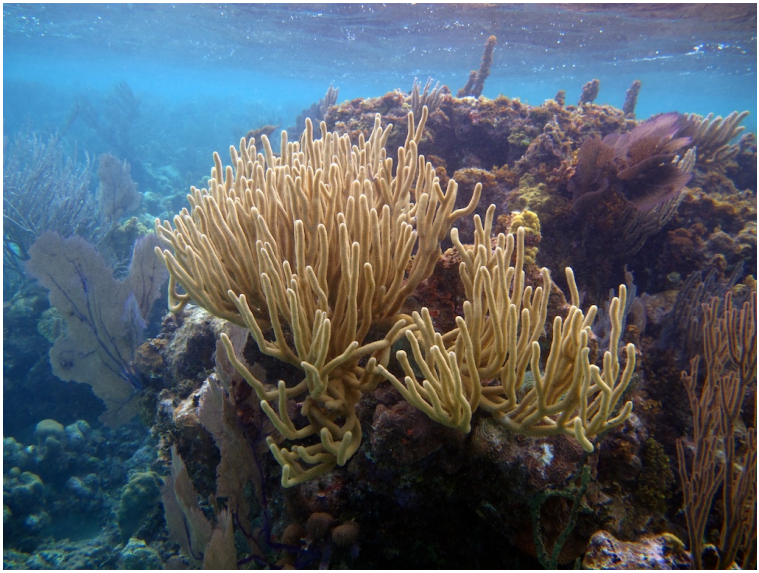

Figure 9.5a Coral. By lowjumpingfrog from Salt Lake City, USA – Coral Reefscape, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=36517926

Today, there are four main classes of antacids. These are:

1. Aluminum based
2. Magnesium based
3. Calcium Based
4. Sodium bicarbonate based

<p">Antacids are alkaline compounds that neutralize stomach acid. They all differ in their acid neutralizing capacity (ANC), onset and duration of action, effect on the bowel (constipation vs. diarrhea) and other systems. The antacids most widely used have aluminum hydroxide and magnesium hydroxide in the formulation.

Refer to the **Comparing Antacid Medications** table for comparisons of the different antacids.

Drug Interactions:

Consider the strong possibility of drug interactions when taking antacids with other drugs. By raising gastric pH, antacids can influence the dissolution and absorption of many other drugs. Many drugs when combined with antacids have a decreased effect due to decreased absorption of that drug, from raising the gastric pH, chemically inactivating the drug or increasing the urinary pH leading to increased excretion. For example, some anti infectives such as tetracycline and ketoconazole will be less effective if taken at the same time as an antacid. Vitamin B12 malabsorption occurs when stomach acidity is altered, which in turn, can impact bone density.

Other drugs effected by antacids include thyroid hormones, or cardiovascular meds such as captopril or digoxin. Due to a long list of meds impacted by antacid use, nurses need to consider the best timing of a clients medications. What would be an important advice to a client? Or when you are administering meds to a client in the hospital?

Example in Practice:

A nurse is preparing the scheduled morning

medications for a client. The client expressed they are experiencing heartburn and the nurse checks the orders and sees an antacid is ordered prn. Recognizing the potential for drug interactions, the nurse administers the scheduled meds at a separate time from the antacid.

Give any med 2 hours before or one hour after giving an antacid.

Antacid Medication Cards

Prototype: Calcium Carbonate

Class: Antacid **Generic Name:** Calcium Carbonate		**Indications:** Decreased symptoms of heartburn Source of calcium	
Mechanism of Action: Neutralizes hydrochloric acid in gastric secretions. (Calcium salts neutralize gastric acidity, resulting in increased gastric and duodenal bulb pH; they also inhibit pepsin's proteolytic activity if the pH is greater than 4 and increase lower esophageal sphincter tone. The calcium released from calcium carbonate is known to increase peristalsis in the esophagus, pushing the acid into the stomach and providing relief from heartburn symptoms. The calcium salts also form combined insoluble compounds with dietary phosphate and prevent the phosphate absorption.			
Administration: High ANC, long duration of action Orally, take as prescribed.	**Side Effects:** Constipation Other: GI: abd pain, Anorexia, N&V, Flatulence, headache Risk of rebound hyperacidity when discontinued	**Contraindications/ adverse effects:** Drug interaction with ceftriaxone Kidney stones risk if taken long time. Adverse effects: Hypercalcemia Xerostomia, Hypophosphatemia, Milk-alkali syndrome	**Nursing Considerations:** • Don't admin within 1-2 hrs of other meds • Drink a full glass of water after admin • Use cautiously with renal disease

Downloadable file (.docx): Calcium Carbonate – Antacid Medication Card

Prototype: Magnesium Hydroxide

Class: Antacid **Generic Name:** magnesium hydroxide **Trade names:** Milk of Magnesia		**Indications:** Decreased symptoms of heartburn Laxative effect	
Mechanism of Action: Neutralizes hydrochloric acid in gastric secretions. Laxative effect by causing osmotic fluid retention in the colon… colon distention → stimulates peristalsis.			
Administration: Orally, take as prescribed suspension, chewable tablets, tablets with a full glass (250 mls) of liquid. Avoid with undiagnosed abdominal pain (ie. Appendicitis query)	**Side Effects:** Diarrhea	**Contraindications/ adverse effects:** Hypophosphatemia: muscle weakness, bone pain, confusion, and fatigue. Can be toxic if kidney disease	**Nursing Considerations:** • Shake well before using • administer on empty stomach. • best administered in the morning or at bedtime. • Take with 250 ml water • Don't admin within 1-2 hrs of other meds

Downloadable file (.docx): Magnesium Hydroxide – Antacid Medication Card

Prototype: Aluminum Chloride

Class: Antacid **Generic Name:** aluminum chloride **Trade names:** Amphogel		**Indications:** Decreased symptoms of heartburn	
Mechanism of Action: Neutralizes hydrochloric acid in gastric secretions.			
Administration: Orally, take as prescribed, often TID or QID Onset 20-40 minutes Rarely used on own, often combined with other antacids Ie. Magnesium-aluminum combination Minimal absorption	**Side Effects:** Constipation, nausea	**Contraindications/ adverse effects:** Hypophosphatemia if taking high doses: muscle weakness, bone pain, confusion, and fatigue. Risk of bone demineralization Drug interactions due to antacid decreasing stomach pH Ex. Binds with tetracycline, reducing its effects.	**Nursing Considerations:** • Don't admin within 1-2 hrs of other meds

Downloadable file (.docx): Aluminum Chloride – Antacid Medication Card

Prototype: Sodium Bicarbonate

Class: Antacid **Generic Name:** Sodium Bicarbonate **Trade names:** Alka-Seltzer		**Indications:** Decreased symptoms of heartburn Can be used to treat acidosis and elevated urinary pH	
Mechanism of Action: Neutralizes hydrochloric acid in gastric secretions.			
Administration: Orally, take as prescribed Rapid acting, short duration	**Side Effects:** Bicarb reacts with stomach HCL → releases CO_2 → burp. Can cause bloating If taking too much, can lead to alkalosis (confusion, irritability, slow resps, vomiting)	**Contraindications/ adverse effects:** Can exacerbate HTN and heart failure – may promote fluid retention Renal patients – can cause metabolic alkalosis. Drug interactions	**Nursing Considerations:** • Don't admin within 1-2 hrs of other meds

Downloadable file (.docx): Sodium Bicarbonate – Antacid Medication Card

Additional Antacid considerations

Combined formulas: Many antacids are formulated in combination with a second antacid. For example, Magnesium hydroxide and Aluminum hydroxide are combined to create a balanced formula. This combination is beneficial to improve the acid neutralizing action and can minimize some side effects. Magnesium is well known for its laxative effect, but combined with aluminum phosphate, which can cause constipation, the bowel effects are minimized.

Simethicone:

Many antacids also contain simethicone; an antiflatulent used for gas relief. This med decreases the surface tension of gas bubbles in the GI tract, dispersing the gas bubbles and then removed with

belching or flatulence. It does not reduce the production of gas in the GI tract (Curtis & Akhondi, 2023).

Take as prescribed: Clients should be reminded to take OTC meds appropriately as prescribed and should not exceed the maximum dose. If symptoms persist or not effectively relieved, they should see their health care provider.

Figure 9.5b Example of Antacid tablets bottle

(*Midnightcomm*; *Antacid-L478.jpg*/ *Wikimedia Commons*) CC BY-SA 3.0

Clinical Reasoning and Decision Making 1

Would you recommend this med?

A 72 year-old client attends a home health clinic for IV antibiotic therapy from a blood infection from an insect bite. She reports to the nurse she is concerned about an unrelated acid reflux issue. She reports 8/10 heartburn, mostly in the evening and sometimes it keeps her up at night.

History: hypertension, occasional constipation, osteoarthritis Rt knee, mild renal insufficiency. Otherwise, healthy. She is on two meds for hypertension and takes Ibuprofen as needed.

VS: HR 82 reg, BP 152/82, RR 16 breaths/min, T 37.6 C

The nurse recommends: Milk of Magnesium (magnesium hydroxide) 30 mLs po before bedtime.

a. Is this a good recommendation? Explain your answer.

b. What client teaching is important?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 9: Gastrointestinal Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition sections at the end of the book.

Lifespan Considerations

Hyperacidity relief during pregnancy

Heartburn or hyperacidity is a common symptom experienced with pregnant clients. Heartburn is especially prevalent in this population: 22% of pregnant clients experience heartburn in the first trimester, going up the 60-72% in the third trimester (Garg, Narang & Taneja, 2022).

Causative factors for heartburn include the increased levels of female hormones including progesterone which can reduce lower esophageal sphincter pressure (Garg, Narang & Taneja, 2022). Antacids are first line treatment after lifestyle modifications are no longer effective. The only antacid not recommended is sodium bicarbonate, due to risk of fluid overload. If symptoms persist despite antacid use, then H2 RAs are an option following prescriber advice.

Anti-Secretory Medication: H2-Receptor Antagonist (H2RA)

H2RA's are a well tolerated, effective option, if antacids are not effective. H2RA's have been around for many years, and there are a number of meds under this classification. It is available OTC or by prescription, depending on the medication. The two we will review are cimetidine and famotidine. Ranitidine, previously a popular option, was taken off the market a few years ago due to impurities in the manufacturing process.

Uses:

H2RA Famotidine is used for a number of conditions including GERD, active duodenal ulcers, peptic ulcer disease and other hyperacidity conditions such as **Zollinger-Ellison syndrome**.

It is available OTC for the treatment of GERD, as well as it is given IV in the hospital setting for stress ulcer prophylaxis and upper GI bleeds.

Cimetidine is used for peptic ulcer disease, GERD and erosive esophagitis, but is used short term due to a number of side effects and drug interactions. It is also used for other conditions such as urticaria, mastocytosis, and erythropoietic protoporphyria (Pino & Azer, 2023).

A comparison of the two meds can be found below.

Diagram of a parietal cell and the action of a H2RA on the H2 receptors.

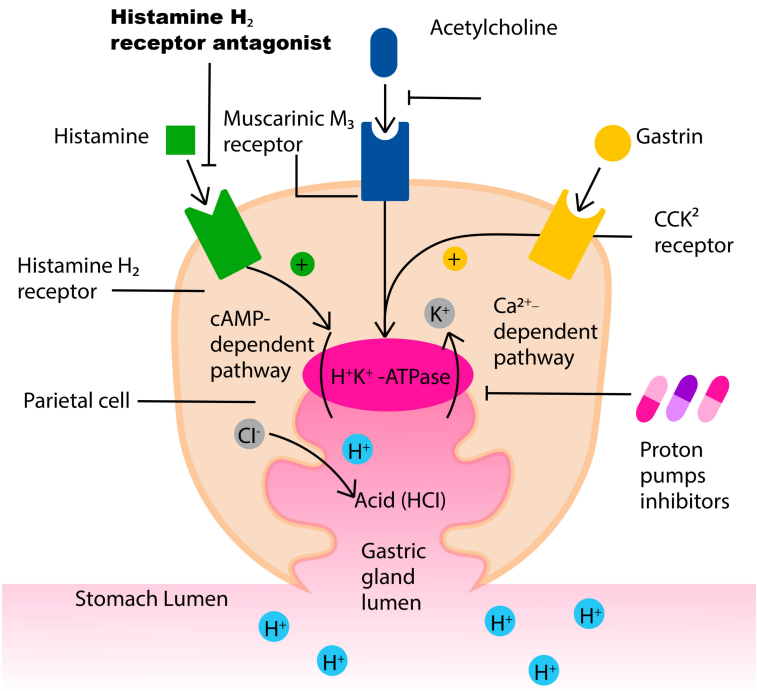

Figure 9.5c Image made by TRU Open Press

Parietal cells are located in the fundus and body regions of the stomach and are responsible for secreting hydrochloric acid via the hydrogen-potassium adenosine triphosphatase (H^+/K^+ ATPase) proton pump. Parietal cells secrete acid in response to three types of stimuli:

- Histamine, stimulates H2 histamine receptors

- Acetylcholine (Ach) (from parasympathetic activity from the vagus nerve and enteric nervous system) stimulates M3 receptors.
- Gastrin stimulates CCK2 receptors.

Activation of histamine through H2 receptor causes increases in the intracellular cAMP level, while ACh through M3 receptor and gastrin through CCK2 receptor increases intracellular calcium level. Through the combined actions, the proton pump moves hydrogen out of the parietal cell into the lumen in exchange for K+. Cl- moves into the lumen through Cl- channels. H+ and Cl- combine to produce HCL in the gastric lumen of the stomach (Wikipedia contributors, 2025, October 4).

$H^+ + Cl^- \rightarrow HCl$

This results in an acidic gastric fluid with a pH 1-2.

Comparison of two H2RA medications:

Two common H2RA's, Cimetidine and Famotidine, that are available OTC or by prescription. Both meds are effective at reducing HCL production. Famotidine is often a drug of choice due to being more potent, less drug interactions and other adverse effects. Our prototype med will be famotidine.

Cimetidine	**Famotidine**
Less potent	More potent Longer duration of action
Drug interactions Potent inhibitor of P 450 enzymes leading to drug interactions (increased concentration of warfarin, tricyclic antidepressants, lidocaine, calcium channel blockers, oral sulfonylureas, phenytoin, theophylline, benzodiazepines, and beta-blockers).	No inhibition of P450 enzyme in liver, no drug interactions.
Anti-androgenic effects · results in gynecomastia, impotence, and ↓ libido in males. All reversible once med is stopped.	No anti-adrogenic effects
Crosses blood-brain barrier · results in confusion, dizziness, and headaches	
Slow absorption if taken with food	Can take with food
Avoid in the elderly (on Beers Criteria) due to more side effect risk and risk of cognitive impairment.	Safe with the older adult and pediatric clients over 1 year of age
Common side effects: GI: constipation, nausea and vomiting Musculoskeletal pain, myalgia/ reversible myalgia Rash Fatigue, confusion Cimetidine→ ↓ creatinine clearance. Reversible once med is stopped. Monitor renal function. Decrease dosing due to prolonged effect	Anxiety, headache, Diarrhea, constipation Dizziness
Similarities of the two medications:	
Both meds considered safe during pregnancy; consult prescriber before taking.	

Impairs B12 absorption with long term use; take B12 supplement.

Preexisting liver and kidney disease may require dosage adjustment. Famotidine is supported by evidence as safe for use in pediatric clients younger than 1 year old, as well as in geriatric clients (McCuistion, Vuljoin-DiMaggio, Winton, & Yeager, 2018)

Figure 9.5d A common H2-receptor antagonist is famotidine, (see Figure 9.5d).

H2 Receptor Antagonist: Famotidine

Class: Anti-ulcer H2 Receptor Antagonist **Prototype**: Famotidine (other Cimetidine)		**Indications:** Cimetidine: erosive esophagitis, GERD, PUD, hypersecretory disorders, dermatological conditions. Famotidine: GERD, PUD, prophylaxis for stress ulcer management in critically ill pts or prior to surgery; H.Pylori treatment **Therapeutic Effects:** Reduce gastric acid production and healing of ulcers.	
Mechanism of Action: H2 Antagonists selectively block H2 receptors located on the parietal cells in the stomach. If H2 receptors are blocked… HCl release is ↓			
Administration: Well-absorbed PO: chewable, tablets, power with or without food. Once daily at bedtime or if BID, am and bedtime. Take 15-30 min prior to food IV: famotidine for stress prophylaxis Onset: 60 min T1/2: 2.5-3 hours Long duration of action: 6-12 hours Renal excretion 70% unchanged Short term use with cimetidine (2 weeks)	**Side Effects**: high efficacy, high safety profile, well-tolerated Anxiety, headache, constipation Dizziness	**Contraindications:** Caution with renal insufficiency and older adult (dose adjusted) Caution with CNS depressants	**Nursing Considerations**: Safe with peds > 1 year Assess older adult for confusion. Take as directed, do not double doses. Smoking interferes with histamine antagonists Avoid alcohol, NSAIDs and trigger foods. Increase fluid & fiber Report black tarry stools, dizziness, rash or confusion. Do not take antacid same time.

Downloadable file (.docx): H2 Receptor Antagonist_ Famotidine

Nursing Considerations:

- Monitor for abdominal pain, symptom relief
- Check renal panel and CBC before treatment.
- Obtain med profile, including OTC and herbal remedies.

Client Teaching:

- Oral suspension: shake vigorously 5-10 seconds prior to use
- Explain importance of lifestyle changes (smoking cessation, avoid NSAIDs, avoid trigger foods).
- Advise client to eat small, frequent meals than larger meals
- Increase fluid and fiber to decrease risk of constipation
- Avoid alcohol that can cause gastric irritation.
- If taking for a long time, B12 levels will decrease. Advise to increase B12 levels by including foods such as red meat, poultry, fish and eggs.

(Adams et al, 2018; McCuistion, Vuljoin-DiMaggio, Winton, & Yeager, 2018)

Proton Pump Inhibitors

Proton pump inhibitors (PPI) are the most effective anti-ulcer drugs available to suppress gastric acid secretion. They are used commonly for GERD, PUD and H. Pylori treatment, as well as other hypersecretory conditions. There are a few different PPIs available, both OTC and by prescription, but most are very similar in their effects. Prescribers may choose one over the other due to prescriber preferences, cost, dosing and client therapeutic response.

Proton pump options: pantopr**azole**, omeprazole, rabeprazole, lansoprazole. All PPI end in suffix 'azole'

Our prototype will be pantoprazole

Indications for use

Pantoprazole is used in the treatment of GERD (regurgitation, heartburn) by blocking the production of hydrochloric acid and allowing time for the gastric mucosa to heal. It is also used for treatment of hypersecretory conditions, such as Zollinger-Ellison syndrome, and erosive esophagitis. It is also used for the treatment of H. Pylori infections, NSAID induced ulcers and preventing duodenal ulcers (Bernshteyn, Patel, Masood, 2025).

Figure 9.5e OTC Omeprazole. [Prilosec Box 001](#)" *by* [cygnus921. CC BY 2.0](#)

Mechanism of Action

PPIs bind irreversibly to the hydrogen-potassium ATPase enzyme system (proton pump) of the parietal cell, inhibiting the secretion of hydrochloric acid, the final step in gastric acid production. Due to the irreversible binding to the proton pump, it has a long duration

of action up to 24 hours. Refer to the diagram located in the H2RA section.

Pantoprazole has a relatively quick onset of action within a few hours, with the maximal effect occurring between 2 and 6 hours after administration. It can be given orally, both immediate release or delayed release options. It is also used intravenously with bleeding ulcers in the hospital setting. PPIs have a long duration of action due to the irreversible binding of the PPI to the proton pump. Although the half life is 2 hours, the irreversible binding to the proton pump means the body must create new proton pumps to resume acid production. The drug's effect on stomach acid continues long after it has been cleared from the bloodstream (Bernshteyn, Patel, Masood, 2025).

Nursing Considerations

- Enteral administration: mix delayed-release granules with applesauce or apple juice and give by mouth or feeding tube.
- Drug interactions: can interfere with liver metabolism of other drugs. Check for drug compatibility.
- Monitor for symptoms of GI bleeding (black tarry stools, coffee ground emesis).
- IV administration can potentially exacerbate zinc deficiency.
- Check baseline liver function tests (ALT, AST) and renal function depending on client context.
- Long term therapy can lead to vitamin deficiencies.
- If long term use, monitor bone density.
- Safe during pregnancy, but always consult health care provider prior to taking the PPI.

(Adams et al, 2018; McCuistion, Vuljoin-DiMaggio, Winton, & Yeager, 2018).

Adverse effects of Proton Pump Inhibitors

PPIs are a relatively safe medication if used correctly. Side effects can include diarrhea, headache, upper respiratory tract infection, and abdominal pain. These are often self-limiting.

Long term complications:

Long term use of PPIs have the potential to lead to numerous adverse effects.

- Diarrhea that does not resolve, especially with hospitalized clients. The diarrhea can be attributed to *Clostridium difficile.*
- Small-intestinal bacterial overgrowth, due to reduction of hydrochloric acid allowing overgrowth of bacteria.
- Numerous vitamin deficiencies including vitamin B12, iron, calcium, magnesium. Hypomagnesemia can result in tetany, seizures or arrythmias.
- Bone demineralization, leading to higher risk of bone fractures. This risk is significant for the older adult and those with renal insufficiency.
- Drug interactions: diminished absorption of medications such as clopidogrel. Other drug interactions include warfarin and antiretrovirals.
- Interstitial nephritis – slight risk for acute kidney injury (AKI) and interstitial nephritis.
- Older adult: PPI in the older adult for longer than 8 weeks can lead to higher risk of *Clostridium difficile* infection and bone density loss which can lead to higher risk of bone fractures. As such, PPIs are on the Beers Criteria for inappropriate med with the older adult.

Client Teaching:

- Can take with or without food, but do not crush or chew. Preferable to take 30 minutes prior to meals.
- Avoid NSAIDs, alcohol or foods that cause gastric irritation.
- Advise clients to take PPIs as prescribed and do not take longer than 8 weeks unless advised by their health care provider.
- Report persistent diarrhea and abdominal pain.

Bernshteyn, Patel, Masood (2025); Sealock & Seneviratne (2021).

Treatment of H. Pylori

Following the diagnosis of H. Pylori, the recommended treatment includes two antibiotics and a PPI taken for 10 days. If the triple therapy is not effective, bismuth salicylate may be added to the regime. H. Pylori has become increasingly difficult to treat, so some changes to treatment include adding a third antibiotic and these are taken for 14 days (Canadian Digestive Health Foundation, 2025).

Mucosal Protectants

Sucralfate is a mucosal protectant to treat duodenal ulcers. It is also used off label for other medical conditions such as GERD, epithelial wounds, chemo-induced mucositis, and burn wounds. It forms a protective layer, enhancing bicarbonate production and has anti-peptic properties making it ideal for gastric ulcer healing. It further fosters tissue growth and regeneration. It is used for short term treatment to help heal ulcers, not prevent ulcer formation.

Mechanism of Action

Sucralfate covers the ulcer site in the GI tract and protects it against further attack by acid, pepsin, and bile salts. It works several ways once ingested:

- It forms a chemical reaction over the ulcerated site, forming a protective barrier. It binds to positively charged proteins in exudates, locally forming a thick viscous substance (Kudaravalli, Patel, & John, 2024).

- It stimulates the production of mucus and bicarbonate, which further fortify the stomach's protective lining.
- It increases growth factors such as epidermal and fibroblast growth factors, promoting healing by facilitating tissue regeneration and repair.

It is minimally absorbed by the gastrointestinal tract. It is considered a relatively safe medication but some side effects and drug interactions occur.

Nursing Considerations

Onset of action is 1-2 hours, with a duration of 6 hours.

Considered safe with pregnancy, as not systemically absorbed.

Caution with clients with chronic renal failure: use cautiously with clients with chronic renal failure or those receiving dialysis due to impaired excretion of small amounts of absorbed aluminum that can occur with sucralfate.

Side effects:

- Constipation (primary side effect)
- Nausea, gas, indigestion
- Hyperglycemia with diabetic clients.
- Rash
- Dizziness, drowsiness
- Headache

Drug interactions:

- Sucralfate can decrease the serum concentrations of many medications, including digoxin, levothyroxine, furosemide, quinolones, oral phosphate supplements, warfarin. Ensure a 2-hour gap from administering these medications.
- Multivitamins can increase the serum concentration of sucralfate.
- Antacids can reduce efficacy by decreasing the binding ability of sucralfate to gastric ulcers. Do not take antacids within 15 minutes of taking sucralfate.

Client Teaching

- Take on an empty stomach, 2 hours after or 1 hour before meals.
- Take this med as prescribed, and for the full length of time, even if symptoms improve.
- If taking other meds, drug interactions may occur. Follow pharmacy guidelines when taking other meds.
- If pregnant or breastfeeding, ensure to check with your health care prescriber.

Anti-flatulent

Gas is a common issue that occurs in the GI tract due to digestive processes and the swallowing of air. Gaseous distension can also occur with post operative clients. For clients who have troublesome gas, simethicone is an anti-flatulent that is commonly found in other OTC antacids (see Figure 9.5f). It is a relatively safe medication and can be used in infants and children.

Figure 9.5f OTC Simethicone

Indications

Simethicone is used to treat the symptoms of gas such as uncomfortable or painful pressure, fullness, and bloating.

Mechanism of Action

Simethicone works by altering the surface tension of the mucous-coated gas bubbles, which cause them to break into smaller bubbles, thus reducing pain and facilitating expulsion.

Specific Administration Considerations

Simethicone is usually taken four times a day, after meals and at bedtime. For liquid form, shake drops before administering. It may cause minor side effects such as diarrhea, nausea, vomiting and headache.

Client Teaching

Clients can be instructed about other measures to assist with gas expulsion such as changing position, ambulation, avoiding the use of straws, and tapering intake of beans and cruciferous vegetables (Adam Medical, 2019; Lilley, Collins & Snyder, 2014; McCuistion, Vuljoin-DiMaggio, Winton & Yeager, 2018).

Comparing Medication Tables

To help with comparing the medications and to learn important considerations for each medication, refer to the medication tables Chapter 9 Comparing Antacids Medication table and Chapter 9 Comparing Anti-ulcer Medications Table

The medication cards are also intended to assist students to learn key points about each medication. Because information about

medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Clinical Reasoning and Decision-Making Activity 2

A client who recently underwent surgery has a medication order for daily pantoprazole. The nurse reviews the client's medical history and finds no history of GERD or peptic ulcer disease. The client does not report any symptoms of heartburn, stomach pain, or sour stomach. The nurse reviews the physician's orders for an indication for this medication before calling the provider to clarify.

What is the likely indication for this drug therapy for this client?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the "Answer Key" sections at the end of the book.

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:

https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=2486#h5p-38

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- Figure 9.5d OTC Famotidine. A common H2-receptor antagonist is famotidine. My Still LIfe" by Bast Productions. CC BY-NC-ND 2.0 ↵

- Figure 9.5e OTC Omeprazole"Prilosec Box 001" by cygnus921. CC BY 2.0 ↵
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9.6 Antidiarrheal Medications

Diarrhea is a common complaint and is defined as "an increase in the frequency and fluidity of bowel movements." (Adams et al, 2019, p. 417). It occurs when not enough water is removed from the stool during transit, making the stool loose and poorly formed. Diarrhea can be self-limiting or chronic. It can be a defensive process to remove toxins, bacteria, viruses, or protozoa from the GI tract.

Causes of Diarrhea

- Infections: viral or bacterial infections most common cause. Helminths or parasites found in contaminated food or water
- Medications such as antibiotics can kill off normal flora, allowing opportunistic growth of organisms.
- Food intolerances such as lactose intolerance
- Diseases of the colon: inflammation of the bowel from Chron's disease or irritable bowel syndrome can lead to diarrhea.

Following an assessment that includes vital signs, health history and med profile, and a GI assessment (physical assessment along with history of bowel patterns and stool characteristics), it may be recommended to take an anti-diarrheal medication. Anti-diarrheal

medications can be taken if diarrhea is prolonged or severe, but typically diarrhea does not need to be treated. If the diarrhea is severe, it can lead to fluid and electrolyte losses. Children and the elderly are particularly susceptible to dehydration related to diarrhea and should be treated more urgently.

There are three common mechanisms of action of **antidiarrheal** medications:

- **adsorbents,** which help eliminate the toxin or bacteria from the GI tract.
- **antimotility** agents, which slow peristalsis. Two types: anticholinergics and opiate-like meds
- **probiotics**, which help to restore the normal bacteria found in the lower intestine.

Nurses should closely monitor for dehydration; oral rehydration agents may be needed to replace fluid and electrolyte loss, but they do not treat diarrhea. Antibacterial agents may also be used to treat diarrhea caused by specific infections, such as campylobacter or giardia, but they are not routinely needed (Lilley, Collins & Snyder, 2014).

Choosing which anti-diarrheal will depend on the cause and the severity of the symptoms. For example, if the diarrhea is related to food poisoning, taking an adsorbent, might be useful. Often the cause of the diarrhea is not known and is only assumed through assessing the client.

Adsorbents

Adsorption is the adhesion of molecules to a surface. This process differs from absorption, where a substance is dissolved or penetrates into a surface. Bismuth subsalicylate (brand name Pepto Bismol) is an example of an adsorbent (see Figure 9.6a).

It is used for a variety of digestive conditions including traveler's diarrhea, heartburn, nausea and stomach upset. It is also used in the treatment of H.Pylori pathogen, and as part of quadruple therapy with antibiotics, and a proton pump inhibitor. It is available OTC.

Figure 9.6a Bismuth Subsalicylate

Mechanism of Action

Adsorbent medications work by coating the walls of the GI tract and binding the causative bacteria or toxin for elimination from the GI tract through the stool (Lilley, Collins and Snyder, 2014). Bismuth subsalicylate also decreases the flow of fluids and electrolytes into the bowel, reducing inflammation within the intestine (A.D.A.M, 2019).

Nursing Considerations

Administration: oral formulas. Liquid products should be shaken well before use. Tablets should be swallowed whole and not chewed unless they are a chewable tablet.

Bismuth subsalicylate is not recommended during pregnancy or breast feeding.

Drug interactions are common and adsorbents can decrease the effectiveness of many meds, such as digoxin, and antihyperglycemics. It can cause increased bleeding in clients taking warfarin.

Adverse/ Side Effects:

Common side effects include nausea, bitter taste, and dark/black stools.

A blackened tongue is less common, but may be seen if taking the medication for prolonged period of time.

If symptoms worsen, a fever, or ringing in the ears occurs, or if diarrhea lasts longer than 48 hours, contact the provider (A.D.A.M, 2019; Budisak, Patel & Abbas, 2024).

Allergy to salicylates: Bismuth subsalicylate contains salicylate. It should be avoided if the client has an allergy to salicylates (including aspirin) or if the client is taking other salicylate products such as aspirin. It should not be used if the client has an ulcer, a bleeding problem, or bloody or black stool.

Risk of Reyes Syndrome: Children and teenagers who have or are recovering from chickenpox or flu-like symptoms should not use this product. When using this product, if changes in behavior with nausea and vomiting occur, consult a doctor because these symptoms could be an early sign of Reye's syndrome, a rare but serious illness.

Client Teaching:

- Clients should be advised to take medication as directed.
- Excessive use can cause toxicity, and although rare, can lead to impaired cognition, tremors and insomnia (Budisak, Patel, Abbas, 2024).
- They should be aware of potential color changes to stool that may occur and that the medication contains aspirin.

Example in Practice

A client has had a mechanical valve replacement inserted a few months ago and is on warfarin. They developed diarrhea, which they suspect is due to a traveler's bug from their recent vacation. The client goes

to their medicine cupboard and takes out Pepto Bismol which has been effective in relieving occasional diarrhea. This med has been effective in the past, but is it safe to use now?

Pepto Bismol (bismuth subsalicylate) contains salicylates (aspirin-like compounds) that can increase warfarin's effect. The client may experience a higher risk of bleeding, bruising, or severe gastrointestinal issues. This client should not take the adsorbent, and plan to take a different anti-diarrheal.

Antimotility

Antimotility medications help to treat diarrhea by slowing peristalsis. There are two categories of antimotility medication: anticholinergics and opiate-like medication. Both are typically used in more severe cases of diarrhea.

Anticholinergics

Hyoscyamine is an anticholinergic that works on the smooth muscle of the GI tract to inhibit propulsive motility, and decreases gastric acid secretion.

Specific Administration Considerations

Read drug label information for all contraindications, including but not limited to glaucoma, myasthenia gravis, and paralytic ileus. Diarrhea may be an early symptom of incomplete intestinal obstruction, and the use of this drug would be inappropriate and possibly harmful. CNS symptoms and other adverse effects that are common with anticholinergic medications may occur (Opentextbc, n.d.).

Client Teaching

Clients should receive instruction that these medications may cause dizziness and drowsiness. If clients experience dry mouth, frequent oral hygiene may alleviate discomfort (Opentextbc, n.d.).

Opioid-like medications:

This drug class is the most effective for symptomatic treatment of diarrhea. There are three drugs: codeine sulfate, diphenoxylate hydrochloride with atropine sulfate and loperamide. Loperamide is the only one available OTC as the others have more risks. Our prototype med will be loperamide.

Prototype: Loperamide

Loperamide is used for treat various forms of diarrhea, including to treat the adverse effects of chemotherapy-induced diarrhea. It is used off label for opioid withdrawal symptoms.

Mechanism of Action

Loperamide has an opioid-like chemical structure but causes fewer CNS effects. It binds to opiate receptors in the intestinal wall, inhibiting the release of acetylcholine and prostaglandins, leading to a decrease in peristalsis and transit time (Sealock & Seneviratne, 2021). By decreasing the flow of fluids and electrolytes into the bowel and by slowing down the movement of the bowel, less bowel movements is the result. It also increases anal tone which helps avoid incontinence. (see Figure 9.6b).

Figure 9.6b Loperamide

Nursing Considerations

Loperamide should not be given to a child younger than two years of age because of the risk of respiratory depression and heart problems.

Taking more than the prescribed dose can cause a serious abnormal heart rhythm that can lead to death.

Read the drug label carefully for information about interaction with other medications, especially antidysrhythmic and antipsychotics

Physical dependence is not a concern as with other opiate medications. (ADAM, 2019; Sealock & Seneviratne, 2021).

Contraindicated for clients with GI disorders such as ulcerative colitis, pseudomembranous colitis. Consult the health care prescriber for treatment options.

Side effects:

Numerous side effects can occur but typically well tolerated. These include: dry mouth, flatulence, abdominal cramps, nausea, constipation, urinary retention, drowsiness

Adverse effects: Serious adverse effects can include cardiac dysrhythmias, and toxic megacolon. Take only as prescribed and consult the health care provider if symptoms do not resolve.

Client Teaching

- Loperamide comes in tablets, capsules, liquid and orodispersible tablets (dissolve on the tongue). Clients should take medications as directed.
- Take 30 minutes before a meal to decrease colonic activity. Stop taking if no diarrhea for 24 hours or if solid/hard stools develop.
- Avoid alcohol and other CNS depressants as the combined effect may cause drowsiness.

Other opiate-like antidiarrheals is diphenoxylate hydrochloride

with atropine sulphate (Lomotil). It works on the smooth muscle of the GI tract, decreasing gastric motility. Although it has no analgesic activity, it is still prone to misuse. To discourage misuse, atropine is added to the formula, so if taken in large doses, anticholinergic effects will occur (dry mouth, abdominal pain, tachycardia).

Sahi, Nguyen, Patel & Santos (2024); Sealock & Seneviratne (2021).

Probiotics

Probiotics are used for the prevention and treatment of diarrhea. They are sometimes referred to as intestinal flora modifiers. They are often used concomitantly with antibiotics to prevent the common associated side effects of diarrhea (see Figure 9.6c). An example of a probiotic is lactobacillus.

Figure 9.6c Probiotics come in several forms

Mechanism of Action

Probiotics help replenish normal bacterial flora in the gastrointestinal tract, leading to a suppression of growth of pathogenic bacteria.

Specific Administration Considerations/ Client Teaching & Education

Probiotics can be obtained by drinking lactobacillus milk or eating yogurt or kefir with live or active culture (not all yogurts have live culture). Supplements are also available.

Side effects of probiotics, such as gas and bloating, are mild. Probiotics are safe for use in children (Adams et al, 2019).

Evaluating the effectiveness of anti-diarrheal medications

Antidiarrheals only treat the symptoms of diarrhea and do not eliminate the cause. Advise clients if their symptoms do not start to decrease within 48 hours, they should see their health care provider.

Evaluate for dehydration and encourage clients to drink fluids to replenish any fluid loss. The risk of dehydration is greater in children and the elderly, monitor closely. If significant diarrhea, consider electrolyte imbalance and the need for serum electrolytes to be drawn.

In general, the client should seek out further treatment if:

- Symptoms worsen
- Symptoms last more than 14 days
- Diarrhea does not begin to improve within 48 hours

- They develop other symptoms such as fever, severe abdominal pain.
- They develop blood in the stool.

Now let's take a closer look at the medication grids comparing medications used to treat diarrhea, in Table 9.6

Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Table 9.6 Anti-diarrheal Medication Comparison

Class	Prototype/Generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Adsorbents	bismuth subsalicylate (Pepto Bismol)	Avoid if taking other salicylates. Do not use in children or teenagers recovering from chickenpox or flu-like symptoms as may cause Reye's syndrome. Do not use if the client has an ulcer, bleeding problem, or bloody or black stool.	Decreased diarrhea symptoms	May cause black or darkened tongue. Contact provider if symptoms worsen, a fever or ringing in the ears occurs, o if diarrhea lasts longer than 48 hours
Anticholinergic	hyoscyamine	Contraindicated in glaucoma, myasthenia gravis, or paralytic ileus.	Decreased diarrhea symptoms	May cause CNS and othe adverse effect associated with anticholinergi medication.
Opiate-like medication	loperamide (Imodium)	Contraindicated in children younger than 2 and with several other medications; read drug label information before administering.	Decreased diarrhea symptoms	Black Box Warning: May cause abnormal heart rhythm.
Probiotics	lactobacillus	Pediatric dosing is age-based and varies by product.	Prevention of diarrhea or decreased symptoms of diarrhea	Mild, such as gas and bloating.

Clinical Reasoning and Decision Making Activities

1. A client has been prescribed loperamide for diarrhea associated with gastroenteritis. The client begins to complain of "heart palpitations." What is the nurse's next best response?
2. A child, aged 6, has diarrhea. The mother asks the nurse what OTC medications she can provide to her child to help resolve diarrhea. What is the nurse's best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 9: Gastrointestinal Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition sections at the end of the book.

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9.7 Laxatives

In contrast to diarrhea, constipation is when there are too few stools, or stools that require effort to eliminate. It can be generally characterized by infrequent and hardened bowel movements, less than 3 times per week (Diaz et al, 2023). The large intestine is where water is reabsorbed from the stool. If stool stays in the large intestine too long, more water is reabsorbed, leaving the stool hard and dry and may be difficult to excrete. Along with hardened stool, clients may experience abdominal distention, flatulence and cramping.

Constipation can occur at any age, from the newborn to the elderly. It can be a minor inconvenience, extending to negatively impacting the person's quality of life. If severe, it can lead to fecal impaction requiring urgent medical care.

The causes of constipation are often not clear. Although it is a problem at any age, it is more prevalent as we get older, 30-40% of adults over the age of 65 report having constipation. There is also a higher prevalence in the female population (Diaz et al, 2023). People sometimes need laxatives for constipation caused by gastrointestinal disorders such as irritable bowel syndrome (IBS) with constipation, chronic idiopathic constipation (CIC), and opioid-induced constipation (Bashir & Sizar, 2024).

Causes of Constipation

- Dietary:

    - low fiber intake
    - low fluid intake
    - poor dietary habits

- Alcohol overuse
- Lack of exercise
- Medications: anticholinergics, narcotics, antidepressants
- Endocrine disorders – hypothyroid, diabetes mellitus
- Neurological disorders – neuropathy, Parkinson's

(Diaz et al, 2023; Adams et al, 2019)

Occasional constipation is not a cause for concern or requiring medications for treatment. Many clients increase their fiber and fluid intake to be proactive against constipation. Fiber options include whole grains, vegetables such as asparagus, broccoli, cabbage and spinach, and fruits such as figs or apples. From there, bulk-forming (fiber supplements) laxatives and stool softeners are available to prevent constipation. To treat constipation or for bowel movements that are painful or require a lot of straining, there are a number of medications available OTC, both oral and suppositories. Untreated and severe constipation, especially in at-risk groups such as the elderly, can lead to fecal impaction and bowel obstruction.

There are five categories of laxative medications commonly used to treat or prevent constipation. They are based on the mechanism of action.

- fiber supplements,
- stool softeners

- osmotic agents
- lubricants
- stimulants

Table 9.7 compares the mechanism of action for each laxative category and includes common prototype and OTC brand names (Daniels & Schmelzer, 2013; National Institute of Health, 2018)

Table 9.7 Categories of Laxatives Used to Treat Constipation

Category	Prototypes	Mechanism of Action
Fiber supplements/ Bulk Forming	Psyllium (Metamucil)	Bulk-forming to facilitate passage of stool through the rectum. Absorb water in the bowel creating 'bulk'. Swelling of the fecal mass stretches the intestinal wall and stimulates peristalsis. Similar to dietary fiber.
Stool softeners	Docusate (Colace)	Facilitates movement of water and fats into stool. Surface-active agent that emulsifies and wets the stool; allows more water and fat into the stool. The stool mass becomes larger and thus promotes peristalsis. Water penetrates the feces, softening stool.
Osmotic agents	Magnesium hydroxide (Milk of Magnesia); polyethylene glycol (PEG) 3350 (Miralax); sodium biphosphate (Fleet saline enema) Ex. Glycerin, lactulose PEG 3350 and PEG-ES	Causes water to be pulled into the intestine, and then the stool, increasing osmotic pressure in bowel. Stool consistency changes to liquid, stretch receptors are stimulated, increase in peristalsis. Result is increased number of bowel movements and softer stool. Each type have different intensity of action due to isotonic or hyperosmotic action. PEG 3350 – mild osmotic effect, softer stools. PEG-ES – isotonic effect; bowel cleanser for bowel prep
Lubricants	mineral oil enema (Fleet mineral oil enema)	Lubricants (coats) the stool & intestinal walls and prevents reabsorption of water from intestines. Water in bowel softens and expands the stool… bowel distention, peristalsis, defecation. Used for fecal impaction, acute or chronic constipation.
Stimulants	Bisacodyl (Dulcolax) Senna (Sennakot) Ie. Restoralax	Colon responds to chemical irritants bey secreting mucous, water and electrolytes to dilute irritants and stimulate peristalsis. Also, intestinal motility increases by stimulating nerves that innervate the intestine resulting in increased peristalsis.

Bulk-forming (Fiber supplements)

Bulk-forming laxatives includes dietary fiber, methylcellulose, and psyllium. A psyllium based laxative is Metamucil (brand name) is an example of a common OTC fiber supplement (see Figure 9.7a). It is similar to dietary fiber and has dual function; it prevents constipation and can also alleviate diarrhea.

Fiber supplements are safe to use while pregnant, if increasing fiber and fluids in diet are not effective.

Figure 9.7a Psyllium in powder form

Mechanism of Action

Psyllium adds bulk to the stool to facilitate passage through the rectum.

Administration Considerations

- Put one dose into an empty glass and mix with at least 8 ounces of water or other fluid. Stir briskly and drink promptly. If mixture thickens, add more liquid and stir.
- Potential for choking, especially with dysphagia. Take with enough water
- Administer at least 2 hours before or 2 hours after other medications as it can affect absorption.
- Psyllium usually produces a bowel movement within 12 to 72 hours.
- It may cause bloating and cramping.
- Caution while using taking other meds: it may decrease the absorption of warfarin, digoxin, and antibiotics.

Client Teaching:

- When teaching clients how to take psyllium at home, in addition to the above considerations, advise them to start with 1 dose per day but may gradually increase to 3 doses per day as necessary to maintain soft stools.

Stool Softeners

Docusate is a common OTC stool softener that is used to prevent constipation. Its gentle action only softens the stool, it does not cause defecation. Stool softeners are well-tolerated and safe for adults. Stool softeners efficacy has been questioned and may have minimal benefits in preventing constipation (Bashir & Sazar, 2024).

They are generally considered safe for pregnancy or lactation, consult with prescriber.

Mechanism of Action:

Docusate facilitates the movement of water and fats into stool. . It acts as a surface-active agent that emulsifies and wets the stool. This allow more water and fat into the stool, resulting in the stool mass becoming larger and this promotes peristalsis. The water penetrates the stool, making it soft and improves the regularity of bowel movements.

Administration Considerations:

- Take with a full glass of water and ensure water intake is adequate through out the day.
- Produces a bowel movement in 12 to 72 hours.
- Mild side effects: stomach cramping, nausea, bitter taste.
- Caution with clients who are sodium restricted, such as cardiac clients.

Client teaching:

- Advise for the client to take with a full glass of water.
- Increase fiber and water in the diet.
- If already constipated, stool softeners will not be effective. They are for prevention of constipation. If already constipated, plan to use a stimulant or osmotic agent to promote a BM.

Osmotic Agents

In this category, there are different types of osmotic agents with different intensity of action. These include:

- Magnesium Hydroxide (Milk of Magnesia)
- Polyethylene glycol 3350 (Miralax)
- Glycerin suppositories
- Lactulose
- Sodium biphosphate (Fleet saline enema).

Magnesium hydroxide

Magnesium hydroxide and polyethylene glycol are perhaps the two most common osmotic agents. Although quite safe to use for most clients, it can result in volume load and should be used cautiously with renal or cardiac disease (Bashir & Sazar, 2024).

Magnesium hydroxide is also used as an antacid. There is a potential risk of metabolic disturbances, especially if renal dysfunction. Avoid with clients with impaired renal function as it is renally excreted.

Polyethylene glycol

Polyethylene glycol is widely used to prevent and treat constipation. It is commonly used in hospitals. It is available in two formulations. PEG 3350 is used to treat constipation. PEG-ELS is used for bowel preparations prior to diagnostic procedures.

PEG 3350:

- Reconstitution: PEG 3350 has a bottle top that can be used as a measuring cap to contain 17 grams of powder when filled to the indicated line. Fill to top of clear section in cap, which is marked to indicate the correct dose (17 g); stir and dissolve in any 4 to 8 ounces of beverage (cold, hot or room temperature), and then administer.
- PEG 3350 is often the first step in a bowel protocol. BM within 1-3 days.

PEG ELS: This formulation is an isotonic solution that results in a bowel cleanse prior to bowel procedures. See the box below for further details.

Glycerin suppositories:

- One suppository (2 or 3 g) per rectum for 15 minutes daily. They typically work within 15-60 minutes. Used as part of a bowel protocol to relief constipation or impacted stool.
- They are safe to use with adults and children.

Figure 9.7b Glycerin suppositories https://commons.wikimedia.org/wiki/File:Glycerin_suppositories.jpg

Lactulose:

- Lactulose is used for two purposes. The first is for constipation, taken once a day with increasing dosages depending on results. The second is for hepatic encephalopathy, taken every hour to promote a bowel movement and rid the body of ammonia (See box below for further information).
- Lactulose has a bitter taste and the syrup is often mixed with juice or milk. BM within 6-12 hours.
- Do not give with antacids (inhibits the action).
- Use lactulose cautiously in pediatric clients, debilitated clients and, and older clients.

- Adverse effects can include bloating, nausea, vomiting, and diarrhea.

Sodium Biphosphate

Better known as fleet saline enemas, they are also used to relieve constipation, for bowel prep, and to treat fecal impaction. They work quickly by drawing water into the intestines and allow the stool to pass more easily.

Lactulose – Not just for constipation

Lactulose is also used for hepatic encephalopathy, and is one strategy to counteract the elevated ammonia levels in the brain that lead to an altered mental status. Lactulose works by decreasing the intestinal production of ammonia and its absorption (by converting intestinal ammonia to ammonium which is then trapped in the intestine and can't be reabsorbed). This all prevents the absorption of ammonia leading to a lower serum ammonia level and ultimately improved mental status (Mukherjee, Patel & John, 2024). The client should have 2-3 bowel movements per day, lowering serum ammonia levels and pH.

Mechanism of Action: Osmotic agents cause water to be retained with the stool, increasing the number of bowel movements and softening the stool so it is easier to pass. The choice of med will depend of desired outcome; this can range from softening the stool, to evacuation of bowels to treat impacted stool.

Administration Considerations

- Side effects of osmotic agents: nausea, bloating, flatulence
- Use with caution with renal failure or poor kidney perfusion (ie. heart failure)
- Contraindicated for suspected bowel obstruction, appendicitis or other bowel conditions.

Client Teaching

- Inform client about common side effects. Potential for loose, watery stools.
- If used at home for more than 2 weeks, follow the advice from a health care prescriber.
- Take with plenty of fluids to avoid dehydration.

Bowel Preparation for Surgery or Diagnostic Procedures

Before any bowel diagnostic procedures such as a colonoscopy or before bowel surgery, clients will be instructed to complete a bowel prep. This includes taking PEG ELS, an isotonic solution. The client mixes the powder

in water (up to 4L) and is required to drink the solution over a period of hours. PEG ELS has poorly absorbed electrolytes and PEG (a molecule too large to be absorbed) so almost no water or lytes are absorbed. The large volume of fluid and stool flush out, with the goal of clear water stools (Daniels & Schmelzer, 2013). It is safe with renal insufficiency or those with fluid and electrolyte imbalances as very little PEG-ELS is actually absorbed.

Other bowel prep options are taking Bisacodyl tabs to first clear out the bulk of the stool, followed by PEG ELS mixed with 2 L of water.

Lubricants

A mineral oil enema (brand name Fleet mineral oil enema) is an example of a lubricant laxative (see Figure 9.7c). It is used for acute or chronic constipation and fecal impaction.

Figure 9.7c Mineral oil enema

Mechanism of Action

Mineral oil coats or lubricates stool and the intestinal walls and prevents reabsorption of water from the intestines. Water in the bowel softens and then expands the stool, leading to bowel distention, peristalsis and then defecation.

Administration Considerations

- Bowel movement in approximately 15 minutes.
- Side effects: stomach cramps, bloating, diarrhea
- Pediatric formulas available
- Risk of perforation for any enema, ensure well lubricated tip.

Client Teaching

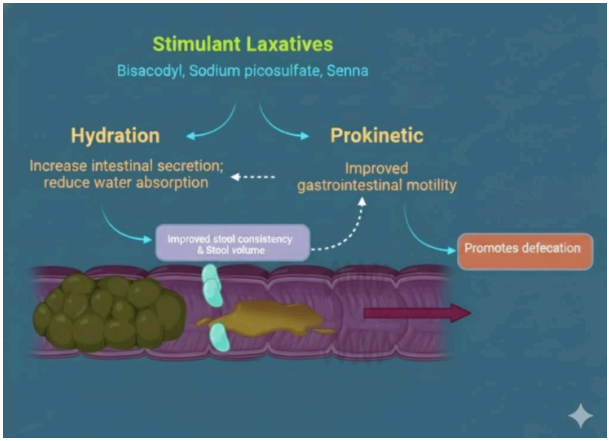
- A mineral oil enema generally produces a bowel movement in approximately 15 minutes.
- It may cause stomach cramps, bloating, upset stomach, or diarrhea.
- Pediatrics: read drug label carefully. Some formulas are not intended for children or children less than 2 years of age.

Stimulants

Stimulant laxatives can be used for constipation when other options are not successful or as part of a bowel cleanse. Bisacodyl (trade name Ducolax) and senna (trade name Sennokot) are two examples commonly used. Bisacodyl comes in both oral and rectal options.

Mechanism of Action

Stimulant laxatives irritate the colon by secreting mucous, water and electrolytes into the intestine to dilute the irritants, stimulating peristalsis to remove them from the body. The oral form of Bisacodyl is activated by bacterial intestinal enzymes as it enters the colon. Senna is a plant-derived compound that is also activated in the large intestine (Daniels & Schmelzer, 2013).



9.7d Stimulant laxatives mechanism of action (Sheila Odubote/ TRU Open Press)

Administration Considerations

- Side effects: abdominal cramping, diarrhea
- Can cause dehydration if a large amount of diarrhea.
- Caution with pregnancy or lactation, consult prescriber prior to use.
- Senna often taken in the evening for BM in the morning. Works within 8-12 hours.
- Bisacodyl suppositories:
    - work within 15 minutes.
    - side effects: abdominal cramps, rectal burning, dizziness
    - do not insert the supp into the rectal mass. Instruct client to retain suppository for 15-30 minutes (see Figure 9.7d).

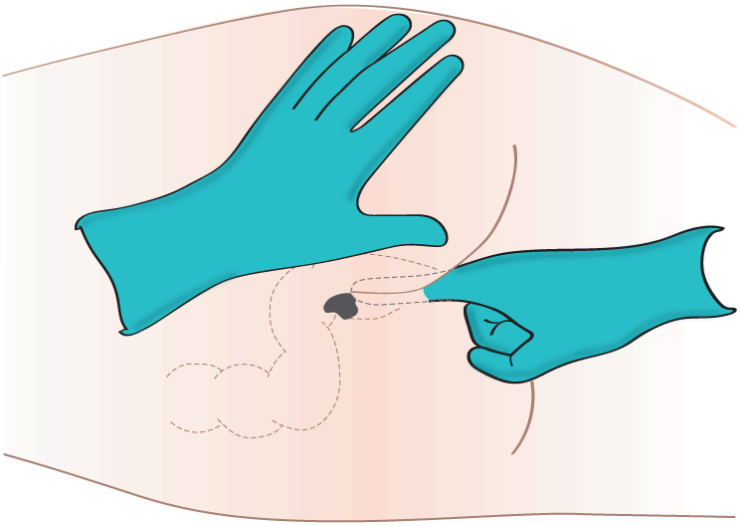


Figure 9.7e Administering a rectal suppository

Client Teaching

- Stimulants should be used for occasional constipation as tolerance can develop for the med. For ongoing constipation, further health teaching to manage constipation is advised.
- Oral senna or bisacodyl usually work within 6-10 hours. A strong and potent urge to defecate may occur, so advise to be close to a bathroom.
- Advise client of side effects
- Caution use with clients at risk for dehydration, especially if they experience significant diarrhea.

(Adams et al, 2019; Daniels & Schmelzer, 2013; Sealock & Seneviratne, 2019).

Comparing Laxative Medications

Now let's take a closer look at the Comparing Laxative Medication Table to help with learning the material.

Medication cards or tables are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult current evidence-based resources before administering specific medication. Basic information related to each class of medication is outlined below.

Click on the link to access Stool Softeners and Laxatives to treat Constipation:

Table 9.7b Stool Softeners and Laxatives Used to Treat Constipation

Adapted from: Chippewa Valley Technical College; Egert, A., Lee, K, Gill, M. (2023). Fundamentals of Nursing Pharmacology (1st Canadian ed.). https://opentextbc.ca/nursingpharmacology/chapter/7-6-antidiarrheal-laxatives/ ; Daniels & Schmelzer, 2013; Sealock & Seneviratne, 2021.

Client Education to Manage Constipation

As one of the most common ailments, most people have experienced constipation at some point in their lives. Health teaching to help prevent or alleviate constipation should include lifestyle changes such as adequate hydration, dietary changes and exercise.

- Diet with fiber-rich foods such as fruits, vegetables such as broccoli, cabbage or spinach, and whole grain breads. Aim for 20-30 grams/day.
- Ensure to maintain hydration. Ensure to include exercise daily.
- Ensure good bowel habits: respond to the urge, set up a

routine.
- If constipation is not managed with lifestyle changes, then stool softeners or laxatives should be considered.

Consult a health care provider for chronic constipation not relieved by lifestyle and the occasional use of laxatives.

For client who are pregnant or breastfeeding, bulk-forming laxatives are considered safe.

Comparing Stool Softeners and Laxatives

To support your learning, you can access the Chapter 9 Comparing Laxatives and Stool softeners table. This is a downloadable and editable document to allow you to update and add content.

Interactive Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here:

https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=2569#h5p-29

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=2569#h5p-30

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=2569#h5p-31

Clinical Reasoning and Decision-Making Activity

A client who underwent hip surgery two days ago has not had a bowel movement since before admission. The client is receiving oxycontin ER 10 mg every 12 hours and oxycodone 5 mg every 4 hours for pain. The client describes abdominal discomfort and the nurse finds decreased bowel sounds in all quadrants. The nurse notifies the physician, follows the bowel protocol, and administers PEG 3350 to the client.

1. What are the potential causes of constipation that should be addressed for this client?
2. What is the mechanism of action for PEG 3350?
3. The client asks how quickly the medication will work. What is the nurse's best response?
4. What other preventative measures for constipation should the nurse teach the client?
5. If PEG 3350 is not effective within 24 hours, what other medications can the nurse anticipate to be ordered?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 9: Gastrointestinal Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition sections at the end of the book.

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9.8 Antiemetics

Nausea is a common condition that can occur temporarily and be self-limiting to more chronic conditions which can be very debilitating. For a review of causative factors of nausea, refer to unit 9.3 Conditions and Diseases of the Gastrointestinal System. For severe cases of vomiting, intravenous fluids may also be needed to treat the accompanying dehydration (Medline Plus, 2019; Bashashati, & McCallum, 2014). The treatment of nausea and vomiting should be tailored to the causative factor. There are several medications that work on different neuroreceptors that can treat nausea and vomiting. Table 9.8 compares the neurotransmitters involved in the nausea and vomiting process, classes of antiemetic medication targeting these neurotransmitters, prototype antiemetic medications, and associated mechanisms of action (Bashashati, & McCallum, 2014; Garrett et al, 2003; Sealock & Seneviratne, 2021). Each medication class is also discussed in more detail later in this section.

Table 9.8 Neurotransmitters and Associated Medications Used to Treat Nausea and Vomiting

Neurotransmitter	Medication Class	Antiemetic Drug	Mechanism of Action
Acetylcholine (M1)	Anticholinergics	Scopolamine	Blocks ACh receptors in vestibular system
Histamine (H1)	Antihistamines	Meclizine, Dimenhydrinate, Diphenhydramine	Blocks H1 receptors and thus blocks ACh in vestibular system
Dopamine (D2)	Dopamine 2 antagonists	Prochlorperazine, Promethazine	Blocks dopamine in CTZ and also block ACh
Dopamine and ACh (DA2 and M1)	DA2 + Prokinetics	Metoclopramide	Blocks dopamine in CTZ and stimulates ACh in GI tract
Serotonin (5HT)	Serotonin antagonists	Ondansetron	Blocks serotonin in GI tract, CTZ, and VC
Substance P (NK1)	Neurokinin antagonists	aprepitant	Inhibits substance P neurokinin receptors
Cannabinoid (CB1)	Tetrahydrocannabinols (THC)	dronabinol or medical marijuana	Activated CB1 receptor leading to inhibitory effects on cerebral cortex, reticular formation & thalamus.

Antiemetic Medication Classes

Anticholinergics

Scopolamine is an example of an anticholinergic medication that is often used to treat motion sickness or nausea and vomiting associated with recovery from anesthesia and/or opiate analgesia.

Mechanism of Action

Anticholinergics block acetylcholine (ACh) receptors in the vestibular center and within the brain to prevent nausea-inducing stimuli to the Chemoreceptor Trigger Zone (CTZ) and the Vomiting Center (VC). They also block receptors in the reticular formation, preventing Ach binding to these receptors and therefore stop the signals to the VC. Due to the anticholinergic effects, they also dry GI secretions and reduce smooth muscle spasms.

Administration Considerations

The scopolamine transdermal patch (see Figure 9.7a) is designed for continuous release of scopolamine following the application to an area of intact skin on the head, behind the ear. The system is formulated to deliver approximately 1 mg of scopolamine to the systemic circulation over 3 days.

Possible side effects and contraindications:

- Due to its anticholinergic properties, scopolamine can decrease gastrointestinal motility and cause urinary retention.

Monitor client and discontinue with client reports difficulty urinating.

- Other side effects: constipation, blurred vision, flushing
- Adverse effects: exacerbate psychosis, induce seizures, and cause drowsiness, confusion, and sedation.
- contraindicated in clients with glaucoma.
- Clients going for MRI: Transderm Scōp contains an aluminized membrane; skin burns have been reported at the application site in clients wearing an aluminized transdermal system during an MRI scan. Remove patch before undergoing an MRI.

Figure 9.8a Scopolamine Transdermal Patch

Application instructions:

- Only wear one transdermal system at any time.

- Do not cut the transdermal system.
- Apply the transdermal system to the skin in the postauricular area (hairless area behind one ear).
- After the transdermal system is applied on the dry skin behind the ear, wash hands thoroughly with soap and water and dry hands.
- If the transdermal system becomes displaced, discard the transdermal system, and apply a new transdermal system on the hairless area behind the other ear.
- For surgeries other than caesarean section, apply one Transderm Scōp transdermal system the evening before a scheduled surgery. Remove the transdermal system 24 hours following surgery (Riad & Hithe, 2023).

Client Teaching

- Ensure clients are aware of potential side effects or adverse effects.
- May impair the mental and/or physical abilities required for the performance of hazardous tasks such as driving a motor vehicle, operating machinery, or participating in underwater sports.
- Concomitant use of other drugs (e.g., alcohol, sedatives, hypnotics, opiates, and anxiolytics) that cause central nervous system (CNS) adverse reactions, or that have anticholinergic properties, may increase this impairment. Inform clients not to operate motor vehicles or other dangerous machinery or participate in underwater sports until they are reasonably certain that Transderm Scōp does not affect them adversely.
- Can cause temporary dilation of the pupils resulting in blurred vision if it comes in contact with the eyes. Advise clients to wash their hands thoroughly with soap and water and dry their hands immediately after handling the patch.

- Upon removal, fold the used transdermal system in half with the sticky side together, and discard in household trash in a manner that prevents accidental contact or ingestion by children, pets, or others (Riad & Hithe, 2023).

Antihistamines

Meclizine is an example of an antihistamine that is often used to treat motion sickness. Other antihistamines include Dimenhydrinate and Diphenhydramine. Diphenhydramine (trade name: Benadryl) is used for many purposes besides nausea such as allergy symptoms and rhinitis. Dimenhydrinate (trade name: Gravol) is used extensively for treating nausea and vomiting. Many antihistamines are available orally OTC.

Mechanism of Action

Antihistamines inhibit the action of histamine at the H1 receptors in the vestibular center. They also block H1 receptors located in nerves, smooth muscle and glands. Further, antihistamines have potent anti-cholinergic activity blocking acetylcholine at the muscarinic receptors in the reticular formation and vestibular nuclei, which leads to many of the side effects experienced by clients.

Nursing Considerations

Antihistamines are a relatively safe medication, used extensively both as an OTC option and in hospital settings.

Given oral, IV, IM. Well absorbed orally.

Motion sickness: dosage should be started one hour before travel begins.

Crosses the placenta, should be avoided in pregnancy or use following a medical consult.

Caution with the older adult; may develop agitation, confusion and hypotension.

Potential Side effects:

- Dry mouth, slower gastric motility (constipation), urinary retention, sedation, drowsiness.
- Some health conditions are contraindicated with antihistamines:
    - clients with narrow angle glaucoma as it can lead to blurred vision
    - benign prostate hypertrophy (enlarged prostate gland) as it can lead to further urinary retention
    - COPD as antihistamines will dry bronchial passages leading to decreased ability to cough up secretions (Sealock & Seneviratne, 2021).

Client Teaching

- Do not exceed recommended dosage.
- Be advised that drowsiness may occur. Due to drowsiness, refrain from driving a motor vehicle or operating machinery.
- Avoid alcohol, sedatives, and tranquilizers, which may increase drowsiness.

Dopamine Antagonists

Phenothiazine is a broad antidopaminergic drug classification with two drugs: promethazine and prochlorperazine. Both are used to treat nausea and vomiting and used commonly in acute care settings. They are used for nausea related to surgery, chemotherapy, migraines, vertigo and even hiccups. Chlorpromazine, under the same antidopaminergic category, has been used as an antipsychotic medication to treat bipolar and schizophrenia. Off label, promethazine can also be used for its sedating properties as it blocks H1 receptors in the brain.

Our prototype medication will be promethazine

Mechanism of Action

Phenothiazine blocks dopamine in the Chemoreceptor Trigger Zone (CTZ). It also has antihistaminergic and anticholinergic effects.

Administration Considerations

Administration: oral, IM or IV.

- It is preferred to be given oral or IM. Deep IM injection as SQ will damage tissue.
- Give with food, water or milk to decrease GI discomfort.
- IV route: extreme caution as if it goes interstitial, tissue necrosis can occur. Only use a large bore IV with a running IV line. Tell client to report any burning at the site, and stop the infusion immediately.

Used for short term therapy due to risk of tardive dyskinesia with long term use.

Contraindicated in clients with:

- Movement disorders such as seizures, Parkinson's disease.
- encephalopathy, comatose, dementia
- bone marrow depression.

Contraindicated with:

- the older adult due to neuro side effects.
- in children under age 2 or under 20 pounds. Due to sedating properties, can cause respiratory depression.

May be given in pregnancy for difficult-to-treat nausea.

Side effects: sedation, confusion, disorientation. Anti-cholinergic effects such as dry mouth, urinary retention and constipation.

Adverse effect: neuroleptic malignant syndrome – rare but potentially fatal adverse effect (cues: hyperpyrexia, altered mental status, muscle rigidity, and autonomic instability)

Client Teaching

- Instruct to take medications as prescribed.
- Avoid alcohol and other CNS depressants.
- May experience increased photosensitivity

Sealock & Seneviratne, 2021; Southhard & Al Khalili, 2024

Dopamine 2 Antagonist and Prokinetics

Prokinetics are named as they get the GI tract moving. It enhances

GI motility by promoting peristalsis and enhances GI emptying. Metoclopramide is an example of a prokinetic medication (see Figure 9.8b). It has both dopaminergic antagonist and prokinetic action. By promoting peristalsis, it can help alleviate nausea and treats a wide range of nausea-related conditions. It is beneficial for clients with delayed gastric emptying and in treating GERD symptoms. It is also used to treat nausea in post op and chemotherapy clients. It can be used off-label for pregnant women with hyperemesis gravidarum. For severe migraines, it has also been shown to be effective.

It is a prescription only medication due to the risk of adverse effects.

Figure 9.8b Prokinetics

Mechanism of Action

The primary action of metoclopramide is that it blocks central and peripheral dopamine 2 receptors in the CTZ, which desensitizes the

CTZ to impulses it receives from the GI tract. Metoclopramide is also a prokinetic, it has a number of actions.

- Antagonizes 5HT3 (type 3 serotonin receptors) and an agonist at 5HT4 receptors.
- Blocks the anti-peristaltic effects of apomorphine, leading to an acceleration of gastric emptying.
- Increases the tone of the esophageal sphincter and relaxes the pyloric sphincter, leading to increased peristalsis action (Isola et al, 2023).

Administration Considerations

Administer Oral, IM or IV. Metoclopramide is lipid-soluble, giving it a large half-life and a large volume of distribution. Its half-life can range from 4.5 hours to 8.8 hours. It is typically used short term use only.

- IV onset of action is 1-3 minutes
- IM onset of action 10-15 minutes
- Oral onset of action 30-60 minutes

It has a long t1/2 ranging from 4.5 to 9 hours, thus a long duration of action. Any renal impairment will prolong its effects.

Do not use if stimulation of GI motility might be dangerous (e.g., in the presence of gastrointestinal hemorrhage, mechanical obstruction, or perforation).

Side effects include:

- Orthostatic Hypotension
- Sedation
- Headache
- Dry mouth, diarrhea

Adverse effects:

- Risk of extrapyramidal effects including tardive dyskinesia with long term use.
- Do not take if already taking meds that have potential to cause extrapyramidal effects such as antipsychotics and tricyclic antidepressants.
- Rare: neuro-malignant syndrome

Contraindicated in clients with:

- pheochromocytoma – may cause hypertensive crisis.
- epilepsy or clients with movement disorders (ie. Parkinson's disease)
- older adult especially due to orthostatic hypotension

Client Teaching

- Advise client of side effects and adverse effects
- Avoid with other meds that may cause sedation such as alcohol or sedatives.
- Teach clients to immediately inform the healthcare provider if they experience new feelings of depression or abnormal muscle movements they cannot control such as:
    - lip-smacking, chewing, or puckering of the mouth
    - frowning or scowling
    - sticking out the tongue
    - blinking and moving the eyes
    - shaking of the arms and legs

To deepen your understanding, visit the *What Is Tardive Dyskinesia?* page on the Tardive Impact website (2025) and watch the available videos under "Recognizing symptoms of TD."

Serotonin Receptor Antagonists

Ondansetron is an example of a serotonin (5HT) antagonist often used to treat severe nausea and vomiting associated with chemotherapy, postoperative nausea and vomiting, and hyperemesis during pregnancy. It is not effective against motion sickness. Ondansetron is considered a safe, well tolerated medication with minimal side effects. It is available by prescription only and is more costly than other options. As such, for clients at home, it is typically prescribed when other anti-emetics have been tried and not successful.

See Figures 9.8c and 9.8d for images of the injectable and oral formulations of ondansetron.

Figure 9.8c Ondansetron in injectable form

Figure 9.8d Ondansetron in tablet form

Mechanism of Action

Ondansetron blocks serotonin receptors in the small bowel, vagus nerve and the chemoreceptor trigger zone (CTZ). This action then decreases the afferent visceral and CTZ stimulation of the vomiting center (VC). Because of the diffuse blocking of serotonin, ondansetron is effective for many causes of nausea.

(See Figure 9.8e for an image of ondansetron blocking the 5-HT3 receptor.[13])

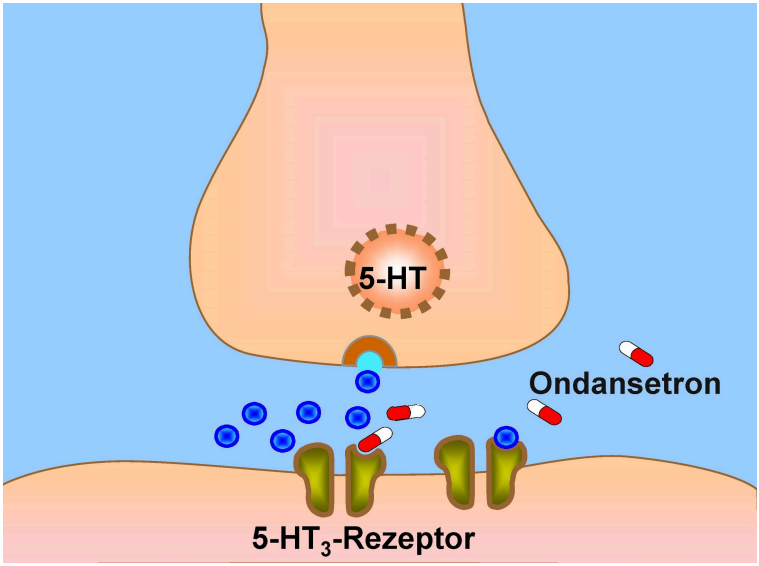

Figure 9.8e Ondansetron blocking the 5-HT3 receptor

Administration Considerations

Ondansetron is available as an orally disintegrating tablet, intramuscularly, and as an injectable for those clients too nauseated to tolerate oral medication. It is well tolerated and very effective. Side effects include:

- Headache is a primary side effect
- Fatigue, drowsiness
- Constipation, diarrhea
- Fever

Other adverse effects, albeit rare, can include hypersensitivity reactions and transient elevation of liver enzymes. Also rare, is the asymptomatic QT prolongation and QRS widening (Flake, Scalley

& Bailey, 2004). Older adults and clients with any cardiac issues, electrolyte imbalances or taking other meds that also prolong QT interval, may be more susceptible to the ECG changes and subsequent risk of torsade's de pointes. When giving ondansetron regularly and in higher doses, closer monitoring may be required (Singh et al, 2023).

Clients that take other serotonin antagonists or selective serotonin reuptake inhibitors (antidepressant), can have a risk of serotonin syndrome.

It can be used for pediatric and adult clients. For children, it is prescribed for gastroenteritis, and particularly effective is the dissolvable tablet. It can also be prescribed for first trimester pregnancy although there is inconclusive evidence of its safety for the fetus (Flake, Scalley & Bailey, 2004).

Client Teaching

Ondansetron has side effects that affect the CNS, cardiovascular and gastrointestinal systems. Clients should be well-informed of these potential effects and take necessary precautions. Teach clients to immediately inform their healthcare provider if they experience:

- heart rate change, light-headedness,
- dizziness,
- hypersensitivity reactions such as fever, chills, rash, or breathing problems

Other side effects such as diarrhea or constipation and headache are usually mild and self-limiting.

(Griddine & Bush, 2023).

Neurokinin Receptor Antagonists

Aprepitant is an example of a neurokinin antagonist used to prevent nausea and vomiting associated with chemotherapy and surgery. It also has anxiolytic and antidepressant properties. It is used as part of an anti-emetic regime, especially for clients undergoing chemotherapy. It is taken orally or by intravenous. Due to being so costly, it is only used in hospital or clinic settings.

Mechanism of Action

Aprepitant, a NK-1 receptor antagonist, competitively binds to the NK-1 receptor, thereby blocking the binding of substance P and preventing the transmission of the emetic signal. It is highly selective in crossing the blood-brain barrier to occupy NK-1 receptors in the brain.

Administration Considerations

Aprepitant is usually administered concurrently with dexamethasone (a corticosteroid) and ondansetron. It can be administered orally or intravenously.

Onset of action: one hour, with a peak effect in four hours, so it is not used for immediate anti-emetic relief, but for anticipatory nausea.

Anticipatory nausea: The duration of action of up to 40 hours makes this med ideal for managing the persistent nausea experienced with chemotherapy.

It is not approved for pregnancy. It might be given to pediatric clients, depending on the client context.

Aprepitant is renally excreted, so dose adjustments are required (Ibrahim, Pellegrini, & Preuss, 2023).

Drug Interactions

It has clinically significant CYP3A4 drug interactions with medications such as pimozide, diltiazem, and rifampin, and can decrease INR levels when taken concurrently with warfarin. It can also reduce the effectiveness of oral contraceptives. (Ibrahim, Pellegrini, & Preuss, 2023).

Aprepitant is metabolized by P450 in particular by CYP3A4, as well as CYP1A2 and CYP2C19. Numerous drug interactions can occur, so prescribers will do a comprehensive review of all medications to minimize or eliminate any drug interactions. Nurses need to complete a thorough medication profile with the client including OTC or herbal remedies (Ibrahim, Pellegrini, & Preuss, 2023).

Side Effects

Aprepitant side effects are mild and can include sleepiness, diarrhea, weakness, constipation, stomach pain, heartburn, nausea, hiccups, loss of appetite, headache, fever, itching, and hair loss.

Rarely, more severe adverse reactions can occur and include hypersensitivity reactions such as a rash, Stevens-Johnson syndrome or angioedema.

Figure 9.8f Steven-Johnson Syndrome rash

Photo Link:https://commons.wikimedia.org/wiki/File:Stevens-johnson-syndrome.jpg

Client Teaching

Advise client to take aprepitant as directed.

Ensure the client is aware of any potential side effects and to report immediately any hypersensitivity reaction such as a rash, angioedema, itching or difficulty breathing.

Many drug interactions can occur. Ensure the client reports any new medications, including OTC, herbal remedies or vitamins. Some drug interactions that require specific teaching include:

- Warfarin – NK-1 antagonists taken along with warfarin can lead to a decreased warfarin effect, and subsequently a higher risk of clot formation. Advise clients to monitor their INR levels more closely, which may require adjustment of the warfarin dosage while taking aprepitant.
- Oral contraceptives – NK-1 receptor antagonists may diminish the effectiveness of oral contraceptives. Advise the client to use a back-up pregnancy protection method, and continue with these measures for one month after discontinuing therapy (Ibrahim, Pellegrini, & Preuss, 2023).

Tetrahydrocannabinoids (THC)

Dronabinol and nabilone are synthetic THC along with medical marijuana are examples of a THC medications used to treat nausea, in particular clients with cancer or palliation when more conventional treatments have not been successful (see Figures 9.7f and 9.7g). It is also used for many other health issues including chronic pain relief, reducing spasticity related to spinal cord injury, seizure disorders, mental health conditions (depression and anxiety), and stimulating appetite (Sealock & Seneviratne, 2021).

Nabilone, another derivative of THC, is more potent than dronabinol and is used as well for the treatment of chemotherapy

induced nausea. Both medications are relatively safe, but dizziness, hypotension, euphoria, ataxia and dry mouth are commonly reported side effects (Drugs.com, 2025).

Figure 9.8g Dronabinol, a THC medication (Steffen Geyer/Marinol – Dronabinol) CC BY-NC 2.0

Figure 9.8h Medical Marijuana [Medical Marijuana](#)" *by* [Circe Denyer](#) *is licensed under* [CC0](#) [↵CC BY-NC 2.0](#)

Mechanism of Action

There is a great deal we are still learning about the effects of cannabinoids and its mechanism of action. Its anti-emetic effects are related to the inhibitory effects on the reticular formation, thalamus and cerebral cortex and through activating cannabinoid receptors in and around the vomiting center. Other effects might include antagonistic effects at 5-HT3 receptors in the brain (Sealock & Seneviratne, 2021).

Administration Considerations

As a lipophilic drug, Nabilone and Dronabinol cross the blood brain barrier and can cause dizziness, vertigo, and the dose-related "high" (easy laughing, elation, and heightened awareness). Although both of these products can produce some of the intoxicating effects similar to cannabis, they have a low abuse potential due to the slow onset of action. There is a risk of being abusable, and as such are a prescription medication.

Older adult: THC should be used cautiously in older adult clients because they may be more sensitive to the neurological, psychoactive, and postural hypotensive effects of the drug. In general, dose selection should be cautious, usually starting at the low end of the dosing range.

Pregnancy and Breastfeeding: THC should not be used while pregnant. Neonates are at risk for fetal growth restriction, low birth weight, and small for gestational age. THC passes through breastmilk, and although studies are limited, it is advised to sustain from breastfeeding for nine days after using THC (Drugs.com, 2025).

Client Teaching

THC has side effects that affect the CNS, GI, and cardiovascular systems. Clients should be well-informed of these potential effects and take necessary precautions.

- Avoid drinking alcohol as it can potentiate dizziness and drowsiness effects.
- Clients should not drive, operate machinery, or engage in any hazardous activity when using THC.
- Keep out of reach of children and pets.
- Nabilone can lead to psychological or physical dependence; use only as needed to treat nausea.

- Drug interactions are common, discuss with prescriber before starting medical cannabis or one of the prescribed medications.

Herbal and Vitamin Supplements

Herbal remedies have been used historically and still used today to treat nausea as part of traditional healing practices. For example, ginger has been used in traditional Indian and Chinese medicine as an antiemetic. Interestingly, 80% of the world population rely on traditional remedies or medicinal plants to treat not only nausea but many ailments. Although we are only highlighting a few herbal remedies, there are many others including cinnamon, lavender, and citrus (Mohsenzadeh et al, 2018).

There is a public perception that herbal remedies are safe, but there can be adverse effects, especially if used along side pharmaceutical medications. A nurse's responsibility is to inform the client of potential risks if taking other medications and to recognize that all medications, including herbal supplements can cause side effects.

Ginger

Ginger is a well-known antiemetic. Although its mechanism of action is not completely understood, ginger is thought to antagonize the 5HT and cholinergic receptors and may have direct effect on the gastrointestinal tract. Although ginger can cause reflux and heartburn and may potentially cause bleeding because of its anticoagulant effects, dosages of up to 2 g per day in divided doses of 250 mg are considered safe, even in pregnant women.

Ginger can be taken in different forms. Tablets or capsules are

convenient and are easily available at most pharmacies and health food stores. Other options are ginger tea or ginger candies if swallowing a capsule is not ideal.

Figure 9.8i Ginger root https://commons.wikimedia.org/wiki/File:Starr_070730-7818_Zingiber_officinale.jpg

Pyridoxine (vitamin B6)

Pyridoxine has also been recommended for treating nausea and vomiting in pregnancy. Typical dosages of pyridoxine, 10 to 25 mg every eight hours, cause minimal adverse effects (Mohr et al, 2021).

Peppermint

Peppermint can help relax the muscles in the digestive tract and can ease the nausea symptoms. It can be used as aromatherapy and has shown some benefit to reducing nausea. It can also be consumed in a tea or in a lozenge. Side effects of peppermint are typically minor and include acid reflux (Mohr et al, 2021).

Figure 9.8j Peppermint plant https://commons.wikimedia.org/wiki/File:Mentha_%C3%97_piperita%E2%80%93IMG_6075.jpg

Comparing Antiemetics Medication Table

Now let's take a closer look at the Chapter 9 Comparing Antiemetics table

Medication cards like this are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

Critical Thinking and Decision Making Questions

1. A four year old is admitted for surgery. The child is very nauseated post-op. The order reads:

   Promethazine 12.5-25mg PO/PR Q 4-6 hours PRN Is this a good choice for this client?

2. A patient is taking chemotherapy with a drug that has a high potential for causing nausea and vomiting. The nurse recognizes that the client will take a number of antiemetic medications. Which anti-emetics will be ordered to manage the nausea?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 9: Gastrointestinal Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition sections at the end of the book.

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9.9 Clinical Reasoning and Decision-Making Learning Activities

Interactive Learning Activities

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Critical Thinking and Decision Making Activities

1. A nurse is caring for a client who underwent surgery earlier today and is experiencing nausea and vomiting. The original post-op orders included prochlorperazine, but the client continues to experience vomiting despite receiving this medication. The nurse calls the provider and receives a new order for ondansetron orally dissolving tablets, 8 mg three times daily as needed.

    a. How will the nurse assess for symptoms of dehydration?

    b. When administering the medication, the client states, “I don’t think I can swallow anything right

now. Is there another way I can get this med?" What is the nurse's best response?

c. What other measures should the nurse teach the clients to reduce feelings of nausea and avoid dehydration?

2. A 82 year old client has been admitted for partial bowel obstruction due to fecal impaction. She has a number of health issues including atrial fibrillation, hypertension and GERD. She tells the nurse she is quite nauseated. The nurse considers two anti-emetics, which one is best for this client? metoclopramide or ondansetron? Explain your answer.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 9: Gastrointestinal Medications Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition sections at the end of the book.

CHAPTER 10: ENDOCRINE SYSTEM: PART 1

10.0 Endocrine System Introduction

Learning Objectives

1. Review the function of the endocrine system, including the glands and hormones.
2. Describe the classifications and actions of endocrine system drugs
3. Provide examples of indications, administration and which populations endocrine system drugs may be administered
4. Identify the side effects and nursing considerations associated with endocrine system drug therapy
5. Identify the considerations and implications of using endocrine system medications across the lifespan
6. Apply evidence-based concepts when using the nursing process and clinical reasoning related to medications that affect the endocrine system
7. Identify indications, side effects, and potential drug interactions associated with the use of herbal supplements

Key Terms

- **A1C**
- **adrenal medulla**
- **aldosterone**
- **antidiuretic hormone**
- **basal insulin**
- **blood osmolality**
- **diabetes insipidus**
- **exocrine gland**
- **general adaptation syndrome**
- **glycolysis**
- **hormones**
- **humoral stimuli**
- **hyperglycemia**
- **hypoparathyroidism**
- **hyperthyroidism**
- **hypothyroidism**
- **hypoglycemia**
- **hypothalamic-pituitary-adrenal axis**
- **hypothalamus–pituitary complex**
- **hypothyroidism**
- **insulin**
- **mineralocorticoids**
- **negative feedback loop**
- **neural stimuli**
- **osmoreceptors**
- **parathyroid hormone**
- **prandial insulins**
- **tropic hormones**
- **type 1 diabetes**
- **type 2 diabetes**

Have you ever wondered how your body controls functions such as digestion, metabolism, and the stress response? The endocrine system is always working behind the scenes, regulating various organs by releasing hormones and using feedback loops. Endocrine is a term that implies that in response to a specific stimulus, the products of those glands are released into the blood stream (Hiller-Stumhofel & Bartke, 1998).

The endocrine system is a crucial communication system that controls critical physiological processes. It consists of specialized cells and glands which release molecules called hormones. There are eight major glands throughout the body. These glands are the thyroid gland, pituitary gland, hypothalamus, adrenal gland, pineal gland, gonads and pancreas. They serve important roles in regulating growth and development, metabolism, sexual function, electrolyte balance and mood. Some examples of biological processes that are controlled by the endocrine system and

hormones are the development and functioning of reproductive organs (hormones estrogen and testosterone). Another example is the regulation of metabolism and nutrient balance (hormones insulin and thyroid hormones) (Health Canada, 2025).

When hormone levels are either too high or too low, this can indicate an endocrine disorder where the body does not respond as it should or that there is a dysfunction of a gland. Sometimes hormone dysfunction is related to substances that change hormone metabolism or prevent them from reaching their targets.

This chapter will begin with an overview of the endocrine system, focusing on some of the glands and hormones that are important for metabolic regulation. Unit 10.2, conditions and diseases related to the endocrine system, will provide a general overview of the common conditions. Lastly, this chapter will discuss medications that affect two of the major endocrine glands: the adrenal glands and the thyroid.

Due to the extensive nature of the endocrine system, medications that affect the pancreas will be examined in chapter 11: Endocrine System: diabetes mellitus and anti-diabetic medications.

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10.1 Metabolic Regulation Concepts

Concepts Related to Metabolic Regulation

For the purposes of this concept discussion, the Concept of Metabolic Regulation is defined as the regulation of hormonal and enzymatic processes required to maintain homeostasis (Giddens, 2017, pg. 241). This unit will review the concepts related to hormone regulation. This will include hypothalamus-pituitary gland complex and a review of the hormones and function of two glands, the pituitary and adrenals. A review of the pancreas, particularly related to glucose regulation will be reviewed in the subsequent chapter, chapter 11, Endocrine System: glucose regulation and anti-diabetic medications.

You may never have thought of it this way, but when you send a text message to two friends to meet you at a restaurant at six, you're sending digital signals that you hope will affect their behavior—even though they are some distance away. Similarly, certain cells send chemical signals to other cells in the body that influence their behavior. This long-distance intercellular communication, coordination, and control are critical for homeostasis, and it is the fundamental function of the endocrine system. Whereas the nervous system uses neurotransmitters to communicate, the endocrine system uses hormones for chemical signaling. These hormone signals are sent by the endocrine organs.

Hormones are transported primarily via the bloodstream throughout the body, where they bind to receptors on target cells, inducing a characteristic response. Some of the glands in the endocrine system include the pituitary, thyroid, parathyroid, adrenal, and pineal glands. Some of these glands have both

endocrine and nonendocrine functions. For example, the pancreas contains cells that function in digestion, as well as cells that secrete the hormones insulin and glucagon, which regulate blood glucose levels (Open Stax, 2022).

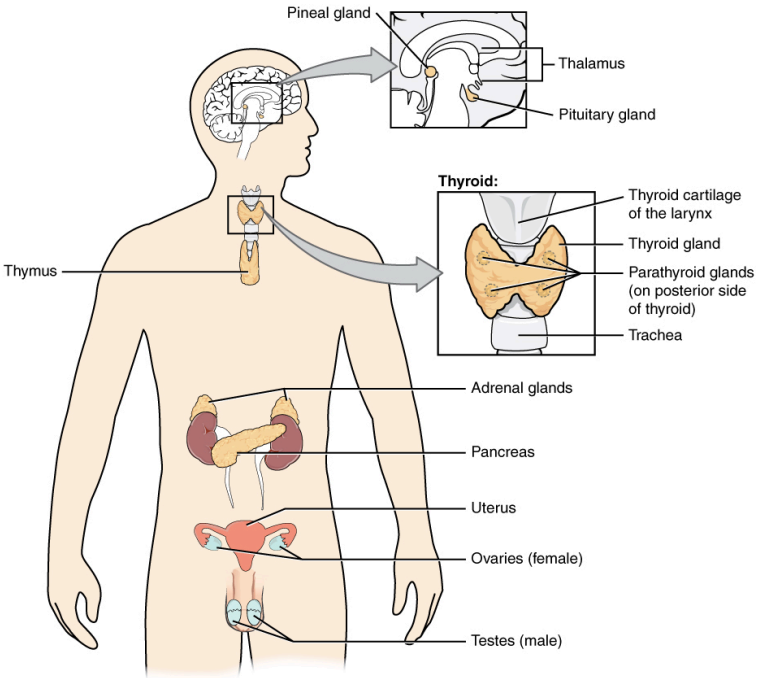

Figure 10.1a Overview of the Endocrine System [Image description] Some of the glands in the endocrine system include the pituitary, thyroid, parathyroid, adrenal, and pineal glands.

What is a hormone?

Hormones are molecules produced by various endocrine glands, which are then carried by the blood to their target cells. A hormone can have very specific target cells or affect numerous cell types throughout the body. Once the hormone binds with the receptor site on a cell, it triggers a cascade of reactions in the target cell resulting in modifying the cell's function or activity.

This module will focus on medications that affect three major endocrine glands and their hormones: the adrenal glands, the pancreas, and the thyroid. See Table 10.2 for a list of hormones associated with each of these glands and their effects.

Table 10.2. Hormones Associated with Adrenal Gland, Pancreas, and Thyroid and Their Effects

Endocrine gland	Hormone	Primary Hormone Function
Adrenal (cortex)	Aldosterone	Helps control the body's water and electrolyte regulation. Increases blood Na^+ levels
Adrenal (cortex)	Cortisol	Helps control carbohydrate, protein and lipid metabolism; Increases blood sugar levels. Protects against stress.
Adrenal (medulla)	Epinephrine and Norepinephrine	Stimulates fight-or-flight response
Pancreas	Insulin	Helps control carbohydrate metabolism; reduces blood glucose levels
Pancreas	Glucagon	Helps control carbohydrate metabolism; Increases blood glucose levels
Thyroid	Thyroxine (T4), triiodothyronine (T3)	Controls metabolic processes in all cells; stimulates basal metabolic rate
Thyroid	Calcitonin	Helps control calcium metabolism; reduces blood Ca^+ levels

Regulation of Hormone Secretion

To prevent abnormal hormone levels and a potential disease state, hormone levels must be tightly controlled. Feedback loops govern the initiation and maintenance of hormone secretion in response to various stimuli.

The most common method of hormone regulation is the negative feedback loop. Negative feedback is characterized by the inhibition of further secretion of a hormone in response to adequate levels of that hormone. This allows blood levels of the hormone to be regulated within a narrow range. An example of a negative feedback loop is the release of glucocorticoid hormones from the adrenal glands, as directed by the hypothalamus and pituitary gland. As glucocorticoid concentrations in the blood rise, the hypothalamus and pituitary gland reduce their signaling to the adrenal glands to prevent additional glucocorticoid secretion (Open Stax, 2022).

See Figure 10.1b for an illustration of a negative feedback loop (Open Stax, 2022).

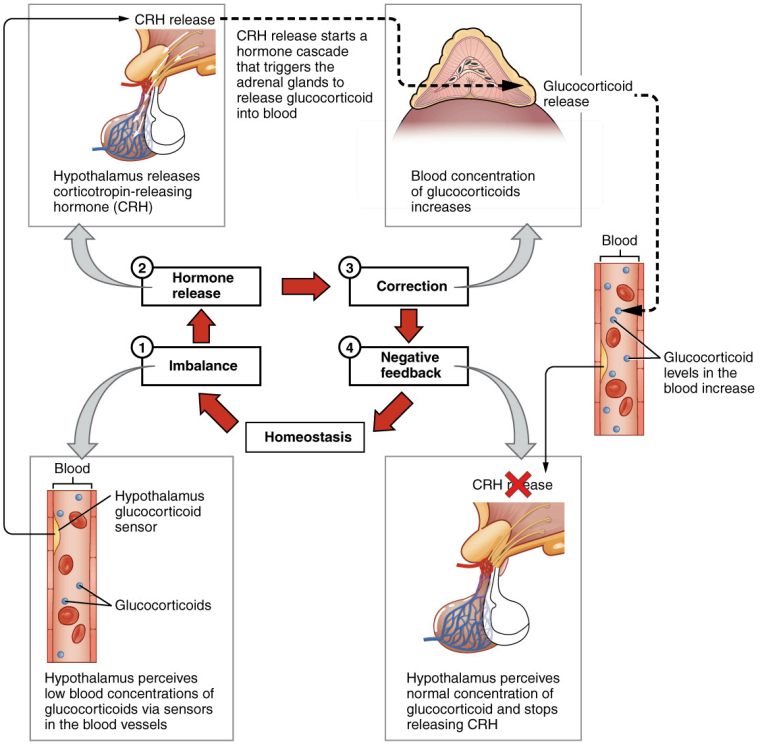

Figure 10.1b Negative Feedback Loop [Image description]

Endocrine Gland Stimuli

Endocrine glands can be stimulated by humoral stimuli, by stimulation of another hormone, or by neural stimuli. Humoral stimuli are changes in blood levels of non-hormone chemicals that cause the release or inhibition of a hormone to maintain homeostasis. For example, osmoreceptors in the hypothalamus detect changes in blood osmolality (the concentration of solutes in the blood plasma). If blood osmolality is too high, meaning that the blood is not dilute enough, osmoreceptors signal the hypothalamus to release ADH (antidiuretic hormone). ADH causes the kidneys to

reabsorb more water and reduce the volume of urine produced. This reabsorption causes a reduction of the osmolality of the blood by diluting the blood to the appropriate level. Another example of humoral stimuli is the regulation of blood glucose. High blood glucose levels cause the release of insulin from the pancreas, which increases glucose uptake by cells and liver storage of glucose as glycogen.

An endocrine gland may also secrete a hormone in response to the presence of another hormone produced by a different endocrine gland. For example, the thyroid gland secretes T4 into the bloodstream when triggered by thyroid-stimulating hormone (TSH) that is released from the anterior pituitary gland.

In addition to these chemical signals, hormones can also be released in response to neural stimuli. An example of neural stimuli is the activation of the fight-or-flight response by the sympathetic nervous system. When an individual perceives danger, sympathetic neurons signal the adrenal glands to secrete norepinephrine and epinephrine. The two hormones dilate blood vessels, increase the heart and respiratory rate, and suppress the digestive and immune systems. These responses boost the body's transport of oxygen to the brain and muscles, thereby improving the body's ability to fight or flee (Open Stax, 2022).

The Hypothalamus–Pituitary Complex

The hypothalamus–pituitary complex can be thought of as the "command center" of the endocrine system. This complex secretes several hormones that directly produce responses in target tissues, as well as hormones that regulate the synthesis and secretion of hormones of other glands. In addition, the hypothalamus–pituitary complex coordinates the messages of the endocrine and nervous systems. In many cases, a stimulus received by the nervous system must pass through the hypothalamus–pituitary complex to be

translated into hormones that can initiate a response. See Figure 10.1d for an illustration of the hypothalamus–pituitary complex (Open Stax, 2022).

The hypothalamus connects to the pituitary gland by the stalk-like infundibulum. The pituitary gland consists of an anterior and posterior lobe, with each lobe secreting different hormones in response to signals from the hypothalamus.

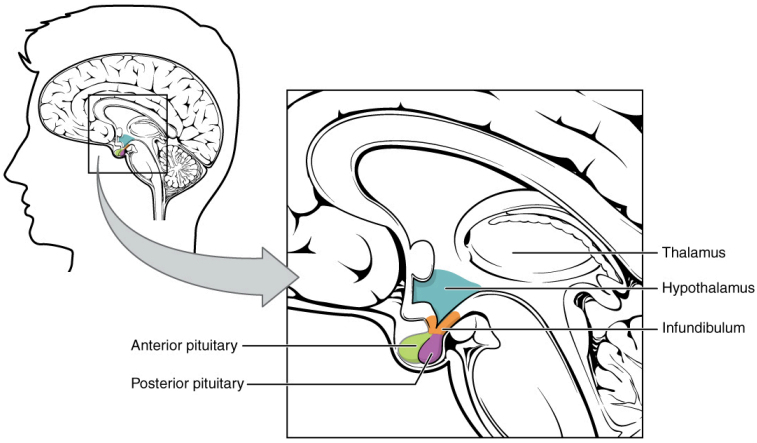

Figure 10.1c Illustration of the Hypothalamus–Pituitary Complex "1806 The Hypothalamus-Pituitary Complex.jpg

The Pituitary Gland and its Hormones

The pituitary is a gland about the size of a small marble and is located in the brain directly below the hypothalamus. The pituitary gland consists of two parts: the anterior pituitary and the posterior pituitary.

Posterior Pituitary

The posterior pituitary gland does not produce hormones, but stores and secretes two hormones produced by the hypothalamus: oxytocin and antidiuretic hormone (ADH).

Oxytocin

Oxytocin stimulates contractions in the uterus during childbirth. In nursing women, the hormone activates milk ejection or the let-down reflex.

Antidiuretic Hormone (ADH)

The antidiuretic hormone, is regulated by the osmolality of the plasma and it is also regulated by baroreceptors in response to hypovolemia and low arterial blood pressure. ADH is released in response to increased serum osmolality and decreased blood pressure, resulting in the reabsorption of water from the urine in the kidney (Copstead & Banasik, 2010).

Blood osmolarity, the concentration of sodium ions and other solutes, is constantly monitored by osmoreceptors in the hypothalamus. Blood osmolarity may change in response to the consumption of certain foods and fluids, as well as in response to disease, injury, medications, or other factors. In response to high blood osmolarity, which can occur during dehydration or following a very salty meal, the osmoreceptors signal the posterior pituitary to release antidiuretic hormone (ADH). Its effect is to cause increased water reabsorption by the kidneys. As more water is reabsorbed by the kidneys, a greater amount of water is returned to the blood, thus causing a decrease in blood osmolarity. The release of ADH is controlled by a negative feedback loop. As blood

osmolarity decreases, the hypothalamic osmoreceptors sense the change and prompt a corresponding decrease in the secretion of ADH. As a result, less water is reabsorbed by the kidneys.

Drugs can also affect the secretion of ADH or imitate its effects. For example, alcohol consumption inhibits the release of ADH, resulting in increased urine production that can eventually lead to dehydration and a hangover. Vasopressin is a synthetic ADH medication used to treat very low blood pressure. It is called vasopressin because in very high concentrations it also causes constriction of blood vessels in addition to the retention of water. Vasopressin is also used to treat a disease called diabetes insipidus (DI) that causes dehydration due to an underproduction of ADH (Open Stax, 2022).

Anterior Pituitary

In contrast to the posterior pituitary, the anterior pituitary does manufacture hormones. There are seven hormones it produces and can be divided into two categories. These hormones either:

- Directly affect target organs. These two hormones are growth hormone (GH) and prolactin.
    - GH stimulates somatic growth and regulates metabolism.
    - Prolactin stimulates breast tissue development and lactation and suppresses reproductive function. Prolactin is also released during sexual activity and stress.

- Stimulate target glands (i.e. adrenal glands, gonads, thyroid gland) to produce target gland hormones.
    - thyroid-stimulating hormone (TSH),
    - adrenocorticotropic hormone (ACTH),
    - follicle-stimulating hormone (FSH),
    - luteinizing hormone (LH),

- beta endorphin

Of the hormones of the anterior pituitary, TSH, ACTH, FSH, and LH are collectively referred to as tropic hormones (trope- = "turning") because they turn on or off the function of other endocrine glands.

The secretion of hormones from the anterior pituitary is regulated by two classes of hormones secreted by the hypothalamus. These are called releasing hormones and inhibiting hormones. They both help regulate growth, metabolism and reproduction. For example, thyrotropes release TSH in response to hypothalamic thyrotropin releasing hormone (TRH). An example of an inhibiting hormone is dopamine, that inhibits the release of prolactin, reducing lactation until needed (Copstead & Banasik, 2010). See Figure 10.1e to review the role of releasing hormones.

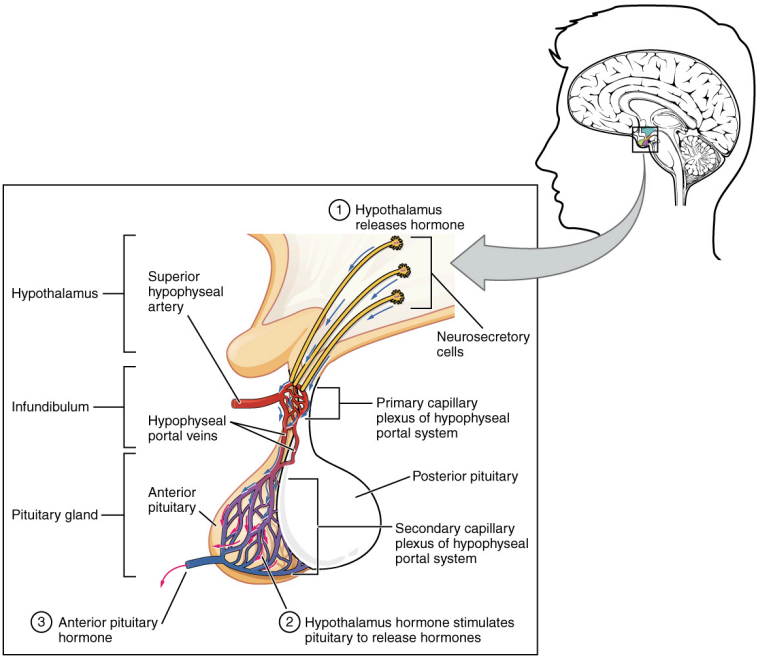

Figure 10.1d The hypothalamus releases hormones to regulate the release of hormones from the anterior pituitary.File:1808 The Anterior Pituitary Complex.jpg File:1808 The Anterior Pituitary Complex.jpg – Wikimedia Commons

Of the anterior pituitary hormones, this unit will focus on the effects of TSH and ACTH.

Thyroid-Stimulating Hormone (TSH)

The activity of the thyroid gland is regulated by the thyroid-stimulating hormone (TSH). TSH is released from the anterior pituitary in response to the thyrotropin-releasing hormone (TRH) from the hypothalamus and triggers the secretion of thyroid hormones by the thyroid gland. In a classic negative feedback loop, elevated levels of thyroid hormones in the bloodstream then trigger a drop in production of TRH and subsequently, the production of TSH. TSH is further discussed in the "Thyroid" submodule.

Adrenocorticotropic Hormone (ACTH)

The adrenocorticotropic hormone (ACTH) is released from the anterior pituitary in response to the corticotropin-releasing hormone (CRH) from the hypothalamus. ACTH then stimulates the adrenal cortex to secrete corticosteroid hormones such as cortisol. A variety of stressors can also influence the release of ACTH, and the role of ACTH in the stress response is discussed under the "Adrenal" submodule (Open Stax, 2022).

Watch the supplementary video about ACTH and the adrenal gland is provided below. ACTH and the Adrenal Gland

Forciea, B. (2015, May 12). Anatomy and Physiology: Endocrine System: ACTH (Adrenocorticotropin Hormone) V2.0. [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/4m7XflJzm2w. ↵

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=281#oembed-1

Adrenal Glands

The adrenal glands are located on top of the kidneys, and consists of the adrenal cortex that is composed of glandular tissue and the adrenal medulla that is composed of nervous tissue. Each region secretes its own set of hormones.

- Adrenal cortex: hormones released are glucocorticoids, mineralocorticoids and androgens.
- Adrenal medulla: hormones released are epinephrine and norepinephrine.

One of the major functions of the adrenal gland is to respond to stress. The body responds in different ways to short-term stress and long-term stress, following a pattern known as the general adaptation syndrome (GAS). Stage one of GAS is called the alarm reaction. This is short-term stress, also called the fight-or-flight response, and is mediated by the hormones epinephrine and norepinephrine from the adrenal medulla. Their function is to prepare the body for extreme physical exertion. If the stress is not soon relieved, the body adapts to the stress in the second stage called the stage of resistance. If a person is starving for example, the body may send signals to the gastrointestinal tract to maximize the absorption of nutrients from food. If the stress continues for a longer term however, the body responds with symptoms such as

depression, suppressed immune response, or severe fatigue. These symptoms are mediated by the hormones of the adrenal cortex, especially cortisol. Adrenal hormones also have several non–stress-related functions, including the increase of blood sodium and glucose levels, which will be described in further detail below.

Adrenal Cortex

The adrenal cortex is a component of the hypothalamic-pituitary-adrenal (HPA) axis. The hypothalamus stimulates the release of ACTH from the pituitary, which then stimulates the adrenal cortex to produce steroid hormones and include glucocorticoids (cortisol), mineralocorticoids (aldosterone), and the sex hormones (androgens). Steroid hormones travel in the circulation bound to proteins and diffuse through their target cell membranes and then binding with their cytoplasmic receptors. These hormones, and especially cortisol, are essential for life. They are important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation (Copstead & Banasik, 2010).

We will review each of the three types of hormones.

Mineralocorticoids: Aldosterone

The most superficial region of the adrenal cortex is the zona glomerulosa, which produces a group of hormones collectively referred to as mineralocorticoids because of their effect on body minerals, especially sodium and potassium. These hormones are essential for fluid and electrolyte balance.

Aldosterone is the major mineralocorticoid that is important in the regulation of the concentration of sodium and potassium ions in the body. Or, in other words, to maintain normal salt and water

balance in the body. To do this, aldosterone promotes sodium retention and potassium excretion at the distal renal tubules (Copstead & Banasik, 2010).

The secretion of aldosterone by the adrenal cortex is prompted by the HPA axis when the hypothalamus triggers ACTH release from the anterior pituitary. It is released in response to elevated blood levels of potassium (K^+), low blood levels of sodium (Na^+), low blood pressure, or low blood volume. Aldosterone targets the kidneys and increases the excretion of K^+ and the retention of Na^+, which, in turn, causes the retention of water, thus increasing blood volume and blood pressure.

The Renin–Angiotensin–Aldosterone System (RAAS) acts as a primary, long-term regulator of blood pressure, blood volume, and sodium/potassium balance. Aldosterone is a key component of RAAS in which specialized cells of the kidneys secrete renin in response to low blood volume or low blood pressure. Renin then catalyzes the conversion of the blood protein angiotensinogen, which is produced by the liver, to the hormone Angiotensin I. Angiotensin I is converted in the lungs to Angiotensin II by the angiotensin-converting enzyme (ACE).

Angiotensin II has three major functions:

- initiating vasoconstriction of the arterioles, thus decreasing blood flow;
- stimulating kidney tubules to reabsorb sodium and water, thus increasing blood volume;
- signaling the adrenal cortex to secrete aldosterone, which further increases blood volume and blood pressure.

It is important to understand these effects because many cardiac medications target the effects of aldosterone and the RAAS system. For example, drugs that block the production of Angiotensin II are known as ACE inhibitors. ACE inhibitors are used to help lower blood pressure in clients with hypertension by blocking the ACE enzyme from converting Angiotensin I to Angiotensin II, which,

in turn, causes vasodilation of the arterioles. Another medication called spironolactone is used as a diuretic because it blocks the effects of aldosterone and, thus, causes the kidneys to eliminate water and sodium to decrease blood volume and blood pressure. Refer to the diagram of the Renin-Angiotensin-Aldosterone System, figure 10.1e.

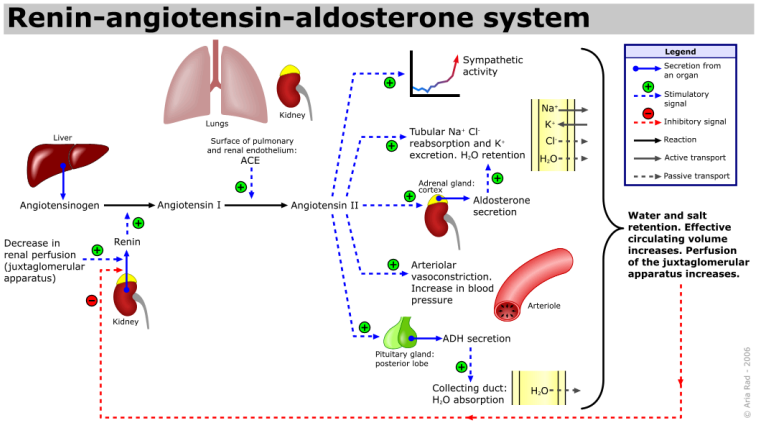

Figure 10.1e The renin–angiotensin system (RAS), or renin–angiotensin–aldosterone system (RAAS), is a hormone system that regulates blood pressure, fluid, electrolyte balance, and systemic vascular resistance. Retrieved from File:Renin-angiotensin-aldosterone system.png [File:Renin-angiotensin-aldosterone system.png – Wikimedia Commons]

Glucocorticoids: Cortisol

The intermediate region of the adrenal cortex produces hormones called glucocorticoids because of their role in glucose metabolism. Glucocorticoids, primarily cortisol, affects nearly every tissue in the body and has a broad range of effects. In simple terms, it has a role in the metabolism of fats, proteins and carbohydrates, it suppresses inflammation, regulates blood pressure, increases blood sugar, alters mood and behaviour, and helps control your sleep-wake cycle. If a person is stressed, cortisol is released to give your

body the energy boost. Some of the physiological effects of cortisol include:

- increases glucose levels in the blood by stimulating gluconeogenesis in the liver and promotes the formation of glycogen in the liver.
- contributes to protein catabolism by releasing muscle stores of proteins, providing amino acids for glucose production in the liver.
- promotes lipolysis and increased blood cholesterol levels
- reduces glucose uptake into muscle and adipose tissue, thereby opposing the effects of insulin and raising blood sugar.
- promotes protein and lipid breakdown into products, amino acids and glycerol, respectively, that can be used for gluconeogenesis in the liver.
- regulates inflammatory and immune responses to protect against the damaging effects of stress. (Copstead & Banasik, 2010, Open Stax, 2022).

In response to long-term stressors, the HPA axis triggers the release of glucocorticoids. Their overall effect is to inhibit tissue building while stimulating the breakdown of stored nutrients to maintain adequate fuel supplies. In conditions of long-term stress, cortisol promotes the catabolism of glycogen to glucose, stored triglycerides into fatty acids and glycerol, and muscle proteins into amino acids. These raw materials can then be used to synthesize additional glucose and ketones for use as body fuels. However, the negative effects of catabolism for energy can result in muscle breakdown and weakness, poor wound healing, and the suppression of the immune system.

It is likely clear that cortisol is a vital hormone in the response to acute stress, such as from infection, injury, hypoglycemia or emotional stress. These stressors lead to an increase in cortisol levels in the blood. Glucocorticoids are often given to treat conditions such as acute inflammation, overactive immune system

or high levels of cortisol. For example, glucocorticoids will suppress tissue inflammation such as a cortisone injection into an inflamed joint or giving steroid-based inhalers to manage inflammation that occurs in asthma.

Androgens

The deepest region of the adrenal cortex produces small amounts of a class of steroid sex hormones called androgens. During puberty and most of adulthood, androgens are produced in the gonads. The androgens produced in the adrenal cortex supplement the gonadal androgens.

Adrenal Medulla

The adrenal medulla is neuroendocrine tissue composed of postganglionic sympathetic nervous system (SNS) neurons, that secretes the hormones epinephrine and norepinephrine. It is an extension of the autonomic nervous system, which regulates homeostasis in the body. See Figure 10.1g for an illustration of the adrenal gland and associated hormones.

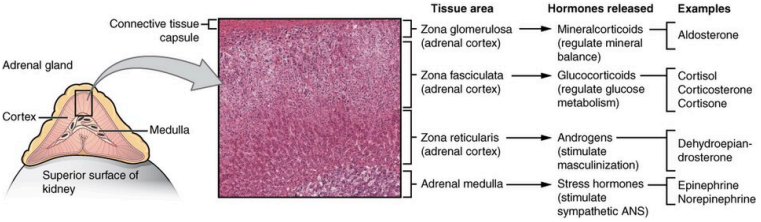

Figure 10.1f The Adrenal Gland and Associated Hormones. Both adrenal glands sit atop the kidneys and are composed of an outer cortex and an inner medulla, all surrounded by a connective tissue capsule. The cortex can be subdivided into additional zones, all of which produce different types of hormones. File:1818 The Adrenal Glands.jpg File:1818 The Adrenal Glands.jpg – Wikimedia Commons

Epinephrine and Norepinephrine

As noted earlier, the adrenal cortex releases glucocorticoids in response to long-term stress such as severe illness. In contrast, the adrenal medulla releases its hormones in response to acute, short-term stress mediated by the sympathetic nervous system (SNS). The medullary tissue is composed of unique postganglionic SNS neurons called chromaffin cells that produce the neurotransmitters epinephrine (also called adrenaline) and norepinephrine (also called noradrenaline), which are chemically classified as catecholamines. Epinephrine is produced in greater quantities and is the more powerful hormone.

The secretion of medullary epinephrine and norepinephrine is controlled by a neural pathway that originates from the hypothalamus in response to danger or stress. Both epinephrine and norepinephrine increase the heart rate, pulse, and blood pressure to prepare the body to fight the perceived threat or flee from it. In addition, the pathway dilates the airways, raising blood oxygen levels. It also prompts vasodilation, further increasing the oxygenation of important organs such as the lungs, brain, heart, and skeletal muscle while also prompting vasoconstriction to blood vessels serving less essential organs such as the gastrointestinal tract, kidneys, and skin. It also downregulates some components of the immune system. Other effects include a dry mouth, loss of appetite, pupil dilation, and a loss of peripheral vision.

In summary, there are many hormones that regulate the metabolic functions of our bodies. These hormones are influenced by a number of factors including circadian rhythms, hormone release from target cells, stress and pain. Endocrine disorders can be related to hyposecretion, hypersecretion and target cell hyperresponsiveness. We will explore some of these disorders in the next unit.

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=281#h5p-25

Media Attributions

- 10.1a "1801 The Endocrine System.jpg"
- 10.1b "1805 Negative Feedback Loop.jpg"
- 10.1c "1806 The Hypothalamus-Pituitary Complex.jpg"
- 10.1d "1808 The Anterior Pituitary Complex.jpg"
- 10.1e The hypothalamus releases hormones to regulate the release of hormones from the anterior pituitary. File:1808 The Anterior Pituitary Complex.jpg File:1808 The Anterior Pituitary Complex.jpg – Wikimedia Commons
- 10.1f The renin–angiotensin system (RAS), or renin–angiotensin–aldosterone system (RAAS), is a hormone system that regulates blood pressure, fluid, electrolyte

balance, and systemic vascular resistance. Retrieved from File:Renin-angiotensin-aldosterone system.png File:Renin-angiotensin-aldosterone system.png – Wikimedia Commons

- 10.1g The Adrenal Gland and Associated Hormones File:1818 The Adrenal Glands.jpg File:1818 The Adrenal Glands.jpg – Wikimedia Commons

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10.2 Conditions and Diseases Related to the Endocrine System

This chapter is attributed to Amanda Egert; Kimberly Lee; and Manu Gill.

As you have just learned, the endocrine system regulates vital hormonal and enzymatic functions. Individuals with metabolic regulation disorders have trouble regulating one or more of these functions. Disorders can be related to hyposecretion, hypersecretion or target tissue resistance. Sometimes the cause is primary, such when the gland releases an inadequate amount of hormone or it can be secondary, when the tropic hormone fails to cause the target gland to secrete adequate amounts of the hormone. Target tissue resistance is related to a deficiency in cellular receptors, leading to hyposecretion or hormone deficiency despite normal hormone levels (Copstead & Banisik, 2010).

Cushing's disease is an example of hypersecretion where the pituitary gland becomes hyperactive and oversecretes ACTH, which induces the adrenal cortex to produce too much cortisol. Another example is thyroid hormone resistance disorder which is caused by a gene mutation. This rare disorder causes a decreased responsiveness in different target tissues, and results in a mix of both hypothyroid and hyperthyroid symptoms. The client with this disorder will exhibit numerous physical alterations (growth delays, goiter) and physiological clinical issues (i.e. cardiovascular issues such as hypertension) (Prakash & Hamid, 2023).

This chapter will focus on metabolic regulation related to adrenal gland disorders, diabetes and thyroid disorders (Karch, 2017).

Disorders Involving the Adrenal or Pituitary Glands

Several disorders are caused by the dysregulation of the hormones produced by the adrenal glands. Dysregulation can occur with any of the hormones. Some conditions include:

- Grave's Disease: this is an autoimmune disorder that can cause hyperthyroidism. It is due to the immune system attacking the thyroid gland, leading to many body functions speeding up. If left untreated, it can lead to osteoporosis, irregular heart rate, vision changes and menstrual irregularities (NIDDKD, 2020).
- Lack of aldosterone secretion or hypoaldosteronism, can be due to a few different disorders. It can be due to hyposecretion of aldosterone (Addison's Disease), decreased stimulation of the adrenal cortex or aldosterone resistance. Sometimes the causes are medication related, such as suddenly stopping steroid therapy or due to diseases of the renal tubules. Addison's disease can be caused by an autoimmune disorder, and presents with symptoms such as hypoglycemia, hyponatremia, fatigue, muscle weakness and weight loss. In any case, finding the cause is important, and treating with a mineralocorticoid and low dose corticosteroid may be prescribed (Adams et al, 2018).
- Hypersecretion of glucocorticoids: Cushing's disease is due to pituitary gland ACTH excess, and less commonly due to adrenal tumours or other endogenous causes (NIDDKD, 2020). It is characterized by high blood glucose levels, the development of a moon-shaped face, a buffalo hump on the back of the neck, rapid central weight gain, and hair loss (Lui et al, 2015; Neiman et al, 2015). Not to be confused with Cushing's syndrome which is a disorder that is due to long-term, high-dose use of exogenous glucocorticoids. It is characterized with many of the above mentioned effects. For Cushing's syndrome,

minimizing these effects is important by prescribing glucocorticoids for the shortest period of time and the lowest dose.

- Acromegaly: this is a condition of hypersecretion of the growth hormone from the pituitary gland. This leads to an increase in size of bones, cartilage, body organs and other tissues. It can occur in both children and adults, and is rare. It can also lead to many other health issues such as arthritis, type 2 diabetes, hypertension and heart disease (National Institute of Diabetes and Digestive and Kidney Diseases (NIDDKD), 2020).

Figure 10.2a Moon face, the face is rounded due to deposits of fat. The moon face is seen in Cushing's syndrome.
Moon face in Cushing's syndrome By Ozlem Celik, Mutlu Niyazoglu, Hikmet Soylu and Pinar Kadioglu. License: CC BY 2.5 måneansigt – Lex

Disorders of the Endocrine System: Diabetes Mellitus

Dysfunction of insulin production and secretion, as well as the target cells' responsiveness to insulin, can lead to a condition called

diabetes mellitus, a common disease that affects the ability of the body to produce and/or utilize insulin. There are two main forms of diabetes mellitus.

Type 1 Diabetes is an autoimmune disease affecting the beta cells of the pancreas. The beta cells of people with type 1 diabetes do not produce insulin; thus, synthetic insulin must be administered by injection or infusion. Presenting symptoms include polyuria, polydipsia, and polyphagia. Clients may also have unexplained weight loss and blurred vision. If left untreated the client can go into ketoacidosis, a life-threatening condition.

Type 2 Diabetes accounts for approximately 95 percent of all cases. It is acquired, with contributing factors of family history, over the age of 40, overweight, and lifestyle factors such as poor diet and inactivity greatly increase a person's risk (Diabetes Care Community, 2023). In type 2 diabetes, the body's cells become resistant to the effects of insulin. In response, the pancreas increases its insulin secretion, but over time, decompensation occurs as the impaired beta cells are unable to produce sufficient insulin to overcome insulin resistance. In many cases, type 2 diabetes can be managed by moderate weight loss, regular physical activity, and consumption of a healthy diet. However, if blood glucose levels cannot be controlled, an oral diabetic medication is prescribed.

Type 2 diabetes is a progressive disease, especially if blood sugars are not kept within target range. The client often begins with one oral anti-diabetic medication, and may be prescribed additional meds depending on their blood sugars, other health issues and symptom management. As with type 1 diabetes, blood sugar control is essential to avoid hypoglycemia and hyperglycemia fluctuations. Over time, long term physiological changes can occur such as retinopathy, neuropathies, nephropathy leading to kidney failure and cardiovascular disease.

Diagnosis of Diabetes

Screening for type 2 diabetes should be done every 3 years for individuals over 40 years of age or anyone considered high risk of developing diabetes. If a client has numerous risk factors, screening may be done q 6-12 months or by the recommendation of their health care provider.

Screening includes fasting plasma glucose and/or glycated hemoglobin (A1C).

High risk factors include: family history of diabetes, history of pre-diabetes or gestational diabetes, overweight, or a member of a high-risk group: African, Arab, Asian, Hispanic, Indigenous or South Asian descent, low socioeconomic status (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2026).

Fasting blood glucose levels (FBG)	Normal: less than 5.6 mmol/L At risk: 5.6-6.0 mmol/L Pre-diabetes: 6.1 to 6.9 mmol/L Diabetes: greater than 7.0 mmol/L	Fasting at least 8 hours. (Slight differences in values between some sources. Normal FBG 4.0-7.0 reported with Diabetes Canada)
Random blood glucose test	Diabetes: 11.1 mmol/L or higher.	No fasting or preparation involved.
Oral glucose tolerance test (OGTT)	Following ingesting 75 grams of glucose in a drink, after 2 hours: Diabetes: BG level 11.1 mmol/L or higher Pre-diabetes: 7.8 – 11.0 mmol/L	measures your body's ability to use glucose. Plasma glucose level drawn, followed by a 75 gram glucose load, then second blood glucose level.
Glycosylated hemoglobin, also called A1C	Normal: under 5.5% At risk: 5.5-5.9% Pre-diabetes: 6-6.4% Diabetes: greater than 6.5%	Used to assess long-term blood glucose levels over 3 months. Good indicator of blood glucose control. (Normal under 5.7% with Diabetes Canada)

For more information on diabetes management in Canada, go to the Diabetes Canada website: About diabetes – Diabetes Canada this is an excellent resource for clients and health care professionals.

Disorders of the Thyroid Gland: Iodine Deficiency, Hypothyroidism, and Hyperthyroidism

Hyposecretion of the thyroid gland results in an inadequate amount of serum thyroid hormone to meet the physiological needs. Inflammation of the thyroid gland is a common cause of **hypothyroidism**, or low blood levels of thyroid hormones. Hypothyroidism is a disorder characterized by a low metabolic rate, weight gain, cold extremities, constipation, reduced libido, menstrual irregularities, and reduced mental activity, and requires long-term thyroid hormone replacement therapy, such as thyroxine.

In contrast, **hyperthyroidism**—an abnormally elevated blood level of thyroid hormones—is often caused by Grave's disease and less commonly by a pituitary tumor. In Graves' disease, the hyperthyroid state results from an autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland. Symptoms of hyperthyroidism include an increased metabolic rate, excessive body heat and sweating, diarrhea, weight loss, tremors, and increased heart rate. The person's eyes may bulge (called exophthalmos) as antibodies produce inflammation in the soft tissues of the orbits. The person may also develop a goiter, an enlarged thyroid gland.

Treatment for hyperthyroidism is thyroid surgery or with radioactive iodine (RAI) therapy. Patients are asked to follow radiation precautions after RAI treatment to limit radiation exposure to others, especially pregnant women and young children, such as sleeping in a separate bed and flushing the toilet 2-3 times after use. The RAI treatment may take up to several months to have its effect. The end result of thyroid surgery or RAI treatment is often hypothyroidism, which is treated by thyroid hormone replacement therapy (American Thyroid Association, 2019).

Other Metabolic Regulation Conditions and Disorders

This unit has provided a brief overview of common health issues related to the endocrine system. For a more detailed understanding of these conditions, refer to relevant resources. Due to the limited scope of this textbook, we will not be discussing other metabolic regulation disorders. If you are interested, consider reviewing resources on the following disorders: Hyper and hypoglycemia, gestational diabetes, diabetic insipidus, diabetic ketoacidosis, and parathyroid disorders.

Media Attributions

- Figure 10.3a Moon face in Cushing's syndrome By Ozlem Celik, Mutlu Niyazoglu, Hikmet Soylu and Pinar Kadioglu. License: CC BY 2.5 måneansigt – Lex

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10.3 Corticosteroids

The adrenal cortex produces three types of hormones that have a role in the normal homeostasis or functioning of our bodies. These include androgens (regulation of sexual function), mineralocorticoids (regulation of water and electrolytes) and glucocorticoids.

Defining terms: corticosteroids is the umbrella term for both glucocorticoids and mineralocorticoids. In practice, corticosteroids generally refer to the glucocorticoid effect.

Glucocorticoids + mineralocorticoids = Corticosteroids

To fully understand how the corticosteroid medications work as well as important nursing considerations, nurses need a solid understanding of the physiological effects of each of these hormones. Refer to unit 10.1 or other references. In this unit, we will do a brief physiology overview. Following that, we will examine corticosteroids, namely glucocorticoids.

The focus of this unit will not include mineralocorticoids, such as aldosterone, which is for water and electrolyte regulation.

Endogenous corticosteroids (glucocorticoids) are involved in a range of metabolic, immunosuppressant, anti-inflammatory and central nervous system effects. They are regulated by a negative feedback mechanism.

Regulation and synthesis of glucocorticoids:

The endogenous storage of glucocorticoids is minimal, so whatever is needed is produced. When cortisol levels are low, such as in the late evening and through the night, the hypothalamus releases cortico-tropin releasing hormone (CRH) into the bloodstream, which travels to the anterior pituitary gland. This triggers the release of adrenocorticotropin hormone (ACTH). ACTH then travels

via the blood to the adrenal cortex which stimulates the production of cortisol. When cortisol levels peak, it signals negative feedback to the hypothalamus and HPA, which is then inhibited, until cortisol levels are low enough to start over again. Basal levels follow the circadian rhythm. Cortisol levels are lowest at bedtime, rise during sleep and reach a peak just before waking.

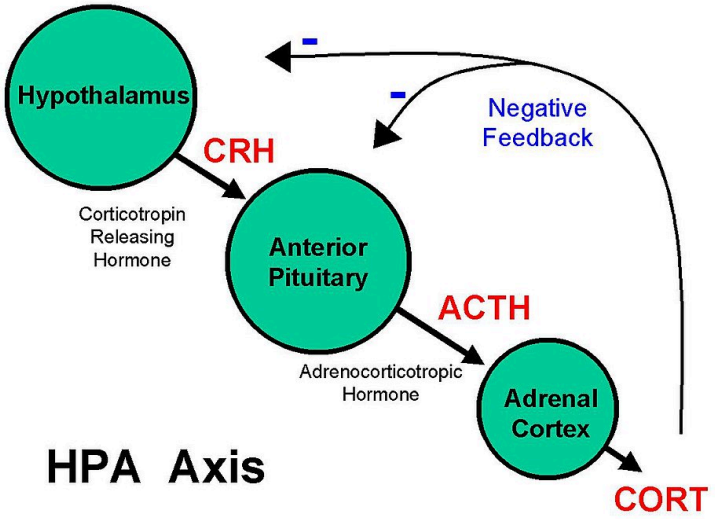

Figure 10.3a Hypothalamus Pituitary Adrenal Axis. File: Basic HPA Axis.jpeg [File:Basic HPA Axis.jpeg – Wikimedia Commons]

If there is stress, such as surgery, emotional stress, infection, or pain, the amount of cortisol released goes up. Cortisol regulates many functions including our immune system and inflammatory mediators. When we are stressed, cortisol will then stimulate physiological functions and then act on the hypothalamus and pituitary gland to suppress further release. If there is acute or chronic stress, which leads to higher cortisol levels, this can lead to higher blood pressure, weight gain, poor sleep among other responses.

Physiological effect vs pharmacological effect:

Corticosteroid medications can be prescribed for two purposes. These distinctions are important to know. The first is for **physiological effect** (maintenance, replacement), which are the to maintain cortisol levels produced by healthy adrenal glands. If the adrenals are not able to produce enough cortisol, the levels will get too low, and the result is adrenal insufficiency. An example is Addison's Disease. In this case, the treatment is to mimic the normal cortisol production and secretion. Hydrocortisone is one option that may be given to correct this deficiency.

Pharmacological effect is when high levels of corticosteroids are given to treat disorders unrelated to adrenocortical function. Examples of conditions include lupus, allergies, or asthma. In these cases, the treatment is for anti-inflammatory or immunosuppressant effects. Many conditions require short term treatment with corticosteroids such as exacerbation of ulcerative colitis, but other conditions may require long term therapy (Sealock & Seneviratne, 2021).

Endogenous corticosteroids regulate whole-body homeostasis with widespread effects:

- Metabolism: carbohydrate, protein and fat metabolism
- Supports skeletal muscle function
- Maintains vascular system
- Support neurological function: affects mood, sleep, behaviour
- Immunity and anti-inflammation

Corticosteroids

Corticosteroids are one of the most widely used medications. There is over 20 different formulations. They are used for numerous conditions and are available to administer in every route. All glucocorticoids do the same thing but differ in their onset of action, their potency, duration of action and amount of mineralocorticoid. They are often prescribed for their anti-inflammatory or immunosuppressive effects. Due to the fact that glucocorticoids are involved in almost every body system and impact the immune system, as well as carbohydrate, fat, and protein metabolism, adverse effects that are experienced when taking these medications, will affect every body system.

Indications of use

Corticosteroids are used for the management of various dermatologic, ophthalmologic, rheumatologic, pulmonary, hematologic, autoimmune diseases, shock, infectious and gastrointestinal (GI) disorders.

Exogenous corticosteroids are used for a variety of disorders such as:

- Endocrine disorders such as adrenocortical insufficiency
- Rheumatic disorders such as rheumatoid arthritis
- Collagen diseases such as systemic lupus erythematosus
- Dermatologic diseases such as severe psoriasis
- Allergic states such as contact dermatitis or drug hypersensitivity reactions
- Ophthalmic diseases such as optic neuritis
- Respiratory diseases such as asthma or COPD
- Neoplastic diseases such as leukemia
- Gastrointestinal diseases such as ulcerative colitis

- Nervous system diseases such as multiple sclerosis (Hodgens & Sharman, 2023).

In respiratory conditions, inhaled corticosteroids (ICS) are used as part of the general asthma management. But in acute exacerbations of chronic obstructive pulmonary disease (COPD) and severe asthma, oral or intravenous corticosteroids are used.

Prednisone is perhaps the most widely used of the systemic oral corticosteroids. It is generally used as an anti-inflammatory and immunosuppressive agent. Methylprednisolone is a commonly used injectable corticosteroid and similar in potency as prednisone.

Hydrocortisone is a commonly used topical cream for itching or eczema. It is obtained OTC in low doses or by prescription in higher doses. Hydrocortisone, given orally, is used to treat Addison's disease or adrenal insufficiency (Daily Med, 2025). Of the corticosteroids, hydrocortisone has one of the highest mineralocorticoid content and the lowest glucocorticoid content. Along with hydrocortisone, fludrocortisone is sometimes also ordered. Fludrocortisone is a potent mineralocorticoid and is used for salt and water balance (Lui et al, 2013).

Example in Practice:

30-year-old client has asthma that is well-controlled with an inhaled corticosteroid, fluticasone, and a beta-2 adrenergic inhaler, salbutamol. Recently, she is experiencing more shortness of breath, dyspnea and fatigue. Due to the severity of her symptoms, she is prescribed prednisone for 10 days to help decrease the inflammation and overall improve her breathing.

Figure 10.3b Example of Corticosteroid Medication: Fluticasone inhaler.

Mechanism of Action

Glucocorticoids cause profound and varied metabolic effects as described in unit 10.2 Endocrine Disorders. They produce anti-inflammatory, immunosuppressive, protein and carbohydrate metabolic effects, skeletal muscle and central nervous system effects (Hodgens & Sharman, 2023).

Glucocorticoids exert their anti-inflammatory and immunosuppressive effects by binding to intracellular glucocorticoid receptors, which then modulates gene expression. This has an effect on anti-inflammatory proteins and also inhibits pro-inflammatory transcription factors resulting in a decrease in most inflammatory cytokine production. The gene inhibition also reduces inflammation by inhibiting the production of COX-2,

thereby inhibiting prostaglandins and leukotrienes. The effects on protein, fat and glucose metabolism have the same effect by modulating enzyme synthesis (Chourpiliadis & Aeddula, 2023).

Figure 10.3c Example of Corticosteroid Medication: Prednisone tablets.

Nursing Considerations

Administration: Dosages are variable and tailored to the disease process and the individual. The lowest possible dose of corticosteroid should always be used. If taking low doses and for short period of time, then low risk of adverse effects.

Routes: parenteral, oral, inhaled, topical, injected (intramuscular, intra-articular, intradermal).

Highly protein bound, metabolized in the liver and renal excretion of metabolites.

When discontinuing the med, orders will often be tapered down to avoid adrenal suppression.

Oral route: given before 0900 to closely mimic cortisol release from adrenals.

- Prednisone is the most frequently used oral formula, with

dosages 5-60 mg/day. Usually ordered for short term basis, i.e. 2-4 weeks to avoid adverse effects.

- Usually taken with food or milk to decrease GI upset (Puckett, Patel, & Bokhari., 2025)

Topical route: Hydrocortisone is the most similar to naturally occurring cortisol. It is used topically for minor skin conditions OTC (0.5-1%) to more severe skin conditions, prescription (2% ointment). When applying topical ointment, use an applicator and spread on thinly. Do not cover the area. Low risk of systemic effects with localized topical route.

IV: methylprednisolone is given in emergent situations or if they are unable to tolerate prednisone by mouth (Hodgens & Sharman, 2023).

Refer to the table below for the differences between the differ glucocorticoid medications.

Least potent to most potent	Uses	Comments
Hydrocortisone	Topical, oral, ophthalmic, ear Adrenal insufficiency, skin conditions (i.e. psoriasis)	Natural, short-acting. Most mineralocorticoid and least amount of glucocorticoid. Sodium and water retention
Prednisone	Oral, medium potency. Onset one hour. Wide variety of uses: COPD exacerbation, allergic conditions	Synthetic, 4x stronger than cortisol (hydrocortisone).
Methylprednisolone Po, IV, IM	Intravenous, higher potency. Wide variety of uses: sepsis, anti-inflammatory, acute illness, etc	Relatively similar potency as prednisone
Dexamethasone po, IM, IV	Oral, IV, highest potency Used for rheumatoid arthritis, chemo nausea, palliative pain control, severe allergic rxns. Premature labor to promote fetal lung development.	Most potent, ideally short-term use, long duration of action. 6x the potency of prednisone.

Pediatrics:

Can be used with children, but risk of growth suppression if long term use (Lui et al, 2013). Growth may resume after prednisone therapy and should be closely monitored. Prior to therapy assess weight, height and nutritional assessment, reassess periodically.

Pregnancy:

There is a modest risk of cleft lip with systemic corticosteroid use. Other previous concerns such as low birth weight, preterm birth, preeclampsia has not been substantiated. For pregnant women, who need corticosteroid therapy for autoimmune diseases, for example, then the lowest dose for the shortest duration is advised (Bandoli et al, 2017).

Drug Interactions:

Corticosteroids interact with many drugs including macrolides, amphotericin B, bupropion, NSAIDs and estrogens. For example, corticosteroids taken with:

- NSAIDs, there is an increased risk of peptic ulcers.
- Warfarin, anticipate an increased anticoagulant effect 3 to 7 days following start of treatment. Check INRs more closely (Puckett, Patel, & Bokhari., 2025).
- Diuretics, risk of hypokalemia.

Long term therapy: Despite their beneficial effects, long-term systemic use of corticosteroids is associated with well-known adverse events. The lowest possible dose is always ordered. Alternate day therapy is a corticosteroid dosing regimen in which twice the usual daily dose of corticoid is administered every other morning. The purpose of this mode of therapy is to minimize undesirable effects that can occur during long-term administration (Lui et al, 2013). Long-term corticosteroid therapy should never be stopped abruptly due to its effect on the hypothalamic-pituitary-adrenal (HPA) axis and potential adrenal suppression. Instead, the dose should be tapered to allow the body to resume natural production of adrenal hormone levels.

High doses with prolonged treatment avoided, unless condition is life-threatening or the potential to cause permanent disability.

Contraindicated with the following conditions, such as masked infections, fungal infections, myopathy, and glaucoma. May contribute to fluid retention, hypertension and hypokalemia (Puckett, Patel, & Bokhari, 2025).

Assessment prior to therapy:

Before initiating long-term systemic corticosteroid therapy, a thorough history and physical examination should be performed to assess for risk factors or pre-existing conditions that may potentially be exacerbated by glucocorticoid therapy, such as diabetes, dyslipidemia, cerebrovascular disease (CVD), GI disorders, affective disorders, or osteoporosis.

- Complete medication profile due to significant drug interactions with glucocorticoids.
- Vital signs, especially blood pressure
- Skin integrity: assess for any wounds to monitor wound healing
- Weight (due to risk of weight gain and fluid retention)
- Labs: complete blood count (CBC), blood glucose values, renal panel, lipid profile.
- Bone mineral density
- Assess for untreated infections, as corticosteroids are contraindicated in clients with untreated systemic infections.

Monitor:

Close monitoring for adverse effects is important especially for long term therapy.

- Blood glucose due to risk of hyperglycemia

- Adherence to medications
- Signs of infection due to immunosuppression
- Risk of myopathy. Assess for muscle weakness and atrophy which can develop over weeks to months. Muscle strength will resolve 3-4 weeks after therapy discontinued.
- Skin integrity: risk of abdominal striae which may be permanent. Thinning of the skin leading to skin tears. Delayed wound healing, assess any wounds.
- Cushingoid features: weight gain and redistribution of adipose tissue. Assess for facial fat (moon face), dorsocervical fat pad (buffalo hump) or truncal obesity.
- Electrolytes (hypokalemia, hyperglycemia)
- Risk of osteoporosis and fractures. Corticosteroids can impair bone mineralization and impair calcium absorption.
- Monitor for GI effects: will decrease mucous production and predispose for peptic ulcers. Assess for GI upset and black tarry stools.

Adverse/side effects

Adverse effects appear with both an average dose and cumulative duration, but most often with chronic use. If used more than 60 days, most clients have some adverse effects. Recall that corticosteroids have an effect on all body systems, so adverse effects are varied. Most common:

- Osteoporosis and fractures
- Cushingoid features: moon face, adipose fat deposit on upper back (buffalo hump)
- Diabetes and hyperglycemia
- Myopathy
- Glaucoma and cataracts
- Psychiatric conditions: psychosis, sleep disturbances,

euphoria, mood swings, depression
- Poor wound healing
- Mask signs of infection
- Fragile skin that bruises and tears easily
- Peptic ulcers

(Hodgens & Sharman, 2023).

To avoid adverse effects, the lowest effective dose should be used for treatment. Monitor regularly all parameters described under 'assessment'. Watch for adrenal suppression in clients who have been on therapy for greater than 2 weeks or in multiple short courses of high-dose therapy.

Risk of fractures: to avoid the risk of fractures, concurrent treatment with Alendronate, a bisphosphonates class of medication, is often used in addition to other osteoporosis preventative measures such as weight-bearing exercise and calcium/Vitamin D supplementation (Lui et al, 2013).

Adrenal insufficiency: Symptoms of adrenal insufficiency include weakness/fatigue, malaise, nausea, vomiting, diarrhea, abdominal pain, headache (usually in the morning), poor weight gain and/or growth in children, myalgia, arthralgia, psychiatric symptoms, hypotension, and hypoglycemia. If these symptoms occur, further lab work, such as an early morning cortisol test, should be performed (Lui et al, 2013).

Client Teaching

- Teach clients taking long-term prednisone therapy to never abruptly stop taking the medication and to report any adverse/side effects or new signs of infection.
- Glucocorticoid medication can cause immunosuppression, which makes it more difficult to detect signs of infection. Clients should seek advice from healthcare providers regarding

vaccination administration while on glucocorticoids. Clients should report unusual swelling, weight gain, fatigue, bone pain, bruising, non-healing sores, visual and behavioral disturbances to the provider.

- Use of glucocorticoid therapy may cause an increase in blood glucose levels. If diabetic, anticipate an increase in anti-diabetic medications.
- Advise clients to consume diets that are high in protein, calcium, and potassium.
- Take oral corticosteroids with food to avoid GI upset.

(Adams et al, 2018; Puckett, Patel, & Bokhari., 2025)

Example in Practice 2:

A 25-year-old client has occasional eczema that flares up from time to time. She currently has a large reddened, scaley patch on both her elbows. She uses hydrocortisone ointment 0.5% that she has picked up OTC from the pharmacy. After a few days, the patches are getting itchier and reddened. She returns to the pharmacy, and they assess the areas. They prescribe Hydrocortisone 2.5% ointment. The pharmacist provides health teaching that includes to apply sparingly with an applicator and do not cover with a band-aid. Do not use more than 7 days and if it still persists, see their health care prescriber for further care.

Example in Practice 3:

A 70-year-old client has been diagnosed with a pancreatic tumour with metastasis to his bones. He is palliative. He has considerable pain and has been on hydromorphone. The physician has recently ordered dexamethasone as an adjunct analgesic. The nurse questions the use of dexamethasone for pain. What he learns is that it is ordered to decrease pain by decreasing inflammation (inhibits prostaglandin synthesis), reduces vascular permeability (prevents edema) and reduces nerve conduction (decreases neuropathic pain). Depending on how the client is doing with fluid overload, dexamethasone has the least amount of mineralocorticoid than the other options, so it will not cause more fluid retention. Dexamethasone can be given oral or SQ so a good option for a palliative client who can't tolerate swallowing.

Figure 10.3d Example of Corticosteroid Medication: Intravenous methylprednisolone.

Glucocorticoid: Prednisone, Methylprednisolone, Hydrocortisone Medication Card

Now let's take a closer look at the medication card for glucocorticoid medications. These example cards are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information is outlined below.

Refer to the Comparing Corticosteroids table that provides further information of the different formulations of corticosteroids (AHFS, 2019; Bornstein et al, 2016; Hodgens & Sharman, 2023; Lui et al, 2019; Nieman et al, 2013).

Glucocorticoid: Prednisone, Methylprednisolone, Hydrocortisone Medication Card

Class: Corticosteroids **Prototype:** Prednisone, Methylprednisolone, hydrocortisone		**Indications:** used as replacement therapy in adrenal insufficiency, and anti-inflammatory, immunosuppressive, anti-proliferative, and vasoconstrictive effects for management of various dermatologic, ophthalmologic, rheumatologic, pulmonary, hematologic, and GI disorders. Respiratory: inhaler for asthma management. Systemic corticosteroids for acute exacerbations of COPD and severe asthma. Dexamethasone: sepsis, palliative pain control Hydrocortisone: oral for adrenal insufficiency. Topical for skin conditions.	
Mechanism of Action: exert their anti-inflammatory and immunosuppressive effects by binding to intracellular glucocorticoid receptors, which then modulates gene expression. This has an effect on anti-inflammatory proteins and inhibits pro-inflammatory transcription factors resulting in a decrease in most inflammatory cytokine production. The gene inhibition also reduces inflammation by inhibiting the production of COX-2, thereby inhibiting prostaglandins and leukotrienes. The effects on protein, fat and glucose metabolism have the same effect by modulating enzyme synthesis.			
Administration: Orla, IV, IM, intraarticular, topical Oral: Take with food or milk. Take in the morning. Take as prescribed, do not abruptly stop, doses should be tapered down when d/cing. Topical: apply sparingly, do not wrap. OTC or Rx	**Side Effects:** Short term use and low doses: minimal side effects Long term or higher doses, many potential AEs: Muscle weakness, peptic ulcer, thin fragile skin, poor wound healing, striae on abdomen CNS: euphoria, psychosis, depression Hyperglycemia Moon face, buffalo hump	**Contraindications:** Drug interactions: NSAIDs, anticoagulants, anti-diabetic meds Hypersensitivity to med Do not take live-attenuated vaccines concurrently Caution/avoid with systemic fungal infection, uncontrolled HTN, uncontrolled hyperglycemia, PUD, CHF	**Nursing Considerations:** Complete med profile prior to therapy Monitor VS, weight, fluid status, mood, Labs: lytes, CBC, FBG, LFTs, renal Bone density testing if long term therapy Ophthalmologic exam Peds: height, weight Assess skin integrity, mood, muscle strength, risk of infections Anticipate lowest dose ordered for shortest period of time to decrease AEs

Comparing Corticosteroid Medication Table

To help with comparing the medications and to learn important considerations for each medication, refer to the medication tables Chapter 10 Comparing Corticosteroid Medications table. This file is downloadable and editable, therefore easy to add information as

needed. This table is not intended to replace current drug manuals or monographs prior to administration in the practice setting.

Clinical Reasoning and Decision-Making Activity

Case study 1: A client in a long-term care facility who has COPD receives prednisone 10 mg daily to help manage her respiratory status. Upon reviewing the client's chart, the nurse notices that the client was diagnosed with osteoporosis in the past but is not currently receiving medications indicated for osteoporosis. Other health issues are type 2 diabetes mellitus and dementia. The nurse is concerned because the client requires assistance for mobility and is a high fall risk. The nurse plans to call the provider.

1. What cues in the client's medical history cause the nurse to be concerned about the risk for a fracture?
2. What medication(s) may be prescribed concurrently with prednisone to reduce the risk for a fracture?
3. What other client teaching can the nurse provide to help reduce the client's risk for a fracture?
4. Bedside glucose testing with sliding scale insulin is ordered for this client. Why is insulin ordered when the client has type 2 diabetes? What is the rationale for these orders?
5. What cues would cause the nurse to contact the provider with the hypothesis that adrenal suppression is occurring?

Case study 2: A 54-year-old client has had bowel surgery and has become septic post-operatively. The nurse sees a new order for prednisone for this client. The nurse is concerned with giving prednisone to a client with a large abdominal wound.

1. What is the nurse concerned about?
2. The nurse prepares to give the prednisone in the morning. Why is the morning the best time to give prednisone? To avoid gastric irritation from prednisone, what additional med may be ordered for this client?

Case Study 3: A client with lymphoma is wondering why they are also ordered dexamethasone. Why are corticosteroids ordered to treat lymphoma?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 10: Endocrine System Medications: Part 1 Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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10.4 Thyroid Medications

To understand the purpose of thyroid medications and how they work in the body, this unit will begin with:

- a review of physiology of the thyroid gland including its function, regulation and the release of thyroid hormones.
- an overview of disorders of thyroid gland including iodine deficiency, hypothyroidism, and hyperthyroidism.
- a review of the physiology of the parathyroid glands
- an overview of disorders of the parathyroid gland, hyperparathyroidism and hypoparathyroidism.

Medications that will be examined are:

- hypothyroidism: levothyroxine
- antithyroid medication: propylthiouracil (PTU)
- osteoporosis medications:
    - calcitonin
    - bone reabsorption inhibitor: alendronate

Thyroid Basics: A&P Review

The thyroid is a butterfly-shaped organ located anterior to the

trachea, just inferior to the larynx (see Figure 10.4a).[1] Each of the thyroid lobes is embedded with parathyroid glands.

Illustration and micrograph showing thyroid and surrounding structures.

Figure 10.4a The Thyroid Gland

Synthesis and Release of Thyroid Hormones

Thyroid hormone production is dependent on the hormone's essential component: iodine. T3 and T4 hormones are produced when iodine attaches to a glycoprotein called thyroglobulin. The following steps outline the hormone's assembly: Binding of TSH to thyroid receptors causes the cells to actively transport iodide ions across their cell membrane from the bloodstream. As a result, the concentration of iodide ions "trapped" in the thyroid cells is many times higher than the concentration in the bloodstream. The iodide ions undergo oxidation (i.e., their negatively charged electrons are removed) and enzymes link the iodine to tyrosine to produce triiodothyronine (T3), a thyroid hormone with three iodines, or thyroxine (T4), a thyroid hormone with four iodines. These hormones remain in the thyroid follicles until TSH stimulates the release of free T3 and T4 into the bloodstream. In the bloodstream, less than one percent of the circulating T3 and T4 remains unbound. This free T3 and T4 can cross the lipid bilayer of cell membranes and be taken up by cells. The remaining 99 percent of circulating T3 and T4 is bound to specialized transport proteins called thyroxine-binding globulins (TBGs), to albumin, or to other plasma proteins.

1. "1811 The Thyroid Gland.jpg" by OpenStax College is licensed under CC BY 3.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-4-the-thyroid-gland

This “packaging” prevents their free diffusion into body cells. When blood levels of T3 and T4 begin to decline, bound T3 and T4 are released from these plasma proteins and readily cross the membrane of target cells. T3 is more potent than T4, and many cells convert T4 to T3 through the removal of an iodine atom.

Regulation of Thyroid Hormone Synthesis

A negative feedback loop controls the regulation of thyroid hormone levels. As shown in Figure 9.6b,[2] low blood levels of T3 and T4 stimulate the release of thyrotropin-releasing hormone (TRH) from the hypothalamus, which triggers secretion of TSH from the anterior pituitary. In turn, TSH stimulates the thyroid gland to secrete T3 and T4. The levels of TRH, TSH, T3, and T4 are regulated by a negative feedback system in which increasing levels of T3 and T4 decrease the production and secretion of TSH.

Figure 10.4b Negative Feedback Loop. A negative feedback loop controls the regulation of thyroid hormone levels

Functions of Thyroid Hormones

The thyroid hormones T3 and T4 are often referred to as metabolic hormones because their levels influence the body’s basal metabolic rate, which is the amount of energy used by the body at rest. When T3 and T4 bind to intracellular receptors located on the

2. "1813 A Classic Negative Feedback Loop.jpg" by OpenStax College is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-4-the-thyroid-gland

mitochondria, they cause an increase in nutrient breakdown and the use of oxygen to produce ATP. In addition, T3 and T4 initiate the transcription of genes involved in glucose oxidation. Although these mechanisms prompt cells to produce more ATP, the process is inefficient, and an abnormally increased level of heat is released as a byproduct of these reactions. This calorigenic effect (calor- = "heat") raises body temperature.

Adequate levels of thyroid hormones are also required for protein synthesis and for fetal and childhood tissue development and growth. They are especially critical for normal development of the nervous system both in utero and in early childhood, and they continue to support neurological function in adults. Thyroid hormones also have a complex interrelationship with reproductive hormones, and deficiencies can influence libido, fertility, and other aspects of reproductive function. Finally, thyroid hormones increase the body's sensitivity to catecholamines (epinephrine and norepinephrine) from the adrenal medulla by upregulation of receptors in the blood vessels. When levels of T3 and T4 hormones are excessive, this effect accelerates the heart rate, strengthens the heartbeat, and increases blood pressure. Because thyroid hormones regulate metabolism, heat production, protein synthesis, and many other body functions, thyroid disorders can have severe and widespread consequences.

Disorders of the Thyroid Gland: Iodine Deficiency, Hypothyroidism, and Hyperthyroidism

As discussed above, dietary iodine is required for the synthesis of T3 and T4. For much of the world's population, foods do not provide adequate levels of iodine because the amount varies according to the level in the soil in which the food was grown, as well as the irrigation and fertilizers used. Marine fish and shrimp tend to have

high levels because they concentrate iodine from seawater, but many people in landlocked regions lack access to seafood. Thus, the primary source of dietary iodine in many countries is iodized salt. Fortification of salt with iodine became mandatory in Canada in 1949, and international efforts to iodize salt in the world's poorest nations continue today.

Iodine deficiency

Dietary iodine deficiency can result in the impaired ability to synthesize T3 and T4, leading to a variety of severe disorders. When T3 and T4 cannot be produced, TSH is secreted in increasing amounts. As a result of this hyperstimulation, thyroglobulin and colloid accumulate in the thyroid gland and increase the overall size of the thyroid gland, a condition called a goiter (see Figure 10.4b). A goiter is only a visible indication of the deficiency. Other disorders related to iodine deficiency include impaired growth and development, decreased fertility, and prenatal and infant death. Moreover, iodine deficiency is the primary cause of preventable mental retardation worldwide. Neonatal hypothyroidism (cretinism) is characterized by cognitive deficits, short stature, and sometimes deafness and muteness in children and adults born to mothers who were iodine-deficient during pregnancy.

Figure 10.4c Goiter

Hypothyroidism

In areas of the world with access to iodized salt, dietary deficiency is rare. Instead, inflammation of the thyroid gland is a common cause of hypothyroidism or low blood levels of thyroid hormones. Hypothyroidism is a disorder characterized by a low metabolic rate, weight gain, cold extremities, constipation, reduced libido, menstrual irregularities, and reduced mental activity, and requires long-term thyroid hormone replacement therapy.

Hyperthyroidism

Hyperthyroidism is an abnormally elevated blood level of thyroid hormones. It is often caused by Grave's disease and less commonly due to a pituitary tumor. In Graves' disease, the hyperthyroid state results from an autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland. Hyperthyroidism can lead to an increased metabolic rate, excessive body heat and sweating, diarrhea, weight loss, tremors, and increased heart rate.

The person's eyes may bulge (called exophthalmos) as antibodies produce inflammation in the soft tissues of the orbits. The person may also develop a goiter.

Hyperthyroidism is often treated by thyroid surgery or with radioactive iodine (RAI) therapy. Clients are asked to follow radiation precautions after RAI treatment to limit radiation exposure to others, especially pregnant women and young children, such as sleeping in a separate bed and flushing the toilet 2-3 times after use. The RAI treatment may take up to several months to have its effect. The end result of thyroid surgery or RAI treatment is often hypothyroidism, which is treated by thyroid hormone replacement therapy.[3]

Calcitonin

The thyroid gland also secretes another hormone called calcitonin. Calcitonin is released in response to elevated blood calcium levels. It decreases blood calcium concentrations by:

- Inhibiting the activity of osteoclasts (bone cells that breakdown bone matrix and release calcium into the circulation)
- Decreasing calcium absorption in the intestines
- Increasing calcium loss in the urine

Pharmaceutical preparations of calcitonin are prescribed to reduce osteoclast activity in people with osteoporosis. Osteoporosis is a disease that can be caused by glucocorticoids.

Calcium is critical for many other biological processes. It is a

3. American Thyroid Association. (2019). *Radioactive iodine*. https://www.thyroid.org/radioactive-iodine/

second messenger in many signaling pathways and is essential for muscle contraction, nerve impulse transmission, and blood clotting. Given these roles, it is not surprising that blood calcium levels are tightly regulated by the endocrine system. The parathyroid glands are primarily involved in calcium regulation.

Calcium Regulation: Parathyroid Glands

The parathyroid glands are four tiny, round structures usually embedded in the posterior surface of the thyroid gland (see Figure 10.4d).[4] The primary function of the parathyroid glands is to regulate blood calcium levels by producing and secreting **parathyroid hormone (PTH)** in response to low blood calcium levels.

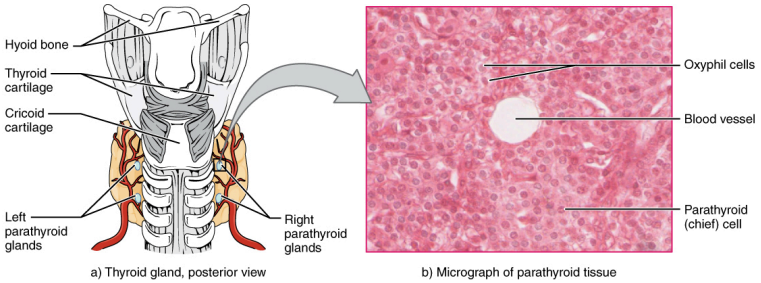

Figure 10.4d The Parathyroid Glands

PTH secretion causes the release of calcium from the bones by stimulating osteoclasts that degrade bone and then release calcium

4. "1814 The Parathyroid Glands.jpg" by OpenStax College is licensed under CC BY 3.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-5-the-parathyroid-glands

into the bloodstream. PTH also inhibits osteoblasts, the cells involved in bone deposition, thereby keeping calcium in the blood. PTH also causes increased reabsorption of calcium (and magnesium) in the kidney and initiates the production of the steroid hormone calcitriol, which is the active form of vitamin D3. Calcitriol then stimulates increased absorption of dietary calcium by the intestines. A negative feedback loop regulates the levels of PTH, with rising blood calcium levels inhibiting further release of PTH. (See Figure 10.4e for an illustration of the role of parathyroid hormone in maintaining blood calcium homeostasis.)[5]

5. "1817 The Role of Parathyroid Hormone in Maintaining Blood Calcium Homeostasis.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-5-the-parathyroid-glands

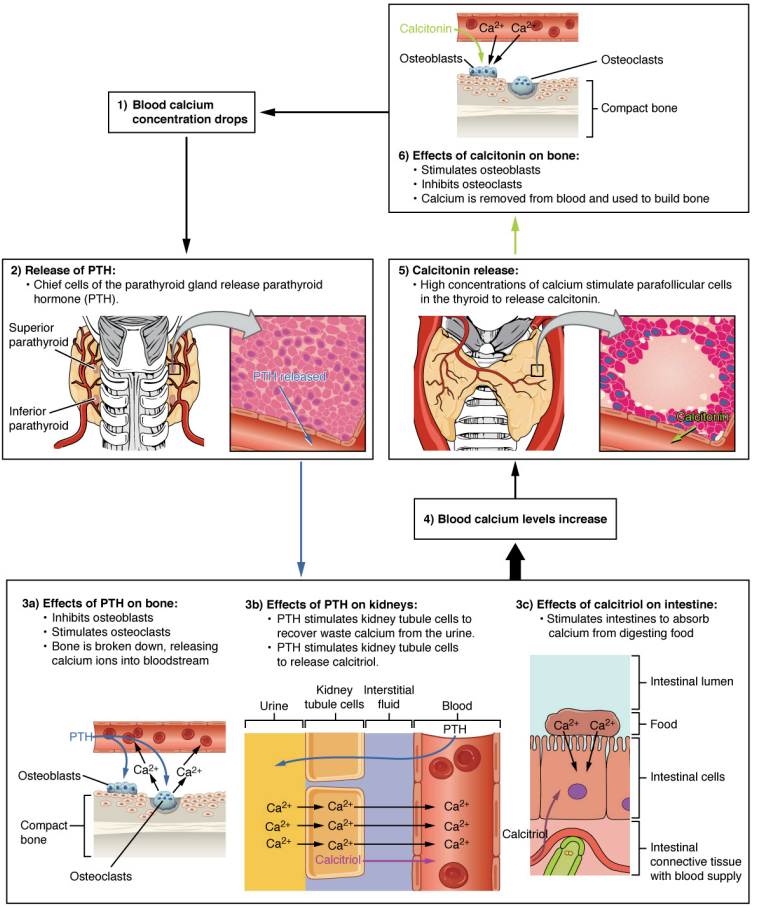

Figure 10.4e Parathyroid Hormone in Maintaining Blood Calcium Homeostasis

Disorders of the Parathyroid Glands

Abnormally high activity of the parathyroid gland can cause **hyperparathyroidism**, a disorder caused by an overproduction of PTH that results in excessive degradation of bone and elevated

blood levels of calcium, also called hypercalcemia. Hyperparathyroidism can thus significantly decrease bone density, which can lead to spontaneous fractures or deformities. As blood calcium levels rise, cell membrane permeability to sodium is also decreased, and thus the responsiveness of the nervous system is reduced. At the same time, calcium deposits may collect in the body's tissues and organs, impairing their functioning.

In contrast, abnormally low blood calcium levels may be caused by parathyroid hormone deficiency, called **hypoparathyroidism**, which may develop following injury or surgery involving the thyroid gland. Low blood calcium increases membrane permeability to sodium, thus increasing the responsiveness of the nervous system, resulting in muscle twitching, cramping, spasms, or convulsions. Severe deficits can paralyze muscles, including those involved in breathing, and can be fatal.

Endocrine Gland Medications

In this section, we will examine three different types of thyroid medications. This includes medications for hypothyroidism (levothyroxine), for hyperthyroidism (Propylthiouracil or PTU), and two osteoporosis medications, calcitonin and alendronate.

Levothyroxine

Levothyroxine is a thyroid replacement drug used to treat hypothyroidism. It is used to treat primary, secondary and tertiary hypothyroidism. Primary is when there is a problem with the thyroid gland, secondary is then there is a problem with the pituitary gland and tertiary is sporadic (Eghtedari & Correa, 2023)

Figure 10.4f Levothyroxine

Mechanism of Action

Oral levothyroxine sodium is a synthetic T4 hormone that exerts the same physiologic effect as endogenous T4, thereby maintaining normal T4 levels when a deficiency is present.

Nursing Considerations

Administration: oral, comes in many forms such as capsule, solution, and tablets. Intravenous route also available.

- Administer 30-60 minutes before breakfast or 3-4 hours after dinner. Gastric acidity is needed for absorption.
- Do not give with foods contained calcium or iron

- Tablet: take on an empty stomach with a full glass of water
- Capsules: do no crush or cut, swallow whole.
- Avoid taking levothyroxine with soybean, papaya and grapefruit as absorption can be impaired.

No dose adjustments with hepatic or renal disease.

Pregnancy: monitor TSH levels and may need to adjust levothyroxine requirements (Daily Med, 2026).

Drug interactions:

- Do not give with antacids or proton pump inhibitors as they may decrease absorption.
- Calcium carbonate and iron bind to levothyroxine and reduce the absorption.
- Give 4 hours apart from bile acid sequestrants (e.g., colesevelam) as they reduce levothyroxine absorption.
- Levothyroxine increases the response to oral anticoagulant therapy. Therefore, a decrease in the dose of anticoagulant may be warranted with correction of the hypothyroid state or when the levothyroxine dose is increased. Closely monitor INR results and anticipate dosage adjustments.

Assessment

- Narrow therapeutic window so closely monitored with TSH levels. Assess TSH levels before and then 4-6 weeks after starting the med. Once at therapeutic levels, monitor every 4-6 months, and then yearly (Eghtedari & Correa, 2023).
- Monitor pulse and blood pressure prior to therapy and regularly.

Contraindicated with hyperthyroidism and adrenal insufficiency.

Diabetic clients: may worsen glycemic control. Clients may need a higher dosage of antidiabetic medications. Carefully monitor glycemic control, especially when thyroid therapy is started, changed, or discontinued

Adverse/Side Effects

Due to narrow therapeutic window, there is a risk of under or over dosage. Adverse effects affect most body systems, including growth and development, cardiovascular function, bone metabolism, reproductive function, cognitive function, emotional state, GI function and glucose and lipid metabolism (Drug Bank, 2026).

Adverse effects that result from excessive dosing can result in a hyperthyroid-like presentation, particularly increased heart rate, cardiac wall thickness, and cardiac contractility that may precipitate angina or arrhythmias, particularly in clients with cardiovascular disease and in elderly clients. Levothyroxine should be started at lower doses. If cardiac symptoms develop or worsen, hold the dose and contact the health care provider. Anticipate a lower dose prescribed or the medication to be withheld for one week then restarted at a lower dose.

Adverse effects can include:

- CV effects: angina, palpitations, myocardial infarction, atrial fibrillation.
- Neuro: insomnia, anxiety
- GI: weight loss, diarrhea, fatigue
- Integument: rash, alopecia, diaphoresis
- Endocrine: goiter, menstrual irregularities, heat intolerance, decreased bone density
- Elevated liver enzymes

Report any adverse effects as dosage adjustment may be warranted.

Signs of overdose or over-medicated with elevated levels of thyroid hormone, can cause cardiac dysrhythmias. Immediately report any symptoms of tachycardia, chest pain, or palpitations to the provider. In the event of overdose or elevated TSH levels, hold the next dose and potentially for 2-6 days.

Client Teaching

- Clients should take thyroid replacement medications at the same time each day. If a dose is missed, take as soon as possible, unless already the next day.
- Notify the prescriber if more than 2-3 doses are missed.
- Clients should be aware that thyroid replacement medications do not cure hypothyroidism and therapy is lifelong.
- Clients should notify their healthcare provider if they experience signs of headache, diarrhea, sweating, increased heart rate, palpitations, or heat intolerance.
- Medications should be spaced four hours apart from medications like antacid, iron, or calcium supplements.
- Clients will be followed closely by their healthcare provider regarding their response to medication therapy and serum thyroid levels will be taken (Vallerand & Sanoski, 2024).

Example in Practice

A 35 year old client visits her nurse practitioner as she has been experiencing unusual fatigue, an intolerance to cold and weight gain. She says she exercises and eats well. She wakes up in the morning tired. Her BP is 105/65 mmHg, heart rate 55 bpm, RR 12 breaths/min and

afebrile. The NP orders lab work: thyroid panel (TSH, T3 and T4), ferritin and CBC, fasting blood sugar, A1C and renal panel. The results come back that she has high TSH with the rest of her labs within normal limits. The client is ordered levothyroxine 112 mcg once a day.

Teaching is provided on how to take the med correctly, precautions and adverse effects. The client is able to teach back to the nurse that she needs to take the med 30-60 minutes prior to breakfast. She knows to avoid juices such as grapefruit juice and to not take antacids or calcium supplements at the same time as taking the med. She will let the NP know if she plans to get pregnant. Lastly, she is able to verbalize possible side effects and knows which ones to report right away. She knows she will be on thyroxine for the rest of her life and is looking forward to feeling better.

Antithyroid Medication: Propylthiouracil (PTU)

Propylthiouracil (PTU) is an antithyroid medication used to treat hyperthyroidism or to ameliorate symptoms of hyperthyroidism in preparation for thyroidectomy or radioactive iodine therapy.

Mechanism of Action

Propylthiouracil inhibits the synthesis of thyroid hormones.

Nursing Considerations

Administration: oral administration. The total daily dosage is usually given in 3 equal doses at approximately 8-hour intervals. Propylthiouracil can cause hypothyroidism necessitating routine monitoring of TSH and free T4 levels, with adjustments in dosing to maintain a euthyroid state.

Pregnancy: Propylthiouracil crosses the placenta and can cause fetal liver failure, goiter, and cretinism if administered to a pregnant woman. It can be given in the first trimester. Clients who plan to get pregnant or who are pregnant must consult with their prescriber.

Adverse/side effects:

Liver injury resulting in liver failure, liver transplantation, or death has been reported. Clients should be instructed to report any symptoms of hepatic dysfunction (anorexia, pruritus, and right upper quadrant pain), particularly in the first six months of therapy.

Agranulocytosis is a potentially life-threatening side effect of propylthiouracil therapy. Agranulocytosis typically occurs within the first 3 months of therapy. Clients should be instructed to immediately report any symptoms suggestive of agranulocytosis, such as fever or sore throat.

Cases of vasculitis resulting in severe complications and death have been reported in clients receiving propylthiouracil therapy. If vasculitis is suspected, discontinue therapy and initiate appropriate intervention.

Client Teaching

- Clients should take the medication as directed at regular

dosing intervals.
- They should monitor their weight 2-3 times per week.
- Clients should be advised that medications may cause drowsiness, and they should report any signs of sore throat, fever, headache, jaundice, bleeding, or bruising.

Osteoporosis Medication: Calcitonin

Calcitonin is used to treat osteoporosis in post-menopausal women, particularly if they are in the post-menopausal phase for a minimum of five years. It is also used as a secondary treatment option for Paget disease of the bone. It can provide relief from bone pain, reverse neurological deficits, reduce blood flow to the diseased bone, and may even improve hearing loss that is associated with Paget disease (McLaughlin, Awosika & Jialal, 2023).

Mechanism of Action

Calcitonin is a calcitonin receptor agonist. Calcitonin is released by the thyroid gland. It acts primarily on bone and also has effects on the kidneys and the gastrointestinal tract. Calcitonin inhibits osteoclasts, resulting in lower bone mineral density (BMD) losses and the risk of osteoporotic fractures can be lowered. Calcitonin also exerts its effects on tubular epithelium of the kidneys, inducing diuresis and decreases reabsorption, which results in reduced serum calcium and phosphate levels (McLaughlin, Awosika & Jialal, 2023).

In summary: when calcium levels are too high, the thyroid gland secretes more calcitonin. This decreases the osteoclasts activity and causes the kidney to excrete more calcium. If the osteoclast activity is decreased, the osteoblasts still continue to work building

up bone matrix, resulting in stronger bones. If we give calcitonin to prevent osteoporosis, then calcium is taken from the blood and used by osteoblasts to improve the bone matrix.

Note: Osteoclasts consume bone matrix by taking calcium from the bone and putting it into the blood to maintain serum calcium levels. Osteoblasts build up bone matrix by taking calcium from the blood to create more bone matrix.

Nursing Considerations

Administration: nasal spray with one spray in one side of the nose daily, alternating nostrils. See Figure 10.4g for an image of calcitonin nasal spray.

The nasal spray pump should be primed before the first administration.

Unopened calcitonin can be stored in the refrigerator until opened, but should not be refrigerated between doses. Opened bottles stored at room temperature should be discarded after 30 days of initial dose.

Pregnancy: Calcitonin should not be used during pregnancy.

Caution with clients with bipolar disorder and taking lithium. It can potentially lower lithium levels (McLaughlin, Awosika & Jialal, 2023).

Adverse/Side Effects:

Adverse effects include serious hypersensitivity reactions (bronchospasm, swelling of the tongue or throat, anaphylaxis and anaphylactic shock), hypocalcaemia, nasal mucosa adverse events, and malignancy.

Client Teaching

- Clients should be advised to take medications as directed.
- They should report any signs of hypocalcemia or an allergic response.
- Ensure clients are taught how to administer correctly.
- Advise clients that they may experience flushing and warmth following injection.
- Post-menopausal women should adhere to a diet high in calcium and vitamin D, and should be educated regarding the importance of exercise for reversing bone loss.

Figure 10.4g Administration of Calcitonin

Bone Reabsorption Inhibitor: Alendronate

Alendronate is a Bisphosphonate, used for the prevention and treatment of osteoporosis in postmenopausal women, to increase bone mass in men with osteoporosis, and for glucocorticoid-induced osteoporosis (Vallerand & Sanoski, 2024).

Mechanism of Action

Alendronate is a bisphosphonate that inhibits osteoclast-mediated bone resorption. By preventing the breakdown of bone and enhancing the formation of new bone, alendronate assists in reversing bone loss and decreases the risk of fractures.

Nursing Considerations

Administration: oral formulations. May be ordered once a day or weekly. Tablet or effervescent tablets

- Alendronate should be taken upon arising for the day, but should be administered at least one-half hour before the first food, beverage, or medication of the day with plain water only. Other beverages (including mineral water), food, and some medications are likely to reduce the absorption of alendronate.
- Effervescent tablets: dissolve in 125 mL of plain water, wait 5 minutes, stir for 10 seconds, then drink.
- Clients should not lie down for at least 30 minutes and until after their first food of the day.
- Clients may also require calcium and vitamin D supplementation, especially if concurrently taking glucocorticoids.

Pre-treatment Assessment and Monitoring:

- Assess bone mass before and periodically during therapy
- Assess for symptoms of Paget's disease (bone pain, headache, decreased visual or auditory acuity)
- Labs: serum calcium, vitamin D levels

Pregnancy: do not take if pregnant as it may cause fetal harm.

Contraindicated with clients with kidney disease with creatinine clearance less than 35 mL/min.

Contraindicated in the following conditions: hypocalcaemia, preexisting vitamin D deficiency, the inability to sit or stand for 30 minutes after swallowing, esophageal abnormalities that delay emptying, and clients at risk for aspiration.

Adverse/Side Effects:

Discontinue alendronate if severe musculoskeletal pain occurs. A bone mineral density measurement should be made at the initiation of therapy and repeated after 6 to 12 months of combined alendronate and glucocorticoid treatment.

Client Teaching

- Clients should take medication as directed at the same time each day, first thing in the morning. Only take with 250 mL of plain water. Do not double doses if a dose is missed.
- Clients should remain upright after they take medication for 30 minutes to minimize stomach and esophageal irritation.
- Clients should eat a balanced diet and may seek advice from the healthcare provider regarding supplementation with

calcium and vitamin D.
- Clients should participate in regular exercise to help increase bone strength.

Vallerand & Sanoski, 2024

Medication Card Comparing Thyroid (levothyroxine, propylthiouracil) and Osteoporosis Medications (calcitonin, alendronate).

Now let's take a closer look at the Chapter 10 Endocrine System Thyroid Medications 2026 This table is intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below.

10.4.1 Comparing Thyroid (levothyroxine, propylthiouracil) and Osteoporosis Medications (calcitonin, alendronate)

Class/ Medication	Therapeutic Effects	Administration Considerations	Adverse/Side Effects and Contraindications
Thyroid replacement levothyroxine	Increases T4 levels in hypothyroidism	Take with a full glass of water as tablet may rapidly disintegrate Administer levothyroxine as a single daily dose, on an empty stomach, one-half to one hour before breakfast Administer at least 4 hours before or after drugs known to interfere with levothyroxine absorption Anticipate lower dosages in elderly clients with pre-existing cardiac disease Assess TSH levels before and then 4-6 weeks after starting the med. Once at therapeutic levels, monitor every 4-6 months, and then yearly	Many potential adverse effects, including cardiac, neuro, GI, and endocrine effects. CV: palpitations, angina, dysrhythmias Neuro: anxiety, insomnia GI: nausea, diarrhea, weight loss Integ: alopecia, Endocrine: menstrual irreg., decr bone density Hypersensitivity reactions Drug interactions: PPI, antacids and bile acid sequestrants will decrease absorption. Take 4 hours apart from levothyroxine. Anticoagulants with Levothyroxine: increases anticoagulant effects. Dose adjustment needed. Narrow therapeutic window so closely monitored with TSH levels. Diabetic clients: may worsen glycemic control, adjust dosing.

Antithyroid propylthiouracil (PTU)	Inhibit production of T4 to treat hyperthyroidism	Usually administered every 8 hours May cause hypothyroidism so TSH and T4 levels should be monitored	Risk of Hypothyroidism, monitor TSH levels Risk of liver injury. agranulocytosis Vasculitis Do not take if pregnant: risk of fetal harm
Calcium regulator calcitonin	Treats osteoporosis Used for post-menopausal women, 5 years post menopause Secondary treatment of Paget's disease	Administer nasal spray with one spray in one side of the nose daily Discard unrefrigerated bottle after 30 days of opening May store unopened bottles in refrigerator until expiration date	Serious hypersensitivity reactions (bronchospasm, swelling of the tongue or throat, anaphylaxis, and anaphylactic shock) Hypocalcemia Nasal mucosa irritation Malignancy Contraindicated during pregnancy Caution if client on lithium, may lower lithium levels

Bisphosphonates alendronate	Enhances bone mineral density in osteoporosis prevention and treatment of osteoporosis in postmenopausal women, and for glucocorticoid-induced osteoporosis	Administered upon arising and at least one-half hour before the first food or drink or other meds. Take with plain water only sit or stand for 30 minutes after administration Concurrent calcium and vitamin D supplements may be required Assess bone mass before and periodically during therapy	Adverse effects include: upper GI tract, severe musculoskeletal pain Risk of osteonecrosis of the jaw Contraindicated in pregnancy, hypocalcaemia, and kidney disease

Critical Thinking and Decision-Making Learning Activities

1. A client has type 1 diabetes and has recently been diagnosed with hypothyroidism. The client has been provided some teaching on how to take levothyroxine (Synthroid) and other important considerations. The client states, "I am glad I will need a much lower dose of insulin now that I am on thyroxine." Does the client need more health teaching?
2. A post-menopausal women has osteoporosis and the prescriber is concerned with the risk for fractures if the client fell. They are prescribed calcitonin. What

are some concerns while taking this med?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 10: Endocrine System Medications: Part 1 Answer Key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Image Descriptions

Figure 9.6b Negative Feedback Loop: A flowchart demonstrating the negative feedback loop regulating thyroid hormone levels. It details the following steps:

1. Metabolic rate and/or T3 and T4 concentration in blood:
    - High? Hypothalamus stops TRH release. Anterior pituitary stops TSH release.
    - Low? Hypothalamus releases TRH. This triggers TSH release by the pituitary.
2. Effects of TSH release: Triggers release of T3 and T4 by thyroid follicle cells.
3. Effects of T3 and T4 release:
    - Increased basal metabolic rate of body cells.
    - Rise in body temperature (calorigenic effect).

4. Negative feedback:
    - Elevated T3 and T4 levels inhibit release of TRH and TSH.
5. If T3 and T4 are high:
    - Hypothalamus stops TRH release.
    - Anterior pituitary stops TSH release.

[Return to Figure 10.4b]

Figure 9.6e Parathyroid Hormone in Maintaining Blood Calcium Homeostasis: A flowchart demonstrating how parathyroid hormone (PTH) helps to maintain blood calcium homeostasis. It details the following steps:

1. Blood calcium concentration drops.
2. Release of PTH: chief cells of the parathyroid gland release parathyroid hormone (PTH).
3. This has the following effects:
    1. Effects of PTH on bone:
        - Inhibits osteoblasts.
        - Stimulates osteoclasts.
        - Bone is broken down, releasing calcium ions into bloodstream.
    2. Effects of PTH on kidneys:
        - PTH stimulates kidney tubule cells to recover waste calcium from the urine.
        - PTH stimulates kidney tubule cells to release calcitriol.
    3. Effects of calcitriol on intestine:
        - Stimulates intestines to absorb calcium from digesting

food.

4. Blood calcium levels increase.
5. Calcitonin release: high concentrations of calcium stimulate parafollicular cells in the thyroid to release calcitonin.
6. Effects of calcitonin on bone:
    - Stimulates osteoblasts.
    - Inhibits osteoclasts.
    - Calcium is removed from blood and used to build bone.

[Return to Figure 10.4e]

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CHAPTER 11: ENDOCRINE MEDICATIONS: PART 2 ANTI-DIABETIC MEDICATIONS

11.0 Endocrine System: glucose regulation and anti-diabetic medications

Learning Objectives

1. Describe the functions of the pancreas, including endocrine and exocrine functions.
2. Understand the differences between diabetes mellitus type 1 and type 2, including the pathophysiology and treatments.
3. Compare and contrast the types of insulin, including onset, peak and duration of action.
4. Understand the differences between the different types of oral anti-diabetic medications and indications for each type of medication.
5. Articulate nursing considerations for each medication class to promote safe medication use.
6. Identify the side effects and special considerations associated with antidiabetic medications.
7. Identify the considerations and implications of using endocrine system medications across the lifespan
8. Apply evidence-based concepts when using the nursing process and clinical reasoning related to medications that affect the endocrine syste

To maintain body homeostasis, the body is dependent on tight control of blood glucose levels. The pancreas is key in glucose regulation as it secretes various hormones such as insulin, glucagon and somatostatin, as well as neuropeptides. Other organs have a role, namely the brain, liver and intestines, as well as skeletal muscle. The pancreas maintains blood glucose levels within a very narrow range by the opposing and balanced actions of glucagon and insulin (Roder et al, 2016). If this balance is not maintained, diabetes mellitus can occur.

Diabetes mellitus is divided into two primary types. Type 1 diabetes is characterized by a lack of insulin secretion due to autoimmune destruction. Type 2 diabetes is caused by a lack of sensitivity of insulin receptors at the target cells and a deficiency in insulin secretion. Both types can lead to chronic health conditions that can affect cardiovascular and nervous systems (Adams et al, 2018).

Diabetes Mellitus is a disorder of carbohydrate metabolism and symptoms result primarily from a deficiency of insulin, from cellular resistance to insulin or both (Burchum & Rosenthal, 2023). It is the most common endocrine disorder in Canada, as well as globally. The International Diabetes Federation (IDF) has identified diabetes as one of the largest global health emergencies of the 21st century, with high blood sugar the third highest risk factor for premature mortality, after high blood pressure and tobacco use (Diabetes Canada, 2020). Canada has seen rising rates of diabetes with an estimated 9.3% of the population in 2015 having diabetes, and predicted to rise to 12.1 % by 2025 (Diabetes Canada, 2020).

Diabetes can lead to numerous health complications. In particular, end-stage renal disease, blindness and cardiovascular complications. Along with health complications, the impact on an individual's lifestyle and productivity can be significantly impacted.

In this chapter, you are provided with a basic introduction to the concept of glucose regulation. Unit 11.3, a review of diabetes mellitus is provided. Unit 11.4 and 11.5, medications to treat diabetes is presented, including insulin therapy and oral diabetic

medications. At the end of the chapter, critical thinking and decision-making questions are available to test your understanding.

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11.1 Glucose Regulation and the Pancreas

The endocrine system regulates all body systems by secreting various hormones that the body releases in response to a change in the body's internal environment. The role of hormones is to maintain the homeostasis within the body. Hormones are closely regulated by a negative feedback system. For example, as the hormone level rises so too does its action. Once homeostasis is restored, the target tissue provides negative feedback and the endocrine tissue stops secreting the hormone (Adams et al, 2018). For more information on hormone regulation, refer to chapter 10.

Pancreas

For glucose metabolism, the pancreas secretes digestive enzymes and pancreatic hormones to regulate macronutrient digestion and endocrine energy homeostasis. The pancreas is a long, slender organ located behind the stomach in the upper abdominal cavity (see Figure 11.1a).

It has two functions, exocrine and endocrine. It is primarily an exocrine gland, secreting digestive enzymes into the duodenum. These digestive enzymes include amylase, pancreatic lipase and trypsinogen. The endocrine function is the secretion of insulin and glucagon into the bloodstream. Endocrine cells, called Islets of Langerhans, are clusters of cells in the pancreas. The alpha cells secrete glucagon and the beta cells secrete insulin. Together, glucagon and insulin maintain tight control of glucose levels. Other hormones secreted by the pancreas also have a role in glucose

regulation, such as somatostatin inhibits both glucagon and insulin release (Roder et al, 2016).

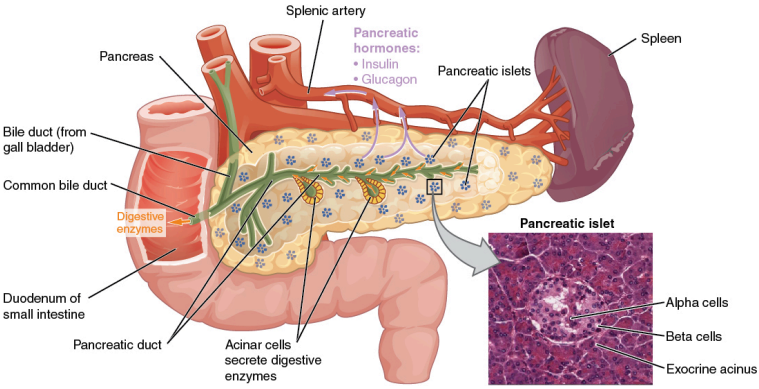

Figure 11.1a Pancreas

Regulation of Blood Glucose Levels by Insulin and Glucagon

Although there are a number of external signals that stimulate hormone release, such as nutrient intake or stress, the main stimulus for beta cells to release insulin are elevated blood glucose levels following a meal. As such, insulin release is regulated by the level of glucose in the blood. Insulin assists in glucose transport and without insulin, glucose cannot enter most cells and be used for energy. One exception is insulin-independent tissues in the brain which can uptake glucose without insulin. Glucose is the preferred fuel for all body cells. The body derives glucose from the breakdown of the carbohydrate-containing foods and drinks we consume. Glucose not immediately taken up by cells for fuel can be stored by the liver and muscles as glycogen or converted to triglycerides and stored in the adipose tissue. Hormones regulate both the storage and the utilization of glucose as required. Receptors located in the pancreas sense blood glucose levels, and subsequently, the

pancreatic cells secrete glucagon or insulin to maintain normal levels.

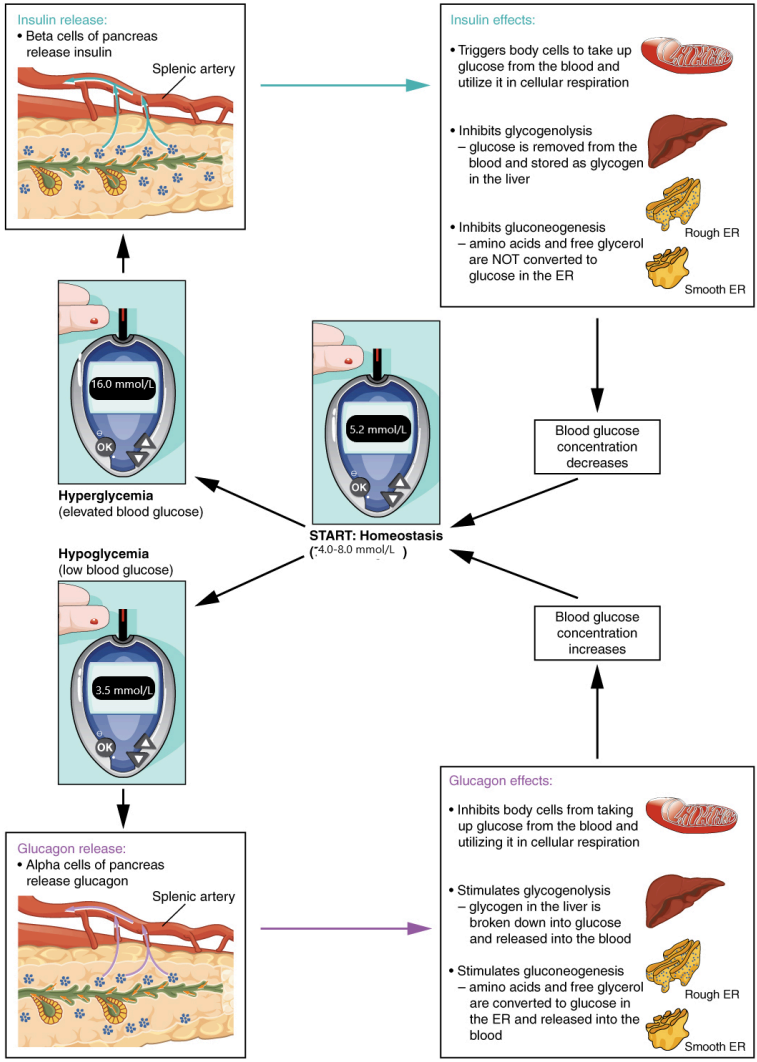

Figure 11.1b Homeostatic regulation of blood glucose levels

Maintenance of blood glucose levels by glucagon and insulin. When blood glucose levels are low, the pancreas secretes glucagon, which increases endogenous blood glucose levels through glycogenolysis. After a meal, when exogenous blood glucose levels are high, insulin is released to trigger glucose uptake into insulin-dependent muscle and adipose tissues as well as to promote glycogenesis.

Glucagon

Receptors in the pancreas can sense the decline in blood glucose levels, such as during periods of fasting or during prolonged labor or exercise. In response, the alpha cells of the pancreas secrete the hormone glucagon, which has several effects:

- It stimulates the liver to convert stores of glycogen back into glucose. This response is known as glycogenolysis. The glucose is then released into the circulation for use by body cells.
- It stimulates the liver to take up amino acids from the blood and convert them into glucose. This response is known as gluconeogenesis.
- It stimulates lipolysis, the breakdown of stored triglycerides into free fatty acids and glycerol. Some of the free glycerol released into the bloodstream travels to the liver, which converts it into glucose. This is also a form of gluconeogenesis.

Taken together, these actions increase blood glucose levels. The activity of glucagon is regulated through a negative feedback mechanism; rising blood glucose levels inhibit further glucagon production and secretion (Jiang & Zhang, 2003). See Figure 9.5b for an illustration of homeostatic regulation of blood glucose levels.

Insulin

Insulin facilitates the uptake of glucose into skeletal and adipose body cells. The presence of food in the intestine triggers the release of gastrointestinal tract hormones. This, in turn, triggers insulin production and secretion by the beta cells of the pancreas. Once nutrient absorption occurs, the resulting surge in blood glucose levels further stimulates insulin secretion.

Insulin triggers the rapid movement of glucose transporter vesicles to the cell membrane, where they are exposed to the extracellular fluid. The transporters then move glucose by facilitated diffusion into the cell interior.

Insulin also reduces blood glucose levels by stimulating glycolysis, the metabolism of glucose for generation of ATP. It further stimulates the liver to convert excess glucose into glycogen for storage, and it inhibits enzymes involved in glycogenolysis and gluconeogenesis. Finally, insulin promotes triglyceride and protein synthesis. The secretion of insulin is regulated through a negative feedback mechanism. As blood glucose levels decrease, further insulin release is inhibited.

Insulin is considered having a hypoglycemic effect, meaning it causes blood glucose levels to fall. Glucagon, in contrast, has a hyperglycemic effect. Endogenous glucagon is released when blood glucose levels are low and its function is to maintain glucose levels between meals (Jiang & Zhang, 2003). Its main role is to stimulate hepatic glucose output, leading to increases in glycemia. We can also give exogenous glucagon, and in these cases, glucagon can be administered IM, SQ or IV in hypoglycemic situations.

Blood glucose levels are also regulated by other hormones such as thyroid hormones, epinephrine, corticosteroids and growth hormones. Many medications can also affect glucose levels such as beta-adrenergic blockers, non-steroidal anti-inflammatory drugs, alcohol and many more.

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- 11.1c Glucose regulation concept map description

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11.2 Disorders of the Endocrine System: Diabetes Mellitus

The following section is the same as in the unit 10.2 Disorders of the Endocrine System. It is reproduced here as it can apply to both units.

Dysfunction of insulin production and secretion, as well as the target cells' responsiveness to insulin, can lead to a condition called diabetes mellitus, a common disease that affects the ability of the body to produce and/or utilize insulin. There are two main forms of diabetes mellitus.

Type 1 Diabetes is an autoimmune disease affecting the beta cells of the pancreas. The beta cells are destroyed by the immune system but can also occur due to a trauma or injury to the pancreas (Thota & Akbar, 2023). The beta cells of people with type 1 diabetes do not produce insulin; thus, synthetic insulin must be administered by injection or infusion. Presenting symptoms include polyuria, polydipsia, and polyphagia. Clients may also have unexplained weight loss and blurred vision. If left untreated the client can go into ketoacidosis, a life-threatening condition.

Type 2 Diabetes accounts for approximately 95 percent of all cases. It is acquired, with contributing factors of family history, over the age of 40, overweight, and lifestyle factors such as poor diet and inactivity greatly increase a person's risk (Diabetes Care Community, 2023). In type 2 diabetes, the body's cells become resistant to the effects of insulin. In response, the pancreas increases its insulin secretion, but over time, decompensation occurs as the impaired beta cells are unable to produce sufficient insulin to overcome insulin resistance. In many cases, type 2 diabetes can be managed by moderate weight loss, regular physical

activity, and consumption of a healthy diet. However, if blood glucose levels cannot be controlled, oral diabetic medication is prescribed.

Type 2 diabetes is a progressive disease, especially if blood sugars are not kept within target range. The client often begins with one oral anti-diabetic medication, and may be prescribed additional meds depending on their blood sugars, other health issues and symptom management. As with type 1 diabetes, blood sugar control is essential to avoid hypoglycemia and hyperglycemia fluctuations. Over time, long term physiological changes can occur especially in the arteries, such as retinopathy, neuropathies, nephropathy leading to kidney failure and cardiovascular disease.

Gestational Diabetes Mellitus (GDM):

Gestational Diabetes is a form of glucose intolerance or hyperglycemia that is first recognized during pregnancy. Left untreated, it poses significant short and long-term risks to both the mother and the fetus. GDM is similar to type 2 diabetes, caused by increased insulin resistance and a deficiency in insulin. Maternal pancreatic β-cell dysfunction results in decreased insulin secretion, leading to the inability to control maternal insulin resistance and maternal hyperglycemia. Screening for GDM occurs in week 24-28 of pregnancy. Risks to the mother include preeclampsia. The risk to the infant is macrosomia, shoulder dystocia and increased risk of diabetes later in life. GDM is treated with diet, exercise, and either insulin or metformin depending on client factors. Post-partum, many mothers return to their pre-pregnancy state. To learn

more about GDM, go to Gestational diabetes – Diabetes Canada

Diagnosis of Diabetes

Screening for type 2 diabetes should be done every 3 years for individuals over 40 years of age or anyone considered high risk of developing diabetes. If a client has numerous risk factors, screening may be done every 6-12 months or by the recommendation of their health care provider.

Screening includes fasting or random plasma glucose and glycated hemoglobin (A1C).

High risk factors include: family history of diabetes, history of pre-diabetes or gestational diabetes, overweight, or a member of a high-risk group: African, Arab, Asian, Hispanic, Indigenous or South Asian descent, low socioeconomic status (Diabetes Canada Clinical Practice Guidelines Expert Committee, 2026).

Table 11.2.1 Diagnosis for Diabetes

Fasting blood glucose levels (FBG)	Normal: 4.0-7.0 mmol/L At risk: 5.6-6.0 mmol/L Pre-diabetes: 6.1 to 6.9 mmol/L Diabetes: greater than 7.0 mmol/L	Fasting at least 8 hours. (Slight differences in values between some sources. Normal FBG 4.0-7.0 reported with Diabetes Canada)
Random blood glucose test	Diabetes: 11.1 mmol/L or higher.	No fasting or preparation involved.
Oral glucose tolerance test (OGTT)	Following ingesting 75 grams of glucose in a drink, after 2 hours: Diabetes: BG level 11.1 mmol/L or higher Pre-diabetes: 7.8 – 11.0 mmol/L	measures your body's ability to use glucose. Plasma glucose level drawn, followed by a 75 gram glucose load, then second blood glucose level.
Glycosylated hemoglobin, also called A1C	Normal: under 5.7% At risk: 5.5-5.9% Pre-diabetes: 6-6.4% Diabetes: greater than 6.5%	Used to assess long-term blood glucose levels over 3 months. Good indicator of blood glucose control. (Normal under 6.5% with Diabetes Canada)

Tests for Diabetes Screening and Monitoring

For more information on testing for diabetes, go to: Diabetes Care

Community (2023). Blood sugar levels in Canada. Blood Sugar Levels In Canada

For more information on diabetes management in Canada, go to the Diabetes Canada website: About diabetes – Diabetes Canada this is an excellent resource for clients and health care professionals.

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11.3 Clinical Reasoning and Decision Making for Diabetes

Assessment

Type 1 diabetes mellitus results from the autoimmune destruction of the islets of Langerhans, which are pancreatic cells responsible for producing insulin; the body is then unable to produce insulin. Most clients who first develop diabetes, present with hyperglycemia. Hyperglycemia cues include polyuria, polydipsia and polyphagia which are the typical signs. Other cues that can be present are weight loss, fatigue, irritability and blurred vision. For diagnostic testing, along with hyperglycemia and an elevated A1C level, glucosuria is present. A new onset of type 1 diabetes can lead to diabetic ketoacidosis if left untreated, which can lead to coma and death. All clients with type 1 diabetes will be on insulin therapy lifelong (Goyal et al, 2023).

In type 2 diabetes mellitus, the pancreas is capable of producing insulin but the body cannot properly utilize insulin, commonly referred to as "insulin resistance." Overtime, the insulin production can eventually decrease. Type 2 diabetes can initially go undetected as the blood sugars may be elevated but not to the degree that serious symptoms occur. Symptom onset is usually gradual, and may include blurred vision, fatigue and recurrent infections. Clients should be assessed routinely over the age of 40 years, or if they have any predisposing risk factors (Diabetes Canada, 2026).

Risk factors for type 2 diabetes include:

- belonging to a certain ethnic group (Indigenous, Arab, African, Hispanic, South Asian),
- over the age of 40,

- overweight or obese,
- family history of diabetes,
- history of heart disease or hypertension,
- hyperlipidemia,
- history of gestational diabetes.

For type 2 diabetics who are newly diagnosed, diet and exercise are important and can sometimes increase the sensitivity of insulin receptors enough to help keep the blood sugars close to target range (HbA1C less than 7%). Exercise plays an important role in managing diabetes. Exercise increases cellular responsiveness to insulin, lowering the amount of insulin needed. The oral anti-diabetic medication, the biguanide metformin, is typically the initial drug therapy. As the disease progresses, other medications are added depending on the client's other health issues such as heart disease, obesity or renal dysfunction.

Along with pharmacological management, all diabetic clients need to follow healthy eating habits, exercise regularly and not smoke as part of their treatment plan to prevent long term complications. Complications result from long term damage to arteries, which can lead to heart disease, stroke, kidney disease (nephropathy), and vision alterations (diabetic retinopathy). With chronically high blood sugars, there is a higher risk of infections. There can also be nerve damage with the resulting peripheral neuropathy. Lastly, it is important for the client to avoid blood glucose fluctuations from hyperglycemia to hypoglycemia within a short time frame (Goyal et al, 2023).

Hemoglobin A1C:

what it is and why is it important? To learn more about A1C, watch the following YouTube video:

Khan Academy (2011). A1C levels

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=4071#oembed-1

Hypoglycemia is a life-threatening condition. Nurses must be acutely aware of the risk of hypoglycemia and to provide immediate treatment. Hyperglycemia is less likely to occur if medications are taken as prescribed. Report symptomatic hyperglycemia to the prescriber. For clients who have an illness or if they are under stress, anticipate blood sugar alterations and monitor more closely.

Hypoglycemia Signs and Symptoms

Table 11.3.1 Hypoglycemia Signs and Symptoms

Mild-to-Moderate	Severe
• Shaky or jittery • Sweaty • Hungry • Headache • Blurred vision • Sleepy or tired • Dizzy or lightheaded • Confused or disoriented • Pale • Uncoordinated • Irritable or nervous • Argumentative or combative • Changed behavior or personality • Trouble concentrating • Weak • Fast or irregular heart beat	• Unable to eat or drink • Seizures or convulsions • Unconsciousness

Pre-assessment

- Obtain a complete health history, including allergies
- Obtain a complete medication profile, including drug interactions
- Vital signs
- Blood glucose monitoring. If infection or stress, assess more frequently for hyperglycemia
- Physical assessment may include: skin assessment for wounds, eye examination (blurred vision), numbness or tingling in feet

If on insulin therapy

- Assess appetite and plan to eat the next meal
- Blood glucose monitoring: before each meal and as needed
- Assess for hypoglycemia. For long term diabetic clients, hypoglycemia symptoms can be subtle
- Assess subcutaneous areas for insulin injections, rotate sites to avoid lipodystrophy

Implementation

The nurse should follow agency policy and ISMP guidelines for safe insulin administration. Onset and peak times of insulin and sulfonylureas, in association with anticipated meal times, should always be considered to avoid hypoglycemia episodes. If a hypoglycemia episode occurs, the nurse should intervene quickly using the agency's established hypoglycemia protocol, and the event should be reported to the provider and in the shift-to-shift report.

Hypoglycemia Protocol

In the event of hypoglycemia, with blood sugars less than 4.0 mmol/L or if a change in mood or mental status or other signs of hypoglycemia, quickly follow the agency protocol. Hypoglycemia protocols contain orders for immediate treatment by the nurse.

This will include:

- give a fast-acting carbohydrate (simple sugar): 15-20 grams glucose tablets, 125 ml of juice, honey or glucose tablets. If unable to swallow, the nurse may give honey, but be aware of

aspiration risk. If NPO or unconscious, give dextrose 50% IV or glucagon 1 mg IM/SQ.

- goal of therapy is blood glucose greater than 4 mmol/L. Repeat blood glucose every 15 minutes x 2 and give fast-acting carbohydrate until blood sugar is above 4 mmol/L,
- after 3 rounds of simple sugar, and if more than one hour before next meal, eat a snack of a starch (crackers, toast) and protein (milk, cheese, peanut butter).

Figure 11.3a Glass of orange juice. For a hypoglycemic episode, ingest a fast-acting sugar such as drinking 125 ml of orange juice.

Orange juice (50531482356).jpg (amanda.sophia.ac at https://flickr.com/photos/190653512@N07/50531482356)

Monitor closely for the following 24 hours because they are at increased risk for another episode. The provider and the oncoming nurse should be notified of hypoglycemia episodes todiscuss the possible cause of the hypoglycemic event and make insulin

adjustments, if needed, to avoid additional hypoglycemia. Tracking hypoglycemia episodes and analyzing causes are important performance improvement activities (Seggelke & Everhart, 2012).

Client education is a vital component of effectively managing diabetes. Client education should be provided to clients, family members, and/or caregivers according to ISMP guidelines.

- All clients must know the signs or symptoms of hypoglycemia
- All clients must know how to avoid and treat hypoglycemia
- Ensure clients follow a healthy diet and exercise plan
- Check blood sugars as required by their prescriber and as needed.
- Follow the recommendations for insulin therapy or for oral anti-diabetic medications to avoid adverse effects (see insulin therapy or oral anti-diabetic medication sections for more detailed information).

Evaluation

Monitor for complications

As mentioned in the assessment, complications will occur with long term diabetes or with diabetes that is poorly managed. Assessing for any signs of complications such as blurred vision, numbness or tingling in the feet, or poorly healing wounds. Routinely ask the client about these symptoms to identify early any changes.

Avoid hypoglycemia and hyperglycemia

Effective management requires a client who is able to follow the treatment plan such as check blood sugars as required, take their anti-diabetic medications as prescribed, and avoid hyperglycemia or hypoglycemia episodes. Along with blood sugar levels, completion of routine A1C levels to determine effectiveness of the treatment regimen.

Diabetic Ketoacidosis

Although severe hyperglycemia is less common than hypoglycemia, recognizing cues is important to avoid diabetic ketoacidosis. Severe hyperglycemia cues include the 3 P's: polyuria, polydipsia and polyphagia along with abdominal pain and nausea. The characteristic fruity breath is another cue. Hyperglycemia can be due to infection, inadequate insulin or skipping doses. So, any uncontrolled elevations in blood sugars must be examined.

Acetone fruity odour to the breath can occur when glucose is unable to enter cells, and lipids are used as an energy source and keto acids are produced as waste products. The keto acids give the client the fruity breath odor. The high levels of ketones lower the pH of the blood, leading to diabetic ketoacidosis. This is a life-threatening condition that can result in coma and death if not treated promptly (Adams et al, 2018).

If hyperglycemia occurs while on insulin therapy, notify the prescriber and anticipate a trip to the emergency department for a thorough assessment and treatment. Treatment includes IV insulin, electrolyte and fluid replacement (Lizzo, Goyal & Kaur, 2025).

Management of blood sugars for all diabetic clients includes:

- healthy diet, physical activity and a healthy lifestyle (i.e. no smoking, minimal alcohol intake).
- A goal of tight glycemic control that includes an A1C less than 7% and to maintain blood glucose levels within normal range.

Type 1 diabetics will be on insulin that includes both basal and bolus (prandial) insulin.

Type 2 diabetics will be on one or more oral anti-diabetic medications, depending on their glycemic control. If the oral meds are no longer effective, insulin may be added.

Hypokalemia

Hypokalemia is one of the most common electrolyte disturbances secondary to poor glycemic control. All insulin products cause a shift in potassium from the extracellular to intracellular space, which can possibly lead to hypokalemia. Hypokalemia is defined as serum potassium concentration less than 3.5 mEq/L. The main causes of hypokalemia in diabetics are the use of high doses of insulin or when attempting to correct diabetic ketoacidosis or hyperglycemic hyperosmolar state. The other cause of hypokalemia is the use of diuretics such as thiazides or loop diuretics (Coregliano-Ring, Nishide & Rangel, 2022). Mild cases of hypokalemia can present as muscle weakness, fatigue, cramping

and heart palpitations. If severe, cardiac dysrhythmias, respiratory failure and severe abdominal pain. Monitor potassium levels in clients at risk for hypokalemia due to other medications such as diuretics.

Glycemic control during sick days

Clients who are sick, either at home or in the hospital, will need closer monitoring. Blood sugars should be checked every 2-4 hours, and if blood sugars are high, then also check urine ketones every 2 – 3 hours. Hydration and food are important so drinking at least 250 cc of fluids and eating 15 grams of carbohydrates every hour. If the client is on insulin, continue to take insulin and anticipate higher prandial dose needs. If the client is on oral anti-diabetic meds such as metformin or SGLT-2 inhibitors, the prescriber may temporarily stop these meds until they are feeling better. For clients managing their illness at home, advise them that if blood sugars are over 16.1 mmol/L, there is high ketones in the urine, or they cannot eat or drink, they should plan to go to the hospital.

Alcohol and Diabetes

Clients with diabetes can continue to drink alcohol but need to drink in moderation, which is considered 1-2 drinks/day or depending on if their diabetes is under control, or if they have other health considerations. Key

points to consider if a client plans to consume alcohol and they are on insulin:

- Before consuming alcohol, continue to eat regular meals. While drinking, eat carbohydrate-rich foods and consider alternating between alcoholic and non-alcoholic beverages. After drinking, ensure there is a responsible person who knows how to monitor for signs of hypoglycemia.
- Delayed hypoglycemia: hypoglycemia may occur up to 24 hours after alcohol consumption
- Morning hypoglycemia: if a client consumes alcohol 2-3 hours following an evening meal, hypoglycemia may occur in the morning
- Check blood sugars more often for the next 24 hours.

For more information, go to Diabetes Canada (2026). Alcohol and Diabetes: https://guidelines.diabetes.ca/GuideLines/media/Docs/Patient%20Resources/alcohol-and-diabetes.pdf

Lifespan Considerations

Older Adult

The older adult are at higher risk for hypoglycemia episodes. The following are evidence-based recommendations for elderly clients with diabetes:

- In older adults at increased risk of hypoglycemia, medication classes with low risk of hypoglycemia are preferred.
- Overtreatment of diabetes is common in older adults and should be avoided.
- Deintensification (or simplification) of complex regimens is recommended to reduce the risk of hypoglycemia, if it can be achieved within the individualized A1C target (American Diabetes Association, 2019).

Children and Adolescents

Type 1 diabetes is the most common form of diabetes in youth. Unique aspects of care and management of children and adolescents with type 1 diabetes must be considered, such as changes in insulin sensitivity related to physical growth and sexual maturation, ability to provide self-care, supervision in the child care and school environment, neurological vulnerability to hypoglycemia and hyperglycemia in young children, as well as possible adverse neurocognitive effects of diabetic ketoacidosis (DKA). Evidence-based recommendations for glycemic control for children and adolescents include:

- The majority of children and adolescents with type 1 diabetes should be treated with intensive insulin regimens, either via multiple daily injections or continuous subcutaneous insulin infusion.
- All children and adolescents with type 1 diabetes should self-monitor glucose levels multiple times daily (up to 6–10 times/day), including pre-meal, pre-bedtime, and as needed for safety in specific situations such as exercise, driving, or the presence of symptoms of hypoglycemia.
- Continuous glucose monitoring should be considered in all children and adolescents with type 1 diabetes, whether using

injections or continuous subcutaneous insulin infusion, as an additional tool to help improve glucose control. Benefits of continuous glucose monitoring correlate with adherence to ongoing use of the device.

- Automated insulin delivery systems appear to improve glycemic control and reduce hypoglycemia in children and should be considered in children with type 1 diabetes.
- An A1C target of <7.5% should be considered in children and adolescents with type 1 diabetes but should be individualized based on the needs and situation of the client and family (American Diabetes Association, 2019).

The following concept map provides a summary of key information to help understand glucose regulation. You can revisit this map after you have completed the chapter. The information for the map was informed by several resources (Giddens, 2017, pg. 241).

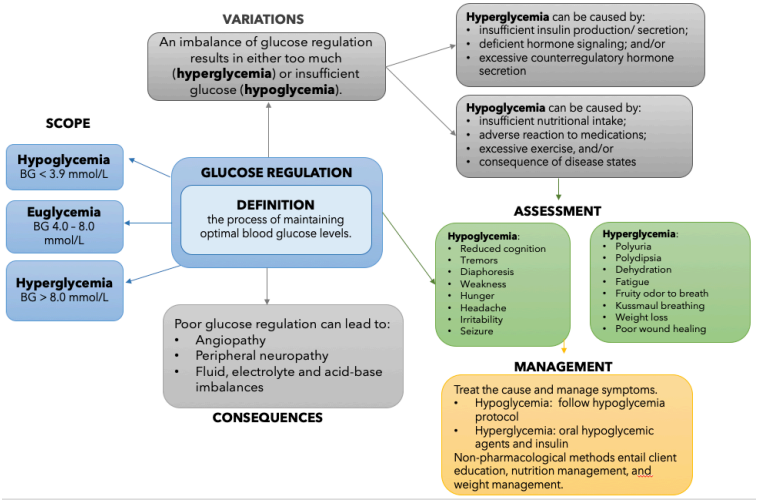

Figure 11.3b Glucose Regulation Concept Map [Image Description]

Image Description

Figure 11.3b Glucose Regulation Concept Map description: This flowchart describes the Concept of Glucose Regulation. In the centre of the chart, Glucose Regulation is defined.

The definition of the Concept of Glucose Regulation is: the process of maintaining optimal blood glucose levels.

Next, there are 3 arrows pointing from the definition to the Scope of Glucose Regulation. The scope is divided into 3 categories: Hypoglycemia (BG < 3.9 mmol/L), Euglycemia (BG 4.0 – 8.0 mmol/L), and Hyperglycemia (BG > 8.0 mmol/L).

Next, one arrow points from the definition to the Variation of Glucose Regulation. An imbalance of glucose regulation results in either too much (**hyperglycemia**) or insufficient glucose (**hypoglycemia**). Both hyperglycemia and hypoglycemia are further described.

- Hyperglycemia can be caused by: insufficient insulin production/ secretion; deficient hormone signaling; and/or excessive counterregulatory hormone secretion.
- Hypoglycemia can be caused by: insufficient nutritional intake; adverse reaction to medications; excessive exercise, and/or consequence of disease states.

Next, an arrow points down towards Assessment for Glucose Regulation. Here, a summary of hypoglycemia and hyperglycemia symptoms are listed.

- Hypoglycemia: Reduced cognition, Tremors, Diaphoresis, Weakness, Hunger, Headache, Irritability, Seizure.
- Hyperglycemia: Polyuria, Polydipsia, Dehydration, Fatigue, Fruity odor to breath, Kussmaul breathing, Weight loss, Poor wound healing.

Media Attributions

- Figure 11.3a Orange juice (50531482356).jpg (amanda.sophia.ac/ *Wikimedia Commons*) at https://flickr.com/photos/190653512@N07/50531482356)
- Figure 11.3b *Glucose Regulation Concept Map* [*Image Description*]

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11.4 Insulin Therapy

Since the discovery of insulin in 1921-1922 by the Canadian researchers Frederick Banting and Charles Best, and with ongoing improvement in insulin therapies and overall diabetic management, type 1 diabetics can effectively manage their blood sugars and glycemic control.

Anti-Diabetic Medication Classes: Insulins

Because the hallmark of type 1 diabetes is absent or near-absent β-cell function, insulin treatment is essential for individuals with type 1 diabetes. Current evidence-based recommendations regarding pharmacological treatment of type 1 diabetes include:

- Most people with type 1 diabetes should be treated with multiple daily injections of prandial and basal insulin or continuous subcutaneous insulin infusion.
- Most individuals with type 1 diabetes should use rapid-acting insulin analogs to reduce hypoglycemia risk.
- Individuals with type 1 diabetes on prandial insulin doses should be educated on carbohydrate intake, premeal blood glucose levels, and anticipated physical activity.
- Individuals with type 1 diabetes who have been successfully using continuous subcutaneous insulin infusion should have continued access to this therapy after they turn 65 years of age.

Mechanism of Action

Insulin is an essential hormone that has a number of functions. It restores a client's ability to metabolize fats and carbohydrates, it increases protein synthesis, it allows glucose transport into most cells (the brain and liver are exceptions) and promotes the conversion of glucose into glycogen in the liver and muscle.

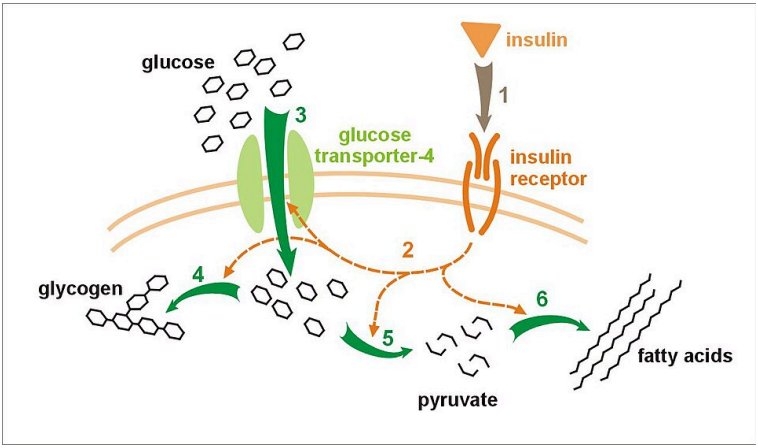

Figure 11.4a Effect of insulin on glucose uptake and metabolism. Insulin binds to its receptor (1) which in turn starts many protein activation cascades (2). These include: translocation of Glut-4 transporter to the plasma membrane and influx of glucose (3), glycogen synthesis (4), glycolysis (5) and fatty acid synthesis (6). (Meiquer/Wikimedia Commons) CC BY-SA 3.0

Insulin acts directly by binding to the receptors on the plasma membranes of all cells. Once the insulin binds to the beta subunit of a cell, this initiates other actions. The glucose transporter in the cell allows the influx of glucose from the blood into the cell, thus reducing blood glucose levels. It also initiates other events such as glycogen synthesis, inhibits glucagon release, promotes lipogenesis, among other actions. Insulin acts like a key, helping glucose enter

cells. If the pancreas does not produce insulin, such as with type 1 diabetics, the cellular uptake of glucose does not occur (Thota & Akbar, 2023).

In type 2 diabetes, the cells are resistant to the action of insulin. The pancreas will secrete more insulin to try to get the glucose into cells but eventually there is progressive beta-cell dysfunction, leading to a buildup of glucose in the blood.

All insulins have the same mechanism of action, that is, they lower blood glucose by stimulating peripheral glucose uptake by skeletal muscle and fat and by inhibiting hepatic glucose production.

Types of Insulin

Initially, insulin was prepared from cow or pig pancreas. Since the 1980s, insulin is genetically engineered to produce a synthetic human insulin. Normally, the pancreas secretes a steady stream of insulin called basal. This provides the background insulin needed to supply cells with glucose around the clock while preventing the release of excess glucose from the liver and excess fat from the adipose cells. When we eat, we need more insulin so a bolus amount of insulin is produced over the next few hours. Once carbohydrate absorption is complete, insulin levels decline. When we give insulin, we are mimicking this effect.

Insulins fall into different categories, based on their source, onset, and duration of action:

- Bolus (prandial) insulin: used with meals
    - rapid-acting (insulin lispro, insulin aspart, or insulin glulisine)
    - short-acting (regular insulin)
- Basal insulins:
    - Intermediate-acting (insulin isophane suspension [NPH])
    - Long-acting (insulin glargine or insulin detemir)

There are also pre-mixed insulins, such as premixed regular insulin Humulin 30/70 and Novolin 30/70 or 40/60.

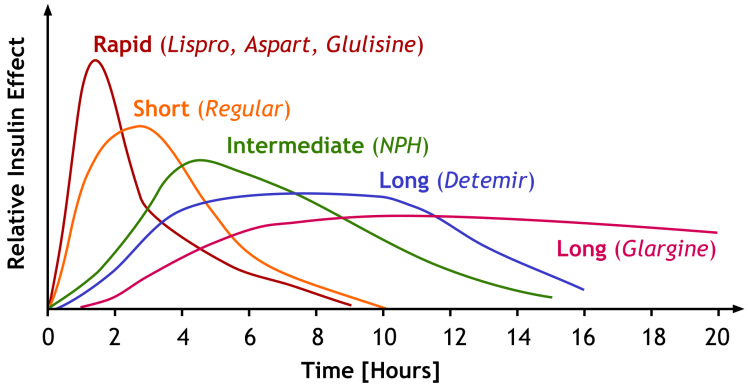

Figure 11.4b Types of insulin and duration of action (M Komorniczak/Wikimedia Commons) CC BY-SA 3.0

Insulin Facts

- The goal of insulin therapy is to mimic both the normal transient insulin secretion following food intake and the basal between-meal insulin levels as close as possible (Diabetes Canada, 2026).
- Insulin can be used alone or in combination with other types of insulin to stimulate normal insulin secretion.
- All type 1 diabetic clients will be on a basal insulin and a bolus insulin. Type 2 diabetics may also be on insulin if they have significant risk factors such as coronary artery disease or other vascular conditions or become more resistant to insulin (Thota & Akbar, 2023).

Therapeutic Effects:

- Regulates the movement of glucose from blood into cells
- Insulin lowers blood glucose by stimulating peripheral glucose uptake primarily by skeletal muscle cells and fat, and by inhibiting glucose production and release by the liver
- Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)

Adverse effects:

- All insulins have risk of hypoglycemia or hyperglycemia
- Ensure correct injection technique to avoid lipodystrophy, bruising and pain at the site.

Depending on the duration of action, insulin is categorized as rapid acting, short-acting, intermediate-acting, and long-acting. In the table below is a comparison of the different insulins.

Comparing Insulins

Class	Prototypes	Onset/ Peak/ Duration	Administration Considerations	Other
Rapid-Acting Insulin **(Prandial)**	insulin lispro (Humalog) insulin aspart (Novolog) inhaled insulin (Afrezza)	Onset: 15-30 minutes Peak effect: 1-3 hours Duration: 3 – 5 hours	· Administer within 15 minutes before a meal or immediately after a meal. · Afrezza is contraindicated in patients with asthma or COPD Ensure the client plans to eat their meal	Afreeza can cause bronchospasm in COPD
Short-Acting Insulin **(Prandial)**	Humulin R	Onset: 30 minutes Peak effect: 3 hours Duration: 8 hours	· Administer 30 minutes before a meal	
Intermediate-Acting Insulin **(Basal)**	Humulin N Novolin N	Onset: 1-2 hours Peak effect: 6 hours (range 2.8-13 hours) Duration: up to 24 hours	· Administer once or twice daily · SQ only · Gently roll or invert vial/ pen several times to re-suspend the insulin before administration · Do not mix with other insulin	

Combination: Intermediate-Acting/ Rapid-Acting	Humalog Mix 50/50 Humalog Mix 75/25 Novolog Mix 70/30 *First number is % intermediate-acting insulin, second number is % rapid-acting	Onset: 15-30 minutes Peak effect: 50/50: 1-5 hours Duration: 11-22 hours	· Administer twice daily, 15 minutes before a meal or immediately after a meal · Only administer subcutaneously · Gently roll or invert vial/ pen several times to re-suspend the insulin before administration	
Combination: Intermediate-Acting/ Short-Acting	Humulin 70/ 30 Novolin 70/ 30	Onset: 30-90 minutes Peak effect: 1.5-6.5 hours Duration: 18-24 hours	· Administer twice daily, 30-45 minutes before a meal · SQ only · Gently roll or invert vial/ pen several times to re-suspend the insulin before administration · Do not mix with other insulins	
Long-Acting Insulin **(basal)**	insulin glargine (Lantus) insulin detemir (Levemir)	Onset: 3-4 hours Peak effect: none Duration: >24 hours	· Administer once daily (sometimes dose is split and administered twice daily) · SQ only · Do not mix with other insulins	

Hyperglycemic agent Treats severe hypoglycemia	Glucagon	SQ, IM, IV or inhaled IVP: onset is 5-30 minutes IM: 30 min for peak glucose response Duration of action 90 minutes GlucPen SQ	. Supplementary carbohydrate should be given as soon as possible, especially to a pediatric patient · Used to reverse hypoglycemic episode if oral administration of sugar is not appropriate or effective. safe with peds SE: nausea, nasal congestion, headache, abd pain, dizziness	Risk of hyperglycemia For severe hypoglycemia not responsive to administration of simple CHOs or if oral administration of CHOs is not possible.

Note: All onset, peak and duration times are approximate and may differ depending on reference (Diabetes Canada, 2026)

Comparing Insulins

Rapid-Acting Insulin

Rapid-acting insulins include insulin lispro (Humalog) and insulin aspart (Novolog) and are also available via inhalation (Afrezza). See Figure 11.4c for an image of Novolog insulin

Figure 11.4c Image of Novolog insulin (Alan Levine/ PXHere)CC BY-SA 2.0

Indications: Rapid-acting insulins are also called prandial insulins because they are administered with meals to mimic the effects of endogenous insulin release when food is eaten. Dosages of rapid-acting insulin are individualized based on carbohydrate intake, premeal glucose levels, and anticipated activity.

Administration Considerations

Concentration differences: Lispro Humalog-100 (100 units per ml) and Humalog-200 (200 units per ml) are both rapid-acting insulins.

- Humalog-100:
  - SQ or IV continuous injection.
  - can be mixed with NPH insulin. It is available in vials, KwikPens and cartridges.
- Humalog-200:
  - should not be mixed with other insulins.
  - SQ, only available in KwikPens.
  - twice as concentrated as Humalog-100, used for clients who require high levels of insulin.

Inspect insulin visually before use. It should appear clear and colorless; do not use if particulate matter or coloration is seen.

Administer subcutaneously into the abdominal area, thigh, or deltoid, and rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy.

Because of the rapid onset of insulin lispro and insulin aspart and the potential for hypoglycemia, these insulins should be administered within 15 minutes before or right after eating a meal. Peak serum levels are seen 30 to 90 minutes after dosing.

Inhaled insulin enters the bloodstream within 1-15 minutes and peaks in 30-60 minutes. Inhaled insulin is contraindicated in clients with chronic lung disease such as asthma or COPD. May cause acute bronchoconstriction.

Adverse effects of all insulins include hypoglycemia and hypokalemia.

Short-Acting Insulin

Short-acting insulins include regular insulin with a brand name of Humulin R or Novolin R. A concentrated formulation of Humulin R u-500 is also available.

Indications

Short-acting insulins are given with meals to mimic the effects of endogenous insulin release when food is eaten. Dosages of short-acting insulin are individualized based on carbohydrate intake, premeal glucose levels, and anticipated activity levels.

Administration Considerations

Administer: SQ or IV.

- Regular insulin is generally administered subcutaneously. It can be given intravenously, either intermittent or continuous infusion, under close supervision of blood glucose and potassium levels.

- It is available in vials and insulin pens.

Inspect insulin visually before use. It should appear clear and colorless; do not use if particulate matter or coloration is seen.

Administer subcutaneously into the abdominal area, thigh, or deltoid, and rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy. Subcutaneous doses should be administered approximately 30 minutes before meals because this is the typical onset of action. Peak effects occur in 3 hours with a duration of 8 hours. Do not mix with insulin preparations other than NPH.

Humulin R u-500 should only be administered in u-500 insulin syringes to avoid dosage calculation errors.

Intermediate-Acting Insulin

NPH insulin, also known as isophane insulin, is an intermediate–acting insulin. Brand names include Humulin-N or Novolin-N. Mixtures of short- and intermediate-acting insulin include Humulin 70/30 or Novolin 70/30.

Indications

Intermediate insulins are administered once or twice daily to mimic endogenous basal insulin levels.

Administration

NPH insulin is a white and cloudy suspension. Gently roll or invert vial/pen several times to re-suspend the insulin before administration. It should only be administered subcutaneously. It may be mixed with rapid-acting or short-acting insulins, but those insulins should be drawn into the syringe before the NPH is added.

Administer subcutaneously into the abdominal area, thigh, or deltoid, and rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy.

The onset of action and peak are affected by the site of injection,

physical activity level, and other variables but the median peak level occurs in 4 hours. See Figure 11.4e for an image of Novolin-N (a cloudy insulin) that can be mixed with Novolin R (a clear insulin).

Figure 11.4d Comparison of Novolin-N (a cloudy insulin) that can be mixed with Novolin-R (a clear insulin) (Johnson; *https://www.flickr.com/photos/ladytaz/1836553797*)

Mixed medications such as Humulin 70/30 should be administered subcutaneously approximately 30 minutes before a meal. They are typically dosed twice daily (with each dose intended to cover 2 meals or a meal and a snack).

Unopened vials should be stored in the refrigerator until the expiration date. Opened vials should be labelled with the open date and stored in the refrigerator for up to 28-42 days (depending on the formulation/insulin type) and then discarded. Unopened pens should be stored in the refrigerator until the expiration date. Used pens should be stored at room temperature, but kept away from heat and light, for up to 10-28 days (depending on the formulation/insulin type) and then discarded.

Long-Acting Insulin

Insulin glargine (Lantus) and insulin detemir (Levemir) are long-acting insulins given once or twice daily. See Figure 11.4f for an image of a levemir insulin pen.

Figure 11.4e Vial used for Levemir insulin pen. (Wesalius/Insulin analog 100 IU-1ml penfill levemir yellow background.jpg/*Wikimedia Commons*). CC BY 4.0 ↵

Indications

Long-acting insulins are given once or twice daily. In type 1 diabetics, long-acting insulin should be used concomitantly with rapid- or short-acting insulin at mealtimes.

Administration

Long-acting insulin has a relatively constant concentration/time profile over 24 hours with no pronounced peak in comparison to NPH insulin. It should only be administered subcutaneously and is available in vials and insulin pens.

Inspect insulin visually before use. It should appear clear and colorless; do not use if particulate matter or coloration is seen. Administer subcutaneously into the abdominal area, thigh, or deltoid, and rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy.

Dosing and Administration

Dosing is highly individualized for each client. Insulin requirements can be estimated based on weight, with typical doses ranging from 0.4 to 1.0 units/kg/day. Higher amounts are required during puberty, pregnancy, and medical illness. Physiologic insulin secretion varies with glycemia, meal size, and tissue demands for glucose. To approach this variability in people using insulin treatment, strategies have evolved to adjust meal-time doses based on predicted needs. Thus, education of clients on how to adjust insulin to account for carbohydrate intake, premeal glucose levels, and anticipated activity is important. Ensuring that clients and/or caregivers understand correct insulin injection technique is also important to optimize glucose control and insulin use safety (American Diabetes Association, 2019).

Insulin administration is typically given by subcutaneous route. It is the preferred route, easy to administer and can be given by insulin syringes, pens and pumps (See figure 11.4f). it can be injected into almost any fatty area under the skin, but typically the back of the upper arm, abdomen, or thigh. The insulin absorbs the fastest when given in the abdomen. It is important to rotate injection sites to avoid complications such lipodystrophy.

Intravenous route: It can be given intravenous which may be seen in clients who are in the hospital and who need a very tight glycemic control. For example, clients with sepsis, diabetic ketoacidosis, severe hyperkalemia, or beta-blocker toxicity (Thota & Akbar, 2023).

Other routes: It can also be given intramuscular, although rarely used. Recently, an inhalable insulin has been developed, where it passes through the lungs into the bloodstream and provides a rapid onset of 12 minutes (Thota & Akbar, 2023). Insulin is never given orally due to low bioavailability from the acidic stomach environment and the various proteolytic enzymes in the gastrointestinal tract that break down the insulin peptide structure,

making it inactive. It is also a large molecule, unable to be absorbed in the intestinal lumen (Limenh, 2024).

Insulin Delivery

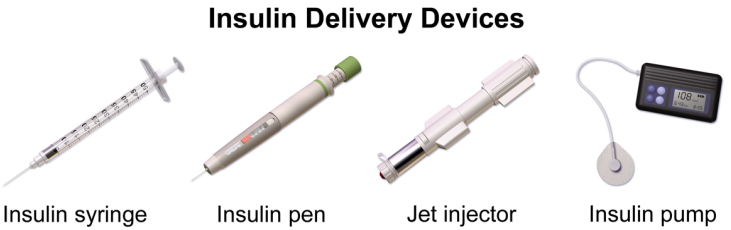

Figure 11.4f Diagram depicting insulin delivery devices, such as insulin syringe, insulin pen, jet injector and insulin pump. By BruceBlaus – Own work, http://commons.wikimedia.org/wiki/File:Insulin_Delivery_Devices_(hy).png/Wikimedia Commons). CC BY-SA 4.0.

Insulin is delivered subcutaneously to respond precisely to blood glucose levels. The ideal device for a client should be economically feasible and easy to use to promote long-term adherence.

Insulin Syringe

Insulin syringes require clients to manually fill insulin from a vial and

subcutaneously inject the required dose. Insulin syringes are the lowest cost of the available devices. Only specific insulin syringes can be used for insulin and are typically identified with an orange cap.

Insulin Pens

Insulin pens are often used in inpatient settings, as well as for self-administration at home, to facilitate safe and accurate self-administration of insulin. See Figure 11.4g for an image of an insulin pen. According to the ISMP, insulin pens offer several advantages over vials beyond dosing accuracy, convenience, and ease of use:

- Each pen is already labeled by the manufacturer with the product name and product barcode (whereas syringes of insulin prepared on the client care unit from vials run the risk of being unlabeled).
- Each pen can be individually labeled with the client's name (and ideally with a client-specific barcode).
- The pen provides the client's insulin in a form ready for administration.
- The pen lessens nursing time needed to prepare and administer insulin.
- Insulin pens reduce medication waste that can occur when dispensing 10 mL-sized insulin vials for each client.

However, improper sharing of insulin pens among multiple clients has exposed clients to bloodborne pathogens. Insulin pens should never be reused for multiple clients; even if the needle is changed between clients, there can still be body fluid exposure (Institute for Safe Medication Practices, 2017).

Figure 11.4g Human Insulin Pen 100IU-1ml (Wesalius/ https://commons.wikimedia.org/wiki/ File:Human_insulin_100_IU-1ml_pen_yellow_background_(02).jpg) CC BY-SA 4.0

Insulin Jet Injectors

Jet injectors are needle-less devices that produce high-pressure air jets which deliver a stream of vaporized insulin through the skin. With a jet injector, the insulin is delivered by pressing a button on the device. It is a beneficial option as it minimizes skin trauma or bruising and may enhance early insulin absorption and glycemic control. It is also beneficial for clients with severe insulin induced lipoatrophy or those with needle phobias. Drawbacks to the jet injector is cost and is larger in size (Wang et al, 2021).

Insulin Pumps

Insulin pumps are small, computerized devices about the size of a pager that continuously infuses insulin from a reservoir in the device to a subcutaneous catheter that is inserted into the client's abdomen, hip, arm or leg (Wang et al, 2021). Similar to a combined basal-bolus regimen that is attained by injecting long and rapid acting insulin, the pump is designed to mimic the human pancreas. The delivery of insulin continuously and in response to meal times, promotes normoglycemic levels.

Continuous Glucose Monitors: The arrival of continuous glucose monitors to clinical practice has been proven to reduce nocturnal hypoglycemia in people using insulin pumps with glucose sensors due to automatic suspension of insulin delivery at a preset glucose level. Health Canada has also approved the first hybrid closed-loop pump system (BC Diabetes Association, 2020. A hybrid closed-loop pump system automatically adjusts basal insulin delivery every 5 minutes based on sensor glucose to maintain blood glucose levels as close to a specific target as possible (Weaver & Hirsch, 2018).

Other devices

To further promote client adherence, improve efficacy and glycemic outcomes, as well as being affordable, researchers continue to explore new delivery systems. Ongoing research to expand delivery routes include inhaled, buccal, nasal and transdermal delivery devices. These under-developing routes and the associated devices have been shown to be convenient to use with high patient compliance, but so far lack in the ability to be glucose-responsive (Wang et al, 2021).

The cost of insulin and insulin delivery devices can be a barrier to many clients. Further, the cost of blood glucose monitoring kits and lancets can all add up to thousands of dollars per year. Canada now covers the cost of insulin and insulin pens in most provinces, and it also covers many oral anti-diabetic medications (Health Canada, 2024). There are individual differences between provinces with exact coverage.

High-Alert Medication and Prevention of Errors

Insulin is a high-alert medication that can be associated with

significant client harm when used in error. A variety of error types have been associated with insulin therapy, including administration of the wrong insulin product, improper dosing (underdosing and overdosing), dose omissions, incorrect use of insulin delivery devices, wrong route (intramuscular versus subcutaneous), and improper monitoring.

Many errors result in serious hypoglycemia or hyperglycemia. Hypoglycemia is often caused by a failure to adjust insulin therapy in response to a reduction in nutritional intake or an excessive insulin dose stemming from a prescribing or dose measurement error.

Other factors that contribute to serious hypoglycemia include inappropriate timing of insulin doses with food intake, creatinine clearance, body weight, changes in medications that affect blood glucose levels, poor communication during client transfer to different care teams, and poor coordination of blood glucose testing with insulin administration at meal time.

TALL MAN lettering to reduce med errors: One strategy for look-alike medications such as Humalog and Humalin is tall man lettering on the label. Tall man lettering describes a method for differentiating the unique letter characters of similar drug names known to be confused with one another, such as HumaLOG and HumaLIN.

ISMP recommends the following safe practice guidelines for the administration of insulin by the nurse:

- A coordinated process is developed to ensure timely blood glucose checks and administration of prandial insulin in conjunction with meal delivery.
- Verbal communication of point-of-care blood glucose value results are avoided as much as possible and are NEVER routinely used as the only source of information when determining insulin doses.
- Appropriately label all clinician-prepared syringes of subcutaneous insulin, unless the medication is prepared at the client's bedside and is immediately administered to the client

without any break in the process.

- Prior to subcutaneous insulin administration, the practitioner:
    - Confirms that there is an appropriate indication
    - Assesses the client's most current blood glucose value
    - Assesses the client for symptoms of hypoglycemia
    - Informs the client of their most current blood glucose level
    - Informs the client of their dose, the full name of the product, and the insulin's intended action
- Insulin pens:
    - An individual insulin pen is never used for more than one client.
    - Barcode scanning is used to verify that a client-specific pen is used to administer the correct insulin to the correct client.
    - Client-specific insulin pens are stored on clinical units in a manner that prevents their inadvertent use on more than one client.

There are several different types of insulins that vary in terms of onset, peak, and duration. It is critical for the nurse to be knowledgeable of these differences to help prevent episodes of hypoglycemia due to mismatched administration of insulin with food intake.

Transitions of care and discharging client to home:

Prior to transitions of care, a process is in place to ensure that clients will have the necessary prescriptions, supplies, a follow-up care plan, and printed instructions for all prescribed insulin and blood glucose monitoring.

Clients discharged on insulin are assessed for understanding of their self-management, including:

- Demonstration of proper dose measurement and self-administration using the same administration device that will be used at home (e.g., vial and syringe, pen, pump)

- Correct monitoring of blood glucose values
- The signs and symptoms of hyper- and hypoglycemia and how to respond if these symptoms occur
- Common types of errors possible with their insulin therapy and how to prevent or detect these errors
- The importance of regular follow-up with their primary care provider/specialist, including the date of their next appointment
- Clients who self-administer concentrated U-500 insulin using a vial and syringe are taught to use only a U-500 syringe and communicate their doses in terms of the name and concentration of the insulin and the actual dose in units using only the U-500 syringe[1]

Client education that includes lifestyle modifications that improve health should be emphasized, along with any pharmacologic therapy. Lifestyle modifications include healthy food choices to stabilize blood glucose levels, as well as daily exercise (Diabetes Canada, 2026).

General Considerations for Insulin therapy:

- Review orders closely because they may include more than one type of insulin, such as basal and bolus insulins.
- Always read drug labelling closely as there are several types of dosages and formulations.
- See agency policies and ISMP guidelines for safe

1. Institute for Safe Medication Practices. (2017). ISMP Guidelines for Optimizing Safe Subcutaneous Insulin Use in Adults. https://www.ismp.org/sites/default/files/attachments/2017-11/ISMP138-Insulin%20Guideline-051517-2-WEB.pdf

administration of insulin.

- Closely monitor blood glucose levels before each meal and before insulin administration
- Ensure client is ready to eat if giving rapid or short acting insulin. If blood sugar is low or if client not eating, consider holding short acting or rapid acting insulin.
- Assess for signs of hypoglycemia and intervene appropriately. See unit 11.3 for more information on managing hypoglycemia. Hypoglycemia is defined as a blood glucose level below 4.0 mmol/L; severe hypoglycemia refers to a blood glucose level below 2.8 mmol/L.
- Ensure proper technique when giving insulin. When administering, after inserting the pen count to 5 before removing the needle.
- Rotate sights to avoid lipodystrophy
- Refrigerate insulin unopened vials. Keep out of fridge one month. Cold insulin can be irritating to tissues.
- General therapeutic effects: Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)

Adverse/Side Effects of Insulin

Hypoglycemia is a common side effect. Closely monitor for signs of hypoglycemia, such as sweating, tachycardia, nausea, tremor and confusion. Clients who have been type 1 diabetic for a long time, may have only subtle symptoms.

Lipodystrophy is a disorder of adipose tissue due to repeated injections into the same site, leading to damage to the subcutaneous tissue. It is one of the most common complications. It is reported to be as high as 45% with type 1 diabetics (Gentile et al, 2016). It can present as lipohypertrophy or lipoatrophy.

- Lipohypertrophy is a thickened rubbery tissue swelling which is often firm or lumpy. It is caused by repeated injections to the same site with insulin. The insulin molecule has strong growth-promoting capabilities and injecting into the same area repeatedly can cause the lump.
- Lipoatrophy is a retracted scar on the skin that often large and deep.
- Lipodystrophy can be avoided with proper injection technique such as rotating sites. Injecting into these sites leads to poor glycemic control as the insulin is not properly absorbed (Gentile et al, 2016).

Pain at the injection site and bruising are also commonly seen (Thota & Akbar, 2023).

Drug Interactions

Some medications can cause lower blood glucose readings, while others can increase blood sugar levels. For clients who are started on new medications, ensure to check drug information or contact the pharmacist if closer blood glucose monitoring is required or if insulin or oral anti-diabetic med adjustments are required.

Drugs that cause hypoglycemia: sulfa antibiotics, alcohol, monoamine oxidase inhibitor antidepressants, and some herbal remedies such as ginseng and garlic.

Drug that cause hyperglycemia: corticosteroids block the entry of glucose into the muscle and fat tissues by preventing the glucose-transport proteins in the cells of those tissues from reaching the cell membrane. They also stimulate the production of glucose and increase insulin resistance. As such, clients on corticosteroids, like prednisone or dexamethasone, will require closer glucose monitoring and higher insulin needs.

Sympathomimetics (i.e. epinephrine) may increase insulin requirements by stimulating glycogenolysis, lipolysis, and inhibiting

insulin secretion. Beta blockers, such as propranolol, can reduce insulin secretion, and can impair insulin-stimulated glucose uptake, leading to possible hyperglycemia in some clients. Beta-blockers can also mask the signs of hypoglycemia, such as tachycardia, which is an early cue of low blood sugar levels (May & Schindler, 2016).

Glucagon

Glucagon is indicated as a treatment for severe hypoglycemia (low blood sugar), which may occur in clients with diabetes mellitus. Glucagon injection is used for clients who are unable to safely swallow carbohydrates to treat hypoglycemia due to the effects of hypoglycemia or other medical conditions.

Mechanism of Action

Glucagon increases blood glucose concentration during an episode of hypoglycemia. Glucagon acts only on liver glycogen, converting it to glucose. Glucagon administered through a parenteral route relaxes smooth muscle of the stomach, duodenum, small bowel, and colon (Daily Med, 2021). Glucagon is not effective in treating hypoglycemia if there is insufficient liver glycogen available, such as with starvation, adrenal insufficiency or chronic hypoglycemia. In these cases, treat the hypoglycemia with glucose.

Indications

Glucagon is indicated as a treatment for severe hypoglycemia (low blood sugar), which may occur in clients with diabetes mellitus.

Glucagon injection is used for clients who are unable to safely swallow carbohydrates to treat hypoglycemia due to the effects of hypoglycemia or other medical conditions.

Figure 11.4h Emergency glucagon kit (Glucagon emergency rescue kit.JPG" mbbradford) is licensed under CC0)

Administration Considerations

Glucagon may be administered subcutaneously, intramuscularly, or intravenously. Peak glucose levels occur within 13-20 minutes of SQ or IM injection. It may cause nausea or vomiting.

Client Teaching

Clients with type 1 diabetes may have less of an increase in blood glucose levels compared with a stable type 2 client, so a supplementary carbohydrate should be given as soon as possible, especially to a pediatric client (Daily Med, 2021).

Comparing Insulin Medications Table

Now let's take a closer look at the Comparing Insulins Medications table (Daily Med, 2023). This table is intended to consolidate the information about each insulin but it is also editable for you to add information that helps you with learning about each medication. As information with medications is always changing, refer to a drug reference or monograph.

Click on the link for the downloadable and editable copy: Comparing Insulin Table 2026

Media Attributions

- Figure 11.4a Effect of insulin on glucose uptake and metabolism by Meiquer on Wikimedia Commons is used under the CC BY-SA 3.0 license.
- Figure 11.4b Types of Insulin and their duration of action. Insulin_short-intermediate-long_acting.png https://upload.wikimedia.org/wikipedia/commons/c/cd/Insulin_short-intermediate-long_acting.png
- Figure 11.4c for an image of Novolog insulin. Free Images : medicine, glass bottle, medical 4504×3001 – – 197979 – Free stock photos – PxHere *Alan Levine/PXHere*) CC BY-SA 2.0

- Figure 11.4d Comparison of Novolin-N (a cloudy insulin) that can be mixed with Novolin-R (a clear insulin). The Gift of Life | These insulins are what give me the Gift ... | Flickr "The Gift of Life" by Melissa Johnson is licensed under CC BY 2.0 ↵
- Figure 11.4e Image of a levemir insulin pen. (Wesalius/Insulin analog 100 IU-1ml penfill levemir yellow background.jpg/*Wikimedia Commons*). CC BY 4.0 ↵
- Figure 11.4f Diagram depicting insulin delivery devices, such as insulin syringe, insulin pen, jet injector and insulin pump. By BruceBlaus – Own work/, http://commons.wikimedia.org/wiki/File:Insulin_Delivery_Devices_(hy).png/*Wikimedia Commons*). CC BY-SA 4.0,
- Figure 11.4g Insulin Pen Human insulin 100 IU-1ml pen yellow background (02).jpg" by Wesalius is licensed under CC BY 4.0. ↵https://commons.wikimedia.org/wiki/File:Human_insulin_100_IU-1ml_pen_yellow_background_(02).jpg)
- Figure 11.4h Emergency glucagon kit. "Glucagon emergency rescue kit.JPG" by mbbradford is licensed under CC0 ↵

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11.5 Antidiabetics: oral medications

There are a number of oral anti-diabetic medications available to manage type 2 diabetes. Type 2 diabetes is complex, especially as the disease progresses and the client develops different health complications. Treatment will aim to prevent hyperglycemia and reduce the risk of cardiovascular (CV) and microvascular complications (Lipscombe et al, 2018). There are many factors the prescriber considers when prescribing oral agents:

- degree of hyperglycemia,
- medication efficacy for reducing diabetes complications (microvascular and/or CV) and lowering glucose,
- medication effects on the risk of hypoglycemia, body weight, other side effects,
- concomitant medical conditions, including level of frailty,
- renal function,
- ability to adhere to regimen,
- broader health and social needs, affordability of medications,
- patient values and preferences.

Lipscombe et al, (2018).

The importance of glycemic control in diabetes:

Controlling postprandial hyperglycemia is essential especially in the early years after a diabetes diagnosis. Good control reduces the incidence and progression of microvascular complications and in the long term (over 10 years) the risk of cardiovascular diseases (Lipsombe et al, 2018; Senior et al, 2020).

To obtain good glycemic control, healthy lifestyle behaviours that includes diet modifications and moderate exercise is needed for any anti-diabetic therapy.

The overall goal with treatment is to achieve an A1C of less than 7% for most clients.

Pharmacotherapy is started early and after a trial of healthy behaviour interventions. Metformin is the first line treatment if glycosated hemoglobin (A1C) target is not achieved after 3 months. Metformin is the first medication used due to its high safety profile, low cost and heart benefits. As the disease progresses, the addition of other oral meds will depend on many factors (outlined earlier), but controlling hyperglycemia and preventing CV disease are primary concerns. The addition of other medications may look like the following: the client is on metformin along with following healthy lifestyle behaviours. As the glycemic control gets worse, sulfonylurea medication (glipizide) is added. Over time, then the addition of a DPP-4 agent or SGLT2 inhibitor may be considered as they are associated with effective A1C lowering with less hypoglycemia than insulin or Thiazolidinediones (TZDs). If the client has cardiovascular or renal disease, SGLT2 and DPP-4 may be prescribed earlier.

For some clients, insulin will be required. The addition of insulin is based on the degree of glycemic control. It may be decided to add insulin to oral anti-diabetic medication regime, so the insulin dose is small but still provides good glycemic control with less risk of hypoglycemia. In summary, the decision with all these medications is to manage any medication side effects, other health status issues such as hypertension or weight gain, and minimize microvascular complications (Lipsombe et al, 2018).

In this unit, the following meds that will be covered are:

- Biguanides (metformin)
- Sulfonylureas (glipizide)
- Alpha-glucosidase inhibitor (acarbose)
- Sodium-glucose cotransporter 2 inhibitors (canagliflozin),

- Dipeptidyl peptidase-4 (DPP-4) (sitagliptin)

Other medications that will not be covered include Thiazolidinediones (pioglitazone) and Cycloset (bromocriptine). Pioglitazone is what is considered an insulin sensitizer, and works by decreasing insulin resistance. It is an option for those who can't take metformin or glipizide.

Bromocriptine, a sympathomimetic dopamine D2 receptor agonist, helps reverse insulin resistance and decreases glucose production (Ganesan, Rana & Sultan, 2023)

For an overview of how oral anti-diabetic medications work, watch the following YouTube video: Hasudungan, A. (2016). Pharmacology -Diabetic Medications. Pharmacology – Diabetes Medication

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=4111#oembed-1

Biguanides

Metformin is in the only medication in the biguanide class of antihyperglycemics. It is the first medication that is prescribed for the majority of type 2 diabetic clients. It is effective, safe and low cost, making it an ideal drug as first line therapy. The therapeutic goal should be to decrease both fasting plasma glucose and glycosylated hemoglobin levels to near normal by using the lowest

effective dose of metformin (Liscombe et al, 2018). Metformin can be used as monotherapy or in combination with sulfonylurea or insulin.

One of the distinct advantages of metformin is that it does not cause weight gain, making it ideal for clients overweight or average weight.

See Figure 11.5a for an image of a metformin tablet.

Figure 11.5a Metformin tablets File: Metformin 500mg Tablets.jpg File: Metformin 500mg Tablets.jpg – Wikimedia Commons

Indications for use:

Metformin is used for type 2 diabetic clients as well as pre-diabetes and gestational diabetes. It improves glycemic control by lowering

fasting and post-prandial blood glucose levels and improves glucose tolerance. It is quite effective and can lower A1C by 1.5-2%.

Off label, metformin can also be used for polycystic ovary syndrome (PSOS). PSOS is an endocrine disorder affecting androgen production and metabolism, resulting in irregular periods, infertility hirsutism and ovarian cysts. Metformin can increase insulin sensitivity and decrease insulin levels which indirectly can lower androgen levels. This results in improved glucose tolerance, improved ovulation and an increase in pregnancy rates (Rosenjack Burchum & Rosenthal, 2019).

Mechanism of Action

Metformin decreases hepatic glucose production, decreases intestinal absorption of glucose, and improves insulin sensitivity by increasing peripheral glucose uptake and utilization. It is quite effective in reducing A1C to near normal. Metformin has also shown benefit in reducing myocardial infarction in overweight clients (Lipscombe et al, 2018).

The benefit of metformin is that it does not produce hypoglycemia and does not cause weight gain. Unlike sulfonylureas, metformin does not produce hypoglycemia.

Nursing Considerations

Administration:

- Metformin should be given in divided doses with meals. Taking it with a meal will reduce the GI effects.
- Oral formula only, immediate release and extended release.
- May take up to 4 weeks to be fully effective.

As metformin does not cause hypoglycemia, it is suitable for clients who do not eat meals regularly. If they skip a meal, the blood sugars will not be affected (Rosenjack Burchum & Rosenthal, 2019).

Not metabolized and excreted unchanged in the kidney. It's onset of action is one hour, and has a long t1/2 of 17 hours, therefore takes up to 4 days to leave the system.

Monitoring

- Fasting blood sugar and pre-meal blood sugar as recommended by prescriber. Hgb A1C twice a year or more frequently depending on glycemic control.
- Renal function, complete blood count (CBC), B12 and folate at start of therapy and then yearly (Ganesan, Rana & Sultan, 2023)

Contraindicated in clients with kidney disease (e.g., serum creatinine levels ≥ 115 µmol/L [males] or ≥ 95µmol/L [females]).

Contraindicated with hepatic disease, heart failure, and metabolic acidosis. Cautious use of the medication with the elderly due to renal function.

Caution with CT scan: temporarily discontinue metformin undergoing radiologic studies involving IV administration of iodinated contrast, due to acute alteration of renal function.

Caution with surgery: clients who are going for surgery, Metformin should be held on the day of surgery and restarted 48 hours after surgery. Renal function, creatinine, will be monitored.

Drug Interactions:

Advise clients to not take new medications or herbal supplements without consulting with their prescriber.

- The effects of metformin are increased with furosemide, cimetidine, and digoxin.

- Ginseng and garlic herbal supplements have an additive effect leading to hypoglycemia

Adverse/Side Effects

The most common side effects are decreased appetite, nausea and diarrhea which go away after a few weeks. Common adverse reactions include vomiting, weakness, flatulence, indigestion, abdominal discomfort, and headache.

Reduction in B12 levels and folate with long term use. B12 deficiency can contribute to peripheral neuropathy which is a long-term consequence of diabetes. B12 levels should be monitored yearly and the client should be taking supplements (Rosenjack Burchum & Rosenthal, 2019).

Lactic Acidosis Risk:

- Lactic acidosis is a rare, but serious, metabolic complication that can occur due to metformin accumulation, often due to high doses or acute kidney injury so it is not excreted. Symptoms include hypotension, bradycardia, diarrhea and dizziness, and often subtle nonspecific symptoms such as malaise, myalgias, increasing somnolence, and nonspecific abdominal distress.
- when it occurs, it is fatal in approximately 50% of cases.
- The risk of lactic acidosis increases with the degree of renal dysfunction and the client's age. Metformin inhibits the mitochondrial oxidation of lactic acid. If metformin is not normally excreted, it accumulates, and lactic acid occurs.
- Hold metformin in the presence of any condition associated with hypoxemia, dehydration, or sepsis. Because impaired hepatic function may significantly limit the ability to clear lactate, metformin should be avoided in clients with hepatic disease.

(Ganesan, Rana & Sultan, 2023)

Client Teaching

- Clients should take the medication at the same time each day.
- This medication does not cause hypoglycemia. But clients should be instructed regarding the signs of hyperglycemia and hypoglycemia.
- The client may be at risk for lactic acidosis and should report chills, low blood pressure, muscle pain, or dyspnea immediately to the healthcare provider.
- The use of medications like metformin can cause a metallic taste in the mouth.
- May cause GI upset, but will subside after a few weeks.
- Regularly monitor blood glucose levels.
- If going for surgery, anticipate metformin to be discontinued the day before surgery and resumed 48 hours afterwards.
- Avoid or limit alcohol intake as it can increase risk of hypoglycemia and lactic acidosis.

Sulfonylureas

Sulfonylureas are considered a second line treatment option after metformin. They can be taken as monotherapy or along with other anti-diabetic meds.

Our prototype medication is glipizide. Glyburide is the long-acting formula.

Mechanism of Action

Sulfonylureas, also called 'insulin secretagogues" due to the action of stimulating insulin. It works by stimulating insulin secretion from the beta cells of pancreatic islet tissue. It is dependent on functioning beta cells and works regardless of blood sugar levels. They stimulate insulin release by blocking ATP-sensitive potassium channels in the cell membrane, the membrane depolarizes, permitting calcium into the beta cell and thereby releases insulin. Secondary actions include reducing glucagon production in the liver and increasing insulin sensitivity in peripheral tissues, which overall reduces blood glucose levels (Rosenjack Burchum & Rosenthal, 2019).

Nursing Considerations

Administration: oral only, taken once a day or BID.

- Take 30 minutes before a meal
- Immediate release formula is glipizide, taken once daily or BID.
- Long-acting formula is glyburide, taken once or twice a day. Duration of action is 16-24 hours.
- Effectiveness will diminish over time.
- Onset of action 45-50 minutes, with t 1/2 10 hours

Metabolized in the liver by P450 enzymes and renally excreted.

Contraindicated with glucose 6-phosphate dehydrogenase (G6PD) deficiency as can lead to hemolytic anemia.

Monitoring:

- Ensure to check blood glucose regularly
- Observe for signs of hypoglycemia (sweating, hunger, weakness, tachycardia, tremor, dizziness)

- Ensure client eats regular meals and does not skip
- Avoid alcohol
- Monitor renal function (GFR, creatinine, BUN) and liver function
- Before first dose, ensure no allergy to sulfa antibiotics

Do not use if pregnant as it will cross placental barrier and may lead to teratogenic effects. The only oral anti-diabetic medication to take while pregnant is metformin.

Gliclazide preferred over glyburide due to lower risk of hypoglycemia.

Drug Interactions:

- Increased risk of hypoglycemia with nonsteroidal anti-inflammatory agents or drugs that are highly protein bound.
- Cross sensitivity with sulfa antibiotics. If allergic to sulfa antibiotics, should be avoided.
- Beta blockers can mask signs of hypoglycemia.

(Lipscombe et al, 2018; Vallerand & Sanoski, 2024)

Adverse/Side Effects

The two main side effects are hypoglycemia risk and weight gain.

Risk of hypoglycemia (recall it lowers blood sugar levels regardless of level). Hypoglycemia risk increased if:

- elderly client. Avoid if client over 80 years of age
- taking the long-acting formulation, Glyburide.
- alcohol should be avoided to prevent hypoglycemia
- Skipping meals

Client Teaching

- Clients should take the medication at the same time each day. If a dose is missed, take as soon as you remember, unless close to the time of the next dose.
- It is important that clients understand that the medication helps control episodes of hyperglycemia but does not cure diabetes.
- Clients should be instructed regarding the signs of hyperglycemia and hypoglycemia.
- The use of sulfonylureas and alcohol may cause a disulfiram-like reaction, such as flushed skin, tachycardia, nausea and abdominal pain.
- Advise client to monitor pre-meal glucose periodically.
- If sick, monitor glucose and ketone levels. If not eating, do not take sulfonylurea med.
- Use sunscreen due to risk of photosensitivity.
- Carry a form of sugar in case of hypoglycemia

(Ganesan, Rana & Sultan, 2023; Vallerand & Sanoski, 2024)

Alpha–glucosidase Inhibitors

Alpha-glucosidase inhibitors (AGI) are a class on anti-diabetic medications that are used for clients who do not tolerate metformin or sulfonylureas, or who are a high risk of hypoglycemia. They are also used for clients with impaired glucose tolerance, which can delay the onset of diabetes (Akmal, Patel & Wadhwa, 2024). They are used as an adjunct to healthy diet and exercise.

The prototype medication is acarbose. Other medication in this class is miglitol.

Mechanism of action

Acarbose hampers the digestive enzyme, alpha-glucosidase, that breaks down carbohydrates into smaller sugars that can be absorbed by the intestines. This slowing of the digestion and absorption of carbohydrates results in a slower rise in blood sugar levels and insulin has more time to work effectively. In more detail, acarbose competitively inhibits alpha-glucosidase enzymes in the intestinal brush border cells that digest dietary starch. This results in inhibiting polysaccharide reabsorption and the metabolism of sucrose to glucose and fructose (Ganesan, Rana & Sultan, 2023).

This action is useful in reducing postprandial hyperglycemia, and also glycosylated hemoglobin levels and also reduce postprandial insulin concentration. AGIs also reduce glucose variability throughout the day which is a contrast to other oral anti-diabetic meds (Akmal, Patel & Wadhwa, 2024).

AGIs are sometimes referred to as 'starch blockers'.

Nursing Considerations

Administration: oral dosing, taken three times a day, with 'first bite of a meal'. Peak effect is one hour. Dose should be started low and tapered up depending on adverse effects and desired glycemic control.

Contraindicated with bowel disease such as inflammatory bowel disease or Crohn's disease.

Contraindicated with hepatic disease. Monitor liver enzymes (AST and ALT) as there is a slight risk of hepatitis. Risk decreases over time.

Drug Interactions:

Acarbose can decrease the absorption of acetaminophen, digoxin and propranolol.

(Akmal, Patel & Wadhwa, 2024).

Adverse/Side Effects

AGIs are very safe, and are not absorbed systemically. They do not cause hypoglycemia or weight gain, as with other oral meds.

Side effects of flatulence and diarrhea are common and subside over time. Flatulence is due to the fermentation of unabsorbed carbohydrates in the intestine.

Other side effects include: abdominal distention and borborygmus. May cause decreased absorption of iron.

Client Teaching

- Clients should take the medication as prescribed. Take the med with each meal, three times a day and with the first bite of their meal.
- It is important that clients understand that the medication will help with glycemic control.
- Routine blood work including blood glucose levels and A1C are required. Liver enzymes will be assessed prior to therapy and periodically.
- Do not start new medications or herbal supplements without discussing with prescriber.

Dipeptidyl peptidase-4 (DPP-4)

Also known as the 'gliptins', DPP-4 inhibitors are a well-tolerated anti-diabetic medication that works by stimulating glucose-dependent insulin secretion, inhibits glucagon release and slows gastric emptying. In Canada, there a number of combination or individual medication formulations available. All DPP-4 inhibitors end in '-gliptin', and include sitagliptin, saxagliptin, vildagliptin, and linagliptin. Our prototype medication in this class will be sitagliptin.

What is DPP-4?

DPP-4 is an enzyme that acts on incretin hormones, mainly GLP-1 (glucagon-like peptide-1) and GIP (gastric inhibitory peptide), both which maintain glucose homeostasis by increasing insulin secretion and decreasing glucagon secretion.

- GLP-1 is a hormone secreted by enteroendocrine L cells of the small intestine, which lowers blood glucose by stimulating insulin secretion, reducing glucagon concentrations, and delaying gastric emptying.
- GIP is a hormone secreted in the stomach and proximal small intestine by neuroendocrine K-cells.

These incretins are released within minutes of food intake, and DPP-4 degrades these hormones immediately due to their short half-life. By inhibiting the DPP-4 enzyme, DPP-4 inhibitors increase the levels of GLP-1 and GIP, which in turn increase beta-cell insulin

secretion in the pancreas, thereby reducing postprandial and fasting hyperglycemia (Kasina & Baradhi, 2023).

Mechanism of Action

Sitagliptin is an orally-active inhibitor of dipeptidyl peptidase-4 (DPP-4) enzyme that slows the inactivation of incretin hormones involved in the regulation of glucose homeostasis. The incretin hormones, glucose-dependent insulinotropic polypeptide (GIP) and glucagon-like peptide (GLP-1), become deactivated, and control glucose by decreasing glucagon release, increasing glucose-dependent insulin release, decreasing gastric emptying and increasing satiety. The main effects are increasing insulin release and decreasing glucagon levels in the circulation. See figure 11.5b.

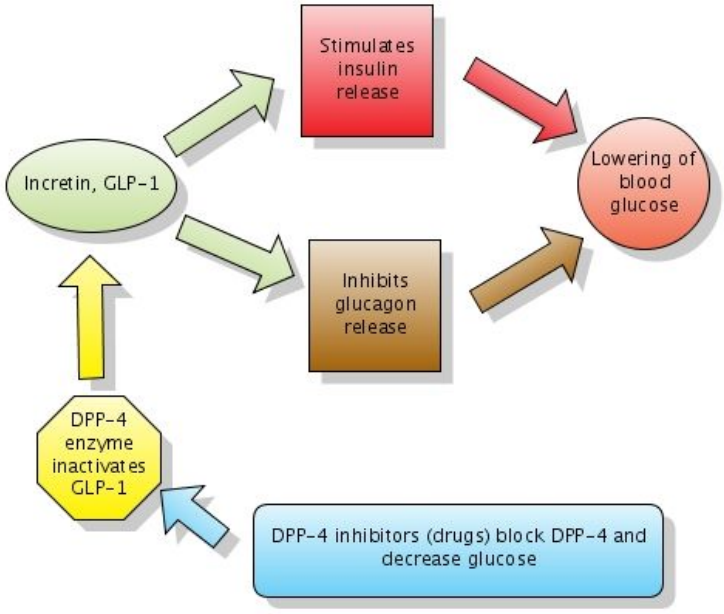

Figure 11.5b Mechanism of Action of DPP-4 Inhibitors

Incretins_and_DPP_4_inhibitors.jpg (488 × 427 pixels, file size: 26 KB, MIME type: image/jpeg

Retrieved from File:Incretins and DPP 4 inhibitors.jpg – Wikipedia

Nursing Considerations

Administration: oral dosing, taken once a day. Can be taken with or without food. Can be taken before or after meals.

It is absorbed rapidly with a duration of action of 24 hours.

Dose adjustment should occur for clients with kidney disease depending on their glomerular filtration rate.

Monitoring includes A1C prior to therapy and periodically. Monitor renal function prior to and periodically during therapy.

There are few clinically significant drug interactions. Increased risk of hypoglycemia if taken with insulin or sulfonylurea medications.

Adverse/Side Effects

Sitagliptin is generally well-tolerated. It has a slight risk of causing hypoglycemia, especially if taken with other oral anti-hypertensives.

Risk of nasopharyngitis, with symptoms such as runny nose and sore throat.

It may cause an increased serum creatinine levels so monitor renal panel periodically.

In rare circumstances, it may cause:

- Pancreatitis: symptoms such as upper abdominal pain, anorexia, nausea, and fever.
- severe joint pain or myalgia
- hypersensitivity reaction such as Steven-Johnson syndrome. DPP-4 is found in T cells, so inhibiting DPP-4 may lead to an increased hypersensitivity response. Report any rash, blisters/erosions.

Report hypersensitivity reactions, blisters/erosions, headache, or symptoms of pancreatitis, heart failure, severe arthralgia, and upper respiratory infection.

(Ganesan, Rana & Sultan, 2023; Kasina & Baradhi, 2023)

Client Teaching

- Take the medication at the same time each day. Do not double up a dose if one is missed.
- Inform client this med helps control hyperglycemia, and is a long-term medication.
- Ensure to continue with a healthy diet and exercise plan.
- Clients should stop taking the medication if symptoms of hypersensitivity occur such as a rash, swelling of the tongue or face, difficulty breathing. Follow up immediately with their provider to determine the next course of treatment.

(Vallerand & Sanoski, 2024)

Sodium-Glucose Cotransporter 2 Inhibitors

Sodium-glucose cotransporter 2 inhibitors (SGLT-2i) are prescribed for type 2 diabetic clients with later stage diabetes that have cardiovascular disease or with end-stage renal disease or diabetic nephropathy. It is also prescribed to heart failure clients without diabetes. SGLT2 drugs improve glycemic control, lowering A1C levels by 0.5% to 1.0% in clients with T2DM (Padda, Mahtani & Parmar, 2025). They also reduce the risk of cardiovascular death including nonfatal MI and stroke, and reduce the risk of end-stage renal disease (Vallerand & Sanoski, 2024).

Medications in this class include canagliflozin and dapagliflozin. Our prototype medication will be canagliflozin. Canagliflozin is always used along with a healthy diet and exercise.

Mechanism of Action

SGLT-2 inhibitors work in the proximal renal tubule. They inhibit glucose being reabsorbed back into the blood stream so more glucose is excreted in the urine. Water will follow glucose, so the client will experience increased urination. Overall, it inhibits the reabsorption of glucose, lowers the renal threshold for glucose and increases the excretion of glucose in the urine (Vallerand & Sanoski, 2024).

What is sodium-glucose cotransporter-2?

SGLT-2 is a transport protein of glucose uptake in cell membranes. They are located in the proximal tubule of the nephron and also in the small intestine. SGLT-2 is responsible for 80-90% of filtered glucose reabsorption back into the bloodstream. SGLT-2 inhibitors block this transport, so more glucose is excreted by the kidney.

Nursing Considerations

Administration: taken orally, once a day before breakfast.
Metabolized in the liver, and renally excreted.
Pediatric clients: can be used for clients over the age of 10.

Drug interactions:

- Hyperkalemia risk with clients also on angiotensin-converting

enzyme inhibitor or angiotensin receptor blockers. Monitor electrolytes and renal function. This is more of a concern if client as renal impairment (Padda, Mahtani & Parmar, 2025).
- Hypoglycemia risk with clients taking insulin secretagogues, such as a sulfonylurea, or insulin. Dose reduction of the insulin secretagogue or insulin to minimize this risk.
- Lithium: clients on lithium and SGLT-2 inhibitors can have reduced serum lithium concentrations. This is due to lithium-glucose reabsorption is decreased, resulting in higher amount of renal excretion of sodium, glucose, and lithium. Concurrent use of an SGLT2 inhibitor with lithium can reduce serum lithium concentrations (Padda, Mahtani & Parmar, 2025).
- If the client is on a diuretic such as furosemide, dosage may need to be reduced.

There are cardioprotective effects to make it advantageous for clients with cardiovascular disease. These include:

- Blood pressure reduction: by inhibiting SGLT2 in proximal tubules, resulting in an increase in distal tubular sodium delivery, resulting in suppressing the renin-angiotensin-aldosterone system. This leads to a reduction in preload, driven by natriuresis and diuresis, and afterload, mediated by arterial vasodilation.
- Weight loss due to a slight decrease in adipose tissue and interstitial fluid
- Small increase in HDL
- Potentially improving cardiac efficiency and exerting antiarrhythmic effects through membrane potential stabilization (Padda, Mahtani & Parmar, 2025).

Other benefits include improved glycemic control with a reduced A1C, and no risk of hypoglycemia. It also reduces the progression

of nephropathy. SGLT2 inhibitors also decrease effective circulating volume, lower blood pressure, and induce modest weight loss.

Monitoring:

Labs: prior to therapy and periodically: A1C, renal panel, electrolytes, serum lipid levels.

Monitor for hypoglycemia and volume depletion (dizziness, weakness, orthostatic hypotension).

Close monitoring is required for the older adult, clients with hypotension, renal insufficiency with a GFR less than 45, and clients with history of urinary tract infections (UTI).

- History of UTIs: due to glycosuria from SGLT-2 inhibitors, there is a higher risk of UTIs. Ensure the client has good perineal hygiene, and is well-hydrated.
- Hypotension risk: SGLT-2 inhibitors may cause hypotension. Assess for dizziness or syncope. Ensure the client is well-hydrated.
- SGLT-2 inhibitors can cause euglycemic diabetes (Normal blood glucose but with increased ketones in the urine). Monitor ketone levels periodically. If the client is sick or can't drink, ensure to check ketones and notify prescriber.

Renal or hepatic impairment: SGLT2 inhibitors is not recommended for glycemic control in clients with an eGFR less than 30 mL/min/1.73 m^2. For mild to moderate hepatic impairment, dose adjustment of SGLT2 inhibitors is not required.

Pregnancy: Not recommended for clients who are pregnant, due to risk of fetal harm especially in the 2nd and 3rd trimesters.

Surgery or major illness: for clients going for major surgery or who are very ill, hold SGLT-2 inhibitors.

(Lipsombe et al, 2018; Padda, Mahtani & Parmar, 2025; Vallerand & Sanoski, 2024).

Adverse/ Side Effects

Sodium-glucose cotransporter-2 inhibitors are generally well-tolerated with a good safety margin. For clients who are more at risk for adverse effects, close monitoring is required.

Adverse effects include:

- Urinary tract infections and female genital mycotic infections (vulvovaginal candidiasis, bacterial vaginitis): glycosuria creates a favourable environment of bacterial growth, resulting in infections.
- Acute kidney injury: higher risk due to the decrease in intravascular volume. Older adults, those on diuretics or those with renal impairment are more at risk.
- Small increase in LDL-C: monitor lipid profile prior to therapy and periodically. Clients may also experience a small increase in HDLs.
- Diabetic ketoacidosis: less common but monitor for symptoms of DKA such as metabolic acidosis and ketones in the urine. Discontinue SGLT-2 inhibitors.
- Hypotension and intravascular volume reduction: monitor for dizziness, assess blood pressure. Additional hydration may be required.

Client Teaching:

- Take the medication at the same time each day. Do not double up a dose if one is missed.
- Inform client this med helps control hyperglycemia, and is a long-term medication.
- Review signs of hypoglycemia with the client. If hypoglycemia occurs, drink orange juice, eat 2-3 tsp of sugar or honey.
- Monitor blood sugars periodically and urine ketones, especially

when unwell or under stress.
- Ensure to continue with a healthy diet and exercise plan.
- Inform client of a risk of urinary bacterial or yeast infections, and monitor for symptoms. Ensure good personal hygiene and hydration.
- Report any new pain or tenderness, sores or infections especially if it involves the feet or legs, genital area. Report any fever or unexplained malaise.
- Clients should stop taking the medication if symptoms of hypersensitivity occur such as a rash, swelling of the tongue or face, or difficulty breathing. Follow up immediately with their provider to determine the next course of treatment.

(Vallerand & Sanoski, 2024)

Oral Anti-Diabetic Medication Card

Now let's take a closer look at the oral anti-diabetic medications. This table is intended to consolidate the information about each medication. Access the downloadable and editable format to add information that helps you with learning about each medication.As information with medications is always changing, refer to a drug reference or monograph. Comparing Oral Anti-Diabetic Medications table

Note:

- All anti-diabetic medications require healthy lifestyle behaviours such as healthy diet, moderate exercise and limit alcohol intake.
- Tight glycemic control is important to prevent hyperglycemia and minimize long term cardiovascular complications.
- Oral anti-diabetic therapy usually begins with metformin, and then additional meds added to improve glycemic control and

manage health issues.

Class	MOA /Therapeutic effects	Administration Considerations /Key points	Adverse/Side Effects
Sulfonylureas Gliclazide "insulin secretagogues"	MOA: Stimulates pancreas to make more insulin & reduces glucagon levels Reduce FBG & glycosylated hemoglobin to near normal	• Time dose with meals; usu BID and 30 min before meal. Long duration of action • Peak plasma concentrations occur 1 to 3 hours after administration • Effectiveness decreases within 5 years • Avoid with ETOH as can precipitate drop in BG… flushed, nausea, abd pain, tachycardia	• Hypoglycemia; espec in elderly • May be potentiated by NSAIDs and other drugs that are highly protein bound (cimetidine, beta blockers) • Weight gain • Do not take if sulfa allergy • Caution with renal and liver dysfunction. Monitor renal and hepatic function. • Photosensitivity- use sunscreen

Biguanide Metformin	MOA: Blocks livers release of glucose and ↓ insulin resistance. Increases glucose uptake by cells (muscle, fat) PCOS: increases insulin, results in decrease androgen levels Safe with Gestational Diabetes Reduce FBG & glycosylated hemoglobin to near normal	• No weight gain/no hypoglycemia • Hold 24 hours prior to CT scan radiologic studies involving IV iodinated contrast, resume med 48 hrs post and after GFR and creatinine. • Hold day of surgery and resume 48 hours post-op. monitor renal fcn (creatinine clearance) • Contraindicated in renal and hepatic disease	• Common AEs: GI -diarrhea, nausea/ vomiting, weakness, flatulence, indigestion, abdominal discomfort, and headache • Metallic taste Stop immediately if signs of lactic acidosis (LA) or any condition associated with hypoxemia, dehydration, AKI, or sepsis occurs. • Risk of LA with furosemide, cimetidine. • Drop in B12 levels with long term use. Monitor and take supplements if needed.
DPP-IV inhibitor Sitagliptin **"gliptins"**	MOA: Inhibits DPP-4 – inhibits incretin GIP and GLP-1 decrease glucagon release and increase insulin release, decr gastric emptying and increase satiety Reduce FBG & glycosylated hemoglobin to near normal	• Give with or without food; OD • Rapid absorption, peak 1-4 hours, 24 hour duration of action. • Lowers A1C by 0.7% • Only drug interaction is digoxin but no dose change recommended	• Hypoglycemia • Upper respir tract infections, sore throat, diarrhea, headache Slight risk of Steven Johnson syndrome – report hypersensitivity reactions, assess for rash, blisters/ erosions. • Assess for symptoms of pancreatitis, heart failure, severe arthralgia • Slight risk of pancreatitis

Alpha Glucosidase Inhibitors Acarbose "starch blockers"	MOA: inhibits alpha-glucose digestive enzyme that breaks CHOs into simple sugars in intestine… slower absorption of CHO and slower rise in BG. Does not depend on insulin.	• TID with meals… first bite • Decrease surge in BG after meals • Less effective than other meds • Lowers A1C by 0.6 % • No weight gain, no hypoglycemia	• Flatulence, diarrhea – decreases with time • Do not take if bowel disorders • Monitor se Creatine and se transaminase levels q 3months first year of tx then yearly • Decrease iron absorption • Decr absorption of acetaminophen, digoxin, propranolol.
Sodium Glucose Cotransporter 2 inhibitors Canagliflozin	MOA: Inhibits SG cotransporter 2 in proximal tubule of renal glomeruli – 90% reduction of glucose reabsorption. Lower glucose reabsorption / Glycosuria and increased urine output CV benefits – lowers BP, ↑HDL, weight loss	• Once a day before breakfast • Not for ESRD • No hypoglycemia • Lowers A1C 0.5-1% • Weight loss through diuretic effect	• ↑LDL and ↑HDLs • UTI risk and bacterial vaginosis – good hygiene, hydrate • Risk of euglycemic DKA • increased urine output – Risk of volume depletion/ hypotension • Ketoacidosis espec if unwell or sick. Monitor ketones and se glucose Monitor renal fcn and LDL – baseline and periodically Client teaching: drink 1-2 extra glasses of H2O each day, monitor for dehydration, monitor for yeast infections, stop med if ill or can't drink

Semaglutides Ozempic, Rybelsus "Incretin mimics"	MOA: Activates GLP-1 receptors in intestine, pancreas and hypothalamus · In intestine, slows gastric emptying · Stimulates glucose-dependent insulin secretion and release, lowers prod of glucagon from liver, · in hypothalamus to decrease cravings and increase satiety. **Used for:** T2 DM, CV risk management, weight loss. Long term management	· Ozempic: SQ weekly, doses titrated up each week until goal dose reached. · Rybelsus: oral once a day, doses titrated up each week until goal dose reached. · Lowers BP, improves myocardial contractility, mild diuretic effect, lowers lipids. · Improves glycemic control, weight loss	• GI: nausea, diarrhea, flatulence • Lowers blood glucose Adverse effects: gastroparesis, pancreatitis, retinopathy, thyroid tumours precuation, vision changes Long term management. If med d/c'd: weight gain

Critical Thinking and Decision-Making Learning Activities

A client with diabetes mellitus type 2 is admitted to the

hospital for hip replacement surgery. The nurse reviews the following orders:

Bedside blood glucose testing before meals and at bedtime with sliding scale Humalog insulin

Sliding scale Humalog insulin based on preprandial glucose level:

- 0 – 8.0 mmol/L: No coverage
- 8.1 – 10.0 mmol/L: 2 units
- 10.1 – 11.0 mmol/L: 4 units
- 11.1 – 12.5 mmol/L: 6 units
- 12.6 – 14.0 mmol/L: 8 units
- Over 14.0 mmol/L: call the provider

Metformin 1000 mg twice daily

Humulin-N 20 units at breakfast and at bedtime

Hypoglycemia protocol

1. Explain the difference between type 1 and type 2 diabetes.
2. The client states that he usually does not take insulin at home. What is the likely rationale for insulin therapy while hospitalized?
3. The client's blood sugar before breakfast is 12.4 mmol/L. What types and amounts of insulin will the nurse administer?
4. The nurse reviews the client's morning lab results and finds a creatinine of 160 μmol/L. She plans to call the provider to discuss the impact of the results on the medications ordered. Which medication may require a dosage adjustment based on these results?
5. When the nurse enters the room around 4 p.m., she

discovers that the client has become irritable and is shaky. The nurse performs a bedside blood glucose and obtains a value of 3.1 mmol/L. What is the nurse's best response?

6. What is the likely cause of the client's condition? Explain using the onset and peak actions of the insulin orders.
7. On admission, the client's A1C level was 10%. What does this lab value indicate?
8. The provider states the discharge plan is to initiate Lantus insulin therapy at home, based on the admitting A1C level. What client teaching should the nurse plan to provide before discharge?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 11: Endocrine System Medications: anti-diabetic medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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Media Attributions

- Figure 11.5a Metformin tablets. File:Metformin 500mg Tablets.jpg File:Metformin 500mg Tablets.jpg – Wikimedia Commons
- Figure 11.5b Mechanism of Action of DPP-4 Inhibitors. Incretins_and_DPP_4_inhibitors.jpg (488 × 427 pixels, file size: 26 KB, MIME type: image/jpeg. Retrieved from File:Incretins and DPP 4 inhibitors.jpg – Wikipedia

11.6 Semaglutide: Glucagon 1 Peptide agonist (GLP1)

Semaglutide, a glucagon-like peptide-1 (GLP-1) receptor agonist, is used for glycemic control in type 2 diabetics and is also used for weight management. There are three separate brand name medications. Ozempic and Rybelsus are both typically used for glycemic control for diabetics and to reduce CV risk. Wegovy was developed for weight management in obesity. Both Wegovy and Ozempic are subcutaneous injections. Rybelsus is an oral preparation used for glycemic control. The differences between the medications are the formulation and dosages.

In this unit, we will focus on Ozempic and Rybelsus. As mentioned, Ozempic and Rybelsus are used to improve glycemic control for type 2 diabetic adult clients, and to also reduce the risk of adverse cardiovascular (CV) events with type 2 diabetes and CV disease. It is also used to slow the progression of GFR decline in clients with renal disease (Med Scape, 2025).

Mechanism of Action

Ozempic and Rybelsus are semaglutide medications that work by mimicking GLP-1 incretin, a naturally occurring hormone released from the intestine after a meal. GLP-1 receptors are in various locations in the body such as the pancreas, liver, and in the stomach. Upon activation of the GLP-1 receptor, semaglutide does a number of actions:

- enhances glucose-dependent insulin secretion, providing a physiological response to elevated blood glucose levels after a meal.

- it slows gastric emptying,
- improves pancreatic β-cell proliferation,
- reduces glucagon release, improving glycemic control.
- in the hypothalamus, it may mitigate sensations of hunger, alleviate food cravings, and enhance the feelings of satiety.

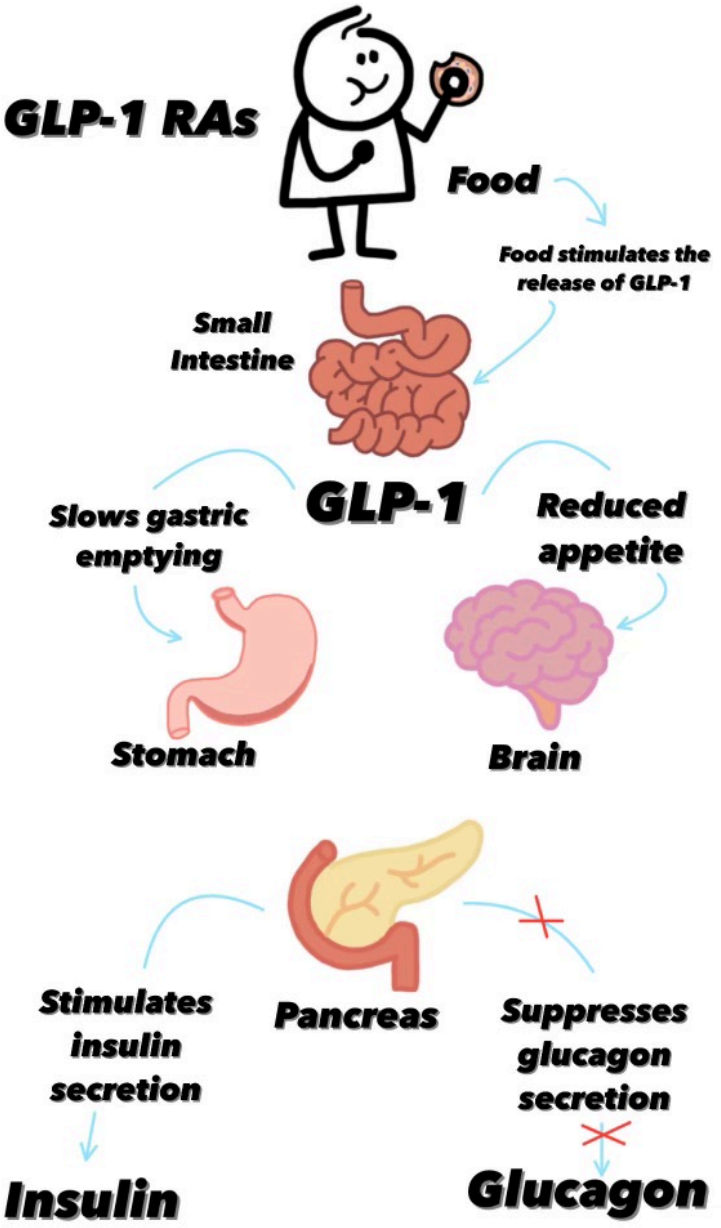
GLP-1 RAs
Food
Food stimulates the release of GLP-1
Small Intestine
GLP-1
Slows gastric emptying
Reduced appetite
Stomach
Brain
Pancreas
Stimulates insulin secretion
Suppresses glucagon secretion
Insulin
Glucagon

Figure 11.6a Mechanism of action of semaglutides

(Myluckynumber7; https://commons.wikimedia.org/w/index.php?curid=149634259/ *Wikimedia Commons*) CC BY 4.0

In simple terms, GLP-1, which Semaglutide is similar to, regulates digestion and blood sugar. The small intestine releases GLP-1 when food is eaten. It reduces hunger, signals fullness, stimulates insulin, and inhibits glucagon, maintaining glucose levels.

These actions all help manage blood glucose levels and facilitate weight loss by delaying gastric emptying. The use of semaglutides should always be used along with diet and exercise for enhancing glycemic control in adults with type 2 diabetes mellitus (Kommu & Whitfield, 2024).

Figure 11.6b Ozempic, a Semaglutide injection pen

Ozempic, a Semaglutide injection pen (Dennis Sylvester Hurd – Saturdays;https://commons.wikimedia.org/w/index.php?curid=175778404 Ozempic (53899794358).jpg /*Wikimedia Commons*) CC

Nursing Considerations

Administration:

- Ozempic: subcutaneous injection, starting with a low dose of 0.25 mg weekly for 4 weeks, and then titrated up to 0.5 mg weekly depending on glycemic control. The SQ injections are given weekly to a maximum dose of 2 mg/week.
- Rybelsus: oral dosing, taken once a day. Depending on the formulation, dosages are gradually titrated up (MedScape, 2025). Onset of action is one hour, with steady state reached in 4 to 5 weeks of daily administration. For optimal absorption, administer at least 30 minutes before consuming food, beverages or other medications. Take with 120 mL of water (Kommu & Whitfield, 2024).

Monitor blood glucose levels and A1C prior to therapy and throughout treatment.

Dosage adjustments for renal and hepatic impairments are generally not required.

Drug Interactions

- Numerous drug interactions can occur which is attributed to the delay in gastric emptying leading to a delay in absorption of concurrently administered oral medications. This is particularly a concern with narrow therapeutic index medications. There are no reported absorption delays with Ozempic, which is given SQ, and oral meds.
- Medications that can increase the hypoglycemic effects of semaglutide include beta blockers, monoamine oxidase inhibitors, salicylates, selective serotonin reuptake inhibitors, and other antidiabetic medications.

- Medications that can decrease the effects of semaglutides include furosemide and thiazide diuretics.
- Semaglutide may increase the serum concentrations of levothyroxine.

(Kommu & Whitfield, 2024)

Discontinuing semaglutides: for clients on semaglutides for weight loss, rebound weight gain of two-thirds of the initial weight loss can occur after one year. Semaglutides are considered a long-term treatment.

Adverse/Side Effects

The most common side effect is nausea. Other GI effects include abdominal pain, diarrhea, constipation, decreased appetite and dyspepsia.

Hypoglycemia: GLP-1 agonists lower blood glucose levels. As doses are increased, risk increases. Higher risk of hypoglycemia also occurs if taken with anti-hyperglycemic medications such as sulfonylureas, metformin, or insulin.

Acute Kidney Injury: For clients who experience nausea, vomiting, diarrhea, or dehydration during the treatment are at higher risk of acute kidney injury.

Other adverse effects include gallbladder issues such as cholelithiasis and cholecystitis, retinopathy, and pancreatitis.

Client Teaching

- Inform client to take the medication as prescribed. Do not double doses.

- Continue to maintain healthy lifestyle with diet and exercise.
- Administer SQ injection weekly, rotate sites in upper arm, thigh and abdomen.
- May cause nausea. To minimize the nausea, eat smaller, frequent meals.
- Report any signs of pancreatitis (upper abdominal pain, fever, anorexia), change in urination, or vision changes immediately.
- Limit alcohol intake.
- Inform prescriber if pregnant or plan to become pregnant.

(Mayo Clinic, 2025).

References

Kommu, S. & Whitfield, P. (2024). Semaglutide. *National Library of Medicine*. StatPearls [Internet]. Semaglutide – StatPearls – NCBI Bookshelf

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Medscape (2025). Semaglutide. Ozempic, Rybelsus, Wegovy (semaglutide) dosing, indications, interactions, adverse effects, and more

Media Attributions

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- Figure 11.6b Ozempic, a Semaglutide injection pen Ozempic, a Semaglutide injection pen (Dennis Sylvester Hurd – Saturdays;

https://commons.wikimedia.org/w/index.php?curid=175778404_Ozempic (53899794358).jpg /*Wikimedia Commons*) *CC*

11.7 Clinical Reasoning and Decision-Making Activities

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=4120#h5p-113

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=4120#h5p-114

Critical Thinking and Decision-Making Activities

Complete the following questions. Refer to the answer key to check your answers.

1. A client has been started on a sulfonylurea

(Glyburide) to help control their type 2 diabetes. This client reports that they often skip meals.

   a. Is this medication a good option for this client?
   b. The client says they used to be on metformin but got switched to glyburide. What might have been the rationale?

2. A 22-year-old client is a type 1 diabetic, and enjoys going to the occasional party with his friends. He likes to have some alcoholic drinks. What advise should be provided, recognizing that he will drink alcohol at the party?
3. A type 2 diabetic client has had the disease for many years. There has been a progressive increase in oral anti-diabetic medications and now they will be started on insulin. The physician has said that they will continue on their SGLT-2 inhibitor and metformin.

   a. What is the benefit of adding insulin but still keeping the other oral meds?
   b. What might be important medication teaching to start on insulin (basal and bolus)?

4. A 75-year-old type 1 diabetic client has been on insulin since they were in their early 20's. They have managed very well over the years, managing their blood glucose levels through following the required insulin and healthy lifestyle requirements. Despite their efforts, they have developed some complications, and currently is dealing with a diabetic

foot ulcer. The home health nurse is at the home for a dressing change on the diabetic foot wound. The client tells the nurse that lately, they have had trouble with their blood sugar levels being as consistent as they were a few months ago. The nurse asks some question and does an assessment, noticing hardened areas on the client's abdomen where the client has been repeatedly injecting the insulin.

a. What are the hardened areas that can occur with repeated insulin injections?
b. What is the complication that can occur because of this finding? What is the solution?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 11: Endocrine System Medications: anti-diabetic medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

CHAPTER 12: ANTIMICROBIALS

12.0 Infection and Antimicrobials Introduction

Learning Objectives

- Identify the classifications and actions of antimicrobial medications
- Provide examples of when, how, and to whom antimicrobial drugs may be administered
- Identify the side effects and special considerations associated with antimicrobial therapy
- Explain considerations and implications of using antimicrobial medications across the lifespan
- Apply evidence-based concepts when using the nursing process, clinical reasoning and decision-making

Key Terms

- **antagonistic interactions**
- **antifungal**
- **antiviral**
- **bactericidal**
- **bacteriostatic**
- **black box warnings**
- **broad-spectrum antimicrobial**
- **clostridioides difficile (C diff)**
- **culture**
- **dose dependent**
- **gram positive infection**

- **gram negative**
- **gram stain**
- **half-life**
- **indications**
- **mechanism of action**
- **methicillin-resistant S. aureus (MRSA)**
- **narrow-spectrum antimicrobial**
- **pathogen**
- **prototype**
- **resistance**
- **sensitivity analysis**
- **superinfection**
- **synergistic interaction**
- **time dependent**
- **trough**
- **vancomycin-resistant S. aureus (VRSA)**

Have you ever been prescribed an antibiotic for an infection and asked, "Why do I have to finish taking all these pills when I already feel better"? Or, perhaps you wondered why the healthcare provider chose a certain medication over another or why the pharmacist told you to avoid certain foods when taking a certain antibiotic.

You may have had these questions in your own healthcare experiences. It is important to remember that if you have these questions, many of your patients will as well. Learning about the various types of antimicrobials and how they work will help you provide better health education to your patients.

Did you know that the use of antimicrobial agents dates back to ancient times?

Although the discovery of antimicrobials and their subsequent widespread use is commonly associated with modern medicine, there is evidence that humans have been exposed to antimicrobial compounds for millennia. Chemical analyses of the skeletal remains from between 350 and 550 AD of people living near the Nile River have shown residue of the antimicrobial agent

tetracycline in high enough quantities to suggest the purposeful fermentation of tetracycline-producing Streptomyces during the beer-making process. The resulting beer, which was thick and gruel-like, was used to treat a variety of ailments, including gum disease and wounds, in both adults and children.

Additionally, the antimicrobial properties of plants and honey have been recognized by various cultures around the world, including Indian and Chinese herbalists who have long used plants for a wide variety of medical purposes. Healers of many cultures understood the antimicrobial properties of fungi, and their use of moldy bread or other mold-containing products to treat wounds has been well documented for centuries.

The section on the ancient use of antimicrobial agents was adapted from "History of Chemotherapy and Antimicrobial Discovery" in *Microbiology* by Nina Parker, Mark Schneegurt, Anh-Hue Thi Tu, Philip Lister, Brian M. Forster (© 2022 OpenStax), which is licensed under a CC BY 4.0 licence.

12.1 Infection Concepts

The following section was adapted from *Microbiology* by Nina Parker, Mark Schneegurt, Anh-Hue Thi Tu, Philip Lister, Brian M. Forster (© 2022 OpenStax), which is licened under a CC BY 4.0 licence.

Concepts Related to Infection

For the purposes of this concept discussion, the Concept of Infection is defined as "the invasion and multiplication of microorganisms in body tissues, which may be clinically unapparent or result in local cellular injury" (Giddens, 2017). This resource provides a basic introduction to the concept of infection as it relates to pharmacology. The example concept map below provides a summary of the key information necessary to understand infection. You can revisit this map after you have completed the chapter. The information for the map was informed by several resources (Giddens, 2017).

Fig 12.1a: Concept Map for Infection [Image Description]

Before learning about medications that are used to treat infections in our clients, it is important for nurses to first understand the basics of microbiology. Bacteria are found in nearly every habitat on earth, including within and on humans. Most bacteria are harmless or considered helpful. Recall that the normal flora on humans, which is a mixture of microorganisms that are found on every anatomical site of the body, serve an important first line of defense against pathogens. It is only when the innate defense mechanisms that exist in humans (and all vertebrates) is bypassed, evaded or overwhelmed that infections can occur (Janeway, Travers, Walport, et al (2001).

The innate immune system consists of two defenses. The first consists of the physical and chemical barriers such as skin and mucous membranes or ciliated surfaces. The second line of defense is the internal defenses that counter any pathogen invasion which includes phagocytosis, inflammation, complement, among others. Let's use an example of a urinary tract infection. Our urinary tract is exposed to bacteria all the time, but infections are rare due to such defenses as the physical barrier of urination that flushes out bacteria, a protective mucus layer in the bladder, and the sterile, acidic environment of the urine. When bacteria such as E. Coli bypass these defenses and the second line of defense cannot overcome the E. Coli, an infection occurs. Our own defenses can also be weakened by medications or illness which makes the client more susceptible to pathogens.

A **pathogen** is defined as an organism causing disease to its host. Pathogens can be bacteria, viruses or other organisms that when they overcome our innate defense mechanisms, will lead to an infection. Infections can be mild, that we can eventually overcome, or overwhelm the client and lead to significant health problems such as sepsis.

Bacteria may be identified when a client has an infection by using a culture and sensitivity test or a gram stain test. Antimicrobials may be classified as broad-spectrum or narrow-spectrum, based on the variety of bacteria they effectively treat. Additionally, antibiotics

may be bacteriostatic or bactericidal in terms of how they target the bacteria. Finally, the mechanism of action is also considered in the selection of an antibiotic.

In addition to antibiotics, antimicrobials also include medications used to treat viruses and fungi. Each of these topics will be discussed in more detail below, along with the issue of drug resistance.

Concepts Related to Bacterial Infections

Culture and Sensitivity

When a client presents signs or symptoms of an infection, healthcare providers will begin the detective work needed to identify the source of the infection. A **culture** is a test performed to examine different body substances for the presence of bacteria or fungus. These culture samples are commonly collected from a client's blood, urine, sputum, wound bed, etc. Nurses are commonly responsible for the collection of culture samples and must be conscientious to collect the sample prior to the administration of antibiotics. Antibiotic administration prior to a culture can result in a delayed identification of the organism and complicate the client's recovery. Once culture samples are collected, they are then incubated in a solution that promotes bacterial or fungal growth and spread onto a special culture plate (Kristof & Pongracz, 2016). Clinical microbiologists subsequently monitor the culture for signs of organism growth to aid in the diagnosis of the infectious pathogen. A **sensitivity analysis** is often performed to select an effective antibiotic to treat the microorganism. If the organism shows **resistance**to the antibiotics used in the test, those antibiotics will not provide effective treatment for the client's infection.

Sometimes a client may begin antibiotic treatment for an infection, but will be switched to a different, more effective antibiotic, based on the culture and sensitivity results (Vorvick, 2019).

Gram-Positive vs. Gram-Negative

A **gram stain** is another type of test that is used to assist in classification of pathogens. Gram stains are useful for quickly identifying if bacteria are "gram-positive" or "gram-negative," based on the staining patterns of their cellular walls. Utilizing gram stain allows microbiologists to look for characteristic violet (Gram +) or red/pink (Gram -) staining patterns when they examine the organisms under a microscope. Identification of bacteria as gram-positive or gram-negative assists the healthcare provider in quickly selecting an appropriate antibiotic to treat the infection.

Sample Gram-Positive Infections

Photos of Gram Stain Specimins
Figure 12.1b Gram Stain Specimen Streptococcus

Streptococcus, the name of which comes from the Greek word for twisted chain, is responsible for many types of infectious diseases in humans. Streptococcus is an example of a **Gram + infection** and is identified by its ability to lyse, or breakdown, red blood cells when grown on blood agar.

S. pyogenes is a type of β-hemolytic *Streptococcus*. This species is considered a pyogenic pathogen because of the associated pus production observed with infections it causes (see Figure 12.1b for an image of Streptococcus undergoing gram staining). *S. pyogenes* is the most common cause of bacterial pharyngitis (strep throat); it is also a common cause of various skin infections that can be relatively

mild (e.g., impetigo) or life-threatening (e.g., necrotizing fasciitis, also known as flesh-eating disease).

Photo of Staphylococcus auerus

Figure 12.1c Staphylococcus aureus illustrates the typical "grape-like" clustering of cells

Staphylococcus is a second example of a Gram + bacteria. The name "Staphylococcus" comes from a Greek word for bunches of grapes, which describes their microscopic appearance in culture. Strains of S. aureus cause a wide variety of infections in humans, including skin infections that produce boils, carbuncles, cellulitis, or impetigo. Many strains of S. aureus have developed resistance to antibiotics. Some antibiotic-resistant strains are designated as **methicillin-resistant S. aureus (MRSA)** and **vancomycin-resistant S. aureus (VRSA)**. These strains are some of the most difficult to treat because they exhibit resistance to nearly all available antibiotics, not just methicillin and vancomycin. Because they are difficult to treat with antibiotics, infections can be lethal. MRSA and VRSA are also contagious, posing a serious threat in hospitals, nursing homes, dialysis facilities, and other places where there are large populations of elderly, bedridden, and/or immunocompromised individuals. See Figure 12.1c for an image of Staphylococcus bacteria microscopically.

Sample Gram-Negative Infections

Photo shoing Neisseria meningitidis growing in colonies on a chocolate agar plate

Figure 12.1d Neisseria meningitidis growing in colonies on a chocolate agar plate

Gram negative bacteria often grow between aerobic and anaerobic areas (such as in the intestines). Some gram-negative bacteria cause severe, sometimes life-threatening disease. The genus *Neisseria*, for example, includes the bacteria *N. gonorrhoeae*, the causative agent of the sexually transmitted infection gonorrhea, and *N. meningitides*, the causative agent of

bacterial meningitis. See Figure 12.1d for an image of Neisseria meningitides. Another common gram-negative infection that is seen in hospitalized clients is *Escherichia coli* (E. Coli). This is a frequent culprit for urinary tract infections due to its presence in the GI tract.

Broad-Spectrum vs. Narrow-Spectrum Antimicrobials

Spectrum of activity is one of the factors that is useful when selecting antibiotics to treat a client's infection.

When a person has an infection, we want an antimicrobial that will be as specific as possible to that infection. The spectrum of antimicrobial activity can be very broad and eradicate many organisms, or narrow and only target certain organisms, particularly the pathogen. A **narrow-spectrum antimicrobial** targets only specific subsets of bacterial pathogens. For example, some narrow-spectrum drugs target only gram-positive bacteria, but others target only gram-negative bacteria. If the pathogen causing infection has been identified in a culture and sensitivity test, it is best to use a narrow-spectrum antimicrobial and minimize collateral damage to the normal microbacteria.

A **broad-spectrum antimicrobial** targets a wide variety of bacterial pathogens, including both gram-positive and gram-negative species, and is frequently used to cover a wide range of potential pathogens while waiting for the laboratory identification of the infecting pathogen. Broad-spectrum antimicrobials are also used for polymicrobial infections (a mixed infection with multiple bacterial species) or as prophylactic prevention of infections with surgery/invasive procedures. Finally, broad-spectrum antimicrobials may be selected to treat an infection when a narrow-spectrum drug fails because of development of drug resistance by the target pathogen.

Photo of Clostridium difficile

Figure 12.1e Clostridium difficile, a gram-positive, rod-shaped bacterium, causes severe colitis and diarrhea, often after the normal gut microbiota is eradicated by antibiotics

One risk associated with using broad-spectrum antimicrobials is that they will also target a wide range of native or normal microbiome that colonize the body. This disruption of normal bacteria that colonize the intestine, lungs and bladder can lead to a number of risks. Broad spectrum antimicrobials often are associated with an increase in gastrointestinal distress (nausea, abdominal pain, diarrhea) due to normal microbial disruption, antibiotic resistance and secondary infections from the overgrowth of some bacteria or fungi. A **superinfection**, is a secondary infection in a client having a preexisting infection. A superinfection develops when the antibacterial intended for the preexisting infection kills the protective microbiota, allowing another pathogen resistant to the antibacterial to proliferate and cause a secondary infection.

Common examples of superinfections that develop as a result of antimicrobial use include yeast infections (candidiasis) and pseudomembranous colitis caused by **Clostridium difficile (C-diff)**, which can be fatal. Probiotics, such as lactobacillus, are sometimes used as a supportive therapy (along with anti-infectives) for individuals with C-diff to introduce normal bacteria into the gastrointestinal system and improve bowel function. See Figure 12.1e for an image of C-diff microscopically.

When antimicrobials are prescribed, the concept of **selective toxicity** is important, which is the ability of a drug to injure a target cell or target organism without injuring the surrounding cells or organisms. To avoid the negative outcomes of prescribing a broad spectrum antimicrobial, prescribers will aim for a narrow spectrum antibiotic, to avoid these adverse effects.

Let's Recap....

- A broad-spectrum antibiotic will treat gram-positive **and** gram-negative bacteria.
- A narrow-spectrum antibiotic will treat **either** gram-positive **or** gram-negative bacteria.

If a client is started on an antibiotic that is gram + and the culture identifies a gram – organism, the medication will not improve the client's status. The selection of an incorrect antibiotic can lead to adverse reactions and increase bacterial resistance.

At times, a broad-spectrum antibiotic may be administered prior to receiving the culture report due to the severity of the illness of the client. Once the culture is reported, the antibiotic therapy is tailored to the client. It is the nurse's responsibility to review culture results and ensure that the results have been communicated to the prescribing provider.

Antibacterials' Actions – Bacteriostatic vs. Bactericidal

When a provider selects an antibacterial drug, it is important to consider how and where the drug will ultimately target the

bacteria. Antibacterial drugs can be either bacteriostatic or bactericidal in their interactions with the offending bacteria. **Bacteriostatic** drugs cause bacteria to stop reproducing; however, they may not ultimately kill the bacteria. In contrast, **bactericidal** drugs kill their target bacteria.

The decision about whether to use a bacteriostatic or bactericidal drug often depends on the type of infection and the overall immune status of the client. In a healthy client with strong immune defences, both bacteriostatic and bactericidal drugs can be effective in achieving clinical cure. However, when a client is immunocompromised, a bactericidal drug is essential for the successful treatment of infections. Regardless of the immune status of the client, life-threatening infections such as acute endocarditis require the use of a bactericidal drug to eliminate all offending bacteria.

Mechanism of Action

Another consideration in the selection of an antibacterial drug is the drug's mechanism of action. Each class of antibacterial drugs has a unique **mechanism of action**, the way in which a drug affects microbes at the cellular level. For example, cephalosporins act on the integrity of the cell wall. In contrast, aminoglycosides impact ribosome function and inhibit protein synthesis, which stops the proliferation of cells. See Figure 12.1f for a summary of how various antibiotics affect the cell wall, the plasma membrane, the ribosomes, the metabolic pathways, or DNA synthesis of bacteria.

Viral Infections

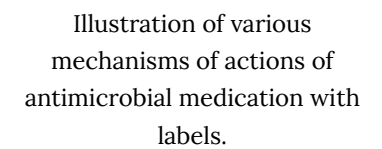

Illustration of various mechanisms of actions of antimicrobial medication with labels.

Figure 12.1f Various mechanisms of actions of antimicrobial medication. [Image Description]

A virus is a tiny, infectious unit that reproduces only when infecting a host cell. Viruses are small particles of DNA or RNA surrounded by a protein or capsid. They enter the body through the respiratory tract, the GI tract or from the mother to fetus via the placenta and replicate when they attach and enter host cells. Once they take over the cell, they begin the process of replicating to make new viral proteins. Following viral replication, the new viruses go on to infect new hosts. Common viral infections are the common cold, chicken pox, and influenza.

Antiviral

Similar to antibacterial medications, **antiviral** drugs directly impact the interaction and reproduction of the offending microorganism. Antibacterial medications are required for treating bacterial infections; antivirals treat specific viral infections. For example, oseltamivir (Tamiflu) is commonly prescribed to treat influenza. Unlike antimicrobials, antiviral medications do not kill the offending virus, but they work to reduce replication and development of the virus.

Review this quick video on how antiviral medications work: How Antiviral Drugs Work: the viral lifecycle [1:58] by High Impact (2021):

One or more interactive elements has been excluded from this version of the text. You can view them online

here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=3984#oembed-1

Fungal Infections

Antifungal

Antifungal, or antimycotic agents, are medications that are used to treat fungal infections. These medications work by killing the cells of the fungus or inhibiting the reproduction of the cells. Unlike antibacterial and antiviral medications, many antifungals are applied topically to the affected area. Fungal infections commonly affect surface areas of the body, including the toes, nails, mouth, groin, etc. For example, *Candida albicans* is a type of fungi that when overgrown in the mouth produces oral thrush. Clients experiencing thrush may be prescribed oral antifungal swish and spit medication such as nystatin.

Principles of Anti-Microbial Treatment:

Drug Resistance

Although there is a wide availability of medications that are useful for treating infection, greater limitations in effectiveness are being seen. The emergence and spread of resistance can be attributed

to many factors, some that can be attributed to how antimicrobials are prescribed and to client factors. When prescribers choose an antimicrobial, they will choose a medication that has maximum effect with the least amount of harm to the client. The three principles of antimicrobial therapy are identifying the correct pathogen, identifying which med the pathogen will be sensitive to, and considering the host factors such as the site of infection and the host defenses. If an inappropriate antimicrobial is chosen, antimicrobial resistance is accelerated (Lounsbury et al, 2025). Client factors also contribute to drug resistance such as inappropriate use of the prescribed antimicrobial including not completing the prescription or inadequate dosing. It is estimated that 1 in 16 Canadians admitted to hospital will develop an infection from a resistant superbug (Chief Public Health Officer, 2019). "Superbugs" is a term used to describe pathogens that have evolved to resist antimicrobial drugs that are designed to kill them.

Prevention Strategies to Overcome Drug Resistance

In Canada and many other countries, most antimicrobial drugs are self-administered by clients at home. Unfortunately, many clients stop taking antimicrobials once their symptoms dissipate and they feel better. If a 10-day course of treatment is prescribed, many clients only take the drug for 5 or 6 days, unaware of the negative consequences of not completing the full course of treatment.

The Problem: A shorter course of treatment not only fails to kill the target organisms to the expected levels but also assists in creating drug-resistant variants within the body. A client's nonadherence amplifies drug resistance when the recommended course of treatment is long.

For example...

Treatment for tuberculosis (TB) has a recommended treatment regimen lasting from 6 months to a year. The CDC estimates that about one-third of the world's population is infected with TB, most living in underdeveloped or underserved regions where antimicrobial drugs are available over the counter. In such countries, there may be even lower rates of adherence than in developed areas. Nonadherence leads to antibiotic resistance and more difficulty in controlling pathogens. As a direct result, the emergence of multidrug-resistant strains of TB is becoming a huge problem.

The overprescription of antimicrobials also contributes to antibiotic resistance. Clients often demand antibiotics for diseases that do not require them, like viral colds and ear infections. Pharmaceutical companies aggressively market drugs to physicians and clinics, making it easy for them to give free samples to clients, and some pharmacies even offer certain antibiotics free to low-income clients with a prescription.

In recent years, various initiatives have aimed to educate parents and clinicians about the judicious use of antibiotics. However, previous studies have shown the parental expectations for antimicrobial prescriptions for children actually increased.

One possible solution that is being explored is a regimen called directly observed therapy (DOT), which involves the supervised

administration of medications to clients. Clients are either required to visit a health-care facility to receive their medications, or health-care professionals must administer medication in clients' homes or another designated location. DOT has been implemented in many cases for the treatment of TB and has been shown to be effective; indeed, DOT is an integral part of WHO's global strategy for eradicating TB. If interested, more information about DOT programs in Canada for TB therapy is available through the Public Health Agency of Canada.

But is this a practical strategy for all antibiotics? Would clients taking penicillin, for example, be more or less likely to adhere to the full course of treatment if they had to travel to a health-care facility to receive each dose? Who would pay for the increased cost associated with DOT? When it comes to overprescription, should providers or drug companies be policed when it comes to overprescribing antibiotics to enforce best practices? What group should assume this responsibility, and what penalties would be effective in discouraging overprescription?

This is a complex issue with no clear, easy solution. However, what is clear is that all clients need extensive education regarding the judicious and complete use of medications to increase adherence and decrease the opportunity for antimicrobial resistance.

Critical Thinking and Decision-Making Activities

Image of a circle containing a speech bubble with a question mark in it

1. Reflecting on current healthcare challenges regarding the ongoing emergence of antimicrobial-resistant organisms, what actions could you take within your nursing

practice to help prevent drug resistance?

2. Sometimes antimicrobials are prescribed before the culture and sensitivity results come back from the lab. Why would an antimicrobial be prescribed before the lab results, since the bacteria is not yet identified?
3. How does the age of the client determine the type of antimicrobial prescribed?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Image Description

Figure 3.2a – Concept Map for Infection: This flowchart describes the Concept of Infection. In the centre of the chart, Infection is defined.

The definition of the Concept of Infection is: the invasion and multiplication of microorganisms in body tissues, which may be clinically unapparent or result in local cellular injury

Next, there are 4 arrows pointing from the definition to the Scope of Infection. The scope is divided into 4 categories: Bacterial, Viral, Fungal and Parasitic.

Next, one arrow points from the definition to the Variation of Infection. Types of infection can vary by severity, location, host response to treatment, and potential for debilitating consequences.

Next, the Physiological Process of Infection is outlined. The steps

included in the process are: 1) Pathogen invades body; 2) Immune responses initiated to minimize tissue and organ damage; 3) vasodilation, increased vascular permeability, WBC recruitment, phagocytosis, cytokine release.

From the Physiological Process, an arrow points down towards Assessment for Infection. Here, a summary of site-specific and general signs and symptoms is listed, as well as laboratory studies used to confirm presence of infection. The symptom listed are: redness, heat, swelling, pain, exudate, cough, fever, fatigue. The laboratory studies listed are: C+S, CBC (↑ WBC count), radiographic studies, ↑ CRP, ESR, Serological tests for virus or ab's)

Finally, an arrow connects Assessment to Management of Infection. The treatment/management depends on the cause and symptoms. For Bacterial infection – treat with antibiotics, for Viral infection – treat with antivirals, for Fungal infection – treat with antifungals, for Parasitic infection – treat with antiprotazoals. [Return to Figure 3.2a]

Figure 3.2f Various mechanisms of actions of antimicrobial medication: A pill representing antimicrobial medication is sliced open to reveal what looks like the parts of a cell. The image provides examples of different antimicrobial medications that affect these parts of the cell. Parts and processes of the cell affected by antimicrobial medication include:

- The cell wall, which is impacted by:
  - β-lactams, such as penicillins, cephalosporins, monobactams, carbapenems;
  - Glycopeptides, such as vancomycin;
  - Bacitracin.
- The plasma membrane, which is impacted by:
  - Polymyxins, such as polymyxin B, colistin;
  - Lipopeptides, such as daptomycin.
- Ribosomes, including:
  - 30S subunit, which is affected by aminoglycosides,

tetracyclines;
    - 50S subunit, which is affected by macrolides, lincosamides, chloramphenicol, oxazolidinones.
- Metabolic pathways, including:
    - Folic acid synthesis, which is affected by sulfonamides, sulfones, trimethoprim;
    - Mycolic acid synthesis, which is affected by izoniazid.
- DNA synthesis, which is impacted by:
    - Fluoroquinolones, such as ciprofloxacin, levofloxacin, moxifloxacin.
- RNA synthesis, which is impacted by:
    - Rifamycins, including rifampin.

[Return to Figure 3.2f]

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12.2 Conditions and Diseases Related to Infection

Amanda Egert; Kimberly Lee; and Manu Gill

As discussed previously, humans are constantly exposed to a multitude of microorganisms in the forms of bacteria, viruses, parasites, or fungi. Although many microorganisms do not pose a health threat to humans, some microorganisms cause human disease and are known as pathogens. Typically, an individual's immune system is able to rid the body of pathogens without developing an infection. An infection occurs when a susceptible host is invaded by a pathogen that multiplies and causes disease.

Bacterial Infections

In this section, we will review common bacterial infections that nurses will see in the hospital and in the community. Bacteria are one-celled organisms without a true nucleus or cellular organelles. They synthesize deoxyribonucleic acid (DNA), ribonucleic acid (RNA), and proteins, and can reproduce independently, but they require a host for a suitable environment for multiplication. Bacteria cause cellular injury by releasing toxins that are either exotoxins (enzymes released by gram-positive bacteria into the host) or endotoxins (part of the bacterial cell wall of gram-negative bacteria that can cause damage to the host even if the bacteria are dead). Diseases caused by bacterial invasion depend on the type of bacterial pathogen and the area of the body that is primarily invaded (Giddens, 2017).

General symptoms of bacterial infections

Individuals of any age can develop a bacterial infection. Bacteria can infect any area of the body, including the skin, bladder, lungs, intestines, brain, and more. A bacterial infection can also spread throughout the blood, causing a condition described as **sepsis**.

Some generalized symptoms of infection include fever, chills, and fatigue. Localized symptoms of infection can include swelling, pain at the site, redness and organ dysfunction.

Table 3.1: Systemic and Localized Symptoms of Bacterial Infection

Systemic	Localized
• Fever • Chills • Fatigue	• Swelling • Pain • Redness • Drainage • Organ dysfunction (depending on the organ(s) impacted)

Common bacterial infections

1. **Salmonella** is a type of infection often described as food poisoning. It causes severe stomach cramps, fever, diarrhea, and vomiting. Salmonella is caused by a non-typhoidal salmonellae bacteria found in the intestinal tracts of humans and other animals, and the most recognized method of infection is through undercooked poultry. Salmonella strains sometimes cause infection in urine, blood, bones, joints, or the nervous system (spinal fluid and brain), and can cause severe disease.
2. **Escherichia coli (E. Coli)** causes gastrointestinal (GI) distress. The infection usually resolves on its own, but if it affects the

kidney it can be severe or even fatal. E. Coli bacteria commonly spread through contaminated food (typically meat products, but sometimes even via uncooked vegetables).

3. **Tuberculosis (TB)** is a highly contagious disease caused by the Mycobacterium tuberculosis bacteria. It primarily causes a lung infection, and it rarely affects other systems (i.e. CNS). Common symptoms of TB include cough, chest pain, weakness, weight loss, fever and lack of appetite. Although the incidence of active TB disease in the overall Canadian population has been decreasing over time and is among the lowest in the world, high rates persist among Aboriginal peoples and among foreign-born individuals.
4. **Methicillin-resistant Staphylococcus aureus (MRSA)** is an antibiotic-resistant bacteria that can be deadly, particularly in people who have compromised immune systems. Staphylococcus bacteria normally live on the skin and in the nose, usually without causing problems. But if these bacteria become resistant to antibiotics, they can cause serious infections, especially in people who are ill or weak. Symptoms of MRSA depend on where the infection is – for example, if MRSA is causing an infection in a wound, that area of the skin may have purulent drainage, and may be red, tender and warm to touch. MRSA is different from other types of staphylococcus because it cannot be treated with certain antibiotics, such as beta lactams, making treatment complex and prolonging hospitalization. MRSA can be spread by contact with contaminated persons or through contaminated objects. It is a common **hospital-acquired infection**.
5. **Clostridioides (Clostridium) difficile (C. diff)** is a bacteria normally found in the intestine. For most healthy people, C. diff is not a health risk. It can cause GI illness when it overgrows due to antibiotic use or an impaired immune system. C. diff is the most frequent cause of infectious diarrhea in hospitals and health care facilities. Symptoms include watery diarrhea, fever, loss of appetite, nausea, and abdominal

pain/tenderness. It can spread from person to person through the fecal-oral route; for example, if a health care provider does not clean their hands with soap and water after caring for a client with C. diff, they can potentially pass on the infection to other people they touch. It is important to note that C. diff bacterial spores cannot be killed with alcohol hand sanitizer, therefore infected persons and their care providers must always wash using soap and water, and practice frequent hand hygiene.

6. **Bacterial pneumonia** is a lung infection that can be caused by an array of different bacteria, including Streptococcus pneumonia (main culprit), Haemophilus Influenzae, Staphlyococcus aureus and others. Note that some pneumonia are caused by viruses and/or fungi, but bacterial pneumonias are the most common. These infections are typically spread through air particles from coughing or sneezing (droplets) and aspiration, which then leads to an infection in the respiratory tract. Pneumonia can be further divided into community-acquired, hospital-acquired (HAP) and ventilator-associated (VAP). Community-acquired bacterial pneumonia is less likely to involve multi-drug resistant bacteria, so is therefore usually less severe compared to HAP and VAP.
7. **Helicobacter pylori (H. pylori)** is a type of bacteria associated with stomach ulcers and chronic gastritis. The environment of the GI system can change due to reflux, acidity, and smoking, which predisposes individuals to this bacterial infection. H. pylori exists in the stomachs of approximately 50% of the population, typically causing no harm. Issues arise when H. pylori are able to adhere to the cells of the stomach, and begin to disrupt cell function, causing inflammation and ulcer formation. Symptoms of H. pylori infection include abdominal pain, loss of appetite, nausea, and bloating. In some cases, H. pylori infection can lead to duodenal ulcers as well.

Sepsis

If unmanaged, bacterial infections can lead to a state of severe disease, called sepsis. Sepsis is a life-threatening condition as it can result in damage to body tissues and organs. Severe sepsis can lead to low blood pressure, and therefore poor blood flow and organ dysfunction. If sepsis persists, worsens and does not improve with fluid replacement, septic shock can occur. In order to gain a better understanding of Sepsis and Septic Shock [Video], review the linked Khan Academy resources.

Viral infections

A virus is a pathogen with nucleic acid molecule within a protein coat. It requires a living host for replication. An invading virus may immediately cause disease or may remain relatively dormant for years. Diseases develop as a result of interference of normal cellular functioning of the host, with the destruction of the virus by the immune system also requiring death of the host cell.

Common viral infections:

1. Human immunodeficiency virus (HIV)
2. Hepatitis A, B, C, or E
3. Human papillomavirus (HPV)
4. Respiratory syncytial virus (RSV)
5. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

Vaccines – how they work against viral infections

Vaccines work with the body's natural defenses to develop immunity against certain viruses. Vaccines are weakened or inactive parts of a particular organism (antigen) that triggers an immune response within the body. Our bodies then respond to the antigen by building a specific antibody against this antigen. If the person is exposed to an antigen as part of real organism, the body already has antibodies to defeat it (World Health Organization, 2025). Vaccines are used for many illnesses including influenza, chicken pox, polio, smallpox, measles, mumps, rubella and many others.

Fungal Infections

A fungus is any spore-producing microorganism, which includes yeasts, molds, and mushrooms. Fungi typically grow and proliferate in moist areas of the body, such as between the toes, in the groin, under the panniculus, and under the breasts. Fungal infections can occur in both healthy and immunocompromised persons. In an otherwise healthy individual, some fungi can be contained by the body's natural flora. Many fungal infections, such as candidiasis, can be easily treated. For example, thrush, a candida infection in the mouth in susceptible clients, can be treated with an antifungal medication. In the immunocompromised individual, some fungal infections can overwhelm the host, resulting in serious infections that lead to death. Obese people and people with diabetes are also more susceptible to fungal infections.

Common fungal infections

1. Tinea pedis (athlete's foot)
2. Candidiasis (yeast infection)
3. Aspergillosis (lung infection caused by mold)

4. Histoplasmosis (fungal lung infection)

Parasitic Infections

Parasites or protozoa infect both healthy and immunocompromised individuals. They are typically found in dead material in water and soil and are spread by the fecal–oral route by ingesting food or water that is contaminated with the parasitic spores or cysts. Disease may develop in an otherwise healthy individual when the spores invade organs and stimulate an immune response, interfering with normal functioning of the organ system.

Common parasitic infections

1. Giardiasis
2. Cryptosporidium
3. Toxoplasmosis
4. Malaria

In the next chapters, we will review assessment and management for infection, focusing primarily on bacterial infections.

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12.3 Clinical Reasoning and Decision-Making for Infection

Now that we have reviewed antimicrobial basics, we will take a closer look at specific antimicrobial classes and administration considerations, therapeutic effects, adverse effects, and specific teaching needed for each class of antimicrobials. But before we do that, let's reexamine the importance of the nursing process in guiding the nurse who administers antimicrobial medications. The nursing process consists of assessment, diagnosis, outcome identification, planning, implementation of interventions, and evaluation. Because diagnosis, outcome identification, and planning are specifically tailored to the individual client, we will broadly discuss considerations related to assessment, implementation of interventions, and evaluation when administering antimicrobials.

Assessment

Although there are numerous details to consider when administering medications, it is always important to first think more broadly about what you are giving and why. As a nurse who is administering an antimicrobial, you must remember some important broad considerations.

First, let's think of the why? Recognizing cues...

Antimicrobials are given to prevent or treat infection. If a client is prescribed an antimicrobial, an important piece of the nursing assessment is to recognize and analyze cues. The nurse should look for signs and symptoms of infection, and always know WHY the client is receiving an antimicrobial to effectively evaluate whether the client is improving or deteriorating. Remember, the nurse must assess how this medication is working, and having pre-administration assessment information is an important part of this process.

In order to define a baseline, typical data that a nurse collects at the start of a shift include:

- temperature
- heart rate
- blood pressure
- respiratory rate, and
- white blood cell count.

Focused assessments are then made based on the type of infection. For example, if it is a wound infection, the wound should be assessed for redness, inflammation, drainage type and amount, and pain. If it is a respiratory infection, the nurse should assess the client's lung sounds, and type/consistency of respiratory expectorate. If a client has a urinary tract infection (UTI), the urine and symptoms related to a UTI (pain with urination, cloudy urine, foul-smelling urine) should be assessed.

The following image summarizes some common signs and symptoms of infection (by system) that a nurse needs to monitor for.

Graphic anatomical image of a human, outlining the signs and symptoms of infection that can be present in various areas of the human body.

Figure 12.2a Summary of common signs and symptoms of infection. [Image Description]

Additionally, whenever a client has an infection, it is important to continually monitor for the development of sepsis, a life-threatening condition caused by severe infection. As you recall from the previous chapter, early signs of sepsis include new-onset confusion, elevated heart rate, decreased blood pressure, increased respiratory rate, and elevated fever. The bedside screening tool, Quick Sequential Organ Failure Assessment (qSOFA), is used to identify clients with suspected infection who are at high risk of poor outcomes (mortality or ICU stay). Refer to the Canadian Sepsis Foundation to learn more about sepsis. https://www.canadiansepsisfoundation.ca/about-sepsis

Additional baseline information to collect prior to the administration of any new medication order includes a client history, current medication use, including herbals or other supplements, and history of allergy or previous adverse response. Many clients with an allergy to one type of antimicrobial agent may experience cross-reactivity to other classes. This information should be appropriately communicated to the prescribing provider prior to the administration of any antimicrobial medication.

When a nurse has completed a thorough assessment, they are able to prioritize their concerns/hypotheses before implementing further intervention.

Interventions

With administration of the antimicrobial medication, it is important

for the nurse to anticipate any additional interventions associated with the medications. For example, antimicrobials often cause gastrointestinal upset (GI) such as nausea, diarrhea, etc. The nurse may need to refine their assessments and interventions, accordingly. The client should be educated about these potential side effects, and proper interventions should be taken to minimize these occurrences. For example, the nurse may instruct the client to take certain antimicrobials with food to diminish the chance of GI upset, whereas other medications should be taken on an empty stomach for optimal absorption.

Hypersensitivity/allergic reactions are always a potential adverse reaction, especially when administering the first dose of a new antibiotic, and the nurse should monitor closely for these symptoms and respond appropriately by immediately notifying the prescriber. Hypersensitivity reactions are immune responses that are exaggerated or inappropriate to an antigen and can range from itching to anaphylaxis. Anaphylaxis is a medical emergency that can cause life-threatening respiratory failure. Early signs of anaphylaxis include, but are not limited to, hives and itching, the feeling of a swollen tongue or throat, shortness of breath, dizziness, and low blood pressure.

Evaluation

Finally, it is important to always evaluate the client's response to a medication. With antimicrobial medications, the nurse should assess for the absence of or decreasing signs of infection, indicating the client is improving. It is important to document these findings to reflect the client's trended response.

Additionally, it is also important for the nurse to promptly identify and communicate signs of worsening infection to the provider. For example, increasing white blood cell count, temperature, heart rate, and respiratory rate may indicate that the client's body is

experiencing a life-threatening response to the infection. These signs of worsening clinical assessment require prompt intervention to prevent further clinical deterioration. Additionally, clients receiving antibiotics should be closely monitored for developing a complication called "C. diff," resulting in frequent, foul-smelling stools. C. diff stands for Clostridioides difficile, which is a spore-forming, gram-positive bacterium that colonizes the human intestinal tract after the normal gut flora has been disrupted (frequently in association with antibiotic therapy). C. diff is one of the most common health care-associated infections and a significant cause of morbidity and mortality, especially among older adult hospitalized clients. Management of C-diff requires the implementation of modified contact precautions, including the use of soap and water, not hand sanitizer (as this does not kill the spores), as well as antibiotic therapy (Kelly et al, 2019).

Image Description

Figure 12.2a Summary of common signs and symptoms of infection: A diagram showing a cartoon version of a human body. This diagram gives an internal view of the body, including organs, veins and arteries, and bones. Indicating various points on the body, this diagram lists common signs and symptoms of infection based on where in the body they can originate. These include:

- Respiratory (lungs): crackles, tachypnea, decreasing oxygen saturation, atelectasis.
- Gastrointestinal (digestive system): diarrhea, N/V (nausea and vomiting), stool sample positive.
- Incision/wound: purulent drainage, erythema, swollen, painful, warm.
- Central nervous system (brain): confusion, fever.
- Cardiac (heart): tachycardia, hypotension.

- Skin: red, swollen, painful, purulent, warm; phlebitis.
- Genitourinary (bladder): cloudy urine, dysuria, frequency, urgency, pelvic pain, urinalysis positive.
- Systemic: fever, hypotension, fatigue.

[Return to Figure 3.4]

Reference

Kelly, C.P., Lamon, J.T., & Bakken, J.S. (2019). Clostridioides (formerly Clostridium) difficile infection in adults: Treatment and prevention. *UpToDate*. Retrieved on July 8, 2019, from https://www.uptodate.com/contents/clostridioides-formerly-clostridium-difficile-infection-in-adults-treatment-and-prevention?search=Clostridioides%20(formerly%20Clostridium)%20difficile%20infection%20in%20adults&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1

12.4 Administration Considerations

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The administration of antimicrobial drug therapy involves special considerations to ensure that the therapeutic drug effect is achieved while maintaining client safety and minimizing complications.

Let's consider some of the variables that may impact antimicrobial administration:

Half-Life

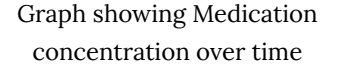

Figure 12.4a Medication concentration over time demonstrates half-life

Many antimicrobial medications are administered to ensure that a certain therapeutic level of medication remains in the bloodstream, and may require interval or repeated dosing throughout the day. For example, the **half-life**, or time required for 50% elimination of a drug from the plasma, can vary significantly between drugs. Some drugs have a short half-life of only 1 hour and must be given multiple times a day, but other drugs have half-lives exceeding 12 hours and

can be given as a single dose every 24 hours. Although a longer half-life can be considered an advantage for an antibacterial when it comes to convenient dosing intervals, the longer half-life can also be a concern for a drug with serious side effects. Medications that have longer half-life and more concerning side effects will exert these side effects over a longer period of time.

See Figure 12.4a for an illustration of half-lives and the time it takes for a medication to be eliminated from the bloodstream.

Lifespan Considerations

A majority of medications are calculated specifically based on the client's size, weight, and renal function. Client age and size are especially vital in pediatric clients. A child's stage of development and the size of their internal organs will greatly impact how the body absorbs, digests, metabolizes, and eliminates medications.

Liver & Renal Function

Additionally, there are many antimicrobial medications that will require tailored dosing based on individual client response and the potential impact of the medication on the client's liver and renal function. For more information about the effects of liver and renal function on medications, refer to Chapter 1 regarding metabolism and excretion. Oftentimes, pharmacists and providers will order **peak** and **trough** drug blood levels for select antimicrobials (i.e. Vancomycin, aminoglycosides) to determine how an individual client's body is responding to an antimicrobial. Follow-up interval dosing is then prescribed based on these blood levels. This is especially important for older adults or those with known liver/

renal impairment. Individuals with diminished liver and renal function are more prone to drug toxicity because of the reduced ability of the body to metabolize or clear medications from the body. For more information about peak and trough levels, refer to Chapter 1 regarding medication safety.

Dose Dependency/Time Dependency

The goal of antimicrobial therapy is to select an optimal dosage that will result in clinical cure, while reducing complications or significant side effects. Many medications may be **dose-dependent**. This means that there is a more significant killing of the bacterial with increasing levels of the antibiotic. For example, fluoroquinolones are dose-dependent medications with the treatment goal to optimize the amount of the drug. Other medications are **time-dependent**. Time-dependent medications have optimal bacterial killing effect at lower doses over a longer period of time. Time-dependent antimicrobials exert the greatest effect by binding to the microorganism for an extensive length of time. Penicillin is an example of a time-dependent medication where the goal is to optimize the duration of exposure.

Route

It is also important to consider the route of drug administration within the client's body. Many of us may have been prescribed oral antibiotics and have simply filled our prescription and completed the drug regimen within the comfort of our own homes. However, there are many types of infections or disease processes that do not respond well to the use of oral antimicrobial therapy. For these

diseases, clients may require intravenous or intramuscular injections. Clients requiring intravenous or intramuscular injections may need to be hospitalized, have home health nursing arranged, or travel to the hospital/clinic for their therapy. Concerns with treatment compliance exists with all routes of administration. For more information about considerations regarding routes of administration, refer to Chapter 1 on absorption. See Figure 12.4b[1] for an illustration of three common routes of medication within the body.

Illustration of human body, from waist up, showing routes of medication administration

Figure 12.4b Common routes of medication administration include oral, inhalation, and IV

Drug Interactions

For the optimum treatment of select infections, two antibacterial drugs may be administered together. Concurrent drug administration produces a **synergistic interaction** that is better than the efficacy of either drug alone. A classic example of synergistic drug combinations is trimethoprim and sulfamethoxazole (Bactrim). Individually, these two drugs provide only bacteriostatic inhibition of bacterial growth, but combined, the drugs are bactericidal.

Although synergistic drug interactions provide a benefit to the client, **antagonistic interactions** produce harmful effects. Antagonism can occur between two antimicrobials or between antimicrobials and non-antimicrobials being used to treat other

1. [2]
2. [2]

conditions. The effects vary depending on the drugs involved, but antagonistic interactions cause diminished drug activity, decreased therapeutic levels due to elevated metabolism and elimination, or increased potential for toxicity due to decreased metabolism and elimination.

Let's consider an example of these antagonistic interactions.

Many antibacterials are absorbed most effectively from the acidic environment within the stomach. However, if a client takes antacids, the antacids increase the pH of the stomach and negatively impact the absorption of the antibacterial, thus decreasing their effectiveness in treating an infection.

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=3999#h5p-120

Media Attributions

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- Figure 12.4b "A drug's life in the body (with labels)" by National Institute of General Medical Sciences Image and Video

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12.5 Penicllins

Penicillin's "Mechanism of Action" was adapted from *Principles of Pharmacology* by Carl Rosow, David Standaert, and Gary Strichartz (republished by LibreTexts), which is licenced under a CC BY-NC-SA 4.0 licence.

Now that we have reviewed antimicrobial basics, common bacterial infections and the nursing process when administering antimicrobials, and general administration considerations, we will take a closer look at specific antimicrobial classes and administration considerations, therapeutic effects, adverse effects, and specific teaching needed for each class of antimicrobials. Each of the following sections of this chapter is based on a class or subclass of anti-infective medications. Each section discusses the mechanism of action, specific administration considerations, and common client teaching for this class/subclass of medication. Each section is then followed by a medication table with a common generic medication and its specific administration considerations, therapeutic effects, and side effects/adverse effects for this medication.

To help with comparing the medications and to learn important considerations for each medication, refer to the: Chapter 12 Antimicrobials Medication Cards

Penicillin was the first antibiotic discovered and its detection came as a bit of an accident. In 1928, Alexander Fleming, a professor of bacteriology at St. Mary's Hospital in London, discovered

penicillin accidentally growing in a petri dish in his lab. The penicillin was the result of mold juice that had grown there inadvertently. Fleming noted that this "mold juice" inhibited the growth of Staphylococcus bacteria that was previously growing in the petri dish. Subsequently, the first antibiotic discovery was made.[1]

Indications for Use

Penicillins are prescribed to treat a variety of infectious processes such as Streptococcal infections, Pneumococcal infections, and Staphylococcal infections. They are considered **broad-spectrum** for **gram-positive bacteria**, and are less effective against**gram-negative** bacteria. Some penicillins have gram-negative coverage such as amoxicillins.

Mechanism of Action

Penicillins are **bactericidal** and kill bacteria by inhibiting cell wall synthesis (peptidoglycan). When the bacterial cell wall is impaired, the cell is rapidly broken down and destroyed.

Nursing Considerations

Administration: oral, IV, IM

1. [2]
2. [1]

- Oral: take with a full glass of water. Some penicillin medications should not be taken with acidic juices, tomato juice, cola, caffeine as these will inactivate the med. Take of an empty stomach as food can decrease absorption. If GI upset, take with food.

Pediatrics: Penicillin are considered safe for children, with dosages varying based on pediatric clients' weight.

No dosage adjustment is required for clients with hepatic impairment. Dosage adjustment may be required for renal impairment.

Pregnancy: Penicillin can be used during pregnancy and safe to use while breast feeding.

Some penicillins have a high concentration of potassium. Caution with client if taking potassium supplements.

Monitoring:

- check for allergies to Penicillin or cephalosporins before first dose.
- prior to first dose, ensure that cultures are not required.
- if high doses, assess INR, platelet count and PT
- monitor for systemic effects such as temperature, WBCs, and cultures
- monitor for changes in stool due to risk of C. Diff
- narrow therapeutic range so ensure regular dosing.

Drug Interactions:

There is a cross-sensitivity for clients allergic to cephalosporins. Clients on high doses of penicillin may experience significant coagulation abnormalities.[3]

3. [4]

Other notable drug interactions with Pen include the use of diuretic therapy, NSAIDs, oral contraceptives

Drugs that can lead to a decrease effectiveness of Pen include tetracycline. Parenteral aminoglycosides (e.g., neomycin) may have a synergistic effect, especially against bacteria such as enterococcus species (Pen damages the cell wall to allow better penetration of aminoglycoside).

In addition to general antimicrobial administration considerations, it is important to monitor clients who receive penicillin for signs of superinfections such as C-diff or yeast infections. Be alert for a change in bowel movements such as diarrhea, bloody stools and abdominal pain.

Client Teaching

- Notify the health care provider (HCP) if fever or diarrhea develops, especially if the stool contains blood, pus, or mucus. Advise the client not to treat diarrhea without advice from HCP.
- If GI upset occurs, the client may take the medication with meals but should avoid taking with citrus-based products, which can impede absorption. Additionally, clients should be instructed to chew oral chewable tablets thoroughly before swallowing.
- Report a rash or any signs of superinfection (black, furry overgrowth on tongue; vaginal itching or discharge; loose or foul-smelling stool).
- Clients should be instructed to take medication around the clock and to finish the drug completely as directed. Doses should be spaced evenly to achieve the desired therapeutic

4. [2]

effect.

- Do not share medication, and that any sharing of medications may be dangerous.
- Clients with a history of rheumatic heart disease or valve replacement should receive instruction regarding the importance of using antimicrobial prophylaxis before invasive medical or dental procedures.
- Female clients taking oral contraceptives should use an alternative form of contraception during therapy with amoxicillin and until their next period.
- Clients should notify their HCP if symptoms do not improve (Unbound Medicine, n.d.).

Penicillin Medication Card

Now let's take a closer look at the penicillin medication card (Velarde, 2018). Medication grids are intended to assist students to learn key points about each medication. Basic information related to a common generic medication in this class is outlined. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Medication Card: Penicillins

Prototypes: penicillin V (PO), penicillin G (IV), amoxicillin, piperacillin/ tazobactam (combination product)

Indications: broad spectrum for Gram + bacteria (streptococcus, Enterococcus, staphylococcus)

Soft tissue and ear infections, Pneumonia, UTI, STIs, Prophylaxis, pre → post-surgery

Mechanism of Action: Bactericidal. Interferes with cell wall synthesis, resulting in cell death.

Certain bacteria can produce an enzyme called lactamase, which breaks down the lactam ring in penicillin before it can inhibit cell wall synthesis. To overcome this, penicillin is often combined with a lactamase inhibitor, such as clavulanic acid, to preserve its effectiveness.

Administration:

Well-tolerated, IM, IV, PO

Given q 4-6 hours due to rapid excretion

Take w/ full glass of water; no acidic juice. Empty stomach (food ↓ absorption)

Take 1 hour before and 2 hours after meals to improve absorption

If GI upset – take with meal

Take with probiotics

If high doses; monitor INR, platelets, PT

Adverse/Side Effects

- GI most common: n/v, diarrhea
- Monitor for C. diff, candidiasis
- Risk of hyperkalemia
- Allergies: urticaria, pruritus, angioedema.

Serious – anaphylaxis, wheezing

- Oral (thrush or vaginal yeast infection, Black 'hairy' tongue (will go away when dose finished)

SAFETY: If an allergic reaction occurs, penicillin should be discontinued. Serious anaphylactic reactions require emergency treatment with epinephrine and airway management

Contraindications

Hypersensitivity/ penicillin allergy

Other antibiotics = additive, inhibitory effects

Drug interactions: NSAIDs, oral birth control, potassium supplements, anticoagulants (i.e. Warfarin). Drug interaction (↓ effectiveness of Pen) with tetracycline, (synergistic effect with aminoglycosides neomycin).

Nursing Considerations

Monitor for systemic signs of infection: elevated WBC count, fever, culture results. Monitor site of infection for improvement.

Check for allergies to penicillin or cephalosporins

Obtain culture, if ordered, before first dose

Avoid caffeine, citrus, cola, juices, tomato juice = can inactivate drug

Monitor for skin (rash) or bowel changes (diarrhea, bloody stools)

Monitor labs

Critical Reasoning and Decision-making Activities

Using the above information, consider the following clinical scenario questions:

1. Mr. Jones was admitted to the medical-surgical floor with a Pneumococcal respiratory infection and prescribed penicillin V 500 mg PO every 6 hours. You bring the client his 0800 medications, which include his penicillin. The client has just finished his breakfast that included orange juice. Would you proceed with the penicillin administration at this time? Why or why not?
2. Roberta was admitted yesterday after a fall that resulted in a fractured tibia. She is also diagnosed with pneumonia. She lives in an assisted living facility, and she has recently experienced a productive cough, a low-grade fever and dizziness for a few days prior to her fall. The antimicrobial order reads:

Piperacillin-tazobactam 2.25 G IV every 8 hours.

a. Explain the rationale for tazobactam with piperacillin.

b. After a few days, Roberta will be going home and is prescribed Penicillin V 125 mg oral every 8 hours for 10 days.

What should be important client teaching?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.6 Cephalosporins

Cephalosporins are a slightly modified chemical "twin" to penicillins due to their beta-lactam chemical structure. (See Figure 12.6 for a comparison of the beta-lactam ring structure, spectrum of activity, and route of administration across different classes of medications.) Because of these similarities, some clients who have allergies to penicillins may experience cross-sensitivity to cephalosporins (Bui, Patel & Preuss, 2024).

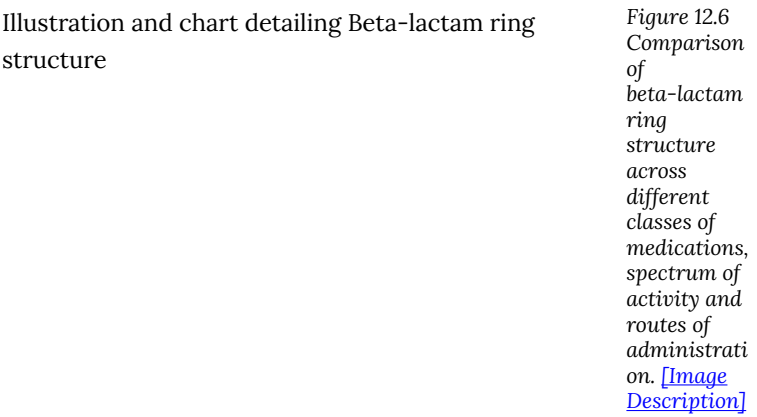

Figure 12.6 Comparison of beta-lactam ring structure across different classes of medications, spectrum of activity and routes of administration. [Image Description]

Indications for Use

Cephalosporins are used to treat skin and skin-structure infections, bone infections, genitourinary infections, otitis media, and community-acquired respiratory tract infections. There are five generations of cephalosporins with many medications in each generation. They are widely used due to their broad range of coverage. In general, generation 1st and 2nd are effective against gram-positive cocci. The newer generations, 3rd-5th, have improved gram-negative coverage and CNS penetration (Bui, Patel & Preuss, 2024). More detail on specific coverage is below.

Mechanism of Action

Cephalosporins are typically bactericidal and are similar to penicillin in their action within the cell wall. They are beta-lactam antibiotics and are classified into five generations which is based on their antimicrobial properties. Higher generations generally have expanded spectra against aerobic gram-negative bacilli.

First generation drugs, such as cefazolin and cephalexin, are mainly effective against gram-positive organisms. Cefazolin is the cephalosporin of choice for surgical prophylaxis. They are also used for uncomplicated skin and soft tissue infections, such as cellulitis.

Second generation cephalosporins include cefuroxime. Second generation meds are less active against gram-positive cocci than first-generation cephalosporins but have improved activity against gram-negative bacilli. They are often prescribed to treat respiratory infections such as bronchiolitis or pneumonia.

Third generation includes ceftriaxone. They have extended gram-negative bacteria coverage, often used to treat gram-negative infections resistant to the first- and second-generation or other β-lactam antimicrobials. They can penetrate the blood brain barrier and are used of meningitis. Fourth-generation cephalosporin includes cefepime and is a broad-spectrum antimicrobial that can penetrate the cerebral spinal fluid (Bui, Patel & Preuss, 2024). The 5th-generation cephalosporins are active against methicillin-resistant Staphylococcus aureus (MRSA) or other complicated infections (Werth, 2018). 5th generation medications include ceftolozane.

Nursing Considerations

Most cephalosporins are generally well-tolerated. Depending on the drug, they may be given orally or parenterally. Most are renally excreted so dose adjustment is required for those with renal impairment (Ceftriaxone has biliary excretion). Monitor blood urea nitrogen (BUN) and creatinine and assess for signs of nephrotoxicity.

Lifespan:

- Pediatrics: most cephalosporins are considered safe for use with children.
- Older adult: some dose adjustments are required based on renal dysfunction in older adults. Older adults with CNS disorders are at risk for neurotoxicity.
- Pregnancy: Cephalosporins can typically be given during pregnancy, with monitoring.

Caution if consuming alcohol with a cephalosporin, in particular cefotetan and cefoperazone. There is a risk of disulfiram-like reactions including severe headache, flushing, nausea, vomiting, etc (Ren et al, 2014).

May interfere with coagulability and increase a client's risk of bleeding.

Adverse/side effects:

Clients who are allergic to pencillin may also be allergic to cephalosporins. The most common side effects from cephalosporins are nausea, vomiting, lack of appetite, and abdominal pain.

Depending of the generation of cephalosporin, other adverse effects include:

- Vitamin K deficiency: some cephalosporins may inhibit vitamin K, leading to a decrease synthesis of coagulation factors.
- Hypersensitivity reactions: more common in first and second generation drugs, monitor for rash, hives and swelling.
- Disulfiram reaction: monitor for headache, flushing, nausea and vomiting.
- Drug induced hemolytic anemia

Bui, Patel & Preuss, 2024: Ren et al, 2014

Client Teaching

- Ensure to take the med as prescribed and to take the entire prescription even if they are feeling better.
- Avoid alcohol while on a cephalosporin: risk of a disulfiram reaction, which can occur when alcohol is ingested while taking the medication.
- Monitor for a rash and signs of superinfection (such as black, furry overgrowth on tongue; vaginal itching or discharge; loose or foul-smelling stool) and report to the prescribing provider.
- Taking a cephalosporin while breastfeeding is discouraged. It does enter breastmilk and may alter bowel flora of the infant (Vallerand & Sanoski, 2024).

Cephalosporin Medication Card

Now let's take a closer look at the cephalosporin medication card (Daily Med, 2019). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Medication Card: Cephalosporins

Prototypes: 1st generation: cephalexin and Cefazolin; 2nd generation: cefprozil; 3rd generation: ceftriaxone; 4th generation: cefepime; 5th generation: ceftolozane

Mechanism of Action: Similar to penicillin. Bactericidal. Effective against streptococcus, staphylococcus organisms

Indications: UTIs, respiratory tract infections (pneumonia), ear infections, STIs. Prophylaxis pre→post surgery

Administration:

- Onset, peak and duration of action varies
- PO: Administer without regard to food; if GI distress, give with food. Well absorbed orally.
- IV: Reconstitute drug with sterile water or normal saline; shake well until dissolved. Inject into large vein or free-flowing IV solution over 3-5 minutes
- Geriatrics: may need dose adjustment d/t age-related ↓ in renal function
- OB, Lactating: ½ life ↓ & blood levels lower during pregnancy

Side Effects:

- CNS: Seizures, headaches
- GI: N/V, diarrhea (Diarrhea can start 4-5 days

in)

- Derm: Stevens-Johnson syndrome, rashes
- Local: Pain @ IV site, Phlebitis @ IV site

SAFETY: If an allergic reaction occurs, antibiotic should be discontinued and appropriate therapy instituted. Serious anaphylactic reactions require emergency treatment with epinephrine and airway management.

Contraindications

- caution if penicillin allergy
- Lactam drug hypersensitivity: Pts allergic to penicillin ↑likely to be allergic to cephalosporins
- Hx of GI disease

Like penicillin:

- Other antibiotics = additive, inhibitory effects
- NSAIDs
- Oral birth control
- K+ supplements

Drug interaction with aminoglycosides or oral anti-coagulant drugs (eg warfarin)

Nursing Considerations

- Concurrent use of Loop diuretics and Aminoglycosides may ↑ risk of nephrotoxicity
- Alcohol should not be consumed until 72 hrs after stopping med.
- Monitor skin (rash, peeling skin), bowel (diarrhea, loose or bloody stools), hearing loss,

breathing issues, seizures. Report any of these changes.

- Monitor for systemic signs of infections: elevated WBC count, fever, culture results.

Antimicrobial Med Cards

To support your learning, editable and printable drug cards for all the antimicrobials are available. Chapter 12 Antimicrobials Medication Cards. These drug cards are intended to support your learning and are not intended to replace accessing current drug guides prior to drug administration in practice.

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

Mrs. Jenkins is an 89-year-old client admitted to the medical-surgical floor for treatment of a skin infection. The admitting provider prescribes Cefazolin 1 gram every 8 hours IV.

Mrs. Jenkins' admission laboratory tests include renal laboratory studies reflecting:

- Creatinine: 120 µmol/L (Normal range: 50-110 µmol/L[1]
- Blood urea nitrogen (BUN): 10.5 mmol/L (Normal: 2.9-8.2 mmol/L)
- Glomerular Filtration Rate: 55 ml/min (Normal: 90-120 ml/min)[3]

On Day 3 Mrs. Jenkins has renal laboratory studies performed again. The results are:

- Creatinine: 150 µmol/L
- Blood urea nitrogen (BUN): 16.8 mmol/L
- Glomerular Filtration Rate: 20 ml/min

1. [2]
2. [7]
3. [4]
4. [8]

Are Day 3 findings expected or not? What course of action should the nurse take?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Image Description

Figure 3.7 Comparison of beta-lactam ring structure across different classes of medications, spectrum of activity and routes of administration: Diagrams showing the chemical structures of various medication classes. These medications are:

- Penicillin.
- Cephalosporin.
- Monobactam.
- Carbapenem.

Each of these medications has a becta-lactam ring at the centre.

Comparison of different classes of medications, their spectra of activity, routes of administration, and chemistry

Drug name	penicillin G	penicillin V	ampicillin	amoxicillin	methicillin
R group	CH_2	CH_2 bonded to O	CH bonded to NH_2	CH bonded to NH_2 on one side of the molecule, and OH bonded to the other side	CH_3O bonded to one side of the molecule, and CH_3O bonded to the other side
Spectrum of activity	G+ and a few G−	similar to penicillin G	G+ and more G− than penicillin	similar to ampicillin	G+ only, including β-lactamase producers
Route of administration	parenteral	oral	parenteral and oral	oral (better than ampicillin)	parenteral

[Return to Figure 12.6]

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12.7 Carbapenems

Carbapenems are a beta-lactam "cousin" to penicillins and cephalosporins. Examples are meropenem and imipenem. They are typically reserved for severe, multi-drug resistant infections.

Indications for Use

Carbapenems are useful for treating life-threatening, multidrug-resistant infections due to their broad spectrum of activity (Papp-Wallace, 2011). These antibiotics are effective in treating gram-positive and gram-negative infections. Because of their broad spectrum of activity, these medications can be especially useful for treating complex hospital-acquired infections or for clients who are immunocompromised. Imipenem is often combined with cilastatin (imipenem/cilastatin) to prevent the renal inactivation of imipenem (Vallerand & Sanoski, 2024).

Mechanism of Action

Carbapenems are typically bactericidal and work by inhibiting the synthesis of the bacterial cell wall.

Nursing Considerations

Intravenous and intramuscular administration only.

Carbapenems are similar to cephalosporins. Potential for cross sensitivity in clients allergic to penicillin or cephalosporins.

Across the Lifespan: Some carbapenems (eg. meropenem) are considered safe for use in pediatrics. Information related to carbapenems in pregnancy is limited.

Dose adjustments are required based on renal dysfunction in older adults.

Monitoring:

- Labs prior to and periodically include renal panel, CBC and liver panel.
- Obtain history of reactions to penicillin drugs prior to initiating therapy.
- Obtain culture and sensitivity before initiating therapy, with first dose may be given prior to results returning.

Side / Adverse Effects:

- Side effects include nausea, vomiting, diarrhea, and rash. They are mostly well-tolerated.
- Adverse effects can include clostridium difficile associated diarrhea. Monitor for any change in bowel patterns. Hypersensitivity reactions may occur, monitor for a rash, hives and swelling.

Client Teaching

- Monitor for signs of superinfection and report any occurrence to the provider. If a client experiences fever and bloody diarrhea, they should contact the provider immediately.
- The client should also be advised that side effects can occur

even weeks after the medication is discontinued.

(Vallerand & Sanoski, 2024)

Carbapenems Medication Card

Now let's take a closer look at the medication card for Carbapenems (Daily Med, 2019: UpToDate, 2021). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Chapter 12 Antimicrobials Medication Cards

Medication Card: Carbapenems

Prototypes: imipenem and meropenem

Mechanism: Bactericidal. Broad-spectrum for both gram-positive and gram-negative infections.

Indications

- Complex body cavity, connective tissue infections in hospitalized patients.
- Bone, joint, skin, soft tissues infections
- Bacterial endocarditis
- Intra-abdominal infection
- Pneumonia
- Gynecological infection, UTI
- Septicemia
- Bacterial meningitis (Meropenem often

prescribed)

Administration

- IV, IM only.
- Older adult: use cautiously

Side Effects

- Similar to cephalosporins
- CNS: confusion, seizures (imipenem), Neurotoxicity at high concentrations
- Resp: Apnea
- GI: GI upset (including dysbiosis, C-diff), **N/V, diarrhea, dehydration,** electrolyte imbalance
- Derm: Rash (Drug reaction w/ Eosinophilia and Systemic Systems
- Superinfection

Contraindications

- **Drug Interactions**: Valproic Acid, Cyclosporine, ganciclovir, probenecid (not with Meropenem): worsen seizures, confusion
- pt's who have had **anaphylactic** reactions to beta-lactams
- Impaired renal function
- Pregnancy (only use if benefits outweigh risk to fetus)
- History of renal disease
- Seizure disorder

Nursing Considerations

Monitor for systemic signs of infection: elevated WBC

count, fever, culture results. Monitor site of infection for improvement.

Labs prior to and periodically include renal panel, CBC and liver panel.

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

John Smith was admitted to the hospital with a serious abdominal infection. The nurse notices that this client is allergic to penicillin as he prepares to administer the first dose of imipenem medication. What is the nurse's next best action?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.8 Monobactams

Like penicillin, cephalosporins, and carbapenems, monobactams also have a beta-lactam ring structure. The only med in this category is aztreonam.

Indications for Use

Monobactams are narrow-spectrum antibacterial medications that are used primarily to treat gram-negative bacteria such as Pseudomonas aeruginosa.

Mechanism of Action

Monobactams are bactericidal and work to inhibit bacterial cell wall synthesis. They have a structure that is highly resistant to beta-lactamases. They inhibit the synthesis of peptidoglycan layer of gram-negative bacterial cell walls (Vallerand & Sanoski, 2024).

Nursing Considerations

Aztreonam is only given IV or IM. Inhalation for specific formulations

Clients taking monobactams may experience adverse effects similar to other beta-lactam medications, so nurses should monitor for GI symptoms, skin sensitivities, and coagulation abnormalities.

Across the Lifespan: Monobactams are considered safe for use in pediatrics. Some dose adjustments are required based on renal

dysfunction in older adults. Monobactams can be given during pregnancy if the client is allergic to other, more preferred, antibiotics.

Client Teaching

- Monitor for signs of superinfection and report any occurrence to the provider. If the client experiences fever and bloody diarrhea, they should contact the provider immediately.
- Monitor for rash, hives or swelling and report any occurrence.

Monobactams Medication Card

Now let's take a closer look at the medication card for Monobactams (Daily Med, 2019; UpToDate, 2021). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

To help with comparing the medications and to learn important considerations for each medication, refer to the: Chapter 12 Antimicrobials Medication Cards

Medication Card: Monobactams

Prototypes: aztreonam

Mechanism: Bactericidal. Narrow-spectrum.

Indications

- used primarily to treat gram-negative bacteria such as Pseudomonas aeruginosa.

Administration

- IM, IV, or via inhalation
- Peak: 60 minutes via IM
- ½ life: 1.5-2 hours with normal renal function

Contraindications

- Check for allergies to ceftazidime for potential cross-sensitivity.
- Caution with impaired renal function

Side Effects

- hematologic neutropenia
- increased serum liver enzymes
- GI: GI upset, **N/V, diarrhea, dehydration,** electrolyte imbalance
- Skin sensitivities
- Coagulation abnormalities
- Superinfection

Nursing Considerations

- Anticipate monitoring renal and liver function
- Monitor for signs of anaphylaxis during first dose
- Monitor skin (rash), bowels (diarrhea)
- Monitor for systemic signs of infection: elevated WBC count, fever, culture results. Monitor site of

infection for improvement.

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

A client with cystic fibrosis is diagnosed with ventilator-associated pneumonia and is prescribed Aztreonam 1 gm IV daily for a suspected Pseudomonas aeruginosa infection. The nurse reviews the culture results that just arrived and notices that the results indicate the infection is caused by Methicillin-resistant Staphylococcus aureus. Will this medication be effective against this bacteria? What is the nurse's next best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.9 Sulfonamides

Sulfonamides or 'sulfa' antibiotics are one of the oldest broad-spectrum antimicrobial agents that work by competitively inhibiting bacterial metabolic enzymes needed for bacterial function. There are many drugs in this class, including Sulfamethizole and Sulfamethoxazole.

Indications for Use

Sulfonamides are used to treat urinary tract infections, otitis media, acute exacerbations of chronic bronchitis, and travelers' diarrhea.

Mechanism of Action

This mechanism of action provides bacteriostatic inhibition of growth against a wide spectrum of gram-positive and gram-negative pathogens.

Nursing Considerations

Administration: oral and IV. Oral dosing take with food and lots of water.

Sulfonamides are safe for use in early pregnancy but contraindicated in late pregnancy. Risk of kernicterus in infants less than 2 months of age. Dosing should be altered for any client with renal insufficiency.

Sulfamethoxazole is often combined with trimethoprim, which

is an antifolate antibiotic. Trimethoprim/sulfamethoxazole combination is done to avoid resistance and for synergistic effects of inhibiting folic acid in bacteria at two different points.

Allergy alert: Allergic reactions to sulfonamide medications are common and, therefore, clients should be monitored carefully for adverse effects including delayed hypersensitivity reactions. There is a potential for a cross sensitivity to loop diuretics and thiazide diuretics so ensure to check with the prescriber before giving the first dose.

Drug Interactions

There is numerous drug interactions so ensure to complete a thorough medication profile. Some interactions with this med are:

- Phenytoin: may increase phenytoin levels so closely monitor phenytoin levels.
- Warfarin: may increase bleeding so closely monitor INR and dose should be adjusted.
- Oral anti-diabetic medications (Tolbutamide, tolazamide, glyburide, glipizide, chlorpropamide, metformin, pioglitazone – ↑ risk of hypoglycemia).
- Cyclosporines can ↑ risk of nephrotoxicity.

Adverse/Side Effects

Common side effects include GI effects of nausea, diarrhea, anorexia and abdominal discomfort. May also experience headache and insomnia.

Increased risk of crystalluria that can cause kidney stones or

decreased kidney function; therefore, clients should increase their water intake while taking these medications.

Other adverse effects include:

- Hyperkalemia may occur so monitor serum electrolytes in susceptible clients.
- Kernicterus in neonates
- Photosensitivity: advise client to use sunscreen or to stay out of the sun.

Client Teaching

- The client should receive education to complete the full prescribed dose of medications and take measures to not skip doses. If a dose is missed, the client should take the missed dose as soon as possible unless it is near the next dosing time.
- Can cause increased photosensitivity, and clients should be educated to use sunscreen and protective clothing with sun exposure.
- Report any rash, sore throat, fever, or mouth sores that might occur.
- Unusual bleeding or bruising should also be reported to the provider.
- Report any fever and diarrhea especially if diarrhea contains blood or pus. Contact prescriber for treatment.
- If clients are receiving prolonged therapy, they may require platelet count monitoring.[1]

1. [2]
2. [1]

Sulfonamides Medication Card

Now let's take a closer look at the medication card for trimethoprim-sulfamethoxazole (Daily Med, 2019). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

To help with comparing the medications and to learn important considerations for each medication, refer to the: Chapter 12 Antimicrobials Medication Cards

Medication Card: Sulfonamides

Prototypes: Trimethoprim/Sulfamethoxazole, often referred to as "sulfa drugs"
Example: Septra, Co-trimoxazole (Bactrim)

Mechanism: Bacteriostatic inhibition of growth against a wide spectrum of gram-positive and gram-negative pathogen.

Indications: Broad spectrum, Gram + and – organisms. Very effective against UTIs. Also used for respiratory tract infections and general prophylaxis against infection.

Administration

- oral or IV
- PO: 1-4hr (Peak effect). Take with lots of water to avoid crystalluria.
- IV: immediate onset

Side Effects

- GI: N/V, Diarrhea, anorexia, abdo pain
- CNS: Convulsions, Headache
- GU: Crystalluria
- Hyperkalemia
- anemia
- photosensitivity
- folate deficiency
- Serious adverse effects include Stevens-Johnson syndrome, pancreatitis, bone marrow depression, toxic nephrosis
- "sulfa allergy" – starts with fever and rash

Contraindications/ Caution

- Sulfonylureas. sulfonamide, or thiazide diuretics – increased risk of hypoglycemia
- Hypersensitivity
- Cyclosporin- ↑ Risk of nephrotoxicity
- Pregnancy/ lactating
- Peds: do not give if under 2 years of age. Caution with older adult
- Phenytoin
- Warfarin
- Hx kidney stones or renal disease

Nursing Considerations

- Take with trimethoprim for synergistic effects
- Monitor skin (rash), bowels (diarrhea)
- *must take with LOTS of water. Stay hydrated.

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

A nurse is caring for an elderly diabetic client who has been prescribed trimethoprim-sulfamethoxazole for a urinary tract infection.

a. What nursing interventions will be implemented prior to medication administration?

b. The client has some questions about the instructions with taking this med. Provide a rationale for each question:

-Why do I need to take a full glass of water when I take this med?

– I often experience diarrhea already. How do I know if it is related to the drug?

– Am I able to go outside if I have to avoid the sun?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.10 Fluoroquinolones

Indications for Use:

Fluoroquinolones may be used to treat pneumonia or complicated skin or urinary tract infections.

Mechanism of Action:

Fluoroquinolones are a synthetic antibacterial medication that work by inhibiting the bacterial DNA replication and transcription. They are bactericidal due inhibition of DNA gyrase and topoisomerase IV resulting in halting bacterial growth and cell death. Many fluoroquinolones are broad spectrum and effective against a wide variety of both gram-positive and gram-negative bacteria.

Nursing Considerations:

Administration: oral, IV. Rapid onset of action. Take with plenty of water and food. Avoid taking dairy with the med as absorption will be delayed. Take oral fluoroquinolones with a full glass of water two hours before or after meals to enhance absorption and prevent crystalluria.

Fluoroquinolones are safe to use in pediatrics but only used for complicated UTIs and pyelonephritis,

Dose adjustments are required for renal insufficiency.

Pregnancy: There is limited data on safety in pregnancy.

Drug Interactions: There are numerous drug interactions. Ensure

that a complete medication profile is obtained. Some of the meds that interact with fluoroquinolones are:

- Anticoagulants
- Bronchodilators
- Tizanidines (risk of hypotension and sedation)
- Theophylline use with asthmatics (risk of increased theophylline levels and toxicity)
- Antacids – ensure a 4 hour window before and 2 hour after to avoid slowing absorption.
- NSAIDs (increased risk of seizures)

High Alert Med: **Black Box Warnings** are the strongest warnings issued by the Federal Drug Association (FDA) (equivalent to "Safety Warnings" by Health Canada) and signify that the medical studies have indicated that the drug carries a significant risk of serious or life-threatening adverse effects.

Fluoroquinolones, including, have been associated with disabling and potentially irreversible serious adverse reactions, including:

- Tendinitis and tendon rupture
- Peripheral neuropathy
- Central nervous system effects such as seizures or suicidal thoughts
- Exacerbation of muscle weakness in clients with myasthenia gravis

In clients who experience any of these serious adverse reactions, discontinue the medication immediately, and avoid the use of fluoroquinolones.

Client Teaching:

- Avoid direct and indirect sunlight due to the photosensitivity

that can be experienced while on these medications.
- Ensure dosages are spaced evenly throughout the day and that fluid balance is maintained. It is important to maintain an intake of 1500 mL-2000 mL per day while taking the medication.
- The client should be advised that medications containing calcium, aluminum, iron, or zinc may impair absorption and should be avoided.
- Side effects of fluoroquinolones CNS stimulation (insomnia, agitation). Additionally, the client should be cautioned to monitor for episodes of fainting or decreased heart rate and report any history of prolonged QT syndrome.
- Report right away peripheral neuropathy, increased tendon pain, jaundice, rash, or mood changes.[1]

Fluoroquinolones Medication Card

Now let's take a closer look at the medication card for levofloxacin (Daily Med, 2019; UpToDate, 2021). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review recommendations before administering specific medication.

To support your learning, editable and printable drug cards for all the antimicrobials are available. Chapter 12 Antimicrobials Medication Cards

1. [2]
2. [2]

Medication Card: Fluoroquinolones

Prototypes: levofloxacin, ciprofloxacin

Mechanism: Bactericidal. Works by inhibiting the bacterial DNA replication. Effective against broad-spectrum: Mostly Gram –, some Gram+. Useful against Gram+ bacteria that are resistant to penicillin (use when other less toxic antibiotics have failed). Very potent antimicrobial.

Indications: Complicated UTIs, resp tract infections, infections on the skin, GI, bone or joints. STI and UTIs

Administration

- oral, IV
- Oral: take w/food and plenty of fluid, except dairy
    - Onset: rapid, peak: 1-2 hr, duration:12 hr
    - Administer 2 hours before or after meals, antacid, or iron
    - PO-Extended Release: Onset: rapid, peak: 1-4 hr, duration: 24hr
- IV: onset: rapid, peak: end of infusion, duration: 12 hr. Infuse 500 mg or less over 60 minutes and doses of 750 mg over 90 minutes
  Dosage adjustment if renal or hepatic impairment

Side Effects

- CNS: anxiety, depression, dizziness, insomnia,

nervousness, fever somnolence, headache, restlessness, seizures, elevated ICP
- Rash
- GI: n/v, diarrhea, abdo pain, dyspepsia, C. Diff/ dysbiosis, crystalluria
- Hepatic: ALT, AST
- Increased, Hepatotoxicity
- QT prolongation
- anaphylaxis/allergy to drugs of same class

Contraindications/ Caution

- caution with renal impairment
- caution with known/suspected CNS disorder
- concurrent use of corticosteroids (may increase risk of tendon rupture)
- drug interactions include anticoagulants, bronchodilators, tizanidine
- Cardiac dysrhythmias
- Use cautiously in conjunction w/ theophylline (asthmatics)

Nursing Considerations

- Reduce caffeine if excessive cardiac, CNS stimulation
- Maintain hydration. Drink >2L H20/day
- Labs: hepatic function
- Antacid or meds containing Ca2+, Mg2+, Zn2+, Al3+, Fe3+ (cations = positive ion) should not be taken within 4hr or 2hr after (will slow absorption)
- Discontinue immediately if tendonitis, tendon

rupture, peripheral neuropathy, CNS effects, or muscle weakness in patients with Myasthenia Gravis

- Monitor for: GI upset, Hypersensitivity, Photosensitivity, Hypoglycemia, C-diff

Clinical Reasoning and Decision-Making Activity

Utilizing the above information, consider the following clinical scenario question:

A nurse is administering levofloxacin to a client diagnosed with pneumonia. The client reports that he has pain "above his heel" today. The nurse assesses and discovers the pain is over the Achilles tendon. What is the nurse's next best response?

Note: Answers to the Critical Thinking activities can be found i

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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4. UpToDate (2021). Levofloxacin. https://www.uptodate.com/contents/search ↵

12.11 Macrolides

Macrolides are complex antibacterial broad-spectrum medications that are effective against both gram-positive bacteria, with limited gram-negative bacteria. Two medications are erythromycin and azithromycin.

Mechanism of Action:

Macrolides inhibit protein synthesis by binding to the 50S ribosomal subunit. RNA protein synthesis and suppress reproduction of the bacteria. Macrolides are bacteriostatic as they do not actually kill bacteria but inhibit additional growth and allow the body's immune system to kill the offending bacteria.[1] They can be bactericidal at higher concentrations for some organisms.

Indications for Use:

Macrolides are often used for respiratory infections, otitis media, pelvic inflammatory infections, and chlamydia.

1. [2]
2. [1]

Nursing Considerations:

Administration: oral or IV. For oral dosing, give with or without food. Take with food if GI upset.

Macrolides are safe for children over 6 months of age.

Pregnancy: use with caution with benefits outweighing risk.

Use with caution with liver dysfunction, anticipate dose adjustment. Caution with renal failure for clarithromycin.

Monitor labs: may increase liver enzymes due to risk of hepatoxicity. May monitor ECG is susceptible clients (due to QT prolongation)

Adverse/Side Effects:

Common side effects include GI effects of abdominal pain, nausea, diarrhea.

Adverse effects, although rare, include hypersensitivity reactions, hepatoxicity, torsades de pointes, and Stevens-Johnson syndrome.

Client Teaching:

- GI upset is common and clients can be advised to take medication with food.
- May also cause drowsiness and dizziness. Avoid driving or other activities that require mental alertness.
- Potential for photosensitivity: advise clients to avoid excessive sunlight and to wear protective clothing and use sunscreen when outside, as well as to report any adverse reactions immediately. Advise clients to report symptoms of chest pain, palpitations, or yellowing of eyes or skin.
- Report any severe diarrhea and abdominal pain.

uCentral, n.d.; Vallerand & Sanoski, 2024

Macrolides Medication Card

Now let's take a closer look at the medication card for erythromycin and azithromycin.[34] Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

To help with comparing the medications and to learn important considerations for each medication, refer to the Chapter 12 Antimicrobials Medication Cards

Medication Card: Macrolides

Prototypes: erythromycin, azithromycin

Mechanism: Bacteriostatic – work by inhibiting RNA protein synthesis and suppressing reproduction of the bacteria. It inhibits translocation of proteins (binding to ribosome 50S). It is effective against species that reproduce inside host cells (mycoplasma, chlamydia, legionella) instead of just ones in bloodstream/ interstitial spaces. Macrolides are an alternative to B-

3. [5]
4. [6]
5. [3]
6. [4]

lactam if client is allergic to those class meds, such as penicillin.

Indications

- upper, lower respiratory tract infections (atypical)
- skin and soft tissue infections
- STIs: chlamydia
- Lyme disease
- streptococcus infections

Administration

- Oral, IV
- PO:
    - Don't crush, take with a full glass of water.
    - Best on empty stomach
    - Can be given with or without food. Take with food if GI upset occurs
- IV: Reconstitute and shake until well dissolved. Dilute as instructed and infuse over recommended time. Never give as a bolus or IM injection

Side Effects

- Erythromycin: GI irritation = increase gastric motility.
- drowsiness and dizziness
- Hypersensitivity
- Skin rashes
- Rare: cholestasis
- tinnitus

- May increase serum bilirubin, liver enzymes, potassium, PT, BUN, serum creatinine, and blood glucose. May decrease WBC and platelet count.
- May prolong QT interval segment. Monitor for dysrhythmias
- risk of photosensitivity – wear sunscreen and protective clothing

Contraindications/ Caution

- competes with other drugs for liver metabolism because it is highly protein bound (warfarin, digoxin, phenytoin, cyclosporin)
- decreased efficiency of oral birth control
- caution with using statins as increased risk of myopathy.
- cautious use with pregnancy
- caution with older adult
- risk of hepatotoxicity

Nursing Considerations

- Monitor for systemic signs of infection: elevated WBC, fever, assess culture results
- Monitor site of infection for improvement
- May prolong QT interval segment. Monitor for dysrhythmias consider ECG prior to dose if cardiac concern (assess for dizziness, CP., palpitations)
- monitor skin (rashes) and bowel changes
- monitor labs: liver enzymes, renal panel, CBC, lytes, and blood glucose levels.

- good category if pt allergic to penicillin

Clinical Reasoning and Decsion-Making Activity

Using the above information, consider the following clinical scenario question:

A nurse is administering azithromycin to a client with an acute bacterial worsening of COPD. Today the client's sclera appear yellow, which is a new finding. What is the nurse's next best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.12 Aminoglycosides

Aminoglycosides are potent broad-spectrum antibiotics that are useful for treating severe infections. This class of antimicrobials treats severe staphylococcus infections when penicillins or other less toxic meds are contraindicated. It is often used in combination with other antibiotics due to synergistic effects.

Indications for Use:

Aminoglycosides are primarily effective against aerobic gram-negative organisms, with limited gram-positive use (often in combination). Streptomycin is used primarily for tuberculosis and other severe infections such as endocarditis. Neomycin is used in the treatment of hepatic encephalopathy as adjunct therapy to lower ammonia levels and is also used as a bowel prep for colon procedures. it is also used for enterococcal infections such as urinary tract infections and pelvic inflammatory disease.

Mechanism of Action:

Aminoglycosides are bactericidal against gram-positive and gram-negative organisms. They bind with the area of the ribosome known as the 30S subunit, inhibiting protein synthesis and resulting in bacterial death (see Figure 12.12). Aminoglycosides may be given with beta-lactam medications to facilitate transport of aminoglycoside across the cellular membrane, resulting in a synergistic effect and increasing drug effectiveness. They have a narrow therapeutic index, meaning they require close monitoring due to potential kidney and ear toxicity.

Illustration of medications that inhibit protein synthesis with labels. Breaks medications into three major classes. Chloramphenicol, macrolides and licosamides. Aminoglycosides. Tetracyclines.

Figure 12.12 Medications that inhibit protein synthesis [Image Description]

Nursing Considerations:

Administration: Many aminoglycosides are poorly absorbed in the GI tract; therefore, the majority are given IV or IM. Neomycin is given orally for hepatic encephalopathy.

Ensure client is well-hydrated with 1500-2000 mL/day during therapy.

Aminoglycosides are potentially nephrotoxic, ototoxic and neurotoxic. They should be administered cautiously. Blood peak and trough levels should be performed to titrate a safe dose for each client. Ensure to assess and report any changes indicating early toxicity.

Pediatrics: Caution if used with pediatric clients, with dose adjustments made based on the client's weight.

Pregnancy: Some aminoglycosides are not safe for use in pregnancy, as they may cause fetal harm.

Older adult: monitor renal function and dosages will likely be reduced.

Monitoring:

- Assess the following labs prior to therapy: renal function and liver function.
- **Close monitoring due to risk of nephrotoxic (damaging to kidney; renal tubular toxicity reducing blood flow to the

kidneys), neurotoxic (damaging to the nervous system), and ototoxic (damaging to the ear; auditory impairment and vestibular [8th cranial nerve] impairment).

- Peak and trough levels are used to titrate this medication to a safe dose.
- Assess for signs of decreased renal function such as declining urine output and increasing blood urea nitrogen (BUN), creatinine, and declining glomerular filtration rate (GFR).
- Assess for damage to the neurological system such as increasing peripheral numbness or tingling in the extremities.
- Assess for hearing loss or hearing changes throughout the course of drug administration.

Side /Adverse Effects

Common effects include headache and nausea.

Signs of ototoxicity include dizziness, vertigo and tinnitus.

Signs of nephrotoxicity – elevated GFR. Usually reversible. Higher risk if client pregnant, hepatic dysfunction or dehydrated. Concurrent use of NSAIDs, cyclosporine, and diuretics increase risk.

Risk of neuromuscular blockade, includes muscle weakness or paralysis. Do not give med if they have myasthenia gravis.

Allergic reactions are rare.

(Chades & Tadi, 2023)

Drug Interactions

- Loop diuretics: increased risk of ototoxicity.
- Oral anticoagulants: neomycin increases the effects of

warfarin, assess for bleeding.

Client Teaching:

- Monitor for signs of hypersensitivity and auditory changes. This may include tinnitus and hearing loss.
- Report any issues with muscle weakness.
- Avoid taking NSAIDs and ensure to stay well-hydrated.
- Clients may also experience accompanying vertigo while on the medication.
- Drink plenty of fluids while taking the medication.
- Female clients should notify their provider if pregnancy is planned or if they are actively breastfeeding Unbound Medicine, n.d.)

Streptomycin and Gentamycin Medication Card

Now let's take a closer look at the medication card for streptomycin and gentamycin (Daily Med 2019; UpToDate, 2021). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

To help with comparing the medications and to learn important considerations for each medication, refer to the Chapter 12 Antimicrobials Medication Cards

Medication Card: Aminoglycosides

Prototypes: streptomycin, gentamicin

Mechanism: Bactericidal, gram – and some gram + organisms. They bind with the area of the ribosome known as the 30S subunit, inhibiting protein synthesis and resulting in bacterial death. Very potent. Resistance to med can be overcome if used with penicillin or vancomycin. Inactivated by lactams (penicillin & cephalosporins) when coadministered to pts with renal insufficiency.

Indications

- Serious Gram+ infections
- Enterococcus infections: GI, GU
- Streptococcal Endocarditis, Respiratory infections
- Second line treatment for TB
- Neomycin is used in the treatment for hepatic encephalopathy

Administration

- Routes: IM, IV, topical
- never PO: poor absorption
- given w/B-lactams, vancomycin for synergistic effects.

Side Effects

- Ototoxicity (more common with clients taking furosemide)
- Nephrotoxicity. Risk increases if dehydrated,

pregnant or with hepatic dysfunction.

- 8th cranial nerve damage = dizziness, nystagmus, vertigo, ataxia, tinnitus, roaring in ears, hearing impairment
- GI upset
- Rash
- Risk for severe neurotoxic reactions, especially with renal impairment. Can result in respiratory paralysis if given soon after anesthesia or muscle relaxant
- Can cause harm to fetus and breastfed infants

Contraindications

- Pregnancy/nursing: congenital deafness
- Allergy to med
- Renal impairment
- Loop diuretics
- Oral anticoagulants

Nursing Considerations

- SEs most likely if client has history of renal impairment, is dehydrated, getting high dosage, prolonged therapy, using other ototoxic drugs
- Renal assessment: proteinuria, BUN, creatinine
- Neuro assessment
- Hearing loss may be irreversible following treatment.
- Report diarrhea immediately

Clinical Reasoning and Decision-Making Activity

Using the above grid information, consider the following clinical scenario question:

A client is admitted with streptococcal endocarditis and the nurse is preparing the morning dose of streptomycin. The lab test has not yet arrived to obtain the trough level, and the drug is now overdue to be given. What is the nurse's next best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

Image Description

Figure 3.13 Medications that inhibit protein synthesis: Diagram of a cell undergoing protein synthesis that describes the major classes of protein synthesis–inhibiting antibacterials. These include:

- Chloramphenicol, macrolides, and lincosamides, which:
  - Bind to the 50S ribosomal subunit
  - Prevent peptide bond formation
  - Stop protein synthesis
- Aminoglycosides, which:

    - Bind to the 30S ribosomal subunit
    - Impair proofreading, resulting in production of faulty proteins
- Tetracyclines, which:
    - Bind to the 30S ribosomal subunit
    - Block the binding of tRNAs, thereby inhibiting protein synthesis

[Return to Figure 3.13]

References

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12.13 Tetracyclines

Tetracyclines are broad-spectrum antibiotics that are bacteriostatic, subsequently inhibiting bacterial growth. There are a number of meds in this class, with a few common meds are doxycycline, tetracycline and minocycline. The common suffix '-cycline'.

Indications for Use:

Tetracycline medications are useful for the treatment of many gram-positive and gram-negative infections, yet are limited due to the significance of side effects experienced by many clients. They are used for treating a wide variety of infections including skin conditions such as acne, sexually transmitted infections (chlamydia, syphilis), H. Pylori and Lyme disease.

Mechanism of Action:

Tetracyclines are bacteriostatic. They work by penetrating the bacterial cell wall and binding to the 30S ribosome, inhibiting the protein synthesis (Werth, 2024).

Nursing Considerations:

Administration: well-absorbed after oral dosing. Take with plenty of water and on an empty stomach. Do not take with dairy foods, antacids, calcium containing foods, vitamin or mineral supplements, as tetracycline absorption will be decreased by the metallic cations (aluminum, calcium, magnesium, iron) (Werth, 2024). For bedtime

doses, take one hour before bed and sit upright to avoid esophageal irritation.

IV route available for minocycline, twice a day dosing.

The dosing for each type of tetracycline differ widely, due to different absorption and distribution.

Tetracyclines are contraindicated in later term pregnancy and for children ages 8 and under. This is due to the permanent staining of teeth. Short term use (less than 21 days) of doxycycline in children has been shown to not cause tooth discoloration.

Lactation: Small amounts may be excreted in breast milk.

Caution if renal impairment, dose adjustments need to be made.

Drug interactions:

There are numerous drug interactions with tetracyclines. These include:

- warfarin effects may be increased. Closer monitoring of INR should be ordered.
- oral contraceptives that contain estrogen: effectiveness will be decreased. Have a back up method in place.
- meds that decrease effectiveness of tetracyclines include bile acid sequestrants (cholestyramine), antacids, sucralfate, barbiturates and phenytoin. Compounds that include calcium, magnesium, iron, zinc, aluminum can also form insoluble compounds and decrease tetracycline's effectiveness (Vallerand & Sanoski, 2024).

Adverse/ Side Effects:

All oral tetracyclines cause nausea, vomiting, and diarrhea. Monitor

diarrhea and report any significant changes with bowel movements and if diarrhea contains blood or pus.

Other adverse effects include:

- Oral candida superinfections and esophageal erosions can occur so ensure to take with plenty of water.
- Discolouration of developing teeth and enamel hypoplasia in children under 8. Abnormal bone growth may also occur.
- Photosensitivity may manifest as an exaggerated sunburn.
- Fatty liver, rare effect
- Vestibular dysfunction (with minocycline)

(Werth, 2024; Vallerand & Sanoski, 2024)

Client Teaching:

- Take the med as prescribed. Do not stop taking the med even if feeling better.
- Take with a large glass of water.
- Take on an empty stomach and especially avoid taking the med with food that contain dairy, calcium or iron.
- Numerous med interactions, so avoid taking the med with other drugs.
- Take one hour before bedtime and stay upright to avoid esophageal irritation.
- Avoid direct sunlight exposure and wear sunscreen to prevent skin sensitivities.
- Clients who are on oral contraceptives should be educated that tetracyclines may impede the effectiveness of the oral contraceptive and an alternative measure of birth control should be utilized while on the antibiotic.
- Female clients must be aware to immediately stop tetracycline if they become pregnant. Expired tetracycline should be

immediately disposed of as it can become toxic.
- Expired tetracycline pills can degenerate and, if ingested, cause Fanconi syndrome (defect in renal proximal tubular reabsorption). Patients should be instructed to discard the antibiotics when they expire.
- Report any hypersensitivity reactions such as a rash, hives, swelling. Report any change in bowel patterns such as diarrhea.

(Werth, 2024; Vallerand & Sanoski, 2024)

Tetracycline Medication Card

Now let's take a closer look at the medication card for tetracycline.[12] Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

To help with comparing the medications and to learn important considerations for each medication, refer to the Chapter 12 Antimicrobials Medication Cards.

Medication Card: Tetracyclines

1. [3]
2. [4]
3. [4]
4. [5]

Prototypes: tetracycline

Mechanism: Bacteriostatic. Broad-spectrum for both gram-positive and gram-negative

Indications

- Used for skin, urinary and respiratory infections.
- Skin infections, acne
- STI: Chlamydia
- Pneumonia
- UTI
- Cholera, Mycoplasma

Administration

- well-absorbed orally
- Effectiveness is reduced when drug is given with milk or other dairy products, antacids, or iron products
- For best drug absorption, give drug with a full glass of water on an empty stomach at least 1 hour before or 2 hours after meals
- Give drug at least 1 hour before bedtime to prevent esophageal irritation or ulceration
- ½ life: 12-24hrs
- Use caution with renal or hepatic impairment
- Avoid using in children younger than age 8 because drug may cause permanent discoloration of teeth, enamel defects, and bone growth retardation
- Avoid in pregnancy due to toxic effects on the developing fetus (often related to retardation of

skeletal development and teeth)

Side Effects

- GI: diarrhea, N/V, dysphagia, C-diff, Oral candidiasis
- GU: Yeast infection
- CNS: intra-cranial hypertension. Monitor for headache, blurred vision, diplopia, and vision loss
- Photosensitivity

Contraindications

- Use cautiously if pregnant or breastfeeding; weight benefit vs risk
- Kids<8yrs – will cause permanent teeth discoloration, enamel defects and bone growth retardation.
- Avoid with Calcium, Mg, iron (will ↓effectiveness of tetracycline)
- Drug interactions: Anticoagulants, Oral contraceptives (will decrease effectiveness of OCs), Bactericidal antibiotics

Nursing Considerations

- Monitor for systemic signs of infection: elevated WBC, fever, culture results.
- Monitor site of infection for improvement
- Administration: for best absorption, take med 1 hr before meal OR 2 hr after meal, take least 4 hr after antacids. not to be taken w, food ESP dairy.
- ↓effectiveness of birth control – back up method

- Harmful after expiry date
- Assess: secondary infections (ie. Thrush, C. Diff)

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

1. The nurse is providing medication teaching to a parent of a six-year-old child with strep throat in a clinic setting. Due to multiple drug allergies, tetracycline was prescribed by a doctor who is new to the clinic. What is the nurse's best response and why?

2. A 18-year-old female presents to the clinic with moderate acne. The healthcare provider prescribes Tetracycline 500 mg orally twice daily. During the nursing assessment, the patient reports:

- She drinks milk with every meal
- She spends a lot of time outdoors tanning
- She is currently taking oral contraceptives

What important teaching should the nurse provide about taking tetracycline?

a. What interaction between tetracycline and the patient's diet is concerning?

b. What side effect related to sun exposure should the nurse warn about?

c. What is the concern with oral contraceptive use while taking tetracycline?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.14 Glycopeptides

Vancomycin is a tricyclic glycopeptide antibiotic commonly used to treat MRSA.

Indications for Use:

Vancomycin is a popular glycopeptide that is active against gram-positive bacteria. Vancomycin is commonly used to treat serious or severe infections when other antibiotics are ineffective or contraindicated, including those caused by MRSA. It is useful with staph infections including endocarditis, meningitis, osteomyelitis and septicemia. Oral vancomycin is used to treat antibiotic-associated clostridium difficile (C-diff).

Mechanism of Action:

Glycopeptides are a class of medications that bind to the bacterial cell wall, inhibiting bacterial cell wall synthesis.

Nursing Considerations:

Administration: Can be given IV or oral. It is poorly absorbed in the GI tract, so it is only given orally for intestinal infections.

IV route is the preferred route for systemic infections.

IV: risk of phlebitis. Monitor IV site closely and rotate IV sites. May cause severe pain and necrosis in vein.

High alert med: Vancomycin poses a significant risk to kidney function and hearing; therefore, clients' trough levels must be monitored carefully for effective IV dosing to avoid complications. Reduced renal function can cause vancomycin to accumulate in the body, thereby increasing the risk of adverse effects.

Pregnancy: Do not use during pregnancy unless benefits outweigh the risk. Vancomycin crosses the placenta and can cause fetal ototoxicity and nephrotoxicity.

Adverse/Side Effects

Common side effects for oral dosing include nausea, vomiting, abdominal pain, and diarrhea. Dysgeusia, or a distorted sense of taste, is another common adverse reaction unique to oral vancomycin administration.

Potential side effects for IV dosing include:

- Risk of "red man syndrome" with IV dosing. Results in flushing of the skin and a reddish rash on the upper body when the infusion is administered too rapidly.
- Phlebitis
- Hypotension, monitor BP during IV therapy
- Other effects include: drug fever, skin rash, eosinophilia, and reversible neutropenia.

Risk of nephrotoxicity: monitor serum creatinine levels, assess for pink or cloudy urine, decreased urine output, abdominal pain.

(Patel, Preuss & Bernice, 2024; Vallerand & Sanoski, 2024)

Client Teaching:

- Clients should be counselled to take medications as directed for the full course of antibacterial therapy.
- They should monitor for side effects such as hypersensitivity, tinnitus, hearing loss, and vertigo.
- Clients should promptly follow up with their healthcare provider if no improvement in symptoms is identified (UpToDate, 2021).

Vancomycin Medication Card

Now let's take a closer look at the medication card on vancomycin (Daily Med, 2019). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

To help with comparing the medications and to learn important considerations for each medication, refer to the Chapter 12 Antimicrobials Medication Cards

Medication Card: Glycopeptide

Prototypes: Vancomycin

Mechanism of Action: Bind to bacterial cell wall, inhibiting cell wall synthesis.

Indications

- Generally only used for serious staphylococcal

infections: MRSA

- Effective against Gram + organisms.
- C-diff (pseudomembranous colitis)
- Bone and blood infections

Administration

- IV only (except for C. diff, PO)
- SE can be minimized if infusion rate is slowed
- IV should be administered in a diluted solution over a period of 60 minutes or more to avoid rapid-infusion-related reactions
- Narrow therapeutic range, monitor trough levels.

Side Effects

- Nausea, hypotension
- Ototoxicity, nephrotoxicity
- Neutropenia
- Blood disorders
- "Red man syndrome": Flushing, redness, itchiness upper trunk, face, head

Nursing Considerations:

Dosage adjustment is required for renal impairment

Maintain hydration

Monitor urine output

Narrow therapeutic range. Monitor trough levels

Contraindications/ Caution

Cautious use with:

- drug interactions with aminoglycosides, cyclosporine and NSAIDs – can increase risk of nephrotoxicity
- risk of ototoxicity especially is given with loop diuretics
- Kidney dysfunction; close monitoring and lower dosages
- Neonates and older adult; risk vs benefit

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

1. A nurse is caring for a client who was prescribed vancomycin IV for a MRSA infection. The dose of medication is due now, but a trough level is not yet available in the chart. What is the nurse's next best response?

2. A client is on an oral dose of Vancomycin for pseudomembranous colitis caused by Clostridium difficile. What lab results and assessments should the nurse be carefully monitoring?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.15 Antivirals

Photos of viruses. The first photo shows members of the Coronavirus family. The second photo shows the Ebolavirus, a member of the Filovirus family.

Figure 12.15a Images of viruses (a) Members of the Coronavirus family can cause respiratory infections like the common cold, severe acute respiratory syndrome (SARS), and Middle East respiratory syndrome (MERS). Here they are viewed under a transmission electron microscope (TEM). (b) Ebolavirus, a member of the Filovirus family. (credit a: modification of work by Centers for Disease Control and Prevention; credit b: modification of work by Thomas W. Geisbert)

Unlike the complex structure of fungi or protozoa, viral structure is simple. There are several subclasses of antiviral medications: antiherpes, antiinfluenza, anti-hepatitis, and antiretrovirals. Each subclass will be discussed in more detail below. See Figure 12.15a[1] for images of viruses.

Subclass: Antiherpes

Indications for Use: Acyclovir (Zovirax) and its derivatives are frequently used for the treatment of herpes and varicella virus infections, including genital herpes, chickenpox and shingles.

Mechanism of Action: Acyclovir causes termination of the DNA chain during the viral replication process. Acyclovir can be administered either topically or systemically, depending on the infection.[3]

Special Administration Considerations: Acyclovir use may result in nephrotoxicity.

Client Teaching & Education: Clients who are being treated with antiviral therapy should be instructed about the importance of medication compliance. They may also experience significant fatigue, so periods of rest should be encouraged.[5]

1. [2]
2. [1]
3. [4]
4. [2]
5. [6]
6. [3]

Subclass: AntiInfluenza

Indications for Use: Tamiflu (oseltamivir) is used to target the influenza virus by blocking the release of the virus from the infected cells.

Mechanism of Action: Tamiflu prevents the release of virus from infected cells. It is a neuraminidase inhibitor against influenza A and B.

Special Administration Considerations: This medication does not cure influenza, but can decrease flu symptoms and shorten the duration of illness if taken in a timely manner. Clients are prescribed the medication for prophylaxis against infection, known exposure, or to lesson the course of the illness. If clients experience flu-like symptoms, it is critical that they start treatment within 48 hours of symptom onset.

Client Teaching & Education: Clients who are being treated with antiviral therapy should be instructed about the importance of medication compliance. They may also experience significant fatigue, so periods of rest should be encouraged.[7]

The influenza virus is one of the few RNA viruses that replicates in the nucleus of cells. Antivirals block the release stage. See Figure 12.15b.[9]

Illustration of Influenza virus attaching to target cell and replication within nucleus of cells.

Figure 12.15b Influenza virus replication stages

7. [8]
8. [4]
9. [10]
10. [5]

Subclass: Antiretrovirals

Viruses with complex life cycles, such as HIV, can be more difficult to treat. These types of viruses require the use of antiretroviral medications that block viral replication. (See Figure 3.12 to view the viral replication process of HIV.)[11] Additionally, antiretrovirals fall under the class of antiviral medications.

Illustration with labels showing HIV attached to cell surface receptor

Figure 12.14c HIV attaches to a cell surface receptor of an immune cell and fuses with the cell membrane. Viral contents are released into the cell, where viral enzymes convert the single-stranded RNA genome into DNA and incorporate it into the host genome

Indications for Use: Antiretrovirals are used for the treatment of illnesses like HIV.

Mechanism of Action: Antiretrovirals impede virus replication.

Special Administration Considerations: Many antiretrovirals may impact renal function; therefore, the client's urine output and renal labs should be monitored carefully for signs of decreased function.

Client Teaching & Education: Clients who are being treated with antiviral therapy should be instructed about the importance of antiretroviral compliance. They may also experience significant fatigue, so periods of rest should be encouraged.[13]

11. [12]
12. [6]
13. [14]
14. [7]

Antiviral Medication Cards

Now let's take a closer look at the medication cards for the subclasses of antivirals.[15][16][17][18][19] Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

To support your learning, you can access the Chapter 12 Antimicrobials Medication Cards This is a downloadable and editable document to allow you to update and add content.

Medication Card: Antivirals/ Anti-herpes

Subclass: Antiherpes

15. [20]
16. [21]
17. [22]
18. [23]
19. [24]
20. [8]
21. [9]
22. [10]
23. [11]
24. [12]

Prototypes: acyclovir

Mechanism: Disrupts the DNA chain during viral replication.

Indications:

- Acyclovir is frequently used for the treatment of herpes and varicella virus infections, including genital herpes, chickenpox, and shingles.
- Acyclovir is not a cure for herpes but improves signs and symptoms of herpes lesions if started early. It reduces the viral shedding and decreases the severity of symptoms.
- Can be used long term for prevention of outbreaks

Administration

- Route: PO, IV, or topical; do not give IM or subcutaneously (subcutaneously)
    - Give with food if GI distress
- IV: Give IV infusion over at least 1 hour to prevent renal tubular damage
- Use cautiously if renal impairment, neurological problems, or dehydration
- Start therapy as early as possible after signs or symptoms occur
- Encourage fluid intake
- Check for allergies

Side Effects

- GI distress: nausea, diarrhea. Headache

- Monitor renal function in long-term use, especially if renal impairment

Nursing Considerations

- Discuss importance of medication compliance
- Monitor for significant fatigue
- Avoid sexual contact while lesions present

Medication Card: Antivirals

Sub-Class: Anti-influenza Agents

Prototype: Oseltamivir (Tamiflu)

Mechanism: Prevents release of virus from infected cells. This results in a reduction in the duration of the flu symptoms.

Indications: Oseltamivir is used to target the influenza virus by blocking the release of the virus from the infected cells.

Administration

- Check for allergies
- Route: PO
- Must be given within 48 hours of onset of

symptoms
- Administer with food to avoid GI distress

Side Effects

- GI distress
- Serious skin/ hypersensitivity reactions; discontinue immediately
- Monitor for neuropsychiatric symptoms
- Use cautiously in patients with renal failure, chronic cardiac or respiratory diseases, or any medical condition that may require imminent hospitalization

Nursing Considerations:

- Does not replace need for annual influenza vaccination
- Monitor for symptoms of the flu

Medication card: Antivirals

Sub Class: Anti-hepatitis agents

Prototype: Adefovir

Mechanism of Action: A nucleotide analog that blocks the enzyme reverse transcriptase, which the hepatitis B virus needs to replicate, reducing the overall viral load.

Indications: Second-line treatment for chronic hepatitis B, if other drug options are not effective.

Administration:

- Route: PO, once a day. Take with or without food.
- Prolonged therapy (>1 year or indefinitely) based on patient status
- Offer HIV testing; may promote resistance to antiretrovirals in patients with chronic HBV infection who also have unrecognized or untreated HIV infection

Side Effects

- Potential side effects include headache, abdominal pain, weakness, nausea, and diarrhea.
- Risk of nephrotoxicity
- Lactic acidosis
- Severe hepatomegally

Nursing Considerations:

- Do not stop taking medication unless directed.
- Monitor hepatic function several months after stopping therapy

Medication Card: Antivirals

Sub Class: Anti-retrovirals

Prototype: Lamivudine- zidovudine

Mechanism of Action: Lamivudine and zidovudine tablet, a combination of 2 nucleoside analogue reverse transcriptase inhibitors, is indicated in combination with other antiretroviral agents for the treatment of HIV-1 infection.

Indications:

- Antiretrovirals are used for the treatment of illnesses like HIV. Decreases chance of developing acquired immunodeficiency syndrome (AIDS) and HIV-related illnesses such as serious infections or cancer
- Lamivudine used to treat HIV-1 infection contains a higher dose of the active ingredient than the lamivudine used to treat chronic HBV infection. Patients with HIV-1 infection should receive only dosing forms appropriate for HIV-1 treatment

Administration:

- Oral dosing typically, IV
- Use cautiously in patients with renal or hepatic impairment

Side Effects

- Common side effects include nausea, diarrhea, headache, malaise and fatigue.
- Lactic acidosis
- Severe hepatomegaly
- Risk of pancreatitis: stop treatment immediately if symptoms develop.
- Risk of anemia and/or neutropenia for those with advanced disease.

Nursing Considerations

- Inform patient that drug doesn't cure HIV infection, that opportunistic infections and other complications of HIV infection may still occur, and that transmission of HIV to others through sexual contact or blood contamination is still possible.
- Taking these medications, along with practicing safer sex and making other lifestyle changes, may decrease the risk of transmitting (spreading) the HIV or hepatitis B virus to other people.
- Teach symptoms of pancreatitis
- Prolonged use of this med may cause myopathy.

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

A client is prescribed oseltamivir (Tamiflu) for influenza symptoms. The client states to the nurse, "I hope this medication works quickly! I have felt lousy for the past 5 days!" What is the nurse's next best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.16 Antifungals

Photomicrograph of the fungus Candida albicans, with nucleus labeled.

Figure 12.16 Candida albicans is a unicellular fungus, or yeast. It is the causative agent of vaginal yeast infections as well as oral thrush, a yeast infection of the mouth that commonly afflicts infants. [1]

Fungi are important to humans in a variety of ways. Both microscopic and macroscopic fungi have medical relevance, but some pathogenic species that can cause **mycoses** (illnesses caused by fungi). See Figure 12.16 for a microscopic image of candida albicans that is the causative agent of yeast infections. Some pathogenic fungi are opportunistic, meaning that they mainly cause infections when the host's immune defenses are compromised and do not normally cause illness in healthy individuals. Fungi are important in other ways. They act as decomposers in the environment, and they are critical for the production of certain foods such as cheeses. Fungi are also major sources of antibiotics, such as penicillin from the fungus *Penicillium*.[3].

Indications:

Imidazole's are synthetic antifungals commonly used in medical applications and also in agriculture to keep seeds and harvested crops from molding. Examples include miconazole, ketoconazole, and clotrimazole, which are used to treat fungal skin infections such

1. [2]
2. [1]
3. [4]
4. [2]

as ringworm, specifically tinea pedis (athlete's foot), tinea cruris (jock itch), and tinea corporis.

Triazole drugs, including fluconazole, can be administered orally or intravenously for the treatment of several types of systemic yeast infections, including oral thrush and cryptococcal meningitis, both of which are prevalent in clients with AIDS. Triazoles also exhibit more selective toxicity, compared with the imidazole, and are associated with fewer side effects.[5]

Allylamines, a structurally different class of synthetic antifungal drugs, are most commonly used topically for the treatment of dermatophytic skin infections like athlete's foot, ringworm, and jock itch. Oral treatment with terbinafine is also used for fingernail and toenail fungus, but it can be associated with the rare side effect of hepatotoxicity.[7]

Polyenes are a class of antifungal agents naturally produced by certain actinomycete soil bacteria and are structurally related to macrolides. Common examples include nystatin and amphotericin B. Nystatin is typically used as a topical treatment for yeast infections of the skin, mouth, and vagina, but may also be used for intestinal fungal infections. The drug amphotericin B is used for systemic fungal infections like aspergillosis, cryptococcal meningitis, histoplasmosis, blastomycosis, and candidiasis. Amphotericin B was the only antifungal drug available for several decades, but its use has associated serious side effects, including nephrotoxicity.[9]

Mechanism of Action: Antifungal agents exhibit distinct mechanism of action. Some antifungals (Azoles, allylamines) disrupt

5. [6]
6. [3]
7. [8]
8. [4]
9. [10]
10. [5]

ergosterol biosynthesis of the cell membrane increasing cellular permeability and causing cell lysis. Other antifungals inhibit nucleic acid synthesis, resulting in cell membrane stress, impaired growth or cell death. Polyenes act by binding to ergosterol, creating pores in the cell membrane that lead to cell lysis (Bennett, 2025).

Special Administration Considerations: Administration guidelines will vary depending on the type of fungal infection being treated. It is important to monitor response of the affected area and examine class-specific administration considerations to monitor client response.

Client Teaching: The client should be advised to follow dosage instructions carefully and finish the drug completely, even if they feel their symptoms have resolved. The client should report any skin rash, abdominal pain, fever, or diarrhea to the provider. The client should monitor carefully for unexplained dark urine, jaundice and fatigue, which may be a sign of liver dysfunction.[11]

Antifungal Medication Card

Now let's take a closer look at the medication card for various antifungals.[131415161718]

11. [12]
12. [6]
13. [19]
14. [20]
15. [21]
16. [22]
17. [23]
18. [24]

To support your learning, you can access the Chapter 12 Antimicrobials Medication Cards. This is a downloadable and editable document to allow you to update and add content. In clinical practice, consult a current drug manual and agency policy for up-to-date information.

Medication Card: Antifungals

Indications

- Clotrimazole
  - fungal skin infections
  - athlete's foot (tinea pedis)
  - jock itch (tinea cruris), or
- Flucanazole
  - yeast infections
- Terbinafine
  - most commonly used topically for the treatment of dermatophytic skin infections, such as athlete's foot (tinea pedis), jock itch

19. [7]
20. [8]
21. [9]
22. [10]
23. [11]
24. [12]

(tinea cruris), or ringworm.

- Nystatin
    - typically used as a topical treatment for yeast infections of the skin, mouth, and vagina, but may also be used for intestinal fungal infections
- Amphotericin B
    - for systemic fungal infections like aspergillosis, cryptococcal meningitis, histoplasmosis, blastomycosis, and candidiasis

Administration

- Clotrimazole
    - Topical cream: apply liberally twice daily to affected area
- Fluconazole
    - Route: PO/IV
    - Single or multiple doses
    - Caution if liver dysfunction
- Terbinafine
    - Cream or aerosol
    - Wash affected area with soap and water and allow to dry completely before applying
- Nystatin

- PO: If order is "'swish and swallow," instruct client to hold medication in mouth for several minutes before swallowing
- Topical cream/powder: apply liberally twice daily

- Amphotericin B
  - Route: IV
  - Reconstitute and dilute as directed on packaging
  - Administer slowly over several hours initially and monitor VS every 30 minutes; may require premedication
  - Therapy may take several months
  - Alert: Different amphotericin B preparations aren't interchangeable
  - Caution if renal impairment

Side Effects

- Clotrimazole
  - topical-skin irritation
  - rash
- Flucanazole
  - hepatotoxicity
- Terbinafine
  - hepatotoxicity
- Amphotericin B

- nephrotoxicity

- hypokalemia
  - may be ototoxic

Amphotericin B: Therapeutic Effects and Nursing Considerations

- Monitor fluid intake and output; report change in urine appearance or volume
- Monitor BUN and creatinine levels two or three times weekly. Kidney damage may be reversible if drug is stopped at first sign of renal dysfunction
- Hydrate client before infusion to reduce risk of nephrotoxicity
- liver function tests once or twice weekly
- Monitor potassium level closely and report signs of hypokalemia

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

A client has been admitted two weeks ago to a hospital. They developed a fungal infection in the perineal area, and have been ordered nystatin. The nurses have been applying

the ointment to the groin folds twice daily for several weeks, but there is no sign of improvement. What is the nurse's best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.17 Antimalarials

Malaria is a prevalent protozoal disease impacting individuals across the world. Malaria is a disease caused by a parasite. The parasite is spread to humans through the bites of infected mosquitoes. Other modes of transmission include mother to unborn fetus, blood transfusions and sharing of needles (Mayo Clinic, 2023). Worldwide, malaria infections in tropical or sub-tropical areas number 290 million cases, with approximately 400,000 deaths per year. In Canada, malaria infections are approximately 480 cases per year (Government of Canada, 2026).

Once bitten by an infected mosquito it may take up to two weeks for symptoms to appear. For certain species (e.g., *Plasmodium vivax/ovale*) the infection remains dormant for up to a year. Symptoms include a high fever and chills, and may also have headache, and diarrhea. If left untreated, the symptoms can be cyclical and the client will experience a 'malaria attack', with feeling well to symptomatic (Mayo Clinic, 2023).

Prevention is the best defense. Obtaining an anti-malarial prescription prior to travelling is important. Some meds begin a week prior to travel and continue for a week after returning home. Other prevention includes using DEET products, wearing light clothing and using a mosquito net for sleeping. For more information of prevention strategies, go to Health Link BC: Malaria prevention | HealthLink BC

Indications for Use:

Antimalarials are used for the prevention or treatment of malaria. There are a number of anti-malarial medications, with some prescribed for malaria that is resistant to other meds. Medication

options include atovaquone/proguanil (Malarone), doxycycline, mefloquine, and chloroquine. All the med options have the risk of adverse effects and must be used as prescribed. All require a prescription.

Our prototype med will be atovaquone/proguanil (ATQ-PG). It is first line therapy and most often the med prescribed in Canada. It is well-tolerated due to minimal adverse effects so adherence if higher than with other meds.

Mechanism of Action:

Antimalarial agents work by targeting specific intracellular processes that impact cell development (Achieng, et al., 2019).

Nursing Considerations:

Antimalarial agents are safe to use for all age groups. Most medications need to be started prior to travel and continue for one week after arriving home.

ATQ-PG: (example of dosing, dependent of region)

- take one tablet orally, 1–2 days before entering a malaria-endemic area. Take one tablet at the same time each day for the duration of the stay in the endemic area, and continue for 7 days after leaving the endemic area.
- Take with food or milk to increase absorption and efficacy and to decrease GI effects (Stiyka & Savitz, 2020).

Dose adjustments are not needed for liver dysfunction. Renal dysfunction (creatinine clearance < 30mL/min) is contraindicated.

Contraindicated if hypersensitivity reactions such a anaphylaxis,

angioedema, or Stevens-Johnson syndrome to atovaquone or proguanil HCL.

Drug Interactions:

- Rifampin will reduce the effectiveness of ATQ-PG.
- Anti-coagulants: warfarin used with ATQ-PG will lead to increased anticoagulant effects. Monitor INR closely.
- Use of tetracycline concurrently can lead to decreased ATQ-PG effects.

Adverse/ Side Effects:

Common side effects include fever, chills, nausea, vomiting, abdominal pain, headache and stomatitis. Most are not severe enough to warrant discontinuation of the drug (Stiyka & Savitz, 2020).

Rare adverse effects include seizures, rash, mouth ulcers and hepatitis.

Client Teaching:

- Clients should receive instruction to take medication as prescribed and adhere to the full prescription regimen.
- Clients should minimize additional exposure to mosquitoes using preventative means such as repellents, protective clothing, netting, etc.

Chloroquine Medication Card

Now let's take a closer look at the medication card on chloroquine (Daily Med, 2019;UpToDate, 2021). Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Go to the Chapter 12 Antimicrobials Medication Cards

Clinical Reasoning and Decision Making Activity

Using the above information, consider the following clinical scenario question:

A nurse is providing medication teaching to a client who is planning on visiting a country with high rates of malaria to do mission work. The client states, "I'm glad I only have to take this medication for a week. I am terrible at remembering to take any pills." What is the nurse's best response regarding the length of therapy?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition section at the end of the book.

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12.18 Antiprotozoals

Figure 12.18 Giardia lamblia

Antiprotozoal drugs target infectious protozoans such as Giardia, an intestinal protozoan parasite that infects humans and other mammals, causing severe diarrhea (see Figure 12.18 for a microscopic image of Giardia). [1]

Indications:

Metronidazole is an example of an antiprotozoal antibacterial medication that is commonly used to treat a range of infections that effect the reproductive system, gastrointestinal (GI) tract, skin, heart, bone, joint, lung, blood, nervous system, and other areas of the body. It is used for conditions such as acne rosacea, bacterial vaginosis, or trichomonas. Metronidazole oral is used to treat protozoal GI infections such as Giardia and also serious anaerobic bacterial infections such as Clostridium difficile (C. diff) (MedLine Plus, 2023).

1. [2]
2. [1]

Mechanism of action:

Many antiprotozoal agents work to disrupt DNA synthesis in anaerobic organisms and protozoa (not folic acid synthesis)

Nursing Considerations:

It can be administered PO, parenterally, or topically. Orally is the preferred route for GI infections. Do not crush or chew extended release tablets. Take with food to avoid GI upset.

Drug Interactions:

- Alcohol: Causes severe vomiting/nausea and disulfiram-like effects (Physical reaction that includes intense facial flushing, throbbing headache, nausea, vomiting, tachycardia, and hypotension).
- Warfarin: Increases the risk of bleeding.
- Other meds: Lithium, phenytoin, and busulfan

Common side effects include nausea and vomiting, headache, dizziness, diarrhea or constipation. It may cause a metallic taste in the mouth.

Adverse effects such as seizures, peripheral neuropathies, and dizziness may occur.

Client Teaching:

- Discuss with the client the need to take the med as prescribed.
- Inform the client that the medication may cause dizziness, dry mouth, nausea and headache. Additionally, the medication may cause darkening of the urine.
- Discuss good oral hygiene to minimize a metallic taste in the mouth.
- Avoid alcoholic beverages during medication therapy to

prevent a disulfiram-like reaction.

- If clients are being treated for protozoal infections such as trichomoniasis, they should be advised that sexual partners might be sources of reinfection even if asymptomatic. Partners should also receive treatment.[3]

Using the above information, consider the following clinical scenario question:

A 58 year old client develops C-diff after taking multiple antibiotics for a non-healing wound. They are prescribed metronidazole. What would be important health teaching with this med.

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition sections at the end of the book.

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12.19 Anthelmintic

Helminths consist of a diverse group of parasitic worms including nematodes (round worms), trematodes (flatworms or platyhelminths) and cestodes (tapeworms). GI helminth infections are the most common and are caused by pinworms, hookworms or ascaris. Schistosomes reside in the blood stream and are the most common trematode infection. Some trematodes reside in the GI tract, biliary tract or lungs.

See Figure 12.18 for images of a tapeworm and a guinea worm.[1] Of the many species that exist in these groups, about half are parasitic and some are important human pathogens.

Indications:

Anthelmintic medications target parasitic helminths.[3] There are many drugs in this class including: albendazole, thiabendazole, mebendazole, ivermectin, praziquantel, diethylcarbamazine, pyrantel pamoate.

1. [2]
2. [1]
3. [4]
4. [2]

Mechanism of Action:

Because helminths are multicellular eukaryotes like humans, developing drugs with selective toxicity against them is extremely challenging. Despite this, several effective classes have been developed. Many anthelmintic medications work by preventing microtubule formation within the parasitic cell, compromising glucose uptake. Others work by blocking neuronal transmission within the parasite, subsequently causing starvation, paralysis, and death of the worms. Additionally, many anthelmints inhibit ATP formation and impair calcium uptake inducing paralysis and death of the worms.[5]

Nursing Considerations:

Anti-helminth medications have varying dosages and duration of action. Many are taken orally, and usually require 1-2 doses or doses over 1-3 days, although this varies depending on the medication and pathogen. Many of the medications cause paralysis of the parasite which is then expelled.

Prolonged therapy using anthelmintic medication can result in liver damage and bone marrow suppression.

Client Teaching:

- Clients on antihelmintic drug therapy should receive special

5. [6]
6. [3]

instruction to ensure rigorous hygienic precautions to minimize the risk of reinfection.

- Wash all bedding, linens, towels, and clothing following treatment to minimize reinfection risk.[7]

Photo of tapeworm. Second photo shows removal of tapeworm.

Figure 12.18 A) The tapeworm Taenia saginata, that infects both cattle and humans. Eggs are microscopic, but the adult tapeworm like the one show here can reach 4–10 meters, taking up residence in the digestive system. B) An adult guinea worm, Dracunculus medinensis, is removed through a lesion in the patient's skin by winding it around a matchstick

7. [8]
8. [4]

Clinical Reasoning and Decision-Making Activity

Using the above information, consider the following clinical scenario question:

A mother reports that her four-year-old son had a worm in his stool this morning. They live on a dairy farm. She reports that her son enjoys being in the barn during chore time, and it is common for the livestock to develop "worms." Mebendazole was prescribed. What client teaching should the nurse provide to the child and the mother?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition sections at the end of the book.

References

1. This work is a derivative of "Taenia saginata adult 5260 lores.jpg" and "Dracunculus medinensis.jpg" by Centers for Disease Control and Prevention is licensed under CC0 ↵
2. This work is a derivative of Microbiology by OpenStax licensed under CC BY 4.0. Access for free at https://openstax.org/books/microbiology/pages/1-introduction ↵
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12.20 Antituberculars

Mycobacterium tuberculosis is the causative agent of tuberculosis (TB), a disease that primarily impacts the lungs but can infect other parts of the body as well. It has been estimated that one third of the world's population has been infected with M. tuberculosis and millions of new infections occur each year. Treatment of M. tuberculosis is challenging and requires clients to take a combination of drugs for an extended time. Complicating treatment even further is the development and spread of multidrug-resistant strains of this pathogen. [1]

Indications for Use:

Antitubercular medications are selective for mycobacteria. Isoniazid inhibits mycolic acid synthesis, rifampin inhibits RNA synthesis.

Mechanism of Action:

Antitubercular medications work by inhibiting the synthesis or transcription of mycobacteria RNA or inhibiting the synthesis of mycolic acids in the cellular wall. Mycobacteria can develop resistance to antitubercular medications; therefore, strict compliance to drug regimen must be emphasized.

1. [2]
2. [1]

Nursing Considerations:

Antitubercular medications require at least six months of treatment. If the pathogen is drug-sensitive TB, treatment is approximately 6 months. For resistant TB, a longer course of treatment is likely. Many antitubercular medications may impact liver function, and liver enzymes should be monitored carefully. Other side effects to medication administration include GI symptoms, peripheral neuropathy, and vision changes.[3]

Client Teaching:

- Advise clients that medications must be taken as directed.
- It is important that clients understand the significance of continuing drug therapy even after symptoms have resolved to prevent the spread of disease. Drug therapy may be continued for six months to two years.
- If a client notices any change in visual acuity or eye discomfort, it should be reported immediately to the healthcare provider.
- If on Isoniazid, clients should be advised to avoid alcohol during antitubercular therapy because of the increased risk of liver toxicity. Foods containing tyramine such as tuna and Swiss cheese should be avoided.[5]

3. [4]
4. [3]
5. [6]
6. [4]

Critical Reasoning and Decision making activity

Using the above information, consider the following clinical scenario question:

A client has been prescribed isoniazid as part of a multi-drug regimen for resistant TB. Direct observed therapy (DOT) has been initiated. The client asks the nurse, "What does 'direct observed therapy' mean?" What is the nurse's best response?

Note: Answers to the Clinical Reasoning Activities and Critical Thinking questions can be found in the Chapter 12: Antimicrobial Medications answer key – Fundamentals of Nursing Pharmacology – 2nd Canadian Edition sections at the end of the book.

References

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12.21 Clinical Reasoning and Decision-Making Learning Activities

Now that you've learned all about antimicrobials, practice applying your knowledge with the following activities.

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://fundamentals-nursing-pharmacology-2e-ca.pressbooks.tru.ca/?p=4043#h5p-121

LEARNING ACTIVITY ANSWER KEYS

Chapter 1 Introduction to Pharmacology Answer Key

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

1.3 Pharmacokinetics – absorption

1. The rectal route may be a good option for clients who have other health issues such as nausea, vomiting, confusion, sedation, or NPO. PR has less of an impact on the bioavailability of the drug and has a faster onset of action, shorter duration and a shorter peak effect.

Oral route is more convenient and easy to administer, and less embarrassing for some clients. It is a good option if the client can swallow easily. But, oral route is subject to first-pass effect which will have a reduced bioavailability and a slower onset of action.

1. The IV route bypasses the first-pass effect which results in greater drug bioavailability. In addition, IV results in much quicker onset of action, shorter duration, and shorter peak effect. But, if an IV is not yet started, then this may delay giving the med and an IV can be painful to insert. IM route has a slower onset of action and a longer duration of action. It is a good option to achieve a more sustained pain control due to the slower absorption.

1.4 Pharmacokinetics – Distribution

1. Low serum albumin means there are fewer albumin molecules so there is less receptor sites on the albumin molecules for a drug to attach themselves. This leaves more free drug in the

bloodstream that can diffuse to the tissues and target site, leading to a greater drug effect.

2. Since it will be more bound to proteins in the blood, it will have a slower onset of action. If it is also water soluble, it will have less volume of distribution and more of the drug will stay in the blood and have a shorter duration of action. If the drug was lipid soluble and poorly bound to protein, it will more easily be taken up by the tissues and distributed throughout the body.

1.5 Pharmacokinetics – Metabolism

The biotransformations that take place in the liver are performed by the liver enzymes. Therefore, if the liver is damaged, metabolism and excretion are impacted, resulting in the need for lower dosages to avoid toxicity. Clients with cirrhosis requires strict medication management due to the liver's impaired ability to metabolize drugs, which increases the risk of toxicity, adverse drug reactions, and exacerbation of complications. Nurses should monitor blood work such as liver function tests (ALT, AST, Bilirubin), renal function and serum albumin levels. Physical assessment for all liver failure clients should include mental health status, fluid status, nutritional status and blood pressure.

1.6 Pharmacokinetics – Excretion

Kidney function is important because drugs and metabolites in the bloodstream are often filtered by the kidney. In the kidney tubules, a portion of the drug undergoes reabsorption back into the bloodstream, and the remainder is excreted in the urine.

1.7 Pharmacodynamics

Potency refers to the ability of a drug to produce its effect at low doses. It does not mean it will cause more adverse or toxic effects. A high potency drug will produce a strong effect at low doses. For example, fentanyl is considered a potent drug.

1.9 Monitoring for Effects

***Learning Activity* 1**

1. Nursing considerations when administering pain medication include efficacy, dose-response based on the dosage selected, onset, peak, duration, and half-life of the drug. The patient has physical therapy scheduled at 0900, so the nurse should administer acetaminophen now to relieve the pain and evaluate the effectiveness in 60 minutes. The nurse should also plan on reassessing the patient's pain and potentially administering a second dose of acetaminophen just prior to the physical therapy appointment because the half-life of acetaminophen is two to three hours. Additionally, acetaminophen has a 24-hour dose restriction, so the nurse should calculate how many total milligrams the patient has received over the past 24 hours prior to administering the medication.
2. Insulin is a high-alert medication due to severe side effects that can occur if administered incorrectly. The nurse should check the patient's blood sugar reading and consider withholding the medication if the patient continues to refuse food over the next few hours to avoid causing hypoglycemia. The provider may also need to be notified of the patient's change in condition and a change in the medication order may be required.

Learning Activity 2

Mr. Parker's gentamycin level is much higher than the therapeutic level of 5 to 10 mcg/mL. The nurse should inform the prescriber and anticipate the next dose being held, and subsequent dosages decreased. The med may also be substituted with a different med. The client will have repeat peak and trough levels done the following day to ensure they are within the therapeutic window. Gentamycin levels that are in the toxic range can cause nephrotoxicity and ototoxicity. Loss of hearing can be irreversible. The client will likely also have renal function blood work done to ensure there are no issues.

1.10 Critical Thinking and Decision-Making Activities

1. The nurse should select the rectal route due to the patient's difficulty swallowing to reduce the risk of aspiration.
2. The initial dose is less than the standard recommended dose based on Mr. Johnson's age and the likelihood that his kidney functioning is decreased. Decreased kidney function affects the metabolism and excretion of gentamycin and could result in toxicities if the dose is too high.
3. Sara should wait to administer the medication until the patient's trough level is drawn. The trough level is required for the provider and the pharmacist to determine if the medication is within the range of the therapeutic window and to avoid the risk of toxicity to the patient.
4. Sam should evaluate the patient's vital signs, specifically the apical pulse and blood pressure, to be sure they are within the normal range for this patient and the parameters prescribed by the provider. Atenolol has negative inotropic, chronotropic, and dromotropic effects. The negative inotropic effect weakens the contraction of the heart and lowers blood pressure. The negative chronotropic effect decreases the heart rate, and a negative dromotropic effect slows the conduction of the electrical charge in the heart. Understanding the effects of this Beta-1 antagonist medication allows Sam to anticipate the expected actions of the medication and the patient's response.
5. Amiodarone is metabolized by the enzymes in the intestines to its active form. Grapefruit juice contains compounds that slow down this process and affect the levels of this medication in the blood. The nurse should educate Julia about this interaction and encourage other beverage choices in the future that do not cause this interaction.
6. The nurse anticipates that oxycodone/acetaminophen will peak in approximately 1 hour. The patient will likely require another dose of medication for acute, severe pain that accompanies a knee replacement in approximately 4 hours.

Chapter 2 Medication Safety: professional and legal foundations Answer Key

Chapter 2 Clinical Reasoning and Decision-Making Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

2.2 Drug Regulation Process

Learning activity 1

The nurse should clarify the medication order with the provider before administration because pneumonia is not listed as an indication for levofloxacin in the Black Box Warning. Notification of the provider and the provider's response should be recorded in the patient's medical record.

Learning activity 2

1. The nurse should educate the patient that medications should never be shared with others. Sharing medications is not only illegal but also dangerous. The nurse should describe the dangers to the patient, including potential drug interactions, dietary interactions, loss of consciousness, or death if inappropriate drugs or dosages are used.
2. An impaired nurse may endanger the lives of their patients or harm themselves. It is a nurse's professional and ethical responsibility to report a colleague's suspected drug use to their nurse manager or supervisor and, in some states or jurisdictions, to the board of nursing.
3. The nurse can give the vaccines based on that they have done an assessment, obtained a consent from the client and used a decision support tool to determine if the vaccine is appropriate

for this client at this time.

Chapter 3 Medication Safety: preventing med errors Answer Key

Chapter 3 Clinical Reasoning and Decision-Making Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

3.3 Safe Medication Administration

Learning Activity 1

The nurse should provide verbal education regarding when to take medication, side effects to watch for, and potential adverse effects. The patient should also be educated on any restrictions related to diet, over-the-counter medications, and herbal supplements.

Learning activity 2

1. The 7 rights the nurse checks before administering any medication include right patient, right medication, right dose, right route, right time, right reason, and right documentation. Checking allergies and the expiration date of the medication are also included when checking the 7 rights.
2. Nurses confirm patient identification prior to administering medication by asking the patient their name and date of birth, checking the patient's identification band, and by scanning bar codes on the medication and patient's armband. In long-term care settings where patients don't wear armbands and may not be able to recall their name and date of birth, the nurse may

use alternative methods of identification, such as using a patient's picture in the medication record or asking another staff member to confirm the patient's identity.

3. Prior to the administration of morphine, an opioid medication, the nurse should assess the patient's pain level, level of consciousness, respiratory rate, and oxygenation status. If the patient exhibits a decreased respiratory rate, decreased oxygenation level, or an increased sedation, the medication should be withheld and appropriate interventions implemented.
4. After administering an opioid medication, the nurse should evaluate the effectiveness of the medication in treating the pain, as well as continuing to monitor respiratory rate, oxygenation level, and sedation status.
5. The nurse should teach the patient about common side effects, such as constipation and drowsiness.
6. The shift handoff report should include the location of the patient's pain, the reported pain level, pain medications administered during the shift, the time of medication administration, and the patient's response to the medication.

3.4 Health Literacy

The nurse should suggest the mother obtain an oral syringe from the pharmacist to ensure accurate measurement of the medication. Errors can occur when families use spoons in their homes to administer medication. Ensure the caregiver understands the instructions and explore if there are any barriers for the caregiver to go to the pharmacy.

3.8 Factors Affecting Medication Safety — Healthcare Provider, Systems, and Client Factors

In addition to verifying the 7 rights of medication administration, the nurse should confirm the blood glucose level, insulin type, concentration, and the date the insulin vial was opened. The nurse should draw up the dose and confirm correct dosing with another RN prior to administration. The nurse should be aware of onset,

peak, and duration of action and monitor for potential side effects such as hypoglycemia.

3.9 Medication Safety Across the Lifespans — Pediatrics

1. A. Always draw up the med with the syringe closest to the amount required to ensure accuracy.
2. 2.4 mL.

Desire 60 mg = 1 mL
Have 125 mg 5 mL
125x=300
X = 300/125 = 2.4 mL

3. The wasting of controlled substances should be done by two licensed staff. This can be done by RNs, LPNs or NPs. A care aid cannot perform this function.

3.11 Medication Safety in Transitions of Care

The nurse can use alternative sources of medication information when the patient cannot recall their home medication and it is not available in the electronic medical health records. In BC, prescribers have access to the client's Pharmanet, which supplies information about current medications the client is on. The Pharmanet profile should be printed and included in the client's chart. Another common intervention is to ask the patient to bring all of their medications to their appointment, including prescribed medications, over-the-counter medications, vitamins, and herbal supplements. Family members, such as a spouse or adult children, can also provide valid information with the patient's permission. After determining the patient's current medications, the nurse should print a copy of the list of medications and instruct the patient to bring it with them to all of the health care providers and update it as needed.

3.13 Clinical Reasoning and Decision-Making Learning Activities

1.a The social determinants of health (SDOH) are the conditions that can influence their overall health and well-being. These factors play a significant role in medication safety, especially in vulnerable populations like older adults, people from low-income backgrounds, and those with limited access to healthcare.

Economic stability:

Access to Medications: Limited financial resources can lead to difficulties in affording prescriptions, leading to underuse or non-adherence to prescribed medications.

Medication Choices: Patients may opt for cheaper, potentially less effective or inappropriate medications due to financial constraints, increasing the risk of adverse effects or drug interactions.

Health Literacy: Lower levels of education are often associated with lower health literacy, which can lead to difficulties in understanding prescription instructions, including dosages, frequency, and potential side effects.

Support Systems: A lack of social support, such as from family or caregivers, may affect a person's ability to manage complex medication regimens or attend medical appointments.

Cultural Factors: Medications prescribed without considering cultural beliefs or preferences can lead to non-adherence or discontinuation. For example, some patients may not take medications if they perceive them to be incompatible with their cultural practices or values.

Disparities in Healthcare: Racial and ethnic minorities may face implicit biases or unequal access to healthcare, resulting in delayed diagnoses, inappropriate treatment options, and potential medication-related harm

1.b. The client takes over 10 medications and this is considered polypharmacy with a high risk of drug interactions and potential error with administering them correctly. As part of the deprescribing cascade, the nurse should review the meds, and find out more information on when the meds were prescribed and for what purpose (primary issue or prescribed to manage a side effect

from another med?). After speaking with the client and/or caregiver, a call to the pharmacist or prescriber may be needed. The nurse's assessment should also include discussing any symptoms or issues the client is experiencing. Some meds can pose a fall risk due to the effects of dizziness, confusion or fatigue. Consider the Beer's Criteria and any meds that the client is on that puts them at risk.

Chapter 4 Autonomic Nervous System Medications Answer Key

Chapter 4 Clinical Reasoning and Decision-Making Activities Section 4.16

4.7 Muscarinic Antagonists

4.16 Clinical Reasoning and Decision-Making Activities

1. A potential side effect of nicotine is the activation of the sympathetic nervous system, which causes an increased heart rate. Nausea and weakness are potential side effects that can indicate a nicotine overdose. The nurse should provide education to the client regarding the avoidance of additional nicotine when using the nicotine patch. It may also be helpful to remove the patch at bedtime and reapply a new patch in the morning.

You can review additional information about nicotine administration in the "Nicotine" section.

2.a. The nurse should explain to the client that tamsulosin relaxes muscles in the bladder and prostate to improve urine flow.

2.b. The nurse should monitor for hypotension and tachycardia, especially after administering the first dose of medication. The nurse should also advise the client to change positions slowly in order to prevent falls that can occur due to hypotension.

You can review additional information about tamsulosin in the "Alpha-1 Antagonists" section.

3.a. Albuterol stimulates Beta-2 agonist receptors in the smooth muscle of bronchi and bronchioles to produce bronchodilation to ease the work of breathing.

3.b. Beta-1 receptors can also be inadvertently stimulated by albuterol and causes the side effect of tachycardia.

3.c. The nurse should educate the client to take the medication as prescribed and avoid caffeine or other stimulants that can cause tachycardia.

You can review additional information about salbutamol in the "Beta-2 Agonists" section.

4.a. Propranolol is a nonselective beta-blocker and inhibits both Beta-1 and Beta-2 receptors. Inhibiting Beta-1 receptors will decrease the heart rate and reduce the force of the heart's contraction, which will lower the client's blood pressure.

4.b. Before administering propranolol, the nurse should always assess the client's blood pressure and apical pulse. If the systolic blood pressure is less than 100 mm Hg or the apical heart rate is less than 60 beats per minute, the medication should be withheld and the provider notified unless other parameters are provided in the order.

4.c. Propranolol can inadvertently cause bronchoconstriction because it inhibits Beta-2 receptors in addition to Beta-1 receptors. Bronchoconstriction causes wheezing.

4.d. When a nurse notices new wheezing, a focused respiratory assessment should be performed including assessing the client's airway, respiratory rate, and oxygenation status. Depending on the urgency of the assessment findings, the nurse should also check the client's medical record for a history of asthma or chronic obstructive pulmonary disease (COPD) and immediately notify the provider.

You can review additional information about propranolol in the "Beta-2 Antagonists" section.

5.a. Before administering metoprolol, the nurse should always assess the client's blood pressure and pulse.

5.b. If the systolic blood pressure is less than 100 mm Hg or the

apical heart rate is less than 60 beats per minute, the medication should be withheld and the provider notified unless other parameters are provided in the order.

5.c. A new finding of edema can indicate that the adverse effect of worsening heart failure is occurring.

5.d. The nurse should assess the client for additional signs of worsening heart failure, such as fine crackles in the lungs and recent weight gain, and notify the provider regarding this change in client condition.

You can review additional information about metoprolol in the "Beta-1 Antagonists" section.

6.a. Dobutamine is a catecholamine and it will increase heart rate, the force of heart contraction, and speed of conduction between the SA to AV nodes. These actions will help to improve cardiac output for a client experiencing an acute episode of heart failure.

6.b. During administration of dobutamine, the nurse should continuously monitor the client's heart rate, blood pressure, ECG, cardiac output, and urine output. Increased urine output will demonstrate the effectiveness of the medication in perfusing the kidneys.

You can review additional information about dobutamine in the "Alpha and Beta Receptor Agonists (Catecholamines)" section.

Chapter 5: Mood and Cognition Medications Answer Key

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

5.4 CNS Depressants

2. Lorazepam is a benzodiazepine, which is a CNS depressant. The riskiest side effects associated with the use of lorazepam are respiratory depression and oversedation. Other central nervous system depressants, such as scopolamine and alcohol, can cause additive effects and should be avoided when taking lorazepam. Sedation, drowsiness, respiratory depression, hypotension, and unsteadiness may occur when taking lorazepam, so these side effects should be considered when participating in activities on the cruise.
3. Flumazenil IV will be given in incremental doses until the client is more awake. Supportive care will include airway management, oxygen and fluids as needed until the client is awake and responsive, and breathing well. Lab work would include a toxicology screen to determine what other substances may have been ingested. Once stabilized, mental health supports will need to be implemented.
4. After administration, monitor vital signs such as BP and HR. Anticipate hypotension. Monitor RR and oxygen sats and ensure airway is supported with positioning and oxygen if

needed. Assess sedation level and anticipate the client will be drowsy. Implement fall risk precautions to avoid a fall. Assess seizure activity including the duration and characteristics. Avoid giving other sedative type medications.

5.5 CNS Stimulants

Client and parent education about methylphenidate should include taking the medication in the morning and not after 4 p.m. It is important to monitor the child's growth and weight and to provide food and snacks that the child likes if weight loss is a concern. Methylphenidate has a Black Box Warning due to its high abuse potential, and signs of misuse should be reported to the provider. The risks of drinking alcohol while taking this medication should also be discussed.

5.6 Antidepressants

Learning Activity 1

1. a. A client taking an SSRI medication like fluoxetine is at risk for developing serotonin syndrome if they have liver dysfunction or are taking other serotonergic medications. Other serotonergic meds include other antidepressants such as SNRIs, MAOIs or TCAs. Other meds include pain meds such as tramadol, fentanyl or other meds such as lithium. Symptoms of serotonin syndrome begin with mild symptoms, that includes nausea, anxiety, tremor and sweating, and can progress to include confusion, elevated temperature, and rapidly changing levels of blood pressure.

1. b.The nurse should advise the client of the potential for suicidal thoughts with this medication and advise her to notify her provider if she has any thoughts of self-harm.

1.c. Common side effects of SSRIs that the nurse should discuss with the client include sedation, low blood pressure that can cause dizziness, suicidal thoughts, heart palpitations, sexual dysfunction, and anticholinergic side effects such as dry mouth. Clients should be advised to avoid drinking alcohol when taking an SSRI.

1.d. The nurse should advise the client that it may take up to 12 weeks to reach therapeutic levels of this medication where they feel better.

2. Patient Education – Venlafaxine and Sleep. You can provide the following education:

- Timing of venlafaxine:
  Venlafaxine ER can be activating for some individuals. Taking it at bedtime may contribute to insomnia.
  → It may be helpful to take venlafaxine in the morning instead.
  → Morning dosing may also improve daytime fatigue and anhedonia.
- Other nursing interventions
  - Keeping a sleep diary to monitor patterns
  - Reviewing sleep hygiene strategies
- Ongoing risk assessment:
  Although the patient denies active suicidal intent or plan this requires ongoing assessment.

3. Aripiprazole, a 2nd generation antipsychotic medication, may be used to augment their current medication regime for treatment resistant depression.

5.7 Mood Stabilizers

1. The nurse should explain that symptoms of manic episodes include rapid speech, hyperactivity, reduced need for sleep, poor judgment, hostility, aggression, decreased impulse control, and risky behaviors. For more information about mania and bipolar disorder, review the "Disorders of the CNS System" section.
2. Symptoms of lithium toxicity include diarrhea, vomiting, drowsiness, muscular weakness, and a lack of coordination. At higher lithium levels, giddiness, ataxia, blurred vision, tinnitus, and a large output of dilute urine may be seen. Lithium toxicity is prevented by regularly monitoring serum lithium levels to maintain a therapeutic range between 0.6 to 1.2 mmol/L. [1]
3. The nurse should advise the client that lithium reaches therapeutic range within 1 to 3 weeks.

5.8 Antipsychotics

1. Answer A There is a risk of neutropenia, and in severe cases agranulocytosis. Routine blood work is ordered to monitor their white cell count.

   Why the other answers are incorrect:

   Answer B – incorrect – Blood tests are not routinely done to monitor clozapine blood levels unless there is a specific concern, so this is not the main reason for frequent lab work.

   Answer C – incorrect – Clozapine does not commonly cause electrolyte changes that require routine monitoring, so this is not the primary reason for frequent blood tests.

   Answer D – incorrect – Blood tests cannot measure changes in neurotransmitters to determine how well clozapine is working, so this is not an accurate reason.

2. Answer B. Clozapine is associated with a potentially life-threatening adverse effect—**agranulocytosis**, which most commonly occurs within the first few months of treatment. **Fever and chills** in a patient taking clozapine are **red-flag symptoms** that may indicate severe neutropenia or agranulocytosis with infection.

Because agranulocytosis can progress rapidly and lead to sepsis, the patient requires **urgent medical evaluation**, including immediate CBC with differential and clinical assessment. Delaying evaluation or managing the symptoms conservatively would place the patient at significant risk.

Why the other options are incorrect:

- **A.** Flu-like symptom counseling alone is inappropriate because fever in a patient on clozapine must be assumed to be agranulocytosis until proven otherwise.
- **C.** Advising blood work "tomorrow" delays potentially life-saving evaluation; this situation warrants **immediate** assessment.
- **D.** Stopping clozapine without urgent medical evaluation is unsafe; the priority is to rule out agranulocytosis and treat any infection, not simply reschedule.

5.9 Anticonvulsants

1. Gabapentin is classified as an anti-seizure medication, but it is also used to help relieve neuropathic pain that clients with diabetes often describe as a "burning" or "tingling" sensation in their lower extremities.
2. Gabapentin is a CNS depressant and can cause sedation, dizziness, and ataxia that increase a client's risk for falls.
3. The nurse should plan to monitor for worsening depression, suicidal ideation, fever, rash, lymphadenopathy, dizziness, sleepiness, stumbling, and a lack of coordination.

Development of any of these signs should be reported to the provider; suicidal ideation requires urgent notification.

5.10 Anti-Parkinson's

1. Levodopa, the metabolic precursor of dopamine, crosses the blood-brain barrier and is then converted to dopamine in the brain. Carbidopa is combined with levodopa to help prevent the breakdown of levodopa before it is able to cross the blood-brain barrier.
2. Clients taking carbidopa and levodopa have reported suddenly falling asleep without prior warning of sleepiness while engaged in activities of daily living, including operation of motor vehicles. Clients should be advised to exercise caution while driving or operating machines during treatment with carbidopa and levodopa.
3. Dyskinesia is involuntary muscle movements including tics. If a client develops dyskinesia while taking carbidopa-levodopa, dosing adjustment or alternate drug therapy is required.

Chapter 6: Pain and Mobility Medications Answer Key

6.5 Non-Steroidal Anti-Inflammatory Medications

Learning activity 1

The client should be advised that acetaminophen can cause acute liver damage when taken in excessive amounts or when used with alcohol. Many over-the-counter medications contain acetaminophen, so daily amounts must be monitored carefully. Recommended daily restrictions for acetaminophen include less than 4,000 mg of acetaminophen in 24 hours for an adult, less than 3200 mg for geriatric adults, and less than 2000 mg for clients with alcoholism. Fewer than three alcoholic drinks should be consumed daily while using acetaminophen.

Learning Activity 2

The client should be advised that aspirin has an anti-platelet effect, in addition to reducing pain, fever, and inflammation. By preventing the platelets from sticking together, clots that can cause heart attacks and strokes are prevented from forming.

Learning Activity 3

1. Ibuprofen is a nonsteroidal anti-inflammatory drug (NSAID), which can cause severe and life-threatening stomach bleeding and must be taken cautiously. The client should be advised that the risk for bleeding is higher if the client:

- is age 60 or older
- has had stomach ulcers or bleeding problems
- takes a anticoagulant or steroid medication
- takes other drugs containing NSAIDs (such as aspirin, ibuprofen, or naproxen)
- consumes three or more alcoholic drinks every day while using this product
- takes ibuprofen in higher doses, more frequently, or for a longer time than directed

2. The nurse should evaluate the effectiveness of ketorolac IV in relieving the client's pain 30 minutes after administration.

3. The nurse should provide the following client education to a client who has been prescribed celecoxib:

- It may be taken with or without food
- You can sprinkle capsules on applesauce and ingest it immediately with water
- You may experience heartburn, vomiting, or diarrhea with this medication
- Notify the provider immediately if you have abdominal pain, vomit blood or have blood in your stool, develop swelling in your hands or feet, or notice yellowing of your skin

6.6 Opioid Analgesics and Antagonists

Learning Activity 1

1. As this is not the first time the client has received analgesia, the nurse should complete the pain assessment (pain scale, severity, radiation, onset, provoking factors, quality of pain), their level of consciousness or sedation level, respiratory rate, oxygen sats and BP, and previous response to pain meds.
2. Oral drops of morphine, commonly used for clients with metastatic cancer, should be effective within 1 hour of administration.
3. The nurse should assess for adverse effects including: Monitor for hypotension and respiratory status (decreased oxygen saturation, RR, respiratory depth due to respiratory depression risk). Other less urgent adverse effects include itching, constipation, and nausea.

Learning Activity 2

Naloxone immediately reverses the effects of respiratory depression and oversedations caused by opioids. After a client receives naloxone, the nurse should continue to evaluate the client's respiratory status at least every 15-minutes because naloxone has a shorter duration of action than many opioids and repeated doses are usually necessary.

6.7 Adjuvant Analgesics

Learning Activity 1

The nurse should educate the client to take baclofen with milk or food to minimize gastric upset. Advise the client that baclofen may cause dizziness or drowsiness, so they should change positions slowly and avoid driving and operating machines. Clients using baclofen should avoid using alcohol or taking other CNS depressants.

Learning Activity 2

Cyclobenzaprine is a muscle relaxer and may cause drowsiness. If used with alcohol or other CNS depressants, it can impair mental or physical abilities, so the client should be advised not to drive when taking cyclobenzaprine.

6.10 Clinical Reasoning and Decision Making Learning Activity

The correct answers are a), b), and e).

Based on the client's respiratory status, the nurse should immediately raise the client's bed and apply oxygen to rapidly increase their oxygenation level. The nurse should ask for help from a team member and/or call the rapid response team while obtaining naloxone to administer for sedation and respiratory depression. The nurse should continue to monitor the patient's respiratory

status after naloxone is administered because repeated doses may be required.

Chapter 7: Cardiovascular Medications Answer key

7.5 Antiarrhythmics – Answer Key

1. Assess heart rate and blood pressure. Also assess for any weight gain, peripheral edema and fatigue. Listen to their lung sounds to see if any crackles, and ask about any shortness of breath.
2. Answer A
3. Answer: Hypotension with a systolic BP less than 90. Pulse rate less than 50 beats/minute. Follow agency protocol as the parameters to hold may be different. Metoprolol can cause bradycardia and AV block.
4. It can be taken with or without food. Avoid eating grapefruit or drinking grapefruit juice as it can increase the therapeutic levels of verapamil. Drinking small amounts is acceptable. Alcohol consumption will cause additive hypotensive effects.
5. Monitor the heart rate and rhythm as it will prolong the PR interval and widen the QRS. It may prolong the QT interval and report bradycardia. Monitor BP as hypotension can occur during the first few hours of IV therapy. Assess pulmonary status, such as dyspnea, cough and crackles.

7.6 Cardiac Glycosides – Answer Key

1. A nurse should assess the apical pulse for a full minute before

administering digoxin due to its positive inotropic action (it increases contractility, stroke volume, and, thus, cardiac output), negative chronotropic action (it decreases heart rate), and negative dromotropic action (it decreases electrical conduction of the cardiac cells). These actions can lead to bradycardia. If the client's heart rate is less than 60 beats per minute, the nurse should notify the provider before administering digoxin unless other parameters are provided.

2. The nurse evaluates the effectiveness of digoxin based on the client's blood pressure, apical pulse, and decreased symptoms of heart failure for which it is indicated.
3. The nurse should monitor the client's serum potassium level because a decreased potassium level places the client at increased risk of digoxin toxicity. Normal potassium level is 3.5 to 5.0 mEq/L, and a result less than 3.5 should be immediately reported to the provider due the the risk for sudden dysrhythmias. Serum digoxin levels should also be monitored, with a normal therapeutic range being 0.8 to 2 ng/mL.
4. The nurse should assess the client's apical pulse and withhold the administration of digoxin. The nurse should also check for current lab results related to the serum digoxin and potassium levels. The nurse should notify the provider of the client's change in condition that could indicate digoxin toxicity and provide information regarding the client's apical pulse and recent digoxin and potassium levels. An order for a serum digoxin level may be received from the provider. Based on the serum digoxin level, the client may receive a new order for digibind. Digibind is used to treat digoxin toxicity.

7.7 Antianginal Drugs V2 – Answer Key

1. The nurse should monitor the client's blood pressure and heart rate. After 5 minutes, the pain level should be reassessed and a

second dose of nitroglycerin administered if the client's chest pain continues. If there is no improvement in chest pain, emergency services should be obtained by calling 911 or the rapid response team.

2. Answers:
    a. It works by relaxing the blood vessels and increasing the supply of blood and oxygen to the heart while reducing its work load. It has minimal arterial dilation.
    b. Use at the first onset of chest pain. Spray under your tongue. Wait 5 minutes, and if you still have pain, you can give yourself one more spray. Call 911 if pain has not subsided. If pain continues 5 minutes after your 2nddose, give one more spray. Use nitro sitting down as you might feel dizzy.
3. Answers:
    a. Transdermal patches are to prevent chronic angina for clients with coronary artery disease.
    b. The nurse should assess blood pressure, heart rate and if the client has experienced any chest pain.
    c. The patch is removed in the evening for a period of 8-12 hours. A new patch is reapplied in the morning. The purpose is to minimize tolerance to the med. Night time removal is done as most clients experience few angina attacks, whereas optimal nitrate sensitivity during the day.

7.8 Anti-hypertensives V2 – Answer Key

Activity 1

1. Metoprolol is a selective Beta-1 blocker that decreases the heart rate and force of contraction to reduce blood pressure.

Lisinopril is an ACE inhibitor that reduces blood pressure through vasodilation and reduces fluid retention. Verapamil is a calcium channel blocker that causes vasodilation to reduce blood pressure. Hydrochlorothiazide is a thiazide diuretic that reduces fluid retention. For this client, all four medications may be required to maintain a blood pressure within normal range. Recall that triple therapy is considered standard therapy for clients with hypertension. This allows lower dosages, less side effects and the ability to treat hypertension in multiple ways.

2. The nurse should explain that each medication works in different ways within the body to treat high blood pressure. It is vital to explain the importance of maintaining blood pressure within normal range to prevent additional complications such as a heart attack, heart failure, stroke, and kidney failure.

Activity 2

1. The normal potassium level is 2.5-5.0 mEq/L, so ideally they should be within this range. ACE inhibitors can cause hyperkalemia. If slightly elevated, dietary changes may be required. Consider if this client has renal insufficiency or they take NSAIDs regularly, which may be contributing the the higher potassium levels.
2. The plan would be to lower dietary potassium and to ensure they are not on any potassium supplements. Teach about potassium rich foods such as leafy green vegs, avocados and bananas, and eating them in moderation. They can also increase their fiber intake. Teach about S&S hyperkalemia such as muscle weakness, cardiac arrhythmias (heart palpitations), fatigue, nausea and numbness/tingling in their hands or feet.

3. Amlodipine health teaching: monitor blood pressure regularly, especially if taking two anti-hypertensives. Assess for fluid retention in ankles. May cause dizziness with changing positions so change positions slowly.

7.9 Antilipemic Medications V2 – Answer Key

1. Answer: A – It is alright to take this med morning or evening, but it is only once a day as it has a long duration of action.
2. Answer C – With hypoactive bowel sounds and abdominal distention, a more thorough assessment should be completed to rule out the risk of bowel obstruction.
3. Answer D – Statins primarily work to lower LDLs and is currently the best medication for this action.
4. Answer A – Statins may cause muscle aches and tenderness. The client needs to report this change in their prescriber right away. Muscle pain can be an early sign of rhabdomyolysis, which is a rare but life-threatening adverse effect.

7.10 Blood Coagulation Modifiers V2 – Answer Key

Activity 1

1. Warfarin will not dissolve the existing clot, but it will help prevent additional clot formation.
2. When a client is taking warfarin, the nurse should closely monitor INR and PT levels to verify they are in normal range to prevent bleeding complications. Specifically, the therapeutic range for INR is between 2.0 to 3.5 depending upon the

indication.
3. Dietary instructions should be provided to maintain a consistent intake of foods high in vitamin K, like leafy green vegetables. Daily changes in intake of foods that are high in vitamin K will influence the effectiveness of warfarin, as well as the client's INR levels used to maintain the warfarin levels in therapeutic range.
4. Client education should emphasize bleeding precautions, avoidance of NSAIDs and aspirin, the need for routine therapeutic monitoring, and when to call the provider with signs of increased bleeding or clotting.
5. The reversal agent for warfarin is vitamin K.

Activity 2

1. Chewing aspirin will increase the absorption, so it will begin to work within 5 to 10 minutes. Swallowing aspirin whole will take 15 to 20 minutes to obtain anti-platelet effects. Two low-dose aspirins would only be 160 mg. He should be taking 325 mg instead to get the most benefit.
2. Answer: B**.** *Rationale*: The spray should be administered onto or under the tongue to allow for rapid absorption into the sublingual mucosa.
3. Answer: C. *Rationale*: Headache is a very common side effect due to the massive vasodilation of cerebral blood vessels.
4. The higher dose is the loading dose to bring up the client's blood levels to reach a steady state quickly. This med is an anti-platelet drug, a P2Y12 Inhibitor, that has similar effects as ASA. It is often given to clients with unstable angina and following coronary stents.
5. You are on two antiplatelet medications. You will likely be on both meds for the next 6-12 months. Monitor for any significant bleeding such as severe nosebleeds, blood in the

stool, or any bleeding that doesn't stop. use a soft toothbrush to avoid bleeding. Inform your dentist or other prescribers that you are on these meds, especially if you are going for any planned procedures such as dental work. Avoid taking any NSAIDs such as ibuprofen.

6. Warfarin is an anticoagulant and is ordered to prevent venous clots, whereas aspirin or clopidogrel are ordered to prevent arterial clots.

7.11 Diuretics

Activity 1

1. Before administering a diuretic, the nurse should assess blood pressure, the daily weight trend, serum potassium and other electrolyte levels, hydration status including 24-hour input/output, and current renal function.
2. Signs of toxicity include blurred vision, nausea, and visual impairment (such as seeing green and yellow halos). A low potassium level can increase the risk of digoxin toxicity. If a client has digoxin toxicity, severe bradycardia and even death can occur if not treated promptly. The normal range for serum potassium is 3.5-5.0 mEq/L.
3. Furosemide (Lasix) is a loop diuretic. Clients receiving loop diuretics are at high risk of dehydration. Loop diuretics work in the loop of Henle where a great deal of sodium and water are either reabsorbed or eliminated by the kidney tubules. The nurse should assess for the development of dehydration in clients receiving diuretics by monitoring skin and mucus membranes for dryness, blood pressure for hypotension, heart rate for tachycardia, decreased urine output, concentrated urine, and increased serum sodium levels.

4. All electrolyte levels can be decreased in clients taking loop diuretics, but potassium in particular is at high risk for depletion due to the rapid water loss that occurs.
5. There is a close relationship between potassium and digoxin. Furosemide can deplete potassium levels, which then increases the risk for developing digoxin toxicity. This occurs because digoxin treats heart failure by inhibiting the Na-K ATPase pump in cardiac cells. Digoxin and potassium compete for binding sites on the heart muscle's sodium-potassium pump. When furosemide causes low potassium levels, there is less competition, allowing more digoxin to bind to the heart muscle. This can lead to the risk of digoxin toxicity.

Activity 2

1. Answer C: It can cause hyperuricemia. So, inform the prescriber to ensure they are aware. If they need to be on this med, close follow up is required. Thiazides can also cause hyperglycemia so it is not ideal for diabetic clients.
2. Answer D: Spironolactone acts as an aldosterone antagonist, which can cause endocrine-related side effects, including breast tissue growth (gynecomastia) in men and menstrual irregularities in women.

7.12 Clinical Reasoning and Decision Making Learning Activity – case study

1. Answer A and D. Rationale: CCB are used in the treatment of hypertension or in the prophylaxis of angina pectoris. Diltiazem is also used as an anti-arrhythmic. They block calcium entry into the cells of the vascular smooth muscle and

myocardium, resulting in coronary artery dilation and inhibits coronary artery spasm. Diltiazem also decreases AV nodal conduction.

2. True: diltiazem can cause hypotension so tell the client to be careful with position changes to avoid a fall. Peripheral edema can occur due to the vasodilating effects of the med.
3. INR is monitored every 1-2 weeks for a therapeutic range of 2.0-3.0. For clients with a mechanical valve replacement, the therapeutic range is 2.5-3.5.
4. Answer:

- Caution the client to avoid activities that may lead to injury. Also, use a soft toothbrush and be careful with shaving. Anticipate the risk of bruising and report any unusual signs of bleeding such as dark stools and lots of bruising.
- Do not take any OTC meds unless approved by the prescriber including NSAIDs or aspirin.
- Limit alcohol and be consistent with intake. For example, two drinks may increase the anticoagulant effect.
- Be consistent with eating vitamin K rich foods. These foods include leafy greens, avocado, and soy. Some foods increase the risk of bleeding, such as cranberry juice, fish oil, garlic supplements, grapefruit and mango. Some food or supplements decrease the effect of warfarin including high doses of vitamin C, ginseng, and St John's Wort.
- If sick with a fever, diarrhea or unable to eat, inform your prescriber as the INR testing may need to be increased and warfarin dose may need to be reduced.

5. Taken once a day, the best time is in the evening or bedtime. This is when the endogenous cholesterol is being produced.
6. Answer is A Rationale: a productive cough brought on by a cold is not related to taking ramipril. A dry persistent cough, that can begin a few weeks up to months after starting ramipril should be reported to the prescriber. The client will be then

switched from an ACE inhibitor to an Angiotensin Receptor Blocker medication.

7. Common adverse effects include: dizziness, light-headedness, dehydration, constipation.

More significant adverse effects: tinnitus or hearing loss, muscle cramps, electrolyte imbalances (low potassium levels). These should be reported to their prescriber for further assessment and follow up.

Chapter 8: Respiratory Medications Answer Key

8.9 Beta-2 Adrenergic Agonists – Answer Key

1. Answers:
    a. Audible wheezes, wheezes upon auscultation, low oxygen saturations, tachycardia. Client may appear distressed and anxious.
    b. Shake inhaler before administering. Do four shots into the air away from the client's face to prime the inhaler.
    c. When the amount of salbutamol is too high, it binds with beta-1 receptors, leading to tachycardia, shaky, anxiety and nausea. These effects are transient. The client should not be taking their salbutamol inhaler more than 2x/week as a rescue inhaler. If they are, they need to go back to their prescriber as their controller meds may need to be adjusted.
2. Answers:
    a. Correct: Use SABA with acute bronchospasm or prior to exercise induced bronchospasm. Use a spacer to improve the med reaching the lungs.
    b. Incorrect: This is partially correct, take before exercise, but only 15 minutes prior.
    c. Correct: yes, beta 2 adrenergic meds can cause temporary tachycardia and tremor.
    d. If a client becomes pregnant, discuss with prescriber if salbutamol is the best choice. Benefit will outweigh risk.
3. Answer: False: salmeterol is a long-acting beta-2 adrenergic agonist. It is not a rescue med but used as part of the long-

term management of asthma or COPD.

8.12 Leukotriene Receptor Antagonists V2 – Answer Key

1. Answers:

    a. Incorrect: This med is not a rescue or reliever med. Only a beta 2 adrenergic medication, such as salbutamol, should be used for acute bronchospasm.
    b. Correct: there is a risk of neurological changes such as depression, increased risk of suicidal thoughts, aggression and nightmares. Report any behaviour changes to the health care team.
    c. Correct: This med can be taken with or without food. If using granules, ingest package as soon as possible after opening.
    d. Correct: only take the med as prescribed. Never double up medications due to risk of overdose or adverse effects.
2. Answer – False: Montelukast is an oral medication. For inhaled respiratory medications, follow the instructions as outlined by the health care providers and product instructions.

8.14 Clinical Reasoning and Decision Making Learning Activities – Answer Key

Asthma Scenario

1. The correct answer is c) Albuterol. Albuterol is a Beta-2 agonist that relaxes smooth muscle to cause bronchodilation and assist the client with the work of breathing. It is a rapid-

acting bronchodilator that is used during asthma attacks.

2. The nurse should instruct the client to take the following steps to safely administer albuterol:

- Insert the inhaler into the spacer and shake the canister
- Breathe out all the way
- Press down on the inhaler and breathe in slowly through the mouth
- Breathe in for 10 seconds or as long as you can tolerate
- Remove the inhaler from the mouth
- Wait 30 seconds between doses

3. After administering the medication, the nurse should assess the client's vital signs and lung sounds, paying special attention to the respiratory rate, pulse oximetry, and heart rate for signs of improvement, as well as for potential side effects such as tachycardia.
4. The nurse should educate the client regarding the correct method to administer albuterol, potential side effects, and the signs and symptoms of an asthma exacerbation. The nurse should ensure the client has a written copy of their asthma action plan and verify that the client can explain the plan to ensure proper understanding. The nurse should also explain the importance of always having albuterol on hand and to help the client make plans for refills so as to not run out of medication.
5. To ensure correct use of the inhaler, the nurse should ask the client to provide a return demonstration. You can review additional information about asthma in the "Conditions and Diseases relate to Gas Exchange" section and albuterol in the "Beta-2 Agonist" section of this chapter.
6. **Allergy Scenario:** The correct answer is b) Epinephrine. Epinephrine is used to rapidly treat severe allergic reactions.

Review questions

1. Answer C. Take the medication regularly, even when symptoms are not present.
2. Answer A. Monitor for blood levels to avoid toxicity.

You can review additional information about epinephrine and the use of Epi-Pens in the "Alpha and Beta Receptor Agonists (Catecholamines)" section of the "Autonomic Nervous System" chapter.

Chapter 9: Gastrointestinal Medications Answer Key

9.5 Anti-Ulcer Medications

Learning Activity 1

1. Plan to do a complete GI assessment. Let's review the options.

- She reports occasional constipation. Magnesium antacid can be used as a laxative, so this may be a good choice. Magnesium is the only antacid that can cause loose stools. Calcium-based and aluminum-based antacids will cause constipation, so not ideal.
- She has hypertension, so she needs to avoid sodium-based antacids.
- Magnesium hydroxide will be an effective choice.

2. Client teaching: She takes several medications, so she needs to take her other meds two hours before or one hour after her antacid. If she does not get relief, she should see her health care provider for further assessment.

Learning Activity 2

Postoperative clients often require a proton pump inhibitor due to the stress response that occurs during surgery and hospitalization. Pantoprazole suppresses the secretion of hydrochloric acid and prevents the formation of a stress ulcer.

9.6 Anti-diarrheals

1. The client may be experiencing increased heart rate as a symptom of dehydration associated with water loss from diarrhea. Additionally, a Black Box Warning for loperamide is abnormal heart rhythm. The nurse should assess the client's heart rate and rhythm and notify the provider.
2. The nurse can recommend providing over-the-counter probiotics, which are also found in yogurt, for the prevention of diarrhea associated with antibiotic use or to assist in decreasing the symptoms of diarrhea.

9.7 Laxatives

1. A postoperative client has many risk factors for constipation, including side effects of anesthesia and opiates, sedentary levels of activity, and decreased fluid and food intake after surgery. In addition to administering docusate or other laxatives as needed, the nurse should educate the client about nonpharmacological interventions to relieve constipation, such as increased fluid and fiber intake and walking.
2. PEG 3350 has a mild laxative effect. It causes water to be pulled into the intestine, and then the stool, increasing osmotic pressure in bowel.
3. PEG 3350, taken daily, works within 1-3 days. It is also important to continue to increase fluid and fiber intake.
4. Preventative measures for constipation include increasing fluid and fiber intake, ambulating, and using the least amount of opiates needed to effectively treat the pain.
5. Bowel protocols usually include a step-wise approach to constipation. Polyethylene glycol 3350 are often used preventively, but if a bowel movement does not occur within

the expected timeframe, additional laxatives can be added. Most bowel protocols have a step-up process with progressive increase in laxative choices. Some options include stimulants such as senna, bisacodyl or if no results after a few days, an enema may be added. A bisacodyl suppository generally produces a bowel movement within one hour whereas a mineral oil enema usually works within 15 minutes of administration.

9.8 Anti-emetics

1. This med is an effective choice for pediatric clients. The dosage should be based on the child's weight. The child must be over 2 years of age due to risk of respiratory depression with the younger age. Do a thorough assessment including vital signs, nausea level and ability to take fluids. If the client can't manage swallowing, rectal route is an option if necessary. Always do an independent double check with another nurse.
2. Aprepitant is usually administered concurrently with dexamethasone (a corticosteroid) and ondansetron.

9.9 Critical Thinking and Decision Making Activities

1. a. The nurse assesses for dehydration by monitoring blood pressure for hypotension, heart rate for tachycardia, urine output for decreased level, skin for tenting, and mucus membranes for dryness.

1. b. The dissolving tablets eliminate the risk of vomiting the medication before it is absorbed. If the client can't tolerate the

dissolving tablets, the nurse can request the provider to change the route of ondansetron to the intravenous route.

1. c. The nurse should plan to proactively administer medications before meals to prevent nausea.

The client can also be instructed to follow a bland diet to prevent feelings of nausea that can be stimulated by spicy food or strong flavors. Fluids should be encouraged to prevent dehydration, but if fluids increase the client's feelings of nausea, the client can be instructed to take frequent sips of fluid or suck on ice chips.

2. Metoclopramide is an effective antiemetic that works on the D2 receptors. It also causes GI motility and increases peristalsis. In this client's case, increasing peristalsis with a bowel obstruction is contraindicated. It is also not good for older adults due to the risk of adverse effects of tardive dyskinesia.

Ondansetron is a highly effective anti-emetic that is good for many causes of nausea. It can cause headache and fatigue but typically mild. There is a slight risk of prolonging QT interval but this can be monitored if the client will be on it long term.

Chapter 10: Endocrine System Medications: Part 1 Answer Key

10.3 Corticosteroids

Case Study 1:

1. The client is at risk for a fracture due to a previous history of osteoporosis that weakens the bones and increases the risk for a fracture when injury occurs. Corticosteroids can cause muscle weakness that can lead to falls and fractures. Corticosteroids also decrease bone matrix by interfering with calcium absorption. For a client with osteoporosis and also on steroid therapy, this can worsen the process and lead to higher risk of bone fractures. This would be a concern especially with long term therapy.
2. Alendronate, a bisphosphonates class of medication, is often used to treat osteoporosis and reduce the client's risk of fractures. Other preventative measures can be implemented, such as weight-bearing exercise and calcium/vitamin D supplementation.
3. The client should be instructed to avoid getting up without assistance. The room should be well-lit without loose rugs that can cause tripping. If the client uses assistive devices like a cane or walker, these devices should be readily available.
4. The use of glucocorticoids can increase glucose levels through the process of gluconeogenesis. Although the client has not been on insulin previously and was a type 2 diabetic, temporary use of insulin may be required while on

corticosteroids.

5. Signs of adrenal suppression include severe fatigue, gastrointestinal upset, and a suppressed immune response that places the client at risk for developing infections. Long term use of steroids can suppress the production of endogenous steroids through negative inhibition. Any abrupt discontinuation of steroid therapy can cause acute adrenal insufficiency. When steroids will be discontinued, always taper the dose so the body can begin to produce endogenous hormones again.

Case Study 2:

1. The client has a large abdominal incision and taking steroids can impact wound healing due to protein catabolism, decreased fibroblast and collagen deposition. The nurse should watch for signs of wound failure and ensure the client splints their incision when moving or coughing. Steroids can also suppress the immune system and have anti-inflammatory effects therefore signs of infection (redness, swelling) may be masked.
2. Prednisone is always taken in the morning to mimic the normal diurnal rhythm. Circulating cortisol levels increase between 2 and 6 am, and peaks between 6-8 am, then gradually decrease throughout the day until midnight. To protect the gastric mucosa, steroids should be taken with a meal. the prescriber may also order a histamine receptor antagonist such as famotidine to help protect the gastric mucosa.

Case Study 3:

1. Corticosteroids suppress the production of lymphocytes as well as inhibiting their functions such as releasing cytokines. They also are toxic to lymphoma cells, thereby inhibiting the production of cancerous lymphocytes. Another benefit is that

steroids can help manage some chemo side effects such as nausea and vomiting and increase appetite.

10.4 Thyroid Medications

1. T4 levels and insulin are intrinsically linked through metabolic regulation. Hypothyroidism or low T4 levels can reduce glucose metabolism efficiency, leading to a decrease in insulin sensitivity, and increase in insulin resistance and higher fasting glucose levels. The client should be checking their glucose levels more frequently once they start Synthroid and their insulin dosages may need to be adjusted.
2. One concern while taking this med is hypocalcemia. One way to assess low calcium levels is when taking the client's BP. The wrist will start to involuntarily flex, and the fingers will extend. They may also have tingling. Other side effects include hypersensitivity reaction and irritated nasal mucosa.

Chapter 11: Endocrine System Medications: anti-diabetic medications answer key

11.5 Diabetic Case Study

1. Type 1 diabetes is an autoimmune disease affecting the beta cells of the pancreas so they do not produce insulin; synthetic insulin must be administered by injection or infusion.

Type 2 diabetes is acquired, and lifestyle factors such as poor diet and inactivity greatly increase a person's risk for developing this disease. In type 2 diabetes, the body's cells become resistant to the effects of insulin. In response, the pancreas increases its insulin secretion, but over time, the beta cells become exhausted. In many cases, type 2 diabetes can be reversed by moderate weight loss, regular physical activity, and consumption of a healthy diet. However, if blood glucose levels cannot be controlled with these measures, oral diabetic medication is implemented and eventually insulin may be required.

1. Surgery and hospitalization often stimulate a client's stress response, which includes the release of cortisol. Cortisol increases blood glucose levels, so the client may require insulin to control blood sugar levels while hospitalized.
2. The nurse should administer 6 units of Humalog insulin along with the scheduled 20 units of Humulin-N insulin at breakfast.
3. Metformin may be discontinued because it is contraindicated in clients with kidney disease (e.g., serum creatinine levels ≥115 umol/L [males] or ≥ 94 umol/L [females]).

4. The client is displaying signs of hypoglycemia. A supplementary carbohydrate, such as 250 mL of orange juice, should be administered as soon as possible. However, if the client seems confused or unable to swallow, glucagon should be administered.
5. The client has hypoglycemia because the peak effect of Humulin-N is about 6 hours. Because the medication is peaking between meal times, the client's blood sugar continues to decrease. On the other hand, the onset of Humalog insulin is 15-30 minutes, with the peak effect in 1-3 hours, so the food eaten during meal time maintains a normal blood sugar as long as the meals and the insulin administration are matched.
6. The hemoglobin A1C test indicates the client's average level of blood sugar over the past 2 to 3 months. It is also referred to as HbA1c, glycated hemoglobin test, or glycohemoglobin. Normal hemoglobin A1C is less than 5.7%. In clients with diabetes, the goal is to maintain hemoglobin A1C levels less than 7%. The client's recent lab result of 10% indicates the need for additional diabetes medication, as well as client education regarding diabetes management, to avoid the development of long-term complications of diabetes.
7. Lantus is a long-acting insulin that has a duration over 24 hours. It does not have a peak and should be administered once daily at the same time each day. Lantus should only be administered subcutaneously and should not be mixed with other insulin.

11.7 Diabetic Case Studies

1. a. sulfonylurea requires consistent meals to avoid hypoglycemia. If the client does not eat regularly, then they should be switched to a different oral anti-diabetic med.

1. b. Metformin is typically the first line treatment for type 2 diabetes. It has the benefit of no risk of hypoglycemia and no weight gain and is generally well-tolerated. If the client was switched off of metformin, perhaps they did not tolerate the GI side effects, or they had renal impairment or did not tolerate the medication. Most often overt time, metformin is tolerated but less effective, so a second med is added not replacing metformin.
2. Alcohol can cause hypoglycemia the following day and cause dehydration. To avoid the drop in blood sugars, before the party: Eat a regular, carbohydrate-rich meal before the party, and bring treatment (glucose tablets, a can of pop) for low blood glucose levels to the party. At the party: take blood sugars more regularly. Between each drink, have a non-alcoholic drink and carbohydrate-rich food.

   After the party: up to 24 hours after the party, have a responsible adult know the signs of hypoglycemia and monitor your blood sugars every few hours if the client is not able to. Get back into normal routine the next morning with eating food and taking insulin.

3. a. The addition of insulin is to prevent the hyperglycemic episodes that contribute to an increased CV complications over time. Insulin will improve glycemic control. The plan to keep the other oral medications will provide better glycemic control than just switching to insulin. It will also allow a lower dose of insulin and ultimately less risk of hypoglycemia. With SGLT-2 inhibitors, it also has cardioprotective effects such as lowering blood pressure and decreasing fluid through increased urination.
4. There are a number of important teaching points when starting on insulin therapy. The client should be referred to a

diabetic outpatient clinic for ongoing education. Some teaching points include: understanding the rationale for insulin and the different types (bolus vs basal). They should know when to check blood sugars and signs of hypoglycemia. They should understand the onset, peak and duration of their insulins and when they need to eat. They also need to know how to administer the insulin, including site rotation and storage of the vials.

4.a. Lipodystrophy is a potential complication of repeated use of the same injection site. It can occur as lipoatrophy (fat loss) or lipohypertrophy (lumpy, raised, rubbery fat accumulation).

4.b. The complication with lipodystrophy is that the insulin will not be properly absorbed, leading to delayed or reduced insulin absorption, glycemic instability and unexplained hypoglycemia. Some clients have limited mobility and use the same site repeatedly, and some clients need further information of the importance of rotating sites. For this client, the nurse should find out more about any challenges with injecting their insulin and together look for a solution to avoid further issues. Prevention includes rotating sites and daily inspections of the sites. The lipodystrophy will eventually subside.

Chapter 12: Antimicrobial Medications answer key

12.1 Infection Concepts

1. Client education includes:

- The importance of adhering to the prescribed medication regimen is vital to help prevent drug resistance. The nurse should emphasize the need to complete the full course of medication, in the dosages and frequencies prescribed.
- Another solution used to prevent drug resistance in high-risk medications is called directly observed therapy (DOT). DOT is the supervised administration of medications to clients. Clients are required to visit a health-care facility to receive their medications, or a health-care professional administers medications in the clients' homes or other designated location. DOT has been implemented worldwide for the treatment of tuberculosis (TB), and research has been shown it to be effective in treating infections successfully and preventing additional drug resistance.

2. Antimicrobials are prescribed before lab results return for a few reasons. Prescribers will know that certain common pathogens can infect the urinary tract or respiratory system or the gut and will prescribe a broad-spectrum antibiotic initially. Second, some infections, if left untreated, can lead to more serious complications and even be life-threatening, not to mention the client is likely symptomatic and feeling poorly. To wait up to three days before labs return can put the client at risk. Treating early with a broad-spectrum antibiotic is common practice, then once the labs return,

the client may be switched to a different antimicrobial that is narrow spectrum.

3. Clients who are very young or older are more at risk with any meds, and certainly antimicrobials. Infants and children are not able to take some antimicrobials due to negative effects. For example, tetracycline affects developing teeth and bones. Sulfa antibiotics can displace bilirubin and precipitate kernicterus in the newborn.

For older adults, the normal aging process of a decline in renal function and liver function is important for the metabolism and excretion of meds. A lower dose may be prescribed due to this reason. Very often, a client's kidney function will be assessed before meds are prescribed.

12.5 Penicillin

1. The administration of penicillin should be postponed for four hours because citrus juice can impede absorption of drugs like penicillin. The remaining doses of penicillin for the day should be rescheduled based on the time the breakfast dose was actually administered. Additionally, the client should be educated about avoiding citrus juice while taking penicillin, and the dietary department should be notified to remove citrus juice from the meal choices.
2. a. Tazobactam is a beta-lactamase inhibitor. It will extend the antimicrobial action of piperacillin.

2.b. Take full dose of med, even if feeling better. Take the med on an empty stomach as it can interact with certain foods and meds. Avoid juices, cola, caffeine. It is preferable to take with lots of water. Also, take a probiotic such as yogurt. Avoid NSAIDs and antacids. If you need to take these meds, take one hour before or 2

hours after Penicillin. Report any change in stool such as diarrhea and abdominal pain.

12.6 Cephalosporins

The changes in the client's renal labs demonstrate decreased renal function. The prescribing provider should be notified prior to administering additional doses of cefazolin because the medication or the dosage will likely need to be revised based on the client's response.

12.7 Carbapenems

The nurse should check the progress notes in the electronic medical record to determine if anything is documented about John's allergies and the decision to use imipenem. If nothing is documented, then the nurse should notify the prescribing provider of the client's allergies to penicillin to confirm the appropriateness of this medication for John, document the provider's response in the medical record, and provide this information in the end-of-shift handoff report.

12.8 Monobactams

Monobactams are narrow-spectrum antibacterial medications used primarily to treat gram-negative bacteria like Pseudomonas aeruginosa. However, MRSA is a gram-positive bacteria, so aztreonam will not be effective in fighting this infection. The nurse

should notify the prescribing provider of the results of the new culture report before administering the azotreonam.

12.9 Sulfonamides

1. The nurse should review the other medications the client is taking. Trimethoprim-Sulfamethoxazole has many significant drug interactions, including oral anti-diabetic medications. This medication may increase hypoglycemic effects requiring closer monitoring of blood sugars. Additionally, the client's renal status should be verified before administration of trimethoprim-sulfamethoxazole because dose adjustment may be required.
2. The client has many questions to ensure they are comfortable taking the med at home. If they do not understand how to take the med safely, they may not finish the full course of the med or know when to report any issues. Explain to the client the full glass of water is to prevent crystals to form in the kidneys. We taking with lots of water, this will prevent this from occurring. If the client already has diarrhea, find out their bowel patterns. If they experience abdominal pain, and the amount of diarrhea increases, becomes bloody or has pus in it, they need to report to the prescriber. This med can cause an increase in photosensitivity. They can certainly go outside, but try to avoid direct sunlight and wear sunscreen.

12.10 Fluoroquinolones

The nurse should immediately stop the medication and notify the provider regarding the new onset of tendon pain because this

symptom indicates an adverse reaction of levofloxacin may be occurring.

12.11 Macrolides

The nurse should notify the provider of the client's change in condition because it may indicate an adverse effect of liver damage is occurring. Anticipate liver panel that include AST, ALT, alk phosphate. The client may be switched off this med, or a lower dose and closer monitoring may be done.

12.12 Aminoglycosides

The nurse should not administer the medication until the trough levels have been drawn. The nurse should phone the lab and check on the status of the laboratory trough level.

12.13 Tetracyclines

1. The client is under the age of six and is at risk for the adverse effect of teeth discoloration. The nurse should advocate for this client by notifying the prescribing provider of this concern and requesting an alternate medication. If this med was doxycycline, and the infection responds best to this med, then a short course of the antibiotic can be prescribed and shown to have no adverse effects.

    2. a. Teaching points include to take the med on an empty stomach (1 hour before or 2 hours after a meal), avoid dairy

products, antacids and iron supplements, take with a full glass of water. These points will improve absorption. Also, to wait 30 minutes before lying down after taking the med to avoid irritation.

2.b. Milk (calcium) binds with tetracycline and reduces its absorption. It forms insoluble complexes with calcium, resulting in decreased effectiveness.

2.c. Risk of photosensitivity: Tetracycline can cause exaggerated sunburn reactions → advise sunscreen and protective clothing.

2.d. Tetracycline decreases the effects of birth control pills. This occurs due to the antibiotics alter the gut flora, affecting estrogen reabsorption. Always use a back up method while on antibiotics.

12.14 Vancomycin

1. The nurse should not administer the vancomycin until after the trough level is drawn. The nurse should call the lab to request prioritization of completing the trough level.
2. The nurse should monitor renal function due to risk of nephrotoxicity. The nurse should assess the client's urine to see if cloudy or pink, decreased urine output and abdominal pain. If the creatinine level is low, hold the dose and notify the prescriber.

12.15 Anti-virals

Oseltamivir should be administered within the first 24-48 hours of the onset of influenza symptoms. The client may have already passed the window for maximum therapeutic effectiveness of

oseltamivir. The provider should be notified regarding the onset of symptoms to clarify the prescription.

12.16 Anti-Fungals

If there are no signs of improvement from the prescribed medication therapy, the nurse should notify the provider. A stronger ointment may need to be prescribed. Before calling the prescriber, assess the area to determine if the area is getting larger, and document the appearance including redness, exudate, and pain. Ensure that the area is not being irritated by tight clothing and the area is cleaned and dried daily.

12.17 Anti-malarials

In order to prevent malaria, the CDC recommends clients should take antimalarial medications for a few days prior to entering the endemic area, once a day while there and then one week after leaving the endemic area. The client needs to understand the importance of taking the med every day and perhaps setting an alarm to remember. If adverse effect occur, such as diarrhea or nausea, they are usually mild and can be minimized by taking the med with food or a dairy drink. Discuss other preventative measures such as wearing DEET and wearing light coloured clothing.

12.18 Antiprotozoals

Metronidazole is commonly used to treat C-diff. The medication must be given by mouth for the GI infections. Recommend that

the client takes the meds with food to avoid GI upset. They may get a metallic taste in their mouth which can be minimized with practicing good oral hygiene. If they start to feel better, continue to take the entire prescription. Avoid alcohol while on this med at it interacts with the med and can cause nausea and vomiting and even seizures.

12.19 Anthelmintic

The nurse should provide education regarding the use of the medication, as well as ways to prevent re-infection. Methods to prevent reinfection include using proper handwashing, washing all fruits and vegetables, and wearing shoes in the barn or where animals and their feces are present.

12.20 Antituberculars

The nurse should explain that directly observed therapy (DOT) means the administration of this medication will be supervised to ensure all doses are taken as prescribed to be sure the infection is treated properly and drug resistance does not develop. The client will be required to visit a health-care facility to receive their medications or a health-care professional will administer the medication in the client's home or other designated location.

Glossary

adverse effects

An unintended pharmacological effect that occurs when a medication is administered correctly.

antagonistic interactions

Concurrent administration of two drugs causes harmful effects such as a decrease of drug activity, decreased therapeutic levels due to increased metabolism and elimination, or increased potential for toxicity due to decreased metabolism and elimination. An example of an antagonistic interaction is taking antacids with antibiotics, causing decreased absorption of the antibiotic.

autonomic nervous system

Controls cardiac and smooth muscle, as well as glandular tissue; associated with involuntary responses.

bactericidal

Antimicrobial drugs that kill their target bacteria.

bacteriostatic

Antimicrobial drugs that cause bacteria to stop reproducing but may not ultimately kill the bacteria.

broad-spectrum antimicrobial

An antibiotic that targets a wide variety of bacterial pathogens, including both gram-positive and gram-negative species.

central nervous system

culture

A test performed to examine different body substances for the presence of bacteria or fungus.

dose dependent

dose-dependent

A more significant response occurs in the body when the medication is administered in large doses to provide a large amount of medication to the site of infection for a short period of time.

eripheral nervous system

fight or flight response

gram + infection

Infections caused by Streptococcus and Staphylococcus bacteria are examples of gram + infection.

gram stain

A test used to quickly diagnose bacterial infection .Identification of bacteria as gram + or gram - assists the healthcare provider in selecting an appropriate antibiotic to treat the infection.

half-life

The rate at which 50% of a drug is eliminated from the bloodstream.

homeostasis

Balance between the SNS and PNS. At each target organ, dual innervation determines activity. For example, SNS stimulation

causes the heart rate to increase, whereas PNS stimulation causes the heart rate to decrease.

involuntary responses

Responses that the brain controls without the need for conscious thought.

medication

A drug that is considered medically therapeutic. Often medication and drug names are used interchangeably.

methicillin-resistant S. aureus (MRSA)

An infection caused by Methicillin-resistant Staphylococcus aureus that is difficult to treat because it exhibits resistance to nearly all available antibiotics.

motor neurons

Consist of the somatic nervous system that stimulates voluntary movement of muscles, and the autonomic nervous system that controls involuntary responses.

narrow-spectrum antimicrobial

An antibiotic that targets only specific subsets of bacterial pathogens.

neuroleptic malignant syndrome

neurons

Cells that carry electrical impulses to the synapse of a target organ.

Opioid naïve

Opioid naïve refers to a client who has either never had an

opioid or who has not received repeated opioid dosing for a 2 to 3 week period.

opioid tolerance

This is a state of adaptation in which exposure to a drug induces changes that result in a decrease in the drug's effect over time. It is a known pharmacologic effect of opioids.

opioid withdrawal

Opioid withdrawal occurs when an opioid is discontinued abruptly. Withdrawal symptoms last for a few days and include nausea, anxiety, restlessness, diaphoresis, tachycardia and drug craving.

parasympathetic division (PNS)

Includes nerves outside the brain and spinal cord. Associated with the "rest and digest" response. Stimulation of PNS causes decreased heart rate, decreased blood pressure via vasodilation, bronchial constriction, and stimulates intestinal motility, salivation, and relaxation of the bladder.

pathogen

An organism causing disease to its host.

peripheral nervous system

pharmacodynamics

The study of how drugs act at target sites of action in the body.

physiologic dependence

physiologic dependence is a physical condition caused by chronic use of a tolerance-forming drug, in which withdrawal symptoms are produced by abrupt cessation, rapid dose

reduction, decreasing blood level of the drug and / or administration of an antagonist. This can occur with any mu-opioids, GABA agonists or positive allosteric modulators of GABA-a or GABA-b.

preganglionic neurons

All preganglionic neurons (in the SNS and PNS) release acetylcholine (ACh).

resistance

A characteristic of bacteria demonstrating lack of effective treatment by an antibiotic when a sensitivity analysis is performed.

sensitivity analysis

A test performed in addition to a culture in order to select an effective antibiotic to treat the microorganism.

sensory neurons

Sense the environment and conduct signals to the brain that become a conscious perception of that stimulus.

side effects

The effects of a drug, other than the desired effect, sometimes in an organ other than the target organ.

somatic nervous system

Causes contraction of skeletal muscles; associated with voluntary responses.

steady state

steady state is when the rate of drug availability and elimination equal one another.

superinfection

A secondary infection in a patient having a preexisting infection. C diff and yeast infections as a result of antibiotic therapy are examples of superinfections.

Surface epithelium cells

Cells found within the lining of the stomach that secrete mucus as a protective coating.

sympathetic division (SNS)

Associated with the "fight or flight response." Stimulation causes the main effects of increased heart rate, increased blood pressure via the constriction of blood vessels, and bronchodilation.

synapse

The connection between the neuron and its target cell.

synergistic interaction

Concurrent drug administration producing a synergistic interaction that is better than the efficacy of either drug alone. An example of synergistic drug combinations is trimethoprim and sulfamethoxazole (Bactrim).

time dependent

Time dependency occurs when greater therapeutic effects are seen with lower blood levels over a longer period of time.

tolerance

This is a to the analgesic effects of opioids is relatively uncommon.

Total Daily Dose (TDD)

total daily dose is the 24 hour total of a drug that is taken for regular and breakthrough doses.

vancomycin-resistant S. aureus (VRSA)

An infection caused by Vancomycin-resistant Staphylococcus aureus that is difficult to treat because it exhibits resistance to nearly all available antibiotics.

Zollinger-Ellison syndrome

hypersecretory condition of the hormone gastrin due to a tumour of the pancreas or duodenum. Gastrin is the hormonal signal for increasing hydrochloric acid, so when with an increase in acid it overcomes protective defences, leading to multiple gastric and duodenal ulcers. Treatment is aggressive use of acid suppression drugs (Adams et al, 2018).

Versioning History

This page provides a record of changes made to this learning resource, Fundamentals of Nursing Pharmacology – 2nd Canadian Edition. Each update increases the version number by 0.1. The most recent version is reflected in the exported files for this resource.

Version History for Fundamentals of Nursing Pharmacology – 2nd Canadian Edition

Version	Date	Change	Details
1.00	April 2026	Book published by Thompson Rivers University, Open Press	This edition has been revised and expanded to better reflect Canadian nursing practice, contemporary pharmacological knowledge, and accessible, student-centred learning design. Updates include editorial revisions, structural reorganization, accessibility enhancements, and the integration of interactive and multimedia learning supports.

If you identify an error in this resource, please report it using the TRU Open Education Resource Error Form.

1st Canadian Edition of Fundamentals of Nursing Pharmacology:

Version	Date	Change	Details
1.00	2020	Book published by Chippewa Valley Technical College.	
2.00	January 12th, 2023	1st Canadian Edition published by BCcampus.	The text was completely revised to make it fit a British Columbia and Canadian context. This included reordering, renaming, adding, and removing chapters and sections as needed.