Nursing Pharmacology-2e

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OPEN RESOURCES FOR NURSING (OPEN RN)

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Introduction

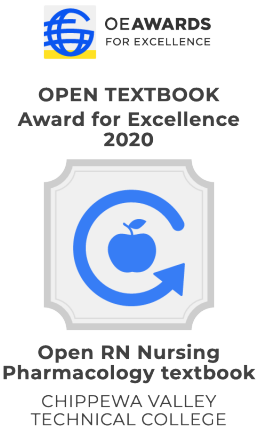
This is the second edition of the Open RN *Nursing Pharmacology* OER textbook. This free online textbook is an open educational resource with CC-BY 4.0 licensing that has been developed for prelicensure nursing students. Affordable print versions are published in collaboration with XanEdu and are available on Amazon or can be ordered by college bookstores. A free printable PDF version is also available for download on the Open RN website.

This edition has been updated according to the 2023 NCLEX-PN and NCLEX-RN Test Plans, and additional NCLEX Next Generation-style learning activities have been added to each chapter. It is aligned with the Wisconsin Technical College System (WTCS) statewide nursing curriculum for the Nursing Pharmacology course (543-103). View a list of updates in the second edition here.

This book introduces the principles of pharmacology and discusses classes of medications and their effects on the body. Emphasis is on the use of the nursing process to safely administer medications. This book is not intended to be used as a drug reference book. However, links are provided for prototype medications for each medication class to DailyMed, a trustworthy U.S. National Library of Medicine website, that contains detailed information about drugs marketed in the United States.

The Open RN project is supported by a $2.5 million grant from the Department of Education and is licensed under a Creative Commons Attribution 4.0 International License. However, these contents do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the federal government. More information about the Open RN project can be found at cvtc.edu/OpenRN.

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.



The following video provides a quick overview of how to navigate the online version.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=18#oembed-1

Preface

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- Medication Safety in High-Risk Situations by World Health Organization is licensed under CC BY-NC-SA 3.0.
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Standards and Conceptual Approach

The Open RN *Nursing Pharmacology 2e* textbook is based on several external standards and uses a conceptual approach.

External Standards

American Nurses Association (ANA)

The ANA establishes Standards for Professional Nursing Practice and the Nursing Code of Ethics.[1,2]

- American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association. https://www.nursingworld.org/ana/about-ana/standards/
- American Nurses Association. (2015). *Code of ethics for nurses with interpretive statements*. American Nurses Association. https://www.nursingworld.org/practice-policy/nursing-excellence/ethics/code-of-ethics-for-nurses

The National Council Licensure Examination for Registered Nurses: NCLEX-RN and NCLEX-PN Test Plans

The NCLEX-RN and NCLEX-PN test plans are updated every three years to reflect fair, comprehensive, current, and entry-level nursing competency.[3]

- https://www.ncsbn.org/nclex.htm

1. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
2. American Nurses Association. (2015). *Code of ethics for nurses with interpretive statements*. American Nurses Association. https://www.nursingworld.org/practice-policy/nursing-excellence/ethics/code-of-ethics-for-nurses/
3. NCSBN. (n.d.). *2023 NCLEX-RN test plan*. https://www.ncsbn.org/exams/testplans.page

The National League of Nursing (NLN): Competencies for Graduates of Nursing Programs

NLN competencies guide nursing curricula to position graduates in a dynamic health care arena with practice that is informed by a body of knowledge to help ensure the public receives safe, quality care.[4]

- https://www.nln.org/education/nursing-education-competencies/competencies-for-graduates-of-nursing-programs

American Association of Colleges of Nursing (AACN): The Essentials: Competencies for Professional Nursing Education

The AACN provides a framework for preparing individuals as members of the discipline of nursing, reflecting expectations across the trajectory of nursing education and applied experience.[5]

- https://www.aacnnursing.org/Portals/42/AcademicNursing/pdf/Essentials-2021.pdf

Quality and Safety Education for Nurses (QSEN) Institute: Prelicensure Competencies

Quality and safety competencies include knowledge, skills, and attitudes to be developed in nursing prelicensure programs. QSEN competencies include patient-centered care, teamwork and collaboration, evidence-based practice, quality improvement, safety, and informatics.[6]

- https://qsen.org/competencies/

Wisconsin State Legislature, Administrative Code Chapter N6

4. National League of Nursing. *Competencies for graduates of nursing programs*. https://www.nln.org/education/nursing-education-competencies/competencies-for-graduates-of-nursing-programs
5. American Association of Colleges of Nursing. (2021). *The essentials: Core competencies for professional nursing education*. https://www.aacnnursing.org/Portals/42/AcademicNursing/pdf/Essentials-2021.pdf
6. QSEN. (n.d.). *About*. https://qsen.org/about-qsen/

The Wisconsin Administrative Code governs the Registered Nursing and Practical Nursing professions in Wisconsin.[7]

- https://docs.legis.wisconsin.gov/code/admin_code/n/6

Healthy People 2030

Healthy People 2030 envisions a society in which all people can achieve their full potential for health and well-being across the life span. Healthy People provides objectives based on national data and includes social determinants of health.[8]

- https://health.gov/healthypeople

Conceptual Approach

The Open RN *Nursing Pharmacology 2e* textbook incorporates the following concepts:

- **Evidence-Based Practice.** Evidence-based practices are referenced by footnotes throughout the textbook. To promote the development of digital literacy, links are provided to credible, free online resources that supplement content. The Open RN series of textbooks will be updated on a three-year cycle in alignment with the release of updated NCLEX Test Plans.
- **Clinical Judgment.** Learning activities include case studies written to reflect verbiage by the NCSBN Clinical Judgment Measurement Model used on the NCLEX-RN. Formative assessments encourage students to recognize cues, analyze cues, prioritize hypotheses, generate solutions, take action, and evaluate outcomes.[9]

7. Wisconsin State Legislature. (2023). *Chapter 6: Standards of practice for registered nurses and licensed practical nurses.* Board of Nursing. https://docs.legis.wisconsin.gov/statutes/statutes/441
8. Healthy People 2030. (n.d.). *Social determinants of health*. U.S. Department of Health and Human Services. https://health.gov/healthypeople/objectives-and-data/social-determinants-health
9. Dickison, P., Haerling, K. A., & Lasater, K. (2019). Integrating the National Council of State Boards of Nursing clinical judgment model into nursing educational frameworks. *Journal of Nursing Education*. *58*(2), 72-78. https://doi.org/10.3928/01484834-20190122-03

- **Cultural Humility.** Nurses have an ethical obligation to practice with cultural humility and provide culturally responsive care to the clients and communities they serve based on the ANA Code of Ethics[10] and the ANA Scope and Standards of Practice.[11]
- **Safe, Quality, Patient-Centered Care.** Content reflects the priorities of safe, quality, patient-centered care.
- **Clear and Inclusive Language.** Clear language is used based on preferences expressed by prelicensure nursing students to enhance understanding of complex concepts.[12] "They" is used as a singular pronoun to refer to a person whose gender is unknown or irrelevant to the context of the usage, as endorsed by APA style. It is inclusive of all people and helps writers avoid making assumptions about gender.[13]
- **Open-Source Images and Fair Use.** Images are included to promote visual learning. Students and faculty can reuse open-source images by following the terms of their associated Creative Commons licensing. Some images are included based on Fair Use as described in the "Code of Best Practices for Fair Use and Fair Dealing in Open Education" presented at the OpenEd 2020 conference. Refer to the footnotes of images for source and licensing information throughout the text.
- **Open Pedagogy.** Students are encouraged to contribute to the Open RN project in meaningful ways by reviewing content for clarity and assisting in the creation of open-source images.[14]

Supplementary Material Provided

Several supplementary resources are provided with this textbook.

10. American Nurses Association. (2015). *Code of ethics for nurses with interpretive statements*. American Nurses Association. https://www.nursingworld.org/practice-policy/nursing-excellence/ethics/code-of-ethics-for-nurses/
11. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
12. Verkuyl, M., Lapum, J., St-Amant, O., Bregstein, J., & Hughes, M. (2020). Healthcare students' use of an e-textbook open educational resource on vital sign measurement: A qualitative study. *Open Learning: The Journal of Open, Distance and e-Learning*. https://doi.org/10.1080/02680513.2020.1835623
13. American Psychological Association. (2021). *Singular "they."* https://apastyle.apa.org/style-grammar-guidelines/grammar/singular-they
14. The Open Pedagogy Notebook by Steel Wagstaff is licensed under CC BY 4.0

- Supplementary, free videos promote student understanding of how to perform procedures.
- Online, interactive, and written learning activities provide formative feedback.
- Critical thinking questions encourage the development of clinical judgment as students apply content to realistic patient scenarios.
- Free downloadable textbook versions are available for offline use.
- Affordable soft cover print versions are published by XanEdu and available on Amazon and in college bookstores.

PART I

PHARMACOKINETICS & PHARMACODYNAMICS

1.1 Pharmacokinetics & Pharmacodynamics Introduction

Learning Objectives

- Discuss the processes of pharmacokinetics
- Use multiple professional resources, including technology, to identify pertinent information related to drugs
- Describe the processes of pharmacodynamics
- Consider pharmacodynamic differences across the life span
- Differentiate among prescription drugs, over-the-counter drugs, herbals, and dietary supplements

Safe medication administration is a vital component of the nursing role. Every day, nurses make critical decisions regarding the safety, appropriateness, and effectiveness of the medications administered to their clients. Examples of decisions that a nurse might make during client care are as follows:

- 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?

To make safe decisions regarding medication administration, the nurse must have a strong understanding of **pharmacology**, the science dealing with actions of drugs on the body. Symptom management and a client's overall well-being are strongly connected to the appropriate administration of medications prescribed in a client's treatment plan. Before a student nurse reviews a medication order, checks a medication administration record, or removes a medication from a dispensing machine, it is essential to have a foundational understanding of how medications interact with the human body. This chapter will review basic concepts related to pharmacokinetics and pharmacodynamics.

1.2 Pharmacokinetics

Pharmacokinetics – Examining the Interaction of Body and Drug

Overview

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 a medication goes through within the human body: absorption, distribution, metabolism, and excretion. This entire process is sometimes abbreviated **ADME**.

Absorption is the first stage of pharmacokinetics and occurs after medications enter the body and travel from the site of administration into the body's circulation. **Distribution** is the second stage of pharmacokinetics. It is the process by which medication is spread throughout the body. **Metabolism** is the third stage of pharmacokinetics and involves the breakdown of a drug molecule. **Excretion** is the final stage of pharmacokinetics and refers to the process in which the body eliminates waste. Each of these stages is described separately in the following sections of this chapter.

Research scientists who specialize in pharmacokinetics must also pay attention to another dimension of drug action within the body: time. Scientists do not have the ability to visualize 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 represent 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.

Pharmacodynamics refers to the effects of drugs in the body and the mechanism of their action. As a drug travels through the bloodstream, it exhibits a unique **affinity** for a drug-receptor site, meaning how strongly it binds to the site. Drugs and receptor sites create a lock and key system (see Figure 1.1[1]) that affect how drugs work and the presence of a drug in the bloodstream after it is administered. This concept is broadly termed as drug **bioavailability**.

The bioavailability of drugs is an important feature that chemists and pharmaceutical scientists keep in mind when designing and packaging medicines. However, no matter how effectively a drug works in a laboratory simulation, the performance in the human body will not always produce the same results, and individualized responses to drugs have to be considered. Although many responses to medications may be anticipated, a person's unique genetic makeup may significantly impact their response to a drug. **Pharmacogenetics** is defined as the study of how people's genes affect their response to medicines.[2]

1. "Drug and Receptor Binding" by Dominic Slausen at Chippewa Valley Technical College is licensed under CC BY 4.0
2. This work is a derivative of Medicines by Design by US Department of Health and Human Services, National Institutes of Health, National Institute of General Medical Sciences and is available in the Public Domain.

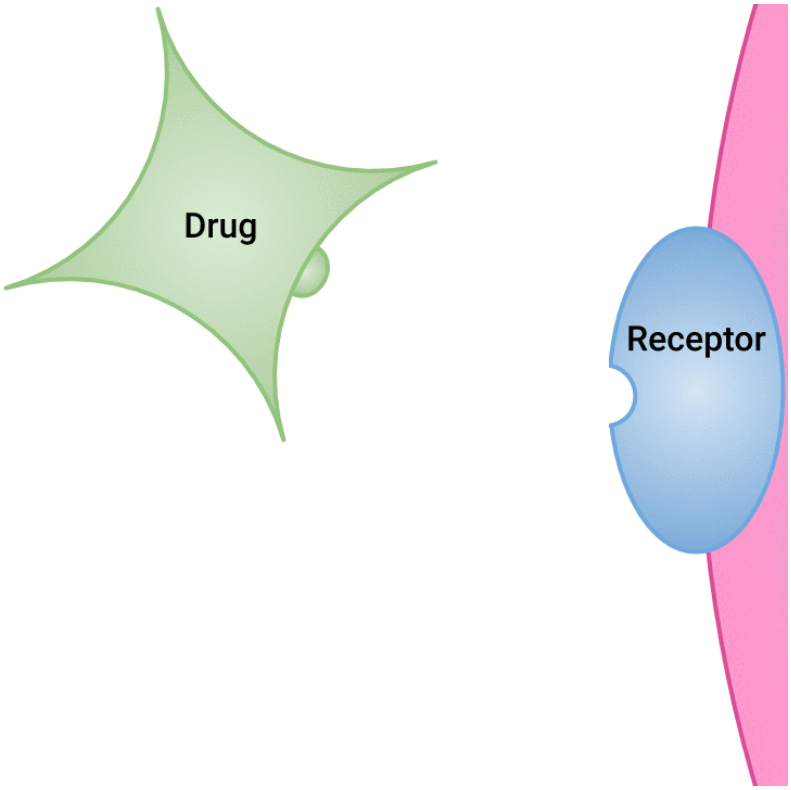

Figure 1.1 Pharmacodynamics: Drug and Receptor Binding

1.4 Distribution

Distribution

The second stage of pharmacokinetics is the process known as **distribution**. Distribution is the process by which a drug is dispersed throughout the body's blood and tissues. After a drug enters into systemic circulation by absorption or direct administration, it will pass from vascular spaces to tissues where a drug-receptor interaction will occur, creating the effect of the drug.

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 and adverse effects can occur when the drug binds to other sites in addition to the target tissue, causing an unintended action. These side effects can range from tolerable to unacceptable and can result in the discontinuation of the medication. For example, a person might take the pain reliever ibuprofen (Advil) to treat a sore leg muscle, and the pain may be subsequently relieved, but there may also be stomach irritation as a side effect.

The distribution of a drug throughout the body is dependent on many body-related factors such as blood flow, tissue differences, plasma protein-binding, the blood-brain barrier, and the placental barrier.

Blood Flow

The circulatory system transports medications throughout the body in the bloodstream. Many factors can affect the blood flow and delivery of medication, such as decreased blood flow (due to dehydration), blocked vessels (due to atherosclerosis), constricted vessels (due to uncontrolled hypertension), or weakened pumping by the heart muscle (due to heart failure). As an example, when administering an antibiotic to a client with diabetes who has an infected toe, it may be difficult for the antibiotic to move through the blood vessels all the way to the area of the toe that is infected because of blocked vessels in the legs and feet due to atherosclerosis.

Tissue Differences

Distribution occurs most rapidly into tissues with a greater number of blood vessels that allow high blood flow (such as the lungs, kidneys, liver, brain). Distribution occurs least rapidly in tissues with fewer numbers of blood vessels (such as fat), resulting in low blood flow. However, lipophilic drugs (i.e., drugs that dissolve in lipid environments) disproportionately distribute into adipose tissue in obese subjects.

The permeability of capillaries is tissue-dependent. Capillaries of the liver and kidney are porous, allowing for greater permeability. Distribution rates are relatively slower or nonexistent into the central nervous system because of the tight junction between capillary endothelial cells and the blood-brain barrier.

Protein-Binding

After a drug enters the bloodstream, a portion of it exists as free drug, dissolved in plasma water, but a portion of it becomes bound to proteins. This is important because only free and unbound drugs will pass from the bloodstream to tissues where drug-receptor interactions will occur, thus producing the first effects of a medication. The other portion of the drug that becomes "protein-bound" is inactive while it is bound. For many drugs, these bound forms can account for 95-98% of the total.[1]

Protein binding can also act as a reservoir as the drug is released slowly, causing a prolonged action. When considering drug distribution, it is important to consider both the amount of free drug that is readily available to tissues, as well as the protein binding that causes the drug to be released over time.

Albumin is one of the most important proteins in the blood. Albumin levels can be decreased by several factors such as malnutrition and liver disease. Therefore, clients with low albumin levels may experience differences in the

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desired actions of administered medication because of the consequence effect on protein-binding and distribution.

Competition for plasma binding can also impact the effects of drugs. For example, aspirin and warfarin are anticoagulants that compete for the same plasma protein-binding site. Administering both drugs at the same time will increase the amount of unbound drug, thereby increasing their effects and increasing the client's risk for bleeding.[2]



Figure 1.4 Protein-Binding Like Available Seats on a Bus

As an analogy of how protein binding affects the distribution of medications, consider passengers at a bus stop going to their destination. See Figure 1.4[3] for an image of a bus related to this analogy. Many passengers (i.e., drug molecules) want to take a ride on the bus. Everyone is eager to get to their destination (i.e., receptor sites) and tries to find a seat. Some passengers are stronger than others and take all the seats first (such as drug molecules with greater protein-binding ability). When there aren't enough seats on the bus, some passengers are left at the bus stop and become "free" to move around or walk to their destination. In a similar way, "free" drug molecules that are not protein-bound circulate freely in the bloodstream. The "free" passengers in this analogy may go directly to their destination, or they may stop at other locations along the route. In a similar manner, "free" drug molecules produce the first intended or unintended effects in the body when they attach to receptors. Furthermore, similar to the passengers who had seats on the bus

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3. "Renault Type r321 Service Bus" by Emslichter is licensed under CC0 1.0

and then later got off at their destination, the medication molecules attached to proteins are eventually released and attach to the receptor sites.

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**. This blockade is built from a tightly woven mesh of capillaries that protect the brain from potentially dangerous substances, such as poisons or viruses. Only certain medications made of lipids (fats) or those with a "carrier" can get through the blood-brain barrier.

Scientists have devised ways for medications to penetrate the blood-brain barrier. For example, the brand-named medication Sinemet® is a combination of two drugs: carbidopa and levadopa. Carbidopa is designed to carry the levadopa medication across the blood-brain barrier, where it enters the brain and is converted into dopamine to exert its effect on symptoms related to Parkinson's disease.

Some medications inadvertently bypass the blood-brain barrier and impact an individual's central nervous system function as a side effect. For example, diphenhydramine is an antihistamine used to decrease allergy symptoms. However, it can also cross the blood-brain barrier, 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 a person trying to carry out daily activities, drowsiness can be problematic.

Placental Barrier

The placenta links mother and fetus, and the blood-placental barrier regulates transfer of molecules between maternal and fetal circulation to protect the fetus. Drug transporters are involved in transport of drugs

through the placenta, affecting potential drug distribution to the fetus.[4] The placenta is known to be permeable to some medications, and furthermore, some drugs can cause significant harm to the fetus. However, many medications have not been specifically studied in pregnant clients and their effects on the fetus are unknown.

For this reason, it is always important to consider the potential effects of medication on the fetus if it is administered to a client who is pregnant or who may become pregnant. Nurses play a critical role in notifying the health care provider regarding potential safety concerns if medication can be distributed to the fetus. Nurses must always check a recent, evidence-based drug reference before administering medications to a client who is pregnant or may become pregnant. This imperative is implied in the remaining chapters.

Life Span Considerations

NEONATE & PEDIATRIC

Fat content in infants and children is decreased because of greater total body water. Additionally, protein-binding capacity is decreased, and the developing blood-brain barrier allows more drugs to enter the central nervous system.[5]

OLDER ADULT

At the same body mass index, older adults, on average, tend to have more body fat than younger adults. This increased body fat can result in a longer duration of action for many medications that accumulate in fatty tissues. Serum albumin also decreases, resulting in more active free drug circulating

4. Liu, L., & Liu, X. (2019). Contributions of drug transporters to blood-placental barrier. *Advances in Experimental Medicine and Biology,* 1141, 505–548. https://doi.org/10.1007/978-981-13-7647-4_11
5. Fernandez, E., Perez, R., Hernandez, A., Tejada, P., Arteta, M., & Ramos, J. T. (2011). Factors and mechanisms for pharmacokinetic differences between pediatric population and adults. *Pharmaceutics, 3*(1), 53–72. https://doi.org/10.3390/pharmaceutics3010053

within the body. For these reasons related to distribution, many older adult clients require lower dosages of medication.[6]

6. Fernandez, E., Perez, R., Hernandez, A., Tejada, P., Arteta, M., & Ramos, J. T. (2011). Factors and mechanisms for pharmacokinetic differences between pediatric population and adults. *Pharmaceutics, 3*(1), 53–72. https://doi.org/10.3390/pharmaceutics3010053

1.3 Absorption

Absorption

The first stage of pharmacokinetics is known as **absorption**. Absorption occurs after drugs enter the body and travel from the site of administration into the body's circulation. Medications can enter the body through various routes. Common routes to administer medications include the following examples:

- Oral (swallowing an aspirin tablet)
- Enteral (administering medication into the gastrointestinal tract via a nasogastric tube)
- Rectal (administering an acetaminophen suppository)
- Intranasal (spraying allergy medication into the nose)
- Inhalation (breathing in asthma medication from an inhaler)
- Intramuscular (injecting an influenza vaccine into the deltoid muscle)
- Subcutaneous (injecting insulin into the subcutaneous tissue in the abdomen)
- Transdermal (wearing a nicotine patch that is absorbed through the skin)
- Intravenous (administering antibiotics directly into a vein)

First-Pass Effect

When a medication is administered orally or enterally, absorption may be significantly hindered in the gastrointestinal (GI) tract. For example, when medications made of protein are introduced into the GI tract, they can be quickly deactivated by enzymes as they pass through the stomach and duodenum. If some of the drug is absorbed from the intestine into the bloodstream, part of the absorbed portion may be broken down by liver enzymes, whereas the remaining part escapes into the general circulation. The portion of the drug that enters the general circulation will either become protein-bound (and thus inactive) or remain free to circulate and create an

action at a receptor site. This entire process that results in reduced concentration of active drug available in an individual's circulation is known as the **first-pass effect**. Due to the first-pass effect, prescribing providers and nurses administering medications must 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. These metabolic effects are further described in the "Metabolism" section later in this chapter.

Alternate Routes

A workaround to the first-pass effect is to administer medication using alternate routes to the GI tract. Examples of alternative routes that avoid the first-pass effect include transdermal, nasal, inhalation, injection, or intravenous administration of medication. Alternative routes of medication administration bypass the first-pass effect by entering the bloodstream directly or via absorption through the skin or lungs. For example, pain relievers may be administered directly into the bloodstream (referred to as intravenous medications) so they are quickly available for distribution to tissues within the body.

Alternative routes of medication have other potential considerations. For example, injections are often painful and cause a break in the skin, an important barrier to infection. They can also be costly and difficult to administer daily, may cause localized side effects, or contribute to unpredictable fluctuations in medication blood levels.

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 1.2[1] for an image of a client self-administering a transdermal patch. Drugs delivered transdermally enter the blood via a meshwork of small arteries, veins, and capillaries in the skin. This makes the transdermal route of drug delivery particularly useful when a medication must be administered over a longer period of time to control symptoms. For example, transdermal application of fentanyl, a pain

1. "Applying transdermal patch.jpg" by British Columbia Institute of Technology (BCIT) is licensed under CC BY 4.0

medication, can provide effective pain management over a several hours; a scopolamine patch can control motion sickness over the duration of a cruise ship vacation; and a nitroglycerin patch is used to prevent chronic chest pain. Despite their advantages, transdermal patches have a significant drawback in that only very small drug molecules can enter the body through the skin, making this application route inappropriate for some types of medications.



Figure 1.2 Applying Transdermal Patch

Inhaling drugs through the nose or mouth is another alternative route for rapid medication delivery that bypasses the liver. See Figure 1.3 for an image of a client self-administering an inhaler.[2] 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.

2. "Adult Using Asthma Inhaler" by NIAID is licensed under CC BY 2.0



Figure 1.3 Adult Using Inhaler

EMERGING DISCOVERIES AND RECENT DEVELOPMENTS

Researchers are currently exploring alternative methods of drug delivery such as the use of inhaled insulin powders. Afrezza® is an example of an inhaled insulin approved by the Food and Drug Administration (FDA) to assist with blood sugar control. This technology stems from novel uses of chemistry and engineering to manufacture insulin particles of just the right size for absorption. If too large, the insulin particles could lodge in the lungs; if too small, the particles will be exhaled.[3]

Life Span Considerations

NEONATE & PEDIATRIC

Gastric absorption in neonates and pediatric clients varies from adults. In infants, the acid-producing cells of the stomach are immature until around the age of one to two years. Additionally, gastric emptying may be decreased because of slowed or irregular peristalsis (coordinated muscle movements of the intestines).

The liver of infants and children is not fully mature, resulting in a decrease in

3. This work is a derivative of Medicines by Design by US Department of Health and Human Services, National Institutes of Health, National Institute of General Medical Sciences and is available in the Public Domain.

first-pass elimination and subsequently higher drug levels in the bloodstream.[4]

OLDER ADULT

As a natural result of aging, older adults will experience decreased blood flow to tissues within the GI tract. In addition, there may be changes in the gastric (stomach) pH that may alter the absorption of certain medications. Older adult clients may also experience variations in available plasma proteins, which can impact drug levels of medications that are highly protein-bound.

Consideration must also be given to the use of subcutaneous and intramuscular injections in older clients experiencing decreased cardiac output because decreased drug absorption of medications can occur when peripheral circulation is decreased. Additionally, as adults age, they often have less subcutaneous fat, resulting in decreased absorption of medication from transdermal patches that require adequate subcutaneous fat stores for proper absorption.[5]

The box below summarizes route considerations that a nurse should consider when administering medication.

Route Considerations

Oral (PO) or Enteral (NGT, GT, OGT) Ingestion

- Oral route is a convenient route for administration of solid and liquid formulations.
- Additional variables that may influence the rate and

4. Fernandez, E., Perez, R., Hernandez, A., Tejada, P., Arteta, M., & Ramos, J. T. (2011). Factors and mechanisms for pharmacokinetic differences between pediatric population and adults. *Pharmaceutics, 3*(1), 53–72. https://doi.org/10.3390/pharmaceutics3010053
5. Fernandez, E., Perez, R., Hernandez, A., Tejada, P., Arteta, M., & Ramos, J. T. (2011). Factors and mechanisms for pharmacokinetic differences between pediatric population and adults. *Pharmaceutics, 3*(1), 53–72. https://doi.org/10.3390/pharmaceutics3010053

extent of absorption include enteric coating or extended-release formulations, acidity of gastric contents, gastric emptying rate, dietary contents, and presence of 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).

Parenteral Injection

- Subcutaneous and intramuscular administration: Injections can be difficult for clients to self-administer at home or to administer on a daily basis. They can be costly and painful. Injections also cause a break in skin that is an important barrier to infection, can cause fluctuation in drug levels, and can cause localized side effects to skin, such as bruising, redness, bleeding, and swelling.
- Intravenous (IV): IV drugs are fully available to tissues after administration into the bloodstream, offering complete bioavailability and an immediate effect. However, this route requires intravenous access that can be painful to the client and also increases risk for infection. Medications must be administered in sterile fashion, and if two products are administered simultaneously, their compatibility must be verified. There is also an increased risk of toxicity to the kidneys or liver.

Pulmonary Inhalation

- Inhalation allows for rapid absorption of drugs in gaseous, vaporized, or aerosol form through the lung tissue.
- 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.

Topical and Transdermal Application

- Topical creams, lotions, and ointments are generally used for local effect; transdermal patch formulations are used for systemic effect.
- Absorption through the buccal or sublingual membranes may be rapid and is used for systemic effect.
- Absorption through skin is generally slower but produces a steady, long-term effect that avoids the first-pass effect. However, absorption of medication is affected by blood flow to the skin.[6] For this reason, heat and cold applications should not be used over transdermal medications.

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1.5 Metabolism

Metabolism

After a drug has been absorbed and distributed throughout the body, it is broken down by a process known as **metabolism** so that it can be excreted from the body. Drugs undergo chemical alteration by various body systems to create compounds that are more easily excreted.

As previously discussed in this chapter, medications that are swallowed or otherwise administered into the gastrointestinal tract are inactivated by the intestines and liver, known as the first-pass effect. Additionally, everything that enters the bloodstream, whether swallowed, injected, inhaled, absorbed through the skin, or produced by the body itself, is metabolized by the liver. See Figure 1.5[1] for an image of the liver. These chemical alterations are known as biotransformations. The biotransformations that take place in the liver are performed by liver enzymes.

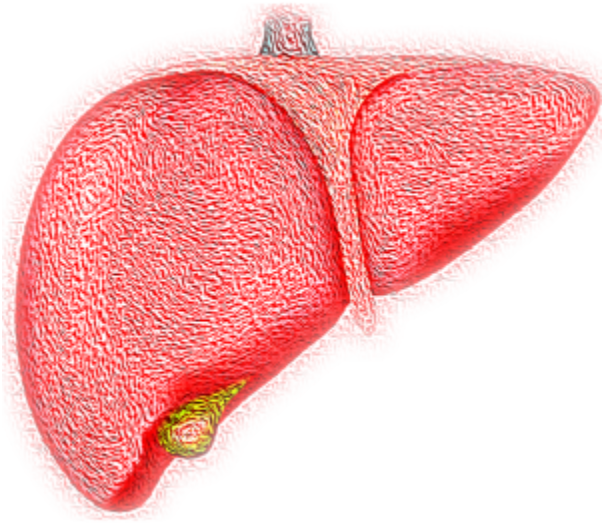

Figure 1.5 Liver

1. "Liver Hepatic Organ Jaundice Bile Fatty Liver - Liver" by VSRao is licensed under CC0

Biotransformations occur by mechanisms categorized as either Phase I (modification), Phase II (conjugation), and in some instances, Phase III (additional modification and excretion.)[2]

Phase I biotransformations alter the chemical structure of the drug. Many of the products of enzymatic breakdown, called metabolites, are less chemically active than the original molecule. For this reason, the liver is referred to as a "detoxifying" organ. An example of a Phase I biotransformation is when diazepam, a medication prescribed for anxiety, is transformed into desmethyldiazepam and then to oxazepam. Both these metabolites produce similar physiological and psychological effects of diazepam.[3]

In some instances, Phase I biotransformations change an inactive drug into an active form called a "prodrug." Prodrugs improve a medication's effectiveness. They may also be designed to avoid certain side effects or toxicities. For example, sulfasalazine is a medication prescribed for rheumatoid arthritis. It is prodrug that is not active in its ingested form but becomes active after Phase I modification.

Phase II biotransformations involve reactions that couple the drug molecule with another molecule in a process called conjugation. Conjugation typically renders the compound pharmacologically inert and water-soluble so it can be easily excreted. These processes can occur in the liver, kidney, lungs, intestines, and other organ systems. An example of Phase II metabolism is when oxazepam, the active metabolite of diazepam, is conjugated with a molecule called glucuronide so that it becomes physiologically inactive and is excreted without further chemical modification.[4]

Following Phase II metabolism, Phase III biotransformations may also occur, where the conjugates and metabolites are excreted from cells.[5]

Factors Affecting Metabolism

Critical factors in drug metabolism are the type and concentration of liver

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4. This work is a derivative of StatPearls by Susa, Hussain, and Preuss and is licensed under CC BY 4.0
5. This work is a derivative of StatPearls by Susa, Hussain, and Preuss and is licensed under CC BY 4.0

enzymes. The most important enzymes for medical purposes are monoamine oxidase and cytochrome P450. These two enzymes are responsible for metabolizing dozens of chemicals.[6]

Drug metabolism can be influenced by a number of factors. One major disruptor of drug metabolism is depot binding. Depot binding is the coupling of drug molecules with inactive sites in the body, resulting in the drug not being accessible for metabolism. This action can also affect the duration of action of other medications susceptible to depot binding. For example, tetrahydrocannabinol (THC), the main psychoactive component of marijuana, is highly lipid-soluble and depot binds in the adipose tissue of users. This interaction drastically slows the metabolism of the drug, so metabolites of THC can be detected in urine weeks after the last use.[7]

Another factor in drug metabolism is enzyme induction. Enzymes are induced by repeated use of the same drug. The body becomes accustomed to the constant presence of the drug and compensates by increasing the production of the enzyme necessary for the drug's metabolism. This contributes to a condition referred to as tolerance and causes clients to require ever-increasing doses of certain drugs to produce the same effect. For example, clients who take opioid analgesics over a long period of time will notice that their medication becomes less effective over time.[8]

In contrast, some drugs have an inhibitory effect on enzymes, making the client more sensitive to other medications metabolized through the action of those enzymes. For example, monoamine oxidase inhibitors (MAOIs) are prescribed as antidepressants because they block monoamine oxidase, the enzyme that breaks down serotonin and dopamine, thus increasing the concentration of these chemicals in the central nervous system. However, this can cause problems when clients taking an MAOI also take other medications that increase the levels of these chemicals, such as dextromethorphan found in cough syrup.[9]

Additionally, drugs that share metabolic pathways can "compete" for the

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7. This work is a derivative of StatPearls by Susa, Hussain, and Preuss and is licensed under CC BY 4.0
8. This work is a derivative of StatPearls by Susa, Hussain, and Preuss and is licensed under CC BY 4.0
9. This work is a derivative of StatPearls by Susa, Hussain, and Preuss and is licensed under CC BY 4.0

same binding sites on enzymes, thus decreasing the efficiency of their metabolism. For example, alcohol and some sedatives are metabolized by the cytochrome P450 enzyme and only a limited number of these enzymes exist to break these drugs down. Therefore, if a client takes a sedative after drinking alcohol, the sedative is not well-metabolized because most of cytochrome P450 enzymes are filled by alcohol molecules. This results in reduced excretion and high levels of both drugs in the body with enhanced effects. For this reason, the co-administration of alcohol and sedatives can be deadly.

Clinical Significance

When administering medication, nurses must know how and when the medication is metabolized and eliminated from the body. Most of the time, the rate of elimination of a drug depends on the concentration of the drug in the bloodstream. However, the elimination of some drugs occurs at a constant rate that is independent of plasma concentrations. For example, the ethanol contained in alcoholic beverages is eliminated at a constant rate of about 15 mL/hour regardless of the concentration in the bloodstream.[10]

HALF LIFE

Half-life refers to the rate at which 50% of a drug is eliminated from the body. Half-life can vary significantly between drugs. Some drugs have a short half-life of only a few hours and must be given multiple times a day, whereas other drugs have half-lives exceeding 12 hours and can be given as a single dose every 24 hours. See Figure 1.6[11] for an illustration of half-life affecting the blood concentration of medication over time.

10. This work is a derivative of StatPearls by Susa, Hussain, and Preuss and is licensed under CC BY 4.0
11. "Concentration_vs_number_of_half-life_periodes.png" by OPPSD is licensed under CC BY-SA 3.0

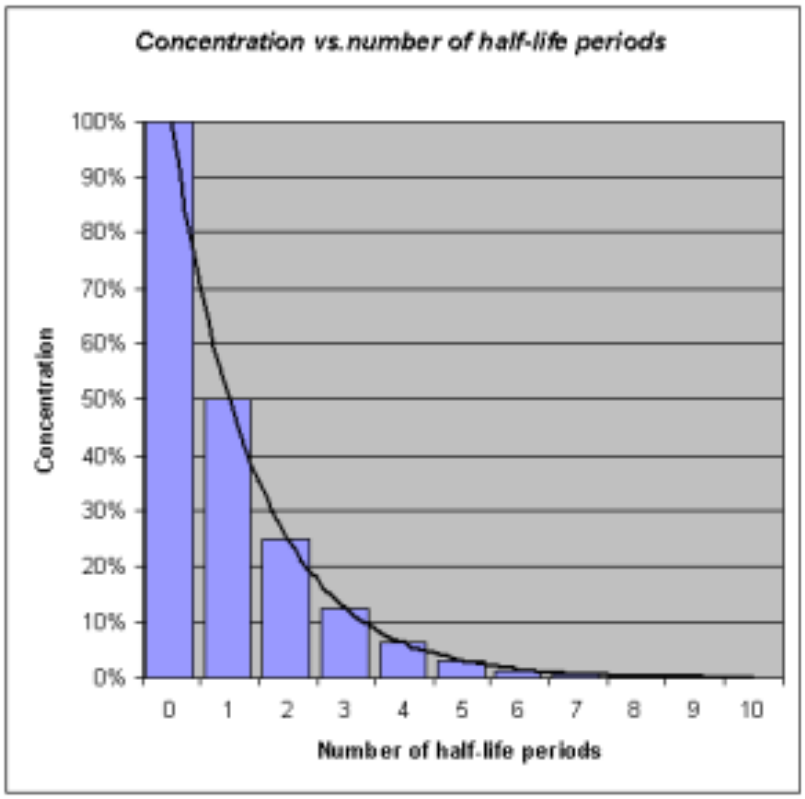

Figure 1.6 Half-Life Affecting Blood Concentration of Medication Over Time

Half-life affects the duration of the therapeutic effect of a medication. Many factors can influence half-life. For example, liver disease can prolong half-life if it is no longer effectively metabolizing the medication. Information about half-life of a specific medication can be found in evidence-based medication references. For example, in the "Clinical Pharmacology" section of the DailyMed reference for furosemide, the half-life is approximately two hours.

Depending on whether a drug is metabolized and eliminated by the kidneys or liver, impairment in either of these systems can significantly alter medication dosing, frequency of doses, anticipated therapeutic effect, and even whether a particular medication can be used at all. Nurses must work with other members of the health care team to prevent drug interactions that could significantly affect a client's health and well-being. Nurses must be alert for signs of a toxic buildup of metabolites or active drugs, particularly if the client has liver or kidney disease, so that they can alert the health care

provider. In other cases, drugs such as warfarin and certain antibiotics are dosed and monitored by pharmacists, who monitor serum levels of the drugs, as well as kidney function.

Life Span Considerations

NEONATE & PEDIATRIC

The developing liver in infants and young children produces decreased levels of enzymes. This may result in a decreased ability of the young child or neonate to metabolize medications. In contrast, older children may experience increased metabolism and require higher doses of medications once the hepatic enzymes are fully produced.[12]

OLDER ADULT

Metabolism by the liver may significantly decline in the older adult. As a result, dosages should be adjusted according to the client's liver function and their anticipated metabolic rate. First-pass metabolism also decreases with aging, so older adults may have higher "free" circulating drug concentrations and thus be at higher risk for side effects and toxicities.[13]

12. Fernandez, E., Perez, R., Hernandez, A., Tejada, P., Arteta, M., & Ramos, J. T. (2011). Factors and mechanisms for pharmacokinetic differences between pediatric population and adults. *Pharmaceutics, 3*(1), 53–72. https://doi.org/10.3390/pharmaceutics3010053
13. Fernandez, E., Perez, R., Hernandez, A., Tejada, P., Arteta, M., & Ramos, J. T. (2011). Factors and mechanisms for pharmacokinetic differences between pediatric population and adults. *Pharmaceutics, 3*(1), 53–72. https://doi.org/10.3390/pharmaceutics3010053

Critical Thinking Activity 1.5

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

When caring for a client with cirrhosis, how can this condition impact the dosages prescribed?

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

Did You Know?

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.

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, 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 felodopine at various times afterward. The team observed that both grapefruit juice and sour orange juice increased blood levels of felodopine, 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.[14]



"Grapefruit" by ExplorerBob is licensed under CC0

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1.6 Excretion

Excretion

Excretion is the final stage of a medication interaction within the body. The body has absorbed, distributed, and metabolized the medication molecules – now what does it do with the leftovers? Remaining parent drugs and metabolites in the bloodstream are often filtered by the kidney, where a portion undergoes reabsorption back into the bloodstream, and the remainder is excreted in the urine. The liver also excretes byproducts and waste into the bile. Another potential route of excretion is the lungs. For example, drugs like alcohol and the anesthetic gases are often eliminated by the lungs.[1]

Routes of Excretion

Kidney

The most common route of excretion is through the kidneys. As the kidneys filter blood, the majority of drug byproducts and waste are excreted in the urine. The rate of excretion can be estimated by taking into consideration several client factors, including age, weight, biological sex, and kidney function. There are known sex differences in the three main renal functions of glomerular filtration, tubular secretion and tubular reabsorption. Renal clearance is generally higher in men than in women.[2]

Kidney function is measured by lab values such as serum creatinine, glomerular filtration rate (GFR), and creatinine clearance. If a client's kidney function is decreased, then their ability to excrete medication is affected, and drug dosages must be altered for safe administration.

1. This work is a derivative of Principles of Pharmacology by LibreTexts and is licensed under CC BY-NC-SA 4.0
2. Soldin, O. P., & Mattison, D. R. (2009). Sex differences in pharmacokinetics and pharmacodynamics. *Clinical Pharmacokinetics, 48*(3), 143–157. https://doi.org/10.2165/00003088-200948030-00001

Renal disorders, such as chronic kidney disease, can reduce kidney function and hinder drug excretion. As kidney function decreases with age, drug excretion becomes less efficient, and dosing adjustments may be needed. Other medical conditions that impact blood flow to the kidneys can also affect drug elimination. For example, heart failure can affect systemic blood flow to the kidney, resulting in decreased filtration and elimination of drugs.

Liver

As the liver filters blood, some drugs and their metabolites are actively transported by hepatocytes (liver cells) to bile. Bile moves through the bile ducts to the gallbladder and then on to the small intestine. During this process, 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 in the feces.

If a client has decreased liver function, their ability to excrete medication is affected, and drug dosages must be adjusted. Lab studies used to evaluate liver function are called liver function tests and include measurement of alanine transaminase (ALT) and aspartate aminotransferase (AST) enzymes that the body releases in response to damage to or disease of the liver.

Conditions that cause decreased blood flow to the liver can also affect the metabolism and excretion of drugs. For example, conditions such as shock, hypovolemia, or hypotension cause decreased liver perfusion and may require adjustment of dosages of medication.

Other Routes to Consider

Sweat, tears, reproductive fluids (such as seminal fluid), and breast milk can also contain drugs and byproducts/metabolites of drugs. This can pose a toxic threat, such as the exposure of an infant to breast milk containing drugs or byproducts of drugs ingested by the mother. Therefore, nurses must refer to a

drug reference and contact a health care provider with any concerns before administering medications to a mother who is breastfeeding.[3]

Life Span Considerations

Neonate & Pediatrics

Neonates and children have immature kidneys with decreased glomerular filtration, resorption, and tubular secretion. As a result, they do not excrete medications as efficiently from the body. Dosing for most medications used to treat infants and pediatric clients is commonly based on weight in kilograms, and a smaller dose is usually prescribed. In addition, pediatric clients may have higher levels of free circulating medication than anticipated and may become toxic quickly. Therefore, it is vital for nurses to diligently recheck dosages before administering medications and closely monitor infants and children for early identification of adverse effects and drug toxicity.[4]

Older Adult

Kidney and liver function often decrease with age, which can lead to decreased metabolism and excretion of medications. Subsequently, medication may have a prolonged half-life with a greater potential for toxicity due to elevated circulating drug levels. Some medications may be avoided or smaller doses recommended for older clients due to these factors, which is commonly referred to as "Start low and go slow."[5]

3. This work is a derivative of Principles of Pharmacology by LibreTexts and is licensed under CC BY-NC-SA 4.0
4. Fernandez, E., Perez, R., Hernandez, A., Tejada, P., Arteta, M., & Ramos, J. T. (2011). Factors and mechanisms for pharmacokinetic differences between pediatric population and adults. *Pharmaceutics, 3*(1), 53–72. https://doi.org/10.3390/pharmaceutics3010053
5. Fernandez, E., Perez, R., Hernandez, A., Tejada, P., Arteta, M., & Ramos, J. T. (2011). Factors and mechanisms for pharmacokinetic differences between pediatric population and adults. *Pharmaceutics, 3*(1), 53–72. https://doi.org/10.3390/pharmaceutics3010053

Putting It All Together

Safely administering medications to clients is a significant concern and requires team effort by pharmacists, prescribing health care providers, and nurses. In addition to the factors described in this chapter, there are many other considerations for safe medication administration that are further explained in the "Legal/Ethical" chapter.

Critical Thinking Activity 1.6

When providing care for a client who has chronic kidney disease, how does this condition impact medication excretion?

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" section 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://wtcs.pressbooks.pub/pharmacology2e/?p=40#h5p-2

"Pharmacokinetics Quiz" by E. Christman for Open RN is licensed under CC BY 4.0

1.7 Pharmacodynamics

Pharmacodynamics

So far in this chapter, we have learned the importance of pharmacokinetics in how the body absorbs, distributes, metabolizes, and excretes a medication. Now let's consider how drugs act on target sites of action in the body, referred to as **pharmacodynamics.**

Mechanism of action is a medical term that describes how a medication works in the body. For example, did you know that an osmotic laxative like magnesium citrate attracts and binds with water? The mechanism of action for this medication is it pulls water into the bowel, which softens stool and increases the likelihood of a bowel movement.

A drug's mechanism of action may refer to how it affects a specific receptor. Many drugs bind to specific receptors on the surface of cells to cause an action. For example, morphine binds to a specific receptor that inhibits transmission of nerve impulses along the pain pathway and decreases a client's feelings of pain.

Other medications inhibit specific enzymes for a desired effect. For example, earlier in this chapter we discussed how monoamine oxidase inhibitors (MAOIs) are prescribed as antidepressants because they block monoamine oxidase, the enzyme that breaks down serotonin and dopamine. This blockage increases the concentration of serotonin and dopamine in the central nervous system and increases a client's feelings of pleasure.

Agonist and Antagonist Actions

Drugs have agonistic or antagonistic effects on receptor sites. An **agonist** binds tightly to a receptor to produce a desired effect. An **antagonist** competes with other molecules and blocks a specific action or response at a

receptor site. See Figure 1.7[1] for an illustration of how a beta-blocker, an antagonist cardiac medication, blocks specific action on the beta receptors of a cardiac cell.

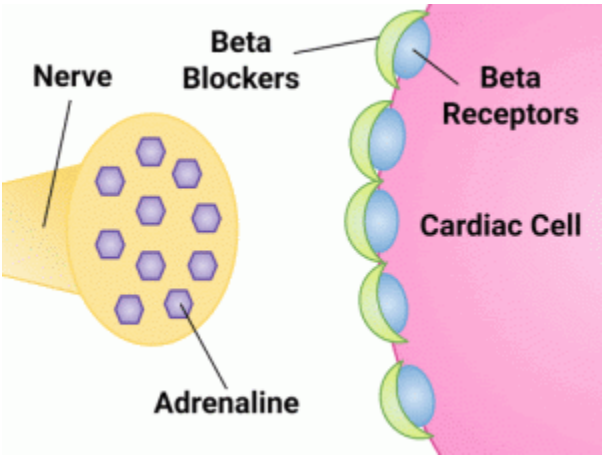

Figure 1.7 Antagonist Action of Beta-Blockers on Beta Receptors of a Cardiac Cell

Agonistic and antagonistic effects on receptors for common classes of medications are further discussed in the "Autonomic Nervous System" chapter.

Critical Thinking Activity 1.7

Atenolol (Tenormin) is an antagonist medication. Does the nurse anticipate this will cause a specific action or block a specific action at a receptor site?

1. "Mechanism of Action" by Dominic Slausen at Chippewa Valley Technical College is licensed under CC BY 4.0

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

1.8 Types of Medications

There are a variety of drugs and substances that clients may utilize for symptom management or to enhance their wellness. Nurses document clients' use of prescription medications, over-the-counter medications, herbal substances, and other supplements in the medical record. Some substances have a long half-life and have the potential to interact with new medications, so accuracy is vital. Ensuring an accurate medical record and knowledge of the different types of substances a client is taking is important for an effective nursing plan of care.

Prescription Medications

Drugs are prescribed by a licensed prescriber for a specific person's use and regulated through the United States Food and Drug Administration (FDA). More information about FDA approval of medications is described in the "Legal/Ethical" chapter. Prescription medications include brand-name medications and generic medications.[1]

COMMON PREFIXES, SUFFIXES, AND ROOTS FOR CLASSES OF MEDICATION

Table 1.8 provides prefixes, suffixes, and roots associated with common prescription medications. As a nurse, familiarizing yourself with the content in the table can help you to quickly organize medications based on their name and recall their mechanism of action and identify potential interactions or side effects. This knowledge can improve your ability to safely administer medications and provide health teaching. Ultimately, this knowledge can lead

1. U.S. Food & Drug Administration. (2017, Nov. 13). *Prescription drug and over the counter drugs: Questions and answers*. https://www.fda.gov/drugs/questions-answers/prescription-drugs-and-over-counter-otc-drugs-questions-and-answers

to improved client outcomes, increased satisfaction, and a reduced risk of adverse events and medication errors.

Table 1.8 Common Classes of Medications, Examples, Suffixes, and Roots

Class of Medication	Example	Common Suffixes	Common Roots
Analgesics	lidocaine	-caine	-morph, -morphe, -morphic
Antacids	omeprazole	-azole	-tidine
Antibiotics	levofloxacin	-mycin, -floxacin	bacter-, vir-, -cidal
Anticoagulants	warfarin	-arin	coagul-
Antidepressants	fluoxetine	-oxetine, -ipramine	serotonin, norepinephrine
Antihistamines	diphenhydramine	-dine, -mine	hist-
Anti-inflammatory	cortisone	-one	-corti-, -flam-, -prost-
Antipsychotics	olanzapine	-azine, -apine	dopa-, sero-, -plegia
Beta-blockers	metoprolol	-olol	adrenergic, beta-
Bronchodilators	albuterol	-terol	bronch-, -pnea
Corticosteroids	prednisone	-sone or -solone	
Diuretics	furosemide	-semide, -thiazide	-uret-, -osm-
Hypoglycemics	glipizide	-ide	gluc-, insulin-
Statins	atorvastatin	-statin	cholesterol, lipid-

Generic Medications

Generic medications can be safe and effective alternatives to their brand-name counterparts at a significantly reduced cost. By law, generic medications must have the same chemically active ingredient in the same dose as the brand name (i.e., they must be “bio-equivalent”). However, the excipients (the base substance that holds the active chemical ingredient into a pill form (such as talc) or the flavoring can be different. Some clients do not

tolerate these differences in excipients very well. When prescribing a medication, the provider must indicate that a generic substitution is acceptable. Nurses are often pivotal in completing insurance paperwork on the client's behalf if the brand-name medication is more effective or better tolerated by that particular client.[2]

When studying medications in nursing school and preparing for the NCLEX, it is important to know medications by their generic name because the NCLEX does not include brand names in their questions.

Over-the-Counter Medications

Over-the-counter (OTC) medications do not require a prescription. They can be bought at a store and may be used by multiple individuals. OTC medications are also regulated through the FDA. 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 (or less for children.)[3]

Herbals and Supplements

Herbs and supplements may include a wide variety of substances including vitamins, minerals, enzymes, and botanicals. Supplements such as "protein powders" are marketed to build muscle mass and can contain a variety of substances that may not be appropriate for all individuals. Herbals and supplements are often considered complementary and alternative medications (CAM). **Complementary and alternative medications (CAM)** are types of therapies that are commonly used in conjunction with or as an alternate to traditional medical therapies. These herbal and supplement

2. U.S. Food & Drug Administration. (2018, June 19). *Patient education*. https://www.fda.gov/drugs/generic-drugs/patient-education
3. U.S. Food & Drug Administration. (2017, Nov. 13). *Prescription drug and over the counter drugs: Questions and answers*. https://www.fda.gov/drugs/questions-answers/prescription-drugs-and-over-counter-otc-drugs-questions-and-answers

substances are not regulated by the FDA, and most have not undergone rigorous scientific testing for safety for the public. While clients may be tempted to try these herbals and supplements, there is no guarantee that they contain the ingredients listed on the label. It is also important to remember that there is a potential for adverse effects or even overdose if the herbal or supplement contains some of the same drug that was also prescribed to a client.[4] By understanding the use of CAM therapies, nurses can help their clients make informed decisions and take a holistic approach to their care. Additionally, being knowledgeable about CAM therapies can help nurses to better educate their clients on the potential benefits and risks associated with these therapies, which can help improve client outcomes and satisfaction.

- Read additional information on complementary and alternative medicine at the National Center for Complementary and Integrative Health (NCCIH) Database.

4. U.S. Food & Drug Administration. (2017, Nov. 13). *What are dietary supplements?* https://www.fda.gov/food/information-consumers-using-dietary-supplements/tips-older-dietary-supplement-users#what

1.9 Efficacy, Dose-Response, 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 a variety of 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. Dose response is the dose of medication required to achieve the desired response to the medication. As the dose increases, the response of the drug may increase, as well as the potential for toxicity. This response helps determine the therapeutic index of a drug, or the effective dose range. The measured response and dose are often graphed perpendicular to each other, with the slope of the graph's curve representing therapeutic index (or overall dose-effect). It is important to note that some medications have a very small therapeutic window, and even small increases in dosages can result in toxic effects. See Figure 1.8[1] for an illustration of a dose-response graph.

1. "Interactive_dose-response_curve.gif" by Egelberg is licensed under CC BY-SA 4.0

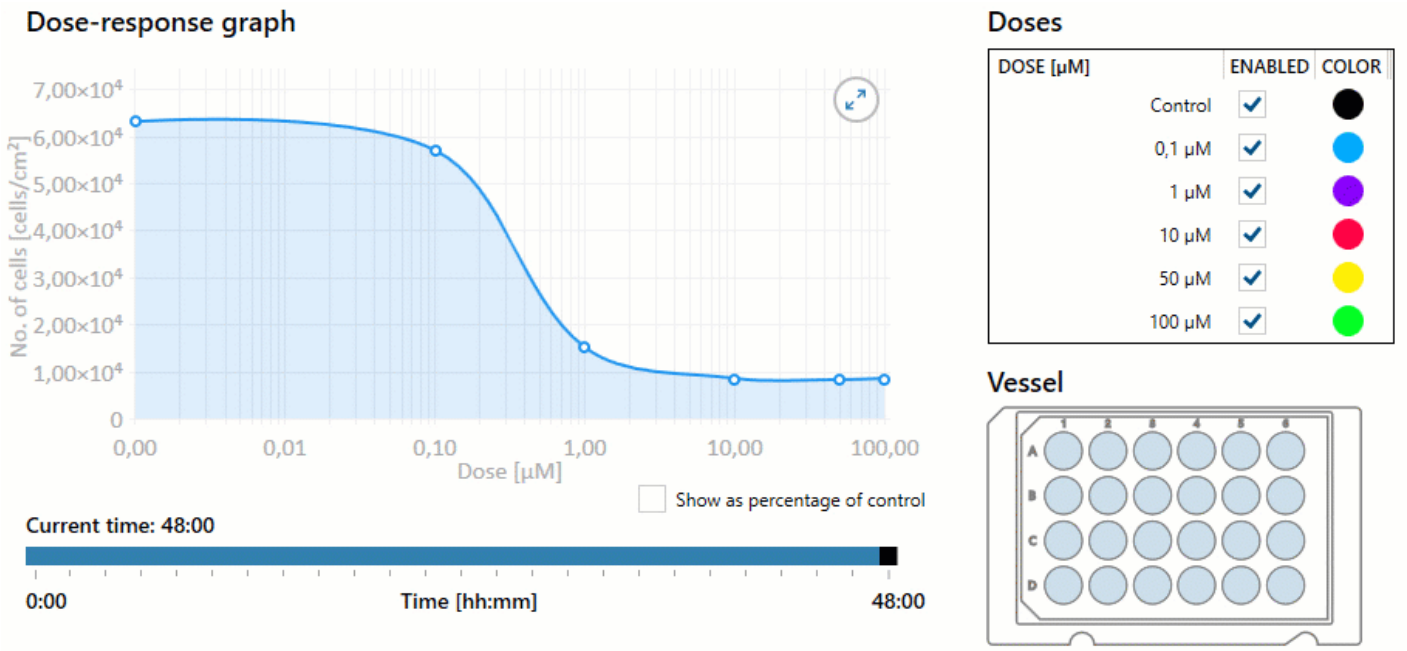

Figure 1.8 Dose-Response Graph

Onset, Peak, and Duration

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

Onset of medication refers to when the medication first begins to take effect. Time of onset is affected by the route of administration. For example, a diuretic given intravenously will begin to take effect much faster than a diuretic administered orally because the intravenous route delivers the drug directly to the systemic circulation and avoids the first-pass effect.

Peak refers to the maximum concentration of medication in the body, and the client shows evidence of greatest therapeutic effect. For example, a client taking ibuprofen can anticipate maximum pain relief in one to two hours when the medication reaches peak serum levels.

Duration refers to the length of time the medication produces its desired therapeutic effect. For example, the duration of oral acetaminophen is four to six hours, at which time the client will likely require an additional dose for pain.

Duration, Dosing, and Steady State

Now let's consider the implication of duration and dosing. Remember the duration of medication is correlated with the elimination. Half-life is the amount of time that it takes for half of the drug to be eliminated from the body.

If a medication has a short half-life (and is therefore 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 therefore are eliminated more slowly from the body, resulting in longer therapeutic duration) and may only be administered 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.

Steady state refers to the point at which the amount of drug entering the body is equal to the amount of drug being eliminated, resulting in a stable drug concentration.[2] When steady state is achieved, there is a state of equilibrium in the body and the concentration of the drug remains constant, resulting in optimal therapeutic effect.

Clinical Example

Consider this client care example and apply the principles of onset, peak, and duration: A 67-year-old female postoperative client rings the call light to request medication for pain related to the hip replacement procedure she had earlier that day. 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 the client, you examine her postoperative medication orders and consider the pain medication options available to you. In reviewing the various options, it is important to consider how quickly a

2. This work is a derivative of StatPearls by Wadhwa and Cascella and is licensed under CC BY 4.0

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.

Critical Thinking Activity 1.9

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) 625 mg ordered every four hours as needed for discomfort. What should you consider in relation to the administration and timing of the client's pain medication?
2. Your client is prescribed NPH insulin to 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

1.10 Therapeutic Levels

Now that the concepts of dose-response, onset, peak, and duration have been discussed, it is important to understand the therapeutic window and therapeutic index.

Therapeutic Window

For every drug, there exists a dose that is minimally effective (the Effective Concentration) and another dose that is toxic (the Toxic Concentration). Between these doses is the **therapeutic window**, where the safest and most effective treatment will occur. For example, see Figure 1.9[1] for an illustration of the therapeutic window for warfarin, a medication used to prevent blood clotting. Too much warfarin administered causes bleeding and vitamin K is required as an antidote. Conversely, not enough warfarin administered for a client's condition can cause clotting. Think of the therapeutic window (the green area on the graph) as the "perfect dose," where clotting is prevented and yet bleeding does not occur.

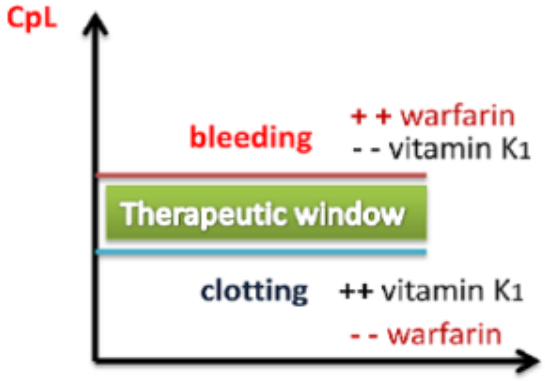

Figure 1.9 Therapeutic Window

1. "Therapeutic Window" by Shefaa Alasfoor is licensed under CC BY-SA 3.0

The effect of warfarin is monitored using a blood test called international normalized ration (INR). For clients receiving warfarin, nurses vigilantly monitor their INR levels to ensure the dosage appropriately reaches their therapeutic window and does not place them at risk for bleeding or clotting.

Peak and Trough Levels

Now let's apply the idea of therapeutic window to the administration of medications requiring the monitoring of peak and trough levels, which is commonly required in the administration of specific IV antibiotics. The dosage of these medications is **titrated**, meaning adjusted for safety, to achieve a desired therapeutic effect for the client. Titration is accomplished by closely monitoring the peak and trough 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 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 after the medication is administered and 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 scheduled dose is given. Medications have a predicted reference range of normal values for peak and trough levels. These numbers assist the pharmacist and provider in gauging how the body is metabolizing, protein-binding, and excreting the drug and are used to adjust the prescribed dose 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 plan the administration of the medication according to the timing of these blood draws.[2]

Therapeutic Index

The **therapeutic index** is a quantitative measurement of the relative safety of

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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.

- A large (or high) therapeutic index number means there is a wide therapeutic window between the effective concentration and the toxic concentration of a medication, so the drug is relatively safe.
- A small (or low) therapeutic index number means there is a narrow therapeutic window between the effective concentration and the toxic concentration. A drug with a narrow therapeutic range (i.e., having little difference between toxic and therapeutic doses) often has the dosage titrated according to measurements of the actual blood levels achieved in the person taking it.

For example, phenytoin has a narrow therapeutic index between the effective and toxic concentrations. Clients who start taking phenytoin to control seizures have frequent peak and trough drug levels to ensure they achieve steady state with a therapeutic dose to prevent seizures without reaching toxic levels.

Critical Thinking Activity 1.10

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 information below to determine the nurse's course of action.

View information on therapeutic drug levels.

(After accessing the information, 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

1.11 Evaluating Effects

Evaluating the Effects

The nurse is responsible for assessing the client, monitoring lab values, and recognizing side effects and/or adverse effects of medications. Drug dosages should be verified to ensure all are within recommended safe ranges according to the client's current status, as well as for their potency.

Potency refers to the amount of the drug required to produce the desired effect. A drug that is highly potent may require only a minimal dose to produce a desired therapeutic effect, whereas a drug that has low potency may need to be given at much higher concentrations to produce the same effect. Consider the example of opioid versus nonopioid medications for pain control. Opioid medications often have a much higher potency in smaller doses to produce pain relief; therefore, the overall dose required to produce a therapeutic effect may be much less than that for other analgesics.

The nurse preparing to administer medications must also be cognizant of drug selectivity and monitor for potential side effects and adverse effects. **Selectivity** refers to the separation between the desired and undesired effects of a drug. Drugs that are selective will search out target sites to create a specific drug action, whereas nonselective drugs may impact many other types of cells and tissues, thus increasing the risk for unintended side effects and/or adverse effects. For example, in Chapter 4 selective and nonselective beta-blockers will be discussed. Selective beta-1 blockers search out specific receptors on the heart to create their effect, whereas nonselective beta-blockers may affect receptors in the lungs in addition to those in the heart, causing potential respiratory side effects like a cough.

A **side effect** occurs when the drug produces effects other than the intended effect. A side effect, although often unintended, is generally anticipated by the provider and is a known potential consequence of the medication therapy. Examples of common side effects are nausea, vomiting, diarrhea, and drowsiness. In some situations, however, side effects may have a beneficial impact. For example, a side effect of hydrocodone is drowsiness. A

client who is having difficulty sleeping due to pain and takes hydrocodone at bedtime may find the drowsiness beneficial in helping them fall asleep.

Conversely, unanticipated effects can occur from medications that are harmful to the client. These harmful occurrences are known as **adverse effects**. Adverse effects are relatively unpredictable, severe, and are reason to discontinue the medication.[1] For example, an adverse effect of ciprofloxacin is tendon rupture. Adverse effects should be reported to the pharmacy and tracked as a client safety concern according to agency policy.

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1.12 Learning Activities

You have been introduced to many concepts related to pharmacokinetics and pharmacodynamics in this chapter. These basic concepts are important to understand as we examine various medication classes.

★ Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=55#h5p-1

"Medication Absorption Quiz" by Open RN is licensed under CC BY 4.0

★ Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=55#h5p-39

"Pharmacokinetics Flashcards" by Open RN is licensed under CC BY 4.0

Light Bulb Moment

Test your knowledge and application. Use the information in the text above, as well as the DailyMed resource, to read more about the medications included in the client scenarios. Additional pharmacokinetics information can be found under the "Clinical Pharmacology" section of each drug in DailyMed.

1. You are working in a nursing home caring for an 86-year-old stroke client who complains of left knee pain secondary to arthritis. The client has right-sided weakness and difficulty swallowing with no gag reflex. You review the client's medication administration record (MAR) and note the provider has prescribed acetaminophen 325 mg either per oral or per 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 gentamicin 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 actions 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? As the nurse, what is your 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 hydrocodone/acetaminophen 5/325 mg (Norco) every six hours for moderate pain. The client complains of pain in the knee, rating it at a "6." Review the "Clinical Pharmacology" section for this medication using the DailyMed, and 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 half-life of this drug?

Note: Answers to the Light Bulb Moment can be found in the "Answer Key" section at the end of the book.

Test your clinical judgment with this NEXT GEN RN

- NCLEX Next Generation-style bowtie question: Pain Medication.[1]

1. "Pain Medication" by Open RN is licensed under CC BY 4.0

I. Glossary

Absorption: The first stage of pharmacokinetics where medications enter the body and travel from site of administration into the body's circulation.

ADME: Four basic stages of pharmacokinetics a medication goes through within the human body: absorption, distribution, metabolism, and excretion.

Adverse effect: An unintended and potentially dangerous pharmacological effect that occurs when a medication is administered correctly.

Affinity: The strength of binding between drug and receptor.

Agonist: A drug that binds to a "receptor" and produces an effect.

Antagonist: A molecule that prevents the action of other molecules, often by competing for a cellular receptor; opposite of agonist.

Bioavailability: The presence of a drug in the bloodstream after it is administered.

Blood-brain barrier: A nearly impenetrable barricade that is built from a tightly woven mesh of capillaries cemented together to protect the brain from potentially dangerous substances such as poisons or viruses.

Complementary and alternative medications (CAM): Therapies that are commonly used in conjunction with, or as an alternate to traditional medical therapies, such as vitamins, herbs, and other supplements. These substances are not regulated by the FDA and most have not undergone rigorous scientific testing for safety for the public.

Distribution: The second stage of pharmacokinetics where medication is dispersed throughout the body via the bloodstream.

Dose-response: The dose of medication required to achieve the desired response to the medication.

Drugs: Medications or other substances that have a physiological effect when introduced to the body.

Duration: The length of time that a medication is producing its desired therapeutic effect.

Efficacy: The maximum effect of which the drug is capable.

Excretion: The final stage of pharmacokinetics where drug byproducts and metabolites are eliminated from the body.

First-pass effect: The inactivation of orally or enterally administered drugs in the liver and intestines.

Half-life: The rate at which 50% of a drug is eliminated from the body when it is metabolized.

Mechanism of action: How a medication works at a cellular level within the body.

Metabolism: The third stage of pharmacokinetics that involves the breakdown of a drug so that it can be excreted by the body.

Onset: When a medication first begins to work and exerts a therapeutic effect.

Peak: When the maximum concentration of a drug is in the bloodstream.

Pharmacodynamics: The effects of drugs in the body and the mechanism of their action.

Pharmacogenetics: The study of how a person's genetic makeup affects their response to medicines.

Pharmacokinetics: The study of how the body absorbs, distributes, metabolizes, and eliminates drugs.

Pharmacology: The science dealing with actions of drugs on the body.

Pharmacy: The science of the preparation of drugs.

Potency: The drug dose required to produce a specific intensity of effect.

Selectivity: The separation between the desired and undesired effects of a drug.

Side effect: Effect of a drug, other than the desired effect, sometimes in an organ other than the target organ.

Steady state: The point at which the amount of drug entering the body is equal to the amount of drug being eliminated, resulting in a stable drug concentration.

Therapeutic index: A quantitative measurement of the relative safety of a drug that compares the amount of drug that produces a therapeutic effect versus the amount of drug that produces a toxic effect. Medication with a large therapeutic index is safer than a medication with a small therapeutic index.

Therapeutic window: The dosing window in which the safest and most effective treatment will occur.

Titration: The process of adjusting a medication dose to achieve a desired therapeutic effect for the client.

Trough: A drug level drawn from the bloodstream when the drug is at its lowest concentration, typically right before the next scheduled dose is given.

PART II

LEGAL/ETHICAL

2.1 Legal/Ethical Introduction

Learning Objectives

- Discuss federal and state laws, regulations, and guidelines for safe medication administration
- Identify drug administration guidelines within the State Nurse Practice Act
- Identify ethical responsibilities related to medication administration
- Identify nursing responsibilities associated with controlled substances
- Identify nursing responsibilities to prevent and respond to medication errors
- Explain how nursing response reflects respect for a client's rights and responsibilities with drug therapy
- Outline nursing actions within the scope of nursing practice as they relate to the administration of medication
- Demonstrate patient-centered care during medication administration by respecting a client's gender, psychosocial, and cultural needs
- Identify nursing responsibilities associated with safe medication administration
- Identify nursing responsibilities associated with health teaching and health promotion[1]

Medication administration is an essential task 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 health care team, as well as legal, ethical, social, and cultural issues. The primary focus of effective medication administration by all health professionals is patient safety. Although many measures have been put into place over the past few decades to promote improved patient safety, medication errors and adverse effects continue to be a common event. The World Health Organization (WHO) states 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.[2] This chapter will examine the legal and ethical foundations of medication administration by nurses, as well as the practice standards and cultural and social issues that must be considered to ensure safe and effective administration of medication.

1. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
2. World Health Organization. (n.d). *Medication without harm.* https://www.who.int/initiatives/medication-without-harm

2.2 Ethical and Professional Foundations of Safe Medication Administration by Nurses

The American Nurses Association (ANA) is a professional organization that represents the interests of the nation's four million registered nurses and is at the forefront of improving the quality of health care for all.[1] The ANA establishes ethical and professional standards for nurses that also guide safe administration of medications. These code of ethics and professional standards are described in ANA publications titled *Code of Ethics for Nurses* and *Nursing: Scope and Standards of Practice*.

Code of Ethics for Nurses

The ANA 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.[2] Several provisions from the *Code of Ethics* impact how nurses should administer medication in an ethical manner. A summary of each provision from the *Code of Ethics* and how it pertains to medication administration is outlined below:

- **Provision 1** focuses on respect for human dignity and the right for self-determination: "The nurse practices with compassion and respect for the inherent dignity, worth, and unique attributes of every person."

1. American Nurses Association. (2019). *About ANA*. https://www.nursingworld.org/ana/about-ana/
2. American Nurses Association. (2015). *Code of ethics for nurses with interpretive statements*. https://www.nursingworld.org/coe-view-only

- **Provision 2** states, "The nurse's primary commitment is to the client…"[3] In health care settings, nurses often experience several competing loyalties, such as to their employer, to the doctor(s), to their supervisor, or to others on the health care team. However, the client should always receive the primary commitment of the nurse. Additionally, the client has the right to accept, refuse, or terminate any treatment, including medications.
- **Provision 3** states, "The nurse promotes, advocates for, and protects the rights, health, and safety of the patient…"[4] This provision includes a nurse's responsibility to promote a culture of safety for clients. If errors occur, they must be reported, and nurses should ensure responsible disclosure of errors to clients. This also includes proper disclosure of questionable practices, such as **drug diversion** or impaired practice by any professional.
- **Provision 4** involves authority, accountability, and responsibility by a nurse to follow legal requirements, such as state practice acts and professional standards of care.
- **Provision 5** includes the responsibility of the nurse to promote health and safety.
- **Provision 6** focuses on virtues that make a nurse a morally good person. For example, nurses are held accountable to use their clinical judgment to avoid causing harm to clients (**maleficence**) and to do good (**beneficence**). When administering medications, nurses should validate the medication is doing more "good" than "harm" (adverse or side effects).
- **Provision 7** focuses on a nurse practicing within the professional standards set forth by their **state nurse practice act**, as well as standards established by professional nursing organizations.
- **Provision 8** explains that a nurse must address the **social determinants of health**, such as poverty, education, safe medication, and health care disparities.[5]

3. American Nurses Association. (2015). *Code of ethics for nurses with interpretive statements*. https://www.nursingworld.org/coe-view-only
4. American Nurses Association. (2015). *Code of ethics for nurses with interpretive statements*. https://www.nursingworld.org/coe-view-only
5. American Nurses Association. (2015). *Code of ethics for nurses with interpretive statements*. https://www.nursingworld.org/coe-view-only

Whenever a nurse provides client care, the ANA's *Code of Ethics* should be used as a guide for professional ethical behavior.

View the ANA's Code of Ethics for Nurses.

Critical Thinking Activity 2.2a

A nurse is preparing to administer medications to a client. While reviewing the chart, the nurse notices two medications with similar mechanisms of action have been prescribed by two different providers.

What is the nurse's best response?

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

Standards and Scope of Practice

The ANA publishes *Nursing: Scope and Standards of Practice*. This resource establishes national standards for nurses and is updated regularly.[6]

The ANA defines the scope of **nursing** as "the protection, promotion, and optimization of health and abilities, prevention of illness and injury, facilitation of healing, alleviation of suffering through the diagnosis and treatment of human response, and advocacy in the care of individuals, families, groups, communities, and populations." A **registered nurse (RN)** is defined as an

6. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.

individual who is educationally prepared and licensed by a state to practice as a registered nurse. Nursing practice is characterized by the following tenets[7]:

- Caring and health are central to the practice of the registered nurse.
- Nursing practice is individualized to the unique needs of the health care consumer.
- Registered nurses use the nursing process to plan and provide individualized care for health care consumers.
- Nurses coordinate care by establishing partnerships to reach a shared goal of delivering safe, quality health care.

The ANA establishes Standards of Practice and Standards of Professional Performance in the *Nursing: Scope and Standards of Practice* publication. State nurse practice acts further define the scope of practice of RNs and Licensed Practical Nurses/Vocational Nurses (LPNs/VNs) within each state. Nurse practice acts are further discussed in the "Legal Foundations and National Guidelines for Safe Medication Administration" section of this chapter.

> The ANA's *Nursing: Scope and Standards of Practice* publication can be purchased on the nursingworld.org website or borrowed from many libraries.

Standards of Practice

The ANA's Standards of Practice are authoritative statements of duties that all registered nurses, regardless of role, population, or specialty, are expected to perform competently. **Standards of Practice** include assessment, diagnosis, outcome identification, planning, implementation, and evaluation (ADOPIE)

7. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.

components of providing client care, also known as the "nursing process." When nurses safely administer medication, all components of ADOPIE are addressed.

ASSESSMENT

The "Assessment" Standard of Practice is defined as, "The registered nurse collects pertinent data and information relative to the health care consumer's health or the situation."[8] A registered nurse uses a systematic method to collect and analyze client data. Assessment includes physiological data, as well as psychological, sociocultural, spiritual, economic, and lifestyle data. For example, when a nurse assesses multiple pieces of data for a hospitalized client with pain, this is considered part of a comprehensive pain assessment.

DIAGNOSIS

The "Diagnosis" Standard of Practice is defined as, "The registered nurse analyzes the assessment data to determine actual or potential diagnoses, problems, and issues."[9] A nursing diagnosis is the nurse's clinical judgment about the client's response to actual or potential health conditions or needs. Nursing diagnoses are used to create the nursing care plan and are different than medical diagnoses.[10]

OUTCOMES IDENTIFICATION

The "Outcomes Identification" Standard of Practice is defined as, "The registered nurse identifies expected outcomes for a plan individualized to the health care consumer or the situation."[11] The nurse sets measurable and

8. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
9. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
10. American Nurses Association. (n.d.). *The nursing process*. https://www.nursingworld.org/practice-policy/workforce/what-is-nursing/the-nursing-process/
11. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.

achievable short- and long-term goals and specific outcomes in collaboration with the client based on their assessment data and nursing diagnoses.

PLANNING

The "Planning" Standard of Practice is defined as, "The registered nurse develops a collaborative plan encompassing strategies to achieve expected outcomes."[12] Assessment data, diagnoses, and goals are used to select evidence-based nursing interventions customized to each client's needs and concerns. Goals, expected outcomes, and nursing interventions are documented in the client's nursing care plan so that nurses, as well as other health professionals, have access to it for continuity of care.[13]

IMPLEMENTATION

The "Implementation" Standard of Practice is defined as, "The nurse implements the identified plan."[14] Nursing interventions are implemented or delegated to licensed practical nurses/vocational nurses (LPNs/VNs) or unlicensed assistive personnel (UAP) with supervision. Interventions are also documented in the client's electronic medical record as they are completed.[15]

The "Implementation" Standard of Professional Practice also includes the subcategories "Coordination of Care" and "Health Teaching and Health Promotion" to promote health and a safe environment.[16]

12. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
13. American Nurses Association. (n.d.). *The nursing process.* https://www.nursingworld.org/practice-policy/workforce/what-is-nursing/the-nursing-process/
14. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (3rd ed.). American Nurses Association.
15. American Nurses Association. (n.d.) *The nursing process.* https://www.nursingworld.org/practice-policy/workforce/what-is-nursing/the-nursing-process/
16. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.

Coordination of Care

The ANA standard for coordination of care states, "The registered nurse coordinates care delivery."[17] When ensuring medications are administered safely, the nurse collaborates with the client and the interprofessional health care team to meet mutually agreed upon outcomes. The nurse also engages the client in self-care to achieve their preferred goals for quality of life. For example, one client with chronic pain may have a pain management goal of "5" with their quality of life preference of having the ability to participate in social activities with friends but not experiencing burdensome side effect of medication. Another client with chronic pain may have a pain management goal of "0" with a quality of life preference of having no pain no matter what the side effects. The nurse advocates for these clients' goals and preferences with the interprofessional team.

Nurses also serve vital roles in ensuring safe transitions and continuity of care regarding clients' use of medications. Additional information about safe medication use and transitions of care is discussed in the "Preventing Medication Errors" section of this chapter.

Health Teaching and Health Promotion

When administering medications, nurses teach clients about the medications and potential side effects to promote optimal health. The ANA standard for health teaching and health promotion states, "The registered nurse employs strategies to teach and promote health and wellness."[18] Specific behaviors related to teaching about medication are as follows[19]:

- Use health teaching and health promotion methods in collaboration with the client's values, beliefs, health practices, developmental level, learning

17. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
18. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
19. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.

needs, readiness and ability to learn, language preference, spirituality, culture, and socioeconomic status.
- Provide clients with information and education about intended effects and potential adverse effects of the plan of care.
- Provide anticipatory guidance to clients to promote health and prevent or reduce risk.

In the book *Preventing Medication Errors* by the Institute of Medicine (2007), the following are additional key national guidelines when teaching clients about 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.[20]

EVALUATION

The "Evaluation" Standard of Practice is defined as, "The registered nurse evaluates progress toward attainment of goals and outcomes."[21] During evaluation, nurses assess the client and compare the findings against the initial assessment to determine the effectiveness of the interventions and overall nursing care plan. Both the client's status and the effectiveness of the nursing care must be continuously evaluated and modified as needed.[22]

20. Institute of Medicine. (2007). *Preventing medication errors.* The National Academies Press. https://doi.org/10.17226/11623
21. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.
22. American Nurses Association. (n.d.). *The nursing process.* https://www.nursingworld.org/practice-policy/workforce/what-is-nursing/the-nursing-process/

Read additional information about the nursing process in the "Nursing Process" chapter of Open RN *Nursing Fundamentals*.

Standards of Professional Performance

ANA's Standards of Professional Performance describe a competent level of behavior for nurses, including activities related to ethics, culturally congruent practice, communication, collaboration, leadership, education, evidence-based practice, and quality of practice.[23]

The ANA defines **culturally congruent practice** as the application of evidence-based nursing that is in agreement with the preferred cultural values, beliefs, worldview, and practices of the health care consumer and other stakeholders. **Cultural competence** represents the process by which nurses demonstrate culturally congruent practice. Nurses must assess the cultural beliefs and practices of their clients and implement culturally congruent interventions when administering medications and teaching about them. Additional information about cultural implications for medication administration is further discussed in the "Cultural and Social Determinants Related to Medication Administration" section later in this chapter.

23. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.

Critical Thinking Activity 2.2b

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 normal range of 60-100.

PLANS to call the provider, as well as report this incident in the shift handoff report.

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

Continues to **EVALUATE** the client status throughout the shift after not receiving the metoprolol.

The nurse is providing health 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 Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Figure 2.1 is an image from *Nursing: Scope and Standards of Practice* by the ANA that illustrates how the scope of practice, standards of practice, and code

of ethics form the "base" of nursing practice.[24] Nursing practice is further guided by the Nurse Practice Act in the state in which a nurse works, federal and state rules and regulations, institutional policies and procedures, and self-determination by the individual nurse. All these components are required to provide quality, safe client care that is evidence-based. These components will be further discussed in the remaining sections of this chapter.

24. American Nurses Association. (2015). *Nursing: Scope and standards of practice* (3rd ed.). American Nurses Association.

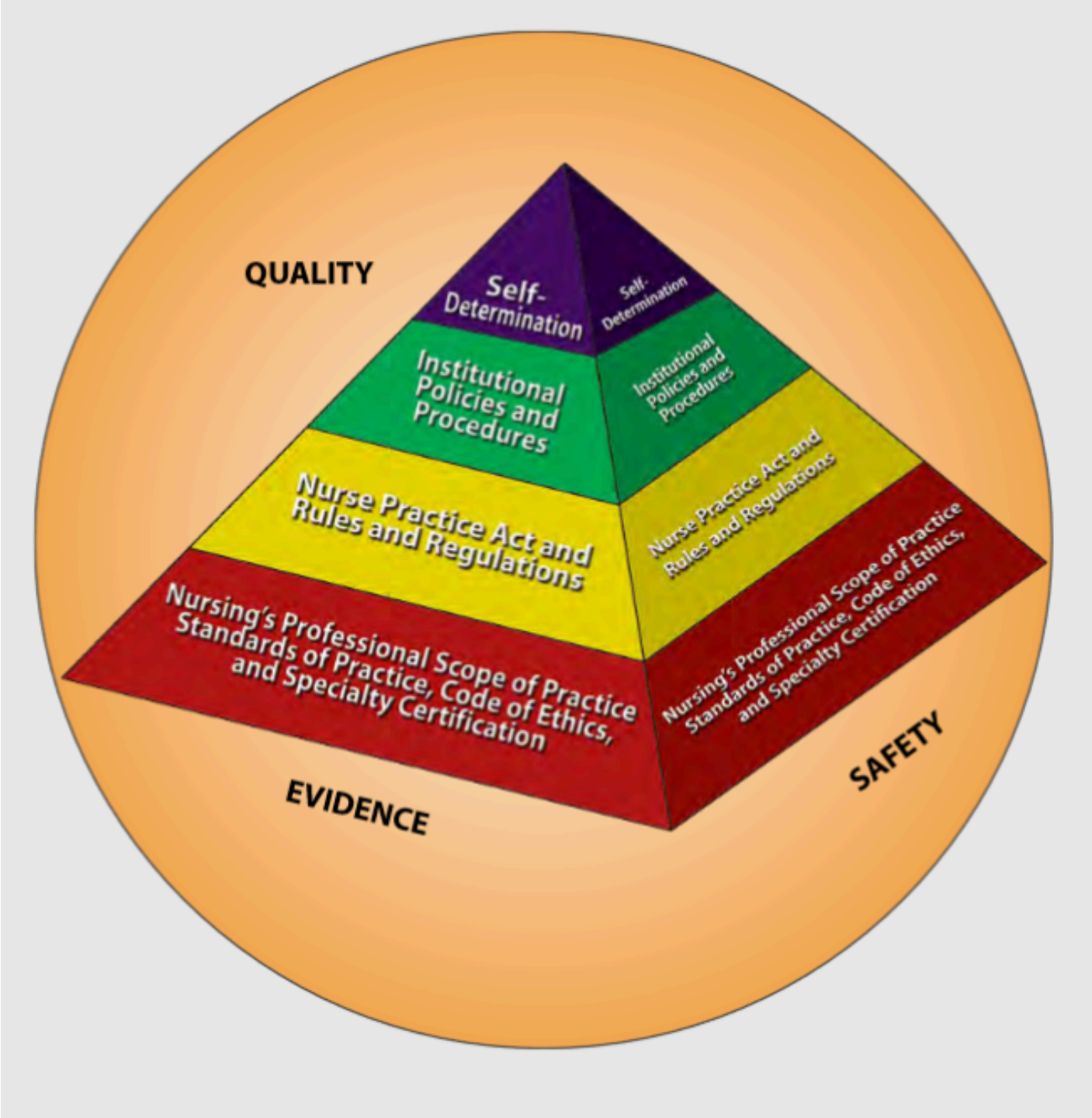


Figure 2.1 ANA Model of Professional Nursing Practice

NCLEX and the Clinical Judgment Model

The National Council Licensure Examination (NCLEX) is the national exam that graduates must pass successfully to obtain their nursing license after

graduating from a nursing program of study. The NCLEX-PN is taken to become a licensed practical/vocational nurse (LPN/VN), and the NCLEX-RN is taken to become a licensed registered nurse (RN). The purpose of the NCLEX is to evaluate if a nursing graduate demonstrates the ability to provide safe, competent, entry-level nursing care. The NCLEX is developed by the National Council of State Boards of Nursing (NCSBN), an independent, nonprofit organization composed of the 50 state boards of nursing and other regulatory agencies.[25]

A new edition of the NCLEX was launched in April 2023 that contains "Next Generation" questions. The Next Generation NCLEX (NGN) assesses how well the candidate can think critically and use clinical judgment. The NCSBN defines clinical judgment as "the observed outcome of critical thinking and decision-making. It is an iterative process with multiple steps that uses nursing knowledge to observe and assess presenting situations, identify a prioritized client concern and generate the best possible evidence-based solutions in order to deliver safe client care."

The NCLEX uses the NCSBN's Clinical Judgment Measurement Model (NCJMM) to assess the candidate's ability to use safe clinical judgment when providing nursing care. Exam questions used to assess clinical judgment may be contained in a case study or as individual stand-alone items. A case study contains six questions that are associated with the same client scenario and addresses the following steps in clinical judgment[26]:

- **Recognize cues:** Identify relevant and important information from different sources (e.g., medical history, vital signs).
- **Analyze cues:** Organize and connect the recognized cues to the client's clinical presentation.
- **Prioritize hypotheses:** Evaluate and prioritize hypotheses (based on urgency, likelihood, risk, difficulty, time constraints, etc.).
- **Generate solutions:** Identify expected outcomes and use hypotheses to define a set of interventions for the expected outcomes.
- **Take action:** Implement the solution(s) that address the highest priority.

25. NCSBN. https://www.ncsbn.org/nclex.htm
26. NCSBN. (n.d.). *2023 NCLEX-RN test plan*. https://www.ncsbn.org/exams/testplans.page

- **Evaluate outcomes:** Compare observed outcomes to expected outcomes.

Throughout this book, learning activities are provided to assist students in learning how to apply the nursing process (i.e., ANA's Standards of Care) to answer NGN-style questions that evaluate clinical judgment. Some of these activities are written, with answers in the Answer Key at the end of the book, and others are interactive and require use of the online book.

2.3 Legal Foundations and National Guidelines for Safe Medication Administration

Many federal and state laws, as well as national guidelines, have been established to protect public health and safety related to medication administration. This section will explain how federal and state laws, agencies, and guidelines protect clients from harm from medications.

Federal Agencies, Laws, and Guidelines

Food and Drug Administration

The United States Food and Drug Administration (FDA) protects public health by ensuring the safety, efficacy, and security of human and veterinary drugs, biological products, and medical devices, as well as the safety of our nation's food supply, cosmetics, and products that emit radiation.[1] The FDA protects public health by enforcing an official drug approval process based on evidence-based research and issuing Boxed Warnings for medications with serious adverse reactions. These actions are further discussed in the following subsections.

DEVELOPING NEW DRUGS

American consumers benefit from having access to the safest and most advanced pharmaceutical system in the world. The main consumer watchdog in this system is the FDA's Center for Drug Evaluation and Research (CDER). The center's best-known job is to evaluate new drugs before they can be sold.

1. U.S. Food and Drug Administration. (n.d). https://www.fda.gov

CDER's evaluation not only prevents misinformation from being provided to the public, but also provides doctors and clients the information they need to use medicines wisely. CDER ensures that drugs, both brand-name and generic, work correctly and their health benefits outweigh their known risks.

Drug companies conduct extensive research and work to develop and test a drug. The company then sends CDER the evidence from these tests to prove the drug is safe and effective for its intended use. Before the drug is approved as safe for use in the United States, a team of CDER physicians, statisticians, chemists, pharmacologists, and other scientists reviews the company's data and proposed labeling. If this independent and unbiased review establishes a drug's health benefits outweigh its known risks, the drug is approved for sale. Before a drug can be tested in people, the drug company or sponsor performs laboratory and animal tests to discover how the drug works and whether it's likely to be safe and work well in humans. Next, a series of clinical trials involving volunteers is conducted to determine whether the drug is safe when used to treat a disease and whether it provides a real health benefit.

Visit the FDA's "Development and Approval Process | Drugs" webpage.

FDA APPROVAL OF A DRUG

FDA approval of a drug means that data on the drug's effects have been reviewed by the CDER, and the drug is determined to provide benefits that outweigh its known and potential risks for the intended population. The drug approval process takes place within a structured framework that includes the following:

- **Analysis of the target condition and available treatments:** FDA reviewers analyze the condition or illness for which the drug is intended and evaluate the current treatment landscape, which provide the context for weighing the drug's risks and benefits. For example, a drug intended to

treat clients with a life-threatening disease for which no other therapy exists may be considered to have benefits that outweigh the risks even if those risks would be considered unacceptable for a condition that is not life-threatening.

- **Assessment of benefits and risks from clinical data:** FDA reviewers evaluate clinical benefit and risk information submitted by the drug maker, taking into account any uncertainties that may result from imperfect or incomplete data. Generally, the agency expects that the drug maker will submit results from two well-designed clinical trials to be sure the findings from the first trial are not the result of chance or bias. In certain cases, especially if the disease is rare and multiple trials may not be feasible, convincing evidence from one clinical trial may be enough. Evidence that the drug will benefit the target population should outweigh any risks and uncertainties.
- **Strategies for managing risks:** All drugs have risks. Risk management strategies include an FDA-approved drug label, which clearly describes the drug's benefits and risks and information pertaining to the detection and management of any risks. Sometimes, more effort is needed to manage risks. In these cases, a drug maker may need to implement a Risk Evaluation and Mitigation Strategy (REMS).

Although many of the FDA's risk-benefit assessments and decisions are straightforward, sometimes the benefits and risks are uncertain and may be difficult to interpret or predict. The agency and the drug maker may reach different conclusions after analyzing the same data, or there may be differences of opinion among members of the FDA's review team. As a science-led organization, the FDA uses scientific and technological information to make decisions through a deliberative process.[2]

BOXED WARNINGS

As discussed in the previous subsection, the FDA approves a drug after

2. U.S. Food and Drug Administration. (n.d.). *Developing new drugs.* https://www.fda.gov/drugs/development-approval-process-drugs

determining that the drug's benefits of use outweigh the risks for the condition that the drug will treat. However, even with the rigorous FDA evaluation process, safety problems can surface after a drug has been on the market and used in a broader population.

Boxed Warnings (formerly known as Black Box Warnings) are the highest safety-related warning that medications can have assigned by the FDA. These warnings are intended to bring the consumer's attention to the major risks of the drug. Medications can have a boxed warning added, taken away, or updated throughout their tenure on the market. Boxed Warnings appear on a prescription drug's label and in current, evidence-based drug references. For this reason, it is important for nurses to verify current drug information in drug references.

Critical Thinking Activity 2.3a

Levofloxacin is an antibiotic that received FDA approval. 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 Boxed Warning with recommendations to reserve levofloxacin for use in clients who have no alternative treatment options for certain indications: uncomplicated UTI, acute exacerbation of chronic bronchitis, and acute bacterial sinusitis.[3]

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.

3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

What is the nurse's best response?

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

U.S. Drug Enforcement Agency (DEA)

The U.S. Drug Enforcement Agency (DEA) enforces the federal laws and regulations of controlled substances. This includes enforcement of the Controlled Substances Act (CSA) that pertains to the manufacture, distribution, and dispensing of legally produced controlled substances that nurses administer to clients.[4]

Because controlled substances have a greater chance of being misused and abused, there are additional laws and procedures that must be followed when working with these medications. The DEA is responsible for enforcing these laws, and many federal laws are summarized in a document called the *Pharmacist's Manual*. Most controlled substance laws, however, come from state governments. Health care professionals are responsible for following the most stringent of the two laws, whether it be state law or federal law.

View the DEA's Pharmacist's Manual PDF.

EXAMPLES OF FEDERAL AND STATE LAWS REGARDING CONTROLLED SUBSTANCES

The following examples of federal laws are applicable to controlled substances administered by nurses:

4. U.S. Department of Justice - Drug Enforcement Administration. (n.d.). *Drug scheduling*. https://www.dea.gov/drug-scheduling

- **Prescriptions:** A prescription for a controlled substance may be written only by a provider (physician or mid-level provider such as a nurse practitioner) who has a DEA registration number. The prescription for a Schedule II medication (i.e., opioids) must be written or electronically sent to the pharmacy through DEA approved software. Prescriptions over the phone or fax are not accepted. Refills for Schedule II medication are not allowed and require new prescriptions. Schedule III or IV medications may be refilled only five times. State law determines how long a written Schedule II prescription is valid and if there are any limits on the quantity of medication that can be dispensed. For example, in Wisconsin, a Schedule II prescription is only valid for 60 days after it is written.
- **Records:** There is a "closed system" for record keeping of controlled substances to prevent drug diversion. Hospitals, clinics, and pharmacies must maintain records on the whereabouts of controlled substances from the time the medication is received by the pharmacy, to when it is administered to the client, to disposal of wasted medication by the nurse. Inventory counts of controlled substances occur frequently and may require a physical count by two licensed staff at the start of each shift. Detailed documentation is required for administration of controlled substances. When a full dose of a controlled substance is not administered, this is referred to as waste. Waste is typically disposed of differently than other medications (i.e., flushed down the sink) and often requires the co-signature of a second licensed staff member.

View the Requirements for Controlled Substances PDF[5] with additional information about Wisconsin state laws regarding controlled substances.

5. Wisconsin Administrative Code. (2022). *Uniform Controlled Substances Act*. https://docs.legis.wisconsin.gov/code/admin_code/phar/8.pdf

SCHEDULES OF DRUGS

The federal Controlled Substances Act (CSA) categorizes drugs regulated under federal law into one of five schedules. This placement is based on the substance's medical use, potential for abuse, and safety or dependence liability. Schedule I drugs have a high potential for abuse and the potential to create severe psychological and/or physical dependence, whereas Schedule V drugs represent the least potential for abuse. Sample medications for each schedule are summarized in Table 2.3.[6]

Table 2.3 Definitions and Sample Medications for Each Type of Scheduled Medication

Schedule	Definition	Examples
Schedule I	No currently accepted medical use and a high potential for abuse.	Heroin, LSD, and marijuana
Schedule II	High potential for abuse, with use potentially leading to severe psychological or physical dependence. These drugs are also considered dangerous.	Vicodin, cocaine, methamphetamine, methadone, hydromorphone (Dilaudid), meperidine (Demerol), oxycodone (OxyContin), fentanyl, Dexedrine, Adderall, and Ritalin
Schedule III	Moderate to low potential for physical and psychological dependence. Abuse potential is less than Schedule I and Schedule II drugs but more than Schedule IV.	Tylenol with codeine, ketamine, anabolic steroids, and testosterone
Schedule IV	Low potential for abuse and low risk of dependence.	Xanax, Soma, Valium, Ativan, Talwin, Ambien, and Tramadol
Schedule V	Lower potential for abuse than Schedule IV and consist of preparations containing limited quantities of certain narcotics. Generally used for antidiarrheal, antitussive, and analgesic purposes.	Robitussin AC with codeine, Lomotil, and Lyrica

6. U.S. Department of Justice - Drug Enforcement Administration. (n.d.). *Drug scheduling*. https://www.dea.gov/drug-scheduling

Read more information about Drug Scheduling on the DEA website and view an alphabetic listing of drugs and their schedule.[7,8]

Drug overdose continues to be a public health crisis in the United States. The misuse of prescription opioids contributes to a large percentage of overdose deaths. Many problems associated with substance use are the result of legitimately made controlled substances being diverted from their lawful purpose into illicit drug traffic. The mission of DEA's Diversion Control Division is to prevent, detect, and investigate the diversion of controlled medications from legitimate sources while ensuring an adequate and uninterrupted supply for legitimate medical, commercial, and scientific needs. The DEA provides education regarding related topics that apply to nurses such as drug diversion, state prescription drug monitoring systems, current drug trends, and proper drug disposal.[9]

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 commonly diverted substances in health care facilities are opioids. Diversion of controlled substances can result in substantial risk, not only to the individual who is diverting the drugs, but also to clients, coworkers, and employers. Impaired health professionals can harm clients by providing substandard care or exposing clients to tainted substances.

7. U.S. Department of Justice - Drug Enforcement Administration. (n.d.). *Drug scheduling*. https://www.dea.gov/drug-scheduling
8. U.S. Department of Justice - Drug Enforcement Administration. (2023). *Controlled substances*. https://www.deadiversion.usdoj.gov/schedules/orangebook/c_cs_alpha.pdf
9. U.S. Department of Justice - Drug Enforcement Administration. (2023). *Controlled substances*. https://www.deadiversion.usdoj.gov/schedules/orangebook/c_cs_alpha.pdf

Tampering is the riskiest and most harmful type of diversion. Tampering occurs when the diverter removes medication from a syringe, vial, or other container and injects themselves with the medication. The diverter then replaces the stolen medication with saline, sterile water, or another clear liquid. The replaced liquid is then unknowingly administered to the client by an unaware nurse.[10,11]

The DEA provides an online reporting form for individuals to report suspected drug diversion anonymously.[12]

> View the RX Abuse Online Reporting form to report drug diversion to the DEA.[13]

Substance Use Disorder in Health Professionals

Substance use disorder (SUD) is an illness caused by repeated misuse of substances such as cannabis, opioids, sedatives, and stimulants. Substances taken in excess have a common effect of directly activating the brain reward system and producing such an intense activation of the reward system that normal life activities may be neglected.[14]

Health care professionals are not immune to developing SUD. It is important for nurses to be aware of the warning signs of SUD and to understand that SUD is a disease that can affect anyone regardless of age,

10. New, K. (2014, June 3). *Drug diversion defined: A patient safety threat*. Centers for Disease Control and Prevention. https://web.archive.org/web/20150716073835/http://blogs.cdc.gov/safehealthcare/2014/06/03/drug-diversion-defined-a-patient-safety-threat/
11. Berge, K. H., Dillon, K. R., Sikkink, K. M., Taylor, T. K., & Lanier, W. L. (2012). Diversion of drugs within health care facilities, a multiple-victim crime: Patterns of diversion, scope, consequences, detection, and prevention. *Mayo Clinic Proceedings, 87*(7), 674–682. https://www.ncbi.nlm.nih.gov/pubmed/22766087
12. U.S. Department of Justice - Drug Enforcement Administration. (n.d.). https://www.deadiversion.usdoj.gov/prog_dscrpt/index.html
13. U.S. Department of Justice - Drug Enforcement Administration. (n.d.). *RX abuse online reporting: Report incident*. https://apps2.deadiversion.usdoj.gov/rxaor/spring/main?execution=e1s1
14. American Psychiatric Association. (2013). *Desk reference to the diagnostic criteria from DSM-5*.

occupation, economic circumstances, ethnic background, or gender. In most states, a nurse with SUD may voluntarily enter a professional assistance program for evaluation and treatment.[15] Read more about professional assistance programs under the "State Law, State Nurse Practice Acts, and State Boards of Nursing" subsection below.

The National Council of State Boards of Nursing (NCSBN) created *A Nurse's Guide to Substance Use Disorder in Nursing* brochure that states many nurses with substance use disorder (SUD) are unidentified, unreported, untreated, and may continue to practice where their impairment may endanger the lives of their clients or themselves. It can be hard to differentiate between the subtle signs of impairment and stress-related behaviors, but three areas to watch for suspected SUD are behavior changes, physical signs, and drug diversion. Behavioral changes can include changes or shifts in job performance, absences from the unit for extended periods, frequent trips to the bathroom, arriving late or leaving early, and making an excessive number of mistakes, including medication errors. Physical signs include subtle changes in appearance that may escalate over time, increasing isolation from colleagues, inappropriate verbal or emotional responses, and diminished alertness, confusion, or memory lapses. When nurses with SUD commit drug diversion, there are often discrepancies that colleagues notice, such as incorrect opioid counts, a pattern of large amounts of opioid wastage, numerous corrections of medication records, frequent reports of ineffective pain relief from clients assigned to that nurse, increased agitation/combativeness of assigned clients with dementia, and patterns of increased administration of opioids to clients when that nurse is scheduled to work.[16]

As a student nurse and nurse, you have a professional and ethical responsibility to report a colleague's suspected SUD to your supervisor and, in some states or jurisdictions, to the State Board of Nursing. The earlier that SUD is identified in a nurse and treatment is started, the sooner clients are

15. National Council of State Boards of Nursing (NCSBN). (2018). *A nurse's guide to substance use disorder in nursing*. https://www.ncsbn.org/public-files/SUD_Brochure_2014.pdf
16. National Council of State Boards of Nursing (NCSBN). (2018). *A nurse's guide to substance use disorder in nursing*. https://www.ncsbn.org/public-files/SUD_Brochure_2014.pdf

protected, and the better the chances for the nurse with SUD to recover and safely return to work.[17]

> Visit the NCSBN's website to read "A Nurse's Guide to Substance Use Disorder in Nursing" brochure.

Drug Disposal Act

The Secure and Responsible Drug Disposal Act of 2010 allows users to dispose of controlled substances in a safe and effective manner. A Johns Hopkins study on sharing of medication found that 60% of people had leftover opioids they saved 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.[18] This act has resulted in "National Take Back Days" in all 50 states, as well as new collection receptacles.[19]

To prevent risk of drug diversion, nurses should teach clients who are prescribed controlled substances how to dispose of them properly so that they don't end up being misused or overdosed by another person. Figure 2.2[20] shows an example of a controlled substances collection receptacle.[21]

17. National Council of State Boards of Nursing (NCSBN). (2018). *A nurse's guide to substance use disorder in nursing.* https://www.ncsbn.org/public-files/SUD_Brochure_2014.pdf
18. U.S. Department of Justice - Drug Enforcement Administration. (2017, December 13). *Federal regulations and the disposal of controlled substances.* https://www.deadiversion.usdoj.gov/mtgs/drug_chemical/2017/wingert.pdf#search=drug%20disposal
19. U.S. Department of Justice - Drug Enforcement Administration. (2017, December 13). *Federal regulations and the disposal of controlled substances.* https://www.deadiversion.usdoj.gov/mtgs/drug_chemical/2017/wingert.pdf#search=drug%20disposal
20. "MedRx box.JPG" by York Police is licensed under CC0
21. U.S. Department of Justice - Drug Enforcement Administration. (2017, December 13). *Federal regulations and the disposal of controlled substances.* https://www.deadiversion.usdoj.gov/mtgs/drug_chemical/2017/wingert.pdf#search=drug%20disposal



Figure 2.2 Controlled Substances Collection Receptacle

Critical Thinking Activity 2.3b

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 medication is no longer needed when the post-op pain subsides, 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 whom 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 that the same types of incidents have occurred with previous clients but didn't want to say anything."
What is the new nurse's best response?

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

The Joint Commission

The Joint Commission is a national organization that accredits and certifies over 20,000 health care organizations in the United States. The mission of The Joint Commission is to continuously improve health care for the public by inspiring health care organizations to excel in providing safe and effective care of the highest quality and value.[22] Some of The Joint Commission's national initiatives regarding medication safety include creating a "Safety Culture" in health care organizations with associated root cause analysis, the Speak Up Campaign, National Patient Safety Goals, and the Official Do not

22. The Joint Commission. (n.d.). https://www.jointcommission.org/

Use List. Each of these safety initiatives is further discussed in the following subsections.

SAFETY CULTURE

The Joint Commission Center for Transforming Healthcare develops effective solutions for health care's most critical safety and quality problems with a goal to ultimately achieve zero harm to clients. Some of the projects the Center has developed include improved hand hygiene,[23] effective handoff communications,[24] and safe and effective use of insulin.[25]

The Center has also been instrumental in building a focus on creating a "Safety Culture" in health care organizations. A **Safety Culture** empowers staff to speak up about risks to clients and to report errors and near misses. These actions reduce the risk of client harm. 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."[26]

> Visit the Joint Commission's Safety Culture Assessment webpage to learn more.

A component of Safety Culture is the submission of incident reports according to agency guidelines whenever a medication error or a "near miss"

23. Joint Commission Center for Transforming Healthcare. (2020). *Hand hygiene*. https://www.centerfortransforminghealthcare.org/improvement-topics/hand-hygiene
24. Joint Commission Center for Transforming Healthcare. (2020.) *Effective hand-off communications*. https://www.centerfortransforminghealthcare.org/improvement-topics/hand-off-communications
25. Joint Commission Center for Transforming Healthcare. (2020). *Safe and effective use of insulin*. https://www.centerfortransforminghealthcare.org/improvement-topics/safe-and-effective-use-of-insulin
26. The Joint Commission. (2014, November). *Facts about the safety culture project*. https://www.centerfortransforminghealthcare.org/-/media/cth/documents/improvement-topics/cth_sc_fact_sheet.pdf

occurs. A near miss is a narrowly avoided error. The incident report triggers a **root cause analysis** by the organization to identify not only what and how an event occurred, but also why it happened. When investigators determine why an error occurred, they can create workable corrective measures to prevent future errors from occurring.[27]

An example of Safety Culture in action is a tragic event in 2006, when three infants died after incorrect heparin doses were used to flush their vascular access devices. A root cause analysis found that pharmacy technicians accidentally placed vials containing concentrated heparin (10,000 units/mL) in medication storage locations that were 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 a root cause analysis, the hospital no longer stores vials of heparin 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. In this manner, corrective measures were implemented to prevent future tragedies from occurring as a result of incorrect doses of heparin.[28]

SPEAK UP CAMPAIGN

The goal of The Joint Commission's Speak Up™ campaign is to help clients become more informed and involved in their health care to prevent medication errors. Speak Up™ materials are intended for the public and have been put into a simplified, easy-to-read format to reach a wider audience.[29]

27. Patient Safety Network. (2019). *Root cause analysis*. https://psnet.ahrq.gov/primer/root-cause-analysis
28. Institute for Safe Medication Practices. (2007, November 29). *Another heparin error: Learning from mistakes so we don't repeat them.* https://www.ismp.org/resources/another-heparin-error-learning-mistakes-so-we-dont-repeat-them
29. The Joint Commission. (n.d.). *Speak up campaigns. https://www.jointcommission.org/resources/for-consumers/speak-up-campaigns/#sort=%40z95xz95xcontentdate%20descending*

- Request additional “SpeakUp” materials from The Joint Commission Speak Up Fact Sheet webpage.

NATIONAL PATIENT SAFETY GOALS

The **National Patient Safety Goals (NPSG)** are established by The Joint Commission to help accredited organizations address current areas of concern related to patient safety. Annually, The Joint Commission determines the current highest priority patient safety issues with input from practitioners, provider organizations, purchasers, consumer groups, and other stakeholders and develops National Patient Safety Goals.

Two of the current National Patient Safety Goals relate specifically to medication administration: “Identify Patients Correctly” and “Use Medicines Safely.”

- Review The Joint Commission’s National Patient Safety Goals for Hospitals PDF[30]

Identify Patients Correctly

Nurses and health care professionals must use at least two ways to identify clients. For example, use the client’s name and date of birth. This is done to make sure that each client gets the correct medicine and treatment.[31]

30. The Joint Commission. (2023). *2023 hospital national patient safety goals.* https://www.jointcommission.org/assets/1/6/2019_HAP_NPSGs_final2.pdf
31. The Joint Commission. (2023). *2023 hospital national patient safety goals.* https://www.jointcommission.org/assets/1/6/2019_HAP_NPSGs_final2.pdf

Use Medicines Safely

Before a procedure, label medications that are not labeled. For example, medications in syringes, cups, and basins should be labelled in the area where medications and supplies are set up. Labels should include medication name, dose, date drawn up, and initials of the person who prepared the medication.[32] Additionally, do not leave medications unattended.

Record and pass along correct information about a client's medications. Find out what medications the client is taking. Compare those medications to new medications given to the client. Make sure the client knows which medications to take when they are at home. Tell the client it is important to bring their up-to-date list of medications every time they visit a doctor. Extra care must be taken with clients who take medications to thin their blood (anticoagulants).[33]

THE JOINT COMMISSION'S OFFICIAL DO NOT USE LIST

The Joint Commission maintains an Official Do Not Use List of abbreviations. These abbreviations have been found to commonly cause errors in client care. Accredited agencies are expected to not use these abbreviations on any written or preprinted materials.[34]

- Read The Joint Commission's Official Do Not Use List Fact Sheet

32. The Joint Commission. (2023). *2023 hospital national patient safety goals.* https://www.jointcommission.org/assets/1/6/2019_HAP_NPSGs_final2.pdf
33. The Joint Commission. (2023). *2023 hospital national patient safety goals.* https://www.jointcommission.org/assets/1/6/2019_HAP_NPSGs_final2.pdf
34. The Joint Commission. (2023). *Do not use list fact sheet.* https://www.jointcommission.org/facts_about_do_not_use_list/

CMS: Centers for Medicare and Medicaid Services

The Centers for Medicare & Medicaid Services (CMS) is a federal agency within the United States Department of Health and Human Services (HHS). The CMS administers the Medicare program and works in partnership with state governments to administer Medicaid and establishes and enforces regulations to protect client safety in hospitals that receive Medicare and Medicaid funding.[35]

CMS regulations related to the administration of medication by nurses include verifying information included in the prescription for a medication, checking the rights of medication administration, reporting concerns about a medication prescription, assessing and monitoring clients receiving medications, and documenting medication administration. Each of these regulations is further discussed below.

VERIFYING PRESCRIPTIONS

Medications and biologicals are administered in response to a prescription from a health care provider or on the basis of a standing order that is subsequently authenticated by a provider. Biologicals are a diverse group of medications that include vaccines, growth factors, immune modulators, monoclonal antibodies, and products derived from blood and plasma. All provider orders for the administration of drugs and biologicals must include the following:

- Name of the client
- Age and weight of the client to facilitate dose calculation when applicable. Agency policies and procedures must address weight-based dosing for pediatric client. Dose calculations for newborns are typically based on the metric weight in grams.
- Date and time of the order

35. U.S. Department of Health & Human Services, Centers for Medicare & Medicaid Services. (2014). *Memo: Requirements for hospital medication administration, particularly intravenous (IV) medications and post-operative care of patients receiving IV opioids*. https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-14-15.pdf

- 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 provider

CHECKING THE RIGHTS OF MEDICATION ADMINISTRATION

The CMS states that agency policies and procedures must reflect accepted standards of practice that require specific information is confirmed prior to administration of medication. This is commonly referred to as "checking the rights of medication administration."

When administering medications, it is essential for nurses to vigilantly check the rights of medication administration at least three times to prevent medication errors. What historically began as checking five rights of mediation administration has been extended to eight rights according to the American Nurses Association. These eight rights include the following[36]:

- **Right patient:** Check that you have the correct client using two patient identifiers according to agency policy (e.g., name and date of birth).
- **Right medication:** Check that you have the correct medication and that it is appropriate for the patent in the current context. Understand the purpose of the medication and why the client is receiving it.
- **Right dose:** Check that the dose is safe for the age, size, and condition of the client. Different dosages may be indicated for different conditions, and pediatric dosages are typically much lower than adult dosages.
- **Right route:** Check that the route is appropriate for the client's current condition.
- **Right time:** Adhere to the prescribed scheduling of the medication.

36. American Nurses Association. (2021). *ANA issue brief: Use of medication assistants/aides/technicians.* https://www.nursingworld.org/~498e32/contentassets/a2ff1bd2d5ca467699c3bc764f7d9198/issue-brief-medication-aides-4-2021.docx

- **Right documentation:** Always verify any unclear or inaccurate documentation prior to administering medications.
- **Right reason:** Verify this medication is being administered to this client at this time for the right reason. If signs and symptoms no longer warrant administration of the prescribed medication, notify the prescribing provider.
- **Right response:** After administering medication, the nurse must evaluate for expected outcomes with the time frame of expected onset and peak. The onset of medication administration occurs when the action of the medication begins to take effect. The peak of the medication administration occurs when the medication is at the highest level in the client's bloodstream. It is important for nurses to be aware of both the peak and onset of medications to know when the client's response to medication may start to be observed. The nurse must also be aware of potential side effects and adverse effects and evaluate for these unexpected outcomes. The prescribing provider should be notified if expected outcomes are not achieved or if adverse effects occur.

Many agencies have implemented barcode medication scanning to improve safety during medication administration. Barcode scanning systems reduce medication errors by electronically verifying the "rights" of medication administration. For example, when a nurse scans a barcode on the client's wristband and on the medication to be administered, the data is delivered to a computer software system where algorithms check databases and generate real-time warnings or approvals. Barcode scanning reduces errors resulting from administration of a wrong medication, incorrect dose, or wrong route. However, it is important for nurses to remember that barcode scanning should be used in addition to checking the rights of medication administration, not in place of this important safety process. Additionally, nurses should carefully consider their actions when errors occur during the barcode 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 patient safety concern that requires further follow-up before the medication is administered. Nurses must investigate errors that

occur during the barcode scanning process just as they would do if an error were discovered while checking the rights of medication administration.

View a YouTube video[37] example of a student preparing to administer medication and checking the rights of medication administration: Medication Administration.

COMMUNICATING CONCERNS ABOUT MEDICATION ORDERS

The CMS encourages hospitals to promote a culture in which it is not only acceptable, but also strongly encouraged, for staff to notify prescribing providers regarding concerns they have regarding medication orders.[38] It is essential for nurses to contact the prescribing provider if they have any concerns when checking the rights of medication administration before administering the medication to the client. Furthermore, nurses can be held liable in a court of law if they administer medication that results in client harm if a "prudent nurse" would have had concerns about the order and questioned it.

MONITORING CLIENTS RECEIVING MEDICATIONS

The CMS states that observing the effects medications have on the client is part of the multifaceted medication administration process. 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.

37. Kimberly Dunker. (2020, April 6). *Mediation Administration.* [Video]. YouTube. All rights reserved. https://youtu.be/MUn4Ec2X93g
38. U.S. Department of Health & Human Services, Centers for Medicare & Medicaid Services. (2014). *Memo: Requirements for hospital medication administration, particularly intravenous (IV) medications and post-operative care of patients receiving IV opioids*. https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-14-15.pdf

Depending on the medication and route/delivery mode, monitoring may include assessment of the following:

- Clinical and laboratory data to evaluate the efficacy of medication therapy, potential toxicity, and adverse effects. For some medications, such as opioids, this monitoring 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. The consequences of errors can be harmful and sometimes fatal to clients. In addition, certain factors place some clients at greater risk for adverse effects of medication. These factors include, but are not limited to, age, altered liver and kidney function, drug-to-drug interactions, and first-time medication use.

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 client medication risk factors and monitoring requirements during hand-off reports to other staff.

Adverse client reactions, such as anaphylaxis or opioid-induced sedation and respiratory depression, require timely and appropriate intervention per agency protocols and should also be immediately reported to the prescribing provider. An example of vigilant post-medication administration monitoring is when a nurse closely monitors a post-surgical client who is receiving opioid pain medication via a patient-controlled analgesia (PCA) pump. Opioid medications are 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. The nurse should closely monitor the client's respiratory rate, oxygen saturation, carbon dioxide levels, level of sedation, blood pressure, and pulse to quickly observe and intervene in the event of an adverse event. In addition, the client and/or family members are educated to notify nursing

staff promptly when there is difficulty breathing or other changes that might be a reaction to medication.[39]

DOCUMENTING

CMS regulations require the agency's documentation regarding medication administration contains providers' orders, nursing notes, reports of treatment, medication administration records, radiology and laboratory reports, vital signs, and other information necessary to monitor the client's condition. Documentation of medication administration is expected to occur immediately after the medication is administered to the client; documenting prior to the administration of the medication is inappropriate and can result in medication errors. Proper documentation of medication administration and client outcomes is essential for planning and delivering future care of the client.[40,41]

Critical Thinking Activity 2.3c

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

39. U.S. Department of Health & Human Services, Centers for Medicare & Medicaid Services. (2014). *Memo: Requirements for hospital medication administration, particularly intravenous (IV) medications and post-operative care of patients receiving IV opioids*. https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-14-15.pdf
40. U.S. Department of Health & Human Services, Centers for Medicare & Medicaid Services. (2014). *Memo: Requirements for hospital medication administration, particularly intravenous (IV) medications and post-operative care of patients receiving IV opioids*. https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-14-15.pdf
41. American Society of Health-System Pharmacists (Ed.). (2018). ASHP guidelines on preventing medication errors in hospitals. *American Journal of Health-System Pharmacy, 75*, 1493–1517. https://www.ashp.org/-/media/assets/policy-guidelines/docs/guidelines/preventing-medication-errors-hospitals.ashx

1. Explain the rights of medication administration the nurse must check prior to administering this medication to the client.
2. Outline three methods the nurse can use to confirm patient 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

State Law, State Nurse Practice Acts, and State Boards of Nursing

In additional to federal laws, regulations, national guidelines, and safety initiatives, state law also protects public health and safety. Each state has a Nurse Practice Act (NPA) that is enacted by the state legislature. The State Board of Nursing (SBON) enforces the NPA.[42] The purpose of the SBON is to protect the public through licensure, education, legislation, and discipline regarding rules of conduct. The SBON regulates the licensure and practice of registered nurses (RNs), licensed practical/vocational nurses (LPNs/VNs), and advanced practice nurse prescribers (APNPs).[43]

42. Wisconsin Department of Safety and Professional Services. (n.d.). *Wisconsin nurse practice act (NPA) course*. https://dsps.wi.gov/Documents/BoardCouncils/NUR/20190110NURAdditionalMaterials.pdf
43. Wisconsin Department of Safety and Professional Services. (n.d.). *Wisconsin nurse practice act (NPA) course*. https://dsps.wi.gov/Documents/BoardCouncils/NUR/20190110NURAdditionalMaterials.pdf

Nurses are responsible for knowing the state laws that relate to nursing care in the state in which they work. Furthermore, nurses must follow the scope of practice outlined in the NPA in the state in which they are employed. Nurses are accountable for the quality of care they provide and are expected to practice at the level of education, knowledge, and skill of someone who has completed an approved nursing program. All nurses are expected to recognize the limits of their knowledge and experience and to appropriately address situations that are beyond their competency.[44]

> See an example of a Nurse Practice Act established by the Wisconsin Board of Nursing.[45]

Nurse Practice Act: Standards of Practice

The NPA outlines the standards of care provided by a registered nurse (RN), also known as the **nursing process**. As previously discussed in this chapter, the steps of the nursing process are also considered a standard of care by the ANA. A nurse utilizes the nursing process when executing nursing care and procedures in the maintenance of clients' health, prevention of illness, or care of the ill. Review the steps of the nursing process in the "Ethical and Professional Foundations of Safe Medication Administration by Nurses" section of this chapter.

Nurse Practice Act: Rules of Conduct

The NPA also outlines rules of conduct expected of nurses. Nurses can receive disciplinary action from the SBON, ranging from a reprimand to revocation of

44. Wisconsin Department of Safety and Professional Services. (n.d.). *Wisconsin nurse practice act (NPA) course*. https://dsps.wi.gov/Documents/BoardCouncils/NUR/20190110NURAdditionalMaterials.pdf
45. Wisconsin Department of Safety and Professional Services. (n.d.). *Board of nursing Wisconsin Administrative Code*. https://dsps.wi.gov/Pages/RulesStatutes/Nursing.aspx

their license, if they do not follow the enacted rules of conduct. A nurse must maintain current knowledge about expected rules of conduct in each state where they practice nursing to protect their nursing license.

View an example of Rules of Conduct established in Chapter N7, "Rules of Conduct," of the Wisconsin Nurse Practice Act PDF.[46,47]

A SBON may take disciplinary action against a nurse's license for many reasons. Common reasons related to medication administration include, but are not limited to, the following:

- Noncompliance with federal, jurisdictional, or reporting requirements, including practicing beyond the scope of practice.
- Confidentiality, client privacy, consent, or disclosure violations.
- Fraud, deception or misrepresentation, including falsification of client documentation.
- Unsafe practice or substandard care, including:
  - Failing to perform nursing care with reasonable skill and safety.
  - Departing from or failing to conform to the minimal standards of acceptable nursing practice that may create unnecessary risk or danger to a client's life, health, or safety. Actual injury to a client does not need to be established.
  - Failing to report to or leaving a nursing assignment without properly notifying appropriate supervisory personnel and ensuring the safety and welfare of the client.
  - Practicing nursing while under the influence of alcohol, illicit drugs, or

46. Wisconsin Department of Safety and Professional Services. (n.d.). *Wisconsin nurse practice act (NPA) course*. https://dsps.wi.gov/Documents/BoardCouncils/NUR/20190110NURAdditionalMaterials.pdf
47. Wisconsin State Legislature. (2016, August). *Chapter N7 rules of conduct*. https://docs.legis.wisconsin.gov/code/admin_code/n/7.pdf

while impaired by the use of legitimately prescribed pharmacological agents or medications.
    - Inability to practice safely due to alcohol or other substance use, psychological or physical illness, or impairment.
    - Executing an order which the licensee knew or should have known could harm a client.
- Improper supervision.
- Improper prescribing, dispensing, or administering medication or drug-related offenses.[48]

State Statutes Related to Controlled Substances

In addition to the NPA, there are other state statutes that guide nursing care and medication administration. State statutes are a compilation of the general laws of the state and often include chapters related to the state regulation of controlled substances (in addition to federal law previously discussed in this section).

View an example of state regulation of controlled substances in Wisconsin Chapter 961: Uniform Controlled Substances Act.

PRESCRIPTION DRUG MONITORING PROGRAM

Examples of state law related to controlled substances are prescription drug monitoring programs (PDMP). Many states have implemented PDMP to help combat the ongoing prescription substance abuse epidemic, as well as to help prevent drug diversion. Pharmacies and health care providers are often required by state law to participate in a PDMP when dispensing or prescribing controlled substances. A PDMP is a statewide electronic database

48. Wisconsin Department of Safety and Professional Services. (n.d.). *Wisconsin nurse practice act (NPA) course*. https://dsps.wi.gov/Documents/BoardCouncils/NUR/20190110NURAdditionalMaterials.pdf

that collects data on substances dispensed in the state. By providing valuable information about controlled substance prescriptions that are dispensed in the state, PDMPs help health care providers make prescribing and dispensing decisions. PDMPs also foster the ability of pharmacies, health care professionals, law enforcement agencies, and public health officials to work together to reduce the misuse, abuse, and diversion of prescribed controlled substances.

- View Wisconsin's Enhanced Prescription Drug Monitoring Program (ePDMP)[49]

PROFESSIONAL ASSISTANCE PROGRAMS

In addition to state statutes related to controlled substances, many states offer professional assistance programs as voluntary, nondisciplinary programs to provide support for health professionals with substance abuse disorders (SUD) who are committed to their own recovery. The goal of professional assistance programs is to protect the public by promoting early identification of professionals with SUD and encouraging their rehabilitation and recovery. Professional assistance programs provide an opportunity for nurses with SUD to continue to be employed while being monitored by the SBON and supported in their recovery.

- View Wisconsin's Professional Assistance Program.[50]

49. Wisconsin ePDMP. (2019). https://pdmp.wi.gov/
50. Wisconsin Department of Safety and Professional Services. (n.d.). *Wisconsin nurse practice act (NPA) course*. https://dsps.wi.gov/Documents/BoardCouncils/NUR/20190110NURAdditionalMaterials.pdf

Critical Thinking Activity 2.3d

A nurse is disciplined by the Wisconsin Board of Nursing for an incident reported by her employer that she arrived at her shift intoxicated. The nurse shares with a nursing colleague, "I love taking care of patients. I worked so hard to obtain my nursing license – I don't want to lose it. I know my drinking has gotten out of control, but I don't know where to turn."

What is the best advice by the nursing colleague for this nurse with a drinking problem?

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

2.4 Cultural and Social Determinants Related to Medication Administration

In addition to the legal and ethical considerations, there are also cultural and social influences that the nurse must consider when administering medication. According to the 2018 U.S. Census report, by the year 2030, the nation's population is projected to age considerably and become even more racially and ethnically diverse. Though health indicators such as life expectancy and infant mortality have improved for most Americans, some people from racial and ethnic minority groups experience a disproportionate burden of preventable disease, death, and disability compared with non-Hispanic white people.[1]

The American Nurses Association's (ANA) *Scope and Standards of Practice* states the need for health care is universal and transcends differences with respect to the culture, values, and preferences of individuals, families, groups, and communities. Diversity characterizes today's health care environment, and nursing is responsive to the changing needs of society. To effectively promote meaningful client outcomes that maximize quality of life across the life span, the ANA states that nurses must engage in cultural humility. **Cultural humility** is a humble and respectful attitude toward individuals of other cultures that pushes one to challenge their own cultural biases, realize they can't possibly know everything about other cultures, and approach learning about other cultures as a lifelong goal and process.[2] As previously discussed in this chapter, culturally congruent practice is the application of

1. Centers for Disease Control and Prevention. (2023). *Minority health and health equity.* https://www.cdc.gov/minorityhealth/index.html
2. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association.

evidence-based nursing that is in agreement with the preferred cultural values, beliefs, worldview, and practices of the health care client.

In addition to cultural beliefs, conditions in the places where people live, learn, work, and play can also affect their health, functioning, quality of life, and risks. These conditions are known as **social determinants of health (SDOH)**. Differences in health can be significant in communities with poor SDOH such as unstable housing, low incomes, unsafe neighborhoods, or substandard education. These differences are referred to as health disparities. By applying what we know about SDOH, nurses can not only improve an individual's health, but also improve health equity for communities and the population as a whole.

Healthy People is a government agency that provides science-based, ten-year national objectives for improving the health of all Americans. Healthy People 2030 highlights the importance of addressing SDOH with a goal to "create social, physical, and economic environments that promote attaining the full potential for health and well-being for all."[3,4]

> Read additional information about Social Determinants of Health on the Healthy People 2030 website.

The U.S. Department of Health and Human Services also sets national standards for Culturally and Linguistically Appropriate Services (CLAS) in health and health care. The national CLAS standards are intended to advance health equity, improve quality, and help eliminate health disparities by "providing effective, equitable, understandable, and respectful quality care and services that are responsive to diverse cultural health beliefs and practices, preferred languages, health literacy, and other communication needs."[5]

3. Social Determinants of Health: Know What Affects Health by Centers for Disease Control and Prevention is available in the Public Domain.
4. Social Determinants of Health by Healthy People 2030 is available in the Public Domain.
5. U.S. Department of Health and Human Services, Office of Minority Health. (n.d.). *National standards for culturally*

The U.S. Department of Health and Human Services (HHS) defines **health literacy** as "the degree to which individuals have the capacity to obtain, process, and understand basic health information needed to make appropriate health decisions." Adequate health literacy may include being able to read and comprehend essential health-related materials such as information on a medication bottle or in a handout. Nurses promote health literacy by including interventions such as visual aids to increase client understanding and, thereby, improve client safety.[6]

View the National CLAS Standards PDF.

Examples of Culturally Congruent Practice Related to Medication Therapy

There are several instances when a nurse must assess and accommodate a client's cultural beliefs and social determinants of health when administering medications or teaching about medications. For example, a nurse addresses health literacy and medication safety by assisting a client to read information on a medication bottle or on a handout.

Another example of culturally congruent practice is when a nurse considers cultural or religious beliefs, such as fasting, when administering medications. For example, a Muslim client may participate in Ramadan, which requires 12-hour fasting. A nurse can advocate for the client and assist in altering the scheduling of medication to accommodate the client's beliefs in order to reduce the risk of treatment failure.

and linguistically appropriate services (CLAS) in health and health care. https://thinkculturalhealth.hhs.gov/assets/pdfs/EnhancedNationalCLASStandards.pdf

6. Health Literacy by Health People 2030 is available in the Public Domain.

Read more about medication intake during Ramadan.[7]

A third example of culturally congruent practice is when a nurse considers how a client's ethnic background may affect their ability to respond to medications. For example, African Americans often require combination therapy to treat hypertension, and Asian and Hispanic clients often respond better to lower doses of antidepressants.

View a free module from the U.S. Department of Health and Human Services: Culturally Competent Nursing Care: A Cornerstone of Caring.

Critical Thinking Activity 2.4

A nurse is providing health teaching to a mother regarding a liquid antibiotic prescribed for her child to take at home. The prescription states amoxicillin 250 mg, give 1 teaspoon (5 mL) every eight hours for seven 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?

7. Aadil, N., Houti, I. E., & Moussamih, S. (2004). Drug intake during Ramadan. *BMJ (Clinical Research Ed.), 329*, 778–782. https://doi.org/10.1136/bmj.329.7469.778

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

2.5 Preventing Medication Errors

Preventing medication errors has been a key target for improving safety since the 1990s. Despite error reduction strategies, implementing new technologies, and streamlining processes, medication errors remain a significant concern with error rates of 8%-25% during medication administration.[1] Furthermore, a substantial proportion of errors occur in hospitalized children due to the complexity of weight-based pediatric dosing.[2]

Several prevention initiatives have been developed to ensure safe medication administration such as the following strategies[3]:

- Routinely checking the rights of medication administration
- Standardizing communication such as “tall man lettering,” alerts to “look alike-sound alike” drug names, avoidance of abbreviations, and standards for expressing numerical dosages
- Focusing on high-alert medications that have a higher likelihood of resulting in patient harm if involved in an administration error, such as anticoagulants, insulins, opioids, and chemotherapy agents
- Standardizing labelling of medication using visual cues as safeguards
- Optimizing nursing workflow to minimize errors, such as minimizing interruptions and double checking high alert medications
- Implementing technology like barcode medication administration and smart infusion pumps

1. MacDowell, P., Cabri, A., & Davis, M. (2021). *Medication administration errors*. https://psnet.ahrq.gov/primer/medication-administration-errors
2. MacDowell, P., Cabri, A., & Davis, M. (2021). *Medication administration errors*. https://psnet.ahrq.gov/primer/medication-administration-errors
3. MacDowell, P., Cabri, A., & Davis, M. (2021). *Medication administration errors*. https://psnet.ahrq.gov/primer/medication-administration-errors

Read the article "Medication Administration Errors" on the Agency of Healthcare Research and Quality (AHRQ) website.[4]

The Joint Commission's National Patient Safety Goals related to mediation administration were previously discussed in the "Legal Foundations and National Guidelines for Safe Medication Administration" section of this chapter. This section will further discuss additional safety initiatives established by the Institute of Medicine (IOM), World Health Organization (WHO), Institute for Safe Medication Practices (ISMP), and Quality and Safe Education for Nurses (QSEN) to prevent medication errors.

Institute of Medicine

To Err is Human: Building a Safer Health System Report

The national focus on reducing medical errors has been in place since the 1990s. The Institute of Medicine (IOM) released a historic report in 1999 titled *To Err is Human: Building a Safer Health System*. The report stated that errors caused between 44,000 and 98,000 deaths every year in American hospitals and over one million injuries. The IOM report called for a 50% reduction in medical errors over five years. Its goal was to break the cycle of inaction regarding medical errors by advocating for a comprehensive approach to improving patient safety. The IOM 1999 report changed the focus of patient safety from dispensing blame to improving systems.[5]

4. MacDowell, P., Cabri, A., & Davis, M. (2021). *Medication administration errors*. https://psnet.ahrq.gov/primer/medication-administration-errors
5. Institute of Medicine. (2000). *To err is human: Building a safer health system*. The National Academies Press. https://doi.org/10.17226/9728

Preventing Medication Errors Report

In 2007 the IOM published a follow-up report titled *Preventing Medication Errors,* reporting that more than 1.5 million Americans are injured every year in American hospitals, and the average hospitalized client experiences at least one medication error each day. This report emphasized actions that health care systems, providers, funders, and regulators could take to improve medication safety. These recommendations included actions such as having all U.S. prescriptions written and dispensed electronically, promoting widespread use of medication reconciliation, and performing additional research on drug errors and their prevention. The report also emphasized actions that client can take to prevent medication errors, such as maintaining active medication lists and bringing their medications to appointments for review.[6]

The *Preventing Medication Errors* report included specific actions for nurses to improve medication safety. The box below summarizes key actions.[7]

Improving Medication Safety: Actions for Nurses

- Establish safe work environments for medication preparation, administration, and documentation; for instance, reduce distractions and provide appropriate lighting.
- Maintain a culture of rigorous commitment to principles of safety in medication administration (for example, consistently checking the rights of medication

6. Institute of Medicine. (2007). *Preventing medication errors*. The National Academies Press. https://doi.org/10.17226/11623
7. Institute of Medicine. (2007). *Preventing medication errors*. The National Academies Press. https://doi.org/10.17226/11623

administration and also performing double checks with colleagues as recommended).

- Remove barriers and facilitate the involvement of client surrogates in checking the administration and monitoring the medication effects.
- Foster a commitment to clients' rights as co-consumers of their care.
- Develop aids for clients or their surrogates to support self-management of medications.
- Enhance communication skills and team training to be prepared and confident in questioning medication orders and evaluating client responses to drugs.
- Actively advocate for the development, testing, and safe implementation of electronic health records.
- Work to improve systems that address "near misses" in the work environment.
- Realize they are part of a system and do their part to evaluate the efficacy of new safety systems and technology.
- Contribute to the development and implementation of error reporting systems and support a culture that values accurate reporting of medication errors.

World Health Organization: Medication Without Harm

In 2019, the World Health Organization (WHO) identified "Medication Without Harm" as the theme for the third Global Patient Safety Challenge with the goal of reducing severe, avoidable medication-related harm by 50% over the next five years. As part of the *Global Patient Safety Challenge: Medication*

Without Harm, the WHO has prioritized three areas to protect clients from harm while maximizing the benefit from medication[8]:

- Medication safety in high-risk situations
- Medication safety in **polypharmacy**
- Medication safety in transitions of care

Read more information about the WHO initiative called Medication Without Harm.

View the follow YouTube video explaining how to avoid harm from medications.

Medication Without Harm[9]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=73#oembed-1

A summary of strategies to reduce harm and ensure medication safety is provided in Figure 2.3.[10]

8. World Health Organization. (n.d.). *Medication without harm*. https://www.who.int/initiatives/medication-without-harm
9. World Health Organization (WHO). (2017, October 17). *WHO: Medication without harm* [Video]. YouTube. https://youtu.be/MWUM7LIXDeA
10. This image is a derivative of Medication Safety in High-Risk Situations by World Health Organization, https://apps.who.int/iris/handle/10665/325131 page 7, licensed under CC BY-NC-SA 3.0

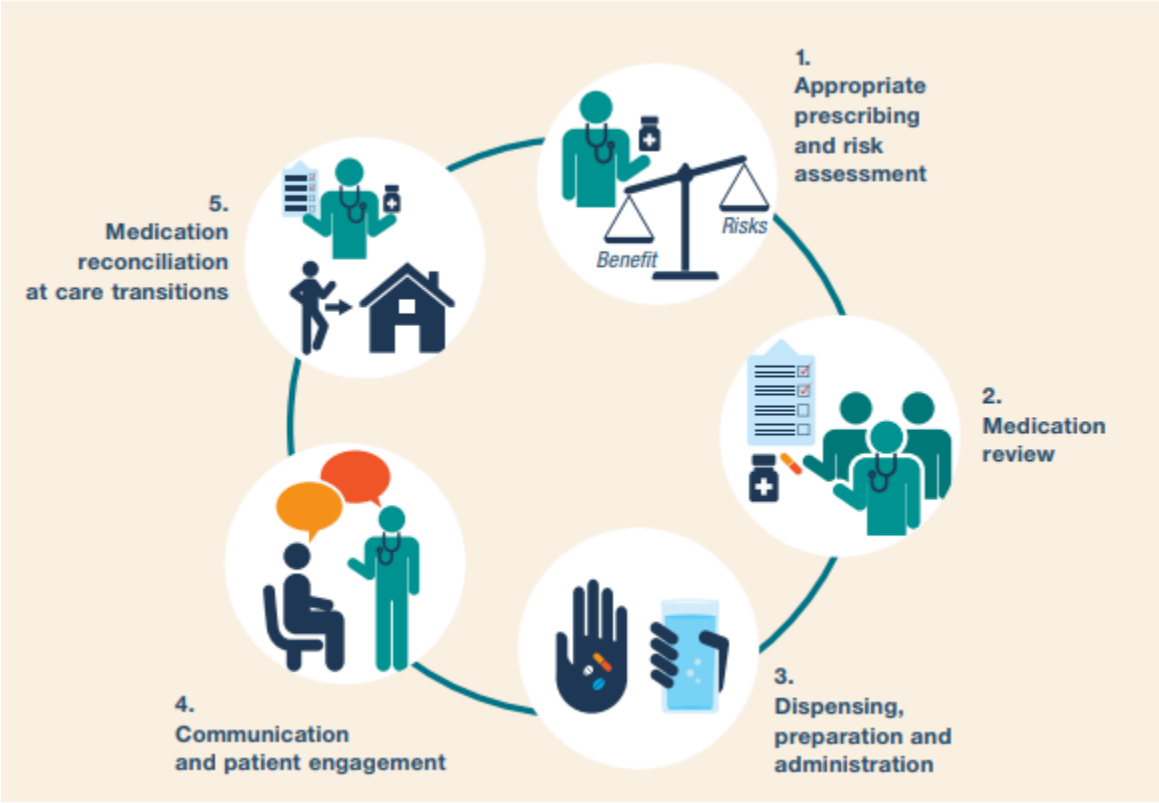


Figure 2.3 Key Steps for Ensuring Medication Safety

Medication Safety in High-Risk Situations

The first priority of the WHO *Medications Without Harm* initiative, medication safety in high-risk situations, includes the components of high-risk medications, provider-client relations, and systems factors.

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.[11]

High-risk medication can be remembered using the mnemonic "A PINCH." The information in the box below describes these medications included with the "A PINCH" mnemonic.

11. Institute for Safe Medication Practices. (2018). ISMP List of High-Alert Medications for Acute Care Settings. https://www.ismp.org/sites/default/files/attachments/2018-08/highAlert2018-Acute-Final.pdf

High-Risk Medication Group	Examples of Medication
A: Anti-infective	Amphotericin, aminoglycosides
P: Potassium & other electrolytes	Injections of potassium & other electrolytes
I: Insulin	All types of insulin
N: Narcotics & other sedatives	Opioids, such as morphine; Benzodiazepines
C: Chemotherapeutic agents	Methotrexate and vincristine
H: Heparin & anticoagulants	Warfarin and enoxaparin

Note: Based on research, the Institute of Safe Medication Practices (ISMP) has expanded this list of high-risk medications. The updated list can be viewed in the box below.

Strategies for safe administration of high-alert medication include the following:

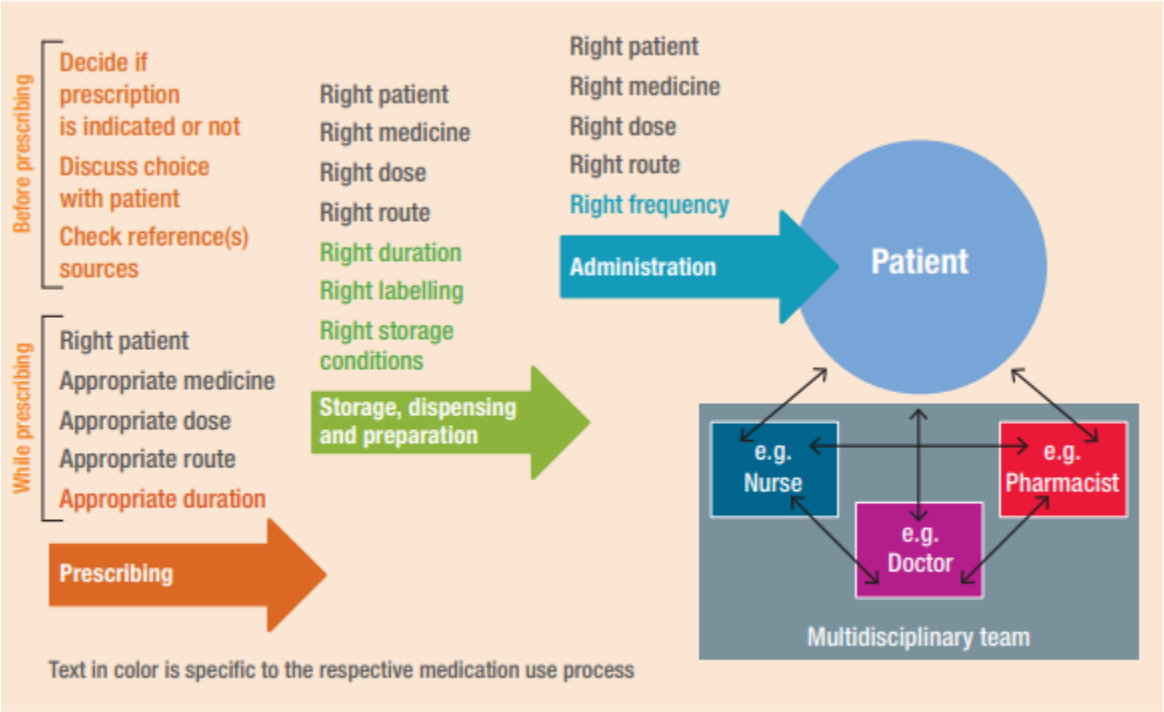
- Standardizing the ordering, storage, preparation, and administration of these products
- Improving access to information about these drugs
- Employing clinical decision support and automated alerts
- Using redundancies such as automated or independent double-checks when necessary

View the ISMP List of High-Alert Medications in Acute Care Settings PDF.

PROVIDER-PATIENT RELATIONS

In addition to high-risk medications, a second component of medication safety in high-risk situations includes provider and client factors. This component relates to either the health care professional providing care or the client being treated. Even the most dedicated health care professional is fallible and can make errors. The act of prescribing, dispensing, and administering a medicine is complex and involves several health care professionals. The client should be the center of what should be a "prescribing partnership."[12] See Figure 2.4 for an illustration of the prescribing partnership.[13]

12. This work is a derivative of Medication Safety in High-Risk Situations by World Health Organization and is licensed under CC BY-NC-SA 3.0
13. This image is a derivative of (2019) Medication Safety in High-Risk Situations by World Health Organization, https://apps.who.int/iris/handle/10665/325131 page 24, licensed under CC BY-NC-SA 3.0



Source: Adapted, with the permission of the publisher, from Routledge *(94)*.

Figure 2.4 Prescribing Partnership

Life Span Considerations

Other risk factors can exist in specific clients across the life span. For example, adverse drug events occur most often at the extremes of life (in the very young and very old). In the older adult population, frail clients are likely to receive several medications concurrently, which adds to the risk of adverse drug events. In addition, the harm of some of these medication combinations may be synergistic, meaning the risk is greater when medications are taken together than the sum of the risks of individual agents. In neonates (particularly premature neonates), elimination routes through the kidney or liver may not be fully developed. The very young and very old are also less likely to tolerate adverse drug reactions, either because their homeostatic mechanisms are not yet fully developed, or they may have deteriorated. 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.

Additionally, certain medical conditions predispose clients to an increased risk of adverse drug reactions, particularly renal or hepatic dysfunction and cardiac failure. Interprofessional strategies to address these potential harms are based on a systems approach with a "prescribing partnership" between the client, the prescriber, the pharmacist, and the nurse that includes verifying orders when concerns exist.

SYSTEMS FACTORS

In addition to high-risk medications and provider-patient relations, systems factors also contribute to medication safety in high-risk situations. Systems factors can contribute to error-provoking conditions for several reasons. The unit may be busy or understaffed, which can contribute to inadequate supervision or failure to remember to check important information. Interruptions during critical processes (e.g., administration of medicines) can also occur, which can have significant implications for patient safety. Tiredness and the need to multitask when busy or flustered can also contribute to error and can be compounded by poor electronic medical record design. Preparing and administering intravenous medications are also particularly error prone. Strategies for reducing errors include checking at each step of the medication administration process; preventing interruptions; using electronic provider order entry; and utilizing prescribing assessment tools, such as the Beers Criteria, to evaluate for potentially inappropriate medication use in older adults.[14] The Beers Criteria is a list of potentially harmful medications or medications with side effects that outweigh the benefit of taking the medication.

Read additional information about the updated Beers Criteria by the American Geriatrics Society.

14. This work is a derivative of Medication Safety in High-Risk Situations by World Health Organization and is licensed under CC BY-NC-SA 3.0

Medication Safety in Polypharmacy

The second priority of the WHO *Medications Without Harm* initiative relates to medication safety in polypharmacy. 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 including over-the-counter, prescription, and complementary medicines.

As people age, they are more likely to suffer from multiple chronic illnesses and take multiple medications. It is essential to use a person-centered approach to ensure their medications are appropriate to gain the most benefits without harm and to ensure the client is part of the decision-making process. Appropriate polypharmacy is present when all medicines are prescribed for the purpose of achieving specific therapeutic objectives that have been agreed with the client; therapeutic objectives are actually being achieved or there is a reasonable chance they will be achieved in the future; 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 medications are prescribed that are no longer needed. One or more medications may no longer be needed because there is no evidence-based indication, the indication has expired or the dose is unnecessarily high, they fail to achieve the therapeutic objectives they were intended to achieve, one or the combination of several medications put the client at a high risk of adverse drug reactions, or the client is not willing or able to take the medications as intended.[15]

When clients transition across health care settings, medication review by nurses is essential to prevent harm caused by inappropriate polypharmacy.[16]

15. This work is a derivative of Medication Safety in Polypharmacy by World Health Organization and is licensed under CC BY-NC-SA 3.0
16. This work is a derivative of Medication Safety in Polypharmacy by World Health Organization and is licensed under CC BY-NC-SA 3.0

Review questions to address during a medication review in Chapter 2 of WHO's Medication Safety in Polypharmacy Technical Report.[17]

Medication Safety in Transitions of Care

The third priority of the WHO *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.

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=73#h5p-5

"Medication Reconciliation Process" by E. Christman for Open RN is licensed under CC BY 4.0

Medication errors can occur during transitions across settings. Figure 2.5[18] is an image from the World Health Organization showing ranges of percentage of errors that occur during common transitions of care.

17. Medication Safety in Polypharmacy by World Health Organization and is licensed under CC BY-NC-SA 3.0
18. This work is a derivative of (2019) Medication Safety in Transition of Care by World Health Organization, https://apps.who.int/iris/bitstream/handle/10665/325453/WHO-UHC-SDS-2019.9-eng.pdf?ua=1 page 15, licensed under CC BY-NC-SA 3.0

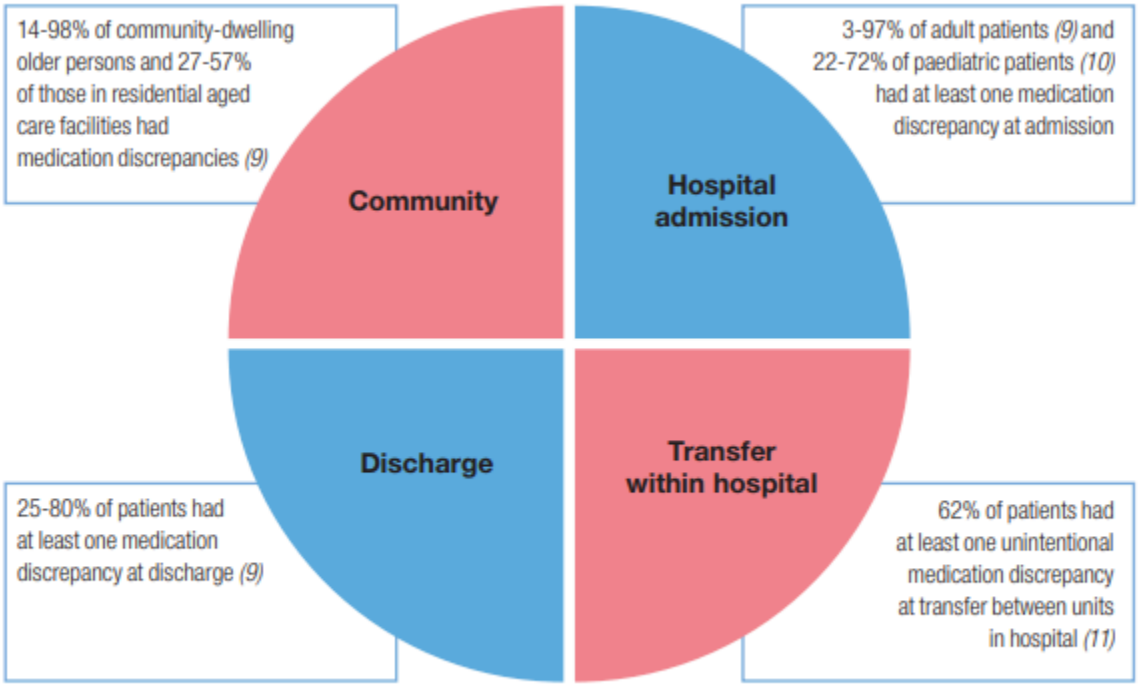


Figure 2.5 Medication Discrepancies at Various Transitions of Care

Key strategies for improving medication safety during transitions of care include the following:

- Implementing formal structured processes for medication reconciliation at all transition points of care. Steps of effective medication reconciliation are to build 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 health care providers about changes in their medications.
- Partnering with clients, families, caregivers, and health care professionals to agree on treatment plans, ensuring clients are equipped to manage their medications safely, and ensuring clients have an up-to-date medication list.
- Where necessary, prioritizing clients at high risk of medication-related

harm for enhanced support such as post-discharge contact by a nurse.[19]

Critical Thinking Activity 2.5a

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 taken at home.

What other sources can the nurse use to obtain medication information?

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

Institute for Safe Medication Practices

The Institute for Safe Medication Practices (ISMP) is respected as the gold standard for medication safety information. It is a nonprofit organization devoted entirely to preventing medication errors. ISMP collects and analyzes thousands of medication error and adverse event reports each year through its voluntary reporting program and then issues alerts regarding errors happening across the nation. The ISMP has established several prevention strategies for safe medication administration, including lists of high-alert medications, error-prone abbreviations to avoid, do not crush medications, look-alike and sound-alike drugs, and error-prone conditions that lead to error

19. This image is a derivative of Medication Safety in Transition of Care by World Health Organization licensed under CC BY-NC-SA 3.0

by nurses and student nurses. Each of these initiatives is further described below.[20]

Error-Prone Abbreviations

ISMP's List of Error-Prone Abbreviations, Symbols, and Dose Designations contains 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. These abbreviations, symbols, and dose designations should never be used when communicating medical information. Note that this list has additional abbreviations than those contained in The Joint Commission's Do Not Use List of Abbreviations. Review the information below for the ISMP list of error-prone abbreviations to avoid. Some examples of abbreviations that were commonly used that should now be avoided are qd, qod, qhs, BID, QID, D/C, subq, and APAP.[21]

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.

- Download the ISMP List of Error-Prone Abbreviations to Avoid PDF.

20. Institute for Safe Medication Practices. (2007, October 18). *Error-prone conditions that lead to student nurse-related errors*. https://www.ismp.org/resources/error-prone-conditions-lead-student-nurse-related-errors
21. Institute for Safe Medication Practices. (2017, October 2). *List of error-prone abbreviations.* https://www.ismp.org/recommendations/error-prone-abbreviations-list

Do Not Crush List

The IMSP 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.[22] 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 maintains a list of drug names containing look-alike and sound-alike name pairs such as Adderall and Inderal. These medications require special safeguards to reduce the risk of errors and minimize harm.

Safeguards may include the following:

- 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
- Configuring computer selection screens to prevent look-alike names from appearing consecutively[23]

Download the ISMP's List of Confused Drug Names PDF.

Error-Prone Conditions That Lead to Student Nurse

22. Institute for Safe Medication Practices. (2020, February 21). *Oral dosage forms that should not be crushed.* https://www.ismp.org/recommendations/do-not-crush
23. Institute for Safe Medication Practices. (2019, February 28). *List of confused drug names.* https://www.ismp.org/recommendations/confused-drug-names-list

Related Error

When analyzing errors involving student nurses reported to the USP-ISMP Medication Errors Reporting Program and the PA Patient Safety Reporting System, it appears that many errors arise from a distinct set of error-prone conditions or medications. Some student-related errors are similar in origin to those that seasoned licensed health care professionals make, such as misinterpreting an abbreviation, misidentifying drugs due to look-alike labels and packages, misprogramming a pump due to a pump design flaw, or simply making a mental slip when distracted. Other errors stem from system problems and practice issues that are rather unique to environments where students and hospital staff are caring together for clients. View the list of error-prone conditions that should be avoided using the following box.

- View Error-Prone Conditions That Lead to Student Nurse-Related Error.

Critical Thinking Activity 2.5b

A nurse is preparing to administer insulin to a client. The nurse is aware that insulin is a medication on the ISMP 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

Quality and Safety Education for Nurses

The Quality and Safety Education for Nurses (QSEN) project's vision is to "inspire health care professionals to put quality and safety as core values to guide their work." QSEN began in 2005 and is funded by the Robert Wood Johnson Foundation. Based on the Institute of Medicine (2003) competencies for nursing, QSEN further defined these quality and safety competencies for educating nursing students:

- Patient-Centered Care
- Teamwork & Collaboration
- Evidence-Based Practice
- Quality Improvement
- Safety
- Informatics[24]

View the QSEN website.

Below are supplementary QSEN learning resources related to patient safety and preventing errors during medication administration.

The Josie King Story and Medical Errors[25]

24. QSEN Institute. (n.d.). *Project overview*. http://qsen.org/about-qsen/project-overview/
25. Healthcare.gov. (2011, May 25). *Introducing the partnerships for patients with Sorrel King* [Video]. YouTube. https://youtu.be/ak_5X66V5Ms

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=73#oembed-2

Summary of Nursing Considerations for Safe and Effective Medication Administration

Medication administration by nurses is not just a task on a daily task list; it is a system-wide process in collaboration with other health care team members to ensure safe and effective treatment. As part of the medication administration process, the nurse must consider ethics, laws, national guidelines, and cultural/social determinants before administering medication to a client. The nurse is the vital "last stop" for preventing errors and potential harm from medications before they reach the client. A list of nursing considerations whenever administering medications is outlined below.

Nursing Considerations for Safe and Effective Medication Administration

BEFORE Administering Medication

Ethics

- Will this medication do more good than harm for this client at this point in time?
- Has the client (or the client's decision maker) had a voice in the decision-making process regarding use of this medication? Have they been informed about this medication and the potential risks/benefits to consider?
- If there are any ethical concerns, advocate for client rights and autonomy and contact the provider and/or pursue the proper chain of command.

Laws and National Guidelines

- Be sure the prescription/order contains the proper information according to CMS guidelines.
- Are there any FDA Boxed Warnings for this drug? If so, is the client aware of the risks and what to do if they occur? This discussion should be documented.
- Is this a controlled substance? If so, follow guidelines and agency policy for controlled substances in terms of counting, wasting, and disposal. For prescriptions for outpatient use, advocate that Prescription Drug Monitoring Program guidelines are followed.
- Be aware of signs of drug diversion in other health care team members and follow up appropriately in the chain of command. You can also directly submit an online tip to the DEA at Rx Abuse Online Reporting.
- Follow the Joint Commission "SPEAK UP" guidelines if you have any concerns about the safe use of this medication, including, but not limited to:
    - Unclear or "do not use" abbreviations
    - Strategies for look alike-sound alike medications
    - Any other concerns for error
- Follow your state's practice act regarding Scope of Practice and Rules of Conduct. Is administering this medication appropriate for your scope of practice and for this client? If not, protect your client from harm and your nursing license by notifying the appropriate contacts within your agency.
- Is this medication administration occurring during a transition of care from unit to unit, home to agency, or in preparation for discharge? If so, be sure proper medication reconciliation has been completed.

DURING Administration

- Use the nursing process as you ASSESS if this drug is appropriate to administer at this time and PLAN continued monitoring. Consider life span and disease process implications. If you NOTICE any findings that this medication may not be appropriate at this time for this client,

withhold the medication and contact the provider.

- Assess if there are any cultural or social determinants that will impact the client's ability to use these medications safely and effectively. IMPLEMENT appropriate accommodations as needed and notify the provider.
- Follow The Joint Commission's National Patient Safety Goals as you correctly identify the client and follow guidelines to use medicines safely.
- If this is a high-alert medication, follow recommendations for safe administration (such as adding a second RN check, etc.).
- Reduce distractions in your environment as you prepare and administer medications.
- Do not crush medications unless safe to do so.
- Follow standards set by The Joint Commission and CMS:
    - Checking rights of medication administration before administering any medication to a client
    - Educate the client about their medication
    - Dispose of unused controlled substances appropriately
    - Document appropriately

AFTER Administration

- Continue to EVALUATE the client for potential side effects/adverse effects, as well as therapeutic effects of the medications.
- Document and verbally share your findings during handoff reports for safe continuity of care.
- If an error occurs, file an incident report and participate in root cause analysis to determine how to prevent it from happening again.

2.6 Learning Activities

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=75#h5p-6

"Legal/ Ethical Flashcards" by E. Christman for Open RN is licensed under CC BY 4.0

Test your nursing clinical judgment with this NCLEX Next-Generation style question: Assessment & Monitoring.[1]

1. "Assessment and Monitoring" by Open RN is licensed under CC BY 4.0

II. Glossary

American Nurses Association (ANA): The professional organization that represents the interests of the nation's four million registered nurses.

Beneficence: To "do good."

Boxed Warnings: The strongest warnings issued by the Federal Drug Association (FDA) that signify a drug carries a significant risk of serious or life-threatening adverse effects.

Code of Ethics for Nurses: Developed by the American Nurses Association as a guide for carrying out nursing responsibilities in a manner consistent with quality in nursing care and the ethical obligations of the profession.

Cultural competence: The process by which nurses demonstrate culturally congruent practice.

Cultural humility: A humble and respectful attitude toward individuals of other cultures that pushes one to challenge their own cultural biases, realize they can't possibly know everything about other cultures, and approach learning about other cultures as a lifelong goal and process.[1]

Culturally congruent practice: The application of evidence-based nursing that is in agreement with the preferred cultural values, beliefs, worldview, and practices of the health care consumer and other stakeholders.

Do Not Crush list: A list of medications that should not be crushed, often due to a sustained-release formulation.

Drug diversion: The transfer of any legally prescribed controlled substance from the individual for whom it was prescribed to another person for any illicit use.

Error-prone abbreviations: Abbreviations, symbols, and dose designations that are frequently misinterpreted and involved in harmful medication errors.

Five rights of medication administration: Standards of practice that

1. American Nurses Association. (2021). *Nursing: Scope and standards of practice* (4th ed.). American Nurses Association

require the following information is confirmed prior to each administration of medication: right patient, right drug, right dose, right time, and right route.

Health literacy: The degree to which individuals have the capacity to obtain, process, and understand basic health information needed to make appropriate health decisions.

High-risk medications: Drugs that bear a heightened risk of causing significant client harm when they are used in error.

Inappropriate polypharmacy: Present when one or more medicines are prescribed that are not or no longer needed.

Look-alike and sound-alike (LASA) drugs: Medications that require special safeguards to reduce the risk of errors and minimize harm.

Maleficence: Causing harm to patients.

National Patient Safety Goals (NPSGs): Goals established by The Joint Commission to help accredited organizations address specific areas of concern related to patient safety.

Nursing: The protection, promotion, and optimization of health and abilities, prevention of illness and injury, facilitation of healing, alleviation of suffering through the diagnosis and treatment of human response, and advocacy in the care of individuals, families, groups, communities, and populations, as defined by the American Nurses Association.

Nursing process: Standards of Practice that include Assessment, Diagnosis, Outcome Identification, Planning, Implementation, and Evaluation components of providing client care.

Nursing Scope and Standards of Practice: A document created by the American Nurses Association that outlines professional nursing performance according to national standards.

Polypharmacy: The concurrent use of multiple medications.

Prescription Drug Monitoring Programs (PDMP): A statewide electronic database that collects designated data on substances dispensed in a state to address prescription drug abuse, addiction, and diversion.

Professional assistance procedure: A voluntary nondisciplinary program to provide support for credentialed professionals in Wisconsin with a substance abuse disorder who are committed to their own recovery.

Registered Nurse (RN): An individual who is educationally prepared and licensed by a state to practice as a registered nurse.

Root cause analysis: An analysis after an error occurs 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.

Safety culture: The culture of a health care agency that empowers staff to speak up about risks to clients and to report errors and near misses, all of which drive improvement in client care and reduce the incident of client harm.

Scheduled medications: The Controlled Substances Act (CSA) places all substances that are regulated under existing federal law into one of five schedules, ranging from Schedule I drugs with a high potential for abuse and the potential to create severe psychological and/or physical dependence, to Schedule V drugs with the least potential for abuse.

Social determinants of health (SDOH): Conditions in the places where people live, learn, work, and play that can affect a wide range of health risks and outcomes.

Standards of practice: Authoritative statements of duties by the American Nursing Association that all registered nurses, regardless of role, population, or specialty, are expected to perform competently. Standards of Practice include Assessment, Diagnosis, Outcome Identification, Planning, Implementation, and Evaluation components of providing client care.

Standards of professional performance: Describe a competent level of behavior in the professional role, including activities related to ethics, culturally congruent practice, communication, collaboration, leadership, education, evidence-based practice, and quality of practice as defined by the American Nursing Association.

State Board of Nursing: A group of officials who enforce the State Nurse Practice Act.

State Nurse Practice Act: Law enacted by state legislatures setting professional standards of nursing care to which nurses are held accountable by the State Board of Nursing.

Substance use disorder: A pattern of behaviors that ranges from misuse to dependency or addiction, whether it is alcohol, legal drugs, or illegal drugs. Addiction is a complex disease with serious physical, emotional, financial, and legal consequences.

The Joint Commission: A national organization that accredits and certifies health care organizations in the United States.

PART III

ANTIMICROBIALS

3.1 Antimicrobials Introduction

Learning Objectives

- Identify the classifications and actions of antimicrobial medications
- Give examples of when, how, and to whom antimicrobial drugs may be administered
- Identify the side effects and special considerations associated with antimicrobial therapy
- Identify considerations and implications of using antimicrobial medications across the life span
- Apply evidence-based concepts when using the nursing process
- Identify and interpret related laboratory tests
- Identify nursing responsibilities associated with health teaching and health promotion

Now that we have discussed the basic concepts of pharmacokinetics, pharmacodynamics, and the legal, ethical, and cultural issues a nurse must consider when administering medications, let's apply these concepts as we discuss antimicrobial therapy.

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?" Perhaps you have wondered why the health care provider chose a certain

medication to treat an infection, or why the pharmacist advised you to avoid certain foods when taking a certain antibiotic.

Nurses must understand how antimicrobials work in the body, be aware of common side effects and adverse effects, and apply the nursing process when administering antimicrobials to clients across the life span. Nurses also provide vital health education to clients regarding how to take the medication at home, watch for potential symptoms to report to their provider, and complete their antibiotic treatment as prescribed to prevent antibiotic resistance. This chapter will discuss these concepts and provide application examples as each type of antimicrobial medication class is reviewed.

Did You Know?

Did you know that the use of antimicrobial agents dates back to ancient times? Although the discovery of antimicrobials and their subsequent widespread use are commonly associated with modern medicine, there is evidence that humans have been exposed to antimicrobial compounds for millennia. Chemical analyses of the skeletal remains of people living near the Nile River between 350 and 550 AD 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 in both adults and children, including gum disease and wounds.

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.[1]

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3.2 Basic Concepts of Antimicrobial Therapy

Basic Concepts Related to Antimicrobial Therapy

Before we learn about antimicrobial medications used to treat infections, we must first understand the basics of microbiology. Let's begin with a review of bacteria. Bacteria are found in nearly every habitat on earth, including within and on humans. Most bacteria are harmless or considered helpful, but some are pathogens. A **pathogen** is defined as an organism causing disease to its host. Pathogens, when overgrown, can cause significant health problems or even death.

Specific bacteria may be identified when a client has an infection by using a culture and sensitivity test or a gram stain test. An antibiotic is selected by the prescribing provider based on the type of bacteria and the mechanism of action of the medication. Antimicrobials are classified as broad-spectrum or narrow-spectrum, based on the variety of bacteria they effectively treat. Additionally, antibiotics are also selected based on their bacteriostatic or bactericidal actions, as well as their mechanism of action. In addition to antibiotics, antimicrobials also include medications used to treat viruses and fungi. These topics will be discussed in more detail in this section, along with the issue of antibiotic resistance.

Culture and Sensitivity

When a client presents with signs or symptoms of an infection, health care 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.[1] These culture samples are commonly collected from a client's blood, urine, sputum, or wound bed.

Nurses are typically responsible for the collection of culture samples and must be conscientious to collect an accurate sample and to obtain the sample prior to the administration of antibiotics. Antibiotic administration prior to obtaining a sample causes inaccurate culture results and can complicate the client's recovery.

After culture samples are collected, they are incubated in a solution that promotes bacterial or fungal growth and spread onto a special culture plate.[2] Clinical microbiologists subsequently monitor the culture for signs of organism growth to aid in the diagnosis of the infectious pathogen. For this reason, it typically takes a one to five days for a client's culture results to be reported by the lab.

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, the provider knows these antibiotics will not provide effective treatment for the client's infection.

Sometimes a client may begin antibiotic treatment for an infection based on common bacterial causes, but after the culture and sensitivity results are reported, the client is switched to a different, more effective antibiotic based on the culture and sensitivity results. The nurse is responsible for monitoring culture and sensitivity results to ensure the prescribed antibiotic therapy is effective and notifying the prescribing provider of any concerns.[3]

Gram-Positive vs. Gram-Negative

A **gram stain** is another type of test that is used to assist in classification of bacteria. Gram stains are useful for quickly identifying if bacteria are "**gram-positive**" or "**gram-negative**," based on the staining patterns of their cellular

1. 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
2. Kristof, K., & Pongracz, J. (2016). Interpretation of blood microbiology results - function of the clinical microbiologist. *The Journal of the International Federation of Clinical Chemistry and Laboratory Medicine, 27*(2), 147-155. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4975230/
3. Vorvick, L. (Ed.). (2019, February 7). *Sensitivity analysis.* https://medlineplus.gov/ency/article/003741.htm

walls. Utilizing gram stain allows microbiologists to look for characteristic staining patterns when they examine organisms under a microscope, with a violet color for gram-positive infections or a red/pink color for gram-negative infections.[4] Identification of bacteria as gram-positive or gram-negative assists the health care provider in quickly selecting an appropriate antibiotic to treat the infection, without waiting for culture and sensitivity results.

SAMPLE GRAM-POSITIVE INFECTIONS

Examples of gram-positive bacteria are *Streptococcus* and *Staphylococcus*. *Streptococcus*, whose name which comes from the Greek word for "twisted chain," is responsible for many types of infectious diseases in humans, especially in the skin or soft tissues.

Streptococcus 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 3.1[5] for an image of *Streptococcus* undergoing gram staining). *Streptococcus pyogenes* is the most common cause of bacterial pharyngitis (i.e., 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).[6]

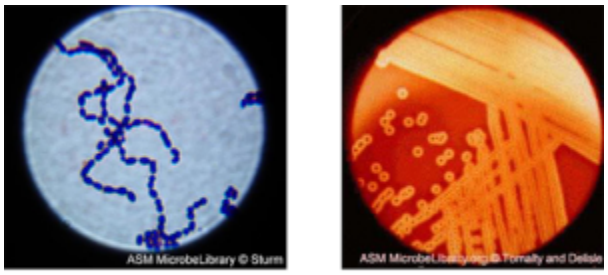

Figure 3.1 Gram Stain Specimen Streptococcus

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5. "OSC Microbio 04 04 Strep.jpg" by CNX OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/microbiology/pages/4-4-gram-positive-bacteria
6. 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

Staphylococcus is a second example of a gram-positive bacteria. The bacteria *Staphylococcus* comes from a Greek word for "bunches of grapes," which describes their microscopic appearance in culture. Strains of *Staphylococcus aureus* cause a wide variety of infections in humans, including skin infections that produce boils, carbuncles, cellulitis, or impetigo. See Figure 3.2[7] for an image of *Staphylococcus* bacteria microscopically.

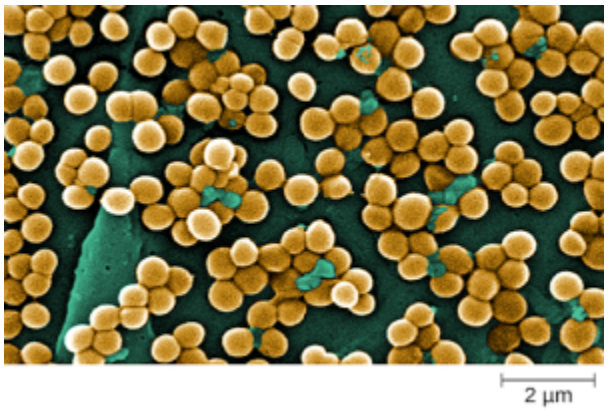

Figure 3.2 Staphylococcus Aureus

Many strains of *Staphylococcus aureus* have developed resistance to many antibiotics. Examples of antibiotic-resistant strains are **methicillin-resistant Staphylococcus aureus (MRSA)** and **vancomycin-resistant Staphylococcus aureus (VRSA)** . Antibiotic resistant strains are difficult to treat because they exhibit resistance to nearly all available antibiotics. Because they are difficult to treat with antibiotics, infections can be lethal. MRSA and VRSA are also very 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 clients.[8]

7. This work is a derivative of "CDC-10046-MRSA.jpg" by Janice Haney Carr, Centers for Disease Control and Prevention and is licensed under CC0
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SAMPLE GRAM-NEGATIVE INFECTIONS

Gram-negative bacteria have a great ability to cause disease in humans and can infect almost all body systems, such as the digestive system, nervous system, urinary system, and bloodstream. A common gram-negative bacterium is *Escherichia coli* (E. coli). E. coli is a common cause of urinary tract infections due to its normal presence in the gastrointestinal tract that can contaminate the urinary tract and cause infection.

Other gram-negative bacteria can cause severe, sometimes life-threatening, disease. The genus *Neisseria*, for example, includes the bacteria *Neisseria gonorrhoeae* and causes the sexually transmitted infection gonorrhea, and *Neisseria meningitidis* causes bacterial meningitis. See Figure 3.3[9] for an image of *Neisseria meningitides*.

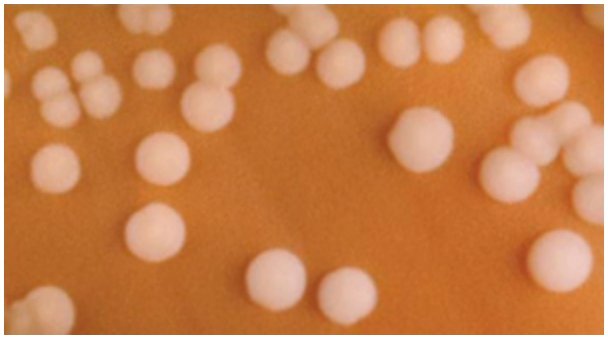

Figure 3.3 Neisseria Meningitidis

Broad-Spectrum vs. Narrow-Spectrum Antimicrobials

The spectrum of activity of an antibiotic is considered by providers when selecting an antibiotic to treat a client's infection. A **narrow-spectrum antimicrobial** targets only specific subsets of bacterial pathogens.[10] For example, some narrow-spectrum drugs target gram-positive bacteria whereas others target gram-negative bacteria.

9. "OSC Microbio 04 02 Neisseria.jpg" by CNX OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/microbiology/pages/4-2-proteobacteria
10. 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

A **broad-spectrum antimicrobial** targets a wide variety of bacterial pathogens, including both gram-positive and gram-negative species. There are many reasons why a broad-spectrum antibiotic is prescribed. Broad-spectrum antibiotics may be prescribed while culture results are pending and then a narrow-spectrum antibiotic may be prescribed based on the culture and sensitivity results. Broad-spectrum antimicrobials are also used for polymicrobial infections (mixed infections with multiple bacterial species) or to prevent infections that may occur from surgery or invasive procedures. Additionally, broad-spectrum antimicrobials may be selected to treat an infection that has not responded to a narrow-spectrum antibiotic because of presumed antibiotic resistance.[11]

EFFECTS ON MICROBIOME AND POTENTIAL SUPERINFECTION

A risk of using broad-spectrum antibiotics is they affect an individual's microbiome. An individual's microbiome consists of microbes that are both helpful and potentially harmful. Most are symbiotic (where both the human body and microbiota benefit), but some are pathogenic and cause disease. Broad-spectrum antibiotics can cause a disturbance in the balance between symbiotic and harmful microbiota, resulting in disease.[12]

For example, in the vagina, normal flora compete with opportunistic pathogens like *Candida albicans*. This competition prevents yeast infection by limiting the availability of nutrients and inhibiting the growth of *Candida*, keeping its population in check. However, when this balance is disrupted by an antibiotic, a yeast infection can occur.

Similar competitions occur between normal flora and potential pathogens in the gastrointestinal tract. Treatment with antibiotics can significantly deplete the normal flora of the gastrointestinal tract, providing an opportunity for pathogenic bacteria such as **Clostridium difficile (C-diff)** to

11. 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
12. Harvard T.H. Chan School of Public Health. (n.d.). The Microbiome. https://www.hsph.harvard.edu/nutritionsource/microbiome/

cause diarrheal infection. Diarrhea caused by C-diff can be severe and potentially lethal. Interestingly, a recent strategy for treating recurrent C-diff infections focuses on restoring normal flora by transplanting fecal matter from a healthy donor with normal flora. See Figure 3.4[13] for an image of C-diff microscopically.

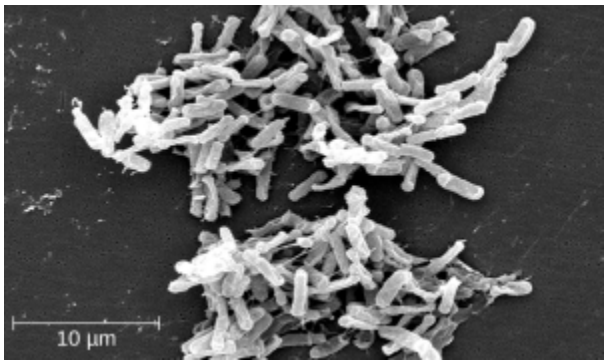

Figure 3.4 Clostridium Difficile

An infection caused by a disruption of the individual's microbiome is also referred to as a **superinfection** (i.e., a secondary infection in a client having a preexisting infection). A superinfection develops when the antibiotic intended for the existing infection also kills the protective microbiome. An example of a severe superinfection is pseudomembranous colitis caused by C-diff, which can be fatal.[14]

Probiotics, such as lactobacillus, are commonly recommended for individuals taking antibiotics to restore normal flora into the gastrointestinal system and prevent diarrhea, yeast infections, and other superinfections.

RECAP

- A broad-spectrum antibiotic treats gram-positive **and** gram-negative bacteria.

13. This work is a derivative of "Clostridium difficile 01.jpg" by Lois D. Wiggs at Centers of Disease Control and Prevention and is licensed under CC0
14. 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

- A narrow-spectrum antibiotic treats **either** gram-positive **or** gram-negative bacteria.
- Broad-spectrum antibiotics impact the individual's microbiome and can cause diarrhea and secondary infections like yeast infections (*Candida*) or C-diff. Probiotics may be prescribed to maintain an individual's microbiome.
- If a client is started on an antibiotic that treats gram-positive infection, but the culture results identify a gram-negative organism, the medication will not improve the client's status.
- At times, a broad-spectrum antibiotic may be prescribed prior to receiving the culture results due to the severity of the illness of the client. After the culture results are reported, the antibiotic therapy is then tailored to the client.
- It is the nurse's responsibility to review culture results, ensure the results have been communicated to the prescribing provider, and request a different antibiotic is prescribed if indicated.

Antibacterial Actions

BACTERIOSTATIC VS. BACTERICIDAL

Antibiotics are selected by providers based on how and where the drug targets the bacteria. Antibiotics can be either bacteriostatic or bactericidal in how they target bacteria. **Bacteriostatic** drugs cause bacteria to stop reproducing but they may not kill the existing bacteria. In contrast, **bactericidal** drugs kill targeted 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 defenses, both bacteriostatic and bactericidal drugs can be effective. However, when a client is immunocompromised, a bactericidal drug is often required for successful treatment of infections. Additionally, life-threatening infections in any client,

such as acute bacterial endocarditis, require bactericidal drugs to eliminate all offending bacteria.[15]

MECHANISM OF ACTION

Another consideration in antibiotic treatment is the drug's mechanism of action. Each class of antibacterial drugs has a unique mechanism of action 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.[16] See Figure 3.5[17] for a summary of how various antibiotics affect the cell wall, the plasma membrane, the ribosomes, the metabolic pathways, or DNA synthesis of bacteria.

15. 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
16. 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
17. "OSC Microbio 14 02 Modes.jpg" by CNX Openstax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/microbiology/pages/14-3-mechanisms-of-antibacterial-drugs

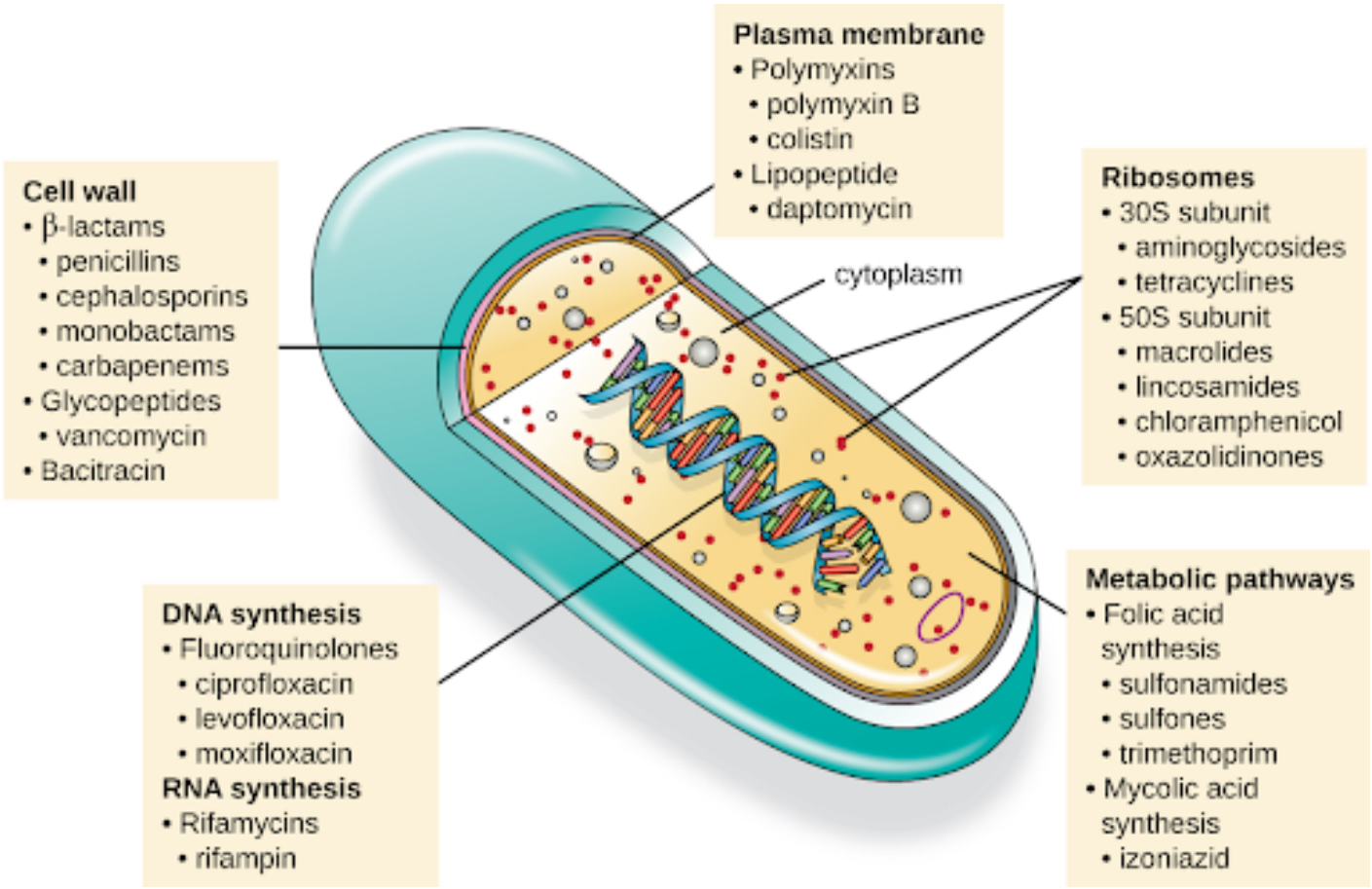

Figure 3.5 Various Mechanisms of Action of Antimicrobial Medication

Antiviral Medications

Similar to antibacterial medications, **antiviral** antiviral drugs directly impact the reproduction of viruses. Unlike antimicrobials, antiviral medications do not kill the offending virus, but reduce replication and development of the virus. For example, oseltamivir (Tamiflu) is commonly prescribed to treat influenza.[18]

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Antifungal Medications

Antifungal agents are medications that are used to treat fungal infections. Fungal infections commonly affect surface areas of the body, such as the toes, groin, nails, or mouth. Antifungal medications work by killing the cells of the fungus or inhibiting the reproduction of the cells. Many antifungals are applied topically to the affected area. For example, tinea pedis (athlete's foot) is typically treated with a topical antifungal cream. Another example is the nystatin, commonly prescribed to treat oral thrush caused by *Candida albicans*. Nystatin may be prescribed as "swish and spit" as a topical oral treatment or "swish and swallow" for additional systemic effects.

Antibiotic Resistance

Although there is a wide availability of medications that are useful for treating infection, limited effectiveness of antibiotics is becoming an international problem. According to the Centers for Disease Control, each year in the United States, at least 2 million people are infected with an antibiotic-resistant infection, resulting in 23,000 deaths.[19]

PREVENTION STRATEGIES

Most antimicrobial drugs are self-administered by clients at home. Unfortunately, many clients stop taking antimicrobials once their symptoms dissipate. For example, if a ten-day course of antibiotic treatment is prescribed, some clients only take the drug for five or six days and stop when they start feeling better, unaware of the negative consequences of not completing the full course of treatment. The problem with failing to complete a full course of antibiotic treatment is it not only fails to kill the target organisms to the expected levels but also facilitates the development of drug-resistant variant of the bacteria within the body. The overprescription of antimicrobials also contributes to antibiotic resistance. Clients may demand

19. Centers for Disease Control and Prevention. (2022). *About antimicrobial resistance*. https://www.cdc.gov/drugresistance/about.html

antibiotics from their health care provider for treatment of infections not caused by bacteria, such as viral upper respiratory infections (i.e., the common cold).

Nonadherence to completing a full course of treatment is often increased when the recommended course of treatment is long. For example, treatment for tuberculosis (TB) typically lasts from six months to a year. Additionally, the Centers for Disease Control and Prevention (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 (OTC). The availability of OTC antibiotics may contribute further to the lack of completion of a full treatment regimen. As a direct result of these factors, multidrug-resistant strains of TB have become a significant problem.

One possible solution to preventing antibiotic resistance is 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 administer medication in clients' homes or another designated location. DOT has been implemented in many countries for the treatment of TB and has been shown to be effective.

But is DOT 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? An additional consideration is who would pay for the increased cost associated with DOT?

Antibiotic resistance is a complex issue with no clear, easy solution. However, it is clear is that clients need extensive health teaching regarding the judicious and complete use of antibiotics to increase adherence and decrease the development of antibiotic resistance.[20]

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Critical Thinking Activity 3.2

Reflecting on current health care challenges regarding the ongoing emergence of antimicrobial-resistant organisms, what actions could you take within your nursing practice to help prevent drug resistance?

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" section 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://wtcs.pressbooks.pub/pharmacology2e/?p=87#h5p-7

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3.3 Antimicrobial Administration Considerations

The administration of antimicrobial drug therapy involves special considerations to ensure that the therapeutic drug effect is achieved while also maintaining patient safety and minimizing complications.

Let's consider variables that impact antimicrobial administration, such as half-life, life span considerations, liver and kidney function, dose dependency/time dependency, route, and drug interactions.

Half-Life

Many antimicrobial medications are administered to ensure a certain therapeutic level of medication remains in the bloodstream, which may require interval or repeated dosing throughout the day. Recall from Chapter 1 that half-life is the rate at which 50% of a drug is eliminated from the plasma. Half-life can vary significantly among antimicrobial drugs. Some antibiotics, such as penicillin, have a short half-life of only a few hours and must be administered multiple times a day, whereas other antibiotics, such as levofloxacin, have long half-lives and can be administered as a single dose every 24 hours.

Although a longer half-life can be considered an advantage for a prescribed antibiotic when it comes to convenient dosing intervals, medications with longer half-lives that cause side effects will also exert these side effects over a longer period of time.

Life Span Considerations

Many antibiotic dosages are calculated based on the client's age and weight. Age and weight are especially important when calculating pediatric dosages,

resulting in common medication errors when these calculations are inaccurate. The size and development of the internal organs in infants and children also impact how the body absorbs, distributes, metabolizes, and excretes medications.

In older adults, metabolism of antibiotics by the liver may significantly decline in the older adult. As a result, dosages should be adjusted according to the client's liver function and their anticipated metabolic rate. First-pass metabolism also decreases with aging, so older adults may have higher "free" circulating drug concentrations and thus be at higher risk for side effects and toxicities.

Liver and Kidney Function

Many antimicrobial medications require tailored dosing based on the client's liver and kidney function. For more information about the effects of liver and kidney function on metabolizing and excreting medications, review Chapter 1.

Peak and trough blood levels are monitored for some antibiotics to determine how a client's body is responding to an antimicrobial. Dosing is then tailored to the individual based on peak and trough levels. This is especially important for older adults or those with known liver and/or kidney impairment. Individuals with diminished liver and kidney function are prone to developing toxic levels of medications because of their reduced ability to metabolize or clear medications from the body. For more information about peak and trough levels, review the "Efficacy, Dose-Response, Onset, Peak, and Duration" section in Chapter 1.[1]

Dose Dependency/Time Dependency

The goal of antimicrobial therapy is to select an optimal dosage that will result in clinical cure, while reducing potential side effects and adverse effects. Many medications are **dose dependent**, meaning there is a more significant killing of the bacteria with increasing levels of the antibiotic. For

1. 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

example, fluroquinolones are dose-dependent medications with higher dosages of antibiotic killing more bacteria.

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 their effect by binding to the microorganism for an extensive length of time. Penicillin is an example of a time-dependent medication where duration of the bacteria's exposure to the medication has the greatest effect.[2]

Route

When administering antimicrobials to clients, nurses must consider the route of drug administration. Many of us may have been prescribed oral antibiotics and have simply filled our prescription and completed the drug therapy within the comfort of our own homes. However, there are many types of infections that do not respond well to oral antimicrobial therapy and require intravenous or intramuscular injections. Clients requiring intravenous or intramuscular injections may require additional considerations regarding hospitalization, home health nursing, or travel to the hospital/clinic for their therapy. For more information about considerations regarding routes of administration, refer to Chapter 1 on absorption.

Drug Interactions

Interactions between drugs may be beneficial or harmful. For example, when treating specific infections, two antibacterial drugs may be administered together to create a greater effect than the efficacy of either medication alone, referred to as **synergistic interaction** . An example of a 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.[3]

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3. 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

In contrast to synergistic drug interactions providing a benefit to the client, **antagonistic interactions** produce harmful effects. Antagonistic interactions may occur between two antimicrobials or between an antimicrobial and medication used to treat other conditions. For example, antacids taken with antibiotics can delay and reduce the absorption of the antibiotic. Potential harmful 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.

★ Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=91#h5p-8

"Antimicrobial Knowledge Check" by E. Christman for Open RN is licensed under CC BY 4.0

3.4 Applying the Nursing Process to Administering Antimicrobials

Now that we have reviewed basic concepts of antimicrobials and administration considerations, let's apply the nursing process. The nursing process consists of the steps of assessment, diagnosis, outcome identification, planning, implementation of interventions, and evaluation. For more information about the nursing process, refer to the "Ethical and Professional Foundations of Safe Medication Administration by Nurses" section in Chapter 1. This book will broadly discuss considerations related to the nursing process steps of assessment, implementation, and evaluation because the steps of diagnosis, outcome identification, and planning steps are specifically tailored to each individual client.

Assessment

Although there are numerous details to consider when administering medications, it is important to first think about what you are administering and why.

First Think WHY?

Antimicrobials are prescribed to prevent or treat infection. If a client is prescribed an antimicrobial, the nursing assessment should include looking for signs and symptoms of infection. The nurse should always know WHY the client is receiving an antimicrobial in order to evaluate if the treatment is resulting in the client improving or deteriorating.

The nurse collects pre-administration information as part of the assessment process. Typical data collected at the start of a shift for a client receiving an

antimicrobial for an infection include a baseline temperature, heart rate, blood pressure, and respiratory rate. The nurse also reviews the most recent white blood cell count. Focused assessments are then made based on the type of infection. For example, if a client has a wound infection, the wound should be assessed. If a client has a respiratory infection, the nurse should assess the client's lung sounds. If a client has a urinary tract infection (UTI), symptoms related to a UTI should be assessed.

Additionally, whenever a client has an infection, it is important to continually monitor for the potential development of sepsis, a life-threatening condition caused by severe infection. Early signs of sepsis include new onset confusion, elevated heart rate, decreased blood pressure, increased respiratory rate, and fever.

Additional baseline information to collect prior to the administration of any new medication order includes a patient 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.

Implementation of Interventions

With administering antimicrobial medication, the nurse anticipates additional interventions associated with the effects of the medications. For example, antimicrobials often cause gastrointestinal (GI) upset such as nausea and diarrhea. The client should be educated about these potential side effects and interventions should be implemented to minimize these occurrences. For example, the nurse may instruct the client to take specific 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 to antibiotics, especially when administering the first dose. 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 and circulatory

collapse. 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. The nurse should monitor for these reactions and respond appropriately by immediately notifying the provider.

Evaluation

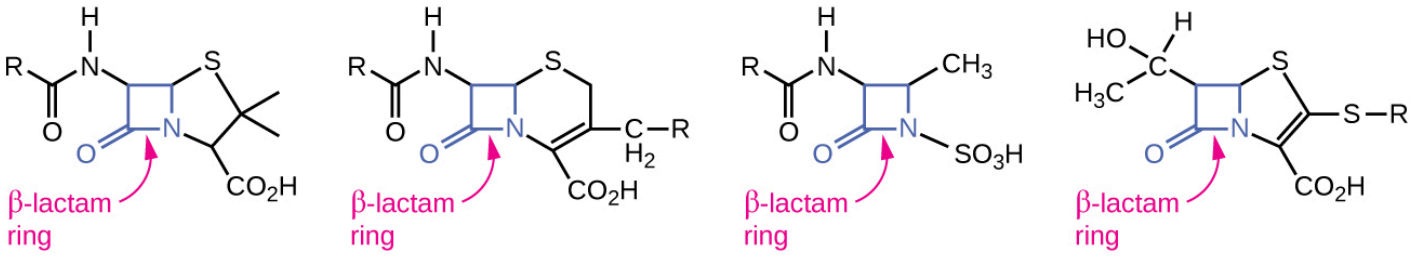
Nurses evaluate the effectiveness of a client's response to medication. With antimicrobial medications, the nurse assesses for decreasing signs of infection, such as fever or white blood cell count, indicating the client is improving. These findings should be documented to reflect the client's response to treatment.

The nurse also monitors for signs of worsening infection and communicate them to the provider. For example, increasing white blood cell count, temperature, heart rate, and respiratory rate may indicate that the client is developing sepsis. These signs of worsening clinical status require prompt notification of the health care provider and intervention to prevent further clinical deterioration.

Additionally, clients receiving antibiotics should be closely monitored for developing superinfections such as *C-difficile* (C-diff) that causes frequent, foul-smelling stools. The provider must be promptly notified of suspected C-diff for additional treatment, as well as the implementation of contact isolation precautions to prevent the spread of infection. Furthermore, C-diff requires the use of soap and water for hand hygiene, not hand sanitizer, because hand sanitizer will not kill the C-diff spores.[1]

1. Kelly, C. P., Lamon, J. T., & Bakken, J. S. (2023). Clostridioides (formerly Clostridium) difficile infection in adults: Treatment and prevention. *UpToDate*. Retrieved on April 12, 2023, from https://www.uptodate.com/

3.6 Cephalosporins



penicillin | cephalosporin | monobactam | carbapenem

R group	$-CH_2-$	CH_2-O-	$-CH(NH_2)-$	$-CH(NH_2)-$	CH_3O, CH_3O
Drug name	penicillin G	penicillin V	ampicillin	amoxicillin	methicillin
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

Figure 3.6 Comparison of Beta-Lactam Ring Structure Across Different Classes of Medications, Spectrum of Activity, and Routes of Administration

Cephalosporins are a slightly modified chemical "twin" to penicillins due to their beta-lactam chemical structure. See Figure 3.6[1] 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 in

1. "OSC Microbio 14 02 BetaLactam.jpg" by CNX Openstax is licensed under CC BY 4.0 Access for free at https://openstax.org/books/microbiology/pages/14-3-mechanisms-"of-antibacterial-drugs

chemical structure, some clients who have severe allergies to penicillins may experience cross-sensitivity to cephalosporins. Nurses should review the type and severity of a client's previous reaction to penicillin to determine if administering cephalosporin is appropriate.

Mechanism of Action: Cephalosporins are typically bactericidal and are similar to penicillin in their action within the cell wall. Cephalosporins are sometimes grouped into "generations" by their antimicrobial properties. The 1st-generation drugs are effective mainly against gram-positive organisms. Higher generations generally have expanded spectra against aerobic gram-negative bacilli. The 5th-generation cephalosporins are active against methicillin-resistant Staphylococcus aureus (MRSA) or other complicated infections.[2]

Indications: Cephalosporins are used to treat skin and skin-structure infections, bone infections, genitourinary infections, otitis media, and community-acquired respiratory tract infections.

Nursing Considerations: Clients who are allergic to pencillins may also be allergic to cephalosporins. Clients who consume cephalosporins while drinking alcoholic beverages may experience disulfiram-like reactions, including severe headache, flushing, nausea, vomiting, etc.[3] Additionally, like penicillins, cephalosporins may interfere with coagulability and increase a client's risk of bleeding. Cephalosporin dosing may require adjustment for clients experiencing renal impairment. Blood urea nitrogen (BUN) and creatinine should be monitored carefully to identify signs of nephrotoxicity.

Side Effects/Adverse Effects: Common side effects of cephalosporin medications include gastrointestinal upset including nausea, vomiting, and diarrhea. Additionally, nurses should monitor for rash, C-diff, and nephrotoxicity. Cephalosporins may also elevate a client's INR and increase bleeding risk. Nurses should also monitor for low blood cell counts and hemolytic anemia.

2. Werth, B. J. (2018, August). *Cephalosporins.* Merck Manual Professional Version. https://www.merckmanuals.com/professional/infectious-diseases/bacteria-and-antibacterial-drugs/cephalosporins
3. Ren, S., Cao, Y., Zhang, X., Jiao, S., Qian, S., & Liu, P. (2014). Cephalosporin induced disulfiram-like reaction: A retrospective review of 78 cases. *International Surgery, 99*(2), 142–146. https://www.internationalsurgery.org/doi/full/10.9738/INTSURG-D-13-00086.1

Health Teaching & Health Promotion: Clients who are prescribed cephalosporins should be specifically cautioned about a disulfiram reaction, which can occur when alcohol is ingested while taking the medication. Additionally, individuals should be instructed to monitor for rash and signs of superinfection (such as vaginal itching or discharge indicating a yeast infection or loose or foul-smelling stool indicating C-diff) and report these symptoms to the prescribing provider.

It is also important to note that cephalosporin can enter breastmilk and may alter bowel flora of the infant. Thus, use during breastfeeding is often discouraged.[4]

Now let's take a closer look at the cephalosporin medication grid in Table 3.6.[5]

Table 3.6 Cephalosporin Medication Grid

4. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

5. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Cephalosporins	1st-generation: ▸ cephalexin ▸ cefazolin 2nd-generation: ▸ cefprozil 3rd-generation: ▸ ceftriaxone 4th-generation: ▸ cefepime 5th-generation: ▸ ceftolozane	Check for allergies, including if allergic to penicillin Dosage adjustment if renal impairment Use with caution with seizure disorder PO: Administer without regard to food; if GI distress, give with food IV: Reconstitute drug with sterile water or normal saline per manufacturer instructions; shake well until dissolved. Inject into large vein or free-flowing IV solution over 3-5 minutes Drug interaction: Anticoagulants	Monitor for systemic signs of infection: -WBCs -Fever Monitor actual site of infection Monitor culture results, if obtained	Common side effects: -Nausea -Vomiting -GI upset -Diarrhea Monitor for: -Rash -Yeast infection -C-diff Nephrotoxicity if preexisting renal disease Elevated INR and bleeding risk Development of hemolytic anemia

Critical Thinking Activity 3.6

Using the above grid information, consider the following clinical scenario question:

An 89-year-old client is admitted to the medical-surgical floor for treatment of a skin infection. The admitting provider prescribes Cefazolin 1 gram every 8 hours IV.

The client's laboratory tests including renal studies include:

- Creatinine: 1.3 mg/dL (Normal range: 1.2 mg/dL)[6]
- Blood urea nitrogen (BUN): 25 mg/dL (Normal: 8-20 mg/dL)
- Glomerular Filtration Rate: 55 mL/min (Normal: 90-120 mL/min)[7]

On Day 3, the renal laboratory studies are repeated. The results are:

Creatinine: 1.6 mg/dL

Blood urea nitrogen (BUN): 57 mg/dL

Glomerular Filtration Rate: 20 mL/min

Are Day 3 findings expected or not? What course of action should the nurse take?

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

6. U.S. National Library of Medicine, Medline Plus. (2020, February 13). *Basic metabolic panel.* https://medlineplus.gov/ency/article/003462.htm
7. U.S. National Library of Medicine, Medline Plus. (2020, February 13). *Glomerular filtration rate.* https://medlineplus.gov/ency/article/007305.htm

3.5 Penicillin

Now that we have reviewed antimicrobial basics, administration considerations, and the nursing process regarding antimicrobials, we will take a closer look at specific antimicrobial classes. 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, **indications** (i.e., therapeutic effects), nursing considerations, common side effects/adverse effects, and health teaching for this class/subclass of medication.

Each section also includes a medication grid to assist students to learn key points about each medication. Basic information related to a common generic medication for each class is outlined, including administration considerations, therapeutic effects, and common side effects/adverse effects. **Prototype**/generic medications listed in the medication grid are also linked to a free resource from the United States National Library of Medicine called DailyMed. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. To read more about specific medications, go to the home page of DailyMed and enter the drug name in the search bar.

Penicillin

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]

1. American Chemical Society International Historic Chemical Landmarks. (n.d.) *Discovery and development of penicillin.* http://www.acs.org/content/acs/en/education/whatischemistry/landmarks/flemingpenicillin.html

Mechanism of Action: Penicillins are bactericidal and kill bacteria by interfering with the synthesis of proteins needed in their cellular walls.[2] When the bacterial cell wall is impaired, the cell is rapidly broken down and destroyed.

Indications: Penicillins are prescribed to treat a variety of infectious processes such as *Streptococcal* infections, *Pneumococcal* infections, and *Staphylococcal* infections. Penicillins may be administered orally, IV, or intramuscularly.

Nursing Considerations: Clients receiving penicillins are at risk for developing superinfections such as C-diff or yeast infections. Probiotics may be encouraged to prevent these superinfections.

There is a cross-sensitivity for clients allergic to cephalosporins, meaning they may also have an allergic reaction to penicillin. Additionally, clients who are prescribed high doses of penicillin may experience significant coagulation abnormalities.[3] Other notable drug interactions include the use of diuretic therapy with penicillin. Penicillin contains a significant amount of potassium, so clients receiving potassium-sparing diuretics or potassium supplementation should be monitored for signs of hyperkalemia. Penicillin is best absorbed on an empty stomach; however, many clients may experience GI upset and subsequently take the medication with food.

Side Effects/Adverse Effects: Common side effects for penicillin include nausea, vomiting, gastrointestinal (GI) distress, and diarrhea. Other side effects may include the presence of a black hairy tongue. Clients should be monitored for C-diff, candidiasis, and hyperkalemia. Other signs of hypersensitivity may include rash (maculopapular to exfoliative dermatitis), urticaria, laryngeal edema, and anaphylaxis. If an allergic reaction occurs, penicillin should be discontinued and appropriate therapy instituted. Serious anaphylactic reactions require emergency treatment with epinephrine and airway management support.

Health Teaching & Health Promotion: The client should 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

2. This work is a derivative of Principles of Pharmacology by LibreTexts licensed under CC BY-NC-SA 4.0
3. Pharmacology Notes: Nursing Implications for Clinical Practice by Gloria Velarde is licensed under CC BY-NA-SA 4.0

advice from HCP. If GI upset occurs, the client may take the medication with meals but should avoid taking it with citrus products, which can impede absorption. Additionally, clients should be instructed to thoroughly chew chewable tablets before swallowing. The client should report a rash or any signs of superinfection such as vaginal itching or discharge (indicating a yeast infection) or loose or foul-smelling stool (indicating a possible C-diff infection).

Clients should be instructed to take medication as prescribed around the clock and to finish the drug completely as directed. Doses should be spaced evenly to achieve the desired therapeutic effect. Additionally, clients should receive instruction to 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, a type of penicillin, and until their next menstrual period. Clients should notify their HCP if symptoms do not improve.[4]

Now let's take a closer look at the penicillin medication grid in Table 3.5.[5]

Table 3.5 Penicillin Medication Grid[6]

4. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
5. Pharmacology Notes: Nursing Implications for Clinical Practice by Gloria Velarde is licensed under CC BY-NA-SA 4.0
6. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

Penicillin	penicillin V (PO) penicillin G (IV) amoxicillin piperacillin/tazobactam (combination product)	Check for allergies to penicillin or cephalosporins Obtain culture, if ordered, before first dose Take with full glass of water; avoid citrus products Best absorbed orally on empty stomach; give with food if stomach upset If high doses, monitor INR, platelets, and PT Recommend alternative birth control for clients taking amoxicillin and oral contraceptives	Monitor for systemic signs of infection: -WBCs -Temp -Culture results Monitor actual site of infection for improvement	Common: Nausea, vomiting, GI upset, diarrhea Monitor for symptoms of yeast infection, C-diff, and hyperkalemia Hypersensitivity: Rash (maculopapular to exfoliative dermatitis), urticaria, laryngeal edema, and anaphylaxis SAFETY: If an allergic reaction occurs, penicillin should be discontinued and appropriate therapy instituted. Serious anaphylactic reactions require emergency treatment with epinephrine and airway management

Critical Thinking Activity 3.5

Using the above grid information, consider the following clinical scenario question:

A client 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?

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

3.7 Carbapenems

Carbapenems are a beta-lactam “cousin” to penicillins and cephalosporins.

Mechanism of Action: Carbapenems are typically bactericidal and work by inhibiting the synthesis of the bacterial cell wall.

Indications: Carbapenems are useful for treating life-threatening, multidrug-resistant infections due to their broad spectrum of activity.[1] 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.

Nursing Considerations: Considerations for carbapenems are similar to those for cephalosporins. Cross-sensitivity may occur in clients allergic to penicillin or cephalosporins.

Side Effects/Adverse Effects: Common side effects of carbapenems include gastrointestinal upset, including nausea, vomiting, and diarrhea. Additional adverse effects include injection site reactions, skin rash, and pruritis.

Health Teaching & Health Promotion: Clients should monitor for signs of superinfection (such as vaginal itching or discharge indicating a yeast infection or loose or foul-smelling stool indicating C-diff) 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.[2]

Now let’s take a closer look at the medication grid for imipenem in Table 3.7.[3]

Table 3.7 Carbapenem Medication Grid

1. Papp-Wallace, K. M., Endimiani, A., Taracila, M. A., & Bonomo, R. A. (2011). Carbapenems: Past, present, and future. *Antimicrobial Agents and Chemotherapy, 55*(11), 4943–4960. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3195018/
2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Carbapenems	imipenem	Route: IV Check for allergies, including penicillin and cephalosporins Dosage adjustment if renal impairment Use with caution with seizure disorder or renal dysfunction	Monitor for systemic signs of infection: -Increased WBCs -Fever Monitor actual site of infection Monitor culture results, if obtained	Similar to cephalosporins

Critical Thinking Activity 3.7

Using the above grid information, consider the following clinical scenario question:

A client was admitted to the hospital with a serious abdominal infection. The nurse notices that this client has a history of a previous severe allergic reaction to penicillin while preparing to administer the first dose of imipenem medication. What is the nurse's next best action?

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

3.8 Monobactams

Like penicillins, cephalosporins, and carbapenems, monobactams also have a beta-lactam ring structure.

Mechanism of Action: Monobactams are bactericidal and work to inhibit bacterial cell wall synthesis.[1]

Indications: Monobactams are narrow-spectrum antibacterial medications that are used primarily to treat gram-negative bacteria such as *Pseudomonas aeruginosa*.

Nursing Considerations: Clients taking monobactams may experience adverse effects similar to other beta-lactam medications, so nurses should monitor for GI upset, skin sensitivities, and coagulation abnormalities.

Side Effects/Adverse Effects: Common side effects related to the use of monobactams include nausea, vomiting, diarrhea, and abdominal pain. Additional adverse effects include skin rash and abnormal metallic or sour taste in the mouth.

Health Teaching & Health Promotion: Clients should monitor for signs of superinfection (such as vaginal itching or discharge indicating a yeast infection or loose or foul-smelling stool indicating C-diff) and report any occurrence to the provider. If the client experiences fever and bloody diarrhea, they should contact the provider immediately. The client should also be advised to notify the provider immediately if symptoms progress or if any sign of allergic response occurs.[2]

Now let's take a closer look at the medication grid for aztreonam in Table 3.8.[3]

Table 3.8 Monobactam Medication Grid

1. 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
2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Monobactams	aztreonam	Check for severe allergies to any beta lactams – penicillin, cephalosporins, or carbapenems – because cross-sensitivity can occur Can be administered IM, IV, or via inhalation	Monitor for systemic signs of infection: -WBCs -Fever Monitor actual site of infection Monitor culture results, if obtained	Similar to cephalosporins

Critical Thinking Activity 3.8

Using the above grid information, consider the following clinical scenario question:

A client with cystic fibrosis is diagnosed with ventilator-associated pneumonia and is prescribed aztreonam (Azactam) 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 bacterium? What is the nurse's next best response?

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

3.9 Sulfonamides

Sulfonamides are one of the oldest broad-spectrum antimicrobial agents and work by competitively inhibiting bacterial metabolic enzymes needed for bacterial function.

Mechanism of Action: This mechanism of action provides bacteriostatic inhibition of growth against a wide spectrum of gram-positive and gram-negative pathogens.

Indications: Sulfonamides are used to treat urinary tract infections, otitis media, acute exacerbations of chronic bronchitis, and diarrhea that can occur when travelling outside one's country.

Nursing Considerations: Allergic reactions to sulfonamide medications are common and, therefore, clients should be monitored carefully for adverse effects, including delayed hypersensitivity reactions. Sulfonamide medications increase the risk of crystalluria that can cause kidney stones or decreased kidney function; therefore, clients should increase their water intake while taking these medications.[1]

Side Effects/Adverse Effects: Common side effects include GI upset such as nausea, vomiting, and diarrhea. Other side effects may include headache and photosensitivity. Sulfonamides should be discontinued at the first appearance of skin rash.

Health Teaching & Health Promotion: The client should be taught 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. The medication can cause increased photosensitivity, and clients should be educated to use sunscreen and protective clothing with sun exposure. The client should also report any rash, sore throat, fever, or mouth sores that might occur. Unusual bleeding or

1. 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

bruising should also be reported to the provider. If clients are receiving prolonged therapy, they may require platelet count monitoring.[2]

Now let's take a closer look at the medication grid for trimethoprim-sulfamethoxazole in Table 3.9.[3]

Table 3.9 Sulfonamides Medication Grid

2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

Sulfonamides	trimethoprim – sulfamethoxazole	Check for allergies Anticipate dose adjustment for renal impairment Administer PO with 8 oz. of water Monitor urine output and for cloudiness or crystals Do not administer IM Use cautiously with cardiac antidysrhythmics Use cautiously with oral antidiabetics; may increase hypoglycemic effects. Monitor glucose level carefully Use cautiously with anticoagulant medications such as warfarin; may increase risk of bleeding. Monitor INR and for signs of bleeding	Monitor for systemic signs of infection: -WBCs -Fever Monitor actual site of infection Monitor culture results, if obtained	GI upset, including nausea, vomiting, and diarrhea Headache Photosensitivity or increased intolerance to sunlight SAFETY: Sulfonamides, including sulfonamide-containing products such as sulfamethoxaole/ trimethoprim, should be discontinued at the first appearance of skin rash of any sign of adverse reaction

Critical Thinking Activity 3.9

Using the above grid information, consider the following clinical scenario question:

A nurse is caring for an elderly client with diabetes who has been prescribed trimethoprim-sulfamethoxazole for a urinary tract infection. What nursing interventions will be implemented prior to medication administration?

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

3.10 Fluoroquinolones

Fluoroquinolones are broad-spectrum antibacterial medications that are commonly used to treat respiratory infections.

Mechanism of Action: Fluoroquinolones are a synthetic antibacterial medication that work by inhibiting the bacterial DNA replication. They are bactericidal due to the action they take against the DNA of the bacterial cell wall. Many fluoroquinolones are broad-spectrum and effective against a wide variety of both gram-positive and gram-negative bacteria.

Indications: Fluoroquinolones may be used to treat pneumonia or complicated skin or urinary tract infections.

Nursing Considerations: Clients taking oral fluoroquinolones should avoid the use of antacid medications because they significantly impede absorption. Clients should also be instructed to take oral fluoroquinolones with a full glass of water two hours before or after meals to enhance absorption and prevent crystalluria. Fluoroquinolone therapy is contraindicated in children except for complicated UTIs, pyelonephritis, plague, or post-anthrax exposure and should be used cautiously in pregnancy.[1]

Side Effects/Adverse Effects: Common side effects to monitor for include drowsiness and GI upset. Additional side effects to monitor for include hypersensitivity, photosensitivity, hypoglycemia, C-diff, and rash. Other adverse effects include fainting, decreased heart rate, prolonged QT syndrome, and mood changes.

Boxed Warning: Fluoroquinolones, including levofloxacin, have been associated with disabling and potentially irreversible serious adverse reactions, including the following:

- Tendinitis and tendon rupture
- Peripheral neuropathy

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- Central nervous system effects
- 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.

Health Teaching & Health Promotion: All clients on fluoroquinolone therapy should be instructed to avoid direct and indirect sunlight due to the photosensitivity that can be experienced while on these medications. The client should take measures to ensure that dosages are spaced evenly throughout the day and that fluid balance is maintained. It is important to maintain an intake of 1,500 mL-2,000 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 not be taken within two hours of ingestion of the medication. Additionally, the client should be cautioned to monitor for episodes of fainting or decreased heart rate and report any history of prolonged QT syndrome. If a client notices peripheral neuropathy occurring, this should be reported to the health care provider. Additional side effects to monitor include increased tendon pain, jaundice, rash, or mood changes.[2]

Now let's take a closer look at the medication grid for levofloxacin in Table 3.10.[3]

Table 3.10 Fluoroquinolone Medication Grid

2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

Fluoroquinolones	levofloxacin	Check for allergies Give with plenty of fluids Oral: Administer 2 hours before or after meals, antacids, or iron IV: Infuse 500 mg or less over 60 minutes and doses of 750 mg over 90 minutes Dosage adjustment if renal or hepatic impairment Use cautiously if history of seizures Boxed Warning: Fluoroquinolones have been associated with disabling and potentially irreversible serious adverse reactions, including the following: • Tendinitis and tendon rupture	Monitor for systemic signs of infection: -WBCs -Fever Monitor actual site of infection Monitor culture results, if obtained	Drowsiness Monitor for: -GI upset -Hypersensitivity -Photosensitivity -Hypoglycemia -C-diff -Fainting -Decreased heart rate -Prolonged QT syndrome -Rash -Mood changes SAFETY: Discontinue immediately if tendonitis, tendon rupture, jaundice, peripheral neuropathy, CNS effects, or muscle weakness in clients with myasthenia gravis

		• Peripheral neuropathy • Central nervous system effects • Exacerbation of muscle weakness in clients with myasthenia gravis		

Critical Thinking Activity 3.10

Using the above grid information, consider the following clinical scenario question:

A nurse is administering levofloxacin to a client diagnosed with pneumonia. The client reports they have pain "above the 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 in the "Answer Key" section at the end of the book.

3.11 Macrolides

Macrolides are complex antibacterial broad-spectrum medications that are effective against both gram-positive and gram-negative bacteria.

Mechanism of Action: Macrolides inhibit 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]

Indications: Macrolides are often used for respiratory infections, otitis media, pelvic inflammatory infections, and chlamydia.

Nursing Considerations: Macrolides can have a significant impact on liver function and should be used cautiously in clients with liver disease or impairment.

Side Effects/Adverse Effects: Common side effects include GI upset. Additional side effects include hypersensitivity and photosensitivity. Adverse effects include prolonged QT interval, cardiac dysrhythmias, jaundice, and onset or worsening of myasthenia gravis.

Health Teaching & Health Promotion: GI upset is common, and clients can be advised to take medication with food. Clients should also be advised 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. Additionally, clients should be advised that these medications can cause drowsiness.[2]

Now let's take a closer look at the medication grid for erythromycin and azithromycin in Table 3.11.[3]

Table 3.11 Macrolides Medication Grid

1. 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
2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
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Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Macrolides	erythromycin azithromycin	Check for allergies PO: Reconstitute suspension with water. Can be given with or without food. Take with food if GI upset occurs IV: Reconstitute and shake until well-dissolved. Dilute as instructed. Infuse a 500-mg dose of azithromycin IV over 1 hour or longer according to agency policy. Never give as a bolus or IM injection	Monitor for systemic signs of infection: -WBCs -Fever Monitor actual site of infection	GI upset Hypersensitivity Photosensitivity Discontinue immediately if: -QT prolongation or dysrhythmias -Signs of liver damage or jaundice -Onset or worsening of myasthenia gravis

Critical Thinking Activity 3.11

Using the above grid 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 appears yellow, which is a new finding. What is the nurse's next best response?

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

3.12 Aminoglycosides

Aminoglycosides are potent broad-spectrum antibiotics that are useful for treating severe infections. Many aminoglycosides are poorly absorbed in the GI tract; therefore, the majority are given IV or IM. Aminoglycosides are potentially nephrotoxic and neurotoxic and should be administered cautiously. Blood peak and trough levels should be performed to titrate a safe dose for each client.

Mechanism of Action: Aminoglycosides are bactericidal and bind with the area of the ribosome known as the 30S subunit, inhibiting protein synthesis in the cell wall and resulting in bacterial death (see Figure 3.7).[1] 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.

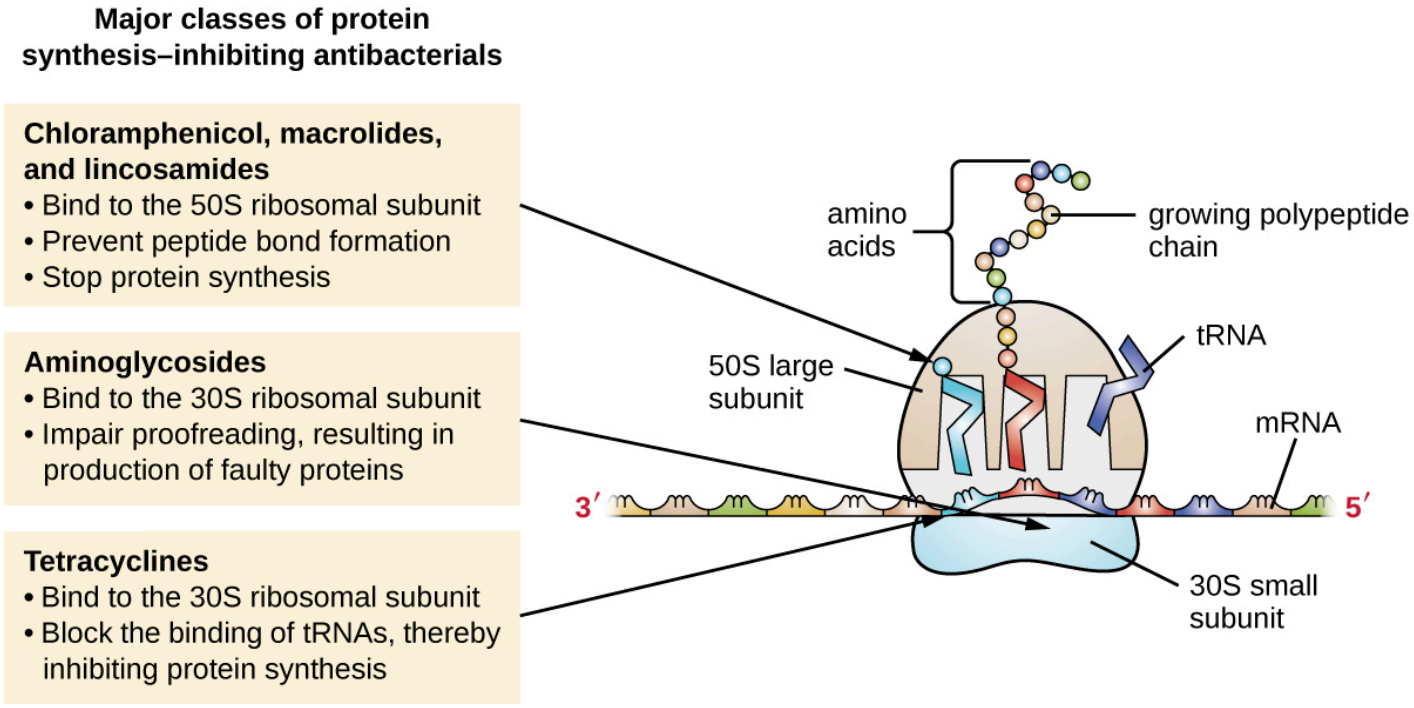

Figure 3.7 Medications That Inhibit Protein Synthesis

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Indications: Streptomycin is used for streptococcal endocarditis and a second-line treatment for tuberculosis. Gentamicin is used to treat serious gram-negative infections caused by bacteria such as meningitis (infection of the membranes that surround the brain and spinal cord) and serious infections of the blood, abdomen, lungs, skin, bones, joints, and urinary tract based on culture results.

Nursing Considerations: Aminoglycosides can result in many adverse effects for the client and, therefore, the nurse should monitor the client carefully for signs of emerging concerns. Peak and trough levels are used to titrate this medication to a safe dose. Aminoglycosides can be nephrotoxic (damaging to kidney), neurotoxic (damaging to the nervous system), and ototoxic (damaging to the ear). Nurses should monitor the client receiving aminoglycosides for signs of decreased renal function such as declining urine output and increasing blood urea nitrogen (BUN), increasing creatinine, and declining glomerular filtration rate (GFR). Indications of damage to the neurological system may be assessed as increasing peripheral numbness or tingling in the extremities. Additionally, the client should be carefully assessed for hearing loss or hearing changes throughout the course of drug administration.

Side Effects/Adverse Effects: Common side effects of aminoglycosides include GI upset and rash. New onset of diarrhea can indicate C-diff and should be reported immediately to the provider. Renal function must be closely monitored to watch for onset of nephrotoxicity. Clients have an increased risk for severe neurotoxic reactions, especially with renal impairment. Additionally, the administration of aminoglycosides can result in respiratory paralysis if given soon after anesthesia or a muscle relaxant. There is also increased risk for ototoxicity when administered with a loop diuretic. The administration of aminoglycosides can cause harm to a fetus and breastfed infants.

Health Teaching & Health Promotion: Clients receiving aminoglycosides should be advised to monitor for signs of hypersensitivity and auditory changes. This may include tinnitus and hearing loss. Clients may also experience accompanying vertigo while on the medication. Clients should be advised to drink plenty of fluids while taking the medication to reduce the

risk of nephrotoxicity. Female clients should notify their provider if pregnancy is planned or if they are actively breastfeeding.[2]

Now let's take a closer look at the medication grid for streptomycin and gentamycin in Table 3.12.[3]

Table 3.12 Streptomycin and Gentamycin Medication Grid

2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
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Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects

Aminoglycosides	streptomycin gentamicin	Check for allergies Obtain culture before administering Blood sample for peak level should be obtained after administration; obtain blood sample for trough level just before administering next dose Inject into a large muscle Handle carefully; use gloves to prepare Monitor peak and trough levels	Monitor for systemic signs of infection: -WBCs -Fever Monitor actual site of infection Monitor culture results	GI upset Rash Report signs of C-diff (diarrhea) immediately SAFETY: Nephrotoxicity: Monitor renal function closely Risk for severe neurotoxic reactions, especially with renal impairment. Can result in respiratory paralysis if given soon after anesthesia or muscle relaxant Risk for ototoxicity, especially if administered with a loop diuretic Can cause harm to fetus and breastfed infants

Critical Thinking Activity 3.12

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 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

3.13 Tetracyclines

Tetracyclines are broad-spectrum antibiotics that are bacteriostatic, subsequently inhibiting bacterial growth.

Mechanism of Action: Tetracyclines work by penetrating the bacterial cell wall and binding to the 30S ribosome, inhibiting the protein synthesis required to make the cellular wall.[1]

Indications: Tetracycline medications are useful for the treatment of many gram-positive and gram-negative infectious processes yet are limited due to significant side effects experienced by many clients.

Nursing Considerations: Significant side effects of tetracycline drug therapy include photosensitivity, discoloration of developing teeth and enamel hypoplasia, and renal and liver impairment.[2] Tetracyclines are contraindicated in pregnancy and for children ages 8 and under. Small amounts may be excreted in breast milk.

Side Effects/Adverse Effects: Side effects of tetracycline medications include GI upset and photosensitivity. Adverse effects include candidiasis and C-diff. Tetracyclines may cause permanent teeth discoloration if given to clients less than 8 years old. Significant adverse effects include increased intracranial pressure, and clients should be monitored for new-onset headaches, blurred vision, diplopia, and vision loss. Tetracyclines also decrease the effectiveness of oral contraceptives; therefore, backup contraceptive methods should be used.

Health Teaching & Health Promotion: Clients should be instructed to avoid direct sunlight exposure and wear sunscreen to prevent skin sensitivities. Additionally, it is important for clients to be educated regarding potential impaired absorption of tetracycline with the use of dairy products. Clients who are on oral contraceptives should be educated that tetracyclines may

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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.[3]

Now let's take a closer look at the medication grid for tetracycline in Table 3.13.[4]

Table 3.13 Tetracycline Medication Grid

3. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

4. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

Tetracyclines	tetracycline	Check allergies Alert: Check expiration date. Using outdated or deteriorated drug has been linked to severe reversible nephrotoxicity (Fanconi syndrome) 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 Use caution with renal or	Monitor for systemic signs of infection: -WBCs -Fever Monitor actual site of infection	Gastrointestinal symptoms C-diff Photosensitivity Oral candidiasis Permanent teeth discoloration if given to clients less than 8 years old Intracranial hypertension: Monitor for headache, blurred vision, diplopia, and vision loss Decreased effectiveness of oral contraceptives

		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)		

Critical Thinking Activity 3.13

Using the above grid information, consider the following clinical scenario question:

The nurse is providing health teaching to a caregiver 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?

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

3.14 Antivirals

Unlike the complex structure of fungi or protozoa, viral structure is simple. There are several subclasses of antiviral medications: antiherpes, antiinfluenza, antihepatitis, and antiretrovirals. Each subclass will be discussed in more detail below. See Figure 3.8[1] for images of viruses.

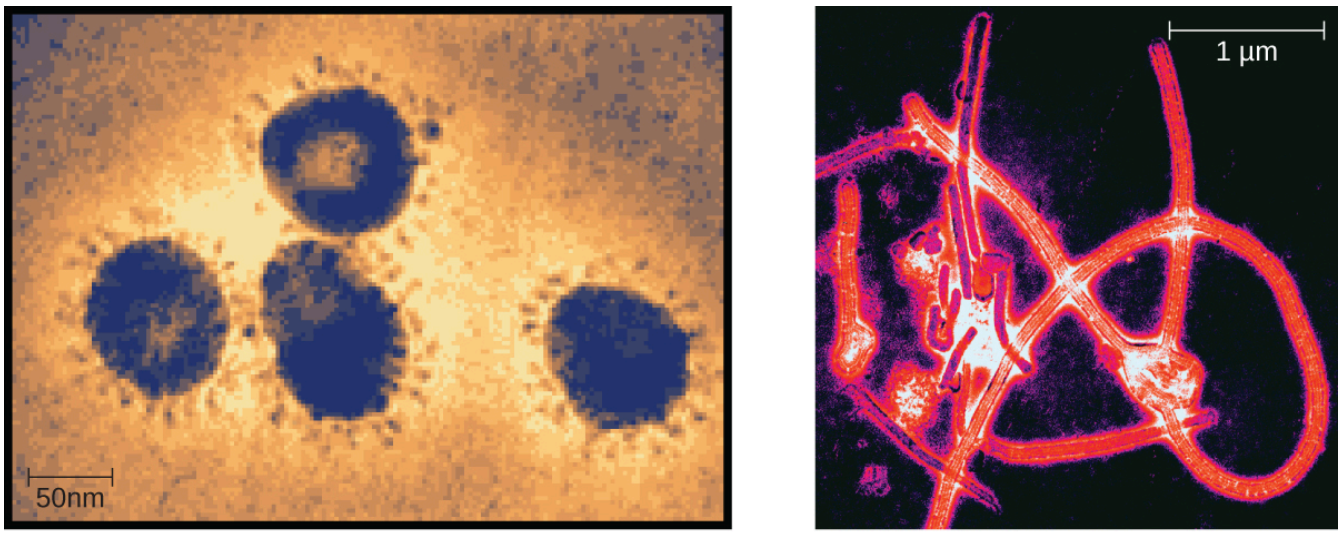

Figure 3.8 Images of Viruses (a) Members of the Coronavirus family can cause respiratory infections like the common cold, severe acute respiratory syndrome (SARS), and Middle East respiratory syndrome (MERS). Here they are viewed under a transmission electron microscope (TEM). (b) Ebolavirus, a member 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)

Subclass: Antiherpes

Mechanism of Action: Acyclovir causes termination of the DNA chain during

1. "Unknown" by CNX OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/microbiology/pages/1-3-types-of-microorganisms

the viral replication process. Acyclovir can be administered either topically or systemically, depending on the infection.[2]

Indications: Acyclovir (Zovirax) and its derivatives are frequently used for the treatment and prevention of herpes and varicella virus infections, including genital herpes, chicken pox, shingles, Epstein-Barr virus infections, and cytomegalovirus infections.

Nursing Considerations: Acyclovir use may result in nephrotoxicity.

Side Effects/Adverse Effects: Common side effects may include gastrointestinal distress. Additional adverse effects may include renal impairment and decreased seizure threshold.

Health Teaching & Health Promotion: 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.[3]

Subclass: Antiinfluenza

Mechanism of Action: Tamiflu prevents the release of virus from infected cells.

The influenza virus is one of the few RNA viruses that replicates in the nucleus of cells. Antivirals block the release stage. See Figure 3.9.[4]

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3. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
4. "Unknown" by CNX OpenStax is licensed under CC BY 4.0 Access for free at https://openstax.org/books/microbiology/pages/6-2-the-viral-life-cycle

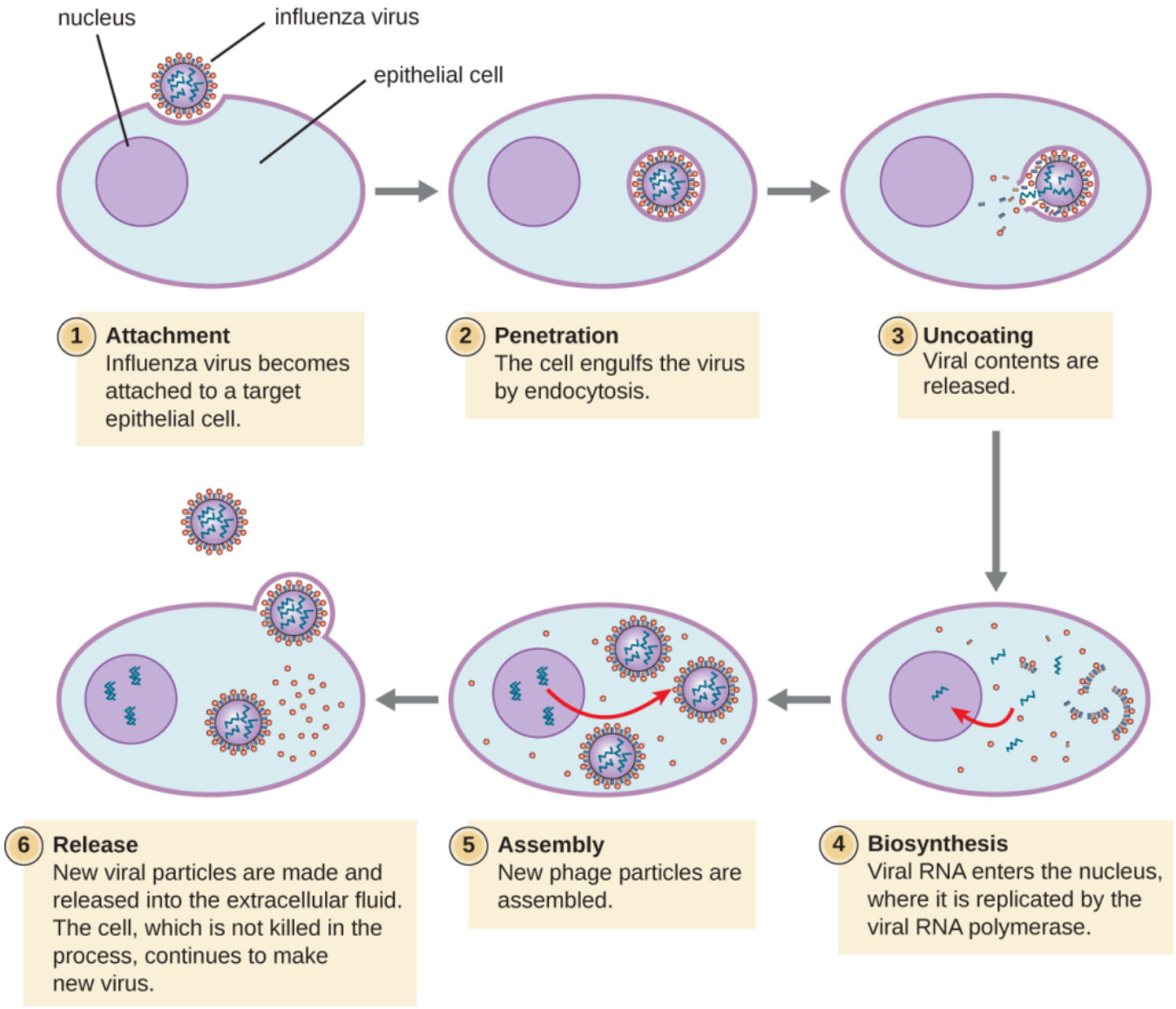

Figure 3.9 Influenza Virus Replication Stages

Indications: Oseltamivir (Tamiflu) is used to target the influenza virus by blocking the release of the virus from the infected cells.

Nursing Considerations: This medication does not cure influenza but can decrease flu symptoms and shorten the duration of illness if taken within 48 hours of symptom onset. Clients are prescribed the medication for prophylaxis against infection, known exposure, or to lessen the course of the illness. If clients experience flu-like symptoms, it is critical that they start treatment within 48 hours of symptom onset.

Side Effects/Adverse Effects: Common side effects include GI upset.

Adverse effects include serious skin hypersensitivity reactions or neuropsychiatric symptoms, especially in children. Use cautiously in clients with renal failure, chronic cardiac or respiratory diseases, or any medical condition that may require imminent hospitalization.

Health Teaching & Health Promotion: 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]

Subclass: Antihepatitis

Mechanism of Action: Antihepatitis medications inhibit translation of viral mRNA into viral proteins. This action impedes the replication of the hepatitis virus.

Indications: Antihepatits medications like adefovir are used to treat chronic hepatitis and the hepatitis B virus and hepatitis C virus.

Nursing Considerations: The medication is used to maintain or improve liver function when active disease is present. Therapy is prolonged, typically greater than 1 year or indefinitely, based on the client's status.

Side Effects/Adverse Effects: Adverse effects of antihepatitis medications include severe acute exacerbations of hepatitis B, nephrotoxicity, lactic acidosis, and severe hepatomegaly.

Health Teaching & Health Promotion: Clients receiving treatment for antihepatitis medications should also be offered HIV testing to ensure that they do not have an unrecognized or untreated HIV infection. Antihepatitis medications may promote resistance to antiretrovirals in clients with chronic Hepatitis B infection. Clients must understand that they should not stop taking medication unless directed by a health care provider. Monitor hepatic function several months after stopping therapy.

Subclass: Antiretrovirals

Viruses with complex life cycles, such as HIV, can be more difficult to treat.

5. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

These types of viruses require the use of antiretroviral medications that block viral replication, often referred to as antiretroviral therapy (ART). (See Figure 3.10 to view the viral replication process of HIV.)[6] Additionally, antiretrovirals fall under the class of antiviral medications.

6. This work is a derivative of "HIV Virus Replication Cycle" by NIAID is licensed under CC BY 2.0

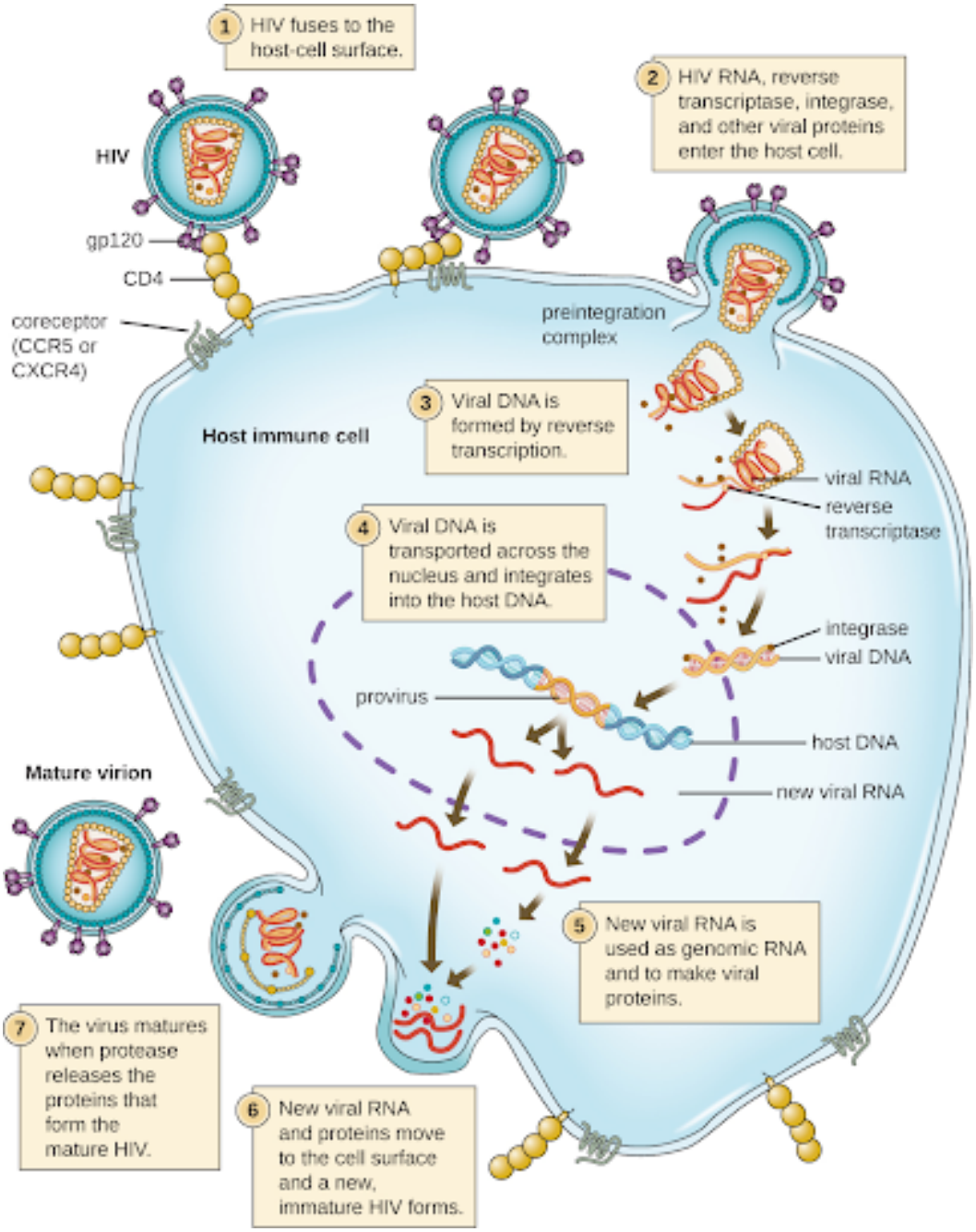

Figure 3.10 HIV attaches to a cell surface receptor of an immune cell and fuses with the cell membrane. Viral contents are released into the cell, where viral enzymes convert the single-stranded RNA genome into DNA and incorporate it into the host genome

Mechanism of Action: Antiretrovirals impede virus replication.

Indications: Antiretrovirals such as lamivudine-zidovudine are used for the treatment of illnesses like HIV.

Nursing 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.

Side Effects/Adverse Effects: Adverse side effects of antiretroviral medications include lactic acidosis and severe hepatomegaly. Clients should cease medication immediately if pancreatitis occurs.

Health Teaching & Health Promotion: 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.[7]

Now let's take a closer look at the medication grids for the subclasses of antivirals in Tables 3.14a-d.[8]

Tables 3.14a Acyclovir Medication Grid

7. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
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Class/ Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Antivirals: Antiherpes	acyclovir	Check for allergies Route: PO, IV, or topical; do not give IM or subcutaneously Give with food if GI upset occurs 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 Avoid sexual contact while genital lesions are present	Drug is not a cure for herpes but improves signs and symptoms of herpes lesions if started early Can be prescribed at lower doses for long-term for prevention of outbreaks	GI distress Monitor renal function in long-term use, especially if renal impairment Lowers seizure threshold

Tables 3.14b Oseltamivir Medication Grid

Class/ Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antivirals: Antiinfluenza Agents	oseltamivir	Check for allergies Route: PO Must be given within 48 hours of onset of symptoms Administer with food to avoid GI distress Does not replace need for annual influenza vaccination	Reduce duration of influenza symptoms	GI distress Serious skin/ hypersensitivity reactions; discontinue immediately Monitor for neuropsychiatric symptoms Use cautiously in clients with renal failure, chronic cardiac or respiratory diseases, or any medical condition that may require imminent hospitalization

Tables 3.14c Adefovir Medication Grid

Class/ Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antivirals: Antihepatitis Agents	adefovir	Route: PO Prolonged therapy (greater than 1 year or indefinitely) based on client status Offer HIV testing; may promote resistance to antiretrovirals in clients with chronic HBV infection who also have unrecognized or untreated HIV infection Do not stop taking medication unless directed. Monitor hepatic function several months after stopping therapy	Maintain or improve liver function when active disease is present	Severe acute exacerbations of hepatitis B Nephrotoxicity Lactic acidosis Severe hepatomegaly

Tables 3.14d Lamuvadine-Zidovudine Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	S

Antivirals: Antiretrovirals Nucleoside–Nucleotide Reverse Transcriptase Inhibitors	lamivudine-zidovudine	Check for allergies Lamivudine used to treat HIV-1 infection contains a higher dose of the active ingredient than the lamivudine used to treat chronic HBV infection. Clients with HIV-1 infection should receive only dosing forms appropriate for HIV-1 treatment Use cautiously in clients with renal impairment Inform client 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 clients to	Decreases chance of developing acquired immunodeficiency syndrome (AIDS) and HIV-related illnesses such as serious infections or cancer

		report symptoms of pancreatitis such as sudden abdominal pain, nausea, or yellowish tinge of the skin or eyes		

Critical Thinking Activity 3.14

Using the above grid 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 awful for the past five days!" What is the nurse's next best response?

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

3.15 Antifungals

Fungi are important to humans in a variety of ways. Both microscopic and macroscopic fungi have medical relevance, but some pathogenic species can cause mycoses (illnesses caused by fungi). See Figure 3.11[1] for a microscopic image of *Candida albicans,* which 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 also major sources of antibiotics, such as penicillin from the fungus *Penicillium*.[2]

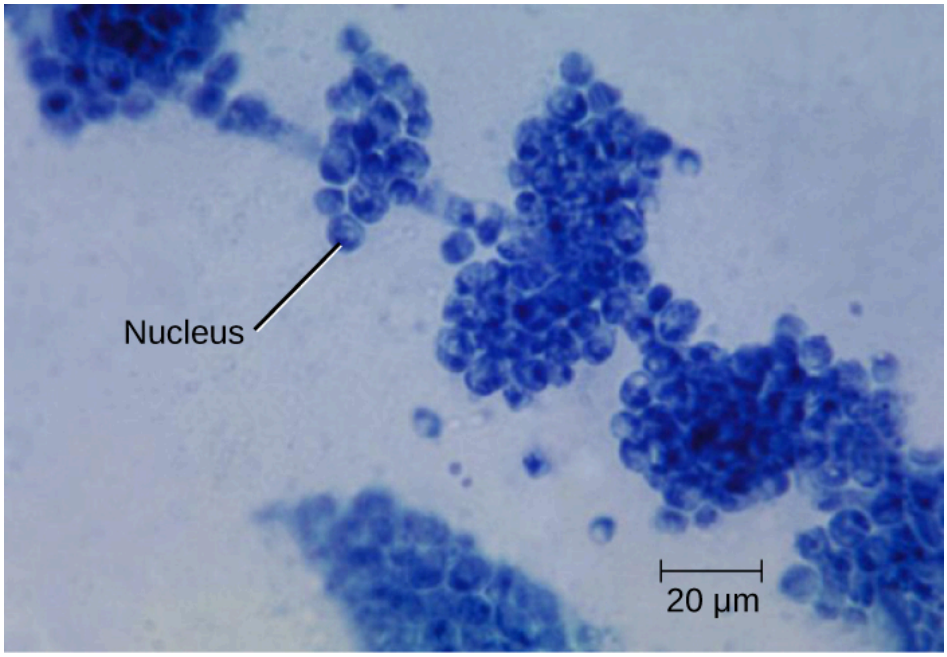

Figure 3.11 Candida albicans is a unicellular fungus, or yeast. It is the causative agent of vaginal yeast infections as well as oral thrush, a yeast infection of the mouth that commonly afflicts infants.

1. This image is a derivative of "Candida albicans" by Dr. Gordon Roberstad, Centers of Disease Control and Prevention. https://cnx.org/contents/y54zcuVm@1/Characteristics-of-Fungi, 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

Mechanism of Action: Antifungals disrupt ergosterol biosynthesis of the cell membrane, increasing cellular permeability and causing cell death.

Indications: There are several classes of antifungals, each with their own indications:

Imidazoles include miconazole, ketoconazole, and clotrimazole, which are used to treat fungal skin infections such as tinea pedis (athlete's foot), tinea cruris (jock itch), and tinea corporis (ringworm of the body).

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 imidazoles, and are associated with fewer side effects.[3]

Allylamines, a structurally different class of synthetic antifungal drugs, are 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.[4]

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.[5]

Nursing Considerations: Administration guidelines will vary depending on the type of fungal infection being treated. It is important to monitor response

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of the affected area and examine class specific administration considerations to monitor client response.

Side Effects/Adverse Effects: Common side effects of antifungal medications can include skin irritations and rashes. Additional adverse effects include hepatotoxicity, nephrotoxicity, hypokalemia, and ototoxicity.

Health Teaching & Health Promotion: 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 bruising or bleeding, which may be a sign of liver dysfunction.[6]

Now let's take a closer look at the medication grid for various antifungals in Table 3.15.[7]

Table 3.15 Antifungal Medication Grid

6. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

7. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antifungals	clotrimazole	Check for allergies Topical cream: Apply liberally twice daily to affected area	Improve symptoms of tinea pedis (athlete's foot), tinea cruris (jock itch), or tinea corporis (ringworm of the body)	Topical: Skin irritation or rash
	fluconazole	Check for allergies Route: PO/IV Single or multiple doses Caution if liver dysfunction Potential for fetal harm	Improve symptoms of yeast infection	Hepatotoxicity
	terbinafine	Cream or aerosol Wash affected area with soap and water and allow to dry completely before applying	Improve symptoms of tinea pedis (athlete's foot), tinea cruris (jock itch), tinea corporis (ringworm of the body)	External use only
	nystatin	PO: If order is "swish and swallow," instruct client to swish for 30 seconds or as long as tolerated before swallowing, and then do not eat or drink for 10-30 minutes afterwards Topical cream/ powder: Apply liberally twice daily	Improve symptoms of yeast infection of skin	Powder/cream is for external use only

	amphotericin B	Check for allergies 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 require several months Alert: Different amphotericin B preparations aren't interchangeable Caution if renal impairment Boxed Warning: Don't use to treat noninvasive forms of fungal disease in clients with normal neutrophil counts	Improvement of systemic fungal infection such as aspergillus	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 Obtain liver function tests once or twice weekly Monitor CBC weekly Monitor potassium levels and report signs of hypokalemia Check calcium and magnesium levels twice weekly Drug may be ototoxic. Report evidence of hearing loss,

				tinnitus, vertigo, or unsteady gait

Critical Thinking Activity 3.15

Using the above grid information, consider the following clinical scenario question:

A client in a skilled nursing facility has been receiving nystatin applied to 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

3.16 Antimalarials

Malaria is a prevalent protozoal disease impacting individuals globally. According to the Centers for Disease Control, approximately 1,700 cases of malaria are diagnosed in the United States each year.[1]

Mechanism of Action: Antimalarial agents work by targeting specific intracellular processes that impact cell development.[2]

Indications: Antimalarials are used for the prevention or treatment of malaria.

Nursing Considerations: Antimalarial medications may impact hearing and vision, so clients should be monitored carefully for adverse effects. Additionally, antimalarial medications may cause GI upset, so clients should be instructed to take these medications with food.

Side Effects/Adverse Effects: Individuals who receive antimalarial medications should be monitored for changes in vision and hearing. Additionally, renal impairment may occur so renal function should be carefully monitored. Adverse effects and signs of toxicity include headache, drowsiness, visual disturbances, nausea and vomiting, cardiovascular collapse, shock, and convulsions.

Health Teaching & Health Promotion: Clients should receive instruction to take medications as prescribed and adhere to the full prescription regimen. Clients should minimize additional exposure to mosquitoes (i.e., the mode of transmission) and use preventative measures such as repellents, protective clothing, bed nets, etc. Clients on chloroquine therapy should also avoid alcohol. Chloroquine can be extremely toxic to children and should be safely stored and out of reach. Clients receiving antimalarial therapy may have increased sensitivity to light and should be counseled to wear protective

1. Centers for Disease Control and Prevention. (2018, November 15). *Choosing a drug to prevent malaria*. https://www.cdc.gov/malaria/travelers/drugs.html
2. Achieng, A., Rawat, M., Ogutu, B., Guyah, B., Ong'echa, J. M., Perkins, D., & Kempaiah, P. (2017). Antimalarials: Molecular drug targets and mechanism of action. *Current Topics in Medicinal Chemistry, 17*, 1-15. https://doi.org/10.2174/1568026617666170130115323

glasses to prevent ocular damage. Treatment often requires sustained regimens of six months or greater so clients should be monitored carefully for adherence and compliance.[3]

Now let's take a closer look at the medication grid on chloroquine in Table 3.16.[4]

Table 3.16 Chloroquine Medication Grid

3. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
4. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antimalarials	chloroquine	Check for allergies Contraindicated in clients hypersensitive to drug and in those with retinal or visual field changes Use cautiously in clients with severe GI, neurologic, or blood disorders; hepatic disease or alcoholism; or G6PD deficiency or psoriasis Take with food to prevent GI upset In severe or resistant cases, artesunate IV may be prescribed	Prevention of malaria or improvement of an acute attack of malaria For malaria prevention, the CDC recommends that clients take the drug for four weeks after leaving a malaria-infected area.	Changes in vision Changes in hearing Monitor renal function closely Monitor client for overdose, which can quickly lead to toxic symptoms: Headache, drowsiness, visual disturbances, nausea and vomiting, cardiovascular collapse, shock, and convulsions

Critical Thinking Activity 3.16

Using the above grid 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. The side effects sound horrific!" What is the nurse's best response regarding the length of therapy?

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

3.17 Antiprotozoals

Antiprotozoal drugs target infectious protozoans such as *Giardia*, an intestinal protozoan parasite that infects humans and other mammals, causing severe diarrhea (see Figure 3.12 for a microscopic image of giardia).[1]



Figure 3.12 Giardia Lamblia

Mechanism of Action: Many antiprotozoal agents work to inhibit protozoan folic acid synthesis, subsequently impairing the protozoal cell.[2]

Indications: Metronidazole is an example of an antiprotozoal antibacterial medication gel that is commonly used to treat acne rosacea, bacterial vaginosis, or trichomonas. Metronidazole IV is used to treat giardia and also serious anaerobic bacterial infections such as *Clostridium difficile* (C-diff).

Nursing Considerations: It can be administered PO, parenterally, or

1. "Giardia lamblia SEM 8698 lores.jpg" by CDC/ Janice Haney Carr 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

topically. Orally is the preferred route for GI infections. The nurse should monitor the client carefully for side effects and adverse effects. Psychotic reactions have been reported with clients with alcohol substance disorder taking disulfiram.

Side Effects/Adverse Effects: Side effects include dizziness and dry mouth. Adverse effects include seizures, peripheral neuropathy, psychotic reactions, and hepatotoxicity.

Health Teaching & Health Promotion: Clients taking antiprotozoal medications should receive health teaching regarding the need for medication compliance and prevention of reinfection. They should be advised that the medication may cause dizziness and dry mouth. Additionally, the medication may cause darkening of the urine. They should also 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] Client teaching should include the avoidance of alcohol during therapy.

Now let's take a closer look at the medication grid in Table 3.17.[4]

Table 3.17 Metronidazole Medication Grid

3. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
4. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adve Effects
Antiprotozoal-Antibacterial	metrogel metronidazole IV	Check for allergies Topical, vaginal, PO, or IV Don't give by IV push. Infuse over 30 to 60 minutes Contraindications: Pregnancy, hypersensitivity, or use of alcohol or disulfiram during therapy Use cautiously with hepatic impairment, blood dyscrasias, or CNS diseases	Improvement of symptoms	Seizures Peripher neuropat Psycho reactions Hepato ity

Critical Thinking Activity 3.17

Using the above grid information, consider the following clinical scenario question:

A client develops C-diff after taking multiple antibiotics for a nonhealing wound. What medication is commonly used to treat C-diff, and what route is used?

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

3.18 Antihelmintics

There are two major groups of parasitic helminths in the human body: roundworms (*Nematoda*) and flatworms (*Platyhelminthes*). See Figure 3.13 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.

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 antihelminths inhibit ATP formation and impair calcium uptake, inducing paralysis and death.[2]

Indications: Anthelmintic medications target parasitic helminths.[3]

Nursing Considerations: Prolonged therapy using antihelmintic medication can result in liver damage and bone marrow suppression.

Side Effects/Adverse Effects: Side effects include GI upset, nausea, vomiting, diarrhea, and loss of appetite. Adverse effects of antihelmintic medications include hepatic effects and bone marrow suppression.

Health Teaching & Health Promotion: Clients on antihelmintic drug therapy should receive special instruction to ensure rigorous hygienic precautions to minimize the risk of reinfection. They should also wash all bedding, linens, towels, and clothing following treatment to minimize reinfection risk.[4]

1. This work is a derivative of "Taenia saginata adult 5260 lores.jpg" and "Dracunculus medinensis.jpg" by Centers for Disease Control and Prevention and 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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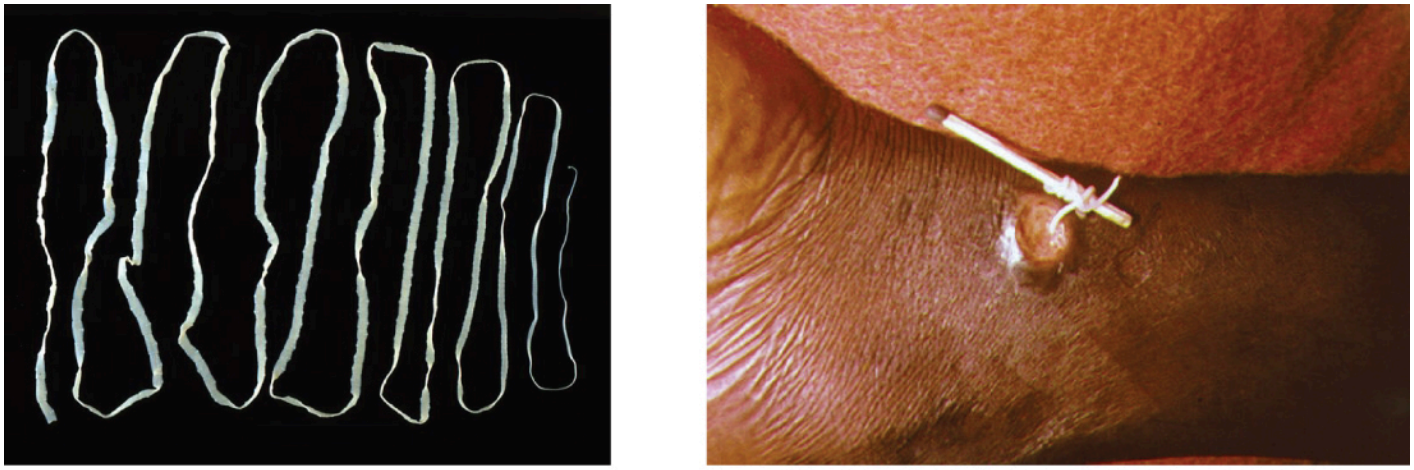
4. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral



(a) (b)

Figure 3.13 A. The tapeworm Taenia saginata that infects both cattle and humans. Eggs are microscopic, but the adult tapeworm like the one shown 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 client's skin by winding it around a matchstick

Now let's take a closer look at the medication grid on mebendazole in Table 3.18.[5]

Table 3.18 Mebendazole Medication Grid

5. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Antihelmintic	mebendazole	Contraindicated during pregnancy; may cause fetal harm To help prevent reinfection: -Wash hands and fingernails with soap often during the day, especially before eating and after using the toilet -Wash all fruits and vegetables thoroughly or cook them well -Wear shoes to prevent exposure	Elimination of worms	In prolonged treatment: -Hepatic effects -Bone marrow suppression

Critical Thinking Activity 3.18

Using the above grid 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 patient teaching should the nurse provide to the child and the mother?

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

3.19 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]

Mechanism of Action: Antituberculars work by impacting 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.

Indications: Antitubercular medications are selective for mycobacteria and work by inhibiting growth or selectively destroying mycobacteria.[2]

Nursing Considerations: Antitubercular medications require at least six months of treatment. 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]

Side Effects/Adverse Effects: Common side effects of antitubercular medications include GI upset. Adverse effects include hepatotoxicity. Antitubercular medications can also decrease the effectiveness of oral contraceptives, so alternative contraceptive methods should be used.

Health Teaching & Health Promotion: Advise clients that medications must

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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 and antibiotic resistance to TB. 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 health care provider. Clients should also 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.[4]

Now let's take a closer look at the medication grid on isoniazid in Table 3.19a and rifampin in Table 3.19b.[5]

Table 3.19a Isoniazid Medication Grid

4. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
5. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

Antitubercular (also known as antimycobacterials)	isoniazid	Direct observed therapy (DOT) may be initiated to ensure compliance with long-term therapeutic regimen Multiple-drug resistant tuberculosis (i.e., resistance to at least isoniazid and rifampin) presents difficult treatment problems. Treatment must be individualized and based on susceptibility studies May decrease effectiveness of oral contraceptives. Clients should be counseled to use alternate form of oral contraception Vitamin B6 supplementation is necessary in some clients for prevention of peripheral neuropathy	Negative sputum smears Prevention or elimination of TB symptoms: Productive cough, fever, and night sweats	GI upset Hepatotoxicity May decrease effectiveness of oral contraceptives

Table 3.19b Rifampin Medication Grid

Class/Subclass	Prototype/Generic	Administration Considerations	Therapeutic Effects	Side/Adverse Effects

Antitubercular (also known as antimycobacterials)	rifampin	Direct observed therapy (DOT) may be initiated to ensure compliance with long-term therapeutic regimen Multiple-drug resistant tuberculosis (i.e., resistance to at least isoniazid and rifampin) presents difficult treatment problems. Treatment must be individualized and based on susceptibility studies May decrease effectiveness of oral contraceptives. Clients should be counseled to use alternate form of oral contraception Vitamin B6 supplementation is necessary in some clients for prevention of peripheral neuropathy	Negative sputum smears Prevention or elimination of TB symptoms: Productive cough, fever, and night sweats Rifampin can also be used to treat meningitis, staph infections, chronic bacterial infections (such as leprosy), and as prophylaxis for meningococcal disease	GI upset Drowsiness Body fluids may turn red-orange, which can permanently stain contact lenses Hepatotoxicity May decrease effectiveness of oral contraceptives

Critical Thinking Activity 3.19

Using the above grid information, consider the following clinical scenario question:

A client has been prescribed isoniazid as part of a multidrug 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 Critical Thinking activities can be found in the “Answer Key” section at the end of the book.

3.20 Miscellaneous Antibacterials: Glycopeptides

Vancomycin is a glycopeptide commonly used to treat MRSA.

Mechanism of Action: Glycopeptides are a class of medications that inhibit bacterial cell wall synthesis.

Indications: 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 and C-diff.

Nursing Considerations: It is poorly absorbed from the GI tract, so it must be given by IV to treat a systemic infection. Oral vancomycin, on the other hand, is used to treat antibiotic-associated *Clostridium difficile* (C-diff) infection. 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. Clients receiving IV vancomycin may also experience a complication known as "vancomycin flushing syndrome" in which they experience a flushing of the skin and a reddish rash on the upper body when the infusion is administered too rapidly.

Side Effects/Adverse Effects: Side effects of glycopeptides include nephrotoxicity and ototoxicity. Additionally, C-diff can occur up to two months after the therapy ends. Vancomycin flushing syndrome can occur if the drug is infused too rapidly. Signs and symptoms include maculopapular rash on face, neck, trunk, and limbs and pruritus and hypotension caused by histamine release.

Health Teaching & Health Promotion: Clients should be counseled 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 health care provider if no improvement in symptoms is identified.[1]

Now let's take a closer look at the medication grid on vancomycin in Table 3.20.[2]

Table 3.20 Vancomycin Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

Miscellaneous Antibacterials: Glycopeptides	vancomycin	Check for allergies Route: IV but for C-diff may be administered PO or rectally as an instilled enema Obtain culture prior to administering first dose Dosage adjustment is required for renal impairment Monitor trough levels IV should be administered in a diluted solution over a period of 60 minutes or more to avoid rapid-infusion-related reactions	Monitor for systemic signs of infection: -WBCs -Fever Monitor actual site of infection for improvement Monitor and report trough levels for targeted dosing	Nephrotoxicity Ototoxicity C-diff can occur up to two months after therapy ends Vancomycin flushing syndrome can occur if drug is infused too rapidly. Signs and symptoms include maculopapular rash on face, neck, trunk, and limbs and pruritus and hypotension caused by histamine release. Stop infusion and contact provider. Prepare to administer diphenhydramine 50mg IV or PO. Monitor BP closely; IV fluids and/or vasopressors may be required if hypotensive. Infusion may be restarted at a slower rate after

				rash and itching resolve

Critical Thinking Activity 3.20

Using the above grid information, consider the following clinical scenario question:

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?

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

3.21 Learning Activities

Exercises

Case Study 1

Hector Ramirez is a 55 -year-old male admitted to the hospital with a chief complaint of redness, swelling, and pain at the site of recent abrasion that he experienced in a construction accident. The accident occurred three days ago.

Medical History: Mr. Ramirez has a medical history of type 2 diabetes, hypertension, and hyperlipidemia. He takes insulin, simvastatin, and lisinopril daily.

Physical Examination: On physical examination, Mr. Ramirez was alert and oriented. The right arm was erythematous, warm to touch, and there was swelling at the site of the abrasion. The client reported pain when the site was touched.

Diagnostic Tests: A sample of fluid was collected from the affected area and sent for culture and sensitivity testing. The results showed the presence of *Staphylococcus aureus*. Blood tests were also performed and revealed no signs of systemic infection.

1. Based upon the presence of *Staphylococcus aureus*, what medication would you expect to be prescribed?
2. What nursing interventions and health teaching should be provided to Mr. Ramirez?
3. What common side effects might the client experience

related to the medication?

Case Study 2

Miss Iso, a 17-year-old, presents to the dermatologist with complaints of persistent acne on her face, neck, and back. She has tried over-the-counter creams and gels but has not seen significant improvement.

Medical History: Miss Iso is otherwise healthy and has no known drug allergies. She has a history of eczema but is currently not experiencing any symptoms. She is not taking any other medications and has no significant family history.

Physical Examination: Miss Iso is an alert and cooperative teenager. Vital signs are within normal limits. Physical examination reveals moderate to severe acne on her face, neck, and back with a few cystic lesions.

Diagnostic Tests: No diagnostic tests were performed.

1. What medication do you anticipate will be prescribed for Miss Iso?
2. What nursing interventions and health teaching should be provided to Miss Iso about this medication?
3. What common side effects might Miss Iso experience while taking this medication?

Note: Answers to the Case Studies can be found in the "Answer Key" section 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://wtcs.pressbooks.pub/pharmacology2e/?p=135#h5p-10

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Interactive Activity

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Interactive Activity

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Test your clinical judgment with this NCLEX Next Generation-style question: Antimicrobials Assignment 1.[1]

Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Antimicrobials Assignment 2.[2]

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- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Antimicrobials Assignment 3.[3]



- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Antimicrobials Assignment 4.[4]



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III. Glossary

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.

Antifungal: Medications that are used to treat fungal infections. For example, nystatin is used to treat *Candida albicans*, a fungal infection.

Antiviral: Medications used to treat viral infections. For example, Tamiflu is used to treat influenza.

Bactericidal: Antimicrobial drugs that kill their target bacteria.

Bacteriostatic: Antimicrobial drugs that cause bacteria to stop reproducing but may not ultimately kill the bacteria.

Boxed Warnings: The strongest warnings issued by the Federal Drug Administration (FDA) that signify the drug carries a significant risk of serious or life-threatening adverse effects.

Broad-spectrum antimicrobial: An antibiotic that targets a wide variety of bacterial pathogens, including both gram-positive and gram-negative species.

Clostridium difficile (C-diff): Causes pseudomembranous colitis, a superinfection that can be caused by broad-spectrum antibiotic therapy.

Culture: A test performed on various body substances for the presence of bacteria or fungus.

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.

Gram-negative: Gram-negative bacteria are classified by the color they turn after a chemical called gram stain is applied to them. *Escherichia Coli* (also known as E. Coli) is an example of a gram-negative infection.

Gram-positive: Gram-positive bacteria are classified by the color they turn

after a chemical called gram stain is applied to them. Infections caused by *Streptococcus* and *Staphylococcus* bacteria are examples of gram-positive infections.

Gram stain: A test used to quickly diagnose types of bacterial infection. Gram-positive and gram-negative bacteria stain differently because their cell walls are different. Identification of bacteria as gram-positive or gram-negative assists the health care 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.

Indications: The use of a drug for treating a particular condition or disease. The FDA determines if there is enough evidence for a labeled indication of a drug. Providers may also prescribe medications for off-label indications if there is reasonable scientific evidence that the drug is effective, but these uses have not been approved by the FDA.

Mechanism of action: The way in which a drug affects microbes at the cellular level.

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.

Narrow-spectrum antimicrobial: An antibiotic that targets only specific subsets of bacterial pathogens.

Pathogen: An organism causing disease to its host.

Prototype: A common individual drug that represents a drug class or group of medications having similar chemical structures, mechanisms of action, and modes of action.

Resistance: A characteristic of bacteria when sensitivity analysis is performed demonstrating lack of effective treatment by a particular antibiotic.

Sensitivity analysis: A test performed in addition to a culture to select an effective antibiotic to treat a microorganism.

Superinfection: A secondary infection in a client having a preexisting infection. C-diff and yeast infections as a result of antibiotic therapy are examples of superinfections.

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.

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.

PART IV

AUTONOMIC NERVOUS SYSTEM

4.1 Autonomic Nervous System Introduction

Learning Objectives

- Identify the classifications and actions of autonomic nervous system drugs
- Give examples of when, how, and to whom autonomic nervous system drugs may be administered
- Identify the side effects and special considerations associated with autonomic nervous system drugs
- Include considerations and implications of using autonomic nervous system drugs across the life span
- Include evidence-based concepts when using the nursing process related to medications that affect the autonomic nervous system
- Identify and interpret related laboratory tests
- Identify nursing responsibilities associated with health teaching and health promotion

Have you ever wondered what causes your heart to beat or 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, gastrointestinal, and conditions by acting on ANS receptors.

This chapter discusses the actions of ANS receptors and neurotransmitters and creates the knowledge base upon which the remainder of this book will build. Although the information in this chapter appears complex, it is a tool by which you will know the therapeutic effects and side effects of many classes of medications by understanding the effects that occur when specific ANS receptors are stimulated or inhibited. For example, by knowing a specific medication is classified as a "beta-blocker," you will immediately know the actions of the drug are to slow the heart rate and lower the blood pressure. Additionally, if you know a medication is classified as an anticholinergic, you will immediately know the common side effects to monitor based on the mnemonic "SLUDGE" (**S**alivation decreased, **L**acrimation decreased, **U**rinary retention, **D**rowsiness/dizziness, **G**I upset, **E**yes (blurred vision/dry eyes).

4.2 Basic Concepts of the Autonomic Nervous System

This section will review key anatomy concepts in the autonomic nervous system (ANS) related to the mechanism of action of medications.

To review detailed information regarding the autonomic nervous system, see the related content below in Open Stax *Anatomy and Physiology*[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.

Review of the Anatomy and Functions of the Nervous System

The nervous system has two major components: the central nervous system

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(CNS) and the peripheral nervous system. See Figure 4.1.[2] 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.

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
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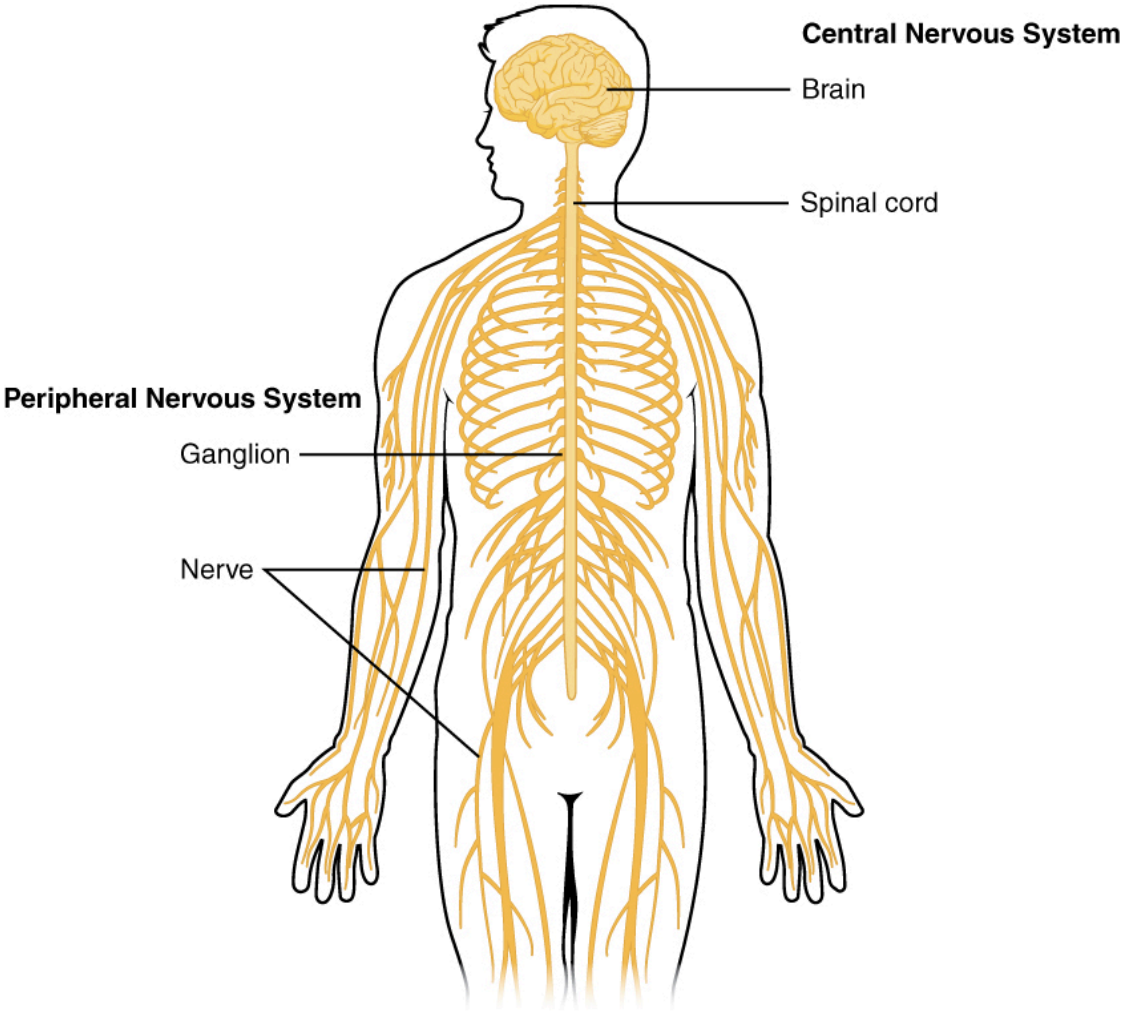

Figure 4.1 Central and Peripheral Nervous System

The two divisions of the autonomic nervous system are the **sympathetic nervous system (SNS)** and the **parasympathetic nervous system (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 4.2 for an image of the divisions of the nervous system and the receptors in the ANS.[4]

4. "Component of the Nervous System" by Blaire Babbitt at Chippewa Valley Technical College is licensed under CC BY 4.0

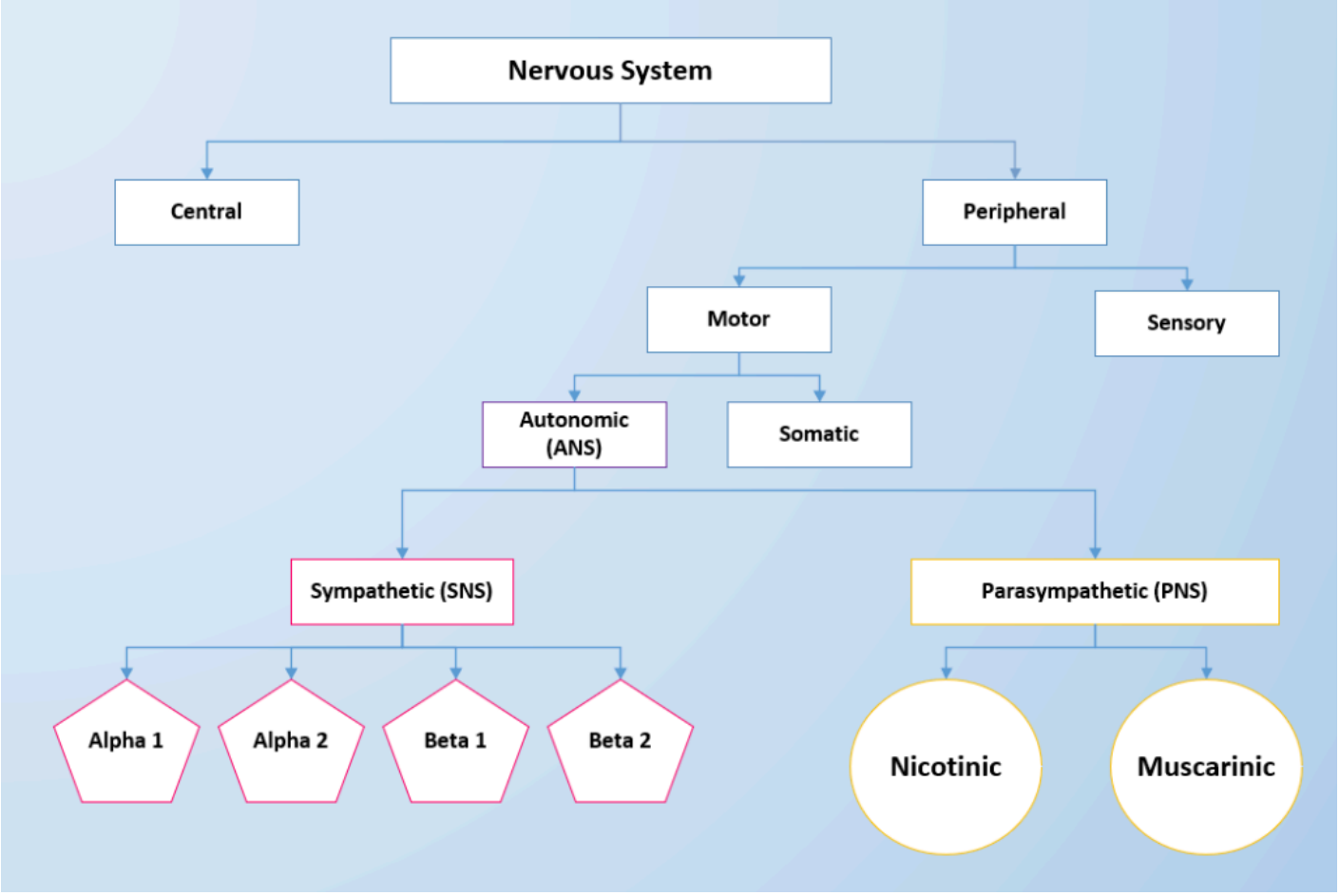

Figure 4.2 Components of the Nervous System and ANS Receptors

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 4.3[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. "Updated SNS-PNS image.png" by Meredith Pomietlo for Open RN is licensed under CC BY 4.0
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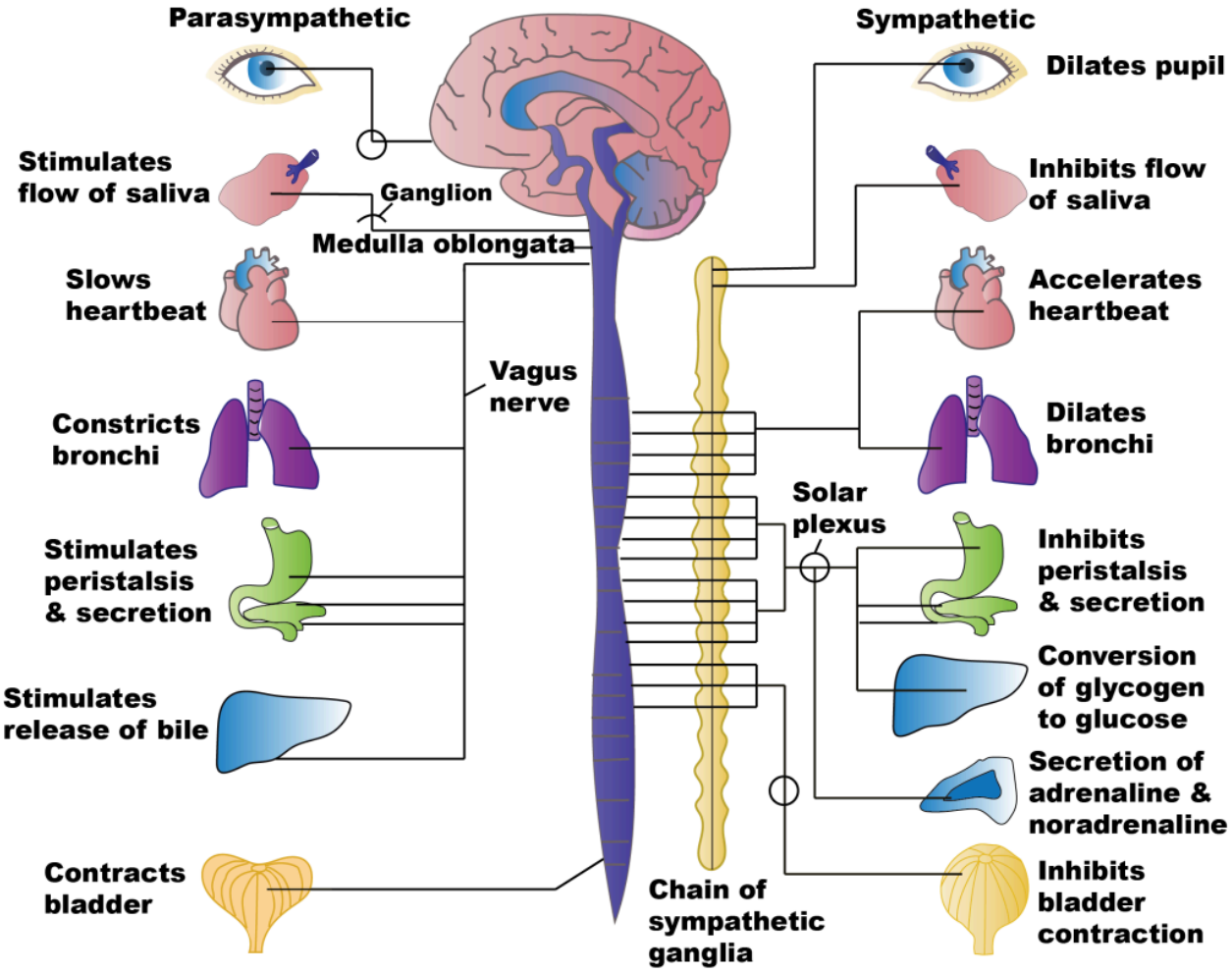

Figure 4.3 Effects of PNS and SNS Stimulation on Target Organs

Stimulation of the 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 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. Because 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]

Chemical Signaling in the Autonomic Nervous System

Neurons conduct impulses to the synapse of a target organ. The **synapse** is a connection between the neuron and its target cell. See Figures 4.4[9] and 4.5[10] for images of synapse connections.

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8. 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
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

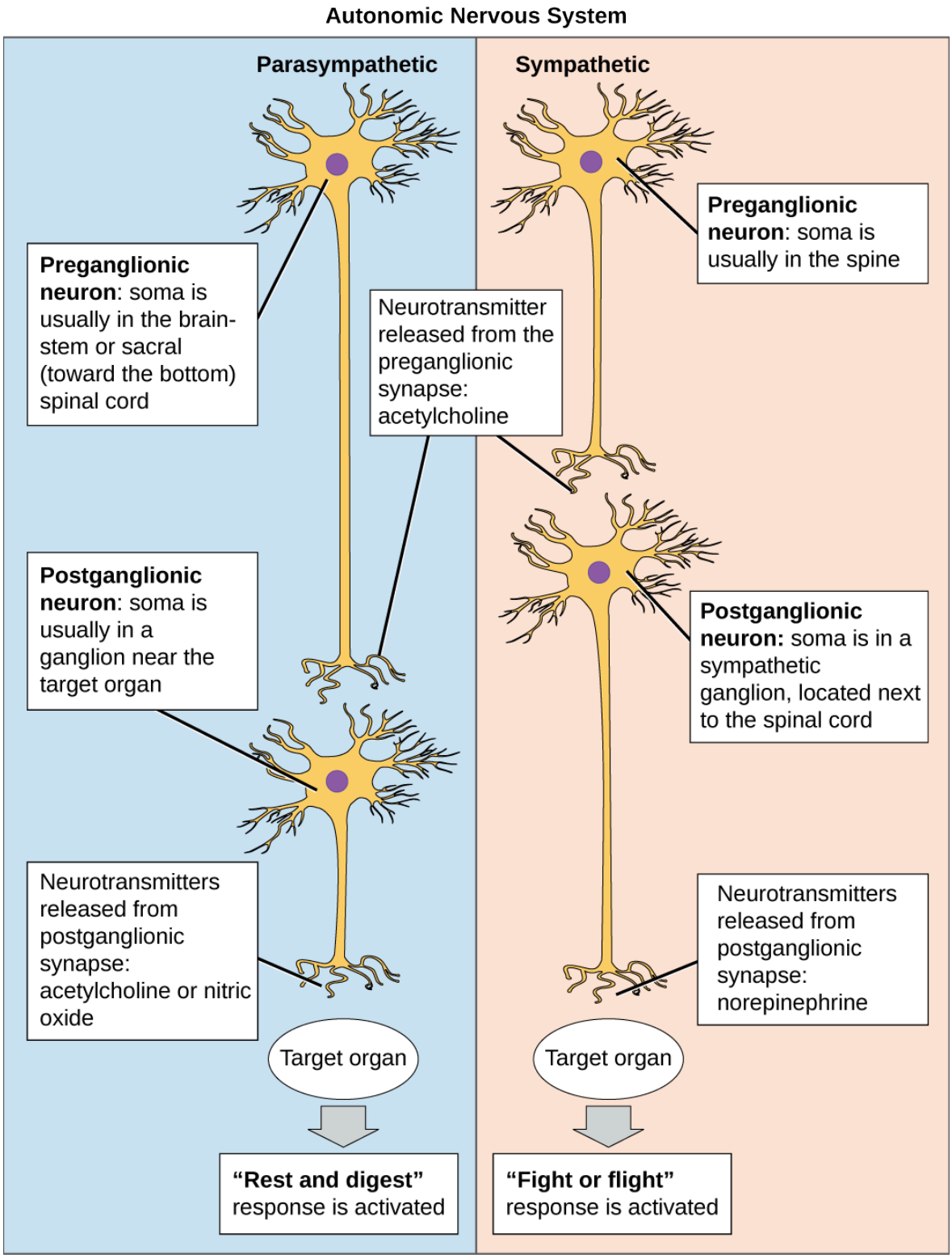

Figure 4.4 Autonomic System Neurons Conduct Signals to Target Organs

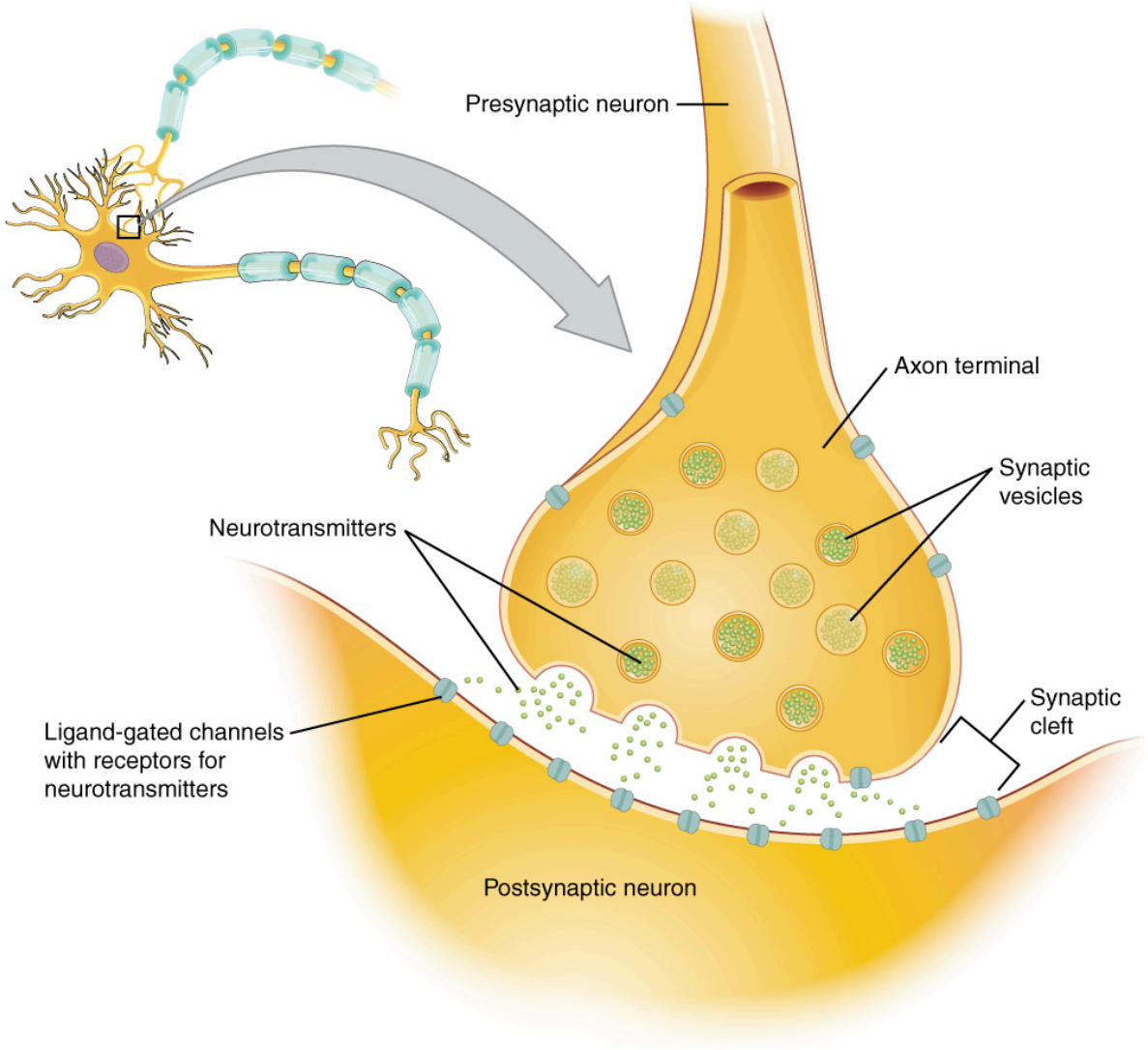

Figure 4.5 Synapse Is Connection Between Neuron and Target Cell Where Neurotransmitters Are Released

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 4.6 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 (CH3) 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]

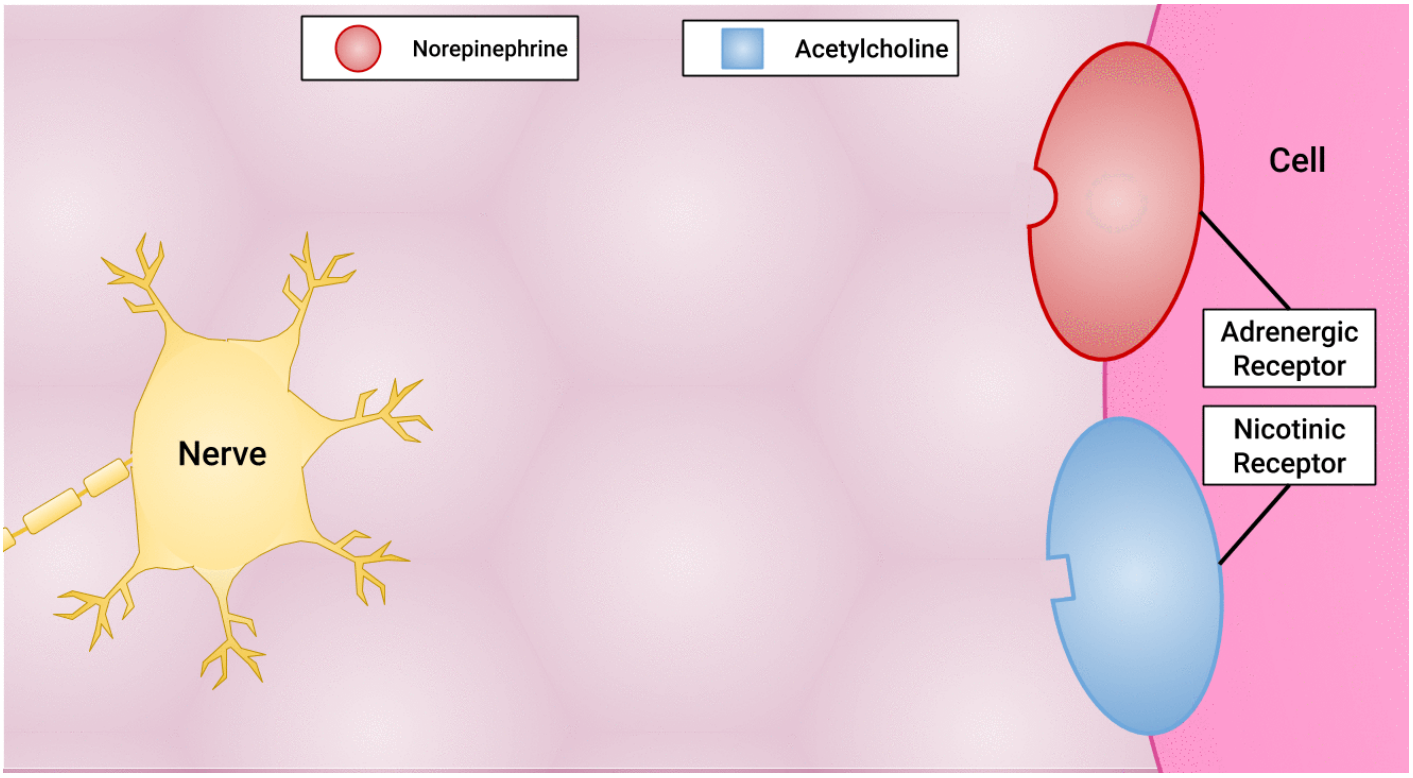

Figure 4.6 Sympathetic and Parasympathetic Pre-and Postganglionic Fibers and Neuroreceptors

ANS Neuroreceptors and Effects

The effects of stimulating each type of neuroreceptor are outlined in this section and sample uses of medications are provided.

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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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 4.2a for a summary of stimulation and inhibition of these SNS receptors. These effects will be covered in more detail in the remaining sections of this chapter.

Table 4.2a Comparison of Medication Effects of Adrenergic Receptor Stimulation and Inhibition

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	Vasodilation 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 relaxes smooth muscle Blood vessels: Vasodilation Lungs: Bronchodilation GI: Decreased motility Liver: Glyconeogenesis 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 receptor so lowers blood pressure but inadvertently causes bronchoconstriction

★ Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=151#h5p-14

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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 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 clients experiencing upper respiratory infections. Examples

of Alpha-1 agonist medications are pseudoephedrine or phenylephrine and are 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 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 4.7[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

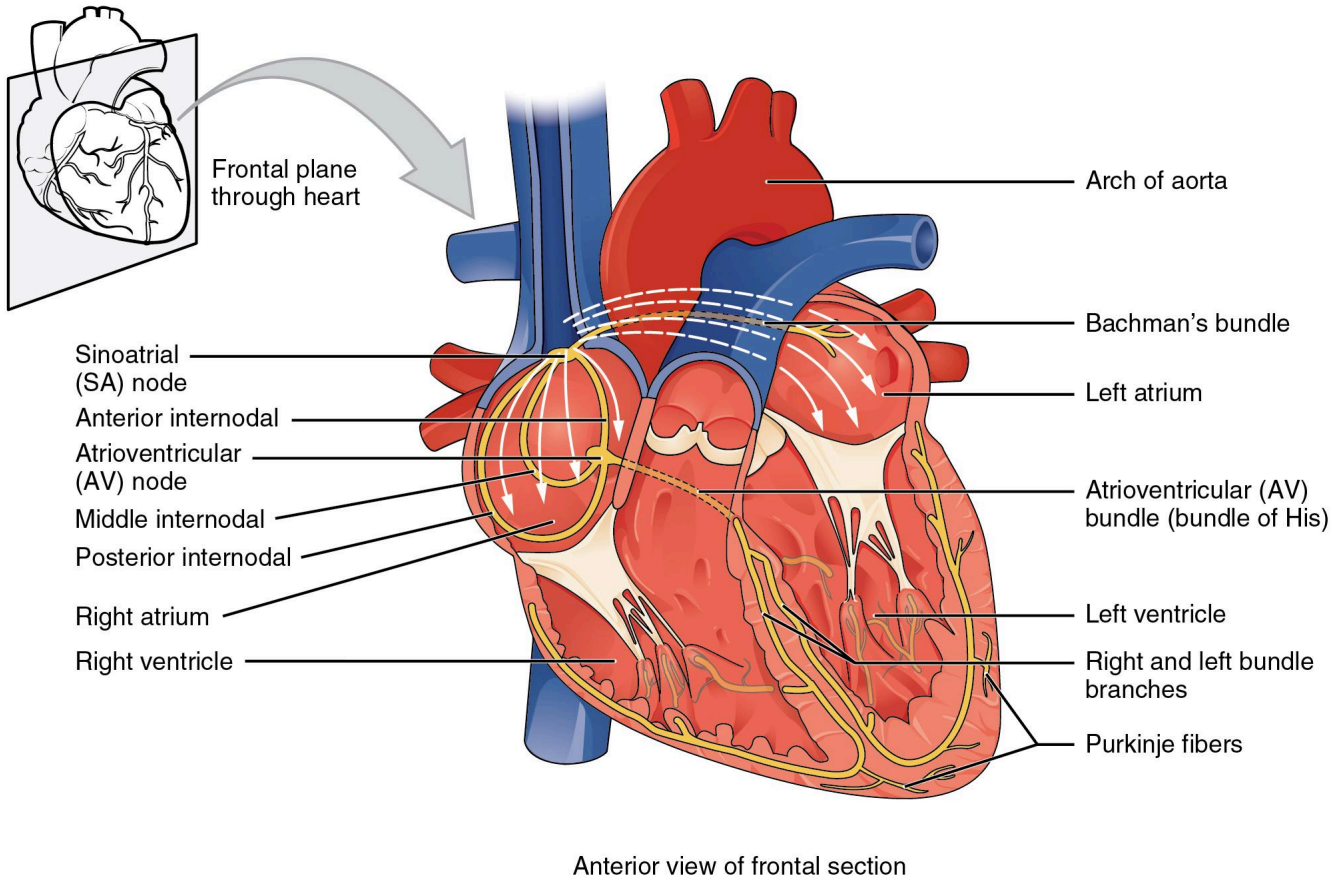

Figure 4.7 Dromotropic Properties Affect the Speed of Conduction Between SA and AV Nodes

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 clients with asthma or chronic obstructive pulmonary disease (COPD). An example of a Beta-2 receptor agonist medication used in asthma is albuterol. See Figure 4.8[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, albuterol can cause tachycardia by stimulating Beta-2 receptors in the heart. Stimulation of

14. "Bronchodilators" by BruceBlaus is licensed under CC BY 4.0

Beta-2 receptors can also inadvertently cause **hyperglycemia** in clients with diabetes because of activation of Beta-2 receptors in the liver, causing **glycogenolysis**.

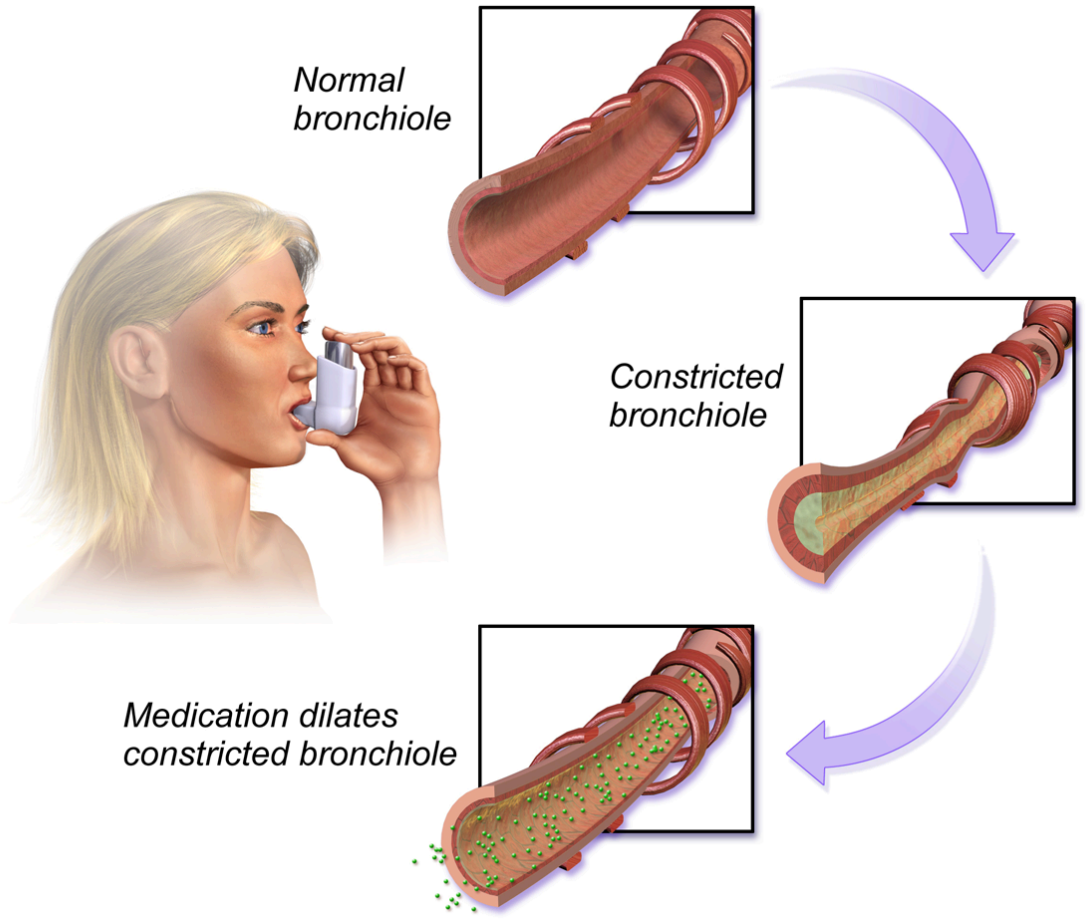

Figure 4.8 Effects of Medications Stimulating Beta 2 Receptors in the Lungs

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 the following:

- 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 clients with hypertension.

Alpha-2 antagonists: This classification is used in research but has limited clinical application.

There are two types of beta antagonists: **selective beta-blockers**, which inhibit Beta-1 receptors and affect the heart only, and **nonselective beta-blockers**, which 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 clients 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 clients with asthma or COPD.

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=151#h5p-15

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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. 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, which is 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 are as follows:

- 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 to release urine

Examples of indirect-acting muscarinic agonist medications include the following:

- Pyridostigmine: Used to reverse muscle weakness in clients with myasthenia gravis
- Physostigmine: Used to treat organophosphate insecticide poisoning
- Donepezil: Enhances memory in some clients 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: **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 4.9[15] for an illustration of the **"SLUDGE"** effects of anticholinergics.

These are examples of anticholinergic medications:

- 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

15. "'SLUDGE' effects of Anticholinergics" by Dominic Slausen at Chippewa Valley Technical College is licensed under CC BY 4.0

medications

- Scopolamine: Decreases GI motility and GI secretions; used for motion sickness and post-operative nausea and vomiting[16,17,18,19]

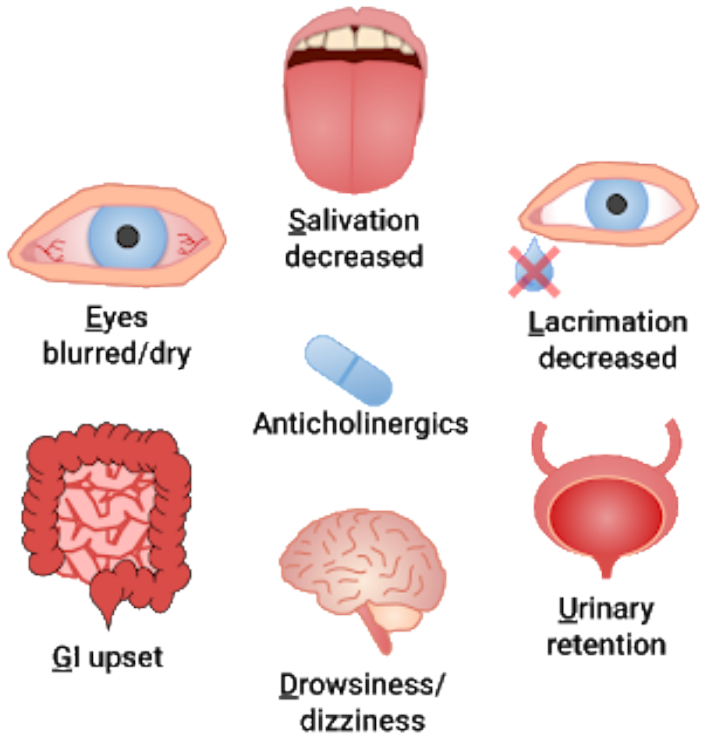

Figure 4.9 "SLUDGE" Effects of Anticholinergics

Please review Table 4.2b for additional examples of anticholinergic medications.

Table 4.2b Common Anticholinergic Medications

16. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. Elsevier.
17. Gersch, C., Heimgartner, N., Rebar, C., & Willis, L. (Eds.). (2017). *Pharmacology made incredibly easy*. Wolters Kluwer.
18. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process*. Elsevier.
19. This work is a derivative of Principles of Pharmacology by LibreTexts licensed under CC BY-NC-SA 4.0

Drug Class	Examples
Antihistamines	diphenhydramine, loratadine
Antipsychotics	chlorpromazine, haloperidol, quetiapine
Antidepressants	amitriptyline, doxepin, imipramine
Antiemetics	scopolamine, ondansetron, prochlorperazine
Antispasmodics	dicyclomine, hyoscyamine
Bladder antimuscarinics	oxybutynin, tolterodine
Bronchodilators	ipratropium, tiotropium
Gastrointestinal agents	atropine, hyoscyamine, glycopyrrolate
Muscle relaxants	cyclobenzaprine, orphenadrine

4.3 Applying the Nursing Process to ANS Medications

Assessment

Many classes of medications stimulate or inhibit specific ANS receptors to create desired effects. By understanding these common effects, it becomes easier for the nurse to recognize common side effects from a variety of medication classes resulting from the stimulation or inhibition of ANS neuroreceptors. Medications that stimulate ANS receptors often impact the heart, lungs, and blood vessels, so the nurse anticipates monitoring the client's blood pressure, heart rate, and lung sounds carefully for expected therapeutic effects and side effects. Medications classified as anticholinergics cause muscle relaxation and the nurse anticipates monitoring for the side effects of urinary retention, constipation, and dry mouth.

Planning

Common goals related to administering medications that affect the ANS include the following:

- Client will adhere to the drug regimen.
- Client's vital signs will be within the desired range.
- Client will be able to verbalize the action of the medication, as well as side effects, to report to the health care provider.

Implementation of Interventions

A nurse should be aware of parameters to administer or withhold medications affecting the autonomic nervous system. If the order parameters are unclear, the nurse should withhold the medication following safe administration guidelines and notify the provider. 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.

Report any marked vital signs changes or suspected adverse effects.

Implement fall precautions, when needed, based on anticipated side effects of ANS medications.

Evaluation

It is essential 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

Classes of medication, categorized according to neuroreceptor, are further discussed in more detail in the following sections. Table 4.4[1] contrasts agonist and antagonist medications for each ANS neuroreceptor.

Table 4.4 Comparison of Prototype Medications That Stimulate Versus Inhibit PNS and SNS Receptors

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Receptor	Stimulation (Agonist)	Inhibition (Antagonist)
Nicotine	Nicotine is a muscle relaxant with CNS effects. A 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	Pseudoephedrine and Phenylephrine cause vasoconstriction, decreased swelling of mucus membranes, and decreased secretions	Tamsulosin relaxes smooth muscle in bladder/prostate to improve urine flow and also decreases blood pressure due to vasodilation
Alpha-2	Clonidine decreases CNS outflow to treat ADHD and also reduces blood pressure and heart rate	Limited clinical use
Beta-1	Dobutamine increases heart rate, force of heart contraction, and speed of conduction between SA to AV nodes	**Selective B blocker:** Metoprolol works on Beta-1 receptors to decrease blood pressure and heart rate
Beta-2	Albuterol used for bronchodilation	**Nonselective B 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 increased heart rate and vasoconstriction for improved blood flow to essential organs Dopamine has dose-dependent effects that target arteries in the kidneys, heart, and brain	Not clinically applicable

See the supplementary YouTube videos in the boxes 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://wtcs.pressbooks.pub/pharmacology2e/?p=155#oembed-1

Parasympathetic Nervous System Drugs[3]

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
3. Forciea, B. (2018, February 2). *Parasympathetic nervous system drugs* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/ZSRk_NkbBPg

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=155#oembed-2

4.5 Nicotine Receptor Agonists

A nicotine patch is a nicotine receptor agonist.

Mechanism of Action: Nicotine binds to and activates nicotinic acetylcholine receptors, mimicking the effect of acetylcholine at these receptors.

Indications: Nicotine patches are used as an aid to smoking cessation and for the relief of nicotine withdrawal signs and symptoms as part of a comprehensive behavioral smoking cessation program.

Nursing Considerations: Nicotine is a hazardous drug; use safe handling and disposal precautions. 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. Wash hands after applying or removing the patch. Save pouch to use for patch disposal. 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 wear more than one patch at a time. The patch may also cause vivid dreams or sleep disturbances. If these side effects occur, clients should be counseled to remove the patch at bedtime and apply a new one in the morning. Clients should also be counseled to not concurrently use other nicotine products due to potential toxicity.

Side Effects/Adverse Effects: Discontinue use and call provider if an allergic reaction occurs, such as difficulty breathing or rash, or if symptoms of nicotine overdose occur, such as nausea, vomiting, dizziness, weakness, and rapid heartbeat. Individuals may also experience vivid dreams or sleep disturbances.

Health Teaching & Health Promotion: Emphasize that 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. If using a nicotine patch, clients should be aware that skin sensitivity at the site of patch placement typically resolves within one hour.[1]

Alert: Advise the client to keep all nicotine products, including used patches, out of the reach of children and pets.

Now let's take a closer look at the medication grid on nicotine patch in Table 4.5.[2] Medication grids 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. Prototype/generic medication listed in the medication grid is also linked directly to a free resource from the U.S. National Library of Medicine called DailyMed. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Table 4.5 Nicotine Patch Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Nicotinic Agonist	nicotine patch	Hazardous drug; use safe handling and disposal precautions Check for allergy to adhesives See administration guidelines in packaging Use cautiously in clients with recent myocardial infarction, serious arrhythmias, coronary artery disease, severe or worsening angina, hypertension, vasospastic diseases, or peripheral vascular disease Clients taking monoamine oxidase inhibitors (MAOIs) require lower dosage Can cause fetal harm	Used for nicotine addiction by slowly reducing dose and avoiding withdrawal effects	Discontinue use and call provider if: -Allergic reaction such as difficulty breathing or rash -Irregular heartbeat or palpitations -Symptoms of nicotine overdose such as nausea, vomiting, dizziness, weakness, and rapid heartbeat

4.6 Muscarinic Receptor Agonists

Pilocarpine is a muscarinic receptor agonist.

Mechanism of Action: Pilocarpine causes the ciliary muscle to contract, allowing for the drainage of aqueous humor from the anterior chamber of the eye, thus reducing intraocular pressure related to glaucoma.

Indications: Pilocarpine is used to treat glaucoma.

Nursing Considerations: Apply light finger pressure on lacrimal sac for 2 minutes after instilling to minimize systemic absorption. Remove contact lens before administration.

Side Effects/Adverse Effects: Adverse effects of muscarinic (cholinergic) agonists can be memorized using the mnemonic "DUMBBELSS" reflecting **D**iarrhea, **U**rination, **M**iosis (constriction of the pupil of the eye), **B**ronchospasm, **B**radycardia, **E**xcitation of the skeletal muscle and CNS, **L**acrimation, **S**weating, and **S**alivation.

Health Teaching & Health Promotion: Advise the client to use caution with night driving. Additionally, use of this medication can cause hypotension.[1]

Now let's take a closer look at the medication grid on pilocarpine in Table 4.6.[2]

Table 4.6 Pilocarpine Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Muscarinic Agonist	pilocarpine	Apply light finger pressure on lacrimal sac for 2 minutes after instilling to minimize systemic absorption. Remove contact lens before administration	Controls intraocular pressure in glaucoma	Individuals should use caution with night driving Individuals may experience light-headedness, bronchospasm, nausea, vomiting, stomach cramps, diarrhea, sweating, lacrimation, and salivation

4.7 Muscarinic Antagonists

Atropine is a muscarinic antagonist.

Mechanism of Action: 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). Large doses decrease motility of the gastrointestinal and urinary tracts, and very large doses will inhibit gastric acid secretion.

Indications: Varying dosages are used preoperatively to diminish secretions, to stimulate the heart rate in conditions causing bradycardia, or to treat muscarinic symptoms of insecticide (organophosphorus or carbamate) poisoning or mushroom poisoning.

Nursing Considerations: As with all anticholinergics, use with caution with the elderly because elderly clients may react with agitation or drowsiness. Heatstroke may occur in the presence of high temperatures. Immediately report symptoms of overdose: urine retention, abnormal heartbeat, dizziness, passing out, difficulty breathing, weakness, or tremors. Physostigmine has been used to reverse anticholinergic effects.

Side Effects/Adverse Effects: Side effects include dry mouth, blurred vision, increased heart rate, flushed skin, agitation, urinary retention, constipation, and delirium. A mnemonic to remember the side effects includes “red as a beet, dry as a bone, blind as a bat, and mad as a hatter.”

Health Teaching & Health Promotion: Advise clients that use of these medications may cause dizziness and drowsiness. Additionally, use of medications may cause dry mouth, and frequent oral hygiene is encouraged. The use of atropine may cause urinary retention in males with benign prostatic hypertrophy (BPH).[1]

Now let’s take a closer look at the medication grid on atropine in Table 4.7.[2]

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Table 4.7 Atropine Medication Grid

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Muscarinic Antagonist	atropine	Use with caution in the elderly Contraindicated in high environmental temperatures because can cause heatstroke Physostigmine reverses anticholinergic effects	Dose dependent: Small dose inhibits secretions; moderate dose increases heart rate; large dose decreases gastrointestinal motility	Constipation, dizziness, drowsiness, dry mouth. flushed skin, blurred vision Immediately report symptoms of overdose: Urine retention, abnormal heartbeat, dizziness, passing out, difficulty breathing, weakness, or tremors

4.8 Alpha-1 Agonists

Pseudoephedrine and phenylephrine are Alpha-1 agonists.

Mechanism of Action: 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.

Indications: These drugs are commonly used for symptomatic relief in upper respiratory infections.

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. Both should be used cautiously in clients with glaucoma, hypertension, or an enlarged prostate gland and are contraindicated in clients taking monoamine oxidase inhibitors (MAOIs), an older class of medication used to treat depression. Monitor for elevated blood pressure, urinary retention, nervousness, or difficulty sleeping. Do not administer within two hours of bedtime.

Side Effects/Adverse Effects: Alpha-1 agonists can cause headache, bradycardia, excitability, and restlessness. Rebound congestion may occur with nasal sprays.

Health Teaching & Health Promotion: Clients should be instructed to take medication as prescribed and be careful not to double doses. If they experience nervousness, breathing difficulties, or heart rate changes, they should notify their health care provider.[1]

Now let's take a closer look at the medication grid on phenylephrine and pseudoephedrine in Table 4.8.[2]

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Table 4.8 Phenylephrine and Pseudoephedrine Medication Grid

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Alpha-1 Agonist	phenylephrine pseudoephedrine	Contraindicated with MAOIs Use cautiously in clients with glaucoma, hypertension, or enlarged prostate Do not administer within 2 hours of bedtime	Decreased swelling of mucous membranes and decreased secretions	Headache, bradycardia, excitability, and restlessness Rebound congestion may occur with nasal sprays

4.9 Alpha-1 Antagonists

Tamsulosin is an Alpha-1 antagonist.

Mechanism of Action: Tamsulosin selectively blocks alpha-receptors in the prostate, 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).

Indications: Tamsulosin is used to treat BPH.

Nursing Considerations: Avoid using with other alpha-blockers. Tamsulosin is contraindicated with strong CYP3A4 inhibitors such as ketoconazole. Assess and monitor blood pressure, especially after first dose because tamsulosin may cause orthostatic hypotension.

Side Effects/Adverse Effects: Alpha-1 antagonists may result in hypotension, weakness, and dizziness.

Health Teaching & Health Promotion: Advise clients to change positions slowly because the drug may cause orthostatic blood pressure changes. Additionally, the client should take the medication at the same time each day. The client should follow up with their health care provider to assess the effectiveness of the medication.[1]

Now let's take a closer look at the medication grid on tamsulosin in Table 4.9.[2]

Table 4.9 Tamsulosin Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Alpha-1 Antagonist	tamsulosin	Avoid using with other alpha-blockers Assess and monitor orthostatic blood pressure, especially after first dose	Relaxes smooth muscle in bladder/ prostate to improve urine flow	Hypotension, especially after first dose. Advise client to change positions slowly

4.10 Alpha-2 Agonists

Clonidine is an Alpha-2 agonist.

Mechanism of Action: Clonidine reduces sympathetic outflow from the central nervous system and decreases peripheral resistance and renal vascular resistance.

Indications: Clonidine is used to treat hypertension (HTN) and attention deficit hyperactivity disorder (ADHD).

Nursing Considerations: Monitor blood pressure and pulse rate. Can cause hypotension, bradycardia, and sedation. Rebound hypertension may occur if stopped abruptly.

Side Effects/Adverse Effects: Side effects of Alpha-2 agonist medications may include hypotension, bradycardia, and rebound hypertension if the medication is stopped abruptly. The medication may also cause drowsiness.

Health Teaching & Health Promotion: Clients should be taught the importance of adhering to the same dosing schedule each day and to not stop taking the medication abruptly or rebound hypertension may occur. Clients may experience orthostatic blood pressure changes and should be cautioned against the use of alcohol while taking this medication. Additionally, clients may experience increased susceptibility to blood pressure changes when exercising and exposed to hot environments. If the client experiences mental depression as a side effect of the medication, a different medication therapy may be needed.[1]

Now let's take a closer look at the medication grid on clonidine in Table 4.10.[2]

Table 4.10 Clonidine Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Alpha-2 Agonist	clonidine	Monitor blood pressure and pulse rate	Treat hypertension or ADHD	Hypotension Bradycardia Sedation Rebound hypertension if stopped abruptly

Alpha-2 Antagonists

Alpha-2 antagonists are used in research with limited clinical application.[3]

3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

4.11 Beta-1 Agonists

Dobutamine is a Beta-1 agonist.

Mechanism of Action: Dobutamine stimulates Beta-1 receptors to increase heart rate, force of contraction, and conduction velocity.

Indications: Dobutamine is used to treat cardiogenic shock and severe heart failure to increase contractility and cardiac output.

Nursing Considerations: In IV administration, dilute concentration before administering. Continuously monitor electrocardiogram (ECG), blood pressure, cardiac output, and urine output during therapy.

Side Effects/Adverse Effects: Adverse effects of Beta-1 agonists include marked increase in heart rate and blood pressure. Individuals should promptly report difficulty breathing, angina, palpitations, or dizziness.

Health Teaching & Health Promotion: 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.[1]

Now let's take a closer look at the dobutamine medication grid in Table 4.11.[2]

Table 4.11 Dobutamine Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Beta-1 Agonist	dobutamine	Continuously monitor ECG, blood pressure, cardiac output, and urine output during therapy	Increases heart rate, force of heart contraction, cardiac output, and speed of conduction between SA to AV nodes	Marked increase in heart rate and blood pressure Report all adverse reactions promptly, especially labored breathing, angina, palpitations, and dizziness

4.12 Beta-1 Antagonists

Metoprolol is a selective Beta-1 antagonist.

Mechanism of Action: Metoprolol 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.

Indications: 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.

Nursing Considerations: Don't crush extended-release (ER) formulations. Assess the client's apical pulse rate and blood pressure before administering the drug. Withhold the drug and call the provider immediately if the heart rate is slower than 60 beats/minute, unless other parameters are provided. In diabetic clients, monitor glucose level closely because the drug masks common signs and symptoms of hypoglycemia.

Side Effects/Adverse Effects: Beta-1 antagonists may result in decreased blood pressure or heart rate. Significant adverse effects include hypotension, bradycardia, and worsening heart failure. Other potential side effects include fatigue, dizziness, depression, insomnia, nightmares, GI upset, erectile dysfunction, dyspnea, and wheezing.

Boxed Warning: When stopping therapy, the dosage should be tapered over 1 to 2 weeks because abrupt discontinuation may cause chest pain or myocardial infarction (MI).

Health Teaching & Health Promotion: Clients should be instructed to take the medication as prescribed. They should be advised that abrupt cessation of medication therapy may result in life-threatening cardiac arrhythmias. Clients should also be taught how to self-check pulse and blood pressure to assess the effectiveness of medication therapy. Additionally, they should be cautioned against sudden changes in position due to orthostatic blood

pressure changes. Clients may experience increased sensitivity to cold and should be cautioned to avoid caffeinated substances.[1]

Now let's take a closer look at the medication grid on metoprolol in Table 4.12.[2]

Table 4.12 Metoprolol Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Beta-1 Antagonist	Selective Beta-1 blocker: ▸ metoprolol	Do not crush extended-release (ER) formulations Always assess apical HR, and if less than 60, do not administer and call the provider unless other parameters are provided Monitor blood sugar in diabetic clients because drug can mask symptoms of hypoglycemia	Decreases blood pressure or controls rapid heart rate	Decreased blood pressure or heart rate Most serious: -Hypotension -Bradycardia -Worsening heart failure (HF) Other: -CNS: Fatigue, dizziness, depression, insomnia, or nightmares -GI upset -GU: Erectile dysfunction -Respiratory: Dyspnea and wheezing

4.13 Beta-2 Agonists

Albuterol is a Beta-2 agonist.

Mechanism of Action: Albuterol is a selective Beta-2 agonist primarily used to cause bronchodilation in the lungs. However, Beta-2 receptors in the heart can also be stimulated, causing cardiovascular side effects.

Indications: Albuterol is commonly used to treat asthma and chronic obstructive pulmonary disease (COPD).

Nursing Considerations: Monitor respiratory rate, oxygen saturation, and lung sounds before and after administration. If more than one inhalation is ordered, wait at least two minutes between inhalations. Use a spacer device to improve drug delivery, if appropriate.

Side Effects/Adverse Effects: Albuterol can cause hypersensitivity or paradoxical bronchospasm. It can also produce a clinically significant cardiovascular effect in some clients by causing increased heart rate and blood pressure, which may require the drug to be discontinued.

Health Teaching & Health Promotion: Clients should remain compliant with the medication dosing regimen. Individuals should contact their health care provider if they experience ongoing shortness of breath unrelieved with medication therapy. If using an inhaler, the client should be sure to prime the inhaler prior to administering the first dose of medication. The medication can cause an unusual taste in the mouth, so clients should rinse their mouth with water after each use.[1]

Now let's take a closer look at the medication grid on albuterol in Table 4.13.[2]

Table 4.13 Albuterol Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Beta-2 Agonist	albuterol	If more than one inhalation is ordered, wait at least two minutes between inhalations Use spacer device to improve drug delivery, if appropriate	Bronchodilation in asthma or COPD	Hypersensitivity Can cause paradoxical bronchospasm Report significantly increased heart rate and blood pressure, which may require the drug to be discontinued

4.14 Beta-2 Antagonists

Propranolol is a nonselective Beta-2 antagonist.

Mechanism of Action: Propranolol is a nonselective beta-blocker because of its inhibition of both Beta-1 and Beta-2 receptors.

Indications: Propranolol is used to treat high blood pressure, angina, various heart dysrhythmias (to lower the heart rate), essential tremors, and in migraine prevention. It is prescribed after a client experiences a myocardial infarction to reduce mortality by decreasing heart workload. It is also used for the management of panic associated with panic disorder and post-traumatic stress disorder (PTSD).

Nursing Considerations: Nonselective beta-blockers must be used cautiously with clients who have coexisting asthma or chronic obstructive pulmonary disease (COPD) because of the effects on Beta-2 receptors that could potentially cause bronchoconstriction. It can also mask symptoms of hypoglycemia in diabetics. Use with caution in clients with impaired hepatic or renal function. Give immediate-release (IR) formulations on an empty stomach. Do not crush extended-release (ER) formulations. Propranolol ER is not considered a simple milligram-for-milligram substitute for conventional propranolol. Check blood pressure and apical pulse before giving drug; withhold and notify provider 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. During IV administration, monitor blood pressure, ECG, and heart rate according to agency policy.

Side Effects/Adverse Effects: The most serious adverse effects include bronchoconstriction, hypotension, bradycardia, and signs of worsening heart failure. Other adverse effects are similar to selective beta-blockers like metoprolol.

Boxed 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.

Health Teaching & Health Promotion: Clients should be instructed to follow

the medication dosing regimen. Stopping medication therapy abruptly may cause life-threatening arrhythmias. Clients should be instructed on how to self-assess pulse and blood pressure to evaluate medication effectiveness. The medication may cause increased susceptibility to orthostatic blood pressure changes and increased sensitivity to cold.[1]

Now let's take a closer look at the medication grid on propranolol in Table 4.14.[2]

Table 4.14 Propranolol Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

Beta-2 Antagonist	Nonselective Beta-2 blocker: ▸ propranolol	Contraindicated in clients with asthma, COPD, or bradycardia Use cautiously in clients who have diabetes mellitus because drug masks some symptoms of hypoglycemia Use with caution in clients with impaired hepatic or renal function Give immediate-release formulations on an empty stomach Do not crush ER formulations Check BP and apical pulse before giving drug; withhold and notify provider if apical pulse is less than 60 or systolic blood pressure is less than 100 unless other parameters are provided During IV	Decrease blood pressure and heart rate Prevent migraines Manage tremors	Most serious: -Bronchoconstriction -Hypotension -Bradycardia -Worsening heart failure Other adverse effects similar to metoprolol

		administration, monitor blood pressure, ECG, and heart rate according to agency policy Boxed Warning: Abrupt withdrawal of drug may cause exacerbation of angina or myocardial infarction. To discontinue drug, gradually reduce dosage over 1 to 2 weeks		

4.15 Alpha- and Beta-Receptor Agonists (Catecholamines)

Epinephrine and Norepinephrine

Epinephrine and norepinephrine (NE) are adrenergics (also referred to as catecholamines) that stimulate the beta- and alpha-receptors on the target cell.

Mechanism of Action: Epinephrine acts on both alpha- and beta-adrenergic receptors and is used in several routes, including intravenously (IV), subcutaneously, intramuscularly, and inhalation. Epinephrine decreases vasodilation and increases vascular permeability through its alpha-adrenergic receptor action, which can lead to loss of intravascular fluid volume and hypotension. Through its action on beta-adrenergic receptors, epinephrine causes bronchial smooth muscle relaxation and helps alleviate bronchospasm, wheezing, and dyspnea that may occur during anaphylaxis.

Indications: Epinephrine is used for severe allergic reactions, acute bronchospasm during asthma attacks, cardiac resuscitation, hypotension in severe shock, or for local injection to control superficial bleeding.

Norepinephrine is used as a peripheral vasoconstrictor (due to alpha-adrenergic action) and as an inotropic stimulator of the heart and dilator of coronary arteries (due to beta-adrenergic action) in clients with critically low blood pressure.

Nursing Considerations: Epinephrine is contraindicated for use in fingers, toes, ears, nose, or genitalia when used with local anesthetic due to the vasoconstrictive action. It is also contraindicated in clients with narrow angle glaucoma. Administer with caution to the elderly and those with preexisting cardiovascular disease. Discard IV solution if discolored. 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. If extravasation occurs, immediately stop IV administration and follow agency policy. Phentolamine, an alpha-adrenergic antagonist, is the reversal agent used to reverse local vasoconstrictive effects if digital ischemia occurs.

Side Effects/Adverse Effects: Common side effects include hypertension and tachycardia.

Health Teaching & Health Promotion: Epinephrine formulated in a pen for injection is known as an EpiPen. An EpiPen is used for severe allergic reactions after exposure to an allergen such as a bee sting. Check expiration date, store at room temperature, and protect from light. Effects fade after 15-20 minutes, so seek medical care immediately.[1]

Now let's take a closer look at the medication grid on epinephrine and norepinephrine in Table 4.15a.[2]

Table 4.15a Epinephrine and Norepinephrine Medication Grid

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Catecholamine	epinephrine norepinephrine	Contraindicated for use in fingers, toes, ears, nose, or genitalia when used with local anesthetic Monitor vitals (blood pressure, heart rate, respiratory rate) and cardiovascular and respiratory systems closely when administering IV If administering IV, monitor IV site for extravasation Discard IV solution if discolored	Reversal of severe allergic reaction, bronchodilation, increased blood pressure, cardiac resuscitation, or control of superficial bleeding	Hypertension Tachycardia

Dopamine

Dopamine is another type of catecholamine specifically used to improve perfusion of organs, improve cardiac output, and increase blood pressure. Dopamine has dose-dependent effects on targeted arteries in the kidneys, heart, and brain.

Mechanism of Action: In low doses, dopamine mainly stimulates dopamine receptors and dilates the renal vasculature. Moderate doses of dopamine stimulate beta-receptors for a positive inotropic effect. Higher doses also

stimulate alpha-receptors, constricting blood vessels and increasing blood pressure.

Indications: Dopamine is used to treat shock, improve perfusion to vital organs, increase cardiac output, and correct hypotension.

Nursing Considerations: During infusion, frequently monitor blood pressure, cardiac output, urine output, and color and temperature of limbs. Dopamine can worsen cardiac ischemia and worsen chest pain for clients experiencing unstable angina or a myocardial infarction due to increased cardiac demand for oxygen. If urine flow decreases without hypotension, notify provider because dosage may need to be reduced. High doses of dopamine cause vasoconstriction and can cause adverse effects if extravasation occurs. Concurrent alpha- or beta-blockers can antagonize dopamine.

Side Effects/Adverse Effects: Common side effects include hypotension with low doses (due to vasodilatory effects) and hypertension in higher doses (due to vasoconstriction). Other side effects include tachycardia, palpitations, and dyspnea. Adverse effects include decreased blood flow to the extremities and decreased urine output.

Health Teaching & Health Promotion: Clients should contact their health care provider immediately if experiencing unusual sweating, dizziness, heart palpitations, or chest pain.

Now let's take a closer look at the medication grid on dopamine in Table 4.15b.[3]

Table 4.15b Dopamine Medication Grid

3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Catecholamine	dopamine	During infusion, monitor ECG, blood pressure, cardiac output, chest pain, pulse rate, urine output, and color and temperature of limbs Check urine output often Monitor for extravasation. High doses of dopamine cause vasoconstriction and can cause adverse effects if extravasation occurs	Increased blood flow to kidneys causing increased urine output in low doses Increased cardiac output and elevated blood pressure in moderate to high doses	Hypotension (low doses) or hypertension (high doses) Tachycardia Palpitations Chest pain Dyspnea Decreased blood flow to extremities If urine flow decreases without hypotension, notify provider because dosage may need to be reduced

4.16 Acetylcholinesterase Inhibitors

Donepezil is an example of a cholinergic and acetylcholinesterase inhibitor. Acetylcholinesterase inhibitors are a class of medications that inhibit the activity of the enzyme acetylcholinesterase. This enzyme is responsible for breaking down the neurotransmitter acetylcholine. When acetylcholinesterase is inhibited, the concentration of acetylcholine at the synaptic cleft between nerve cells increases, improving nerve transmissions between cells.

Mechanism of Action: Anticholinesterase breaks down the neurotransmitter acetylcholine. Acetylcholinesterase inhibitors block this action, increasing the availability of acetylcholine.

Indications: Donepezil is an acetylcholinesterase inhibitor used for the treatment of cognitive symptoms associated with Alzheimer's disease.

Nursing Considerations: When administering donepezil, nurses should be sure to administer with food in order to minimize GI upset. Donepezil should be taken in the evening, just prior to retiring. Donepezil may increase liver enzyme levels.

Side Effects/Adverse Effects: Common side effects of donepezil include GI upset, headaches, dizziness, insomnia, fatigue, muscle cramps, reduced quality of sleep, and nightmares.

Health Teaching & Health Promotion: Depending on the severity of cognitive impairment, clients may require assistance to ensure the medication is taken every evening. If clients miss a dose, the dose should be taken as soon as possible unless it is close to the next dose time. If it is close to the next dose period, the individual should skip the additional dose. Clients should be instructed to take the medication with food to minimize GI upset.

Now let's take a closer look at the medication grid on donepezil in Table 4.16.[1]

Table 4.16 Donepezil Grid

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Acetylcholinesterase Inhibitors	donepezil	Administer with food to minimize GI upset Administer in the evening just prior to retiring.	Improved cognitive function in individuals with mild to moderate Alzheimer's disease. Slowed progression of cognitive decline	GI upset, headaches, dizziness, insomnia, fatigue, muscle cramps, and abnormal dreams. May increase liver enzyme levels

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

4.17 Learning Activities

Light Bulb Moment

Test your knowledge and application.

Practice applying your knowledge regarding ANS neuroreceptors to the following client scenarios where a nurse must use clinical judgment for a solution:

1. A client begins a nicotine patch in an attempt to stop smoking. The client reports feelings of nausea, weakness, and a rapid heartbeat.

a) What is the likely cause of these symptoms?

b) 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 as if 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 the 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 Light Bulb Moment can be found in the "Answer Key" section at the end of the book.

Case Study 1

Mr. Lao is a 42-year-old male who was referred to the outpatient clinic for treatment of hypertension and attention deficit hyperactivity disorder (ADHD). He has a history of uncontrolled hypertension despite lifestyle modifications and multiple medication trials and reports symptoms of inattention, impulsivity, and hyperactivity consistent with ADHD.

Assessment:

- Vital Signs: Blood Pressure: 150/100 mmHg; Heart Rate: 90 bpm; Respiratory Rate: 20 breaths/minute
- Physical Examination: Well-nourished and well-developed male in no acute distress. Lung exam reveals clear breath sounds.
- Patient Report: Mr. Lao reports difficulty with attention and organization and experiences high levels of stress and anxiety, particularly in high-pressure situations at work.
- Laboratory Results: Blood Urea Nitrogen (BUN): 14 mg/dL; Creatinine: 1.2 mg/dL

1. What medication would you expect to be prescribed to treat Mr. Lao's hypertension and ADHD?
2. Prior to administering this medication, what assessments should be performed?
3. It is early August and Mr. Lao wants to begin an exercise regimen that includes running outdoors. What health teaching should be provided to Mr. Lao?

Note: Answers to the Case Study can be found in the "Answer Key" section at the end of the book.

Case Study 2

Mrs. Lenni Anton is a 57-year-old female who was referred to the outpatient clinic for treatment of essential tremor and hypertension. She has a history of uncontrolled hypertension and reports persistent tremors in her hands that interfere with her daily activities.

Assessment:

- Vital Signs: Blood Pressure: 145/90 mmHg; Heart Rate: 80 bpm; Respiratory Rate: 16 breaths/minute
- Physical Examination: Well-nourished and well-developed female in no acute distress. Lung exam reveals clear breath sounds.
- Patient Report: Mrs. Anton reports difficulty with fine motor tasks due to her tremors and experiences high levels of stress and anxiety, particularly in social situations.
- Laboratory Results: Blood Urea Nitrogen (BUN): 18 mg/dL; Creatinine: 0.9 mg/dL

1. What medication do you expect to be prescribed to Mrs. Anton?
2. Mrs. Anton is prescribed an extended-release form of the medication. What special instruction should be given related to this form of the medication?

3. Mrs. Anton monitors her blood pressure and heart rate at home, noting a gradual decline over the past two weeks. This morning she notes that her blood pressure is 89/56 mmHg and her heart rate is 52 bpm. What action should Mrs. Anton take next?

Note: Answers to the Case Study can be found in the "Answer Key" section 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://wtcs.pressbooks.pub/pharmacology2e/?p=179#h5p-16

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★ Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=179#h5p-41

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- Test your knowledge with this NCLEX Next Generation-style question: ANS Receptors.[1]



- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Beta-1 Antagonist.[2]



- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Alpha – 1 Antagonist.[3]



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3. "Alpha-1 Antagonist" by Open RN is licensed under CC BY 4.0

IV. Glossary

Acetylcholine (ACh): Binds to both nicotinic receptors and muscarinic receptors in the PNS.

Adrenergic: Postganglionic neuron where neurotransmitters norepinephrine and epinephrine are released. Includes alpha (α)-receptors and beta (β)-receptors.

Adrenergic agonist: Mimics the effects of the body's natural SNS stimulation on alpha (α)- and beta (β)-receptors. Also called sympathomimetics.

Adrenergic antagonist: Blocks the effects of the SNS receptors.

Anticholinergics: Inhibit acetylcholine (ACh), which allows the SNS to dominate. Also called parasympatholytics or muscarinic antagonists. Overall use is to relax smooth muscle.

Autonomic nervous system: Controls cardiac and smooth muscle, as well as glandular tissue; associated with involuntary responses.

Catecholamines: Include norepinephrine, epinephrine, and dopamine. Stimulate the adrenergic receptors.

Central nervous system (CNS): Anatomical division of the nervous system located within the cranial and vertebral cavities, namely the brain and spinal cord.

Cholinergic: Postganglionic neuron where acetylcholine (ACh) is released that stimulates nicotinic receptors and muscarinic receptors. Also relating to drugs that inhibit, enhance, or mimic the action of ACh.

Chronotropic: Drugs may change the heart rate and rhythm by affecting the electrical conduction system of the heart and the nerves that influence it, such as by changing the rhythm (increasing) produced by the sinoatrial node. Positive chronotropes increase heart rate; negative chronotropes decrease heart rate.

Dromotropic: Stimulation increases speed of conduction between SA and AV node.

Fight-or-flight response: The response when the SNS is stimulated, causing

the main effects of increased heart rate, increased blood pressure, and bronchodilation.

Glycogenolysis: The breakdown of glycogen into glucose, causing elevated blood glucose.

Homeostasis (in ANS): 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.

Hyperglycemia: Elevated blood glucose.

Inotropic: Stimulation causes increased force of contraction.

Involuntary responses: Responses that the brain controls without the need for conscious thought.

Motor neurons: Consist of the somatic nervous system that stimulates voluntary movement of muscles and the autonomic nervous system that controls involuntary responses.

Muscarinic agonists: Also called parasympathomimetics. Primarily cause smooth muscle contraction, resulting in decreased HR, bronchoconstriction, increased gastrointestinal/genitourinary tone, and pupil constriction.

Neurons: Cells that carry electrical impulses to the synapse of a target organ.

Nonselective beta-blockers: Medications that block both Beta-1 and Beta-2 receptors, thus affecting both the heart and lungs.

Parasympathetic nervous system (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.

Parasympatholytics: Inhibit acetylcholine (ACh), which allows the SNS to dominate. Also called anticholinergics or muscarinic antagonists.

Parasympathomimetics: Also called muscarinic agonists. Primarily cause smooth muscle contraction, resulting in decreased HR, bronchoconstriction, increased GI/GU tone, and pupil constriction.

Peripheral nervous system (PNS): An anatomical division of the nervous

system that is largely outside the cranial and vertebral cavities, namely all parts except the brain and spinal cord.

Postganglionic neurons: Differ for the SNS and PNS branches. Postganglionic neurons of the autonomic system are classified as either cholinergic, meaning that acetylcholine (ACh) is released, or adrenergic, meaning that norepinephrine is released.

Preganglionic neurons: Release acetylcholine (ACh).

Selective beta-blocker: Medications that mostly inhibit B1-receptors.

Sensory neurons: Sense the environment and conduct signals to the brain that become a conscious perception of that stimulus.

"SLUDGE": Mnemonic for the effects of anticholinergics: **S**alivation decreased, **L**acrimation decreased, **U**rinary retention, **D**rowsiness/dizziness, **G**I upset, **E**yes (blurred vision/dry eyes).

Somatic nervous system: Causes contraction of skeletal muscles; associated with voluntary responses.

Sympathetic nervous system (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.

Sympathomimetics: Mimic the effects of the body's natural SNS stimulation of adrenergic receptors. Also called adrenergic agonists.

Synapse: The connection between the neuron and its target cell.

PART V

RESPIRATORY SYSTEM

5.1 Respiratory Introduction

Learning Objectives

- Identify the classifications and actions of respiratory system drugs
- Give examples of when, how, and to whom respiratory system drugs may be administered
- Identify the side effects and special considerations associated with respiratory system drugs
- Include considerations and implications of using respiratory system drugs across the life span
- Include evidence-based concepts when using the nursing process related to medications that affect the respiratory system
- Identify and interpret related laboratory tests
- Identify nursing responsibilities associated with health teaching and health promotion

Every year millions of Americans visit their health care provider for respiratory diseases such as allergies, asthma, bronchitis, common cold, chronic obstructive pulmonary disease (COPD), and pneumonia.

Currently, more than 25 million people in the United States have asthma. Approximately 14.8 million adults have been diagnosed with COPD, and approximately 12 million people have not yet been diagnosed. The burden of respiratory diseases affects individuals and their families, schools, workplaces, neighborhoods, cities, and states. Because of the cost to the health care

system, the burden of respiratory diseases also falls on society; it is paid for with tax dollars, higher health insurance rates, and lost productivity. Annual health care expenditures for asthma alone are estimated at $20.7 billion.[1]

Before we learn about medications that are used to treat respiratory conditions in our clients, let's review the respiratory system.

1. This work is a derivative of Respiratory Diseases by Office of Disease Prevention and Health Promotion in the Public Domain.

5.2 Basic Concepts of the Respiratory System

Review of the Anatomy and Physiology of the Respiratory System

The purpose of the respiratory system is to perform gas exchange. Pulmonary ventilation provides air to 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.

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 nonvital functions, such as sensing odors, speech production, and for straining, such as during childbirth or coughing.[1]

See Figure 5.1[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

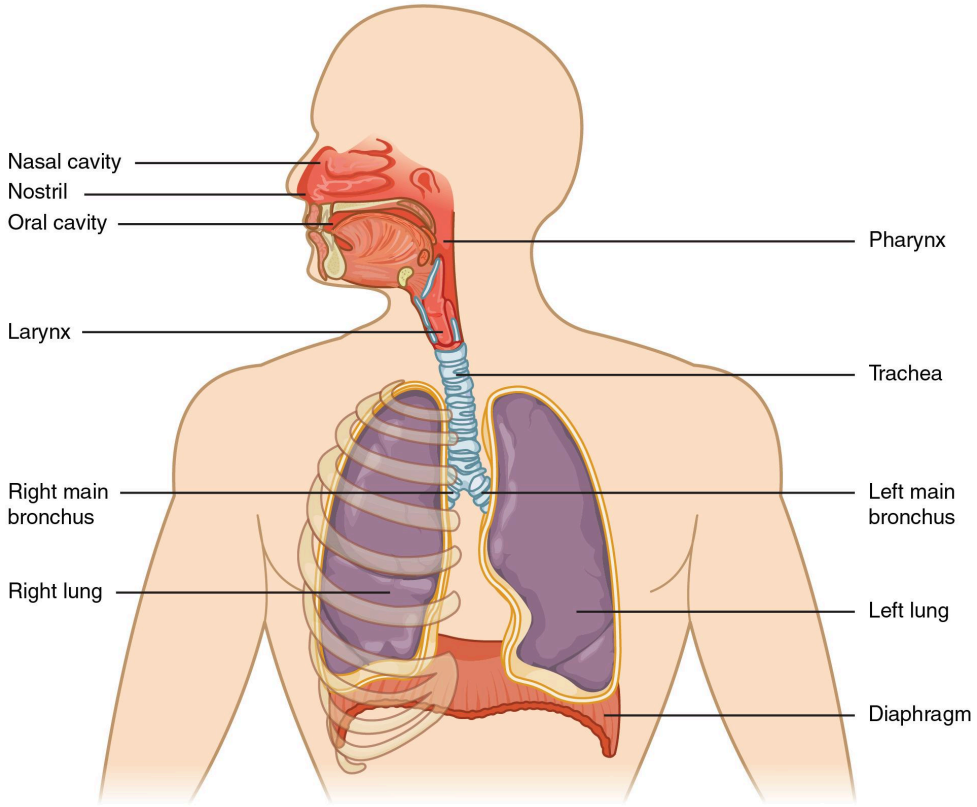

Figure 5.1 Major Respiratory Structures

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 alveoli, where gas exchange occurs. 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 bronchial 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 5.2[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

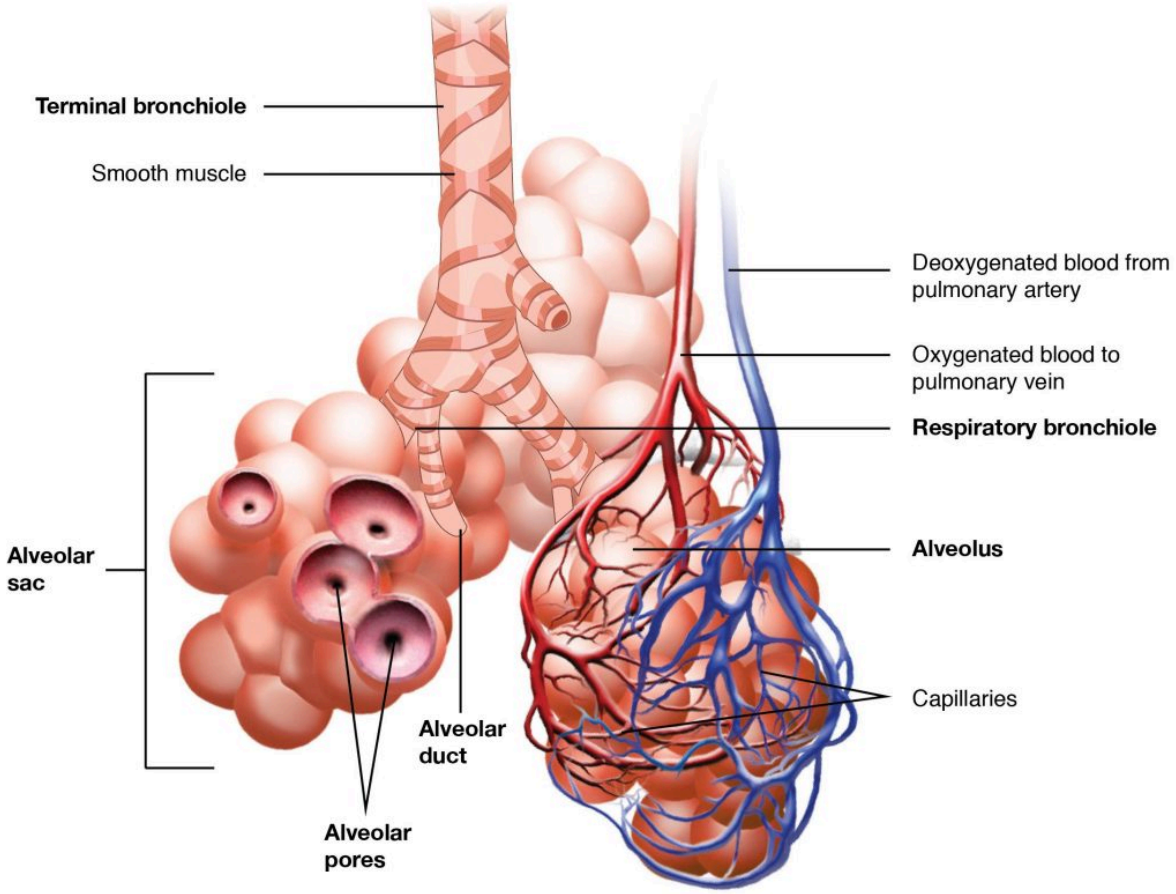

Figure 5.2 The Respiratory Zone

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, grapelike 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 5.3[4] for an illustration of the structures of the respiratory zone.

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

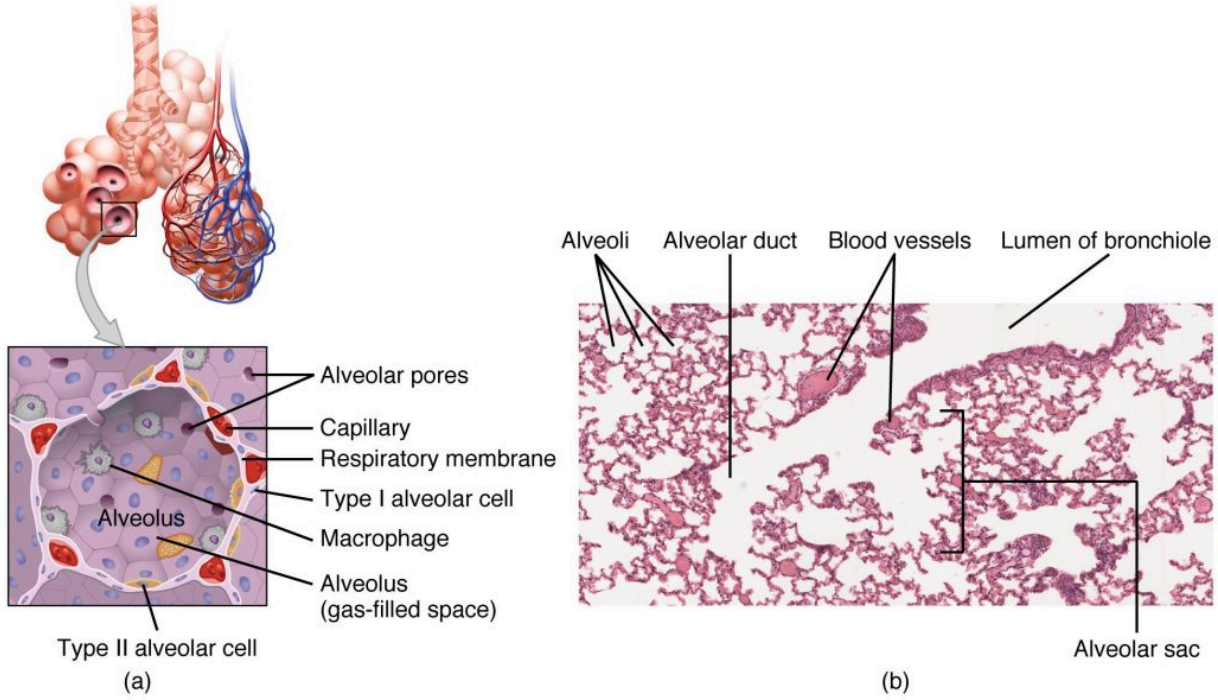

Figure 5.3 Structures of the Respiratory Zone

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 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 5.4[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

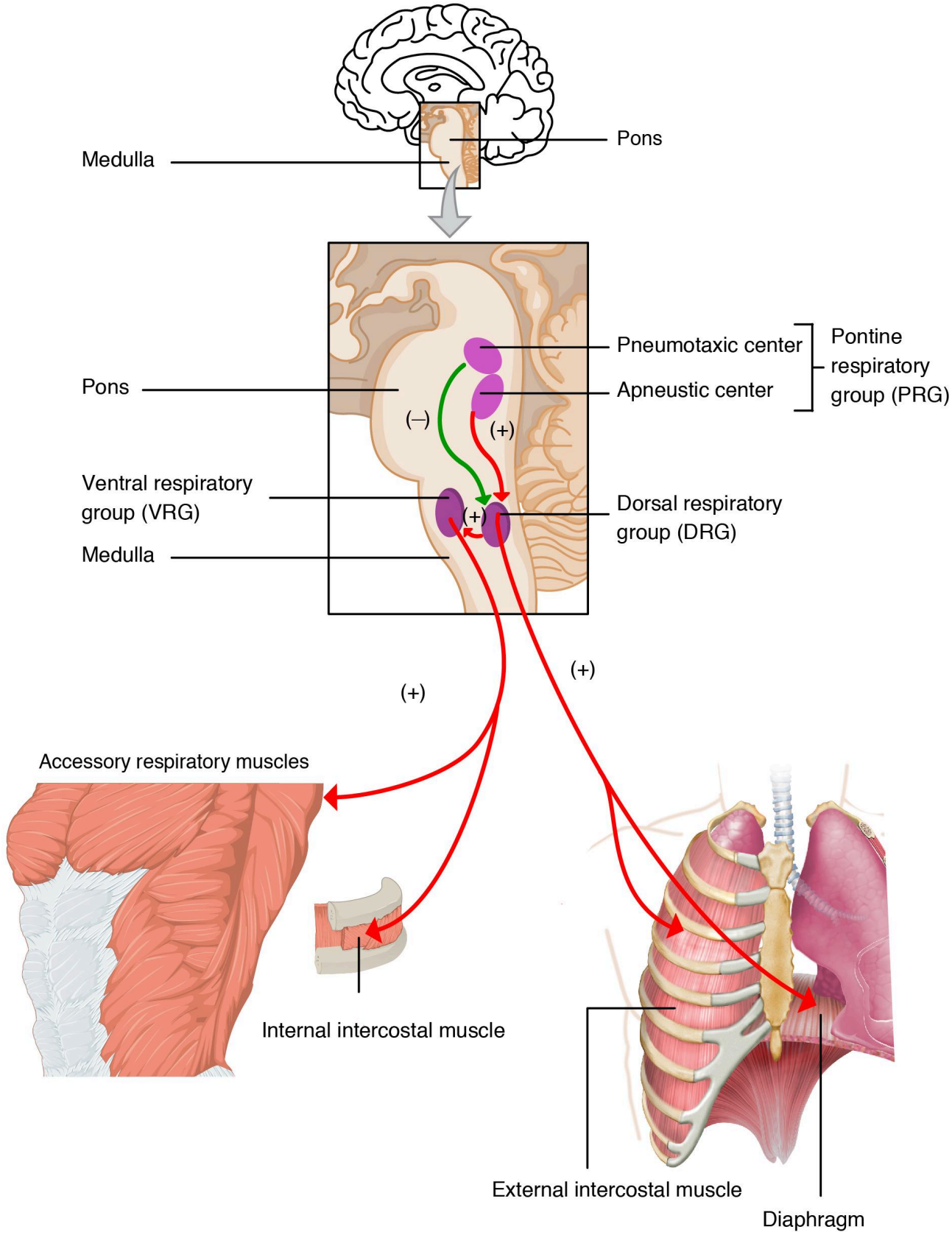

Figure 5.4 Respiratory Centers of the Brain

See the supplementary YouTube 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://wtcs.pressbooks.pub/pharmacology2e/?p=190#oembed-1

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://wtcs.pressbooks.pub/pharmacology2e/?p=190#oembed-2

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://wtcs.pressbooks.pub/pharmacology2e/?p=190#oembed-3

6. Forciea, B. (2015, May 13). *Respiratory system anatomy (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/aqTwrdMS6CE
7. Forciea, B. (2015, May 12). *Anatomy and physiology: Respiratory system: Breathing mechanics (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/X-J5Xgg3l6s
8. Forciea, B. (2015, May 12). *Respiratory 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://wtcs.pressbooks.pub/pharmacology2e/?p=190#oembed-4

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

5.3 Common Respiratory Disorders

This section will provide an overview of common respiratory disorders.

Allergies

Allergies occur when a person's immune system reacts to a foreign substance and makes antibodies that identify that substance as harmful, even though it isn't. Substances identified as allergens can cause inflammation of the skin, sinuses, nasal passages, 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 symptoms.[1]

Hay fever, also called allergic rhinitis, can cause these symptoms:

- Sneezing
- Pruritus (itching) of the nose, eyes, or roof of the mouth
- Runny, stuffy nose
- Watery, red, or swollen eyes (conjunctivitis)

A food allergy can cause the following:

- Tingling in the mouth
- Swelling of the lips, tongue, face, or throat
- Hives
- Anaphylaxis

An insect sting allergy can have these effects:

1. Mayo Clinic Staff. (2018, January 6). *Allergies*. https://www.mayoclinic.org/diseases-conditions/allergies/symptoms-causes/syc-20351497

- 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 the following:

- Hives
- Itchy skin
- Rash
- Facial swelling
- Wheezing
- Anaphylaxis

Atopic dermatitis, an allergic skin condition also called eczema, can cause these effects on the skin:

- Itching
- Reddening
- Flaking or peeling

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. Signs and symptoms of anaphylaxis are as follows:

- Loss of consciousness
- Drop in blood pressure
- Severe shortness of breath
- Skin rash
- Light-headedness
- Rapid, weak pulse
- Nausea and vomiting

Asthma

Asthma is a common condition that affects the lungs in both adults and children. Approximately 8.2 percent of adults (18.7 million) and 9.4 percent of children (7 million) in the United States suffer from asthma. In addition, asthma is the most frequent cause of hospitalization in children.

Asthma is a chronic disease characterized by 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, may also be involved in infiltrating the walls of the bronchi and bronchioles.

Bronchospasms occur periodically and lead to an "asthma attack." An attack may be triggered by environmental factors such as dust, pollen, tobacco smoke, pet hair or dander; changes in the weather; mold; respiratory infections; exercise; and stress.[2]

See Figure 5.5[3] for an illustration of how asthma affects the airways.

2. 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
3. "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/

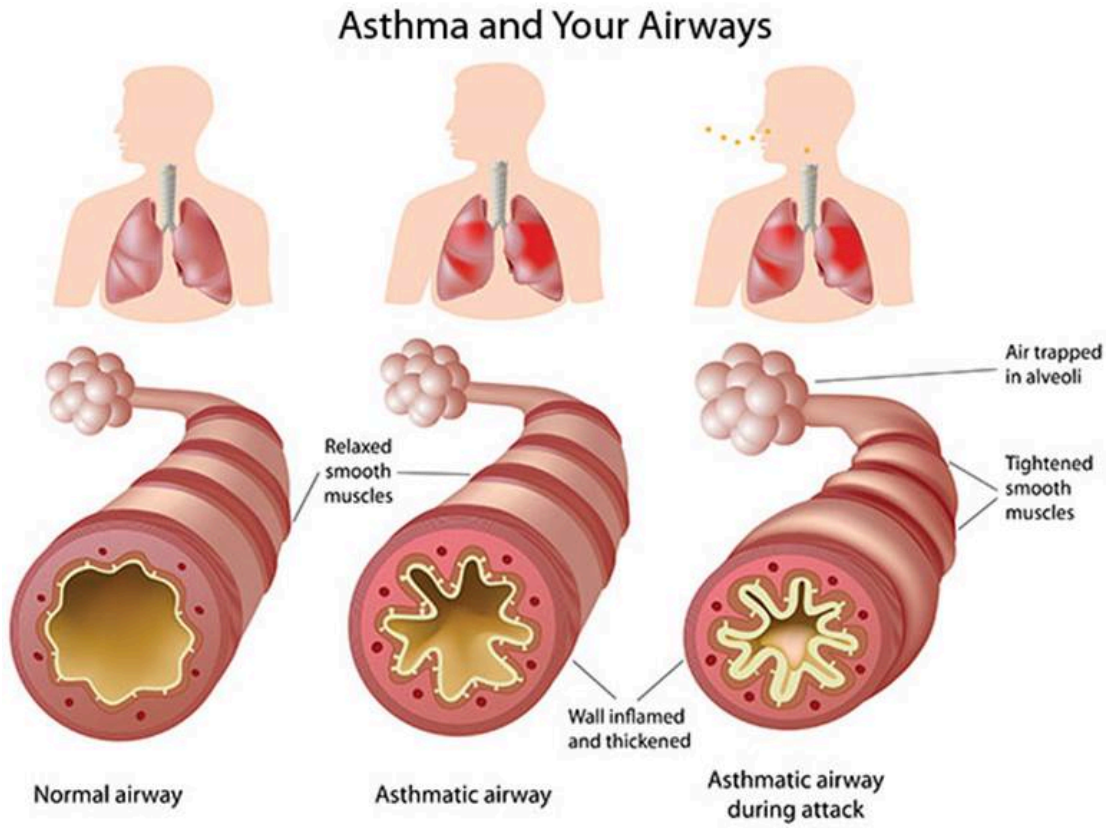

Figure 5.5 How Asthma Affects the Airways

Symptoms of an asthma attack may include coughing, shortness of breath, wheezing, and tightness of the chest. Symptoms of a severe asthma attack requiring immediate medical attention include difficulty breathing that can result 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. Short-term, fast-acting drugs are used to treat an asthma attack and are typically administered via an inhaler or nebulizer. Long-term treatments are prescribed for clients with severe asthma.[4] View the following YouTube video for additional insight into how asthma works.

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How Does Asthma Work? YouTube video[5]

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 ten 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.[6]

Symptoms for either acute bronchitis or chronic bronchitis may include the following:

- 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

5. TED-Ed. (2017, May 11). *How does asthma work? - Christopher E. Gaw* [Video]. YouTube. https://youtu.be/PzfLDi-sL3w
6. Mayo Clinic Staff. (2017, April 11). *Bronchitis.* https://www.mayoclinic.org/diseases-conditions/bronchitis/symptoms-causes/syc-20355566

Common Cold

The common cold is a viral infection of the upper respiratory tract. Many types of viruses can cause a common cold. 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.

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, are as follows:

- Runny or stuffy nose
- Sore throat
- Cough
- Congestion
- Slight body aches or a mild headache
- Sneezing
- Low-grade fever
- Generally feeling unwell (malaise)[7]

Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory lung disease that causes obstructed airflow out of the lungs. 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 of the lungs (bronchioles) are destroyed and hyperinflated. Chronic bronchitis is inflammation of the lining of the bronchial tubes and

7. Mayo Clinic Staff. (2019, April 20). *Common cold*. https://www.mayoclinic.org/diseases-conditions/common-cold/symptoms-causes/syc-20351605

characterized by chronic cough and mucus (sputum) production. See Figure 5.6 for an illustration of normal lungs compared to lungs with COPD.[8]

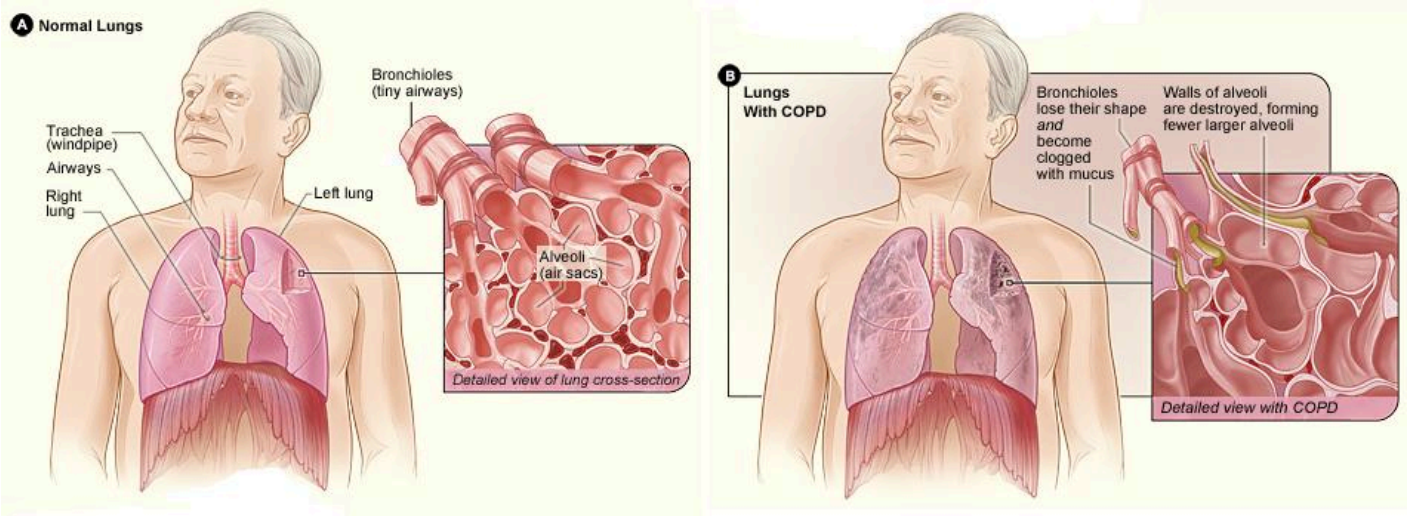

Figure 5.6 Normal Lungs Compared to Lungs in a Person With COPD

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.

These are some other signs and symptoms of COPD:

- 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 or reddish discoloration of the skin
- Frequent respiratory infections
- Lack of energy
- Barrel chest
- Unintended weight loss (in later stages)

8. "Copd 2010Side.JPG" by National Heart Lung and Blood Institute is licensed under CC0

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.[9]

★ Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=194#h5p-17

"Respiratory Disease Match-Up" by E. Christman for Open RN is licensed under CC BY 4.0

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 sidestream

9. Mayo Clinic Staff. (2017, August 11). *COPD*. https://www.mayoclinic.org/diseases-conditions/copd/symptoms-causes/syc-20353679

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 sidestream 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.[10]

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5.4 Applying the Nursing Process to Administering Respiratory Medications

Now that we have reviewed the respiratory system and common respiratory disorders, let's apply the nursing process to the administration of respiratory 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.

Respiratory medications are often given to alleviate allergies, cold symptoms, or to decrease/eliminate shortness of breath (SOB). Nurses assess the client's respiratory status before and after administering respiratory medications. The respiratory assessment includes observing baseline respiratory effort, 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; determining if a cough or **sputum** is present; and determining if intercostal retractions (i.e., muscles between the ribs are "sucked in" during inhalation) are present. Sputum is matter expectorated from the respiratory system that is composed of mucus but may also contain pus, blood, fibrin, or microorganisms. If sputum is present, it should be assessed for color, odor, consistency, and amount (COCA). Signs of respiratory distress (such as increased respiratory rate, decreased oxygen saturation levels, cyanosis, and intercostal retractions) require immediate notification of the health care provider and possible activation of emergency assistance.

Additional baseline information to collect prior to the administration of any

respiratory medication includes previous history of allergic response or side effects/adverse effects.

> Read more information about respiratory assessment in the "Respiratory Assessment" chapter of Open RN *Nursing Skills*.

Implementation of Interventions

Respiratory medications can be administered by many routes, such as nasal spray, inhalation, oral tablets or liquids, injections, or intravenously. The route helps nurses anticipate potential side effects. For example, inhalations deliver medication(s) directly to the lungs and act directly on the lung tissues, minimizing systemic side effects. On the other hand, intravenous medications are administered into the bloodstream to act quickly but can cause systemic side effects.

Some respiratory medications contain more than one drug and exist in different dosages, so the dosages of each drug must be verified when checking the rights of medication administration. For example, Advair inhalers come in various dosages and combine a long-acting bronchodilator (salmeterol) with a glucocorticoid (fluticasone).

Nurses anticipate the expected outcome of medication and any common side effects based on the medication class. For example, albuterol is a short acting Beta-2 agonist that is prescribed for bronchodilation. The nurse plans to perform a focused respiratory assessment before and after administration of albuterol to document the effectiveness of the medication, as well as to 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.[1]

1. Drugs.com. (n.d.). *Respiratory agents.* https://www.drugs.com/drug-class/respiratory-agents.html

Evaluation

Finally, it is important to always evaluate the client's response to a medication. For example, for respiratory medications prescribed for a client with COPD, the nurse should assess for decreased shortness of breath. The nurse should complete a focused respiratory assessment (respirations, pulse oximetry, and lung auscultation) before and after administration of the medication and then compare the results. 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.

5.5 Respiratory Medication Classes

Now that we have reviewed basic concepts, we will take a closer look at specific respiratory medication classes and specific administration considerations, therapeutic effects, adverse/side effects, and teaching needed for each class of medications.

Respiratory medication classes discussed in this chapter include antihistamines, decongestants, antitussives, expectorants, beta-2 agonists, anticholinergics, corticosteroids, leukotriene receptor antagonists, and xanthine derivatives.

5.6 Antihistamines

Diphenhydramine is an example of a first-generation antihistamine. (See Figures 5.7[1] and 5.8.[2]) 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: block histamine at H1 receptors; inhibit smooth muscle constriction in blood vessels and the respiratory and GI tracts; and decrease capillary permeability, salivation, and tear formation.

Indications: Antihistamines are used for relief of allergy or cold symptoms.

Nursing Considerations: This medication is not safe for children under the age of 2 years without a health care provider's order.

Side Effects/Adverse Effects: First-generation medications can cause anticholinergic effects (such as dry mouth, urinary retention, constipation and blurred vision). CNS depression or CNS stimulation with excessive doses can occur, especially in children. First-generation antihistamines should be used with caution in the elderly.

Second-generation medications may cause headache, nausea, vomiting, dysmenorrhea, and fatigue.[3]

Health Teaching & Health Promotion: Clients should be advised that antihistamines may cause drowsiness, and concurrent use of alcohol or other CNS depressants should be avoided. Clients should take only the recommended amount of medication and not exceed dosing recommendations. Some clients may experience side effects such as dry mouth, and frequent oral hygiene may assist in alleviating discomfort.[4]

1. "Benadryl Allergy USA" by ZenBenjamin is licensed under CC BY-NC-SA 2.0
2. "diphenhydramine (1)" by Intropin is licensed under CC BY-NC 2.0
3. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
4. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral



Figure 5.7 Diphenhydramine, a First-Generation Antihistamine Available Orally or IV Medication



Figure 5.8 Diphenhydramine HCl Preparation, Single-Dose Vial for IV Administration

Now let's take a closer look at the medication grid for diphenhydramine and cetirizine in Table 5.6.[5,6,7] Medication grids 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. Prototype/generic medication listed in the medication grid is also linked to a free resource from the U.S. National Library of Medicine called DailyMed. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Table 5.6 Diphenhydramine and Cetirizine Medication Grid

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6. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
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Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
First-generation Antihistamine	diphenhydramine	Take as directed Avoid alcohol or CNS depressants due to sedation	Temporarily relieves symptoms due to hay fever or other upper respiratory allergies: Runny nose; sneezing; itchy, watery eyes; itching of the nose or throat Temporarily relieves symptoms due to the common cold such as runny nose and sneezing	Sedation Anticholinergic effects Gastrointestinal: Nausea and vomiting Paradoxical effect: Excitation in children
Second-generation Antihistamine	cetirizine loratadine	Take as directed Avoid allergens Avoid alcohol or CNS depressants due to sedation	Temporarily relieves symptoms due to hay fever or other upper respiratory allergies: Runny nose; sneezing; itchy, watery eyes; itching of the nose or throat	Non-sedating Anticholinergic effects Gastrointestinal: Nausea and vomiting Paradoxical effect: Excitation in children

5.7 Decongestants

Pseudoephedrine is an Alpha-1 agonist and an over-the-counter (OTC) decongestant (see Figure 5.9[1]). 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. More details regarding pseudoephedrine are described in the "Autonomic Nervous System" chapter.

Mechanism of Action: Pseudoephedrine acts directly on the adrenergic receptors and acts indirectly by releasing norepinephrine from its storage sites. The drug produces vasoconstriction, which shrinks nasal mucosa membranes.

Indications: Decongestants relieve nasal obstruction due to inflammation.

Nursing Considerations: This medication is not safe for children under the age of 4 years.

Side Effects/Adverse Effects: Common adverse/side effects include hypertension, dysrhythmia, dizziness, headache, insomnia, and restlessness. Some clients may experience blurred vision, tinnitus, chest tightness, dry nose, and nasal congestion.

Decongestants are contraindicated in clients with severe hypertension, coronary artery disease (CAD), narrow-angle glaucoma, and some antidepressant use. Also, use with caution in clients who have cardiac dysrhythmias, hyperthyroidism, DM (diabetes mellitus), and prostatic hypertrophy.[2]

Health Teaching & Health Promotion: Clients must take care to follow dosing recommendations. If dosing standards are surpassed, some clients

1. "Project 366 #165: 130612 Helping Hand?" by Pete is licensed under Public Domain.
2. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.

may experience side effects such as increased nervousness, breathing difficulties, heart rate changes, and hallucinations.[3]



Figure 5.9 Pseudoephedrine (Sudafed) is a decongestant that is available OTC

Now let's take a closer look at the medication grid on pseudoephedrine in Table 5.7.[4,5,6]

Table 5.7 Pseudoephedrine Medication Grid

3. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
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5. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
6. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effe
Decongestant	pseudoephedrine	Administration (drops and sprays) Avoid prolonged use for greater than 7 days Use cautiously with cardiovascular disease Maintain hydration (2-3 liters/day)	Temporarily relieves nasal congestion due to the common cold, hay fever, or other upper respiratory allergies Temporarily relieves sinus congestion and pressure	Cardiovascular stimu Rebound congestion nasal route

5.8 Antitussives

Dextromethorphan

Dextromethorphan is an example of an antitussive (see Figure 5.10[1]).

Mechanism of Action: Dextromethorphan suppresses a cough by depressing the cough center in the medulla oblongata or the cough receptors in the throat, trachea, or lungs, effectively elevating the threshold for coughing.

Indications: Antitussives are used for a dry, hacking, nonproductive cough that interferes with rest and sleep.

Nursing Considerations: This medication is not safe for children under the age of 4 years.

Side Effects/Adverse Effects: The most common side effects include nausea and drowsiness. Some clients may experience a rash or difficulty breathing. High doses may cause hallucinations and disassociation, and the drug has been reported to be used as a recreational drug.[2]

Health Teaching & Health Promotion: Clients should take care to avoid irritants that stimulate their cough, such as smoking. Additionally, antitussive medications can cause drowsiness, and clients should avoid taking them with other CNS depressants or alcohol.[3]

1. "Robitussin Cough Cold Flu Congestion decongestant Relief Medicine" by Mike Mozart is licensed under CC BY 2.0
2. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
3. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral



Figure 5.10 Robitussin DM, an OTC Medication Containing Dextromethorphan and Guaifenesin

Now let's take a closer look at the medication grid on dextromethorphan & benzonatate in Table 5.8a.[4,5,6]

Table 5.8a Dextromethorphan & Benzonatate Medication Grid

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5. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
6. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Non-opioid Antitussive	dextromethorphan	Take as directed Administer undiluted No alcohol use due to CNS depression Use with caution in clients with respiratory disease and with those taking monoamine oxidase inhibitors (MAOIs)	Temporarily relieves coughing due to minor throat and bronchial irritation as may occur with the common cold	CNS: Sedation and dizziness Mild gastrointestinal effects

Non-opioid Antitussive	benzonatate	Benzonatate should be taken with food to minimize the risk of gastrointestinal upset. It should be swallowed whole and not crushed, chewed, or dissolved in the mouth No alcohol use due to CNS depression Benzonatate can cause respiratory depression in high doses, especially in clients with preexisting respiratory conditions Benzonatate may interact with other medications, including opioids, benzodiazepines, and alcohol	Utilized to treat of cough associated with respiratory infections and conditions such as bronchitis and pneumonia	CNS: Sedation and dizziness GI: Constipation and nausea Headache Dry mouth Nasal congestion Itching or skin rash

Codeine/Guaifenesin

Codeine/guaifenesin is another example of an antitussive medication. It is combination medication that contains the opioid pain medication codeine and the expectorant guaifenesin.

Mechanism of Action: Codeine works by binding to opioid receptors in the brain and spinal cord. This binding reduces the transmission of pain signals and suppresses the cough reflex in the brain stem. Guaifenesin is an expectorant that works by thinning and loosening mucus in the airways.

Indications: Codeine is a centrally acting cough suppressant that works by reducing the cough reflex in the brain stem. It is effective at reducing both dry and productive coughs. Guaifenesin is an expectorant that works by thinning and loosening mucus in the airway.

Nursing Considerations: With the risk of respiratory depressions associated with this medication, baseline respiratory effort must be assessed. Nurses should monitor for signs of dependence as codeine has the potential for abuse and dependence.

Side Effects/Adverse Effects: Side effects include sedation and drowsiness. It is important to also monitor for respiratory depression, blurred vision, dry mouth, urinary retention, nausea, vomiting, and constipation.

Health Teaching & Health Promotion: Clients should take care to avoid irritants that stimulate their cough, such as smoking. Additionally, antitussive medications can cause drowsiness, and clients should avoid taking them with other CNS depressants or alcohol. Clients should not drive or operate heavy machinery while taking the medication due to the potential for sedation.[7]

Now let's take a closer look at the medication grid on codeine-guaifenesin in Table 5.8b.[8]

Table 5.8b Codeine-guaifenesin Medication Grid

7. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

8. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Opioid Antitussive	codeine-guaifenesin	Take as directed. Monitor for signs of abuse/ dependence Administer in the lowest effective dose for the shortest duration possible to minimize the risk of adverse effects No alcohol use due to CNS depression Use with caution in clients with respiratory disease and with those taking benzodiazepines, antidepressants, and other opioids	Alleviates coughing and loosens mucus in the airways	CNS: Sedation and dizziness Respiratory depression Blurred vision, dry mouth, and urinary retention GI: Constipation, nausea, and vomiting

5.9 Expectorants

Guaifenesin is an example of an expectorant.

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.

Indications: Expectorants are used for a productive cough and for loosening mucus from the respiratory tract.

Nursing Considerations: Avoid in children under the age of four. Guaifenesin is only recommended for use during pregnancy and breastfeeding when benefit outweighs the risk.

Side Effects/Adverse Effects: Guaifenesin may cause a skin rash, headache, nausea, and vomiting.[1]

Health Teaching & Health Promotion: Clients should take care to avoid irritants that stimulate their cough. Additionally, the medication can cause drowsiness. Clients should avoid taking them with other CNS depressants or alcohol.[2] Encourage increased fluid intake to thin secretions, if not contraindicated.

Now let's take a closer look at the medication grid for guaifenesin in Table 5.9.[3,4,5]

Table 5.9 Guaifenesin Medication Grid

1. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
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4. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
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Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Expectorant	guaifenesin	No eating or drinking for 30 minutes after syrup Encourage client to cough and deep breathe Encourage increased fluid intake to thin secretions, if not contraindicated	Helps loosen sputum (mucus) and thin bronchial secretions to make coughs more productive	Increased drowsiness in large doses Gastrointestinal: Nausea, vomiting, and diarrhea

5.10 Beta-2 Agonists

Albuterol is an example of a short-acting Beta-2 agonist. See Figures 5.11[1], 5.12[2] and 5.13[3] for images of an albuterol inhaler, ampule, and nebulizer.

Salmeterol is an example of a long-acting Beta-2 agonist.

See the "Autonomic Nervous System" chapter for more information regarding Beta-2 agonists.

Mechanism of Action: Albuterol 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.

Indications: Short-acting albuterol is used to prevent or treat bronchospasms in people with asthma, reversible obstructive airway disease, or exercise-induced bronchospasm. Long-acting salmeterol is used to prevent bronchospasm.

Nursing Considerations: Nurses should monitor respiratory rate, oxygen saturation, and lung sounds before and after administration.

Side Effects/Adverse Effects: Beta-2 agonists can cause muscle tremor, excessive cardiac stimulation, and CNS stimulation.[4]

Health Teaching & Health Promotion: Clients should be instructed to take medication as directed and report any sustained or worsening symptoms to their health care provider. When first using an inhaler, clients should be instructed to prime the inhaler unit prior to administering their medication. Use of medications like albuterol 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.[5]

1. "Ventolin® HFA (Albuterol Sulfate) Inhaler.jpg" by MisterNarwhal is licensed under CC BY SA 4.0
2. "Albuterol 2.jpg" by Mark Oniffrey is licensed under CC BY SA 4.0
3. "Nebulizer_Mouthpiece.png" by BruceBlaus is licensed under CC BY-SA 4.0
4. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
5. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral



Figure 5.11 Albuterol Inhaler



Figure 5.12 Ampule of Albuterol Sulfate for Inhalation

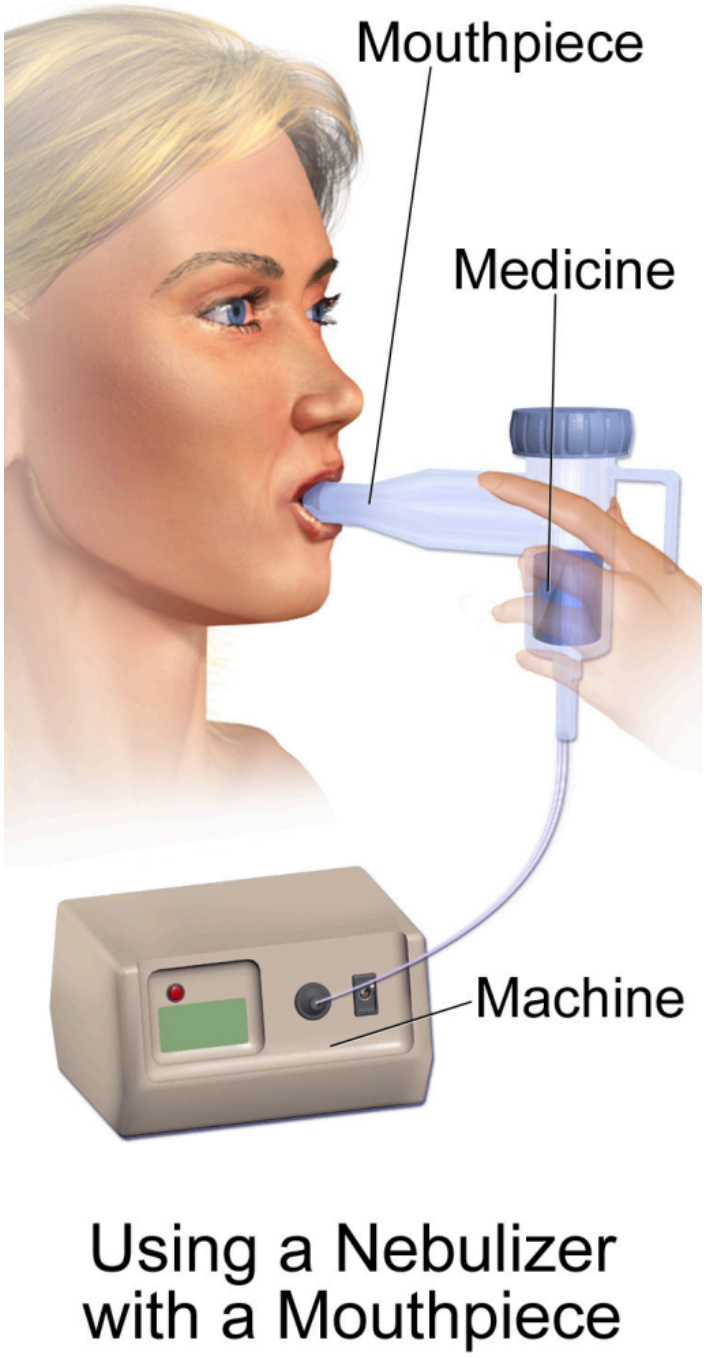

Figure 5.13 Nebulizer

Now let's take a closer look at the medication grid for albuterol and salmeterol in Table 5.10.[6,7,8,9,10]

Table 5.10 Albuterol and Salmeterol Medication Grid

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Short-acting Beta-2 Agonist (SABA)	albuterol	Fast onset of action for prevention or alleviation of bronchospasm	Rapid bronchodilation	CNS stimulation (excitability) Cardiovascular stimulation (tachycardia)
Long-acting Beta-2 Agonist (LABA)	salmeterol	Has a slow onset of action and will not stop an acute bronchospasm Increased risk of death with use during an "asthma attack" due to slow onset of action	Prevention of bronchospasm	Tachycardia, dysrhythmias, hypokalemia, hyperglycemia, paradoxical bronchoconstriction, and increased risk for asthma-related death

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8. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
9. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
10. Adams, M., Holland, N., & Urban, C. (2020). *Pharmacology for nurses: A pathophysiologic approach* (6th ed.). pp. 622-63.

5.11 Anticholinergics

Ipratropium is an example of a short-acting anticholinergic. Tiotropium is an example of a long-acting anticholinergic. (See Figure 5.14[1] for an image of the inhaler cartridge in which the tiotropium dose is inserted.)

Mechanism of Action: Anticholinergics block the action of acetylcholine in bronchial smooth muscle, which reduces bronchoconstrictive substance release.

Indications: Anticholinergics are used for maintenance therapy of bronchoconstriction associated with asthma, chronic bronchitis, and emphysema.

Nursing Considerations: Nurses must be aware that anticholinergic medications commonly cause dry mouth and may result in constipation or blurred vision.

Side Effects/Adverse Effects: Anticholinergics should be used with caution with the elderly and can cause cough, drying of the nasal mucosa, nervousness, nausea, GI upset, headaches, and dizziness.[2]

Health Teaching & Health Promotion: Clients should be instructed to use the inhaler as directed and be careful not to exceed dosage recommendations. They should receive information regarding the onset of medication and differences in usage for short- and long-acting anticholinergics. Some long-acting anticholinergics may cause signs of angioedema, and the health care provider should be notified if this occurs.[3]

1. "Spiriva HandiHaler-brand dry powder inhaler (open).png" by RonEJ at English Wikipedia is licensed under CC0 1.0
2. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
3. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral



Figure 5.14 Tiotropium, a Long-Acting Anticholinergic

Now let's take a closer look at the medication grid for ipratropium and tiotropium in Table 5.11.[4,5,6,7]

Table 5.11 Ipratropium and Tiotropium Medication Grid

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7. Adams, M., Holland, N., & Urban, C. (2020). *Pharmacology for nurses: A pathophysiologic approach* (6th ed.). pp. 622-63.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Anticholinergics (short-acting)	ipratropium	Long-term management of pulmonary disease Slower onset of action	Bronchodilation	Cough and drying of the nasal mucosa
Anticholinergics (long-acting)	tiotropium	Long-term management of pulmonary disease Slower onset of action	Prevents bronchospasm and reduces exacerbations in COPD clients	Cough and drying of the nasal mucosa

5.12 Corticosteriods

Corticosteroids can be prescribed in a variety of routes. Fluticasone is an example of a commonly used inhaled corticosteroid that can be inhaled or used as a nasal spray. Prednisone is an example of a commonly used oral corticosteroid, and methylprednisolone is a commonly used IV corticosteroid. Additional information about corticosteroids and potential adrenal effects is located in the "Corticosteroids" section of the "Endocrine System" chapter.

Mechanism of Action: 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. See Figures 5.15-17[1,2,3] for images of different formulations of fluticasone.

Oral prednisone prevents the release of substances in the body that cause inflammation. It also suppresses the immune system.

Methylprednisolone IV prevents the release of substances in the body that cause inflammation. It also suppresses the immune system. Methylprednisolone comes in powder form and must be reconstituted (mixed) with sterile saline before administration. See Figure 5.17[4] for an image of methylprednisolone.

Indications: Fluticasone inhalers are used to prevent asthma attacks. Fluticasone nasal spray is used to reduce inflammation of sinus passages. In respiratory conditions, oral prednisone is used to control severe or incapacitating allergic conditions, severe asthma, and acute exacerbations of COPD. Oral prednisone is also used to relieve contact dermatitis, atopic dermatitis, serum sickness, and drug hypersensitivity reactions. Methylprednisolone IV is used to rapidly control these same conditions.

1. "Fluticasone Propionate Nasal Spray" by _BuBBy_ is licensed under CC BY 2.0
2. "Fluticasone.JPG" by James Heilman, MD is licensed under CC BY-SA 4.0
3. "Asthmatic Control" by David Camerer is licensed under CC BY-NC-ND 2.0
4. "Methylprednisolone vial.jpg" by Intropin is licensed under CC BY 3.0

Nursing Considerations: Fluticasone is safe for children aged 4 years and older. Prednisone and methylprednisolone are safe for all ages.

Side Effects/Adverse Effects: Fluticasone inhalers can cause hoarseness, dry mouth, cough, sore throat, and oropharyngeal candidiasis. Fluticasone nasal spray can cause dry nasal passages and epistaxis (nosebleeds). Clients should rinse their mouths after using corticosteroid inhalers to prevent candidiasis (thrush).

Prednisone and Methylprednisolone: See more information about adverse effects of corticosteroids in the in the "Corticosteroids" section of the "Endocrine System" chapter. Cardiovascular symptoms can include fluid retention, edema, and hypertension. Imbalances such as hypernatremia (↑Na), hypokalemia (↓K+), and increased blood glucose with associated weight gain can occur. CNS symptoms include mood swings and euphoria. GI symptoms can include nausea, vomiting, and GI bleed. In long-term therapy, bone resorption occurs, which increases the risk for fractures; the skin may bruise easily and become paper thin; wound healing is delayed; infections can be masked; and the risk for infection increases. Long-term corticosteroid therapy should never be stopped abruptly because life-threatening adrenal insufficiency may occur.[5]

Health Teaching & Health Promotion: Instruct clients to rinse their mouths after inhaler use to prevent candidiasis (thrush). Advise clients that corticosteroids are not used to treat an acute asthma attack. They can cause immunosuppression, suppress signs of infection, and cause an increase in blood glucose levels. Clients may experience weight gain, swelling, increased fatigue, bruising, and behavioral changes. These occurrences should be reported to one's health care provider.[6]

5. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
6. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral



Figure 5.15 Fluticasone Nasal Spray Formulation



Figure 5.16 Fluticasone Oral Inhaler Formulation



Figure 5.17 Fluticasone Combination Formulation



Figure 5.18 Methylprednisolone Requires Reconstitution Before Administration

Now let's take a closer look at the medication grid for fluticasone, prednisone, and methylprednisolone in Table 5.12.[7,8,9]

Table 5.12 Fluticasone, Prednisone, and Methylprednisolone Medication Grid

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Class/ Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Corticosteroids	fluticasone	Rinse mouth after use Do not use inhaler as a quick-relief medication for asthma attacks	Nasal spray: Used for management of the nasal symptoms of perennial nonallergic rhinitis Inhaler: Used to improve the control of asthma by reducing inflammation in the airways	Nasal spray: Dry nasal passages and epistaxis (nosebleed) Inhalers: Hoarseness, dry mouth, cough, sore throat, and oropharyngeal candidiasis

Corticosteroids	prednisone	Do not use if signs of a systemic infection When using more than 10 days, the dose must be slowly tapered May increase blood glucose levels	Used to control severe or incapacitating allergic or respiratory conditions	CV: Fluid retention, edema, and hypertension Electrolytes: ↑Na, ↓K+, ↑Ca, and ↑BG CNS: Mood swings and insomnia in high doses GI: Nausea, vomiting, and GI bleed MS: Bone resorption Skin: Acne, paper thin, bruises, infections, and delayed healing Increased appetite and weight gain Adrenal suppression Increased risk for infection, and infections can be masked Long-term use may result in Cushing's syndrome

Corticosteroids	methylprednisolone	May increase blood glucose levels	Used to rapidly control severe or incapacitating allergic or respiratory conditions, in sepsis to reduce systemic inflammation, and to treat adrenal insufficiency	Same as prednisone

5.13 Leukotriene Receptor Antagonists

Montelukast is a leukotriene antagonist medication with a distinctly-shaped square tablet. See Figure 5.19.[1]

Mechanism of Action: Montelukast blocks leukotriene receptors and decreases inflammation.

Indications: 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.

Nursing Considerations: The medication is safe for children 12 months and older. It is available in granule packets and chewable tablets, as well as regular tablets.

Boxed Warning: Serious mental health side effects, including suicidal ideation. Should be avoided for treating mild asthma unless conventional treatment is ineffective.

Side Effects/Adverse Effects: Montelukast can cause headache, cough, nasal congestion, nausea, hepatotoxicity, and suicidal ideation.

Health Teaching & Health Promotion: Clients should be instructed to take medications at the same time each day and at least two hours prior to exercise. They should not discontinue medications without notifying the health care provider.[2]



Figure 5.19 Montelukast Tablets

1. "Singulair 10mg" by FedEx is licenced under CC BY-NC-ND 2.0
2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

Now let's take a closer look at the medication grid on montelukast in Table 5.13.[3,4,5,6]

Table 5.13 Montelukast Medication Grid

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Leukotriene Inhibitor	montelukast	Use as directed; not to be used as a quick relief medication for asthma attacks Typically, 3-7 days to reach effectiveness Boxed warning for serious mental health side effects, including suicidal ideation. Should be avoided for treating mild asthma unless conventional treatment is ineffective	Prevention and treatment of asthma and exercise-induced bronchoconstriction	Headache Cough Nasal congestion Nausea Hepatotoxicity Suicidal ideation

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6. Adams, M., Holland, N., & Urban, C. (2020). *Pharmacology for nurses: A pathophysiologic approach* (6th ed.). pp. 622-63.

5.14 Xanthine Derivatives

Theophylline is a xanthine derivative.

Mechanism of Action: Theophylline relaxes bronchial smooth muscle by inhibition of the enzyme phosphodiesterase and suppresses airway responsiveness to stimuli that cause bronchoconstriction.

Indications: Theophylline is used for the long-term management of persistent asthma that is unresponsive to beta-agonists or inhaled corticosteroids.

Nursing Considerations: Nurses should remind patients that xanthine derivatives are not quick relief medications for asthma attacks. Due to potential CNS stimulation, administer this medication in the morning when possible.

Side Effects/Adverse Effects: Theophylline can cause nausea, vomiting, CNS stimulation, nervousness, and insomnia.[1]

Health Teaching & Health Promotion: Patients should be sure to take medications as prescribed at appropriate intervals. They should avoid irritants, caffeine, and drink fluids to help thin secretions. Patients will need serum blood levels tested every six to twelve months.[2] Due to potential CNS stimulation, suggest taking this medication in the morning.

Now let's take a closer look at the medication grid on theophylline in Table 5.14.[3,4,5]

Table 5.14 Theophylline Medication Grid

1. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
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4. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). Wolters Kluwer.
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Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Xanthine	theophylline	Avoid caffeine Requires evaluation of therapeutic blood level to prevent toxicity Administer this medication in the morning, if possible, due to potential CNS stimulation	Long-term treatment of chronic asthma and COPD unresponsive to other treatment	GI: Nausea and vomiting CNS stimulation Nervousness and insomnia

5.15 Learning Activities

Light Bulb Moment

Let's apply what you have learned in the respiratory unit.

Case Study 1 Asthma Scenario

An adult client presents to the emergency department with complaints of shortness of breath and increased work of breathing. The client is alert and oriented times 3; skin is pink, warm and dry; BP 148/88; T 98; P92; R 24; and pulse oximetry 91% on room air. Assessment of the lung reveals expiratory wheezing throughout the lung fields. The client has a past 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) Albuterol
    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

albuterol 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?

Case Study 2 Allergy Scenario

A pediatric client presents to the emergency department with complaints of shortness of breath, increased work of breathing, and a cough. The client is alert and oriented times 3; skin is pink, warm and dry; BP 112/68; T 99; P106; R 32; and pulse oximetry 90% on room air. Assessment of the lung sounds reveals diminished lung sounds throughout all lung fields. The client has a past medical history of peanut allergy. The mother tells you that they were at a birthday party and after consumption of a cupcake, the symptoms started.

1. The nurse anticipates that which of the following medications will be likely ordered for this client?

a) Diphenhydramine
b) Epinephrine
c) Cetirizine
d) Guaifenesin

Case Study 3 Rheumatoid Arthritis Scenario

A 67-year-old female client diagnosed with rheumatoid arthritis and type 2 diabetes has been prescribed prednisone for the management of her symptoms. She has been taking prednisone 10mg daily for the past two weeks. The client is complaining of insomnia, increased thirst, and weight gain.

1. What are the common side effects of prednisone use?
2. How can the nurse help manage the client's insomnia?
3. What measures can be taken to help the client manage her

increased thirst?

4. What teaching should the nurse provide the client regarding prednisone use?

Note: Answers to the Light Bulb Moment can be found in the "Answer Key" section 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://wtcs.pressbooks.pub/pharmacology2e/?p=230#h5p-18

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★ Interactive Activity

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https://wtcs.pressbooks.pub/pharmacology2e/?p=230#h5p-19

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Interactive Activity

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https://wtcs.pressbooks.pub/pharmacology2e/?p=230#h5p-21

"Respiratory Branching Scenario" by E. Christman for Open RN is licensed under CC BY 4.0[1]

Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Respiratory Assignment 1.[2]

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- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Respiratory Assignment 2.[3]



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V. Glossary

Allergies: Allergies occur when the immune system reacts to a foreign substance and makes antibodies that identify a particular allergen as harmful, even though it isn't.

Anaphylaxis: A severe, potentially life-threatening allergic reaction. It can occur within seconds or minutes of exposure to something you're allergic to, such as peanuts or bee stings.

Cyanotic: A bluish or purplish discoloration (as of skin) due to deficient oxygenation of the blood.

Gas exchange: The process at the alveoli level where blood is oxygenated and carbon dioxide, the waste product of cellular respiration, is removed from the body.

Pallor: A deficiency of color especially of the face; paleness.

Paradoxical effect: An effect that is opposite to what is expected.

Respiratory rate: The total number of breaths, or respiratory cycles, that occur each minute. 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.

Sputum: Matter expectorated from the respiratory system and especially the lungs that is composed of mucus but may contain pus, blood, fibrin, or microorganisms (such as bacteria) in diseased states.

PART VI

CARDIOVASCULAR & RENAL SYSTEMS

6.1 Cardiovascular and Renal System Introduction

Learning Objectives

- Identify the classifications and actions of cardiovascular drugs
- Identify the classifications and actions of renal system drugs
- Give examples of when, how, and to whom cardiovascular system drugs may be administered
- Give examples of when, how, and to whom renal system drugs may be administered
- Identify the side effects and special considerations associated with cardiovascular and renal system drug therapy
- Identify considerations and implications of using cardiovascular system medications across the life span
- Identify considerations and implications of using renal system medications across the life span
- Apply evidence-based concepts when using the nursing process
- Identify and interpret related laboratory tests
- Identify nursing responsibilities associated with health teaching and health promotion

The heart is the powerhouse of the body, providing oxygenated blood to organs 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 oxygenation starvation, impairment, and subsequent death.

Did You Know?

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 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.[1] It is no wonder that the heart is the most important muscle of the body!

In addition to the cardiovascular system, the renal system is also an important regulator of blood volume, electrolyte balance, and blood flow throughout the body. This chapter will review important concepts and disorders related to the cardiovascular and renal systems before discussing common medication classes. It is vital for nurses to understand how these cardiovascular medications work to provide safe, effective client care.

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6.2 Basic Concepts of the Cardiovascular and Renal Systems

To understand the effects of various classes of cardiovascular medications, it is important to first understand the anatomy and physiology of the cardiovascular and renal systems.

Review of Anatomy and Physiology of the Cardiovascular and Renal Systems

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 (i.e., the superior and inferior venae cavae) and the great arteries (i.e., 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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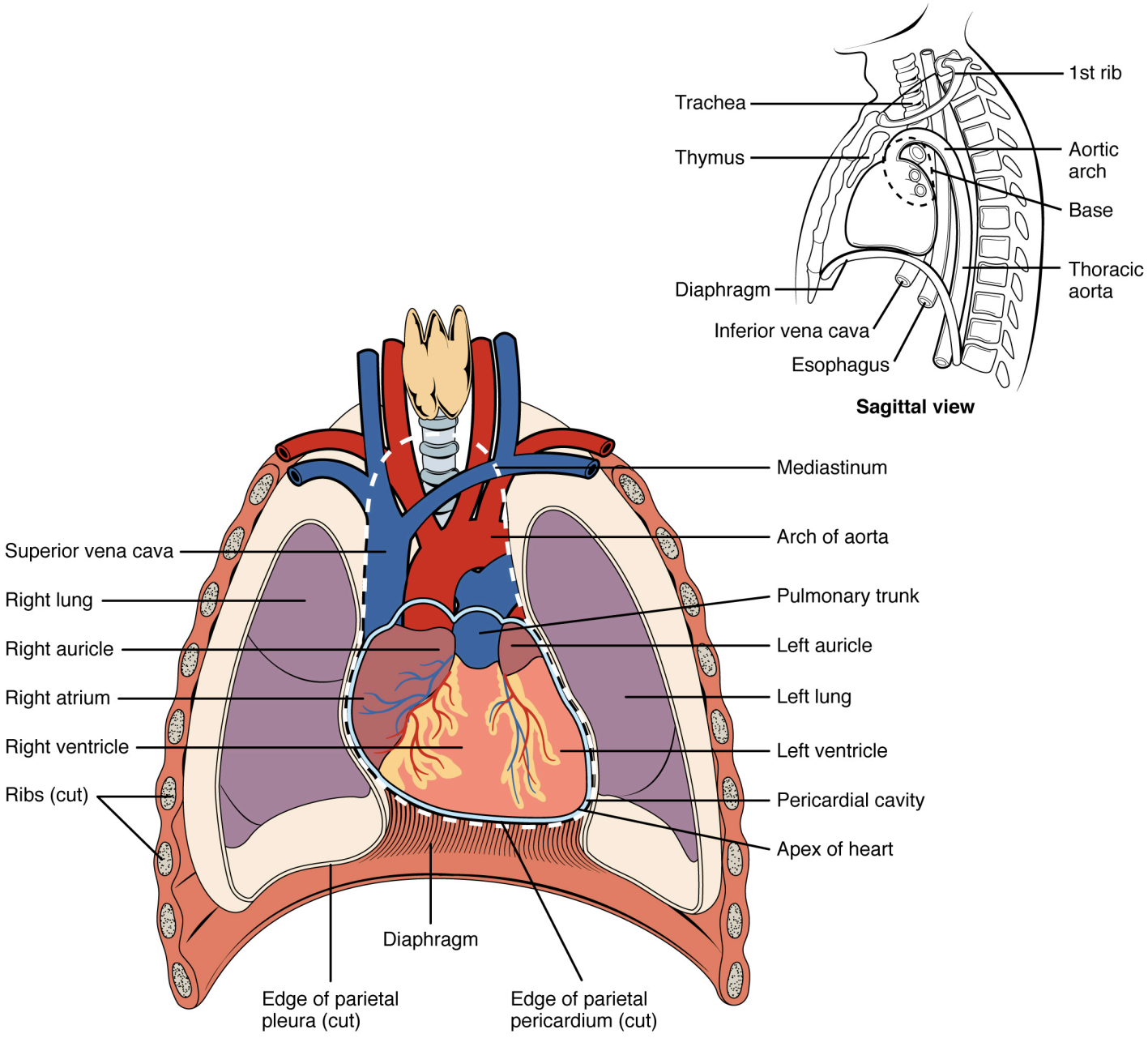

Figure 6.1 Position of the Heart in Thoracic Cavity

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] The blue areas indicate deoxygenated blood flow, and the red areas indicate oxygenated blood flow.

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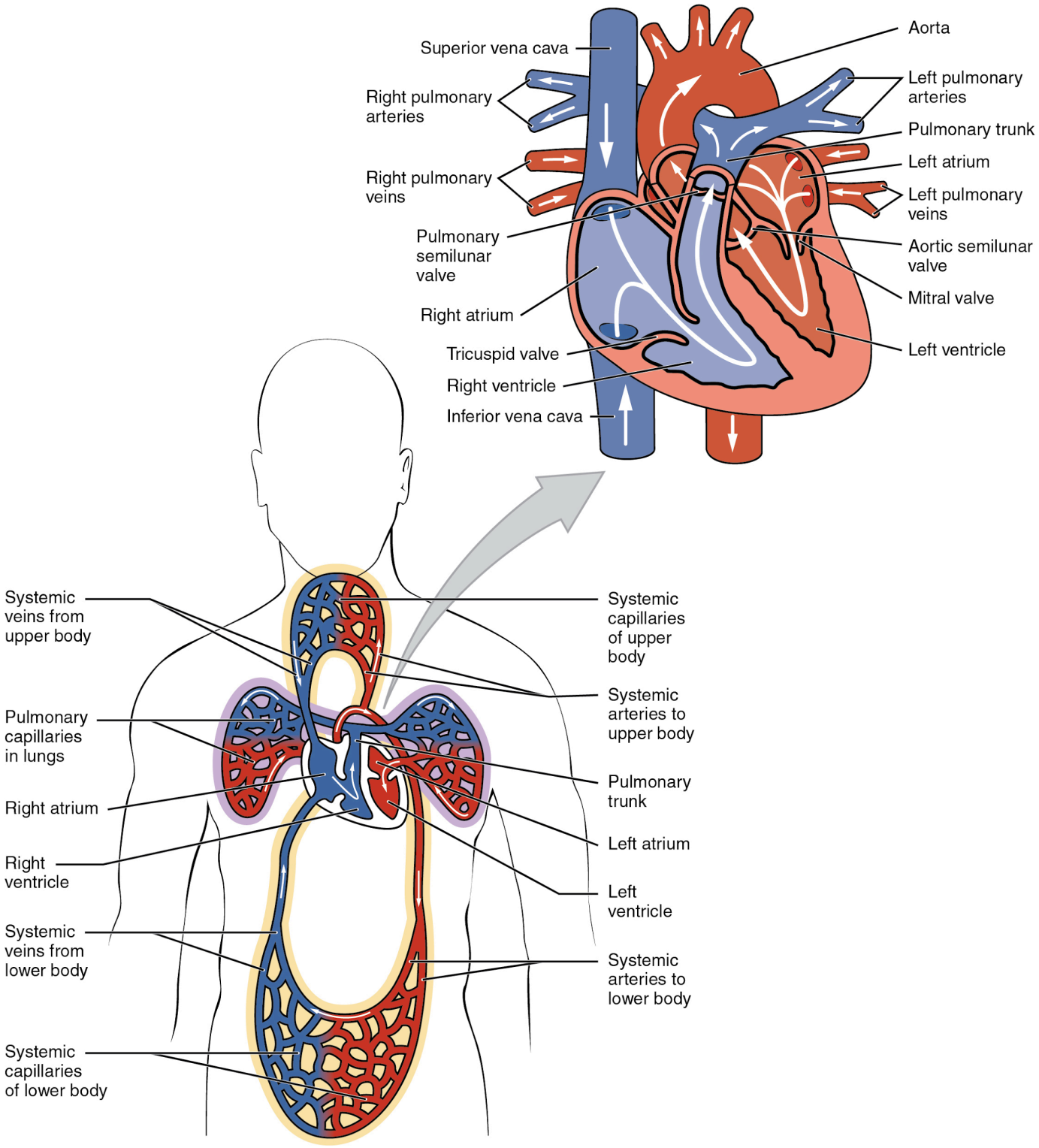

Figure 6.2 Heart Chambers and Blood Circulation to the Lungs and Body

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. 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.

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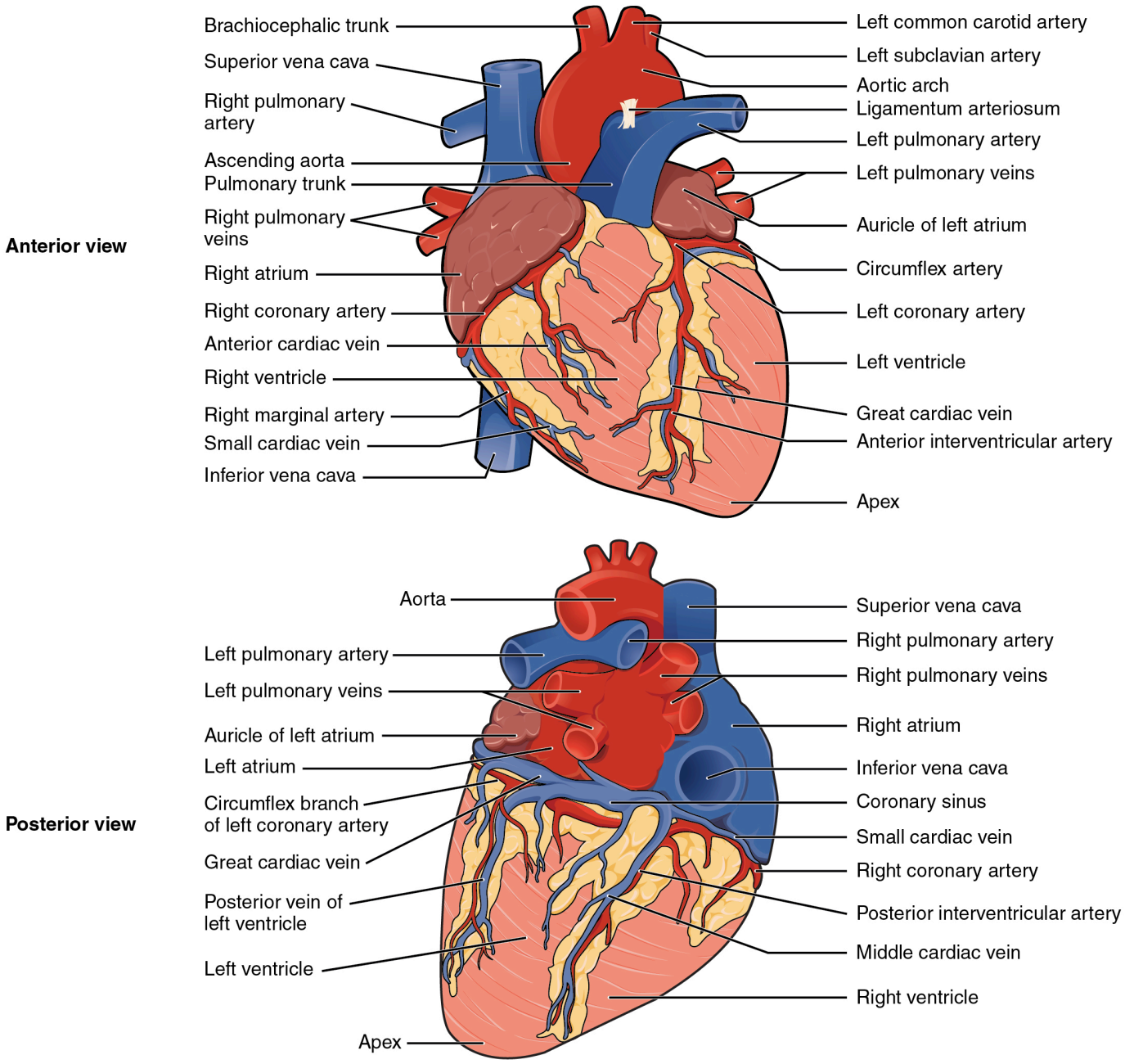

Figure 6.3 Coronary Arteries of the Heart

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])

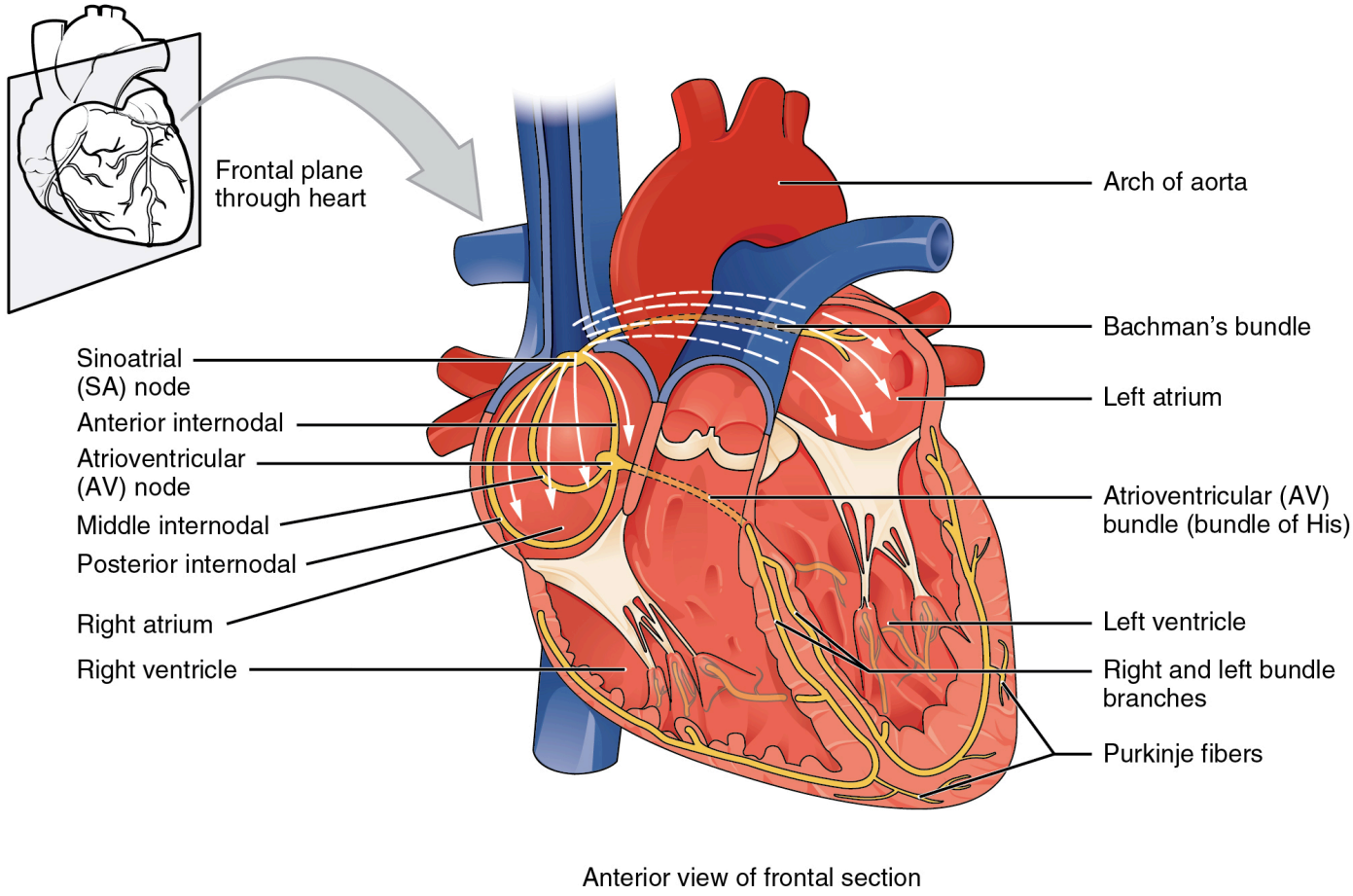

Figure 6.4 Cardiac Conduction System Components

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. It initiates the **sinus rhythm** or normal electrical pattern followed by contraction of the heart. The SA node initiates the action potential, which sweeps across the atria through the AV node to the bundle branches and

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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 neural and endocrine controls, and it is sensitive to other factors, including electrolytes. These factors are further discussed in the “Homeostatic Regulation of the Cardiovascular System” 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

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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. 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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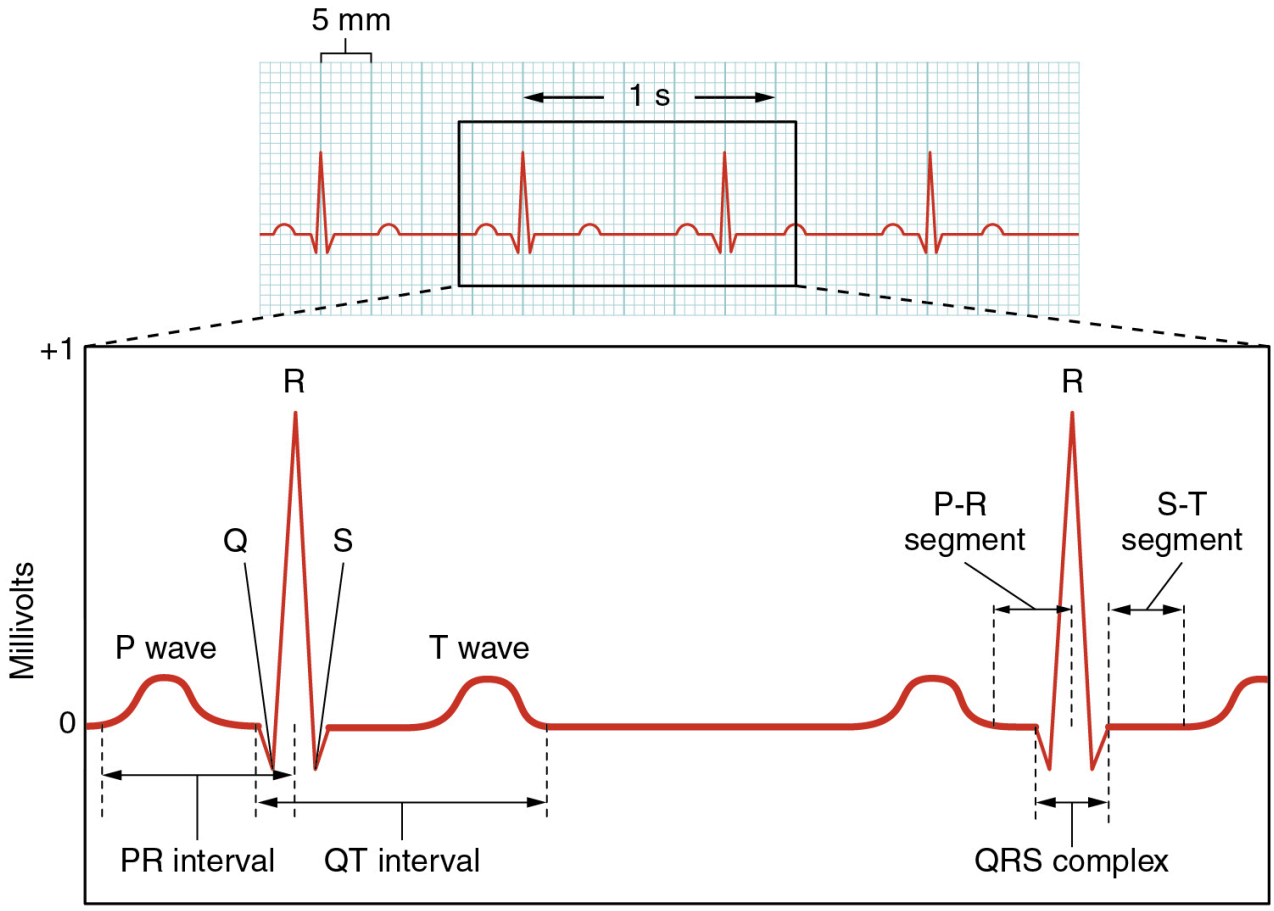

Figure 6.5 Components of an ECG Reading

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 of 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, which is the portion of the blood that is pumped or ejected from the heart with each contraction.

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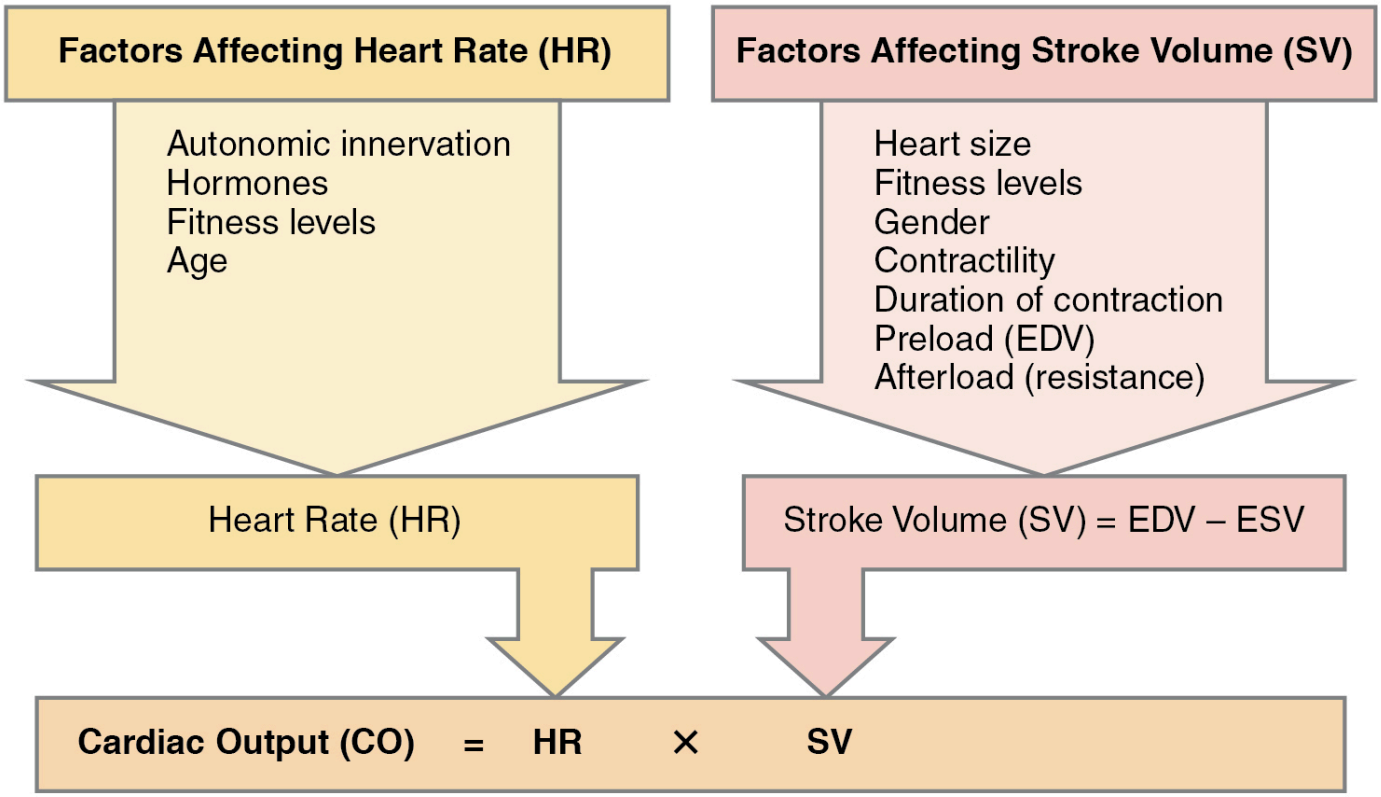

Figure 6.6 Factors Affecting Cardiac Output

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 the resting rate drops below 60 bpm, and tachycardia is the condition in which the resting rate is above 100 bpm.

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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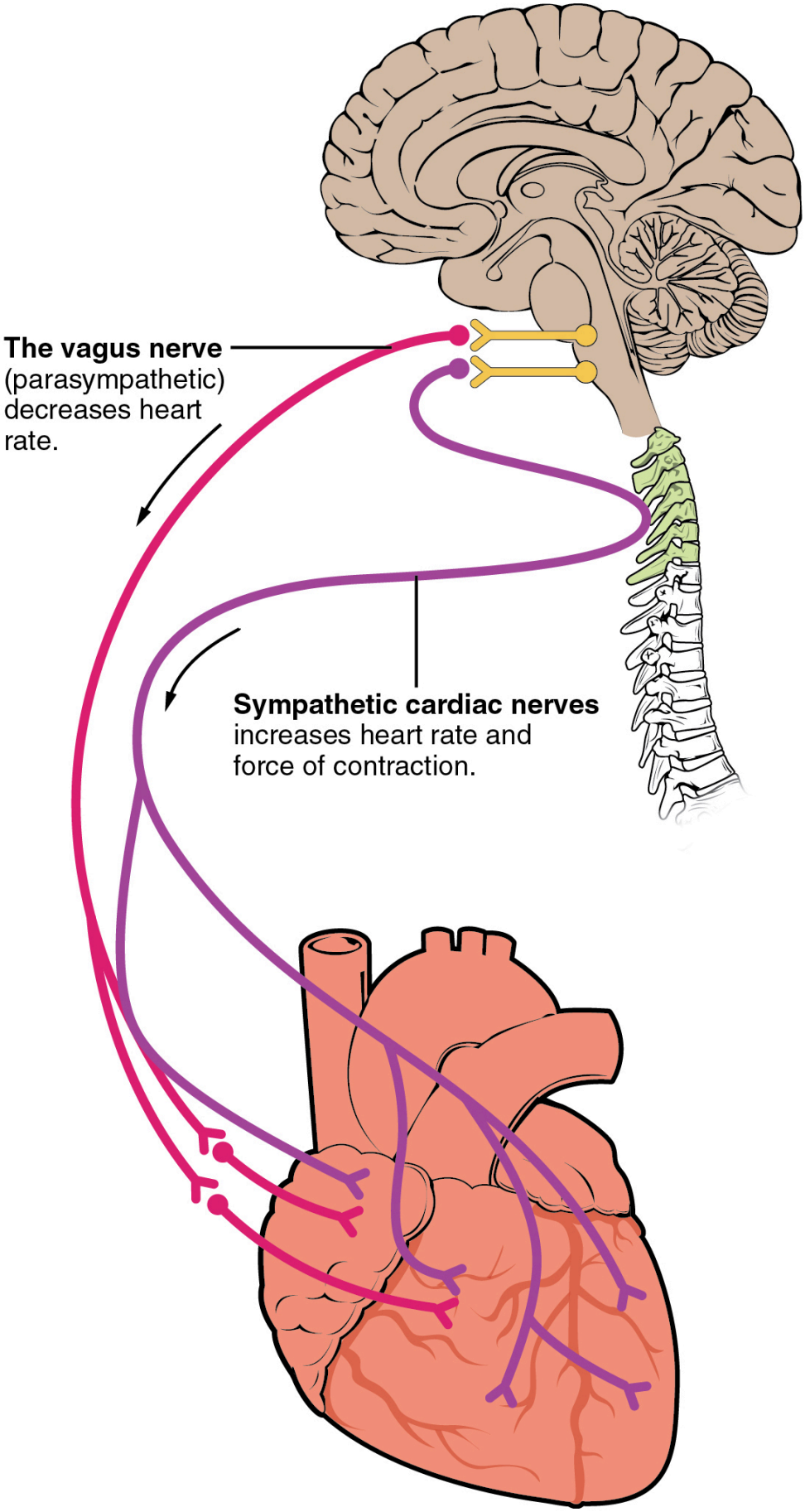
The vagus nerve (parasympathetic) decreases heart rate.
Sympathetic cardiac nerves increases heart rate and force of contraction.

Figure 6.7 ANS Heart Stimulation 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.[17]

Contractility

Contractility refers to the force of the contraction of the heart muscle, which controls SV. Factors that increase contractility are described as **positive**

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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.[18]

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[19] summarizes the major factors influencing cardiac output. Calcium channel blockers such as amlodipine, verapamil, nifedipine, and diltiazem can be used to reduce afterload and thus increase cardiac output.[20]

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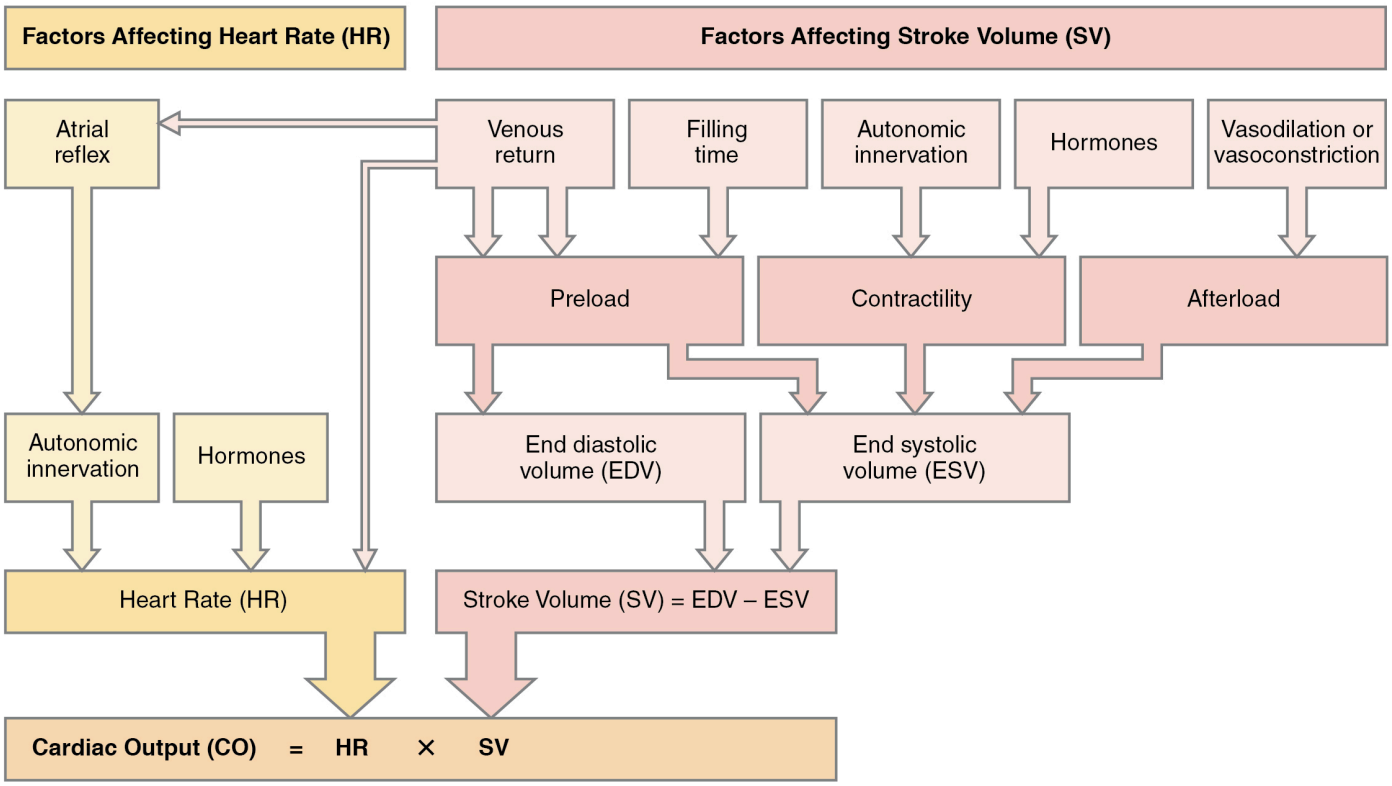

Figure 6.8 Factors Affecting Cardiac Output

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 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.[21]

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 presence of excess tissue fluid around the cells leads to a condition called **edema**. See Figure 6.9[22] for an image of a client with pitting edema.

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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.[23]

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 millimeters of mercury (mm Hg) and is typically obtained using a sphygmomanometer (a blood pressure

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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 "Cardiac Output" section 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.[24]

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 rest or activity. Three homeostatic mechanisms ensure adequate blood flow and, ultimately, perfusion of tissues: neural, endocrine, and autoregulatory mechanisms.[25]

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,

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carbon dioxide, and hydrogen ions (pH). When the cardiovascular center in the brain receives this input, it triggers a reflex that maintains homeostasis.[26]

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.[27]

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 flight-or-fight responses and redirecting blood flow to the liver, muscles, and heart.[28]

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.[29]

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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 circulates in the blood and is then converted into 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[30] for a summary of the effect of hormones involved in renal control of blood pressure.[31]

30. "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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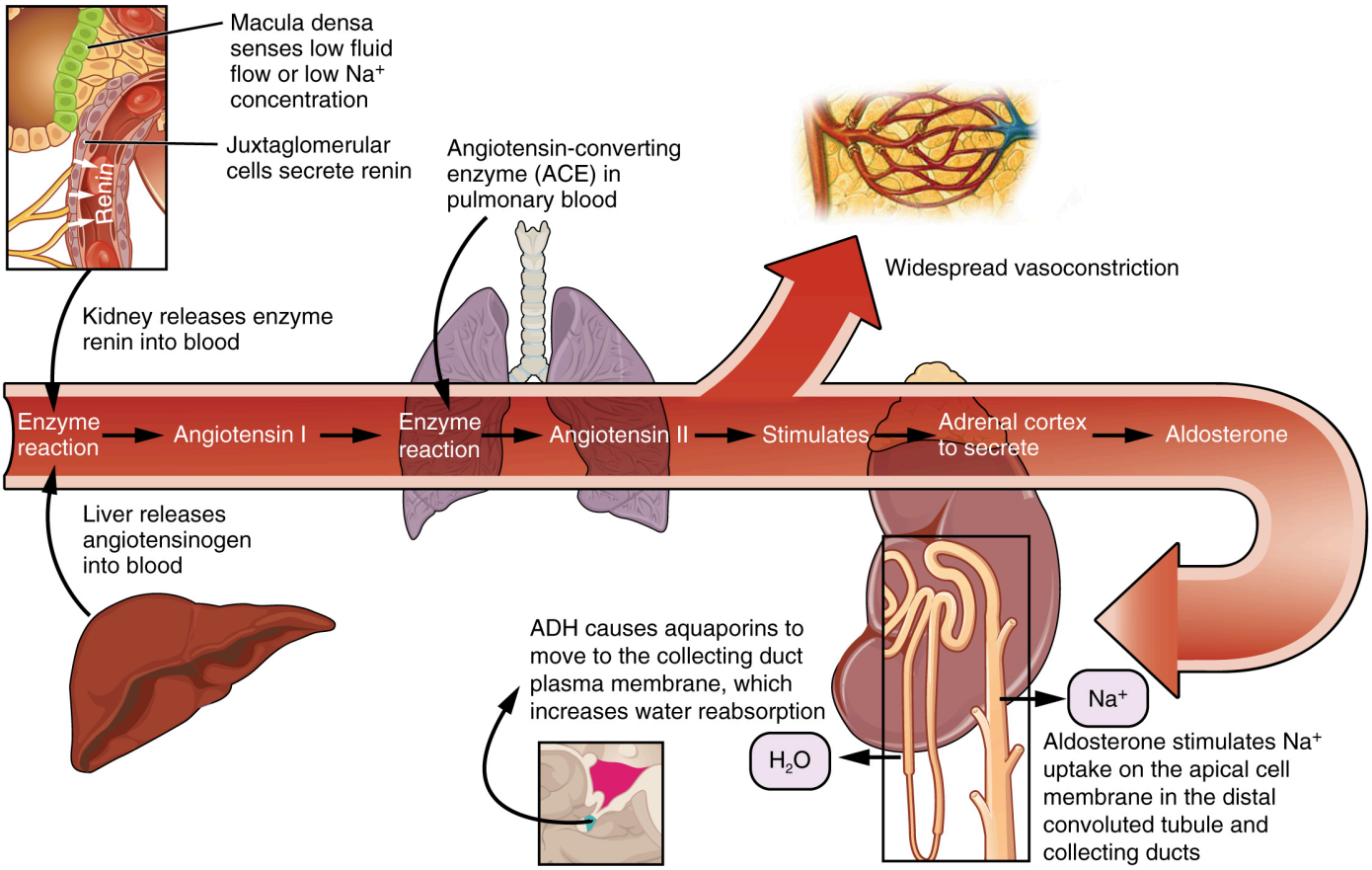

Figure 6.10 Renin-Angiotensin-Aldosterone System

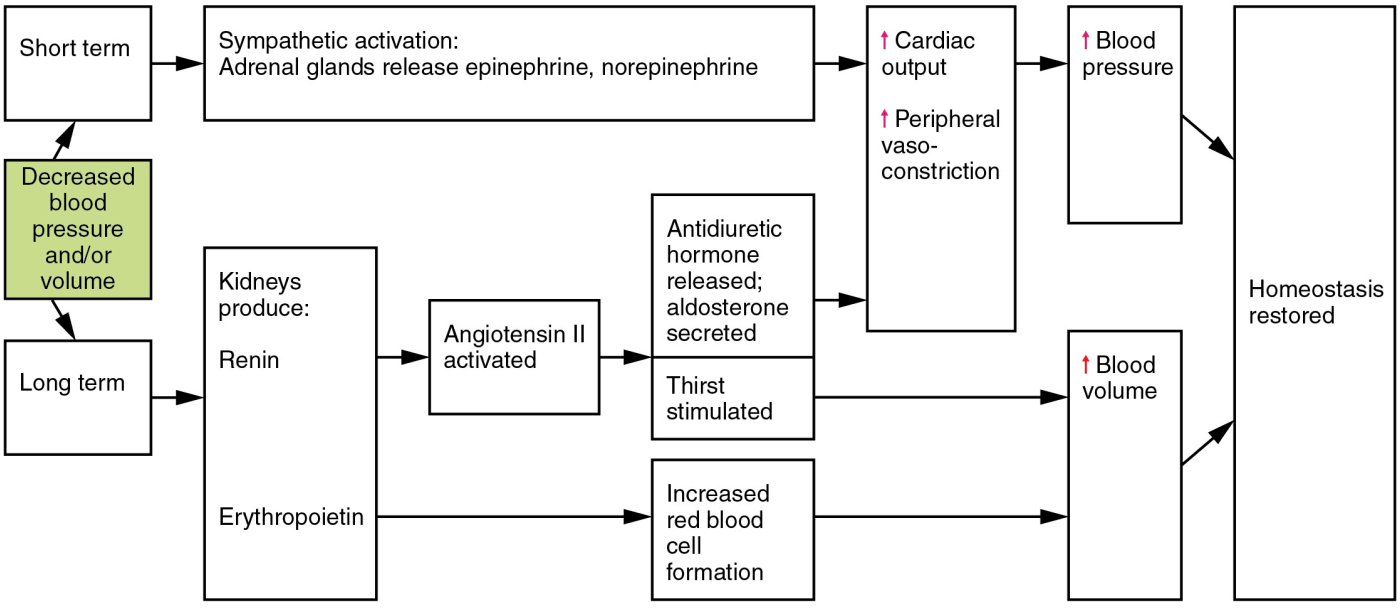

Figure 6.11 Hormones Involved in Renal Control of Blood Pressure

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 Table 6.2 for a summary of these factors and their effects.[32]

Table 6.2 Effects of Nervous, Endocrine, and Local Controls on the Vasoconstriction and Vasodilation of Arterioles

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Control	Factor	Vasoconstriction	Vasodilation
Neural	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
Endocrine	Epinephrine	Similar to sympathetic stimulation for extended flight-or-fight 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
Other Factors	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	n/a	Vasodilation
	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. Nephrons filter the blood and modify 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).[33]

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 efferent

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arterioles.[34] See Figure 6.12[35] for an illustration of blood flow through the kidney and nephrons.

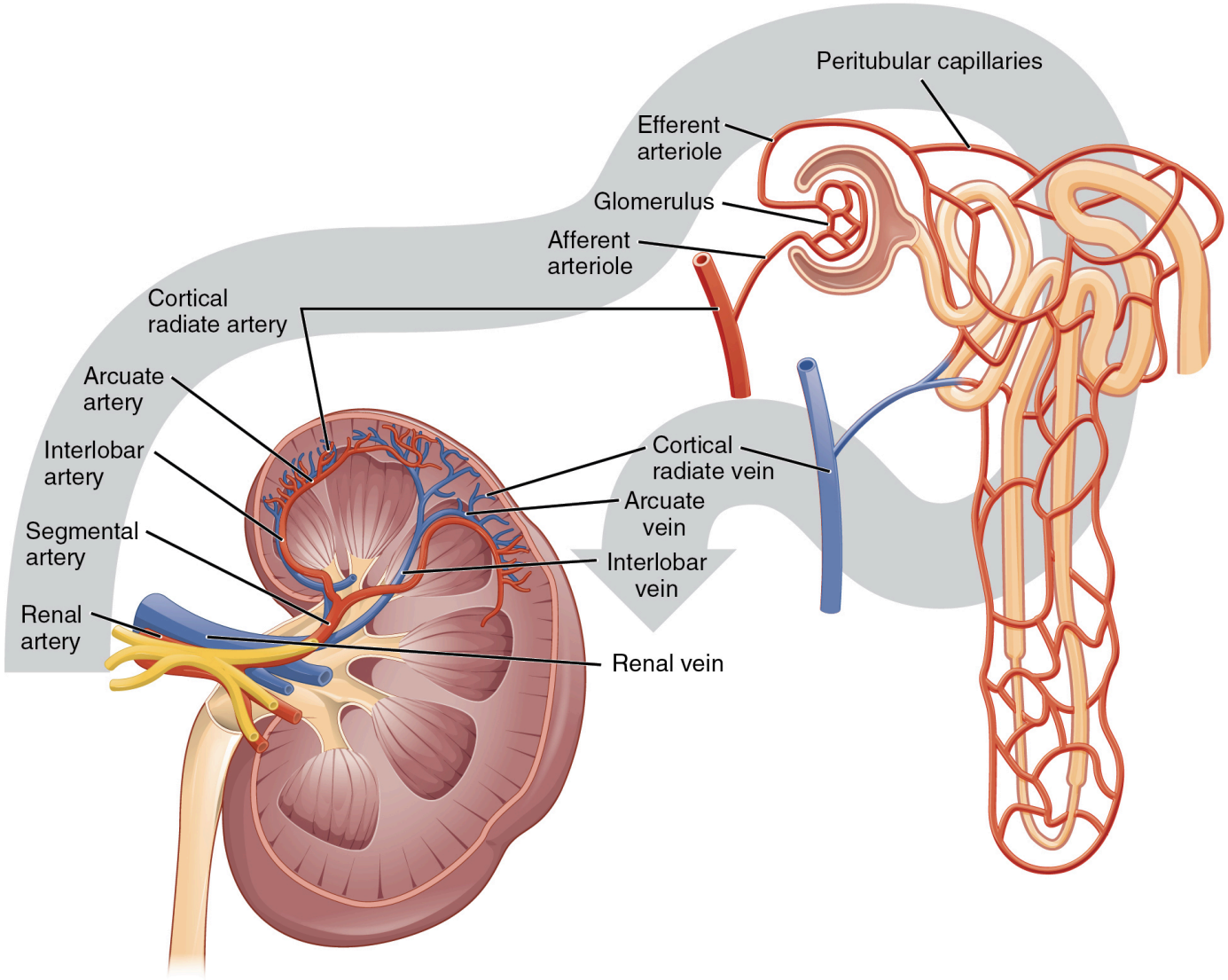

Figure 6.12 Blood Flow Through Kidney and Nephrons

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.

34. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 443-454. Elsevier.
35. "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 6.13[36] 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 filtered 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.[37]

36. "Figure 41 03 04.jpg" by CNX OpenStax is licensed under CC BY 4.0
37. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 443-454. Elsevier.

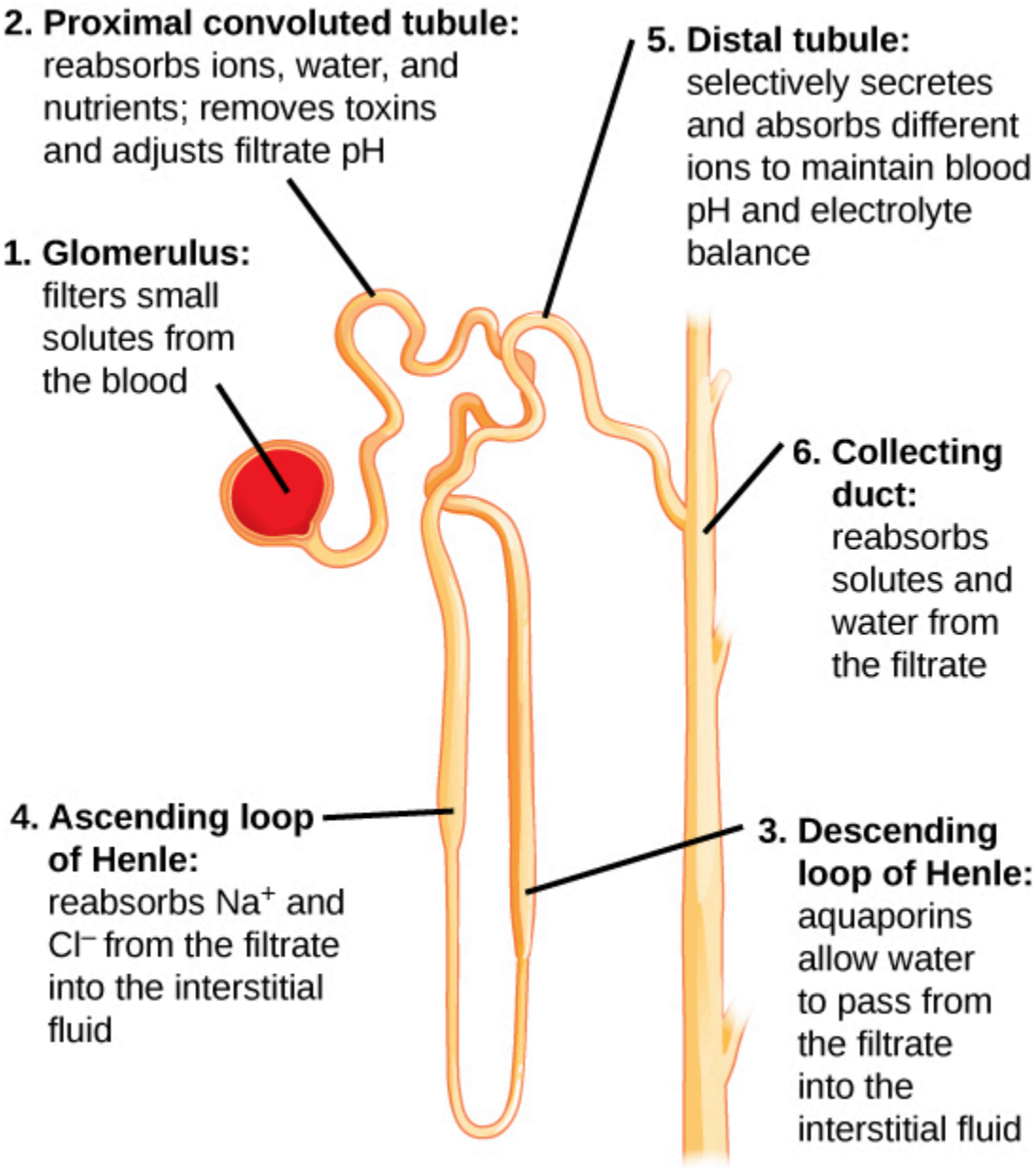

Figure 6.13 Nephron Structure

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).[38]

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.[39]

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.[40]

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39. 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
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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. These are some of the substances released by the platelets:

- 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.[41]

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 multilevel 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 6.14[42] summarizes the three steps of hemostasis when an injury to a blood vessel occurs. First,

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42. "1909 Blood Clotting.jpg" by OpenStax College is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/18-5-hemostasis

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.[43]

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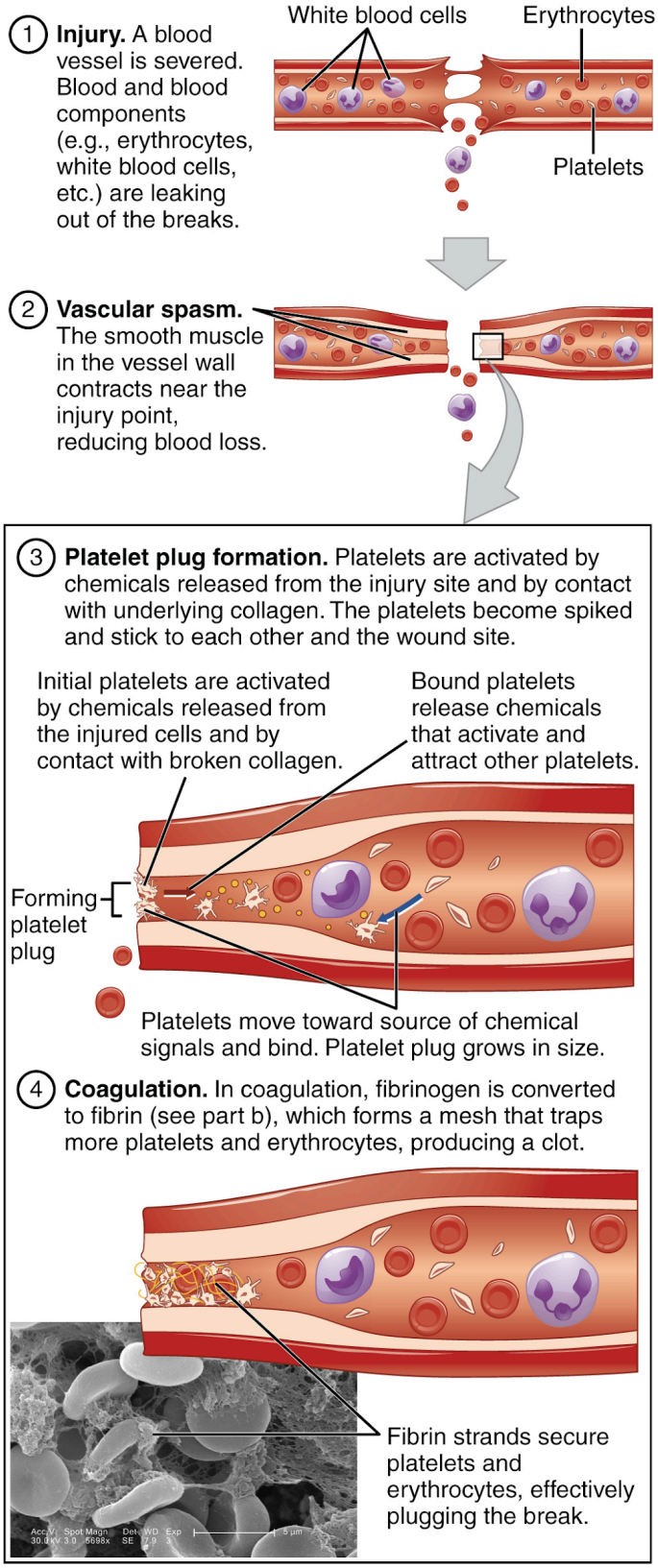
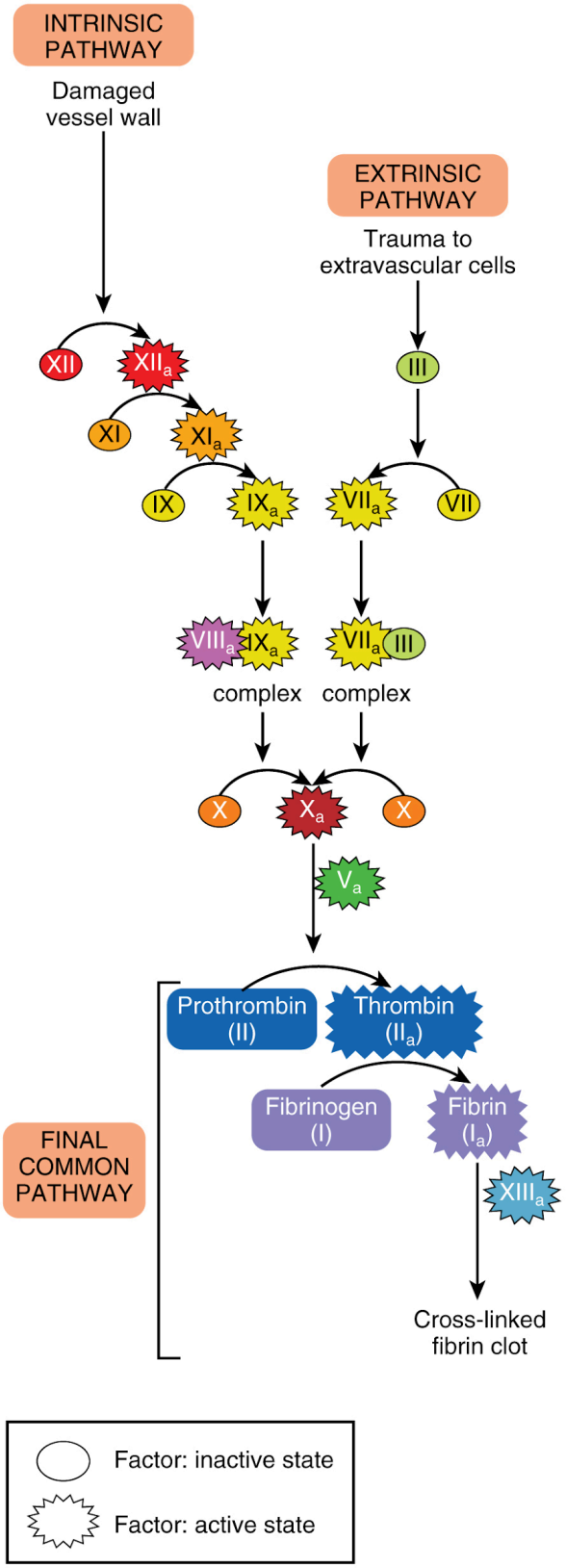


(a) The general steps of clotting



(b) Fibrin synthesis cascade

Figure 6.14 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.[44]

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.[45]

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.[46]

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

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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.[47]

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

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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 known as thrombolytic agents are 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.[48]

See the supplementary YouTube videos below for a review of the basic anatomy and physiology concepts of the cardiovascular and renal systems.

Blood Vessels[49]

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49. Forciea, B. (2018, April 26). *Structure of arteries and veins V2* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/HZAeua5JbrU

Muscle Contraction[50]

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Fluids and Electrolytes: Potassium and Aldosterone[51]

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Fluid and Electrolytes: Sodium[52]

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50. Forciea, B. (2016, September 14). *Muscle contraction physiology* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/TB7TypeksGk
51. Forciea, B. (2017, April 26). *Fluids and electrolytes potassium* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/SNAiGaaYkvs
52. 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[53]

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The Blood[54]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=251#oembed-6

Anatomy of Urinary System[55]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=251#oembed-7

53. Forciea, B. (2015, May 20). *Anatomy of the heart (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/d8RSvcc8koo
54. Forciea, B. (2015, May 19). *Anatomy and physiology: The blood* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/bjfcOSoDSzg
55. Forciea, B. (2015, May 13). *Urinary system anatomy (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/2Wd45Zmq_Ck

Renin-Angiotensin System[56]

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Introduction to ECG[57]

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Circulatory System Anatomy[58]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=251#oembed-10

56. 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
57. 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
58. Forciea, B. (2015, May 12). *Circulatory system anatomy (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/nBSHhkOEKHA

6.3 Common Cardiovascular Disorders

Now that we have reviewed the basic anatomy and physiology concepts of the cardiovascular and renal system, let's review common cardiovascular disorders.

Hyperlipidemia

Cholesterol is a fat (also called a lipid) that your body needs to work properly. However, too much bad cholesterol can increase the risk for heart disease, stroke, and peripheral vascular disease. The medical term for high blood cholesterol is **hyperlipidemia**. There are many types of cholesterol (see Figure 6.15 for basic types of cholesterol[1]).

- **Total cholesterol:** All the cholesterols combined
- **High-density lipoprotein (HDL) cholesterol:** Often called "good" cholesterol because it promotes the excretion of cholesterol. Exercise helps to increase HDL and remove cholesterol from the bloodstream
- **Low-density lipoprotein (LDL) cholesterol:** Often called "bad" cholesterol because it stores cholesterol in the bloodstream, which contributes to atherosclerosis

1. "máu nhiễm mỡ - cholesterol" by LÊ VĂN THẢO is licensed under CC BY-SA 2.0

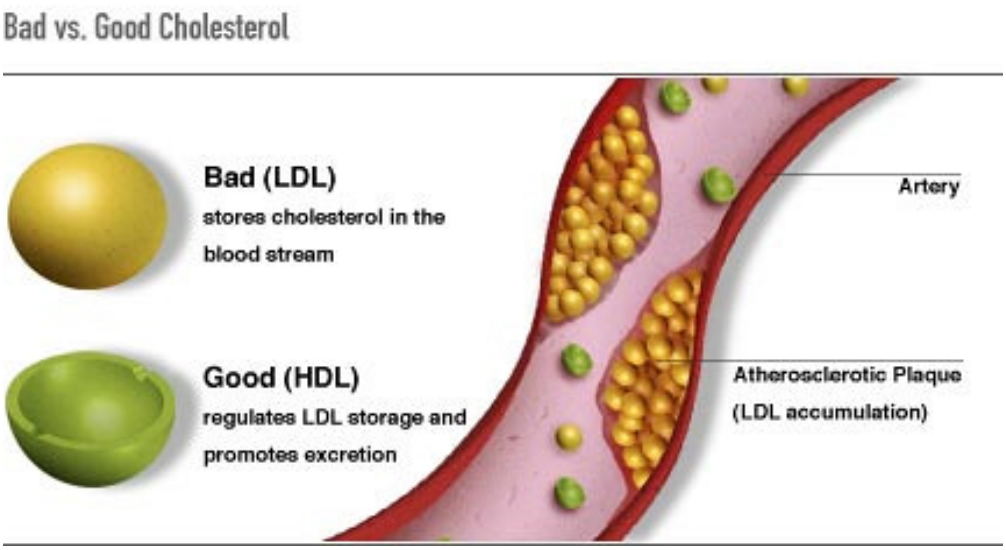

Figure 6.15 Comparison of LDL (bad cholesterol) and HDL (good cholesterol)

For many people, abnormal cholesterol levels are partly due to lifestyle choices, including a diet that is high in fat, being overweight, or lack of exercise. However, disorders can also be hereditary (i.e., passed down through families) that lead to abnormal cholesterol and triglyceride levels.[2] In addition to lifestyle modifications such as a low-fat diet and exercise, hyperlipidemia is treated with antilipidemic medication such as atorvastatin to help prevent long-term complications.

Hypertension

Chronically elevated blood pressure is known clinically as hypertension. High blood pressure is treated with lifestyle changes and medication. The American Heart Association guidelines state that hypertension should be treated at 130/80 mm Hg rather than the previous standard of 140/90 mm

2. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c2019. High blood cholesterol levels; [reviewed 2018 February 22; updated 2018 March 28; cited 2019 November 29]. https://medlineplus.gov/ency/article/000403.htm

Hg.[3] See Figure 6.16[4] for an image of a health care professional obtaining an accurate blood pressure reading that will be used to determine a treatment plan for the client.



Figure 6.16 Accurate Blood Pressure Measurement is Critical for Treating Hypertension

About 68 million Americans currently suffer from hypertension. Unfortunately, hypertension is often a silent disease, 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

3. Whelton, P. K., Carey, R. M., Aronow, W. S., et al. (2018). 2017 Guideline for high blood pressure in adults. *Journal of the American College of Cardiology, 71*. https://www.acc.org/latest-in-cardiology/ten-points-to-remember/2017/11/09/11/41/2017-guideline-for-high-blood-pressure-in-adults
4. "Monthly check up" by Bryan Mason is licensed under CC BY 2.0

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 (heart attack), chronic kidney disease, or heart failure.[5]

Many cardiovascular medications are commonly used to treat hypertension such as diuretics, ACE inhibitors, beta-blockers, and calcium channel blockers.

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. See Figure 6.17[6] for an image of a client experiencing typical symptoms of a DVT, including unilateral edema and redness.[7]

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6. This work is a derivative of "Deep vein thrombosis of the right leg.jpg" by James Heilman, MD licensed under CC BY-SA 3.0
7. 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



Figure 6.17 Typical Signs of 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) or otherwise known as a stroke, or a pulmonary embolism. These are medical emergencies.

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.[8]

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. 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. See Figure 6.18[9] for an illustration of atherosclerosis.[10]

8. 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
9. "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
10. 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

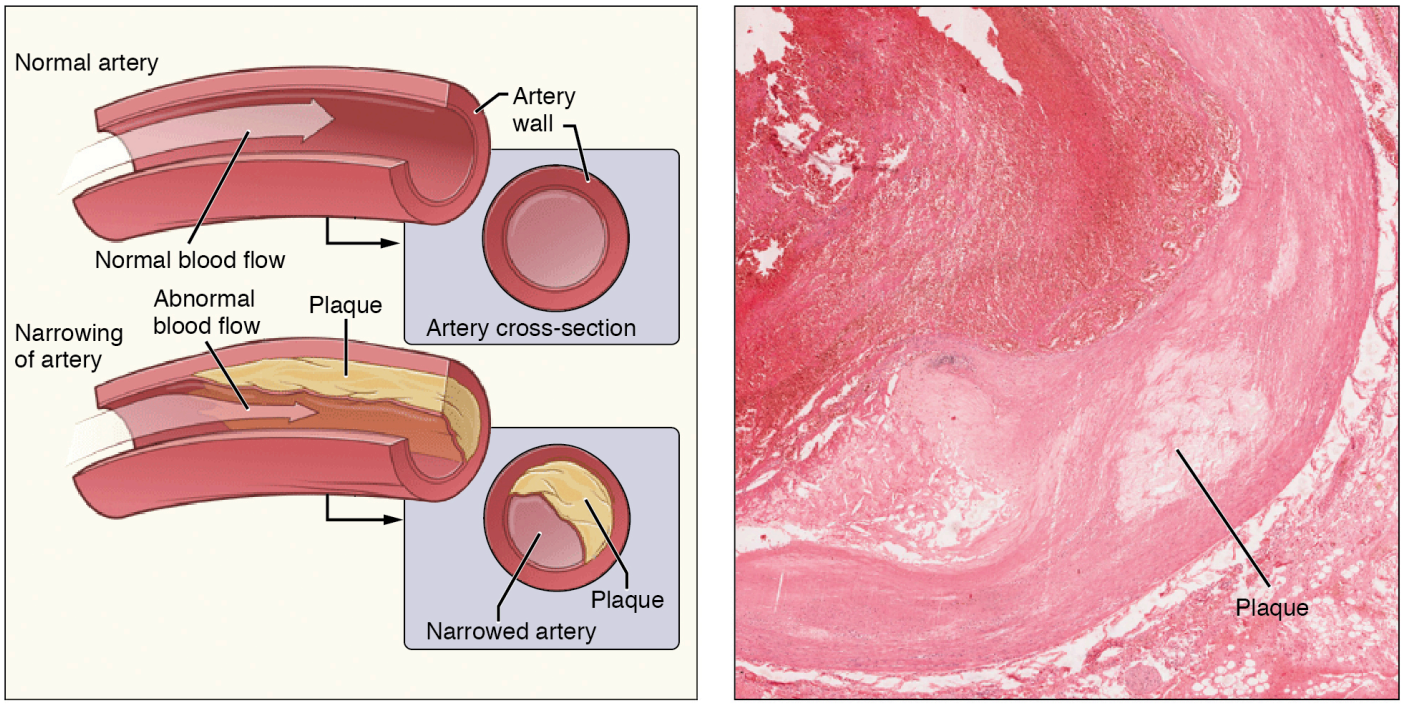

Figure 6.18 Atherosclerosis

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 medications such as atorvastatin are prescribed to reduce cholesterol and help prevent atherosclerosis.

Coronary Artery Disease

Coronary artery disease is the leading cause of death worldwide. It occurs when atherosclerosis within the walls of the coronary arteries obstructs blood flow. As the coronary blood vessels become blocked with plaque, the flow of blood to the tissues is restricted, causing the cardiac cells to receive insufficient amounts of oxygen, which can cause pain called angina. Figure 6.19[11] shows the blockage of coronary arteries highlighted by the injection of dye. Some individuals with coronary artery disease report pain radiating from the chest called angina, but others, especially women, may remain asymptomatic or have alternative symptoms of neck, jaw, shoulder, upper back, or abdominal pain. If untreated, coronary artery disease can lead to a **myocardial infarction** (heart attack). Risk factors include smoking, family history, hypertension, obesity, diabetes, lack of exercise, stress, and hyperlipidemia. Treatments may include medication, changes to diet and exercise, a coronary angioplasty with a balloon catheter, insertion of a stent, or coronary bypass procedure.[12]

11. "2016 Occluded Coronay Arteries.jpg" by OpenStax College is licensed under CC BY 3.0
12. 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

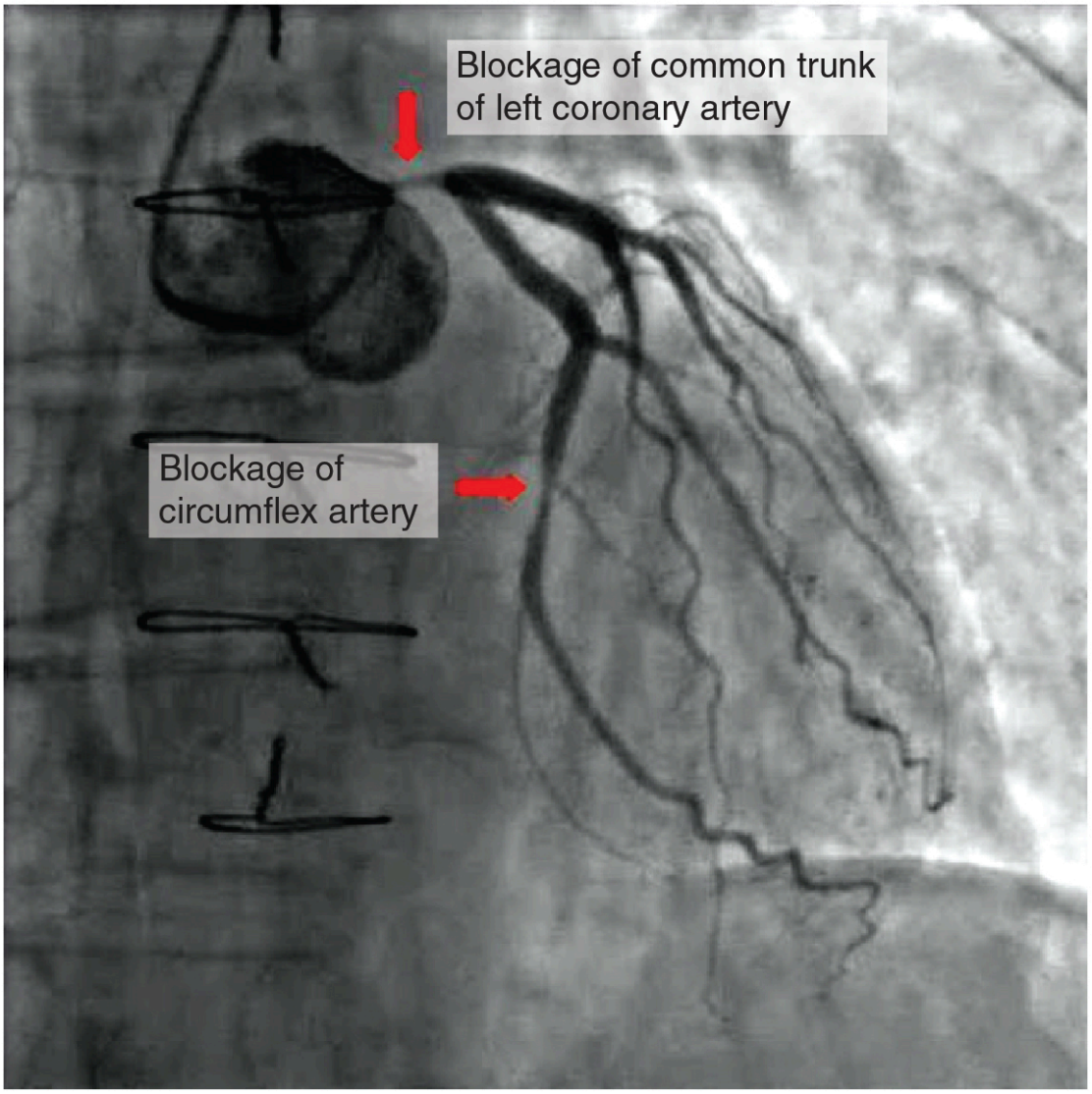

Figure 6.19 Blocked Coronary Arteries Highlighted by Injection of Dye During Coronary Angiogram

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, resulting in death of the cardiac muscle cells. An MI often occurs when a coronary artery is blocked by the 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.

In the case of acute MI, there is often sudden pain beneath the sternum (retrosternal pain) called angina, often radiating down the left arm in male clients, but not as commonly in female clients (see Figure 6.20).[13] In addition, clients typically present with difficulty breathing and shortness of breath (dyspnea), irregular heartbeat (palpitations), nausea and vomiting, sweating (diaphoresis), anxiety, and fainting (syncope), although not all of these symptoms may be present. Many of the symptoms are shared with other medical conditions, including anxiety attacks and simple indigestion, so accurate diagnosis is critical for survival.

An MI can be confirmed by examining the client's ECG, which frequently reveals alterations in the ST and Q components. Immediate treatments for MI are required and include administering supplemental oxygen, aspirin, and nitroglycerin. Longer-term treatments may include injections of thrombolytic agents such as tPA that dissolve the clot, along with 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.[14]

13. "A man having a Heart Attack.png" by https://www.myupchar.com/en is licensed under CC BY-SA 4.0
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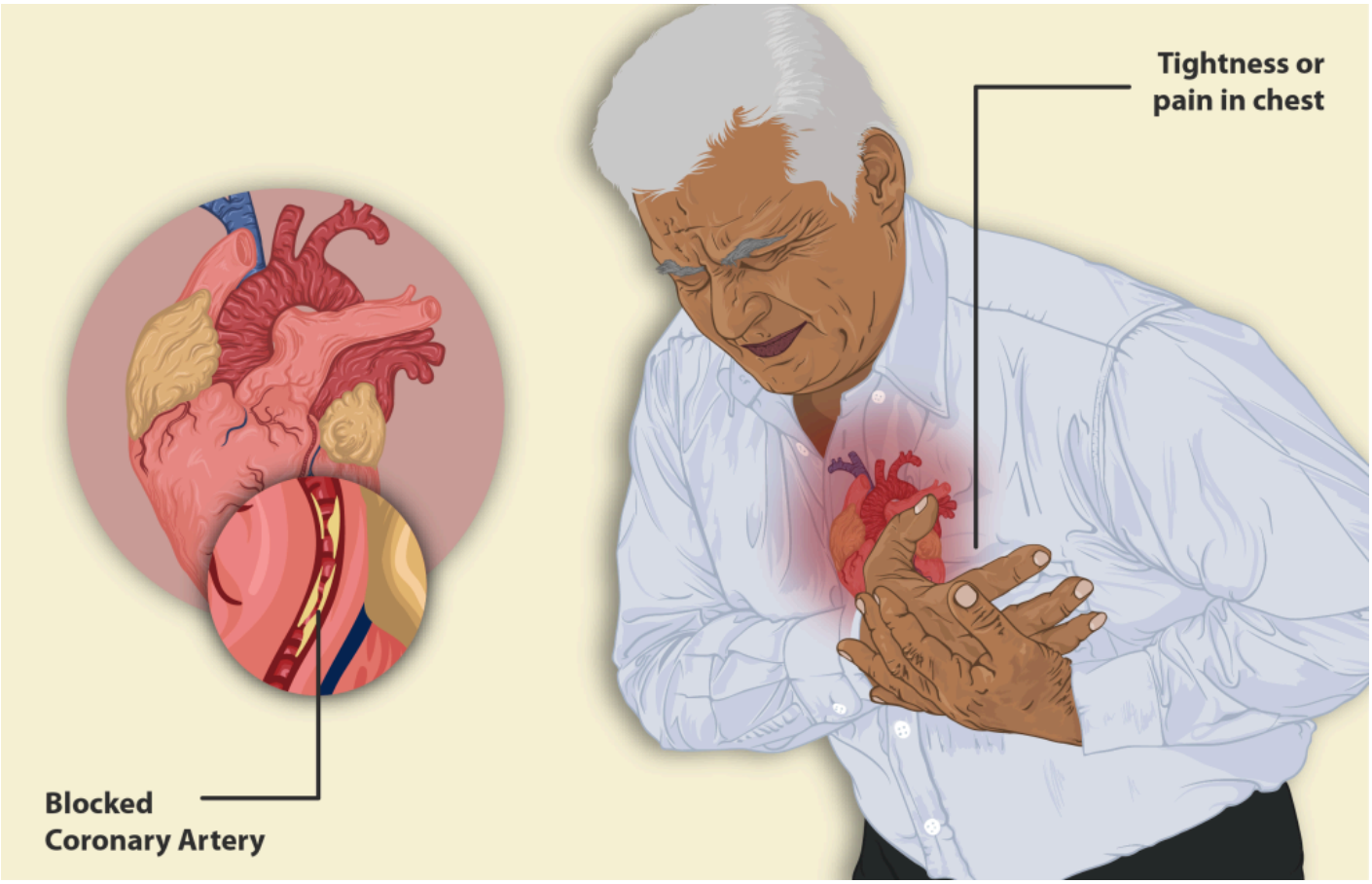

Figure 6.20 Males Often Describe Chest Pain Associated With MI "Like Something is Sitting on my Chest"; Females May Simply Have GI Upset

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 that then move to the brain. When blood flow is interrupted, even for just a few seconds, a **transient ischemic attack (TIA)**, or ministroke, 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)**.[15] 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 6.21).[16] 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.[17] Ischemic strokes are often treated with thrombolytic medication such as tPA to dissolve the clot, whereas hemorrhagic strokes often require surgery to stop the bleeding.

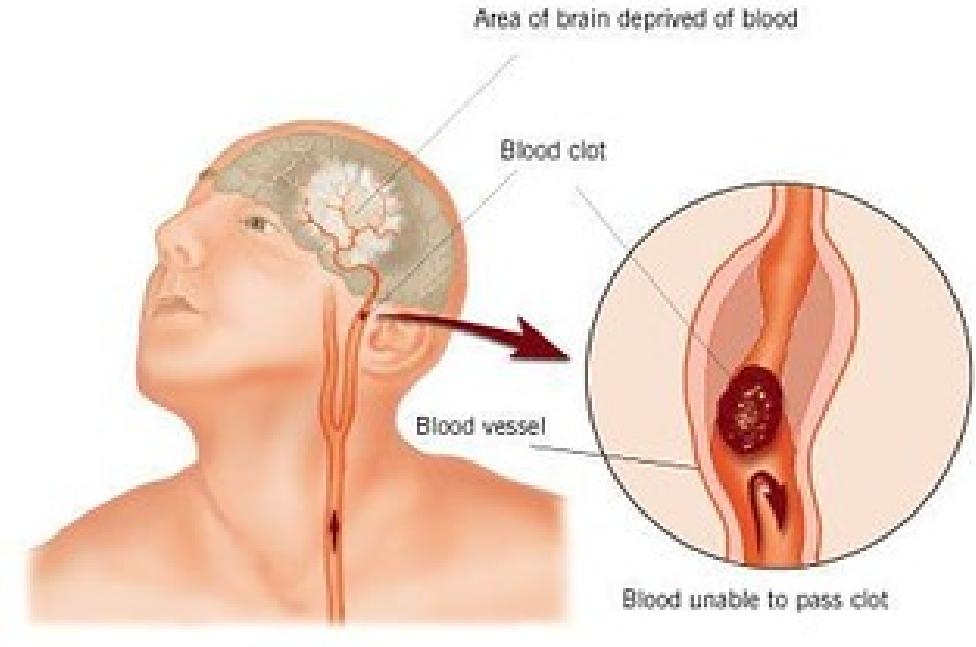

Figure 6.21 Ischemic Stroke

Arrhythmias

Occasionally, an area of the heart other than the SA node will initiate an

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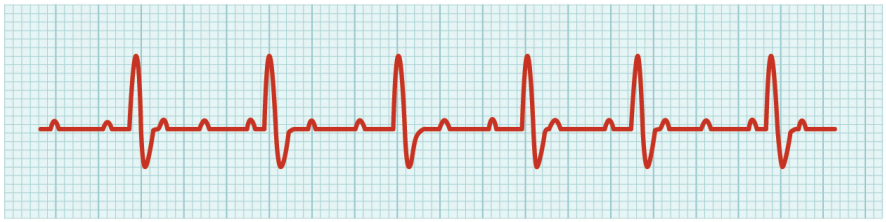
16. "Stroke Diagram" by ConstructionDealMkting is licensed under CC BY 2.0
17. Anderson, P., & Townsend, T. (2015). Preventing high-alert medication errors in hospital patients. *Nurse Today, 10*(5). https://www.americannursetoday.com/wp-content/uploads/2015/05/ant5-CE-421.pdf

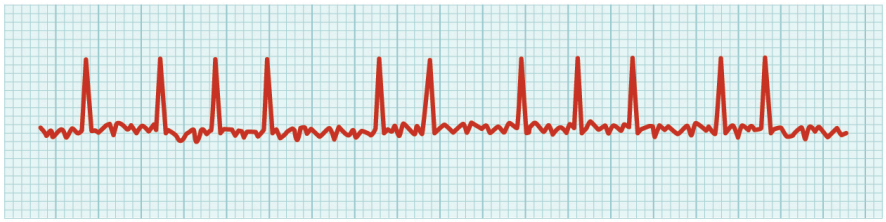
impulse that will be followed by a premature contraction. Such an area is known as an ectopic focus. An ectopic focus may be stimulated by localized ischemia, exposure to certain drugs, elevated stimulation by both sympathetic or parasympathetic divisions of the autonomic nervous system, or several diseases 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 6.22.[18] Anti-arrhythmic medications such as sotalol, diltiazem, and amiodarone are used to treat arrhythmias.

18. "Common ECG Abnormalities" by CNX OpenStax 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



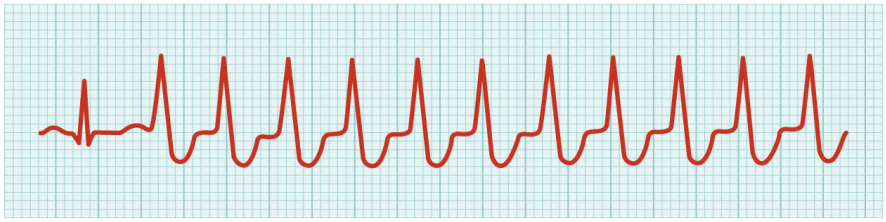
(a) Second-degree (partial) block

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)?



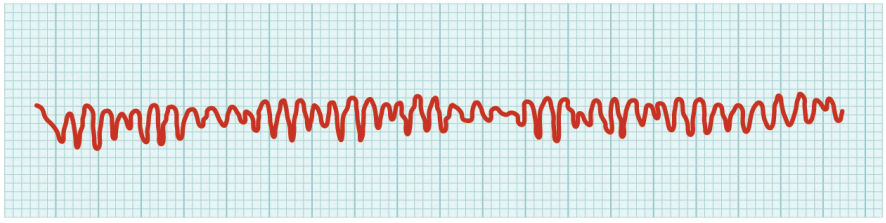
(b) Atrial fibrillation

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)?



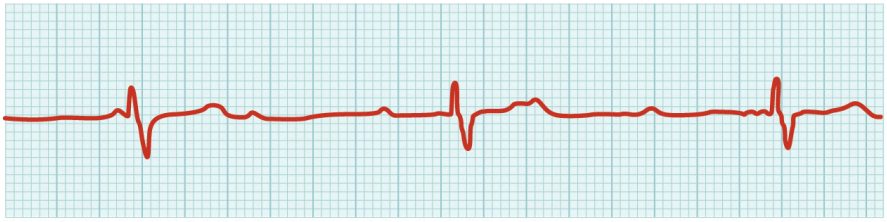
(c) Ventricular tachycardia

Note the unusual shape of the QRS complex, focusing on the "S" component.
Question: What would you expect to happen to heart rate (pulse)?



(d) Ventricular fibrillation

Note the total lack of normal electrical activity.
Question: What would you expect to happen to heart rate (pulse)?



(e) Third-degree block

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)?

Figure 6.22 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 is a condition in which the heart can't pump enough blood to meet the body's needs. Right-side heart failure occurs if the heart can't pump enough blood to the lungs to pick up oxygen, whereas left-side heart failure occurs if the heart can't pump enough oxygen-rich blood to the rest of the body. Heart failure is a very common condition with over 5.7 million people in the United States having this chronic condition. There is no cure, but the symptoms can be managed for several years with lifestyle modifications and several different types of medications. Causes of heart failure include hypertension, myocardial infarction, and other cardiac and respiratory diseases. Common symptoms of heart failure include peripheral edema and shortness of breath that occur as a result of fluid overload. Many clients are treated with diuretics to manage the symptoms of fluid overload and with antihypertensives to manage the blood pressure. Other medications such as digoxin and dobutamine may also be used to increase the contractility of the heart.[19]

19. National Heart, Lung, and Blood Institute, National Institutes of Health. (2019). *Heart failure*. https://www.nhlbi.nih.gov/health-topics/heart-failure

6.4 Applying the Nursing Process to Administering Cardiovascular and Renal Medications

Assessment

Understanding the mechanism of action of cardiovascular medications helps the nurse anticipate appropriate pre- and post-administration assessments to perform on a client. Before administering cardiovascular medications, nurses complete a focused cardiac assessment to establish the client‘s current health status. Based on this baseline status, the client is monitored for effectiveness of the medication, as well as for any adverse effects.

Many cardiovascular medications, such as antiarrhythmics, cardiac glycosides, antihypertensives, or diuretics, alter a client‘s blood pressure or heart rate. Therefore, the nurse assesses a client‘s blood pressure and heart rate prior to administration. Medication parameters are often included in the order by a health care provider. For example, a common medication parameter is to hold a beta-blocker if a client‘s heart rate is less than 60 beats per minute. Additionally, anti-arrhythmic medication will alter the electrical conduction of the heart, so intermittent or continuous ECG monitoring may be required during initial therapy or dose changes.

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 a life-threatening arrhythmia.

Monitoring kidney function is also important when administering many cardiovascular medications. For example, diuretics can injury the kidneys. A nurse should be aware of cardiovascular medications that are affected by impaired kidney function or cause injury to the kidney. In addition, a nurse must appropriately assess and report abnormal kidney function laboratory values such as worsening serum creatinine and glomerular filtration rates (GFR). It is also important to assess for signs of dehydration, including fluid intake and output, for clients 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, such as blood in the urine or stool or bruises on the extremities. Laboratory values, such as INR, PT, 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 administering cardiovascular medication, it is vital for the nurse to determine if this specific 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.

Nurses must also consider the effect of the medication before administering it at the scheduled 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 medication should be rescheduled for after the procedure. A second example illustrating a significant safety concern is when a client who is scheduled for surgery is scheduled to receive an aspirin or anticoagulant. The nurse must communicate with the provider on which scheduled medications are appropriate to administer prior to upcoming procedures.

Evaluation

Nurses evaluate the client‘s response to a medication compared to what is expected. Nurses continue to monitor a client‘s blood pressure, heart rate, intake and output, edema, and other cardiac assessments to evaluate if cardiac medications are effective or if further treatment or dosage adjustment is required. The client is also continually monitored for potential adverse effects of medication, some of which can be life-threatening and require prompt notification to the prescribing provider.

Many medications require dose adjustments to produce the 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). Nurses are responsible for evaluating lab work results that impact the administration of medications.

Nurses also evaluate the client’s understanding of the purpose of cardiac medications and their proper use, as well as when their provider should be notified of new symptoms. Health teaching before discharge home is often required, especially if new medications are prescribed.

6.5 Cardiovascular and Renal System Medications

If you have not done so already, be sure to read the "Basic Concepts of the Cardiovascular and Renal Systems" section earlier in this chapter. To truly understand the mechanisms 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 the cardiovascular and renal systems.

6.6 Antiarrhythmics

An arrhythmia is any deviation from the normal rate or pattern of a heartbeat, including heart rates that are too slow (bradycardia), too fast (tachycardia), or irregular. The terms dysrhythmia (disturbed heart rhythm) and arrhythmia (absence of heart 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 "Basic Concepts of the Cardiovascular and Renal Systems" section and an overview of arrhythmias in the "Common Cardiovascular Disorders" section.

Anti-arrhythmic 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. All anti-arrhythmic medications have a risk of producing an arrhythmia. Some anti-arrhythmic medications are used during emergency situations such as cardiac arrest, whereas others are used long-term, such as those used to control atrial fibrillation. Monitoring electrolytes and the ECG patterns are very important assessments for the nurse administering these types of medications.

Class I – Sodium Channel Blockers

Class I anti-dysrhythmic 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. Quinidine 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: Quinidine slows conduction and prolongs depolarization by decreasing sodium influx into cardiac cells. The conduction rate and automaticity are decreased. This medication also has alpha-antagonistic properties that cause peripheral vasodilation.

Indications: This medication is typically used for life-threatening ventricular dysrhythmias such as ventricular tachycardia or for conversion of atrial fibrillation that has not responded to other therapy.

Nursing Considerations: Sodium channel blockers are contraindicated in clients who have a history of thrombocytopenia or myasthenia gravis. 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. Grapefruit and sour orange juice should be avoided by clients taking this medication.

Side Effects/Adverse Effects: Quinidine may prolong QT interval leading to ventricular arrhythmias, such as ventricular tachycardia or torsades de pointes. There is an increased risk for toxicity with clients who have heart failure and renal or hepatic dysfunction due to drug accumulation. This medication's safety has not been thoroughly evaluated in children and geriatric clients.

Quinidine may induce thrombocytopenia. Routine lab work may be evaluated by a client's health care provider. Common side effects of this medication are nausea, vomiting, diarrhea, fever, chills, abnormal ECG/arrhythmias, and headache.

In many research trials, use of anti-arrhythmic therapy for nonlife-threatening arrhythmias actually resulted in increased risk of death compared to placebo.[1]

Some antiarrhythmic medications may cause dizziness and may increase sensitivity to light.[2]

Health Teaching & Health Promotion: Clients should be instructed regarding the significance of compliance with therapeutic drug regimen and take medications as prescribed, even if not symptomatic. Clients or family members may need instruction on how to take pulse rate and parameters regarding reporting to their health care provider.

Now let's take a closer look at the medication grid for quinidine in Table 6.6a.[3] Medication grids are intended to assist students to learn key points about each medication class. Basic information related to a common generic

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2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

medication in this class is outlined, including administration considerations, therapeutic effects, and side effects/adverse effects. Prototype/generic medication listed in the medication grid is also linked directly to a free resource from the U.S. National Library of Medicine called DailyMed. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Table 6.6a Quinidine Medication Grid

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antiarrhythmic Class I	quinidine	Monitor blood pressure, heart rate, and QT with administration Avoid grapefruit juice Maintain consistent sodium intake Health care provider should review medications, as this medication may interact with many medications	Control supraventricular arrhythmias	Lengthen the QT interval, arrhythmia, dizziness, and headache Thrombocytopenia GI: Nausea, diarrhea, and vomiting

Class II – Beta-Blockers

Class II medications are beta-blockers that are used to decrease conduction velocity, automaticity, and the refractory period of the cardiac conduction

cycle. Read additional information about beta-blockers in the "Autonomic Nervous System" chapter.

Sotalol is a Beta-1 and Beta-2 blocker that also has Class III anti-arrhythmic properties. Recall that other types of beta-blockers, such as metoprolol, are also used to treat hypertension. See the "Antihypertensives" section later in this chapter for more information about the use of beta-blockers to treat hypertension.

Mechanism of Action: Sotalol is a nonselective beta-adrenergic blocker that prolongs the cardiac action potential.

Indications: Sotalol is given to clients for life-threatening arrhythmias, such as ventricular arrhythmias or supraventricular arrhythmias. It is only recommended for clients with severe arrhythmias.

Nursing Considerations: Titration of this medication is done by evaluating renal function and monitoring QTc on the ECG 2-4 hours after each medication upon initiation. Clients with decreased renal function require dosage adjustment. Sotalol is contraindicated for clients with decreased serum potassium, bradycardia, 2nd- or 3rd-degree heart block, heart failure, and conditions leading to bronchospasm.

Side Effects/Adverse Effects: Common side effects for sotalol are arrhythmias, chest pain, palpitations, fatigue, dizziness, hypotension, bradycardia, heart failure, cardiac ischemia, bronchospasm, thyroid abnormalities, and hypoglycemia.[4]

Boxed Warning: 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.

Health Teaching & Health Promotion: Clients should be instructed regarding the significance of compliance with therapeutic drug regimen and 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 health care

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provider. They should report any pulse rate less than 50 bpm and significant changes in blood pressure.

Clients should also be advised that these medications 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. If the client notices irregular, fast heart rate or experiences any fainting episodes, they should notify their health care provider immediately.

Additionally, these medications may also mask the signs of hypoglycemia, so diabetic clients must use extra caution to monitor for low blood sugar. They may also increase cold sensitivity.[5]

Now let's take a closer look at the medication grid for sotalol in Table 6.6b.[6]

Table 6.6b Sotalol Medication Grid

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antiarrhythmic Class 2	sotalol	Boxed Warning: Drug-induced arrhythmias Strict QTc monitoring with initiation of therapy Do not double dose Monitor blood pressure and heart rate	Treatment of life-threatening arrhythmias	Arrhythmias due to lengthening QTc Chest pain, palpitations, dizziness, fatigue, hypotension, heart failure, cardiac ischemia, and bradycardia Bronchospasm Thyroid abnormalities Hypoglycemia

5. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
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Critical Thinking Activity 6.6

What should a nurse assess before and after administration of sotalol?

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

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 ventricular dysrhythmias. Amiodarone is an example of an antidysrhythmic that has predominantly Class III properties.

Mechanism of Action: Class III medications prolong repolarization by blocking the potassium channels in cardiac cells that are responsible for repolarization. Amiodarone also antagonizes alpha- and beta-receptors.

Indications: Amiodarone is indicated only for the treatment of life-threatening recurrent ventricular arrhythmias when these have not responded to documented adequate doses of other available antiarrhythmics or when alternative agents could not be tolerated.

Nursing Considerations: Amiodarone can cause fetal injury when administered to a pregnant client. Use cautiously with the geriatric population who may have decreased hepatic, cardiac, or renal function. Read drug label information carefully due to several potential drug interactions.

Side Effects/Adverse Effects: Neurological impairments (such as fatigue, tremors, involuntary movements, poor coordination, and gait) and GI disturbances are common adverse effects. Vision changes/loss of vision and photosensitivity may also occur.

Boxed Warning: 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. Neurological impairments (such as fatigue, tremors, involuntary movements, poor coordination, and gait) and GI disturbances are common adverse effects. Vision changes/loss of vision and photosensitivity may also occur.

Health Teaching & Health Promotion: 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 health care provider for guidance. Clients should be compliant with all follow-up appointments and monitoring.

Clients should avoid drinking grapefruit and sour orange juice during medication therapy. Some clients may experience photosensitivity and protective measures should be taken.[7]

Now let's take a closer look at the medication grid for amiodarone in Table 6.6c.[8]

Table 6.6c Amiodarone Medication Grid

7. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
8. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antiarrhythmic Class 3	amiodarone	Boxed Warning: Fatal toxicities Read drug label information due to several drug interactions Monitor blood pressure and heart rate for profound hypotension and bradycardia Initiation of therapy typically requires clients to be hospitalized to receive a loading dose	Treatment of life-threatening ventricular arrhythmia	Fatal toxicities Neurological impairments GI upset Worsening arrhythmia, bradycardia, and hypotension Thyroid abnormalities Vision changes Photosensitivity

Class IV – Calcium Channel Blockers

Class IV medications include the calcium channel blockers verapamil and diltiazem. These medications increase the refractory period of the AV node by slowing the influx of calcium ions, thus decreasing the ventricular response and decreasing the heart rate. These medications may be used to control heart rate associated with supraventricular tachycardias. Calcium channel blockers are also used to treat hypertension because they relax smooth muscle and cause vasodilation. See the "Antihypertensives" section later in this chapter for more information about their use in treating hypertension.

Mechanism of Action: Diltiazem inhibits calcium during depolarization to decrease the workload of the heart and increase oxygen supply to the myocardium. This medication will relax smooth muscle and decrease peripheral resistance.

Indications: Diltiazem is used to treat angina, hypertension, and supraventricular tachycardias.

Nursing Considerations: This medication is not given to hypotensive clients, clients with acute myocardial infarction, or clients with 2nd- or 3rd-degree heart block or sick sinus syndrome.

Side Effects/Adverse Effects: Diltiazem can potentially worsen signs and symptoms of heart failure due to the negative inotropic effect. Clients may experience bradycardia, worsening 1st-degree AV block, syncope, edema, hypotension, headache, dizziness, or hepatic injury.[9]

Health Teaching & Health Promotion: 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 and sour orange 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.[10]

Now let's take a closer look at the medication grid for diltiazem in Table 6.6d.[11]

Table 6.6d Diltiazem Medication Grid

9. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
10. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
11. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antiarrhythmic Class 4	diltiazem	Monitor blood pressure and heart rate	Reduce workload of the heart, increase oxygen to myocardium, and control heart rate	Worsening heart failure, hypotension, bradycardia, lower extremity edema, syncope, and worsening 1st-degree block Headache and dizziness Hepatic injury

Adenosine

Adenosine is a unique medication given to clients who are experiencing paroxysmal supraventricular tachycardia. It is given all at once as a bolus in either a 6- or 12-mg dose to slow electrical conduction to restore a normal sinus rhythm.

Mechanism of Action: Adenosine will slow conduction through the AV node to restore normal sinus rhythm.

Indications: Adenosine is used to treat paroxysmal supraventricular tachycardia.

Nursing Considerations: This medication is an emergent type of medication. Use cautiously with geriatric clients with decreased cardiac function.

This medication is contraindicated with clients who have 2nd- or 3rd-degree AV block, sinus node disease, or any known hypersensitivity.

At time of administration, a nurse may see no electrical activity on an ECG for a brief few seconds before normal sinus rhythm is restored. The client should be warned they may feel extremely uncomfortable during this short period of time.

Side Effects/Adverse Effects: Clients receiving adenosine may experience

prolonged asystole, arrhythmias, palpitations, facial flushing, hypotension, bronchospasm, shortness of breath, dizziness, seizures, loss of consciousness, numbness and tingling to upper extremities, and nausea.[12]

Health Teaching & Health Promotion: 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 abnormalities. 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 and sour orange 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.[13]

Now let's take a closer look at the medication grid for adenosine in Table 6.6e.[14]

Table 6.6e Adenosine Medication Grid

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13. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
14. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antiarrhythmic	adenosine	Place the client in a supine position and inject medication rapidly followed by saline flush	Restore normal sinus rhythm	Prolonged asystole, arrhythmias, palpitations, facial flushing, hypotension, bronchospasm, shortness of breath, and dizziness Seizures, loss of consciousness, numbness, and tingling to upper extremities Nausea

6.7 Cardiac Glycosides

Digoxin

Digoxin is a cardiac glycoside medication that has been used for centuries to treat heart failure. It 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 (decreases conduction of cardiac cells).[1]

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.[2]

Indications: This medication is used as second-line treatment for clients who have heart failure or atrial fibrillation. Due to the risk for digoxin toxicity, the clinical use of digoxin has decreased and alternative, safer medications are being used.

Nursing Considerations: 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 prescribing provider notified.

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 for clients on digoxin because hypokalemia increases the effect of digoxin and can result 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 provider.

Nurses should closely monitor for signs of digoxin toxicity. Geriatric clients have an increased risk for developing digoxin toxicity. Digibind is used to treat digoxin toxicity.

1. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 443-454. Elsevier.
2. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 443-454. Elsevier.

Side Effects/Adverse Effects: Overdose or accumulation of digoxin causes digoxin toxicity. Signs and symptoms of digoxin toxicity are bradycardia (heart rate less than 60), nausea, vomiting, visual changes (halos), and arrhythmias. Cardiotoxicity is a serious adverse effect with ventricular dysrhythmias. Toxicity of this medication typically occurs at greater than 2 ng/mL, but some clients may have signs and symptoms at lower levels. Pediatric clients typically present with bradycardia or arrhythmias if toxicity is occurring.

Decreased renal function, hypokalemia, hypercalcemia, and hypomagnesemia may increase risk for digoxin toxicity.

Common side effects include GI symptoms, headache, weakness, dizziness, anxiety, depression, delirium, and hallucination.[3]

Health Teaching & Health Promotion The client should be instructed to follow the prescribed dosing regimen and take medications at the same time each day. The client should be cautious not to double up on medication doses. Additionally, the client should consult the health care provider if two or more doses of medication are missed for follow-up instruction.

Clients should receive health teaching regarding pulse rate monitoring and report any pulse rate less than 60. If the client experiences signs of digoxin toxicity, this should be reported to 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.[4]

Now let's take a closer look at the medication grid for digoxin in Table 6.7a.[5]

Table 6.7a Digoxin Medication Grid

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4. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
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Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Cardiac Glycoside	digoxin	Assess apical heart rate Assess serum digoxin and potassium levels Assess for signs and symptoms of digoxin toxicity	Increased cardiac output	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)

Critical Thinking Activities 6.7

1. Why should a nurse assess the apical pulse for 1 full minute before administering digoxin?
2. How does a nurse evaluate if digoxin is effective?
3. Why must the nurse monitor serum potassium levels, as well as digoxin levels?
4. A nurse enters a client's room, and the client complains "My vision seems strange, and I feel nauseated." What is the

nurse's next best action?

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

Digoxin Immune Fab (DigiFab)

Digoxin immune fab (DigiFab) is used to treat life-threatening digoxin toxicity.

Mechanism of Action: DigiFab binds to digoxin molecules, reducing free digoxin.

Indications: This medication is the antidote for life-threatening digoxin toxicity.

Nursing Considerations: There are no contraindications when using DigiFab.

Side Effects/Adverse Effects: The most common effects a client may experience are to have worsening heart failure, hypokalemia, and worsening atrial fibrillation.

Health Teaching & Health Promotion: Clients should report any signs of worsening heart failure or hypokalemia immediately to the health care provider.

Now let's take a closer look at the medication grid for DigiFab in Table 6.7b.[6]

Table 6.7b Medication Grid for DigiFab

6. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antidote	digoxin immune fab (DigiFab)	Administer when clients are experiencing life-threatening digoxin toxicity	Reduce free digoxin	Worsening heart failure Worsening atrial fibrillation Hypokalemia

6.8 Antianginal - Nitrates

Antianginal medication is used to treat angina pectoris. Angina is chest pain caused by inadequate blood flow, resulting in hypoxia of the cardiac tissue. Angina can be chronic pain caused by atherosclerosis in coronary artery disease or acute pain caused by a myocardial infarction.

Antianginals increase blood flow to the heart or decrease oxygen demand by the heart. Nitrates promote vasodilation of coronary arteries and veins. Beta-blockers and calcium channel blockers are also used to decrease workload of the heart and decrease oxygen demands.

Nitrates may come in a variety of routes, such as sublingual, extended-release tablets, creams, transdermal patches, and intravenously. The grid below focuses on administration via sublingual tablets. Sublingual tablets are prescribed PRN ("as needed") for clients who are experiencing chronic, stable angina due to coronary artery disease.

Mechanism of Action: Nitroglycerin relieves angina by relaxing vascular smooth muscle, resulting in vasodilation.

Indications: Nitroglycerin is used to relieve angina due to coronary artery disease, during times of an acute attack, or prophylactically.

Nursing Considerations: Clients taking sildenafil (Viagra) or similar medications for erectile dysfunction 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.

Nitroglycerin is contraindicated in clients who have severe anemia, increased intracranial pressure, hypersensitivity, or circulatory failure.

Side Effects/Adverse Effects: Clients taking nitroglycerin may experience hypotension, palpitations, headache, weakness, sweating, flushing, nausea, vomiting, or dizziness.

Health Teaching & Health Promotion: Clients should allow medication to dissolve under their tongue. This route allows immediate absorption into the circulation and avoids first-pass metabolism by the liver. Clients may take up

to one tablet every 5 minutes or up to three sublingual tablets within 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.

Instruct clients 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. Nitroglycerin decomposes when exposed to heat or light, so it should be stored in the original, airtight glass container. See Figure 6.23[1] for an image of nitroglycerin containers.[2]

Historically, clients have been taught to seek emergency help (call 911) if pain persists after the third dose of medication. However, new guidelines from the American Heart Association urge clients to call 911 after the first dose if symptoms are not improved or become worse.[3]

1. "Nitroglycerin (1).JPG" by Intropin is licensed under CC BY 3.0
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
3. O'Gara, P., Kushner, F., Ascheim, D., Casey, D., Chung, M., de Lemos, J., Ettinger, S., Fang, J., Fesmire, F., Franklin, B., Granger, C., Krumholz, H., Linderbaum, J., Morrow, D., Newby, L., Ornato, J., Ou, N., Radford, M., Tamis-Holland, J., Tommaso, C., Tracy, C., Woo, Y., & Zhao, D. (2013). ACCF/AHA guideline for the management of ST-elevation myocardial infarction: A report of the American College of Cardiology Foundation/American Heart Association task force on practice guidelines. *Circulation, 127*(4). https://www.ahajournals.org/doi/full/10.1161/CIR.0b013e3182742cf6?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub%3Dpubmed



Figure 6.23 Sublingual Nitroglycerin Stored in Original, Airtight Glass Container

Now let's take a closer look at the medication grid for nitroglycerin in Table 6.8.[4]

Table 6.8 Nitroglycerine Medication Grid

4. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

Nitrate	nitroglycerin	Clients may take up to three sublingual tablets within 15 minutes (one every 5 minutes) to relieve chest pain If symptoms are not improved after the first dose or become worse or if the pain persists after the third dose of medication, seek emergency help (call 911). Nurses should check BP after each dose No eating or smoking during administration of SL tablet Do not chew or crush SL tablet Advise clients to sit while taking this medication Paste/	Decrease chest pain	Hypotension and palpitations Headache, weakness, sweating, flushing, nausea, vomiting, and dizziness

		Transdermal: Apply the paste or transdermal patch to a clean, dry area of skin on the upper body or arm. Rotate application sites to prevent skin irritation. Follow the medication instructions for how often to apply the paste or patch		

Critical Thinking Activity 6.8

A client was administered the first dose of nitroglycerin at 1305 for acute angina. What should the nurse evaluate after administration?

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

6.9 Diuretics

Diuretics are used to decrease blood pressure and to decrease symptoms of fluid overload such as edema. There are many classifications of diuretics. We will discuss loop, thiazide, and potassium-sparing diuretics. Other diuretics, such as osmotic diuretics, are used to decrease fluid from cerebrospinal fluid and the brain.

Diuretics cause diuresis (increased urine flow) by inhibiting sodium and water reabsorption from the kidney tubules. By eliminating excess water, blood volume and blood pressure, as well as preload, are decreased. Diuretic medications can have a significant impact on renal function; therefore, laboratory monitoring of renal function tests may be required. Common tests that are ordered to assess side effects of diuretic medications include blood urea nitrogen (BUN), creatinine, and creatinine clearance. Clients with abnormal BUN and creatinine levels may require a lower dosage of diuretics or a different medication regimen. Creatinine clearance is then calculated based on the amount of creatinine in the urine and the blood, as well as the client‘s age, gender, and weight. The results of the test can help health care providers monitor kidney function in clients who are taking diuretics, as well as adjust dosages or medications if necessary to prevent further kidney damage.

Diuretics are often used in combination with other antihypertensive agents to reduce a client’s blood pressure. Cients on diuretics often require dietary medications. Clients should follow a low-sodium diet to prevent fluid retention and hypertension. However, some clients may substitute salt with high-potassium salt substitutes, which can increase potassium levels and cause hyperkalemia. Health care providers should educate clients regarding the risks of using salt substitutes and provide guidance on dietary recommendations.

Furosemide

Mechanism of Action: Loop diuretics inhibit absorption of sodium and

chloride in the loop of Henle and proximal and distal tubules, thus causing fluid loss, along with sodium, potassium, calcium, and magnesium losses. Loop diuretics are very potent diuretics and are used when a client has an exacerbation of fluid overload.

Indications: Furosemide is used to treat clients with edema and is also used to treat hypertension. IV furosemide is used to urgently treat pulmonary edema in conditions such as congestive heart failure.

Nursing Considerations: The onset of diuresis following oral administration is within 1 hour. 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.

Nurses should continually monitor for dehydration and electrolyte imbalances that can occur with excessive diuresis, such as dryness of mouth, thirst, weakness, lethargy, drowsiness, restlessness, muscle pains or cramps, muscular fatigue, hypotension, oliguria, tachycardia, arrhythmia, or gastrointestinal disturbances such as nausea and vomiting.

Use cautiously in the geriatric population who have decreased renal function. Kidney function should be monitored closely for all clients because this is a potent medication that works within the kidney tubules.

Monitor the client closely for hypokalemia if furosemide is used concomitantly with digoxin. Hypokalemia may increase the risk of digoxin toxicity.

Side Effects/Adverse Effects: Adverse effects include dehydration, hypotension, and electrolyte imbalances such as hypokalemia. Health care providers may add potassium to a client's scheduled medication list to decrease risk of hypokalemia. If using IV route, the administration must be given slowly to reduce the risk of the client developing ototoxicity.[1]

Health Teaching & Health Promotion: 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 to their health care provider.

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Clients should also be encouraged to enjoy potassium-rich foods during loop diuretic drug therapy.[2]

Now let's take a closer look at the medication grid for furosemide in Table 6.9a.[3]

Table 6.9a Furosemide Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Loop Diuretic	furosemide	Assess blood pressure Monitor electrolytes (potassium) Promote potassium-rich diet Assess renal function Assess for dehydration and intake and output Monitor daily weight	Based on indication; decreased blood pressure or edema	Dehydration Electrolyte depletion (especially potassium) Ototoxicity with rapid IV infusion Renal impairment

2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Critical Thinking Activity 6.9

Mrs. Smith is a 79-year-old widow who has lived alone for the past five years. Three years ago, she was hospitalized for an MI, 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 comes into the clinic with generalized weakness, fatigue, nausea, and diarrhea. Her BP is 104/62, pulse 98 bpm and slightly irregular, RR 20, and temp 97.2 F. Blood is drawn and shows serum sodium level of 150 mEq/L, digoxin level of 2.6ng/mL and potassium level of 3.2 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. What is the normal range for serum potassium level?
4. What classification of medication is furosemide?
5. Is dehydration a risk for clients on furosemide? Why or why not?
6. How would you assess for dehydration?
7. What electrolyte imbalance(s) can occur in clients taking furosemide?

8. What relationship exists between this client's furosemide, digoxin, and potassium levels?

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

Hydrochlorothiazide

Mechanism of Action: Thiazide diuretics work near the distal tubule to promote the excretion of sodium and water, thus causing diuresis. They are not effective for immediate diuresis.

Indications: Hydrochlorothiazide diuretics are used to manage hypertension and edema.

Nursing Considerations: Thiazide diuretics are contraindicated for clients who have anuria or hypersensitivity.

After oral use, diuresis begins within 2 hours, peaks in about 4 hours, and lasts about 6 to 12 hours.

Use with caution in severe renal disease.

Side Effects/Adverse Effects: Clients who are taking thiazide diuretics should be monitored for electrolyte depletion, dehydration, weakness, hypotension, renal impairment, and hypersensitivities.[4]

Health Teaching & Health Promotion: Clients should be instructed to take these medications at the same time each day and notify their health care provider if they experience significant changes in weight. Thiazide diuretics may cause orthostatic changes so individuals should change positions slowly. Additionally, some clients may note increased photosensitivity so protective measures should be taken. Clients should monitor their blood pressure and comply with interventions to reduce hypertension. Hydrochlorothiazide (HCTZ) can interact with licorice to increase potassium levels. Clients on HCTZ

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should avoid consuming large amounts of licorice or licorice-containing products to prevent hyperkalemia.[5]

Now let's take a closer look at the medication grid for hydrochlorothiazide in Table 6.9b.[6]

Table 6.9b Hydrochlorothiazide Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Thiazide Diuretic	hydrochlorothiazide	Assess blood pressure Monitor electrolytes (potassium) Promote potassium-rich diet Assess renal function Assess for dehydration and intake and output Monitor weight	Decrease blood pressure Decrease edema	Electrolyte depletion Dehydration and weakness Hypotension Renal impairment Hypersensitivity (vasculitis, respiratory distress, photosensitivity, rash)

Spironolactone

Spironolactone is a potassium-sparing diuretic that is used as a mild diuretic or in combination with another diuretic.

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

5. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
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increased amounts of sodium and water to be excreted, while potassium is retained.

Indications: Spironolactone is used to treat hypertension and to control edema for clients with heart failure or liver dysfunction.

Nursing Considerations: This medication may cause hyperkalemia. Monitor urine output and report if less than 30 mL/hour. Use cautiously with clients who have renal impairment due to increased risk for hyperkalemia. Use cautiously in clients with liver impairment. Administer in the morning to avoid nocturia.

Side Effects/Adverse Effects: Spironolactone can increase the chances of hyperkalemia, hyperglycemia, hyperuricemia, dehydration, hypotension, renal impairment, hypersensitivity, and gynecomastia. This medication may increase risk for lithium toxicity.[7]

Health Teaching & Health Promotion: Clients should be instructed to take these medications at the same time each day and notify their health care provider if they experience significant changes in weight. Diuretics may cause orthostatic changes so individuals should change positions slowly. Clients should be advised to avoid salt substitutes and foods that contain high levels of potassium.[8]

Now let's take a closer look at the medication grid for spironolactone in Table 6.9c.[9]

Table 6.9c Spironolactone Medication Grid

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Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Potassium-Sparing Diuretic	spironolactone	Assess blood pressure Monitor electrolytes (potassium) Assess renal function Assess for dehydration and intake and output Monitor weight	Decrease blood pressure Decrease edema	Hyperkalemia, hyperglycemia, and hyperuricemia Dehydration Hypotension Renal impairment Hypersensitivity (vasculitis, fever, anaphylactic reactions, rash) Gynecomastia

Mannitol

Mannitol is an osmotic diuretic that works by increasing the osmotic pressure of the glomerular filtrate.

Mechanism of Action: Mannitol inhibits the reabsorption of water and electrolytes and promotes the excretion of water and electrolytes in the urine.

Indications for Use: Mannitol is used for the prevention and treatment of acute renal failure, cerebral edema, and intraocular pressure. It is also used to promote the excretion of toxic substances, such as certain drugs and poisons.

Nursing Considerations: Mannitol is administered intravenously, and the dose and rate of administration should be carefully monitored. Clients receiving mannitol should be closely monitored for fluid and electrolyte imbalances, dehydration, and kidney function. Mannitol should be used cautiously in clients with heart failure or pulmonary edema.

Side Effects/Adverse Effects: Adverse effects of mannitol include dehydration, electrolyte imbalances, and kidney dysfunction. Other potential adverse effects include headaches, nausea, vomiting, and allergic reactions.

Health Teaching & Health Promotion: Clients should be advised to report

any adverse effects or changes in symptoms to their health care provider. Clients should also be encouraged to maintain adequate hydration and follow any dietary recommendations provided by their health care provider.

Now let's take a closer look at the medication grid for mannitol in Table 6.9d.

Table 6.9d Mannitol Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Osmotic Diuretic	Mannitol	Dose and rate of administration should be carefully monitored Clients receiving mannitol should be closely monitored for fluid and electrolyte imbalances, dehydration, and kidney function Mannitol should be used cautiously in clients with heart failure or pulmonary edema	Promotes the excretion of water and electrolytes in the urine	Dehydration Electrolyte imbalances Kidney dysfunction Other potential adverse effects include headaches, nausea, vomiting, and allergic reactions

6.10 Antihypertensives

Many different medication classifications are used to treat **hypertension**. Nurses must understand the different mechanisms of action for different classes of antihypertensives because clients are often on a combination of medications that work synergistically to manage blood pressure. These medications are also discussed in the "Autonomic Nervous System" chapter, with more information provided regarding the specific receptors they affect.

Alpha-2 Agonist

Clonidine is an Alpha-2 agonist. You can read more information about Alpha-2 agonists in the "Autonomic Nervous System" chapter.

Mechanism of Action: Clonidine stimulates the alpha-adrenergic receptors, resulting in vasodilation and decreased blood pressure, thus decreasing peripheral resistance, increased blood flow to the kidneys, and decreased afterload.

Indications: Clonidine is used to treat hypertension and ADHD.

Nursing Considerations: Monitor BP and pulse rate. Dosage is usually adjusted to client's blood pressure because it can cause hypotension, bradycardia, and sedation. Rebound hypertension may occur if stopped abruptly.[1]

Side Effects/Adverse Effects: Clients should be monitored for side effects including hypotension, bradycardia, and sedation. If individuals cease taking the medication too suddenly, they may experience rebound hypertension.

Health Teaching & Health Promotion: Clients should be compliant with medication therapy and take the medication at the same time each day. They should be careful not to take more than the prescribed dose within a 24-hour period. Do not abruptly cease medication as rebound hypertension might occur. Medications may cause orthostatic changes so individuals should change positions slowly. Additionally, medications may cause dry mouth and

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dry eyes. Individuals should also avoid the use of alcohol and other CNS depressants while taking these medications.[2]

Now let's take a closer look at the medication grid for clonidine in Table 6.10a.[3]

Table 6.10a Clonidine Medication Grid

Class/Subclass	Prototype	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Alpha-2 Agonist	clonidine	Monitor blood pressure and pulse rate frequently Dosage is usually adjusted to client's BP and tolerance	Treat hypertension or ADHD	Hypotension Bradycardia Sedation Rebound HTN if stopped abruptly

Beta-1 Antagonist

Metoprolol is a selective Beta-1 blocker. You can read more information about Beta-1 antagonists in the "Autonomic Nervous System" chapter.

Mechanism of Action: Metoprolol 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.

Indications: Metoprolol is commonly used to treat high blood pressure, chest pain due to poor blood flow to the heart, and several heart conditions involving an abnormally fast heart rate. It is used as an early intervention during myocardial infarction (MI) to reduce workload of the heart.

Nursing Considerations: Extended-release (ER) formulations should not be crushed. Assess client's apical pulse rate before administering; if it is less than 60 beats/minute, withhold the drug and call the provider immediately, unless

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other parameters are provided. In diabetic clients, monitor glucose level closely because the drug masks common signs and symptoms of hypoglycemia.

Side Effects/Adverse Effects: Other adverse effects include fatigue, dizziness, depression, insomnia, nightmares, GI upset, erectile dysfunction, dyspnea, and wheezing.

Boxed Warning: The most serious potential adverse effects are shortness of breath, bradycardia, and worsening heart failure. When stopping therapy, taper dosage over 1 to 2 weeks because abrupt discontinuation may cause chest pain or MI.[4]

Health Teaching & Health Promotion: Clients should be compliant with medication therapy and take the medication at the same time each day. Do not abruptly cease medication as arrhythmias, hypertension, or ischemia may develop. Clients and families should be instructed to check pulse and blood pressure and report abnormalities to the health care provider. Additionally, these medications may cause side effects of dizziness and cold sensitivity.[5]

Now let's take a closer look at the medication grid for metoprolol in Table 6.10b.[6]

Table 6.10b Metoprolol Medication Grid

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Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Beta-1 Antagonist	Selective B blocker: metoprolol	Do not crush ER formulations Always assess apical HR and if less than 60, do not administer and call the provider unless other parameters are provided Monitor blood sugar in diabetic clients because drug can mask symptoms of hypoglycemia	Decreases blood pressure or controls rapid heart rate	Most serious: Hypotension, bradycardia, and worsening HF Other: CNS: Fatigue, dizziness, depression, insomnia, and nightmares GI upset GU: Erectile dysfunction Respiratory: Dyspnea and wheezing

ACE Inhibitor (Angiotensin Converting Enzyme)

Captopril is an example of an ACE (angiotensin converting enzyme) inhibitor.

Mechanism of Action: This medication blocks the conversion of Angiotensin I to Angiotensin II in the renin-angiotensin-aldosterone system. This will lead to vasodilation and sodium and water excretion by blocking aldosterone. See more information about the renin-angiotensin-aldosterone system in the "Basic Concepts of the Cardiovascular and Renal Systems" section of this chapter.

Indications: Captopril is used to treat hypertension and heart failure. This medication also helps reduce diabetic nephropathy.

Nursing Considerations: Do not administer to clients who are pregnant. Use with caution with clients who have diabetes.

Avoid use with other medications that increase potassium. This medication may increase risk for lithium toxicity.

Side Effects/Adverse Effects: Clients taking this medication may experience hypotension, cough, hyperkalemia, increased risk for infection, angioedema, anaphylactoid reactions, or proteinuria. Clients who 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.[7]

Boxed Warning: Clients who become pregnant should discontinue this medication due to the risk of fetal harm or fetal death.

Health Teaching & Health Promotion: Medications should be taken as directed. Clients taking ACE inhibitors should be cautioned to avoid salt substitutes or other foods high in potassium because this medication increases the risk for hyperkalemia. Additionally, the medication may alter the sense of taste, but this generally resolves within 2-3 months of medication therapy.

Clients taking ACE inhibitors may also experience a persistent cough throughout the duration of medication therapy.[8]

Now let's take a closer look at the medication grid for captopril in Table 6.10c.[9]

Table 6.10c Captopril Medication Grid

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9. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
ACE Inhibitor	captopril	Boxed Warning: Do not use while pregnant Monitor blood pressure Report cough Assess for facial swelling or difficulty breathing	Decrease blood pressure Decrease fluid volume status	Hypotension Cough Hyperkalemia Neutropenia or agranulocytosis Angioedema Anaphylactoid reactions Proteinuria

Angiotensin II Receptor Blocker (ARB)

Losartan is an example of an Angiotensin II receptor blocker, also referred to as an ARB. ARBs are similar to ACE inhibitors in that they act on the renin-angiotensin-aldosterone system (RAAS). However, the difference is that they block Angiotensin II and cause vasodilation and decreased peripheral resistance but are not likely to cause the cough that ACE inhibitors can.

Mechanism of Action: Losartan blocks Angiotensin II in the renin-angiotensin-aldosterone system to produce vasodilation.

Indications: ARB is used for treatment of hypertension and to prevent nephropathy in diabetic clients.

Nursing Considerations: Do not administer to clients who are pregnant. It is not recommended for children under 6. Anticipate dosage adjustment with hepatic impairment. This drug can cause renal impairment and hyperkalemia.

Side Effects/Adverse Effects: Clients taking this medication may experience hypotension, dizziness, increased risk for infection, angioedema, or proteinuria. Clients who experience increased facial swelling or difficulty swallowing or breathing should seek emergency medical attention.

Boxed Warning: Clients who become pregnant should discontinue this medication due to the risk of fetal harm or fetal death.

Health Teaching & Health Promotion: Medications should be taken as directed at the same time each day. Clients should not discontinue therapy unless directed to by their health care provider. Clients should be careful to avoid salt substitutes and foods with high levels of potassium. ARBs may cause orthostatic changes, and clients should be cautioned to change positions slowly.[10]

Now let's take a closer look at the medication grid for losartan in Table 6.10d.[11]

Table 6.10d Losartan Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
ARB	losartan	Boxed Warning: Do not use while pregnant Monitor blood pressure	Decrease blood pressure	Hypotension and dizziness Hyperkalemia Proteinuria

Critical Thinking Activity 6.10

A male 65-year-old client has the following medications ordered: metoprolol succinate 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?"

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1. What is the class and mechanism of action for each of these medications?
2. What is the nurse's best response to the client's question?

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

Vasodilator

Hydralazine is an example of a direct vasodilator.

Mechanism of Action: Hydralazine's direct mechanism of action is unknown, but it causes vasodilation via direct relaxation of vascular smooth muscle. Peripheral vasodilation results in a reduction of blood pressure and decreased vascular resistance, resulting in increased cardiac output.

Indications: Vasodilators are used to treat hypertension.

Nursing Considerations: 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.

Side Effects/Adverse Effects: Clients should be monitored for infection and are at risk of developing systemic lupus erythematosus (SLE). SLE is a chronic disease that causes inflammation in connective tissues. The signs and symptoms of SLE vary among affected individuals and can involve many organs and systems, including the skin, joints, kidneys, lungs, central nervous system, and blood-forming (hematopoietic) system. A characteristic sign of SLE is a flat, red rash across the cheeks and bridge of the nose. This rash is called a "butterfly rash" because of its shape.

Hypotension, palpitations, angina, tremors, numbness, tingling, disorientation, nasal congestion, headache, nausea, vomiting, and diarrhea are effects associated with hydralazine.[12]

Health Teaching & Health Promotion: Clients should remain compliant

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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 health care provider if two or more doses of medication are missed for follow-up instruction. Clients should be instructed to monitor their weight and assess for fluid retention in the feet and ankles. Additionally, the medication can cause side effects of orthostatic hypotension and drowsiness.[13]

Now let's take a closer look at the medication grid on hydralazine in Table 6.10e.[14]

Table 6.10e Hydralazine Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Vasodilator	hydralazine (Apresoline)	Monitor blood pressure Obtain complete blood count (CBC) and antibody titers prior to beginning this medication Report signs and symptoms of infection	Reduce blood pressure	Systemic lupus erythematosus (SLE) Hypotension, palpitations, and angina Tremors, numbness, tingling, and disorientation Nasal congestion Headache, nausea, vomiting, and diarrhea

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6.11 Antilipemics

Antilipemic agents reduce hyperlipidemia that may lead to additional health problems such as stroke, myocardial infarction, angina, and heart failure. Medications should be used in adjunct with a healthy diet and exercise regime approved by the client's health care provider.

Atorvastatin

Mechanism of Action: Atorvastatin inhibits HMG-CoA reductase and cholesterol synthesis, which reduces low-density lipoprotein (LDL).

Indications: This medication is used for hyperlipidemia and the prevention of cardiovascular disease.

Nursing Considerations: Do not use with clients who have hepatic disease.

This medication is contraindicated with clients who are pregnant or breastfeeding. Do not give to clients under 10 years of age.

Use caution with elderly clients due to increased risk for myopathy.

Side Effects/Adverse Effects: A health care provider will assess routine liver function for a client taking atorvastatin. Nausea, diarrhea, dyspepsia, increase in blood glucose, rhabdomyolysis, myalgia, or muscle spasms may be produced by taking this medication. Rhabdomyolysis is a condition in which damaged skeletal muscle breaks down rapidly, causing muscle pain and weakness. Some of the muscle breakdown products are harmful to the kidneys and can cause kidney failure. There may be tea-colored urine or an irregular heartbeat with rhabdomyolysis.[1]

Health Teaching & Health Promotion: Clients should take the prescribed medication as directed and avoid consuming grapefruit juice during drug therapy. The medication should be used with dietary modifications. If the client experiences muscle pain, tenderness, or weakness, these should be reported to the health care provider.[2]

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Now let's take a closer look at the medication grid on atrovastatin in Table 6.11a.[3]

Table 6.11a Atorvastatin Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
HMG-CoA Reductase Inhibitor	atorvastatin	Take at the same time each day, with or without food Report muscle weakness, feeling tired, abdominal pain, or yellowing of skin or eyes Clients who are pregnant or breastfeeding should not take this medication	Reduce LDL	Rhabdomyolysis, myalgia, and muscle spasms Abnormal liver enzymes May increase blood glucose Nausea, diarrhea, and dyspepsia

Ezetimibe

Mechanism of Action: Ezetimibe blocks the absorption of cholesterol in the small intestines to reduce LDL.

Indications: This medication is used for treatment of hyperlipidemia and familial hypercholesterolemia.

Nursing Considerations: If medication is combined with HMG-CoA reductase inhibitors, do not give to pregnant or breastfeeding clients.

Side Effects/Adverse Effects: Use with caution when ezetimibe is

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combined with additional medication. Clients may experience arthralgia, rhabdomyolysis, hepatic impairment, dizziness, upper respiratory infections, or diarrhea if they are taking this medication. Minimal side effects were reported with monotherapy.[4]

Health Teaching & Health Promotion: Clients should take the prescribed medication as directed and avoid consuming grapefruit juice during drug therapy. The medication should be used with dietary modifications. If the client experiences muscle pain, tenderness, or weakness, this should be reported to the health care provider.[5]

Now let's take a closer look at the medication grid for ezetimibe in Table 6.11b.[6]

Table 6.11b Ezetimibe Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Cholesterol Absorption Inhibitor	ezetimibe	Take at the same time each day, with or without food Report muscle weakness, feeling tired, abdominal pain, or yellowing of skin or eyes	Reduce LDL	Arthralgia and rhabdomyolysis Hepatic impairment Dizziness Upper respiratory infection Diarrhea

Cholestyramine

Mechanism of Action: Cholestyramine works by binding to bile acids in the intestines, preventing their reabsorption, and promoting their excretion in the feces.

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Indications: Bile acid sequestrants are given to reduce the amount of bile acids available for the body to use in producing cholesterol, leading to a decrease in cholesterol levels.

Nursing Considerations: Monitor the client's lipid profile, liver function tests, and vitamin levels. These medications should not be used in clients with a history of bowel obstruction or in clients with triglyceride levels greater than 500 mg/dL.

Side Effects/Adverse Effects: Adverse effects of bile acid sequestrants include constipation, bloating, flatulence, and abdominal discomfort.

Health Teaching & Health Promotion: Clients should be advised to increase their fluid and fiber intake to alleviate these symptoms. These medications can also interfere with the absorption of fat-soluble vitamins, so clients should be advised to take supplements as prescribed.

Now let's take a closer look at the medication grid for cholestyramine in Table 6.11c.

Table 6.11c Cholestyramine Medication Grid[7]

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Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Bile Acid Sequestrant	cholestyramine	Monitor the client's lipid profile, liver function tests, and vitamin levels These medications should not be used in clients with a history of bowel obstruction or in clients with triglyceride levels greater than 500 mg/dL	Reduce LDL	Constipation Bloating Flatulence Abdominal discomfort

Niacin

Mechanism of Action: Niacin works by inhibiting the synthesis of triglycerides and LDL cholesterol.

Indications: Niacin is given to reduce the production of very low-density lipoprotein (VLDL) and low-density lipoprotein (LDL) cholesterol, while increasing the levels of high-density lipoprotein (HDL) cholesterol in the blood.

Nursing Considerations: Nursing considerations for administration include monitoring lipid profiles, liver function tests, and blood glucose levels. Clients should be advised to take niacin with meals to minimize adverse effects. Clients should also be advised to report any adverse effects to their health care provider.

Side Effects/Adverse Effects: Adverse effects of niacin include flushing, itching, and tingling, particularly in the face, neck, and chest.

Health Teaching & Health Promotion: Clients should also be advised to

avoid hot beverages or alcohol, as these can exacerbate flushing. Niacin can also cause liver toxicity, so liver function tests should be monitored regularly. In addition, niacin can increase blood glucose levels, so clients with diabetes should have their blood glucose levels monitored closely. Clients should be advised to take niacin with meals to minimize adverse effects.

Now let's take a closer look at the medication grid for niacin in Table 6.11d.

Table 6.11d Niacin Medication Grid[8]

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Vitamin B3	niacin	Monitor lipid profiles, liver function tests, and blood glucose levels Take niacin with meals to minimize adverse effects Report any adverse effects to their health care provider	Reduce LDL	Constipation Bloating Flatulence Abdominal discomfort

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6.12 Blood Coagulation Modifiers

This section will discuss medications that affect blood coagulation and includes several types of medications, including anticoagulants, antiplatelets, and thrombolytics, as well as their associated reversal agents.

Anticoagulants prevent the formation of a clot by inhibiting certain types of clotting factors. 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). Antiplatelets include aspirin and other aggregation inhibitors such as clopidogrel, and thrombolytics include alteplase (tPA). All these types of medications are included on the List of High-Alert Medications (HAMs) by the Institute for Safe Medication Practices (ISMP) and require special safeguards to reduce the risk of errors or adverse effects.[1]

The most common anticoagulant errors in acute hospital settings are administration mistakes, including incorrect dosage calculation and infusion rates. The Health Research and Educational Trust focuses on reducing harm related to HAMs by 50% and recommends the following interventions to achieve this goal:

- Educate staff based on evidence and best practices.
- Use standardized order sets and protocols.
- Perform medication reconciliation at all transitions.

Specific interventions regarding anticoagulant therapy include standardization of protocols for withholding and restarting warfarin perioperatively, including pharmacists on rounds to provide decision support

1. Institute for Safe Medication Practices (ISMP). (2018). *ISMP list of high-alert medications in acute care settings.* https://www.ismp.org/sites/default/files/attachments/2018-08/highAlert2018-Acute-Final.pdf

for staff administering HAMs and to reduce prescribing errors, pharmacist monitoring of anticoagulants, and pharmacist notification when rescue medications are given.[2]

According to the *Institute for Safe Medication Practices (ISMP) 2016 Annual Report*, there is also a high risk of acute injuries for clients taking anticoagulants outside of the hospital setting. Anticoagulants are commonly used by the elderly to reduce the risk of ischemic stroke, with an estimated 3.8 million people taking oral anticoagulants in 2016. CDC data show that adverse effects of oral anticoagulants account for more emergency department visits than any other class of drugs. Adverse effects range from gastrointestinal bleeding to cerebral hemorrhages, resulting in over 3,000 deaths in 2016.[3]

Since 1954 warfarin has been a standard but hazardous treatment for preventing blood clots. 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 (Pradaxa), rivaroxaban (Xarelto), and apixaban (Eliquis), they designed them to be easier to use than warfarin because no laboratory monitoring was required, but not necessarily safer. It is vital for nurses to provide thorough health teaching to clients and their caregivers regarding prescribed anticoagulants administered at home. Suggested health teaching topics are included for each type of medication below.

Heparin Sodium

Heparin sodium is an anticoagulant that can be injected or used intravenously and is formulated in several dosages. (See Figure 6.24.)[4] Due to heparin being a high-alert medication, hospitals use several processes for storing and labeling the medication to help prevent errors. It is also important

2. Anderson, P., & Townsend, T. (2015). Preventing high-alert medication errors in hospital patients. *Nurse Today, 10*(5). https://www.americannursetoday.com/wp-content/uploads/2015/05/ant5-CE-421.pdf
3. Institute for Safe Medication Practices (ISMP). (2017). *QuarterWatch™ (2016 Annual Report) Part II: Oral anticoagulants—The nation's top risk of acute injury from drugs.* https://www.ismp.org/resources/quarterwatchtm-2016-annual-report-part-ii-oral-anticoagulants-nations-top-risk-acute
4. "Heparin Sodium sample.jpg" by LHcheM is licensed under CC BY-SA 3.0 and "Heparin in Dextrose Injection" by Chippewa Valley Technical College is licensed under CC BY 4.0

to note that there is a type of heparin flush often referred to as “Hep-Lock” that is used to maintain the patency of central lines. The dosage of heparin in heparin IV flushes is much different than the heparin dose used as an intravenous medication to prevent or treat a blood clot.

Most hospitals have weight-based protocols for IV heparin administration that titrate a client’s dosage to be within a therapeutic range based on the results of a lab test called **partial thromboplastin time (PTT)**. PTT is a blood test that looks at how long it takes for blood to clot. Clients receiving heparin subcutaneous injections to prevent DVTs (deep vein thrombosis) do not require PTT monitoring.



Figure 6.24 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

Mechanism of Action: Heparin inhibits the activated coagulation factors involved in the clotting sequence, particularly Xa and IIa. Heparin also prevents the formation of a stable fibrin clot by inhibiting the activation of the fibrin stabilizing factor. Heparin does not have fibrinolytic activity; therefore, it will not break down existing clots.

Indications: IV heparin is commonly indicated for the treatment of deep

venous thromboembolism (DVT) or pulmonary embolism. It is also indicated for use during an 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.

Nursing Considerations: When bleeding requires the reversal of heparinization, protamine sulfate by slow infusion will neutralize heparin sodium.

A higher incidence of bleeding has been reported in clients over 60 years of age, especially women.

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.

IV heparin therapy 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.

This drug is 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 medication that affects 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" subsection.

Side Effects/Adverse Effects: There is a high risk of bleeding that can lead to hemorrhaging. Notify the 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.

Some clients may develop heparin-induced thrombocytopenia (HIT) or heparin-induced thrombocytopenia and thrombosis (HITT); therefore, heparin should be immediately discontinued.

Health Teaching & Health Promotion: 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.[5] Clients should avoid medications containing aspirin or NSAIDS. Bleeding precautions should be taken, including the avoidance of IM injections, use of a soft toothbrush, and electric razor.[6]

Now let's take a closer look at the medication grid for heparin in Table 6.12a.[7]

Table 6.12a Heparin Medication Grid

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Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anticoagulant	heparin	Injection (subq) or IV Carefully examine all heparin products to confirm the correct choice prior to administration Closely monitor PTT levels in IV therapy to ensure in therapeutic range Protamine sulfate is the reversal agent	Prevent or treat clots	High risk of bleeding Risk of gastrointestinal or cerebral hemorrhage, especially in elderly Risk of heparin-induced thrombocytopenia (HIT) and heparin-induced thrombocytopenia and thrombosis (HITT)

Low-Molecular Weight Heparin (LMWH)

Enoxaparin (Lovenox) is a low-molecular weight heparin (LMWH) that is supplied in a prefilled syringe (see Figure 6.25).[8] LMWH heparin formulations do not require lab monitoring.

8. "syringe-disposable-syringe-blister-103059" by stux is licensed under CC0



Figure 6.25 Enoxaparin in Prefilled Syringe

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.

Indications: 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.

Nursing Considerations: Enoxaparin is administered subcutaneously and preferably in the abdomen for best absorption.

Safety and effectiveness have not been established in pediatric clients. The risk of bleeding increases with age, especially if used concurrently with antiplatelet medications.

Use with caution in clients with renal impairment; risk of bleeding is increased. A dosage adjustment is recommended for clients with severe renal impairment.

Overdosage can be neutralized with a slow IV infusion of protamine sulfate.

Side Effects/Adverse Effects: There is a risk of bleeding and hemorrhaging,

especially 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).[9]

Boxed Warning: 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.

Health Teaching & Health Promotion: 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.[10] Clients should avoid medications containing aspirin or NSAIDS.[11]

Now let's take a closer look at the medication grid on enoxaparin in Table 6.12b.[12]

Table 6.12b Enoxaparin Medication Grid[13]

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Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anticoagulant	enoxaparin	Use with caution in clients with kidney disease If used for a client undergoing neuraxial anesthesia or a spinal puncture, monitor frequently for neurological impairment. If neurological compromise is noted, urgent treatment is necessary	Prevention or treatment of DVT or PE	Bleeding Risk of hemorrhage Thrombocytopenia, HIT, or HITT

Warfarin

Warfarin (Coumadin) is an oral anticoagulant formulated in various strengths in different colors to help prevent errors when clients self-administer different dosages at home (see Figure 6.26[14]). Close monitoring of **prothrombin time (PT)** or **international normalized ratio (INR)** is required.

14. "Warfarintablets5-3-1.jpg" by Gonegonegone is licensed under CC BY-SA 3.0



Figure 6.26 Warfarin, an Oral Pill With Various Strengths in Different Colors

Mechanism of Action: Warfarin acts by inhibiting the synthesis of vitamin K-dependent clotting factors, which include Factors II, VII, IX, and X and the anticoagulant proteins C and S.

Indications: Warfarin is indicated for the following:

- 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.

Nursing Considerations: Warfarin is contraindicated in pregnant women except for those with mechanical heart valves; it can cause fetal harm.

Vitamin K is the reversal agent. Fresh frozen plasma may be considered if the requirement to reverse the effects of warfarin sodium is urgent.

Close monitoring of prothrombin time (PT) or international normalized ratio

(INR) is required. Therapeutic INR ranges from 2.0 to 3.5, depending on the indication.

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.

Warfarin has significant interactions with many medications; read drug label information before administering.

Warfarin sodium is contraindicated in clients with many conditions, including, but not limited to, the following:

- Hemorrhagic tendencies or blood dyscrasias
- Recent or contemplated surgery of the central nervous system or eye or traumatic surgery resulting in large open surfaces

Bleeding tendencies are associated with the following:

- Active ulceration or overt bleeding of the gastrointestinal, genitourinary, or respiratory tracts
- Central nervous system hemorrhage
- Cerebral aneurysms and dissecting aorta
- Pericarditis and pericardial effusions
- Bacterial endocarditis

Side Effects/Adverse Effects: Boxed Warning: 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.

Health Teaching & Health Promotion: Advise clients to follow these instructions:

- Avoid alcohol, cranberries, and grapefruit as they increase the effect of warfarin and the risk for bleeding.

- Strictly adhere to the prescribed dosage schedule.
- Follow INR monitoring guidelines as provided by the provider.
- Avoid any activity or sport that may result in traumatic injury.
- Tell their provider if they experience frequent falls because warfarin can increase their risk for bleeding in the brain.
- Eat a normal, balanced diet to maintain a consistent intake of vitamin K (such as green, leafy vegetables).
- 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.
- 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.[15]

Now let's take a closer look at the medication grid on warfarin in Table 6.12c.[16]

Table 6.12c Warfarin Medication Grid

15. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
16. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Anticoagulant	warfarin	Oral route Vitamin K is the antidote Monitor INR results before administering medication Use with caution in clients with liver disease	Prevent DVT or PE	Bleeding Hemorrhage

Critical Thinking Activity 6.12

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 health teaching 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

Rivaroxaban

Rivaroxaban (Xarelto) is a selective Xa inhibitor.

Mechanism of Action: Rivaroxaban is a selective inhibitor of factor Xa and indirectly inhibits platelet aggregation induced by thrombin.

Indications: Rivaroxaban is indicated for prevention or treatment of DVT and PE. 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: For overdose, activated charcoal can be used to reduce absorption, and Andexxa is a reversal agent.

Avoid in clients with moderate to severe liver impairment. Report any unusual bleeding or bruising.

Side Effects/Adverse Effects: Risk of bleeding can be fatal.[17]

Boxed Warning: 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.

Health Teaching & Health Promotion: Clients should report any signs of unusual bleeding or bruising to the health care provider. The client should

17. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

also notify the provider of all prescriptions, OTC medications, vitamins, and herbal products.[18]

Now let's take a closer look at the medication grid on rivaroxaban in Table 6.12d.[19]

Table 6.12d Rivaroxaban Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Selective Xa Inhibitor	rivaroxaban	Activated charcoal or Andexxa can be used in overdose Avoid in clients with liver impairment	Prevent DVT and PE and risk of severe cardiovascular events	Bleeding Epidural or spinal hematomas if neuraxial anesthesia or spinal puncture

Dabigatran

Dabigatran (Pradaxa) is a direct-acting thrombin inhibitor.

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.

Indications: This drug is used to prevent or treat deep vein thromboses (DVT) or pulmonary emboli (PE).

Nursing Considerations: If an overdose occurs, idarucizumab, a specific reversal agent, is available.

Safety and effectiveness in pediatric clients have not been established.

Side Effects/Adverse Effects: Risk of bleeding can be fatal.[20]

Boxed Warning: Epidural or spinal hematomas may occur in clients who

18. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
19. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
20. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

are anticoagulated with dabigatran and are receiving neuraxial anesthesia or undergoing spinal puncture. These hematomas may result in long-term or permanent paralysis**.**

Health Teaching & Health Promotion: Clients should report any signs of unusual bleeding or bruising to the health care provider. Additionally, dabigatran bottles should be disposed of four months after opening. The client should also notify the provider of all prescriptions, OTC medications, vitamins, and herbal products.[21]

Now let's take a closer look at the medication grid for dabigatran in Table 6.12e.[22]

Table 6.12e Dabigatran Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Direct-acting Thrombin Inhibitor	dabigatran	Idarucizumab is a specific reversal agent	Prevent or treat DVT or PE	Risk of bleeding that can be fatal Epidural or spinal hematomas if receiving neuraxial anesthesia or undergoing spinal puncture

Antiplatelets

Acetylsalicylic acid (aspirin) and clopidogrel (Plavix) are antiplatelet medications.

During an active myocardial infarction (heart attack), chewable aspirin is used due to its rapid absorption (see Figure 6.27[23]).

21. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
22. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
23. "Bayer Aspirin Low Dose" by Mike Mozart is licensed under CC BY 2.0



Figure 6.27 Chewable Aspirin

Mechanism of Action: Aspirin inhibits platelet activation and aggregation.

Indications: Aspirin is indicated in clients with established peripheral arterial disease or a history of recent myocardial infarction (MI) or stroke to reduce the rate of MI and stroke. It is also indicated to reduce the rate of myocardial infarction (MI) and stroke in clients with ST-elevation and non–ST-segment elevation ACS.

Nursing Considerations: It is important to remember that the effects of these medications last the life of the platelet (7-10 days), so aspirin will need to be withheld for several days before surgery or certain procedures to prevent excessive bleeding. In elderly clients, there is an increased risk of bleeding events with concurrent use of clopidogrel plus aspirin. Aspirin is contraindicated in children under the age of 12 with flu-like symptoms due to the risk of Reye's syndrome.

Overdose is irreversible.

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.

Side Effects/Adverse Effects: There is increased risk of bleeding.

Boxed Warning: There is reduced effectiveness for clients referred to as "CYP2C19 poor metabolizers."

Health Teaching & Health Promotion: Clients should report tinnitus, unusual bleeding of the gums, bruising, or blood in the stool to the health care provider immediately. While on antiplatelet therapy, clients should avoid alcohol to prevent gastric irritation. Additionally, clients should avoid NSAIDs while receiving antiplatelet therapy.[24]

Now let's take a closer look at the medication grid for acetylsalicylic acid and clopidogrel in Table 6.12f.[25]

Table 6.12f Acetylsalicylic Acid and Clopidogrel Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Antiplatelet	▸ acetylsalicylic acid (aspirin) ▸ clopidogrel	Administer with food to reduce risk of GI upset and bleeding Monitor for bleeding Effects last for 7-10 days	Reduce risk of MI and stroke	Increased risk of bleeding

Alteplase (tPA)

Alteplase (tPA) is a thrombolytic used to break up clots. It has a very short half-life of five minutes so it can open a clogged artery rapidly. It is often given with heparin to prevent reocclusion of the affected blood vessel. There is also a smaller dosage form that is used to flush clogged IV or arterial lines.[26]

Mechanism of Action: Alteplase binds to fibrin in a thrombus and converts the entrapped plasminogen to plasmin, thus breaking down the clot.

Indications: Alteplase is indicated for the acute treatment of myocardial infarction (MI), ischemic stroke, or massive pulmonary embolism (PE). It is also

24. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
25. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
26. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 443-454. Elsevier.

used to clear central lines such as a peripherally inserted central line catheter (PICC).

Nursing Considerations: The drug is contraindicated in situations in which the risk of significant bleeding is greater than the potential benefit such as the following:

- Active internal or intracranial bleeding
- History of recent stroke
- Recent (within three 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

A CT scan of the head is completed prior to administration because hemorrhagic stroke and brain tumors are contraindications. Significant post-administration monitoring is performed due to the risk of life-threatening bleeding.

Side Effects/Adverse Effects: This drug can cause significant, sometimes fatal, internal or external bleeding, especially at arterial and venous puncture sites. Avoid intramuscular injections 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.

Health Teaching & Health Promotion: Clients must institute bleeding precautions to prevent complications of therapy.[27]

Now let's take a closer look at the medication grid for alteplase in Table 6.12g.[28]

Table 6.12g Alteplase Medication Grid

27. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
28. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Thrombolytic	alteplase (tPA)	Contraindicated in many conditions where the risk of bleeding outweighs the potential benefit	Break down a life-threatening clot in MI, stroke, or massive PE	Risk of severe bleeding that can be fatal

6.13 Erectile Agents

Sildenafil (Viagra) is commonly known to treat erectile dysfunction. This medication was originally developed for improvement of pulmonary hypertension but has been found to be useful for additional indications. However, clients taking this medication cannot take nitroglycerin due to severe hypotension.

Mechanism of Action: Sildenafil inhibits phosphodiesterase (PDE-5) in the pulmonary smooth muscle and corpus cavernosum. This allows for relaxation in the smooth muscle.

Indications: Sildenafil is used in the treatment of pulmonary hypertension and erectile dysfunction.

Nursing Considerations: Pediatric clients have shown to have an increase in mortality with sildenafil.

Dose adjustments are needed for clients with hepatic and renal impairment.

Use cautiously with geriatric clients with decreased hepatic, renal, and cardiac functions.

Side Effects/Adverse Effects: Clients taking sildenafil may expect to experience hypotension, visual or hearing loss, priapism (male), headache, or vaso-occlusive crisis. If clients have priapism that lasts longer than four hours, they should seek medical attention.[1]

Health Teaching & Health Promotion: Clients should be instructed to take medications as directed and should seek immediate medical attention if chest pain occurs. Clients should report priapism lasting longer than four hours, dizziness, or decreased vision or hearing.[2]

Now let's take a closer look at the medication grid on sildenafil in Table 6.13.[3]

Table 6.13 Sildenafil Medication Grid

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Phosphodiesterase Inhibitor	sildenafil	Do not administer with organic nitrates If priapism persists longer than four hours, seek medical attention	Decrease pulmonary hypertension Improving erectile dysfunction symptoms	Hypotension Visual loss and hearing loss Priapism Headache Vaso-occlusive crisis due to sickle cell anemia

6.14 Learning Activities

Exercises

Case Study 1

Ms. Hernandez is a 45-year-old female client who has been diagnosed with heart failure. She has been prescribed spironolactone by her health care provider to help manage her symptoms. Ms. Hernandez has a history of kidney disease and is also taking other medications for her health conditions.

1. What is spironolactone?
2. What is the purpose of prescribing spironolactone to Ms. Hernandez?
3. What are the potential side effects of spironolactone?
4. What are the potential drug interactions with spironolactone?
5. What laboratory tests are required to monitor the effects of spironolactone?
6. What dietary considerations should Ms. Hernandez be aware of while taking spironolactone?

Case Study 2

Mr. Johnson is a 67-year-old male client who has been diagnosed with atrial fibrillation. He has been prescribed warfarin by his health care provider to help prevent blood clots that can lead to a

stroke. Mr. Johnson has no history of bleeding disorders or other significant medical conditions.

1. What is warfarin?
2. What is the purpose of prescribing warfarin to Mr. Johnson?
3. How does warfarin work?
4. What are the potential risks of taking warfarin?
5. What is the optimal therapeutic range for Warfarin?
6. What laboratory tests are required to monitor the effects of warfarin?
7. What are the potential drug interactions with warfarin?
8. What dietary considerations should Mr. Johnson be aware of while taking warfarin?
9. What should Mr. Johnson do if he misses a dose of warfarin?
10. How often should Mr. Johnson see his health care provider while taking warfarin?

Note: Answers to the Case Studies can be found in the "Answer Key" 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://wtcs.pressbooks.pub/pharmacology2e/?p=288#h5p-22

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An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=288#h5p-23

"Antiarrhythmics Class" by E. Christman for Open RN is licensed under CC BY 4.0

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https://wtcs.pressbooks.pub/pharmacology2e/?p=288#h5p-24

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https://wtcs.pressbooks.pub/pharmacology2e/?p=288#h5p-25

"Nursing Care of the Adult Heart Failure Patient in a Long-Term Care Setting" by E. Christman for Open RN is licensed under CC BY 4.0.[1]

1. "Learning-3245793_960_720.jpg" by harishs is licensed under CC0, "Patient Image in LTC.JPG" by ARISE Project is licensed under CC BY 4.0, Open RN Project. (2020, March 14). *Arise heart failure in LTC setting - Nursing report video - ARISE 1287* [Video]. YouTube. Licensed under CC BY 4.0. https://youtu.be/fGagq4tGYgk, "Diabetic_Socks.JPG" by Enter is licensed under CC BY 4.0, Open RN Project. (2020, March 26). *Arise heart failure - Simulated patient in long-term care - ARISE 0991* [Video]. YouTube. Licensed under CC BY 4.0. https://youtu.be/gH7aDxUzCV0, "Blood-pressure-monitor-3467664_960_720.jpg" by fernandozhiminaicela is licensed under CC0, "Posterior Right Lower Base - ARISE

- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: CV Assignment 1.[2]



- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: CV Assignment 2.[3]



3712.JPG" by ARISE Project is licensed under CC BY 4.0, "Combinpedal.jpg" by James Heilman, MD is licensed under CC BY 3.0, "A_Businessman_Holding_A_Thank_You_Sign.svg" by FriendlyStock.com is licensed under CC BY-SA 4.0

2. "CV Assignment 1" by Open RN is licensed under CC BY 4.0
3. "CV Assignment 2" by Open RN is licensed under CC BY 4.0

VI. 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 client'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 clients 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 client's blood to clot. PTT is used for clients 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 client'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.

PART VII

GASTROINTESTINAL SYSTEM

7.1 Gastrointestinal Introduction

Learning Objectives

- Identify the classifications and actions of gastrointestinal system drugs
- Give examples of when, how, and to whom gastrointestinal system drugs may be administered
- Identify the side effects and special considerations associated with gastrointestinal system drug therapy
- Identify considerations and implications of using gastrointestinal system medications across the life span
- Apply evidence-based concepts when using the nursing process
- Identify indications and adverse/side effects associated with the use of herbal supplements
- Identify and interpret related laboratory tests
- Identify nursing responsibilities related to health teaching and health promotion

Gastrointestinal disorders are common. How many times have you heard someone complaining of an upset stomach, heartburn, nausea, constipation, or diarrhea? Occasionally, these ailments will go away on their own…but if they do not, there are a variety of medications that can be used to treat them. Treatment can include prescription and over-the-counter drug therapy, in

addition to nonpharmacological interventions. In this chapter, you will learn about medications used to treat common disorders within the gastrointestinal system.

7.2 Basics Concepts of the Gastrointestinal System

Prior to discussing specific GI disorders and associated medication classes, it is important to have a clear understanding of the anatomy the gastrointestinal system.

Review of Anatomy of the Gastrointestinal System

It is important to know the basic anatomy and physiology of the gastrointestinal system to understand how gastrointestinal (GI) medications work. See Figure 7.1[1] for an illustration of the anatomical components of the GI system. There are a variety of medications used to treat common GI disorders, so this chapter's content is divided into three subsections discussing medications classes treating common disorders: antiulcer, antidiarrheals/ laxatives, and antiemetics. Each subsection will further review the GI anatomy and physiology related to these conditions and medications.

1. "Components of the Digestive System" by CNX OpenStax is 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

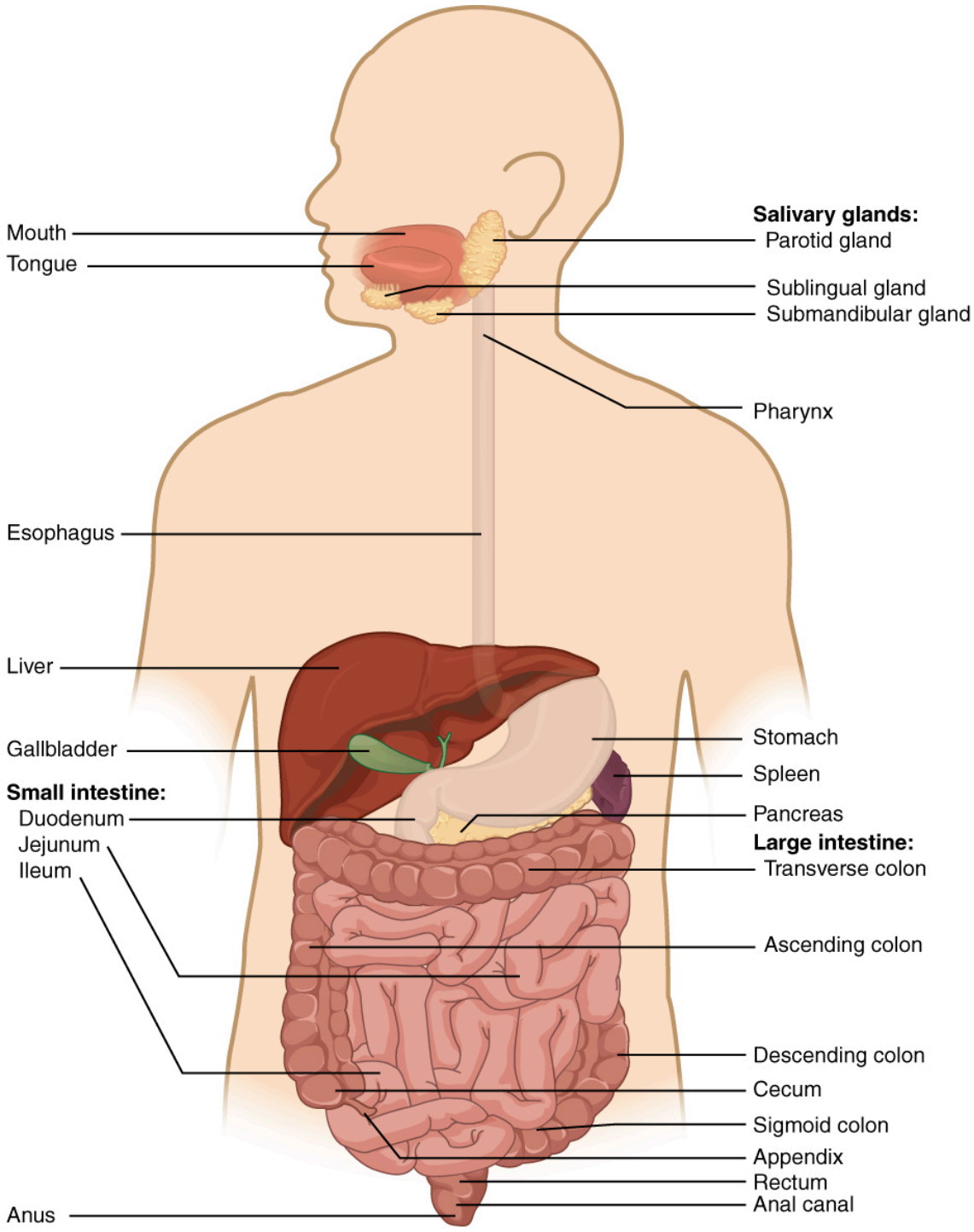

Figure 7.1 Components of GI System

For additional details related to the content in this chapter, review information in OpenStax *Anatomy and Physiology* using the areas noted below[2]:

- Overview of the Digestive System
- Digestive System Processes and Regulation
- The Stomach
- The Small and Large Intestines
- Chemical Digestion and Absorption: A Closer Look

See the following supplementary YouTube videos to review the gastrointestinal system and digestive processes.

Gastrointestinal System Review[3]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=296#oembed-1

2. 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
3. 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

- Ted Ed Review of Digestive System[4]
- Khan Academy Review of GI System[5]

4. Bryce, E. (2017, December 14). *How your digestive system works* [YouTube]. All rights reserved. https://youtu.be/Og5xAdC8EUI
5. "Meet the Gastrointestinal Tract!" by Raja Narayan is licensed under CC BY-NC-SA 3.0

7.3 Antiulcer Medications

This section will review the anatomy and pathophysiology of the digestive process and common hyperacidity disorders and then apply the nursing process to administering several hyperacidity medications.

Review of Anatomy and Pathophysiology of the Digestive Process

This section will discuss antiulcer medications. We will begin by reviewing the anatomy and physiology of the digestive process. 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 7.2.[1]

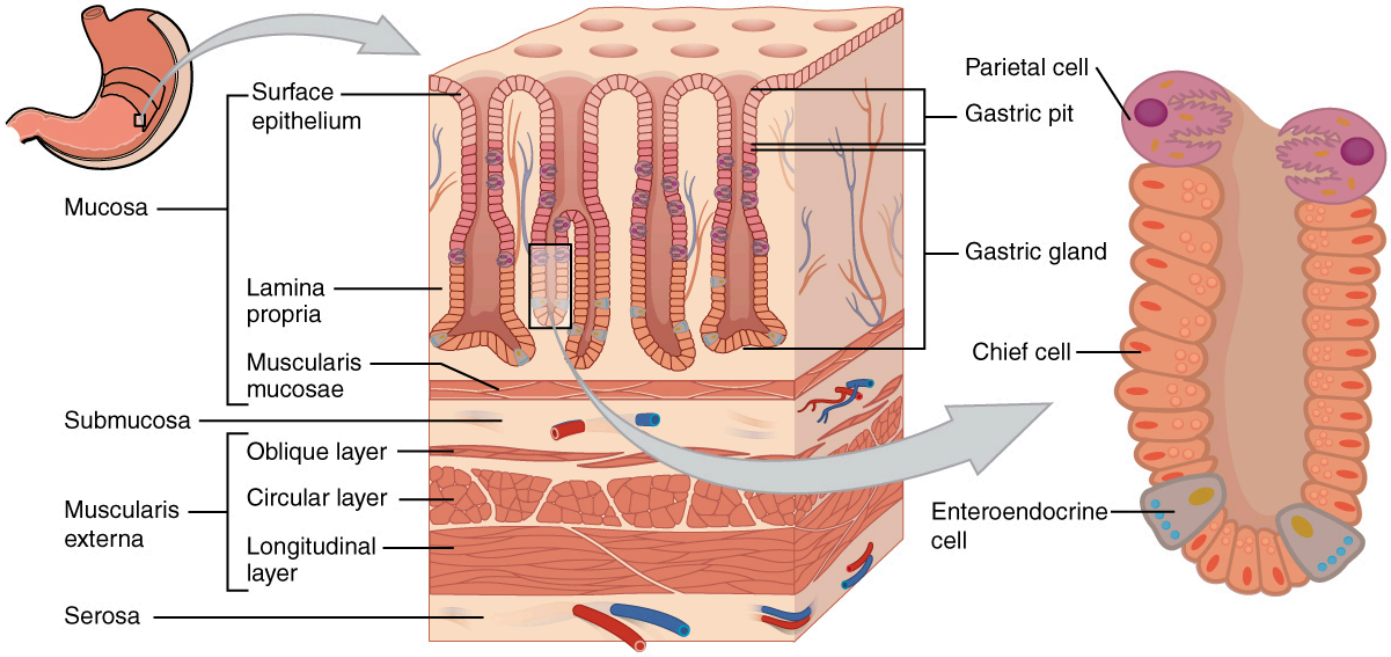

Figure 7.2 An Image of the Stomach With Surface Epithelium Cells in the Mucosa, and an Enlarged Image of the Gastric Gland Showing Chief and Parietal Cells

1. "2415 Histology of StomachN.jpg" by CNX OpenStax is licensed under CC BY 3.0. Access for free at https://cnx.org/contents/FPtK1zmh@16.7:O9dvCxUQ@8/23-4-The-Stomach

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. The most common mild to moderate hyperacidic condition is **gastroesophageal reflux disease (GERD)**, often referred to by clients as heartburn, indigestion, or sour stomach. GERD is caused by excessive hydrochloric acid that tends to back up, or reflux, into the lower esophagus. See Figure 7.3 for an illustration of GERD.[2]

2. "GERD.png" by BruceBlaus is licensed under CC BY-SA 4.0

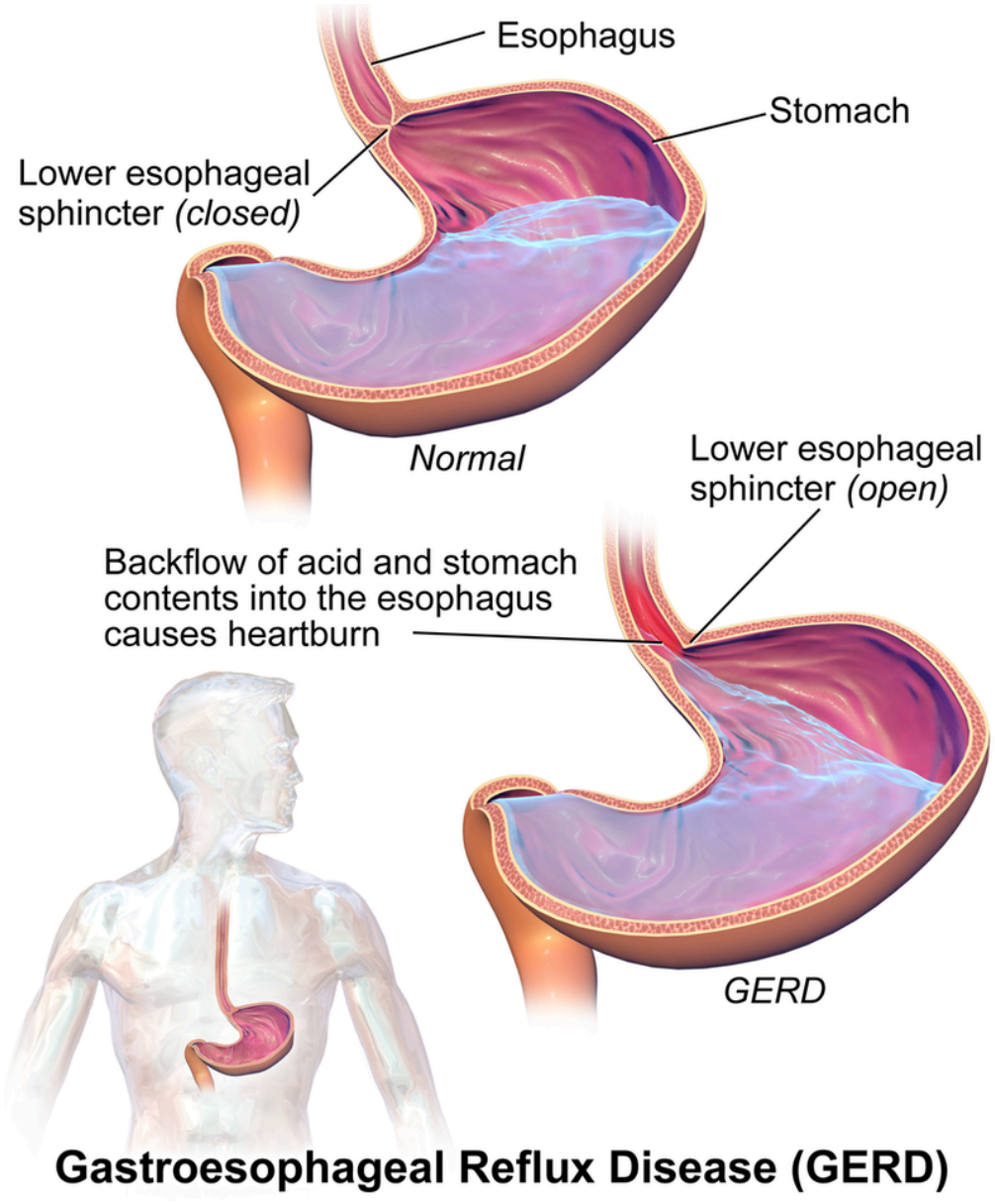

Figure 7.3 Illustration of GERD

Hyperacidity Disorders

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. PUD is the most harmful disease related to hyperacidity because it can result in bleeding ulcers, a life-threatening condition.

Stress-related mucosal damage is another common condition that can

occur in hospitalized clients leading to PUD. Thus, many postoperative or critically ill clients receive medication to prevent the formation of stress ulcers, often referred to as stress ulcer prophylaxis.[3] See an image of a duodenal ulcer in Figure 7.4.[4]



Figure 7.4 Image of a Duodenal Ulcer

View supplementary videos on heartburn and gastric ulcers:

- Heartburn[5]
- Gastric Ulcer[6]

3. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process*. pp. 782-862. Elsevier.
4. "Duodenal ulcer01.jpg" by melvil is licensed under CC BY-SA 4.0
5. MedlinePlus. Bethesda (MD): National Library of Medicine (US); [updated 2019 October 23]. Heartburn; [updated 2019 October 2; cited 2019 October 27] https://medlineplus.gov/ency/anatomyvideos/000068.htm
6. Blausen Medical. (2015, November 17). *Gastric ulcers* [Video]. https://blausen.com/en/video/gastric-ulcers/#

Applying the Nursing Process to Hyperacidity Medications

Assessment

Whenever a nurse administers hyperacidity medications, there are common assessments that should be documented, such as an abdominal assessment and documentation of bowel patterns. During therapy, the nurse should continue to assess for potential medication interactions and side effects and be aware that vitamin B12 malabsorption may occur whenever stomach acidity levels are altered. Based on the category of medication, renal and liver function may require monitoring. Additionally, if a client complains of chest pain, 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.”

Implementation

The nurse should read the drug label information and follow the recommendations for administering hyperacidity 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. A written plan of care with modifications for safe use of medications with these alternative methods may be required.

Evaluation

Clients should experience improvement of symptoms within the defined time period; if not, the provider should be notified. Increased pain or new symptoms of coughing/vomiting of blood should be immediately reported because these symptoms can be signs of a life-threatening bleeding ulcer.

Hyperacidity Medication Classes

There are four major classes of medications used to treat hyperacidity conditions: antacids, H2-receptor antagonists, proton pump inhibitors, and mucosal protectants. Each class of medication is further described below.

Antacids

Antacids (see Figure 7.5[7]) are used to neutralize stomach acid and reduce the symptoms of heartburn. There are many OTC medications available for this purpose, such as calcium carbonate, aluminum hydroxide, and magnesium hydroxide. Calcium carbonate is the prototype discussed as an example. Be sure to read drug label information regarding antacids as you administer them because each type has its own specific side effects. Many antacids also contain simethicone, an antiflatulent used for gas relief. Simethicone is further described in the medication grid below.



Figure 7.5 Antacids

7. "Antacid-L478.jpg" by Midnightcomm is licensed under CC BY-SA 3.0

Mechanism of Action: Antacids neutralize gastric acidity and elevate the pH of the stomach. Elevated pH also inactivates pepsin, a digestive enzyme.

Indications: Antacids are used to relieve heartburn, acid indigestion, and upset stomach.

Nursing Considerations: Calcium carbonate comes in various formations such as a tablet, a chewable tablet, a capsule, or liquid to take by mouth. It is usually taken three or four times a day. Chewable tablets should be chewed thoroughly before being swallowed; do not swallow them whole. The client should drink a full glass of water after taking either the regular or chewable tablets or capsules. Some liquid forms of calcium carbonate must be shaken well before use. Do not administer calcium carbonate within 1-2 hours of other medicines because calcium may decrease the effectiveness of the other medicines. Calcium carbonate may be contraindicated in clients with preexisting kidney disease because it may cause **hypercalcemia**.

Side Effects/Adverse Effects: Common side effects of calcium carbonate include constipation and **rebound hyperacidity** when it is discontinued.[8]

Health Teaching & Health Promotion: In addition to the information under "Nursing Considerations," clients should be reminded to take OTC meds appropriately as prescribed and to not exceed the maximum dose. Other interventions to prevent hyperacidity can also be recommended, such as smoking cessation and avoiding food and beverages that can cause increased acidity (alcohol, high-fat or spicy foods, and caffeine).[9,10,11,12]

H2-Receptor Antagonist

A common H2-receptor antagonist is famotidine. It is available OTC and is also often prescribed orally or as an IV injection in the hospital setting. Other

8. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; Heartburn; https://medlineplus.gov/ency/anatomyvideos/000068.htm
9. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process.* pp. 782-862. Elsevier.
10. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 443-454. Elsevier.
11. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
12. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm

H2-receptor antagonists include cimetidine and ranitidine. Cimetidine has a high risk of drug interactions, especially in elderly clients because of its binding to **cytochrome P-450 enzymes** in the liver, which affects the metabolism of other drugs.

Mechanism of Action: H2-receptor antagonists block histamine's action at the H2 receptor of the parietal cell, thus reducing the production of hydrochloric acid.

Indications: Famotidine (see Figure 7.6[13]) is used to treat GERD, peptic ulcer disease, erosive esophagitis, and hypersecretory conditions or as adjunct treatment for the control of upper GI bleeding. OTC famotidine is also used to treat heartburn or sour stomach.

Nursing Considerations: To prevent symptoms, oral famotidine is taken 15 to 60 minutes before eating foods or drinking drinks that may cause heartburn. 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 elderly clients.

Side Effects/Adverse Effects: Common side effects include headache, dizziness, constipation, and diarrhea. Individuals must immediately report increased pain or other signs of bleeding ulcers such as coughing/vomiting of blood.

Health Teaching & Health Promotion: Clients taking the oral suspension should be instructed to shake it vigorously for 5 to 10 seconds prior to each use.[14,15] The medication may cause constipation so fluids and high-fiber diet should be encouraged. Additionally, smoking interferes with histamine antagonists and should be discouraged.[16,17]

13. "My Still LIfe" by Bast Productions is licensed under CC BY-NC-ND 2.0
14. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process*. pp. 782-862. Elsevier.
15. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 443-454. Elsevier.
16. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
17. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; Heartburn; https://medlineplus.gov/ency/anatomyvideos/000068.htm



Figure 7.6 OTC Famotidine

Proton Pump Inhibitors

A common proton pump inhibitor (PPI) is pantoprazole (see Figure 7.7[18]). It may be prescribed in various routes, including orally, with an NG tube, or as an IV injection in the hospital setting. Other PPIs include esomeprazole, lansoprazole, and omeprazole. PPIs are more powerful than antacids and H2-receptor antagonists.

18. "Prilosec Box 001" by cygnus921 is licensed under CC BY 2.0

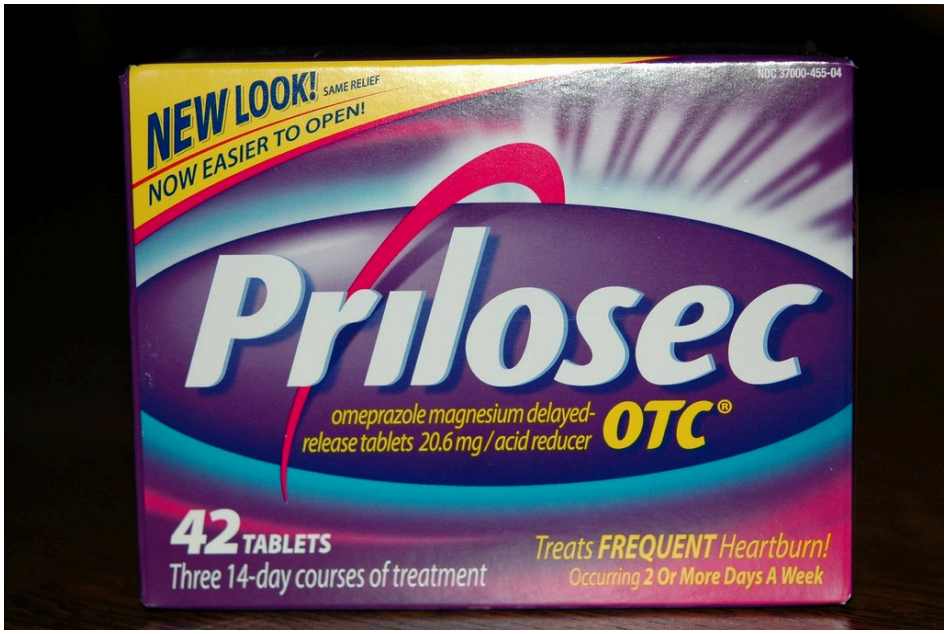

Figure 7.7 OTC Omeprazole

Mechanism of Action: PPIs bind to the hydrogen-potassium ATPase enzyme system of the parietal cell, also referred to as the "proton pump" because it pumps hydrogen ions into the stomach. PPIs inhibit the secretion of hydrochloric acid, and the antisecretory effect lasts longer than 24 hours.

Indications: Pantoprazole is used to treat damage from gastroesophageal reflux disease (GERD) in adults and children five years of age and older by allowing the esophagus to heal and prevent further damage. It is also used to treat conditions where the stomach produces too much acid, such as Zollinger-Ellison syndrome in adults. PPIs may also be given in combination with antibiotics to treat *H. Pylori* infections, a common cause of duodenal ulcers.

Nursing Considerations: Packets of delayed-release granules must be mixed with applesauce or apple juice and taken by mouth or given through a feeding tube. Consult the labeling of concomitantly used drugs to obtain further information about interactions because PPIs can interfere with the liver metabolism of other drugs. IV pantoprazole can potentially exacerbate zinc deficiency, and long-term therapy can cause hypomagnesemia, so the nurse should monitor for these deficiencies.

Side Effects/Adverse Effects: Concerning side effects of proton pump inhibitors include hypersensitivity, anaphylaxis, and serious skin reactions. Individuals taking proton pump inhibits may also be susceptible to zinc, magnesium, and B12 deficiencies. Clients may also experience headache, abdominal pain, diarrhea, or constipation. Individuals taking proton pump inhibitors may also be at risk for acute renal dysfunction, osteoporosis, and acute lupus erythematosus. If individuals experience increased pain or signs of a bleeding ulcer, such as coughing/vomiting blood, this should be immediately reported to their health care provider. Long-term use of PPIs may also increase the risk of pneumonia[19].

Health Teaching & Health Promotion: In addition to the considerations above, instruct clients to call their provider if their condition does not improve or gets worse, especially if bleeding occurs.[20,21] Use of alcohol, NSAIDS, or foods that cause GI irritation should be discouraged.[22,23]

Mucosal Protectants

Sucralfate is a mucosal protectant used to cover and protect gastrointestinal ulcers.

Mechanism of Action: Sucralfate locally covers the ulcer site in the GI tract and protects it against further attack by acid, pepsin, and bile salts. It is minimally absorbed by the gastrointestinal tract.

Indications: Sucralfate is used in the treatment of ulcers.

Nursing Considerations: Administer sucralfate on an empty stomach, two hours after or one hour before meals. Sucralfate should be cautiously used with clients with chronic renal failure or those receiving dialysis due to

19. Driessen, J. A., Hansen, B. E., van der Wall, E., de Boer, A., Janssen, H. L., & de Knegt, R. J. (2019). Proton pump inhibitor use and the risk of pneumonia: A systematic review and meta-analysis of observational studies. *Expert Review of Clinical Pharmacology, 12*(10), 935-947.
20. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process.* pp. 782-862. Elsevier.
21. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 443-454. Elsevier.
22. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
23. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27; https://medlineplus.gov/ency/anatomyvideos/000068.htm

impaired excretion of small amounts of absorbed aluminum that can occur with sucralfate.

Side Effects/Adverse Effects: A common side effect related to mucosal protectant medications includes constipation.

Health Teaching & Health Promotion: In addition to the considerations above, instruct clients to call their provider if their condition does not improve or gets worse.[24,25,26,27]

Antiflatulent

Simethicone is an antiflatulent that is commonly found in other OTC antacids (see Figure 7.8[28]). It is also safe for use in infants. Gas commonly occurs in the GI tract due to digestive processes and the swallowing of air. Gaseous distension can also occur postoperatively.



Figure 7.8 Combination OTC Product With Simethicone

24. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process.* pp. 782-862. Elsevier.
25. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 188-194 and 604-633. Elsevier.
26. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
27. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm
28. "Gelusil Antacid and Anti-Gas" by Wellspring Pharmaceutical is licensed under CC BY 2.0

Mechanism of Action: Simethicone works by altering the elasticity of the mucous-coated gas bubbles, which cause them to break into smaller bubbles, thus reducing pain and facilitating expulsion.

Indications: Simethicone is used to treat the symptoms of gas such as uncomfortable or painful pressure, fullness, and bloating.

Nursing Considerations: Simethicone is usually taken four times a day, after meals and at bedtime. For liquid form, shake drops before administering.

Side Effects/Adverse Effects: Common side effects include nausea, constipation, diarrhea, or headache.

Health Teaching & Health Promotion: Clients can be instructed about other measures to assist with gas expulsion such as changing position, ambulating, avoiding the use of straws, and tapering intake of beans and cruciferous vegetables.[29,30,31,32]

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=304#h5p-26

"GI Meds Hyperacidity Quiz" by E. Christman for Open RN is licensed under CC BY 4.0

29. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process.* pp. 782-862. Elsevier.
30. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 443-454. Elsevier.
31. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
32. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm

Now let's take a closer look at the medication grids comparing medications used to treat hyperacidity in Table 7.3.[33,34,35,36]

Medication grids 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. Detailed information on a specific medication can be found for free at DailyMed. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also linked to a DailyMed page.

Table 7.3 Hyperacidity Medication Grids

33. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process.* pp. 782-862. Elsevier.
34. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 443-454. Elsevier.
35. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
36. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antacid	calcium carbonate	Do not administer within 1-2 hours of other medications Drink a full glass of water after administration Use cautiously with renal disease	Decreased symptoms of heartburn or sour stomach	Constipation Hypercalcemia Rebound hyperacidity when discontinued

Antacid	aluminum/ magnesium	Should be taken after meals and at bedtime as directed by the health care provider Shake well before use to ensure an even distribution of the medication Take with a full glass of water to ensure that the medication is properly distributed throughout the stomach and to prevent potential choking or gastrointestinal irritation Cautious administration for individuals with kidney disease or on a magnesium restricted diet	Relieve symptoms of heartburn, acid indigestion, and sour stomach	Constipation, diarrhea, or stomach cramps

H2 Blocker	famotidine	Administer 15 to 60 minutes before eating foods or drinking drinks that may cause heartburn Preexisting liver and kidney disease may require dosage adjustment	Decreased symptoms of heartburn or sour stomach Decreased pain if ulcers are present	Side effects: Headache, dizziness, constipation, and diarrhea Immediately report increased pain or other signs of bleeding ulcers such as coughing/ vomiting of blood

Proton Pump Inhibitor	pantoprazole	Delayed release can be taken with or without food Administer granules with apple juice or applesauce	Decreased symptoms of heartburn and pain	Hypersensitivity; anaphylaxis and serious skin reactions Potential zinc, magnesium, or B12 deficiency Headache, abdominal pain, diarrhea, or constipation Acute renal dysfunction Osteoporosis-related bone fracture Acute lupus erythematosus Immediately report increased pain or other signs of bleeding ulcers such as coughing/ vomiting of blood
Mucosal Protectant	sucralfate	Administer sucralfate on an empty stomach, two hours after or one hour before meals Use cautiously in clients with chronic renal failure	Healing of ulcer	Constipation

Antiflatulant	simethicone	Shake drops before administering	Relief of gas discomfort	Nausea, constipation, diarrhea, or headache

Critical Thinking Activity 7.3

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 provider 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

7.4 Antidiarrheal Medications and Laxatives

This section will review the anatomy and pathophysiology of defecation and the condition of diarrhea and then apply the nursing process to administering antidiarrheals. From there, we will discuss the condition of constipation, apply the nursing process to treating constipation, and discuss classes of laxatives.

Review of Anatomy and Physiology of Defecation

The digestive system is continually at work, but unless something goes amiss, you don't notice your digestive system working. This section will focus on bowel disorders that occur in the lower intestine during the final step of digestion 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 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 7.9[1] 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

1. "Anorectum.gif" by U.S. Government, National Institutes of Health is licensed under CC0

relax. The next mass movement will trigger additional defecation reflexes until defecation occurs.[2]

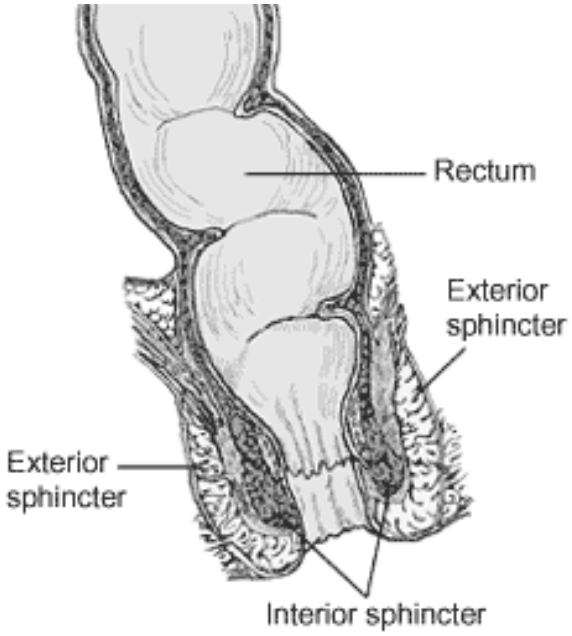

Figure 7.9 Anatomy of the Rectum

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. Figure 7.10[3] demonstrates the Bristol Stool Chart that is used to assess stool characteristics, ranging from very constipated to diarrhea.

2. 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
3. "BristolStoolChart.png" by Cabot Health, Bristol Stool Chart is licensed under CC BY-SA 3.0

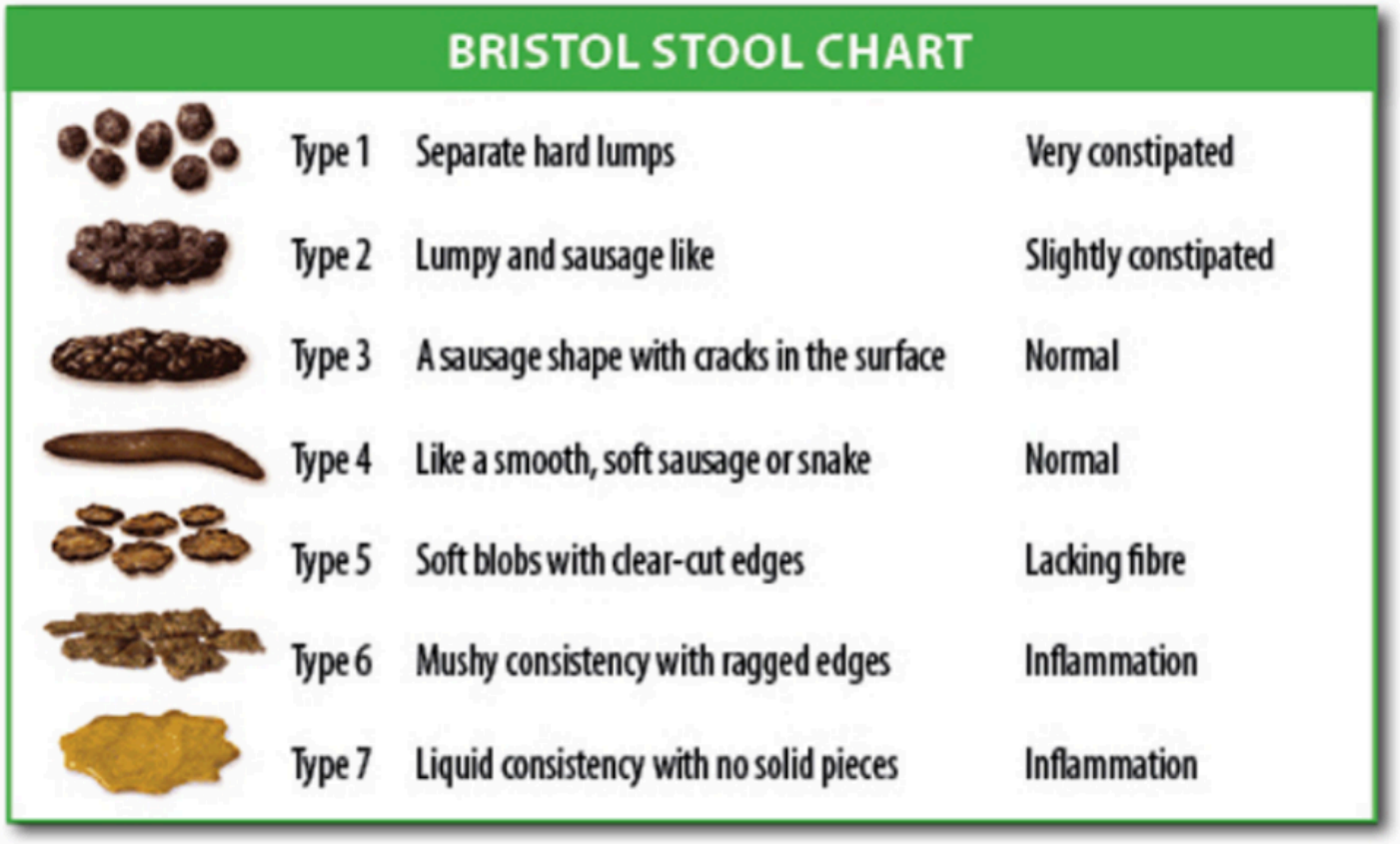

Figure 7.10 Bristol Stool Chart

Additional information about how the digestive system works can be reviewed using the information below:

- "Digestive System Processes and Regulation" in Open Stax *Anatomy and Physiology*.
- Your Digestive System and How it Works[4]

4. National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health. (2018). *Treatment for constipation.* https://www.niddk.nih.gov/health-information/digestive-diseases/constipation/treatment

Video on Digesting Food[5]

Diarrhea

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. Diarrhea has multiple causes such as bacteria from contaminated food or water; viruses such as influenza, 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.[6] The most severe threat posed by diarrhea is dehydration caused by the loss of water and electrolytes. 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.[7] Common medications used to manage the symptoms of diarrhea are discussed below.

Applying the Nursing Process to Administering Antidiarrheals

Assessment

When administering antidiarrheals, the nurse should document an abdominal assessment, frequency of bowel movements and stool

5. "Digesting Food" by Stanford School of Medicine and Khan Academy is licensed under CC BY-NC-SA 3.0
6. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm
7. World Health Organization. (2017, May 2). *Diarrhoeal disease*. https://www.who.int/en/news-room/fact-sheets/detail/diarrhoeal-disease

characteristics, and if there is skin breakdown in the anal area. Dehydration is a serious risk in clients with severe diarrhea, so priority assessments and documentation relate to monitoring for dehydration, especially in vulnerable populations of infants, children, and elderly. If signs of dehydration occur, the provider should be immediately notified, and treatment initiated for dehydration.

Implementation

Teach the client to not exceed dosages of OTC medications because life-threatening adverse effects may occur. Probiotics have been found to be likely 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. In addition to teaching about medication therapy, nurses can also teach clients with diarrhea other nonpharmacological interventions, such as replacing fluid and electrolytes by drinking water, sports drinks, or sodas without caffeine; and eating soft, bland food like bananas, rice, and toast. Children with severe diarrhea may also require oral rehydration solutions to replace lost fluids and electrolytes. The nurse should also keep in mind that antidiarrheals should be used very cautiously with children because some categories are contraindicated.

Evaluation

Because antidiarrheals treat the symptoms of diarrhea but do not eliminate the cause of it, if symptoms do not resolve within 48 hours, the provider should be notified, and other potential causes of diarrhea investigated. Monitor for serious adverse effects such as increased bleeding in clients taking salicylates and for abnormal heart rhythms in clients taking loperamide and notify the provider immediately. Evaluation for dehydration should continuously occur until the condition resolves.

Antidiarrheal Medication Classes

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; and probiotics, which help to restore the normal bacteria found in the lower intestine. Oral rehydration agents may also be used in clients with diarrhea to replace fluid and electrolyte loss, but they do not treat the 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.[8]

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 7.11[9]).

8. World Health Organization. (2017, May 2). *Diarrhoeal disease*. https://www.who.int/en/news-room/fact-sheets/detail/diarrhoeal-disease
9. "PeptoBismol Bottle.JPG" by ParentingPatch is licensed under CC BY-SA 3.0



Figure 7.11 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.[10] Bismuth subsalicylate also decreases the flow of fluids and electrolytes into the bowel, reducing inflammation within the intestine.[11]

Indications: Adsorbent medications are used to treat conditions that involve excess gas or toxins in the digestive system.

Nursing Considerations: 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. Children and teenagers who have or are recovering from chicken pox or flu-

10. Lilley, L., Collins, S., & Snyder, J. (2014). *Pharmacology and the nursing process.* pp. 782-862. Elsevier.
11. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm

like symptoms should not use this product. When using this product, if changes in behavior with nausea and vomiting occur, consult a provider because these symptoms could be an early sign of Reye's syndrome, a rare but serious illness. Liquid products should be shaken well before use. Tablets should be swallowed whole and not chewed unless they are a chewable tablet. Medication can cause a black or darkened tongue. If symptoms worsen, a fever, or ringing in the ears occurs, or if diarrhea lasts longer than 48 hours, contact the provider.[12,13]

Side Effects/Adverse Effects: Side effects of adsorbent medications include black or darkened tongue. Individuals should contract their provider if symptoms worsen or if they experience a fever or ringing in the ears.

Health Teaching & Health Promotion: Clients should be advised to take medication as directed. They should be aware of potential color changes to stool that may occur and that the medication contains aspirin. They should discontinue the medication if tinnitus occurs.[14]

Antimotility

Antimotility medications help to treat diarrhea by slowing peristalsis. There are two categories of antimotility medication: anticholinergics and opiate-like medications.

Anticholinergics

Mechanism of Action: Hyoscyamine is an anticholinergic that works on the smooth muscle of the GI tract to inhibit propulsive motility and decreases gastric acid secretion.

Indications: Anticholinergic medications are a class of drugs that block the action of the neurotransmitter acetylcholine in the nervous system.

Nursing Considerations: Read drug label information for all

12. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
13. A.D.A.M. Medical Encyclopedia [Internet]. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm
14. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

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 may occur that are common with anticholinergic medications.[15,16]

Side Effects/Adverse Effects: Common side effects of anticholinergic medications include dry mouth, constipation, blurred vision, and confusion, especially in older adults.

Health Teaching & Health Promotion: Clients should receive instruction that these medications may cause dizziness and drowsiness. If clients experience dry mouth, frequent oral hygiene may alleviate discomfort.[17]

Opioid-like Medication

Mechanism of Action: Loperamide has an opioid-like chemical structure but causes fewer CNS effects. It works by decreasing the flow of fluids and electrolytes into the bowel and by slowing down the movement of the bowel to decrease the number of bowel movements (see Figure 7.12[18]).

15. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
16. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm
17. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
18. "Loperamide2mg.JPG" by Kristoferb is licensed under CC BY-SA 3.0



Figure 7.12 Loperamide

Indications: Opioid-like medications such as loperamide work by slowing down the movement of the intestines, which reduces the frequency and volume of bowel movements.

Nursing Considerations: Loperamide should not be given to a child younger than two years of age because of the risk of serious breathing 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 antidysrhythmics and antipsychotics.[19,20]

Side Effects/Adverse Effects: Common side effects of loperamide may include constipation, abdominal discomfort, nausea, vomiting, dizziness, drowsiness, or allergic skin reactions such as hives.

Health Teaching & Health Promotion: Clients should take medications as

19. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
20. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm

directed. They should also avoid alcohol and other CNS depressants. The medications may cause drowsiness.[21]

Probiotics

Probiotics are used for the prevention and treatment of diarrhea. They are often used concomitantly with antibiotics to prevent the common associated side effects of diarrhea (see Figure 7.13[22]). An example of a probiotic is lactobacillus.



Figure 7.13 Probiotics Come in Several Forms

Mechanism of Action: Probiotics help replenish normal bacterial flora in the gastrointestinal tract.

Indications: Probiotics are live microorganisms that are beneficial for digestive health.

Nursing Considerations: Probiotic usage should be tailored to the

21. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
22. "WildWood Probiotic Soyogurt" by Veganbaking.net is licensed under CC BY-SA 2.0

individual's specific health needs because not all strains of probiotics have the same health benefits.

Side Effects/Adverse Effects: Probiotics may have some side effects such as gas, bloating, and diarrhea.

Health Teaching & Health Promotion: Side effects of probiotics are mild such as gas and bloating. Probiotics are safe for use in children.[23,24]

Now let's take a closer look at medication grids comparing medications used to treat diarrhea. (See Table 7.4a.[25,26])

Medication grids 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. Detailed information on a specific medication can be found for free at DailyMed. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also linked directly to a DailyMed page.

Table 7.4a Diarrhea Medication Grids

23. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
24. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27]. https://medlineplus.gov/ency/anatomyvideos/000068.htm
25. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
26. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; ©2019. Heartburn; [reviewed 2019 May 10; cited 2019 October 27] https://medlineplus.gov/ency/anatomyvideos/000068.htm

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Adsorbents	bismuth subsalicylate (Pepto Bismol)	Avoid if taking other salicylates Do not use in children or teenagers recovering from chicken pox or flu-like symptoms as it may cause Reye's syndrome Do not use if 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, or if diarrhea lasts longer than 48 hours
Anticholinergic	hyoscyamine	Contraindicated in glaucoma, myasthenia gravis, or paralytic ileus	Decreased diarrhea symptoms	May cause CNS and other adverse effects associated with anticholinergic medication

Opiate-like Medication	loperamide (Imodium)	Contraindicated in children younger than two and with several other medications; read drug label information before administering	Decreased diarrhea symptoms	Constipation, abdominal discomfort, nausea, vomiting, dizziness, drowsiness, or allergic skin reactions such as hives Boxed Warning: May cause abnormal heart rhythm
Probiotic	lactobacillus	Pediatric dosing is age based and varies by product	Prevention of diarrhea or decreased symptoms of diarrhea	Mild such as gas and bloating

Critical Thinking Activity 7.4

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 the diarrhea. What is the nurse's best response?

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

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."[27] 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 7.4b.[28]

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 7.4b Common Causes of Constipation

27. National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health. (2018). *Symptoms and causes of constipation*. https://www.niddk.nih.gov/health-information/digestive-diseases/constipation/symptoms-causes
28. National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health. (2018). *Symptoms and causes of constipation*. https://www.niddk.nih.gov/health-information/digestive-diseases/constipation/symptoms-causes

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

Applying the Nursing Process to Administering Laxatives

Assessment

The nurse should assess for the potential cause of the client's constipation and appropriately individualize the treatment and health teaching. The nurse should document an abdominal assessment that includes discomfort, distention, and decreased bowel sounds. The date of the last bowel movement should also be documented. The client may be asked additional history questions such as the appearance of the stool to determine if it is hard and dry, if passing the stool is difficult or painful, or if there is a feeling of incomplete emptying.

Implementation

Many facilities have a bowel medication protocol with progressive treatment of constipation, ranging from stool softeners to stimulants to enemas, depending on the length of time since the last bowel movement. Medications should be administered according to label instructions, and the client should be instructed when to expect a bowel movement will occur. Measures to prevent constipation should also be discussed with the client.

Patient teaching for all classes of laxative medications should be individualized based on the cause of constipation. These measures to prevent constipation should be reviewed with the client:

- 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[29]

29. National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health. (2018). *Treatment for constipation.* https://www.niddk.nih.gov/health-information/digestive-diseases/constipation/treatment

Evaluation

If a bowel movement does not occur within the expected time frame, 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.

Laxative Medication Classes

There are five categories of laxative medications commonly used to treat constipation: fiber supplements, **stool softeners**, **osmotic agents**, lubricants, and **stimulants.** Fiber supplements and stool softeners are often used daily to prevent constipation, whereas the other laxative categories are used to treat constipation. Table 7.4c compares the mechanism of action for each laxative category and includes common prototype and OTC brand names.[30,31,32]

Table 7.4c Categories of Laxatives Used to Treat Constipation

30. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
31. National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health. (2018). *Treatment for constipation*. https://www.niddk.nih.gov/health-information/digestive-diseases/constipation/treatment
32. Drugs.com [Internet]. *Fleet mineral oil enema (rectal)*; © 1996-2018 [updated 1 October 2019; cited 27 October 2019]. https://www.drugs.com/mtm/fleet-mineral-oil-enema-rectal.html

Category	Prototypes	Mechanism of Action
Fiber supplements	psyllium (Metamucil)	Bulk forming to facilitate passage of stool through rectum
Stool softeners	Docusate (Colace)	Facilitates movement of water and fats into stool
Osmotic agents	Milk of Magnesia; polyethylene glycol (PEG) 3350 (Miralax)	Causes water to be retained with the stool, increasing the number of bowel movements and softening the stool so it is easier to pass
Lubricants	mineral oil enema (Fleet)	Coats the stool to help seal in water
Stimulants	Bisacodyl (Dulcolax)	Causes the intestines to contract, inducing stool to move through the colon

Fiber Supplements

Psyllium (brand name Metamucil) is an example of a common OTC fiber supplement (see Figure 7.14[33]).

33. "Metamucil ad (cropped).jpg" by unknown is licensed under CC0



Figure 7.14 Psyllium in Powder Form

Mechanism of Action: Psyllium adds bulk to the stool to facilitate passage through the rectum.

Indications: A type of soluble fiber that is commonly used as a dietary supplement and as an ingredient in some medications to help treat constipation.

Nursing Considerations: When administering, put one dose into an empty glass and mix with at least 8 ounces of water or other fluid. Taking this product without enough liquid may cause choking. Stir briskly and drink promptly. If mixture thickens, add more liquid and stir. 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.

Side Effects/Adverse Effects: Psyllium is generally well-tolerated; however, some individuals may experience abdominal discomfort, ongoing constipation, diarrhea, or obstruction. It may also interfere with medication absorption.

Health Teaching & Health Promotion: When teaching clients how to take psyllium at home, in addition to the above considerations, advise them to start with one dose per day but may gradually increase to three doses per day as necessary to maintain soft stools.

Stool Softeners

Docusate is a common OTC stool softener that is also used frequently in health care settings.

Mechanism of Action: Docusate facilitates movement of water and fats into stool to make it soft and improve regularity of bowel movements.

Indications: Stool softeners are medications that help to moisten and soften the stool, making it easier to pass.

Nursing Considerations: Docusate usually produces a bowel movement in 12 to 72 hours. It may cause stomach cramping.

Side Effects/Adverse Effects: Stool softeners can cause diarrhea, nausea, vomiting, abdominal cramping, and electrolyte imbalances in some clients.

Health Teaching & Health Promotion: Stool softeners may interact with other medications, such as blood thinners or antibiotics. They should not be used in individuals with intestinal blockages.

Osmotic Agents

Milk of Magnesia and polyethylene glycol 3350 (brand name Miralax) are examples of common osmotic agents used to promote a bowel movement (see Figure 7.15).[34]

34. "MiraLax Mix-In Pax, Unflavored, 20 Little Packets" by Ava Williams is licensed under CC0 and "Phillips' Milk of Magnesia, 1910's" by Roadsidepictures is licensed under CC BY-NC 2.0



Figure 7.15 Miralax & Milk of Magnesia

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.

Indications: They are often used to treat constipation or to prepare for certain medical procedures, such as colonoscopies.

Nursing Considerations: Polyethylene glycol 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 the 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.

Side Effects/Adverse Effects: Side effects of osmotic agents include diarrhea, abdominal cramping, electrolyte imbalance, dehydration, or allergic reactions.

Health Teaching & Health Promotion: In addition to the administration considerations above, teach clients that polyethylene glycol usually produces a bowel movement in 1-3 days. It may cause loose, watery stools.

Lubricants

A mineral oil enema (brand name Fleet enema) is an example of a lubricant laxative (see Figure 7.16[35]).



Figure 7.16 Mineral Oil Enema

Mechanism of Action: Mineral oil coats the stool to help seal in water.

Indications: Mineral oil may be used to relieve constipation by lubricating and softening the stool.

Nursing Considerations: Read drug label for children as some brands can be used in children aged 2 or older, whereas others are not intended for children.

Side Effects/Adverse Effects: Side effects of mineral oil enemas may

35. "fleet_enema" by Logesh79 is licensed under CC BY-NC 2.0

include irritations and inflammation of anal area, electrolyte imbalances, dehydration, or interference with medication absorption.

Health Teaching & Health Promotion: A mineral oil enema generally produces a bowel movement in 2 to 15 minutes. It may cause stomach cramps, bloating, upset stomach, or diarrhea.

Stimulants

Bisacodyl is an example of a stimulant laxative.

Mechanism of Action: Bisacodyl causes the intestines to contract, inducing the stool to move through the colon.

Indications: Stimulant laxatives such as bisacodyl are used to treat constipation and prepare the bowel for medical procedures.

Nursing Considerations: Oral dosage or rectal suppositories are available. See instructions for how to insert a rectal suppository. Instruct the client to retain suppository for about 15 to 20 minutes (see Figure 7.17[36]).

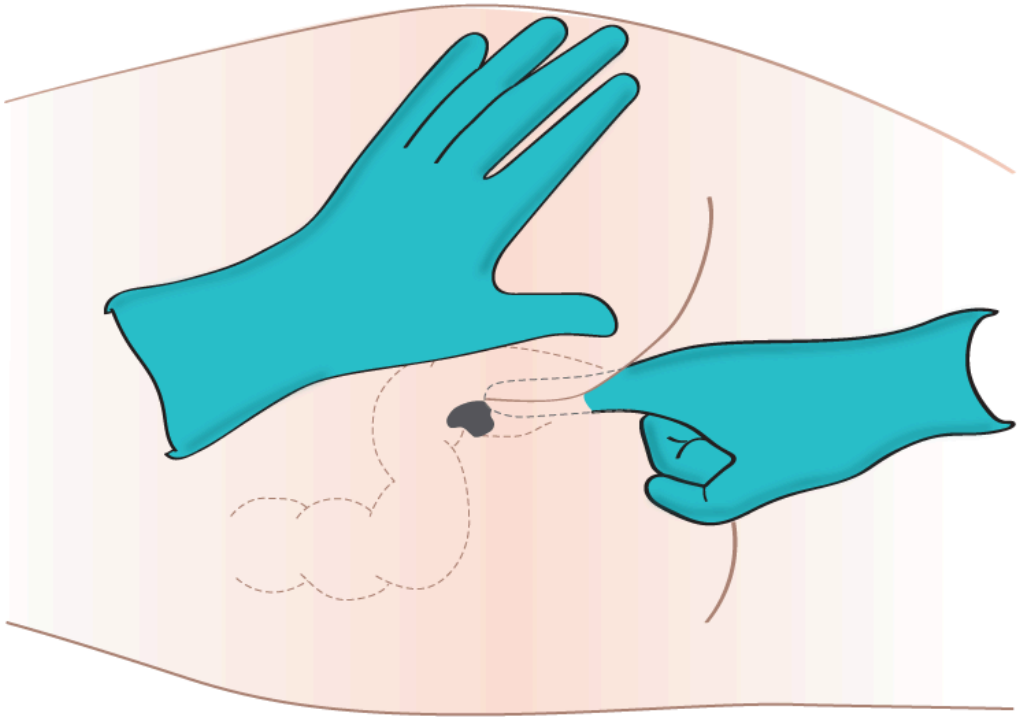

Figure 7.17 Administering a Rectal Suppository

36. "Administering-med-rectally-2.png" by British Columbia Institute of Technology (BCIT) is licensed under CC BY 4.0

Side Effects/Adverse Effects: Common side effects of bisacodyl include abdominal cramps, nausea, and vomiting, diarrhea, rectal irritation, dehydration, or electrolyte imbalances. Adverse effects may include severe abdominal pain, rectal bleeding, severe dehydration, fainting, and hypokalemia.

Health Teaching & Health Promotion: A bowel movement is generally produced in 15 minutes. Bisacodyl may cause stomach cramps, dizziness, or rectal burning.

Herbals

Many herbal substances may be useful in facilitating natural bowel function. Substances such as senna can have a significant benefit in relieving constipation due to its laxative properties. Senna is a plant that belongs to the legume family.

Mechanism of Action: Senna leaves contain compounds known as anthraquinones, which act as stimulant laxatives by increasing motility of the intestines.

Indications: Senna is given to increase motility of the intestines and promote bowel movements.

Nursing Considerations: Overuse of senna can result in diarrhea and dehydration. Clients should take adequate fluids to prevent dehydration. Short-term use is recommended to diminish risk of dependence.

Side Effects/Adverse Effects: Senna can cause cramps, bloating, and abdominal discomfort. Overuse can lead to diarrhea and dehydration, as well an electrolyte imbalance.

Health Teaching & Health Promotion: Senna can cause discoloration of the urine, turning it into a reddish-brown color. It is important that clients take senna at the lowest possible dose for the shortest duration of time**.**

Now let's take a closer look at the medication grids comparing medications used to treat constipation. (See Table 7.4d).[37,38]

37. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
38. Drugs.com [Internet]. *Metamucil*; © 2000-2019 [reviewed 20 November 2017; updated 1 October 2019; cited 27 October 2019]. https://www.drugs.com/mtm/metamucil.html

Medication grids 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. Detailed information on a specific medication can be found for free at DailyMed. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also linked directly to a DailyMed page.

Table 7.4d Medication Grid Comparing Laxatives Used to Treat Constipation

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Laxative/Bulk-Forming	psyllium (Metamucil)	Put one dose into an empty glass and mix with at least 8 ounces of water or other fluid. Taking this product without enough liquid may cause choking. Stir briskly and drink promptly. If mixture thickens, add more liquid and stir Usually produces a bowel movement within 12 to 72 hours Administer at least 2 hours before or 2 hours after other medications as it can affect absorption Start with 1 dose per day; may gradually increase to 3 doses per day as necessary	Improves regularity of bowel movements	May cause bloating and cramping

Laxative/Stool Softener	docusate	Usually produces bowel movement in 12 to 72 hours	Softens stool and improves regularity of bowel movements	May cause abdominal cramping

Laxative/Osmotic Agent	polyethylene glycol 3350 **(Miralax)**	Usually produces a bowel movement in 1-3 days The bottle top is a measuring cap marked to contain 17 grams of powder when filled to the indicated line For adults and children 17 years of age and older: ○ 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 drink ○ use once a day ○ use no more than 7 days	Softens stool and improves regularity of bowel movements	May cause loose, watery stools

Laxative/Lubricant Laxative	Mineral oil enema	Read drug label for children as some brands can be used in children aged 2 or older, whereas others are not intended for children Generally, produces bowel movement in 2 to 15 minutes	Bowel movement within 15 minutes	Stomach cramps, bloating, upset stomach, or diarrhea

Laxative/Simulant Laxative	bisacodyl	Oral dosage or rectal suppositories are available To administer a rectal suppository, position the client on their left side with the right knee up towards the chest. In the presence of anal fissures or hemorrhoids, suppositories should be coated at the tip with petroleum jelly. Remove foil and insert suppository well into rectum touching the bowel wall. Instruct the client to retain suppository for about 15 to 20 minutes. A bowel movement is generally produced in 15 minutes to one	Bowel movement within one hour	Stomach cramps, dizziness, or rectal burning

		hour. For children, read drug label for dosage		
Laxative/Herbal	Senna	Overuse of senna can result in diarrhea and dehydration. Clients should take adequate fluids to prevent dehydration. Short-term use is recommended to diminish risk of dependence	Improved bowel movements	Cramps, bloating, and abdominal discomfort. Overuse can lead to diarrhea and dehydration, as well an electrolyte imbalances

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=316#h5p-28

"GI Bowel Disorder Mediations Quiz" by E. Christman for Open RN is licensed under CC BY 4.0

Critical Thinking Activity 7.4b

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 provider, follows the bowel protocol, and administers docusate sodium 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 docusate?
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 docusate is not effective within 24 hours, what other medications can the nurse anticipate being ordered?

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

7.5 Antiemetics

This section will review the pathophysiology of nausea and vomiting and then apply the nursing process to administering antiemetic medications.

Review of the Pathophysiology of Nausea and Vomiting

Nausea and vomiting are common conditions. Nausea is the unpleasant sensation of having the urge to vomit, and vomiting (emesis) is the forceful oral expulsion of gastric contents.[1] There are many potential causes of nausea and vomiting, such as the following:

- Morning sickness during pregnancy
- **Gastroenteritis** and other infections
- Migraines
- Motion sickness
- Food poisoning
- Side effects of medicines, including those for cancer chemotherapy
- GERD and ulcers
- Intestinal obstruction
- Poisoning or exposure to a toxic substance
- Diseases of other organs (cardiac, renal, or liver)

Nausea and vomiting are common and are usually not serious. However, the 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**)

1. Bashashati, M., & McCallum, R. (2014). Neurochemical mechanisms and pharmacologic strategies in managing nausea and vomiting related to cyclic vomiting syndrome and other gastrointestinal disorders. *European Journal of Pharmacology, 772*, 79. https://doi.org/10.1016/j.ejphar.2013.09.075

- Severe abdominal pain
- Severe headache and stiff neck
- Signs of dehydration, such as dry mouth, infrequent urination, or dark urine

Treatment of nausea and vomiting should be tailored to the cause. There are several medications that work on different neuroreceptors that when used can treat nausea and vomiting. For severe cases of vomiting, intravenous fluids may also be needed to treat the accompanying dehydration.[2,3]

The Vomiting Center and Associated Neurotransmitters

The vomiting center can be activated directly by irritants or indirectly following input from four principal areas: gastrointestinal tract, cerebral cortex and thalamus, vestibular region, and chemoreceptor trigger zone (CRTZ). See Figure 7.18 for an illustration of the pathophysiology of nausea and vomiting.[4]

2. MedlinePlus [Internet]. Bethesda (MD): National Library of Medicine (US); [updated 2019 October 23]. *Nausea and vomiting;* [updated 2019 February 7; reviewed 2016 March 17; cited 2019 October 27]. https://medlineplus.gov/nauseaandvomiting.html
3. Bashashati, M., & McCallum, R. (2014). Neurochemical mechanisms and pharmacologic strategies in managing nausea and vomiting related to cyclic vomiting syndrome and other gastrointestinal disorders. *European Journal of Pharmacology, 772*, 79. https://doi.org/10.1016/j.ejphar.2013.09.075
4. Becker, D. E. (2010). Nausea, vomiting, and hiccups: A review of mechanisms and treatment. *Anesthesia Progress, 57*(4), 150–157. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3006663/

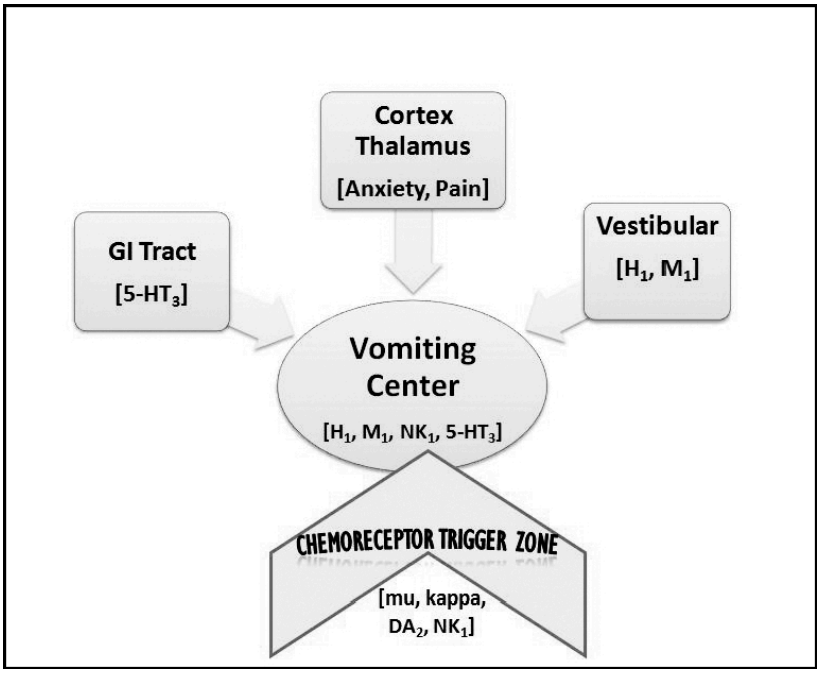

Figure 7.18 Pathophysiology of Nausea and Vomiting

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 vestibular center and cerebral cortex 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. The gastrointestinal tract sends stimuli to the CTZ via cranial nerves IX and X related to obstruction, distension, inflammation, and infection. The cerebral cortex and other parts of the brain can also stimulate a sense of nausea related to odors, tastes, and images and send these stimuli to the CTZ.

The CTZ forwards these signals to the vomiting center in the brain. Pain can also directly stimulate the vomiting center.

The **vomiting center** (VC) is located in the medulla in the brain. In response to these stimuli, 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. Several neurotransmitters are involved in the nausea and vomiting process, and antiemetic medications are targeted to specific neuroreceptors.[5]

Table 7.5a 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.[6] Each medication class is also discussed in more detail later in this section.

Table 7.5a Neurotransmitters and Associated Medications Used to Treat Nausea and Vomiting

5. Becker, D. E. (2010). Nausea, vomiting, and hiccups: A review of mechanisms and treatment. *Anesthesia Progress, 57*(4), 150–157. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3006663/
6. Bashashati, M., & McCallum, R. (2014). Neurochemical mechanisms and pharmacologic strategies in managing nausea and vomiting related to cyclic vomiting syndrome and other gastrointestinal disorders. *European Journal of Pharmacology, 772*, 79. https://doi.org/10.1016/j.ejphar.2013.09.075

Neurotransmitter	Medication Class	Antiemetic Drug	Mechanism of Action
Acetylcholine (M1)	Anticholinergics	scopolamine	Blocks ACh receptors in vestibular system
Histamine (H1)	Antihistamines	meclizine	Blocks H1 receptors and thus blocks ACh in vestibular system
Dopamine (DA2)	Dopamine antagonists	prochlorperazine	Blocks dopamine in CTZ and may block ACh
Dopamine and ACh (DA2 and M1)	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

Applying the Nursing Process to Administering Antiemetics

Assessment

When administering antiemetics, identify factors contributing to the symptoms of nausea and vomiting so that treatment can correctly target the cause. Document the frequency and amount of emesis and effects on the client's appetite and fluid intake. 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.

Implementation

Advocate for the most effective route of administration if the client is vomiting. Consider timing of administration of antiemetics in advance of meals when appetite is affected. Follow drug label administration information and monitor the client closely for potential side effects associated with that category of medication. For example, when administering anticholinergics and antihistamines, monitor for anticholinergic side effects, especially in elderly clients.

Evaluation

Monitor for improvement of nausea and vomiting and notify the provider if expected improvement does not occur so that other treatment can be initiated. Continue to monitor for dehydration. Teach the client these nonpharmacological interventions for nausea:

- Drink enough fluids to avoid dehydration. If you are having trouble keeping liquids down, drink sips of clear liquids every few minutes.
- Eat bland foods; stay away from spicy, fatty, or salty foods.
- Eat smaller meals more often.
- Avoid strong smells because they can sometimes trigger nausea and vomiting.
- If you are pregnant and have morning sickness, eat crackers before you get out of bed in the morning.[7]

Antiemetic Medication Classes

Anticholinergics

Scopolamine is an example of an anticholinergic medication that is often

7. MedlinePlus [Internet]. Bethesda (MD): National Library of Medicine (US); [updated 2019 October 23]. *Nausea and vomiting*; [updated 2019 February 7; reviewed 2016 March 17; cited 2019 October 27]. https://medlineplus.gov/nauseaandvomiting.html

used to treat motion sickness or nausea and vomiting associated with surgical recovery from anesthesia and/or opiate analgesia.

Mechanism of Action: Anticholinergics block 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 dry GI secretions and reduce smooth muscle spasms.

Indications: Anticholinergics, like scopolamine, are commonly used to prevent motion sickness and treat nausea and vomiting

Nursing Considerations: The scopolamine transdermal patch (see Figure 7.19)[8] is designed for continuous release of scopolamine following 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 three days. It is contraindicated in clients with glaucoma. It has been reported to exacerbate psychosis, induce seizures, and cause drowsiness, confusion, and sedation. Due to its anticholinergic properties, scopolamine can decrease gastrointestinal motility and cause urinary retention. Scopolamine should be discontinued in clients who develop difficulty in urination. Scopolamine transdermal patches contain an aluminized membrane; skin burns have been reported at the application site in clients wearing an aluminized transdermal system during an MRI scan. Remove scopolamine transdermal patches before undergoing an MRI.

8. "Scopoderm 278:365" by Andreas Nilsson is licensed under CC BY-NC-ND 2.0

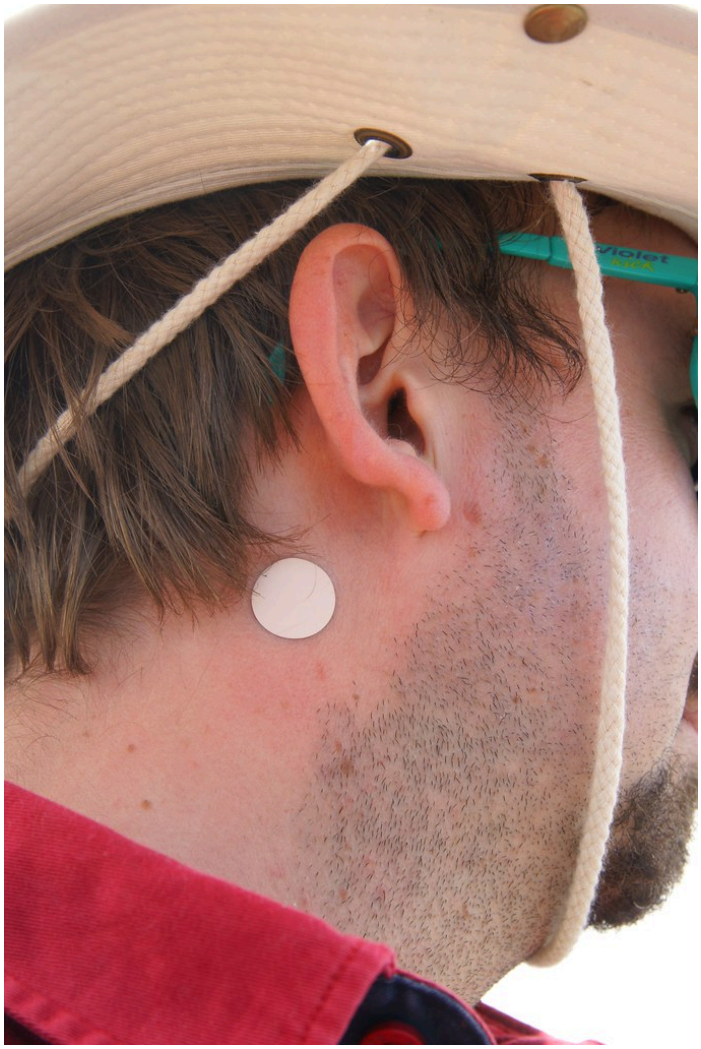

Figure 7.19 Scopolamine Transdermal Patch

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 cesarean section, apply one scopolamine transdermal system the evening before scheduled surgery. Remove the transdermal system 24 hours following surgery.

Side Effects/Adverse Effects: Anticholinergics have potential side effects such as dry mouth, constipation, blurred vision, confusion, and memory impairment, especially in elderly clients.

Health Teaching & Health Promotion: Scopolamine transdermal patches 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 scopolamine does not affect them adversely. Scopolamine 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 transdermal system. 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.[9]

Antihistamines

Meclizine is an example of an antihistamine that is often used to treat motion sickness.

Mechanism of Action: Antihistamines block H1 receptors in the vestibular center and may also block acetylcholine (ACh).

Indications: Antihistamines such as meclizine block the action of histamine

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in the body. When H1 receptors are blocked in the vestibular center, this prevents motion sickness and nausea.

Nursing Considerations: Antihistamines are contraindicated in clients with glaucoma or an enlarged prostate gland. Dosage should be started one hour before travel begins.

Side Effects/Adverse Effects: Antihistamines have potential side effects such as drowsiness, dry mouth, blurred vision, and constipation. Some antihistamines can also interact with other medications or medical conditions.

Health Teaching & Health Promotion: Advise clients of the following:

- Do not exceed recommended dosage.
- Be advised that drowsiness may occur.
- Avoid alcohol, sedatives, and tranquilizers, which may increase drowsiness.
- Avoid alcoholic drinks.
- Be careful when driving a motor vehicle or operating machinery.[10]

Dopamine Antagonists

Prochlorperazine is an example of a dopamine antagonist used to treat nausea and vomiting. It can also be used as an antipsychotic medication.

Mechanism of Action: Prochlorperazine blocks dopamine in the chemoreceptor trigger zone (CTZ). It also calms the central nervous system and may also block acetylcholine.

Indications: Dopamine antagonists block the action of dopamine in the brain and can help treat nausea and vomiting**.**

Nursing Considerations: Prochlorperazine can be administered orally, intramuscularly, rectally or intravenously. It is contraindicated in children under age 2 or under 20 pounds. Severe side effects have occurred when used to treat psychosis.

Side Effects/Adverse Effects: Potential side effects are drowsiness,

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restlessness, dry mouth, constipation, and movement disorders, especially with long-term use.

Health Teaching & Health Promotion: Clients should be instructed to take medications as prescribed. They should avoid alcohol and other CNS depressants. Clients may experience increased photosensitivity, and extreme temperatures should be avoided. Clients should be advised that urine may turn pinkish to reddish-brown.[11]

Prokinetics

Metoclopramide is an example of a prokinetic medication (see Figure 7.20).[12]



Figure 7.20 Prokinetics

Mechanism of Action: Metoclopramide blocks dopamine and may also

11. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
12. "Metoclopramide" by John Campbell is licensed under CC0

sensitize tissues to acetylcholine. It is used to promote peristalsis to empty the gastrointestinal tract and thus reduce nausea.

Indications: Metoclopramide is a dopamine antagonist that can be used to treat gastrointestinal disorders by improving motility.

Nursing Considerations: Metoclopramide can be administered orally, intramuscularly, and intravenously. The onset of pharmacological action of metoclopramide is 1 to 3 minutes following an intravenous dose, 10 to 15 minutes following intramuscular administration, and 30 to 60 minutes following an oral dose. Pharmacological effects persist for 1 to 2 hours.

Metoclopramide should not be used whenever stimulation of gastrointestinal motility might be dangerous (e.g., in the presence of gastrointestinal hemorrhage, mechanical obstruction, or perforation). Metoclopramide is contraindicated in clients with pheochromocytoma because the drug may cause a hypertensive crisis. Metoclopramide should not be used in epileptics or clients receiving other drugs that are likely to cause extrapyramidal reactions because the frequency and severity of seizures or extrapyramidal reactions may be increased. Rare reports of neuromalignant syndrome have occurred.

Side Effects/Adverse Effects: Metoclopramide has potential side effects, such as drowsiness, restlessness, movement disorders, and an increased risk of depression and suicidal thoughts, especially with long-term use.

Health Teaching & Health Promotion: Teach clients to immediately inform the health care provider if they experience new feelings of depression or abnormal muscle movements they cannot control such as the following:

- 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[13]

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Serotonin 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. (See Figure 7.21[14] for an image of ondansetron blocking the 5-HT_3 receptor.)

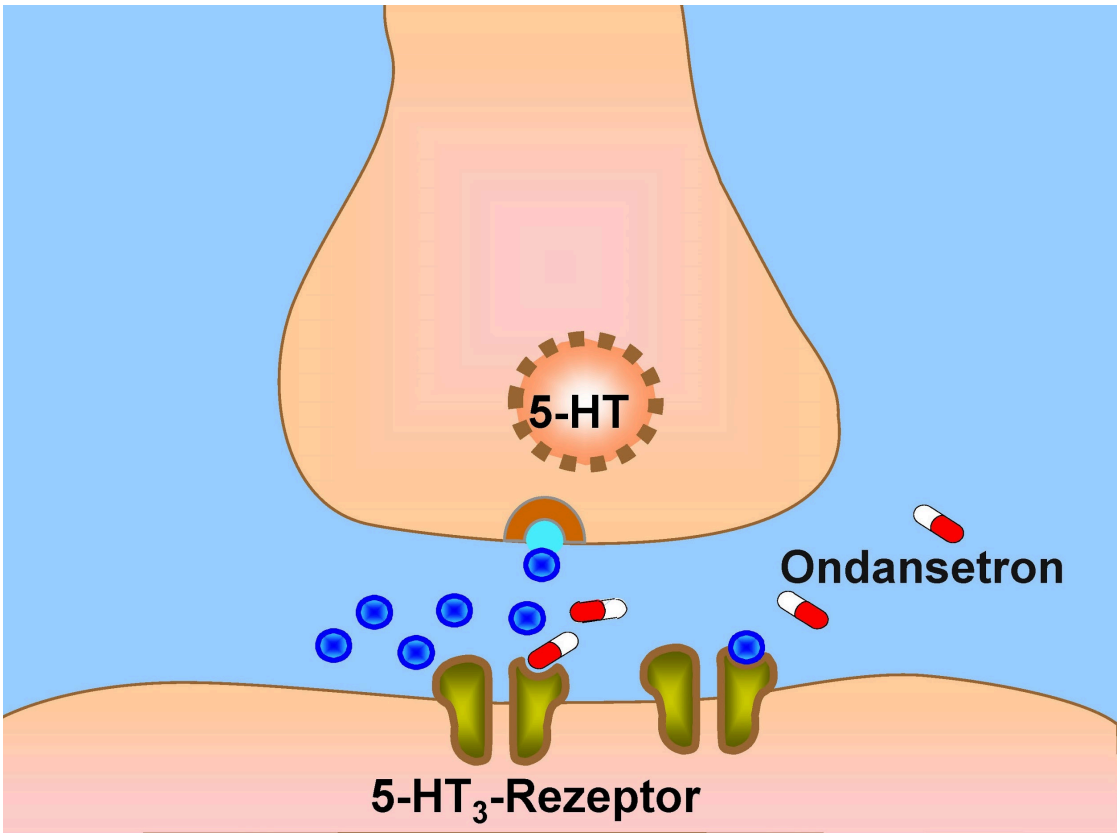

Figure 7.21 Ondansetron Blocking the 5-HT_3 Receptor

Mechanism of Action: Ondansetron blocks serotonin receptors in the GI tract, the chemoreceptor trigger zone (CTZ), and the vomiting center (VC). See Figures 7.22[15] and 7.23[16] for images of the injectable and oral formulations of ondansetron.

14. "Eichelbaum2.jpg" by Michel Eichelbaum is licensed under CC BY-SA 3.0 DE
15. "000817lg Zofran 8 MG Oral Tablet.jpg" by NLM is licensed under CC0
16. "Ondansetron (1)" by M is licensed under CC BY-NC 2.0



Figure 7.22 Ondansetron in Injectable Form



Figure 7.23 Ondansetron in Tablet Form

Indications: Serotonin antagonists, also known as serotonin blockers, are a class of drugs that block the action of serotonin, a neurotransmitter in the brain.

Nursing Considerations: Ondansetron is available as an orally disintegrating tablet and as an injectable for those clients too nauseated to tolerate oral medication. It is contraindicated with apomorphine. **Serotonin syndrome** can occur if administered concurrently with other serotonin antagonists or selective serotonin reuptake inhibitors. Ondansetron can cause headaches, drowsiness, constipation, fever, and diarrhea. A rare but serious adverse effect of ondansetron is QT prolongation that can cause an abnormal cardiac rhythm.

Side Effects/Adverse Effects: It is important to note that serotonin antagonists have potential side effects such as dizziness, headache, constipation, and nausea. Some serotonin antagonists can also interact with other medications or medical conditions.

Health Teaching & Health Promotion: Teach clients to immediately inform their health care provider if they experience a change in heart rate, light-headedness, or feel faint or have any signs and symptoms of hypersensitivity reactions such as fever, chills, rash, or breathing problems.[17]

Neurokinin Receptor Antagonists

Aprepitant is an example of a neurokinin antagonist used to prevent nausea and vomiting associated with chemotherapy and surgery.

Mechanism of Action: Aprepitant inhibits substance-P neurokinin receptors in the brain stem.

Indications: Neurokinin receptor antagonists are a class of drugs that block the action of substance P, a neuropeptide that plays a role in pain, inflammation, and other physiological processes.

Nursing Considerations: Aprepitant is usually administered concurrently with dexamethasone (a corticosteroid) and ondansetron. It can be administered orally or intravenously. It has clinically significant CYP3A4 drug

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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.

Side Effects/Adverse Effects: Neurokinin receptor antagonists have potential side effects such as fatigue, dizziness, constipation, and decreased appetite.

Health Teaching & Health Promotion: Teach clients taking warfarin that they will need to monitor their INR levels more closely, which may require adjustment of the warfarin dosage, while taking aprepitant. Teach clients using an oral contraceptive to use backup birth control.[18]

Tetrahydrocannabinols (THC)

Dronabinol or medical marijuana is an example of a **THC** medication used to treat nausea in clients with cancer or AIDS (see Figures 7.24[19] and 7.25[20]).

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19. "Marinol - Dronabinol" by Steffen Geyer is licensed under CC BY-NC 2.0
20. "Medical Marijuana" by Circe Denyer is licensed under CC0



Figure 7.24 Dronabinol, a THC Medication



Figure 7.25 Medical Marijuana

Mechanism of Action: THC has inhibitory effects in the cerebral cortex causing an alteration in mood and the body's perception of its surroundings, which may relieve nausea and vomiting, as well as stimulate the appetite.

Indications: THC has antiemetic properties and can be used to treat nausea and vomiting associated with chemotherapy or other medical conditions.

Nursing Considerations: THC will cause a dose-related responses such as elation, heightened awareness, and laughing. THC should be used cautiously in elderly clients because they may be more sensitive to the neurological, psychoactive, and postural hypotensive effects of the drug. In general, dose selection for an elderly client should be cautious, usually starting at the low end of the dosing range.

Side Effects/Adverse Effects: THC has potential side effects, including impaired memory and concentration, impaired motor coordination, anxiety,

and paranoia. Additionally, THC can be habit-forming and may have psychoactive effects that can impair daily activities.

Health Teaching & Health Promotion: Teach clients to not drive, operate machinery, or engage in any hazardous activity when using THC. Keep out of reach of children and pets.[21]

Herbal and Vitamin Supplements

Ginger has been used in traditional Indian and Chinese medicine as an antiemetic. Although its mechanism of action is not completely understood, ginger is thought to antagonize the 5HT and cholinergic receptors and may have direct activity 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 grams per day in divided doses of 250 mg are considered safe even in pregnant women. Pyridoxine (vitamin B6) 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.[22]

Now let's take a closer look at the medication grid comparing medications used to treat nausea. See Table 7.5b.[23]

Medication grids 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. Detailed information on a specific medication can be found for free at DailyMed. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also linked to a DailyMed page.

Table 7.5b Antiemetics Medication Grids

21. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
22. Flake, Z., Linn, B., & Hornecker, J. (2015). Practical selection of antiemetics in the ambulatory setting. *American Family Physician, 91*(5), 293-296. https://pubmed.ncbi.nlm.nih.gov/25822385/
23. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anticholinergic	scopolamine	Apply patch to hairless skin behind ear for 3 days or apply the night before surgery and remove 24 hours later Do not cut patch After application, thoroughly wash and dry hands Remove before an MRI Contraindicated in clients with glaucoma	Prevent or reduce nausea and vomiting associated with motion sickness or surgery	Monitor for anticholinergic effects such as decreased GI motility and urinary retention Discontinue if it exacerbates psychosis or causes seizures or cognitive impairment
Antihistamine	meclizine	Contraindicated in clients with glaucoma or an enlarged prostate gland Dosage should be started one hour before travel begins	Prevent or reduce nausea and vomiting associated with motion sickness	May cause drowsiness
Dopamine Antagonist	prochlorperazine	Can be administered PO, IM, PR, or IV	To control nausea and vomiting associated with surgery	Drowsiness, dizziness, amenorrhea, blurred vision, skin reactions, and hypotension may occur

Prokinetic	metoclopramide	Can be administered PO, IM, and IV Onset of action is 1 to 3 minutes following an IV dose, 10 to 15 minutes following IM administration, and 30 to 60 minutes following an oral dose Pharmacological effects persist for 1 to 2 hours	To prevent or treat nausea and vomiting associated with surgery or chemotherapy	Restlessness, drowsiness, fatigue, depression, and suicide ideation Should be immediately discontinued if symptoms of tardive dyskinesia (abnormal muscle movements) or neuromalignant syndrome occur (hyperthermia, muscle rigidity, altered consciousness, irregular pulse or blood pressure, tachycardia, diaphoresis, and cardiac arrhythmias)

Serotonin Antagonist	ondansetron	Can be administered as oral disintegrating tablet, PO, or IV	Prevention or treatment of severe nausea and vomiting associated with surgery, chemotherapy, or hyperemesis in pregnancy	Hypersensitivity reactions, including fever, chills, rash, or breathing problems Headache, drowsiness, constipation, fever, and diarrhea May cause QT prolongation Can cause serotonin syndrome if given concurrently with other serotonin antagonists or SSRIs

Neurokinin Receptor Antagonist	aprepitant	Can be administered PO or IV	Prevention of nausea and vomiting associated with chemotherapy and surgery	Hypersensitivity reaction, such as hives, rash, and itching; skin peeling or sores; or difficulty in breathing or swallowing If taking warfarin, increase monitoring of INR levels If taking oral contraceptives, use a backup method of birth control
THC	dronabinol or medical marijuana	Administered PO Most clients respond to 5 mg three or four times daily Dosage may be escalated during a chemotherapy cycle or at subsequent cycles, based on initial results	For treatment of nausea and vomiting associated with cancer chemotherapy when other treatment fails	Use cautiously in elderly clients because they may be more sensitive to the neurological, psychoactive, and postural hypotensive effects of the drug. In general, dose selection for an elderly client should be cautious, usually starting at the low end of the dosing range

Critical Thinking Activity 7.5

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.

1. How will the nurse assess for symptoms of dehydration?
2. When administering the medication, the client states, "This tastes terrible! Why can't I have a normal pill to swallow?" What is the nurse's best response?
3. What other measures should the nurse teach the client to reduce feelings of nausea and avoid dehydration?

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

7.6 Learning Activities

Exercises

Case Study 1

Mrs. Jones is a 68-year-old female who has been admitted to the hospital for the management of gastroesophageal reflux disease (GERD). She has a history of hypertension and dyslipidemia and is currently taking lisinopril and atorvastatin. Her symptoms include heartburn, chest pain, and difficulty swallowing. Her physician has prescribed omeprazole, a proton pump inhibitor (PPI), to manage her GERD symptoms.

1. What are proton pump inhibitors?
2. What is the mechanism of action of PPIs?
3. What are the potential side effects of PPIs?
4. What should the nurse monitor for in Mrs. Jones while she is taking omeprazole?
5. How should the nurse instruct Mrs. Jones to take omeprazole?
6. What are some important drug interactions with omeprazole?
7. When should the nurse instruct Mrs. Jones to follow up with her health care provider?

Case Study 2

Mr. Lopez is a 45-year-old male who presents to the emergency

department with complaints of severe diarrhea for the past 24 hours. He has been experiencing cramping, nausea, and frequent watery stools. He reports no recent travel or dietary changes. Upon further assessment, the health care provider diagnoses him with acute infectious diarrhea and prescribes loperamide to manage his symptoms.

1. What is loperamide?
2. What is the mechanism of action of loperamide?
3. What are the potential side effects of loperamide?
4. What should the nurse monitor for in Mr. Lopez while he is taking loperamide?
5. How should the nurse instruct Mr. Lopez to take loperamide?
6. What are some important drug interactions with loperamide?
7. When should the nurse instruct Mr. Lopez to follow up with his health care provider?

Note: Answers to the Case Studies can be found in the "Answer Key" sections 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://wtcs.pressbooks.pub/pharmacology2e/?p=328#h5p-29

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- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: GI Assignment 1.[1]

- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: GI Assessment 2.[2]

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2. "GI Assignment 2" by Open RN is licensed under CC BY 4.0

VII. Glossary

Adsorption: The adhesion of molecules to a surface. For example, bismuth salicylate coats the walls of the GI tract and binds the causative bacteria or toxin for elimination from the GI tract through the stool.

Antacids: Used to neutralize stomach acid and reduce the symptoms of heartburn.

Antidiarrheals: Relieve the symptoms of diarrhea, such as an increased frequency and urgency when passing stools, but do not eliminate the cause of it.

Antimotility medications: Medications that help to treat diarrhea by slowing peristalsis.

Area postrema: A structure in the medulla oblongata in the brain stem that controls vomiting. Its location in the brain also allows it to play a vital role in the control of autonomic functions by the central nervous system.

Chemoreceptor trigger zone (CTZ): Area in the brain that responds directly to toxins in the bloodstream and also receives stimuli from several other locations in the body that stimulate the vomiting center.

Cytochrome P-450 enzymes: Enzymes produced from the cytochrome P450 genes involved in the formation (synthesis) and breakdown (metabolism) of various molecules, chemicals, and medications within cells.

Defecation: The digestive process where undigested materials are removed from the body as feces.

Diarrhea: The passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual).

Emesis: The forceful oral expulsion of gastric contents.

Gastroenteritis: Infection of the intestines.

Gastroesophageal reflux disease (GERD): Caused by excessive hydrochloric acid that tends to back up, or reflux, into the lower esophagus.

Hematemesis: Blood in the vomit.

Hypercalcemia: Elevated levels of calcium in the bloodstream.

Intrinsic factor: Necessary for the absorption of vitamin B12 in the small intestine.

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.

Parietal cells: Cells in the gastric glands that produce and secrete hydrochloric acid (HCl) and intrinsic factor.

Pepsin: A digestive enzyme.

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.

Probiotics: Used for the prevention and treatment of diarrhea by restoring normal bacteria flora in the gastrointestinal tract.

Prokinetic: Medications used to promote peristalsis to empty the gastrointestinal tract and reduce nausea.

Proton pump inhibitors (PPIs): Bind to the hydrogen-potassium ATPase enzyme system of the parietal cell and inhibit the release of hydrogen ions into the stomach.

Rebound hyperacidity: A side effect of medication causing elevated levels of hydrochloric acid in the stomach after the medication is discontinued.

Serotonin syndrome: Symptoms associated with serotonin syndrome may include the following: mental status changes (e.g., agitation, hallucinations, delirium, and coma), autonomic instability (e.g., tachycardia, labile blood pressure, dizziness, diaphoresis, flushing, hyperthermia), neuromuscular symptoms (e.g., tremor, rigidity, myoclonus, hyperreflexia, incoordination), and seizures, with or without gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea).

Stimulants: Laxatives that cause the intestines to contract, inducing stool to move through the colon.

Stool softeners: Laxatives that facilitate movement of water and fats into stool to make it soft and improve regularity of bowel movements.

Stress-related mucosal damage: A common condition in hospitalized clients that can lead to peptic ulcer disease (PUD).

Stress ulcer prophylaxis: Medication to prevent the formation of stress ulcers.

Surface epithelium cells: Cells found within the lining of the stomach that secrete mucus as a protective coating.

THC: Tetrahydrocannabinols found in marijuana.

Vestibular system: An area located within the inner ear that gives a sense of balance and spatial orientation for the purpose of coordinating movement with balance.

Vomiting center (VC): An area in the brain that 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.

PART VIII

CENTRAL NERVOUS SYSTEM

8.1 Central Nervous System Introduction

Learning Objectives

- Identify the classifications and actions of central nervous system drugs
- Give examples of when, how, and to whom central nervous system drugs may be administered
- Identify the side effects and special considerations associated with central nervous system drug therapy
- Identify considerations and implications of using central nervous system medications across the life span
- Apply evidence-based concepts when using the nursing process
- Identify and interpret related laboratory tests
- Identify nursing responsibilities related to health teaching and health promotion

In this chapter, you will learn about medications used to treat common disorders of the central nervous system. The nervous system is a very complex organ system. Even though progress continues to grow at an amazing rate within the scientific discipline of neuroscience, our understanding of the intricacies of the nervous system remains limited. You may notice this limitation within some “Mechanism of Action” statements later in this chapter

where exact understanding of how some medications work within the central nervous system is described as “unknown.”[1]

Prior to examining specific CNS medications, let’s review neurotransmitters in the central nervous system.

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8.2 Basic Concepts of the Central Nervous System

To understand how different medications influence the brain, it is important to review the anatomy and physiology of the central nervous system.

Review of Anatomy and Physiology of the 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. 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.[1] (See Figures 8.1[2] and 8.2[3] for illustrations of the central and peripheral nervous systems.)

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2. "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
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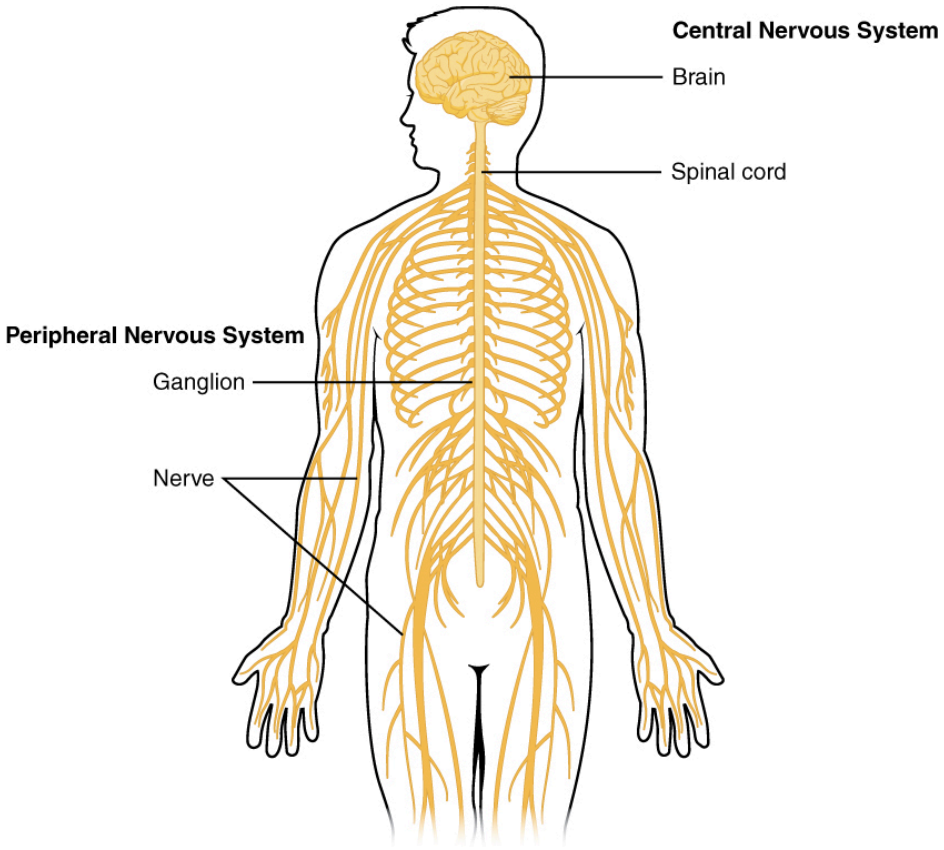

Figure 8.1 The Central and Peripheral Nervous System

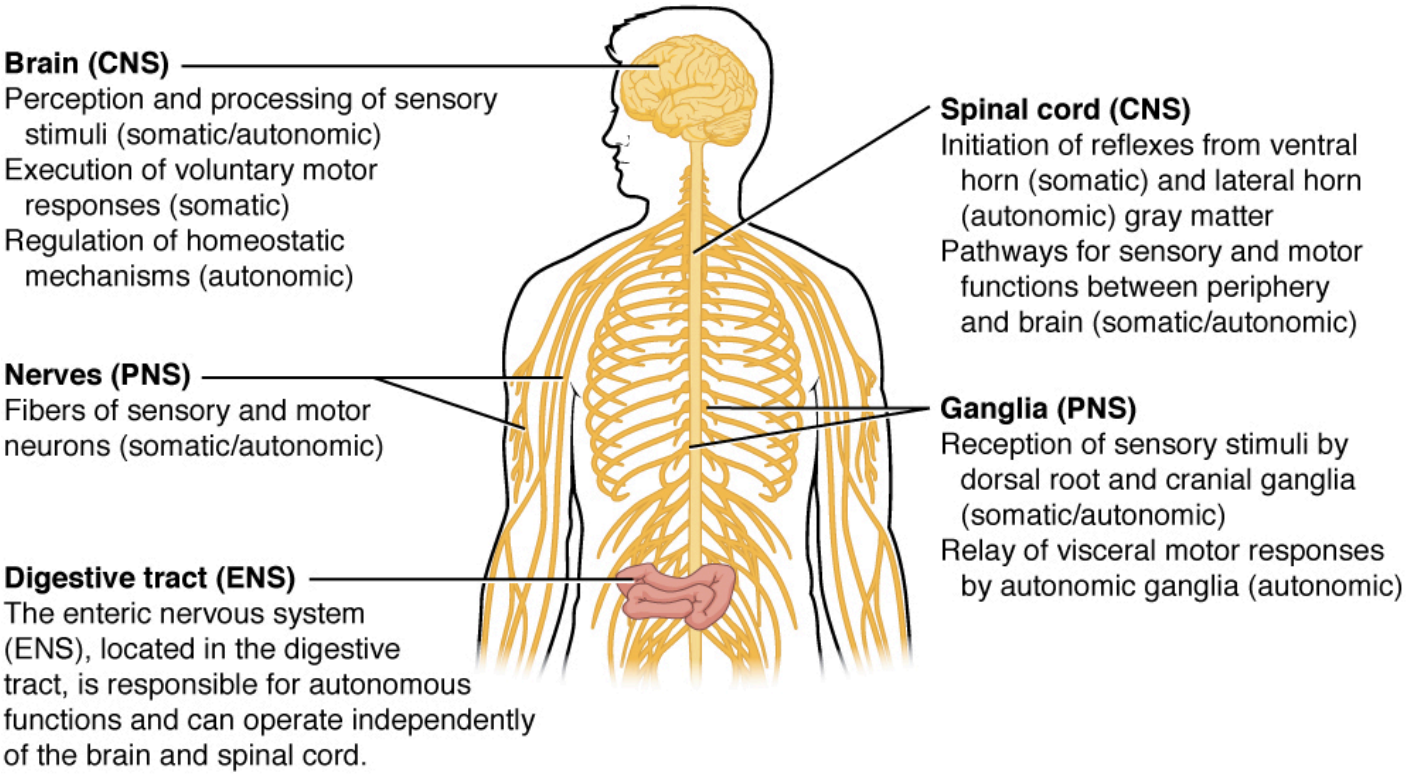

Figure 8.2 Somatic, Autonomic, and Enteric Structures of the Nervous System

> Review more detailed information about the nervous system in "Basic Structure and Function of the Nervous System" in Open Stax *Anatomy and Physiology*.

Communication in the Nervous System

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 medication that works by influencing

neurotransmitters. See Figure 8.3 for an illustration of the major elements in **neuron** communication.[4]

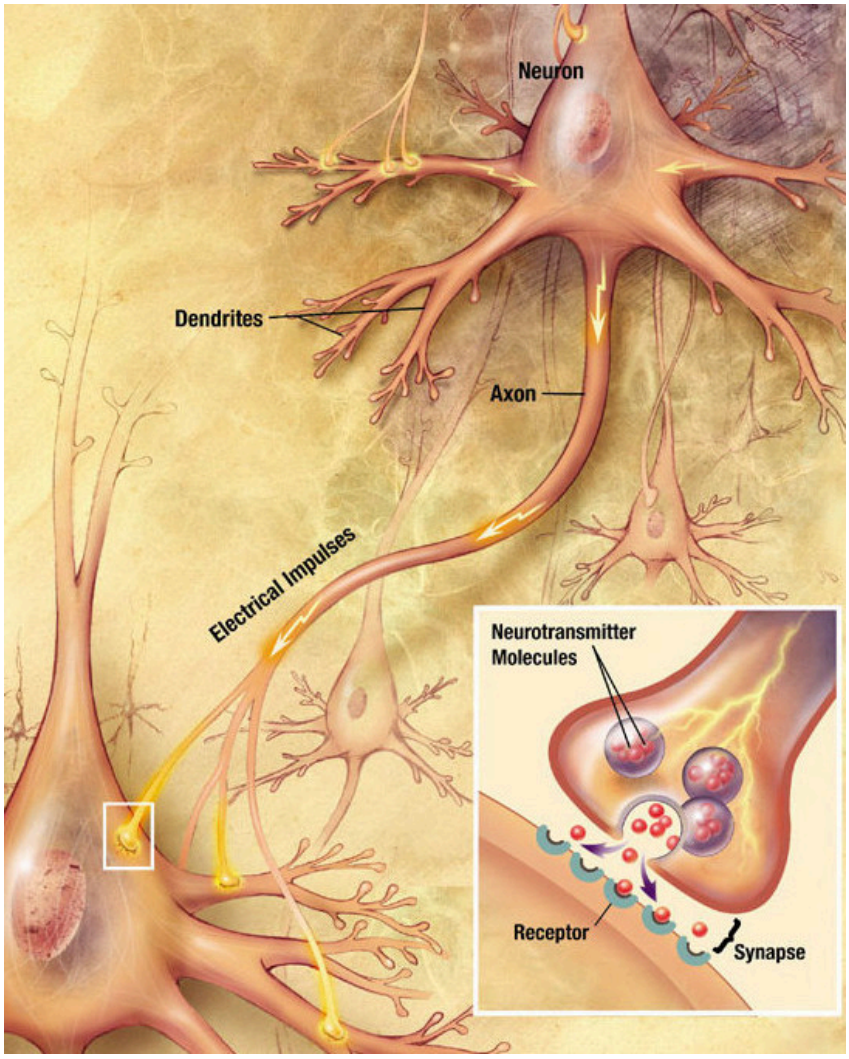

Figure 8.3 Major Elements in Neuron Communication

There are two types of connections between electrically active cells: chemical synapses and electrical synapses. In a **chemical synapse**, a chemical signal—namely, a neurotransmitter—is released from one cell and affects

4. "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

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 chemical synapse. 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.[5] (See Figure 8.4 for an illustration of a synapse.[6])

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6. "1225 Chemical Synapse.jpg" by Young, K. A., Wise, J. A., DeSaix, P., Kruse, D. H., Poe, B., Johnson, E., Johnson, J. E., Korol, O., Betts, J. G., & 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

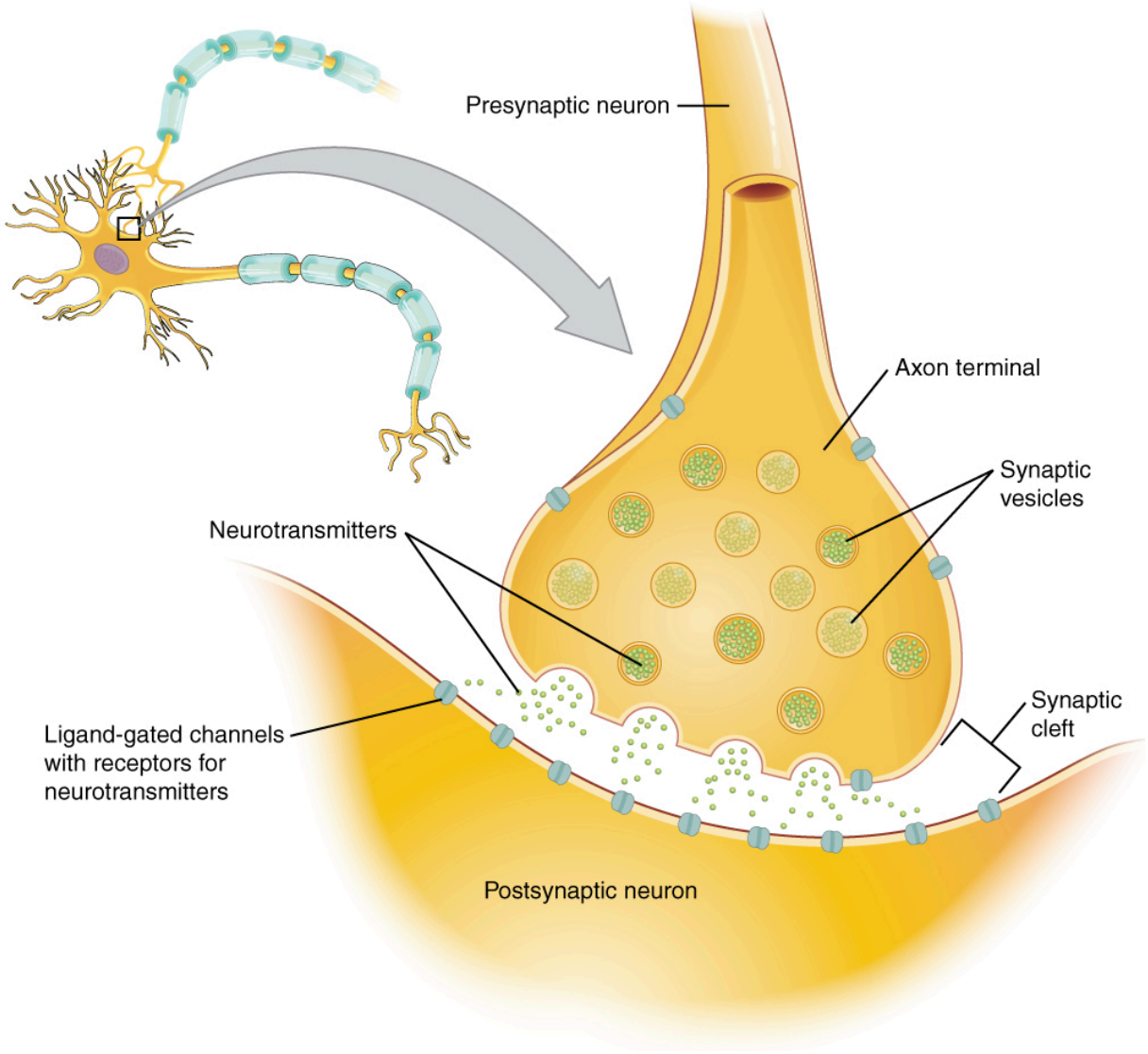

Figure 8.4 Major Elements in Neuron Communication

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.[7]

View a supplementary YouTube video explaining neuron communication via action potentials:

Neuron Communication via Action Potentials[8]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=339#oembed-1

Types of Neurotransmitters

Amino Acids

One group of neurotransmitters are 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 reuptake. A pump in the cell membrane of the presynaptic element, or sometimes a neighboring glial cell, will clear the amino acid from the synaptic cleft so that it can be recycled, repackaged in vesicles, and released again.

7. 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
8. Forciea, B. (2015, May 12). *Anatomy and physiology: Nervous system: Action potential generation V2.0* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/-xFliVq3MKg.

Biogenic Amine

Another class of neurotransmitter is the biogenic amine, a group of neurotransmitters that are enzymatically made from amino acids. For example, serotonin is made from tryptophan. It is the basis of the serotonergic system, which has its own specific receptors. Serotonin is transported back into the presynaptic cell for repackaging.

Other biogenic amines are made from tyrosine and include dopamine, norepinephrine, and epinephrine. Dopamine is part of its own system, the dopaminergic system, which has dopamine receptors. 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. The biogenic amines have mixed effects. For example, dopamine receptors that are classified as D1 receptors are excitatory, whereas D2-type receptors are inhibitory.

The important thing to remember about neurotransmitters and signaling chemicals is that the effect is entirely dependent on the receptor.[9]

Functions of Neurotransmitters

An alteration in CNS function is related to abnormal impulse transmission and can result in an imbalance of a neurotransmitter. A person with an imbalance of neurotransmitters may have signs and symptoms of a CNS disorder. 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 excitability of neurotransmitters, blocking their receptor site, or increasing the inhibitory neurotransmitter. On the other hand, CNS stimulants increase brain activity by increasing excitability of neurotransmitters, decreasing the inhibitory neurotransmitters, or blocking their receptor sites.[10]

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10. This work is a derivative of Pharmacology Notes: Nursing Implications for Clinical Practice by Gloria Velarde licensed under CC BY-NC-SA 4.0

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.[11]

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8.3 Disorders of the CNS System

Now that we have reviewed basic concepts of neurotransmitters and their function, let's review common central nervous system (CNS) disorders.[1]

> Read additional information about mental health disorders in Open RN *Nursing: Mental Health & Community Concepts*.

Anxiety

Anxiety disorders are a group of conditions marked by pathological or extreme anxiety or dread. People with anxiety experience disturbances of mood, behavior, and body systems, making it difficult to complete everyday activities. Many feel anxious most of the time for no apparent reason.

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 does not match the potential for harm or threat to the affected person. Anxiety can be expressed behaviorally or experienced with physical symptoms.[2]

Signs and Symptoms of Anxiety

- Aches
- Pains

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2. This work is a derivative of Supporting Individuals With Intellectual Disability & Mental Illness by Sheri Melrose licensed under CC BY 4.0

- Stomachaches
- Headaches
- Heart racing or pounding
- Trembling
- Sweating
- Difficulty concentrating (see Figure 8.5)[3]
- Increased agitation
- Crying



Figure 8.5 Many Clients With Anxiety Experience Difficulty Concentrating

Treatment can include nonpharmacological interventions, as well as medications. Nonpharmacological interventions to decrease anxiety include relaxation techniques such as deep breathing, exercise, psychotherapy,

3. "stress-2902537_960_720.jpg" by TheDigitalArtist is licensed under CC0 1.0

support groups, or cognitive behavioral therapy. Antianxiety medications can also be used to help both verbal and nonverbal clients feel a much-needed sense of peace.

> Read more about anxiety on the National Institute of Mental Health's website.

Major Depressive Disorder

Major depressive disorder affects up to 5% of the U.S. population. To be diagnosed with major depressive disorder, five of the following symptoms must be present during the same two-week period and represent a change from previous functioning. The symptoms cause clinically significant distress or impairment in social, occupational, or other important areas of functioning. The symptoms of depression cannot be due to effects of a substance or from bereavement.

Signs and Symptoms of Depression

- Depressed mood
- Diminished interest
- 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

Treatment of depression may include medication, psychotherapy, cognitive therapy, electroconvulsive therapy (ECT), and group therapy. Clients who are

depressed may not report symptoms unless specifically asked, and they may be suicidal. Using assessment techniques to gather information about the history of each client's depression, support system, specific triggering events, psychosocial assessment, and risk for harm to self or others is imperative. Each client's response to medication is unpredictable, and often medications will need to be adjusted based on reported symptoms.

> Read more about depression on the National Institute of Mental Health's website.

Bipolar Disorder

Bipolar disorder is marked by serious mood swings. Typically, clients experience extreme highs (called mania or hypomania) alternating with extreme lows (depression). See the "Major Depressive Disorder" subsection for signs and symptoms of depression. Bipolar disorder and major depression disorder are also referred to as "**affective mood disorders**." For some people, the cycles occur so rapidly that they hardly ever feel a sense of control over their mood swings.

Signs and Symptoms of a Manic Episode

- Rapid speech
- Hyperactivity
- Reduced need for sleep
- Flight of ideas
- Grandiosity
- Poor judgement
- Aggression/hostility
- Risky sexual behavior
- Neglect basic self-care
- Decreased impulse control

Treatment for a client diagnosed with bipolar may include medication, safety initiatives during acute mania, 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.

> Read more about bipolar disorder on the National Institute of Mental Health's website.

Schizophrenia

Schizophrenia affects people from all walks of life and typically first appears between the ages of 15 and 30. Schizophrenia refers to a group of severe, disabling psychiatric disorders marked by withdrawal from reality, illogical thinking, delusions (fixed false beliefs that cannot be changed through reasoning), hallucinations (hearing, seeing, smelling, tasting, or feeling touched by things that are not there), and flat affect (lack of observable expressions of emotions, monotone voice, expressionless face, immobile body).

Signs and Symptoms of Schizophrenia

There are three categories of symptoms related to schizophrenia: positive, negative, and cognitive.

POSITIVE SYMPTOMS

Note that in this context, the term "positive" does not refer to "good." Positive symptoms refer to how the individual has lost touch with reality. Positive symptoms include the following:

- 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.

NEGATIVE SYMPTOMS

Negative symptoms refer to a lack of characteristics that should be present. Negative symptoms are as follows:

- Apathy (lack of interest in people, things, activities)
- Lack of motivation
- Blunted affect (lack of display of emotion)
- 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 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.[4]

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COGNITIVE

Cognitive symptoms refer to altered thought patterns and include these behaviors:

- Poor decision-making
- Loss of memory
- Distraction
- Difficulty focusing

Treatment

Treatment for a client diagnosed with schizophrenia may include medications to control positive and/or negative signs and symptoms and nonpharmacological interventions such as limit setting, therapeutic communication, ECT, and psychotherapy. Key assessments for a client with schizophrenia focus on safety with examination for hallucinations and delusions, identifying a support system, and reviewing medication with a focus on adherence to their prescribed therapeutic regimen.

> Read more about schizophrenia on the National Institute of Mental Health's website.

Attention-Deficit/Hyperactivity Disorder

Attention-deficit/hyperactivity disorder (ADHD) 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, but signs and symptoms can last through adulthood.

Signs and Symptoms of ADHD

- Hyperactivity

- Inability to concentrate
- Difficulty with self-control
- Lack of emotional control

A child with ADHD may have difficulty sitting still and focusing at school or have emotional outbursts. See Figure 8.6 for an illustration of the inability to focus on details.[5]

Medication, psychotherapy, behavior management, and family support all play a large part in helping an individual with ADHD. Providing resources for parents is also helpful.



Figure 8.6 Clients With ADHD May Have Difficulty Focusing on Details

5. "RightBrainDominant.jpg" by Elisa Riva is licensed under CC0

Read more about ADHD on the National Institute of Mental Health's website.

View supplementary videos on mental health disorders at Khan Academy.[6]

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 and produce abnormal motor activity. There are different classifications of seizures based on severity of symptoms.[7]

Signs and Symptoms of Seizures

MOTOR SYMPTOMS

- Jerking (clonic)
- Muscles becoming limp or weak (atonic)
- Tense or rigid muscles (tonic)
- Brief muscle twitching (myoclonus)

6. Introduction to Mental Disorders by Khan Academy is licensed under CC BY-NC-SA 3.0
7. Epilepsy Foundation. (2016, December 22). *2017 Revised classification of seizures*. https://www.epilepsy.com/article/2016/12/2017-revised-classification-seizures

- 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 partial or generalized seizures.

PARTIAL SEIZURES

Partial 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.

GENERALIZED SEIZURES

Generalized seizures have bilateral onset on both sides of the brain and are typified by petit mal seizures, which can be recognized by clinical characteristics, as well as interictal EEG abnormalities.[8]

8. Epilepsy Foundation. (2016, December 22). *2017 Revised classification of seizures*. https://www.epilepsy.com/article/2016/12/2017-revised-classification-seizures

STATUS EPILEPTICUS

Status epilepticus is a state of repeated or continuous seizures. It is often defined operationally as a single seizure lasting more than 20 minutes or repeated seizures without recovery of consciousness. Prolonged status epilepticus leads 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.

Parkinson's Disease

Parkinson's disease is a progressive disease of the nervous system that impairs one's ability to move. The typical onset for Parkinson's disease is middle to later stages of life. This disease worsens over time and has no cure. The cause of this disease is unknown, but it is known that it is characterized by a loss of dopaminergic neurons.

Signs and Symptoms of Parkinson's Disease

- **Tremor** at rest
- **Bradykinesia**
- Muscle **rigidity**
- **Postural instability**
- **Gait disturbance**
- **Dystonia**
- **Ophthalmoplegia**
- Active mood disorders

See Figure 8.7 for a typical posture associated with clients with Parkinson's disease.[9] Treatment for a client with Parkinson's disease often includes

9. "Paralysis agitans (1907, after St. Leger).png" by William Richard Gowers is licensed under CC0

medication to increase dopamine in the brain to slow the progression of the disease.



Figure 8.7 Typical Stooping Posture of Parkinson's Disease

Potential New Treatment of Proteins in Alzheimer's and Parkinson's Disease

The underlying cause of some neurodegenerative diseases, such as Alzheimer's and Parkinson's, appears to be related to proteins—specifically, to proteins behaving badly. One of the strongest theories of what causes Alzheimer's disease is based on the accumulation of beta-amyloid plaques, dense conglomerations of a

protein that is not functioning correctly. Parkinson's disease is linked to an increase in a protein known as alpha-synuclein that is toxic to the cells of the substantia nigra nucleus in the midbrain.

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.[10]

10. 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

8.4 Applying the Nursing Process to Administering CNS Medications

Now that we have reviewed CNS anatomy and physiology and common disorders, let's apply the nursing process to administering CNS medications.

Assessment

When administering CNS medication, there are many things a nurse must consider. Each medication is given for a specific purpose, and important data must be collected to safely administer medication.

A nursing assessment completed prior to administering CNS medication is different than an assessment for other body systems because most of the assessments are done by collecting subjective data rather 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.

After reviewing common CNS disorders, you probably noticed there is often an associated neurotransmitter imbalance. Although nurses cannot directly measure neurotransmitters to determine the effects of CNS medications, they can ask questions to determine how the client is feeling emotionally and perceiving the world, both of which are influenced by neurotransmitter levels.

An example of a nurse using therapeutic communication to perform subjective assessment is, "Tell me more about how you are feeling today." While listening to the client, the nurse also uses general survey techniques to observe the client to assess for cues of behavior. Examples of data collected

by a general survey are assessing the client's energy level, hygiene, or movement.

Implementation

With the administration of any medications, it is important to always check the rights of medication administration and anticipate common side effects. When administering CNS medications, pre-assessments must be performed because clients may have changing behaviors and moods that influence their need for medication. Additionally, some medications, such as lithium, require lab value monitoring. Many CNS medications interact with other medications, so careful assessment for potential drug interaction is required.

Evaluation

It is important to always evaluate the client's response to a medication. Some CNS medications will take weeks to become therapeutic for the client. It is key to teach the client when the medication is expected to produce an effect. 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 must also continually monitor for adverse effects, some of which can be life-threatening and require prompt notification to the prescribing provider. Additionally, if symptoms are 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.

Read more by visiting the 988 Suicide and Crisis Lifeline website.

8.5 CNS Depressants

Now that we have reviewed CNS basics, common CNS disorders, and applied the nursing process to CNS medication administration, let's take a closer look at specific classes of CNS medications.

Barbiturates and benzodiazepines are examples of CNS depressants.

Barbiturates

Phenobarbital is an example of a barbiturate primarily used as a sedative and to treat seizure disorders. In high doses it can be used to induce anesthesia, and overdosage can cause death. In the 1960s and 1970s, barbiturates were used to treat anxiety and insomnia, but are no longer used for these purposes due to their serious adverse effects. Barbiturates are a Schedule IV drug under the Federal Controlled Substances Act. However, the abuse of barbiturates continues to occur with street use as a "downer" to counteract the effect of cocaine and methamphetamine.

Mechanism of Action: Barbiturates produce sedation and drowsiness by altering cerebellar function and depressing the actions of the brain and sensory cortex.

Indications: Barbiturates are primarily used for sedation and seizures.

Nursing Considerations: Do not use for children less than 1 month of age. Barbiturates may harm the fetus during pregnancy. Avoid use in geriatric clients. Phenobarbital serum levels should be monitored to ensure adequate therapeutic concentrations for anticonvulsant activity, with a therapeutic range of 15-40 mcg/mL.

Side Effects/Adverse Effects: Clients may experience CNS depression, suicidal thoughts or behaviors, GI disturbances, rashes, or some blood disorders that can be fatal. The concomitant use of alcohol or other CNS depressants may produce additive CNS depressant effects that can cause death. It can be habit forming.

Health Teaching & Health Promotion: The client should be advised to take the prescribed medication as directed. Clients who undergo prolonged

therapy should not discontinue treatment abruptly as this may cause 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 nonhormonal-based contraceptives during therapy.

Overdosage: The onset of symptoms following a toxic oral exposure to phenobarbital may not occur until several hours following ingestion. If overdose occurs, consult with a Certified Poison Control Center (1-800-222-1222) or go to www.poisonhelp.org/help for the latest recommendations.

Now let's take a closer look at the medication grid for phenobarbital in Table 8.5a.[1] Medication grids 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 adverse/side effects. Prototype/ generic medication listed in the grid is also linked to a free resource from the U.S. National Library of Medicine called DailyMed. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication.

Table 8.5a Phenobarbital Medication Grid

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Barbiturates	phenobarbital	May be administered orally, IM, or IV Phenobarbital levels should be monitored to assess for toxicity High abuse potential Should not be combined with other CNS depressants When therapy is discontinued, the dose should be tapered and not stopped abruptly	Primarily used as an anticonvulsant Also used as a sedative and may also be used as a preanesthetic agent	CNS depression; overdosage can cause death May cause suicidal thoughts or behavior Respiratory depression GI: Nausea and vomiting

Benzodiazepines

Lorazepam, a benzodiazepine with antianxiety, sedative, and anticonvulsant effects, is available for oral, intramuscular, or intravenous routes of administration. Benzodiazepines are a controlled Schedule IV substance because they have a potential for abuse and may lead to dependence.

Mechanism of Action: Benzodiazepines bind to specific GABA receptors to potentiate effects of GABA, an inhibitory neurotransmitter.

Indications: Benzodiazepines are used for sedation, antianxiety, and anticonvulsant effects. Lorazepam injection is indicated for the treatment of status epilepticus. It may also be used in adult clients for preanesthetic medication to produce sedation (sleepiness or drowsiness), relieve anxiety,

and decrease the ability to recall events related to the day of surgery. Oral lorazepam is used to treat anxiety disorders.

Nursing Considerations: 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 client response; the initial dosage should not exceed 2 mg. Dosages for clients with severe hepatic insufficiency should be adjusted carefully according to client response.

Side Effects/Adverse Effects: The most important risk associated with the intravenous use of lorazepam injection is respiratory depression. Accordingly, airway patency must be assured, and respiration monitored closely. Ventilatory support should be given as required. 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. Sedation, drowsiness, respiratory depression (dose dependent), hypotension, and unsteadiness may occur with oral dosages as well. The use of benzodiazepines may lead to physical and psychological dependence. Abrupt termination of treatment may be accompanied by withdrawal symptoms. Benzodiazepines should be prescribed for short periods only (e.g., 2 to 4 weeks). Extension of the treatment period should not take place without reevaluation of the need for continued therapy.

Boxed Warning: Concomitant use of benzodiazepines and opioids may result in profound sedation, respiratory depression, coma, and death.

Overdosage: Overdosage of benzodiazepines is usually manifested by varying degrees of central nervous system depression, ranging from drowsiness to coma. Treatment of overdosage 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. The benzodiazepine antagonist flumazenil may be used in hospitalized clients in the management of benzodiazepine overdose. There is a risk of seizure in association with flumazenil treatment, particularly in long-term benzodiazepine users. If overdose occurs, consult with a Certified Poison Control Center (1-800-222-1222) or go to www.poisonhelp.org/help for the latest recommendations.

Health Teaching & Health Promotion: 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 getting out of bed unassisted may result in falling and potential injury if undertaken within 8 hours of receiving lorazepam. 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. Elderly clients should be instructed that lorazepam injection may make them very sleepy for a period longer than 6 to 8 hours following surgery.

Now let's take a closer look at the medication grid for lorazepam in Table 8.5b.[2]

Table 8.5b Lorazepam Medication Grid

2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Benzodiazepines	lorazepam	Boxed Warning: Concomitant use of benzodiazepines and opioids may result in profound sedation, respiratory depression, coma, and death May cause fetal harm in pregnant women May cause paradoxical effect in children Use cautiously in elderly and with those with liver dysfunction	To relieve anxiety, reduce seizure activity, or as a preanesthetic	Oversedation and drowsiness Respiratory depression Unsteadiness and fall risk Overdosage can cause coma and death Flumazenil used for overdose

Critical Thinking Activity 8.5

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 the nausea. The client states, “I can’t wait to relax on the cruise ship and have a margarita as we leave port!”

What health teaching should the nurse provide about the new prescription for lorazepam?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” section at the end of the book.

8.6 CNS Stimulants

Methylphenidate is an example of a CNS stimulant that is often used to treat ADHD. CNS stimulants are Schedule II controlled substances and have a high potential for abuse and dependence.

Mechanism of Action: Methylphenidate stimulates the brain and acts similar to amphetamines. Methylphenidate is thought to block the reuptake of norepinephrine and dopamine into the presynaptic neuron.

Indications: Methylphenidate is used for ADHD.

Nursing Considerations: Methylphenidate is typically prescribed to clients over the age of 6. It should be avoided in clients with known structural cardiac abnormalities, cardiomyopathy, serious heart rhythm arrhythmias, or coronary artery disease. Blood pressure and heart rate should be monitored in all clients.

CNS stimulants have been associated with weight loss and slowing of growth rate in pediatric clients. It 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.

Methylphenidate is contraindicated in clients using a monoamine oxidase inhibitor (MAOI), or use of an MAOI within the preceding 14 days. If paradoxical worsening of symptoms or other adverse reactions occur, the dosage should be reduced, or if necessary, discontinued.

Administer methylphenidate hydrochloride extended-release capsules orally once daily in the morning. Extended-release capsules should not be crushed, chewed, or divided. Monitor for signs of abuse and dependence while on therapy.

Side Effects/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.

Methylphenidate may cause increased blood pressure and increased heart rate. Use of stimulants may cause psychotic or manic symptoms in clients with no prior history and may cause priapism (painful or prolonged penile erections). The most common adverse reactions (greater than 5% incidence) were headache, insomnia, upper abdominal pain, decreased appetite, and anorexia. Alcohol should be avoided because it may cause a rapid release of the drug in extended-release formulations.

If overdose occurs, consult with a Certified Poison Control Center (1-800-222-1222) or go to www.poisonhelp.org/help for the latest recommendations.

Health Teaching & Health Promotion: There are several important topics to provide clients and/or parents of minor children. Each topic is outlined in more detail below.

Controlled Substance Status/High Potential for Abuse and Dependence: Advise clients that methylphenidate is a controlled substance, and it can be abused and lead to dependence. Instruct clients that they should not give methylphenidate to anyone else. Advise clients to store methylphenidate in a safe place, preferably locked, to prevent abuse. Advise clients to comply with laws and regulations on drug disposal. Advise clients to dispose of remaining, unused, or expired methylphenidate by a medicine take-back program if available.

Serious Cardiovascular Risks: Advise clients that there is a potential serious cardiovascular risk, including sudden death, myocardial infarction, stroke, and hypertension. Instruct clients to contact a health care provider immediately if they develop symptoms such as exertional chest pain or unexplained syncope.

Blood Pressure and Heart Rate Increases: Instruct clients that methylphenidate hydrochloride extended-release capsules can cause elevations of their blood pressure and pulse rate. Teach clients, especially those with a history of hypertension, to avoid OTC cold and allergy products containing phenylephrine and pseudoephedrine.

Psychiatric Risks: Advise clients that methylphenidate can 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. Instruct clients to report to their provider 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.[1]

Now let's take a closer look at the medication grid for methylphenidate in Table 8.6.[2]

Table 8.6 Methylphenidate Medication Grid

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
CNS Stimulant	methylphenidate	Boxed Warning: High abuse potential Clients should avoid alcohol Monitor BP and HR Monitor growth and weight in children Monitor for signs of abuse Contraindicated with MAOIs or use of an MAOI within the preceding 14 days	Increases mental focus and attention in clients with ADHD	Immediately report signs and symptoms of abuse, cardiac or peripheral vascular complications, and priapism Report mania or psychotic episodes Common side effects: Headache, insomnia, upper abdominal pain, decreased appetite, and anorexia Gynecomastia

Critical Thinking Activity 8.6

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 provider has prescribed methylphenidate (Ritalin).

What topics should the nurse reinforce while educating the child and his parents about this medication?

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

8.7 Antidepressants

Antidepressants are used to treat depression and other mental health disorders, as well as other medical conditions such as migraine headaches, chronic pain, and premenstrual syndrome. Antidepressants increase levels of neurotransmitters in the CNS, including 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.

This section will discuss four classes of antidepressants: tricyclic antidepressants (TCAs), selective serotonin reuptake inhibitors (SSRIs), serotonin norepinephrine reuptake inhibitors (SNRIs), and monoamine oxidase inhibitors (MAOIs). 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.

Boxed 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.

Tricyclic Antidepressants

Tricyclic antidepressants (TCAs) were one of the original first-generation antidepressants. Due to the popularity of SSRIs and SNRIs, TCAs are now more commonly used to treat neuropathic pain and insomnia.

Mechanism of Action: Amitriptyline is an antidepressant with sedative effects. Its mechanism of action is not known. Amitriptyline inhibits the membrane pump mechanism responsible for uptake of norepinephrine and serotonin in adrenergic and serotonergic neurons. This interference with reuptake of norepinephrine and/or serotonin is believed to underlie the antidepressant activity of amitriptyline.

Indications: TCAs are used to treat depression, neuropathic pain, and insomnia.

Nursing Considerations: TCAs are often administered at bedtime due to sedating effects and are contraindicated with MAOIs.

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.

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.

Side Effects/Adverse Effects: Adverse effects of TCAs are a result of their blockade effects on various receptors, often resulting in anticholinergic adverse effects such as constipation, urinary retention, and drowsiness. Blockage of adrenergic and dopaminergic receptors can cause cardiac conduction disturbances and hypotension. Histaminergic blockage can cause sedation, and serotonergic blockade can alter the seizure threshold and cause sexual dysfunction.

Boxed Warning: Boxed Warnings are in place for all classes of antidepressants used with children, adolescents, and young adults for a higher risk of suicide. Clients receiving antidepressants should be monitored for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed.

Death may occur from overdosage with this class of drugs. Multiple drug ingestion (including alcohol) is common in deliberate tricyclic antidepressant overdose. If overdose occurs, consult with a Certified Poison Control Center (1-800-222-1222) or go to https://www.poisonhelp.org/help for the latest recommendations.

Health Teaching & Health Promotion: 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. Potential side effects discussed above should be reviewed.[1] Over the counter supplements that enhance serotonin, such as St. John's Wort, should be avoided.

Now let's take a closer look at the medication grid for amitriptyline in Table 8.7a.[2]

Table 8.7a Amitriptyline Medication Grid

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Tricyclic	amitriptyline	Boxed Warning: Increased risk of suicidality Taper dose when discontinuing; do not stop abruptly Monitor orthostatic blood pressures and consider fall risk precautions	Based on indication: Decrease feelings of depression, chronic pain, or insomnia	Immediately report signs or symptoms of suicidality Anticholinergic effects Hypotension May lengthen QT interval; risk for arrhythmias Sedation Sexual dysfunction Altered seizure threshold

Selective Serotonin Reuptake Inhibitor (SSRI)

Selective serotonin reuptake inhibitors (SSRIs) are a second-generation antidepressant and have fewer side effects than TCAs and MAOIs. Fluoxetine and citalopram are commonly used SSRIs.

Mechanism of Action: SSRIs inhibit the reuptake of serotonin.

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Indications: SSRIs are primarily used to treat depression, but are also used to treat obsessive compulsive disorder, bulimia, panic disorder, post-traumatic stress disorder, other forms of anxiety, premenstrual syndrome, and migraines.

Nursing Considerations: The onset of fluoxetine's antidepressant effect develops slowly for up to 12 weeks.

Use with caution in clients who are taking other CNS medications or who have liver dysfunction. This drug is contraindicated with MAOIs. Monitor for increased suicide ideation in all populations, as well as for the development of serotonin syndrome. Clients should avoid grapefruit juice due to its effect on the CYP3A4 enzyme that affects the bioavailability of the medication.

Side Effects/Adverse Effects: Side effects include rash; mania; seizures; decreased appetite and weight; increased bleeding associated with the concomitant use of fluoxetine and NSAIDs, aspirin, warfarin, or other drugs that affect coagulation; hyponatremia; anxiety; and insomnia.

Boxed Warning: Boxed Warnings are in place for all classes of antidepressants used with children, adolescents, and young adults for a higher risk of suicide. Clients receiving antidepressants should be monitored for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed.

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 metabolism of serotonin (including MAOIs), or with antipsychotics or other dopamine antagonists. Symptoms of **serotonin syndrome** may include mental status changes (e.g., agitation, hallucinations, coma), autonomic instability (e.g., tachycardia, labile blood pressure, hyperthermia), neuromuscular aberrations (e.g., hyperreflexia, incoordination), and/or gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea). Serotonin syndrome, in its most severe form, can resemble **neuroleptic malignant syndrome** (NMS), which includes hyperthermia, muscle rigidity, autonomic instability with possible rapid fluctuation of vital signs, and mental status changes. Clients should be monitored for the emergence of serotonin syndrome or NMS-like signs and symptoms.

Abrupt discontinuation may cause several adverse effects, so a gradual reduction in the dose rather than abrupt cessation is recommended whenever possible.

Health Teaching & Health Promotion: Clients should be careful to take medications as directed. Abrupt discontinuation may cause anxiety, insomnia, and increased nervousness. Additionally, orthostatic blood pressure changes are common during medication therapy. Clients may also be increasingly drowsy or exhibit some confusion. Use of SSRI medications with alcohol or other CNS depressant drugs should be avoided.

Clients should be monitored carefully by family members and caregivers for suicidal thoughts. Other side effects include possible decreased libido, urinary retention, constipation, and increased photosensitivity.[3]

Now let's take a closer look at the medication grid for fluoxetine and citalopram in Table 8.7b.[4]

Table 8.7b Fluoxetine and Citalopram Medication Grid

3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
4. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
SSRI	fluoxetine citalopram	Boxed Warning: Monitor for increased risk of suicidality Do not stop abruptly; taper dose when discontinuing Contraindicated with MAOIs Use caution with liver dysfunction May take up to 12 weeks before achieve therapeutic effect	Based on indication: Primarily decreases feelings of depression	Immediately report signs/symptoms of increased suicidality or serotonin syndrome Rash, mania, seizures, decreased appetite and weight, increased bleeding, hyponatremia, anxiety, and insomnia

Critical Thinking Activity 8.7

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."

1. What places a client at risk for serotonin syndrome, and

what symptoms should the nurse teach the client about this condition?

2. 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?
3. What potential common side effects should the nurse discuss with the client?
4. The client states, "I can't wait to feel better again. How soon will this medication work?" What is the nurse's best response?

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

Serotonin Norepinephrine Reuptake Inhibitor (SNRI)

Venlafaxine is an example of a serotonin norepinephrine reuptake inhibitor (SNRI).

Mechanism of Action: Venlafaxine inhibits the reuptake of serotonin and norepinephrine, with weak inhibition of dopamine reuptake.

Indications: SNRIs are indicated for treatment of a major depressive disorder.

Nursing Considerations: 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. Elderly clients are at greater risk for developing hyponatremia. Use with caution with other serotonin medications.

Side Effects/Adverse Effects: SNRI medication may cause sustained increase in blood pressure. Other side effects include serotonin syndrome, insomnia, anxiety, decreased appetite, weight loss, mania, hyponatremia, increased bleeding (especially with the concomitant use of fluoxetine and NSAIDs, aspirin, warfarin, or other drugs that affect coagulation), elevated serum cholesterol, somnolence, and nausea.

Boxed Warning: Boxed Warnings are in place for all classes of antidepressants used with children, adolescents, and young adults for a higher risk of suicide. Clients receiving antidepressants should be monitored for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed.

Health Teaching & Health Promotion: Clients should be careful to take medications as directed. The dose should be tapered prior to discontinuation. Clients may also be increasingly drowsy or dizzy. Use of SNRI medications with alcohol or other CNS depressant drugs should be avoided. Clients should be monitored carefully by family members and caregivers for suicidality.[5]

Now let's take a closer look at the medication grid for venlafaxine in Table 8.7c.[6]

Table 8.7c Venlafaxine Medication Grid

5. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
6. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
SNRI	venlafaxine	Boxed Warning: Monitor for increased risk of suicidality Monitor BP Gradually reduce dose when discontinuing when possible Use with caution with clients with liver or renal disease	May take up to 8 weeks before therapeutic effect is recognized Decrease feelings of depression	Increased suicidality Serotonin syndrome Elevated BP Anxiety Insomnia Decreased appetite Weight loss Mania Hyponatremia Increased bleeding Elevated cholesterol Somnolence GI: Nausea and constipation

Monoamine Oxidase inhibitors (MAOI)

Monoamine oxidase inhibitors (MAOIs) are a first-generation antidepressant. Tranylcypromine is an example of an MAOI. A significant disadvantage to MAOIs is their potential to cause a hypertensive crisis when taken with stimulant medications or foods containing tyramine.

Mechanism of Action: The mechanism of action of tranylcypromine tablets as an antidepressant is not fully understood but is presumed to be linked to potentiation of monoamine neurotransmitter activity in the central nervous system resulting from its irreversible inhibition of the enzyme monoamine oxidase (MAO). MAO inactivates norepinephrine, dopamine, epinephrine, and serotonin. By inhibiting MAO, the levels of these transmitters rise.

Indications: Tranylcypromine is indicated for the treatment of major

depressive disorder in adult clients who have not responded adequately to other antidepressants. The drug may also be used to treat Parkinson's disease.

Nursing Considerations: Serious interactions with several medications, as well as foods and beverages containing tyramine, have been reported; check drug labelling before administering. Safety has not been established with the pediatric population. The elderly population is at increased risk for postural hypotension and serious adverse effects. Abuse and dependence have been reported. Withdrawal effects can continue for several weeks after discontinuation.

Side Effects/Adverse Effects: Use with caution due to the risks of hypertensive crisis, serotonin syndrome, and increased suicidality. **Hypertensive crisis** 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. Seizures may also occur. Intracranial bleeding, sometimes fatal, has been reported in association with the increase in blood pressure. See more information about serotonin syndrome in the "Selective Serotonin Reuptake Inhibitor (SSRI)" subsection.

Other potential side effects include mania, **orthostatic hypotension**, hepatotoxicity, seizures, hypoglycemia in diabetic clients, decreased appetite and weight loss, dizziness, headache, drowsiness, and restlessness. Clients should be advised it may impair their ability to operate machinery or drive. MAOIs should be discontinued if hepatotoxicity occurs.

Boxed Warning: Boxed Warnings are in place for all classes of antidepressants used with children, adolescents, and young adults for a higher risk of suicide. Clients receiving antidepressants should be monitored for signs of worsening depression or changing behavior, especially when the medication is started or dosages are changed.

Health Teaching & Health Promotion: Clients should be careful to take medications as directed. They should avoid abrupt cessation of therapy to avoid withdrawal symptoms. 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.[7]

Now let's take a closer look at the medication grid for tranylcypromine in Table 8.7d.[8]

Table 8.7d Tranylcypromine Medication Grid

7. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
8. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
MAOI	tranylcypromine	Boxed Warning: Monitor for hypertensive crisis and increased suicide ideation Avoid foods containing tyramine Many drug interactions Monitor BP Do not stop abruptly; taper dose when discontinuing Discontinue if hepatotoxicity	Based on indication: Decreased feelings of depression or decreased symptoms of Parkinson's disease	Increased suicidality Hypertensive crisis Serotonin syndrome Mania Orthostatic hypotension Hepatotoxicity Seizures Hypoglycemia in clients with diabetes Decreased appetite and weight loss CNS: Dizziness, headache, drowsiness, and restlessness May impair ability to operate machinery or drive

8.8 Antimanias

Mood stabilizers are used to treat bipolar affective disorder. Lithium was the first medication used to treat this disorder and is sometimes referred to as an antimania drug because it can help control the mania that occurs in bipolar disorder. Lithium must be closely monitored with a narrow therapeutic range.

Lithium

Mechanism of Action: Lithium alters sodium transport in **nerve** and muscle cells and affects a shift toward intraneuronal metabolism of catecholamines, but the specific biochemical mechanism of lithium action in mania is unknown.

Indications: Lithium is indicated in the treatment of manic episodes of bipolar disorder and as a maintenance treatment for individuals with a diagnosis of bipolar disorder.

Nursing Considerations: Lithium must be closely monitored with a narrow therapeutic serum range of 0.8 to 1.2 mEq/L. Serum sodium levels should also be monitored for potential hyponatremia.

The drug is contraindicated in renal or cardiovascular disease, severe dehydration or sodium depletion, and to clients receiving diuretics because the risk of lithium toxicity is very high.

Lithium can cause fetal harm in pregnant women. Safety has not been established for children under 12 and is not recommended.

When given to a client experiencing a manic episode, lithium may produce a normalization of symptomatology within 1 to 3 weeks.

Side Effects/Adverse Effects: Fine hand tremor, polyuria, and mild thirst may persist throughout treatment.

Boxed Warning: Lithium toxicity is closely related to serum lithium levels and can occur at doses close to therapeutic levels at 1.5 mEq/L. Facilities for prompt and accurate serum lithium determinations should be available before initiating therapy. Lithium can cause abnormal electrocardiographic (ECG) findings and risk of sudden death. Clients should be advised to seek

immediate emergency assistance if they experience fainting, light-headedness, abnormal heartbeats, or shortness of breath.

Signs of early lithium toxicity include diarrhea, vomiting, drowsiness, muscular weakness, and lack of coordination. At higher levels, giddiness, ataxia, blurred vision, tinnitus, and a large output of dilute urine may be seen. No specific antidote for lithium poisoning is known; treatment focuses on the elimination of the medication.

Health Teaching & Health Promotion: Clients should be taught to take medication as directed, get labs drawn as scheduled, and maintain a consistent salt intake. Clients should also be advised that antimanic drugs may increase dizziness and drowsiness and weight gain may occur. Additionally, if individuals have low sodium levels, it may predispose the client to lithium toxicity.[1]

Now let's take a closer look at the medication grid for lithium in Table 8.8.[2]

Table 8.8 Lithium Medication Grid

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antimanic	lithium	Boxed Warning: Monitor for signs of lithium toxicity Monitor serum lithium and sodium levels Contraindicated in renal and cardiovascular disease and in dehydration	When given during a manic episode, symptoms may resolve in 1-3 weeks When given for maintenance therapy, it should reduce the frequency and intensity of manic episodes	Lithium toxicity Hyponatremia Tremor Cardiac arrhythmia Polyuria Thirst

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Critical Thinking Activity 8.8

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 provider 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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

8.9 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 are sometimes referred to as tranquilizers because they produce a state of tranquility.

Selection of antipsychotic medication is based on the client's ability to tolerate the adverse effects. First-generation antipsychotics, also called "typical" antipsychotics, have similar mechanisms of action and several potential adverse effects. An example of a first-generation antipsychotic is haloperidol. Second-generation antipsychotics, also referred to as "atypical" antipsychotics, have fewer adverse effects. An example of an atypical antipsychotic is risperidone. Both typical and atypical antipsychotics have a Boxed Warning indicating that elderly clients with dementia-related psychosis treated with antipsychotic drugs are at an increased risk of death.

Mechanism of Action: All antipsychotics block dopamine receptors in the brain. However, the precise mechanism of action has not been clearly established. First-generation antipsychotics, such as haloperidol, block dopamine receptors 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, so dopamine blockage thus produces a tranquilizing effect in clients experiencing psychosis. However, several adverse effects are also caused by this dopamine blockade.

Second-generation, or atypical, antipsychotics block specific dopamine 2 receptors and specific serotonin 2 receptors, thus causing fewer adverse effects.

Indications: Haloperidol is primarily indicated for schizophrenia and Tourette's disorder. Risperidone is primarily indicated for schizophrenia but is also used for acute manic episodes and for irritability caused by autism. Some atypical antipsychotics are also used as adjunct therapy for depression.

Nursing Considerations: 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.

Haloperidol is contraindicated in clients with Parkinson's disease or dementia with Lewy body.

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.

Side Effects/Adverse Effects: Elderly clients with dementia-related psychosis treated with antipsychotic drugs are at an increased risk of death due to cardiovascular or infection-related causes.

First-generation and second-generation antipsychotics can cause agranulocytosis.

First-generation antipsychotic medications have increased risk for several potential serious adverse effects such as **tardive dyskinesia**, neuroleptic malignant syndrome (NMS), and **extrapyramidal symptoms**. 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. Table 8.9a describes adverse effects associated with first-generation antipsychotics. Clients should be warned to not consume alcohol and that their ability to operate machinery or drive may be impaired.

Table 8.9a Potential Adverse Effects of Antipsychotic Medication[1]

1. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 227-305. Elsevier.

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 effect that includes high fever, unstable blood pressure, and myoglobinemia.
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.) Often treated with anticholinergic medications such as benztropine and trihexyphenidyl.

Second-generation, or atypical, antipsychotics are less likely to cause adverse effects, but have a potential to do so. Atypical antipsychotics may also cause metabolic changes such as hyperglycemia, hyperlipidemia, and weight gain, which can cause clients to stop treatment.

Health Teaching & Health Promotion: Advise clients to take medication as directed. Medication doses should be evenly spaced throughout the day. It may require several weeks to obtain desired effects. Clients should be advised regarding the possibility of extrapyramidal symptoms and that abrupt withdrawal may cause dizziness; nausea and vomiting; and/or uncontrolled movements of mouth, tongue, or jaw. Additionally, the client should be careful to avoid alcohol or other CNS depressants while using the medication.[2]

Now let's take a closer look at the medication grid for haloperidol and risperidone in Table 8.9b.[3]

Table 8.9b Haloperidol and Risperidone Medication Grid

2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
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Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
1st-Generation (Typical) Antipsychotics **2nd-Generation (Atypical) Antipsychotics**	haloperidol risperidone	Boxed Warning: Monitor elderly clients with dementia closely for symptoms of cardiovascular events or infection Advise clients to avoid alcohol, operate machinery, or drive	Decrease symptoms of psychosis, hallucinations, delusions, and delirium	Life-threatening cardiovascular events or infections Agranulocytosis Tardive dyskinesia Neuroleptic malignant syndrome Extrapyramidal symptoms 2nd generation: Hyperglycemia, hyperlipidemia, and weight gain Hypersensitivity reactions Falls related to sedation, motor instability, and postural hypotension

8.10 Anticonvulsants

Medications used for seizures are called anticonvulsants or anti-seizure drugs. Anti-seizure drugs stabilize cell membranes and suppress the abnormal electric impulses in the cerebral cortex. These drugs prevent seizures but do not provide a cure. Anti-seizure drugs are classified as CNS depressants. There are many types of medications used to treat seizures such as phenytoin, phenobarbital, benzodiazepine, carbamazepine, valproate, and levetiracetam.

There are three main pharmacological effects of anti-seizure 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.

Some drugs work by enhancing the effects of the inhibitory neurotransmitter gamma-aminobutyric acid (GABA), which plays a role in regulating neuron excitability in the brain. Gabapentin, although structurally similar to GABA and classified as an anticonvulsant, is commonly used to control chronic neuropathic pain. 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."[1] An example of neuropathic pain is tingling or burning in the lower extremities that often occurs in clients with diabetes.

Phenytoin

Phenytoin, which was discovered in 1938, was the first anti-seizure medication and is still being used to control seizures.[2]

Mechanism of Action: Phenytoin improves evidence of seizures by

1. Murnion, B. P. (2018, June 1). Neuropathic pain: Current definition and review of drug treatment. *Australian Prescriber, 41*(3), 60–63. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6003018/
2. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 227-305. Elsevier.

interfering with sodium channels in the brain, resulting in a reduction of sustained high-frequency neuronal discharges.

Indications: 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.

Nursing Considerations: Phenytoin should not be administered to pregnant women because it will cause harm to the fetus. When given intravenously, there is a Boxed Warning that the rate of administration should 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 because of the risk of severe hypotension and cardiac arrhythmias. Careful cardiac monitoring is needed during and after administering intravenous phenytoin.

Phenytoin has a narrow therapeutic drug level, usually between 10-20 mcg/mL, so serum drug monitoring is required. 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.

There are many potential drug interactions with phenytoin. Read the 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.

Side Effects/Adverse Effects: 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 administration of phenytoin. These have included thrombocytopenia, leukopenia, granulocytopenia, agranulocytosis, and pancytopenia with or without bone marrow suppression.

The most common adverse reactions encountered with phenytoin therapy are nervous system reactions and are usually dose related. Reactions include nystagmus, ataxia, slurred speech, decreased coordination, somnolence, and mental confusion.

Health Teaching & Health Promotion: 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. Additionally, clients with diabetes should monitor their blood glucose levels carefully.[3]

Now let's take a closer look at the medication grid for phenytoin in Table 8.10a.[4]

Table 8.10a Phenytoin Medication Grid

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Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anticonvulsant	phenytoin	Careful cardiac monitoring is needed during and after administering intravenous phenytoin For IV infusions, an in-line filter (0.22 to 0.55 microns) should be used. Cannot be given with D5W due to precipitate formation and no faster than 50 mg/minute in adults Monitor serum drug levels Contraindicated for clients with heart block Use cautiously in clients with hepatic or renal impairment Taper dose; do not stop abruptly	Decrease or prevent seizure activity	Cardiovascular risk associated with rapid IV infusion Discontinue and notify the provider if a rash occurs Notify the provider immediately if fever, rash, lymphadenopathy, and/or facial swelling occur Cardiovascular: Arrhythmia and hypotension CNS: Nystagmus, ataxia, slurred speech, decreased coordination, somnolence, and mental confusion GI: Constipation, gingival hyperplasia, and hepatotoxicity Hematology: Thrombocytopenia, pancytopenia, and agranulocytosis

Levetiracetam

Levetiracetam is indicated as adjunctive therapy in the treatment of partial onset seizures in clients 12 years of age and older with epilepsy. It is generally well-tolerated.

Mechanism of Action: The exact mechanism of action is unknown. This medication may interfere with sodium, calcium, potassium, or GABA transmission.[5]

Indications: Levetiracetam is used for partial onset seizures in clients with epilepsy.

Nursing Considerations: Plasma levels can gradually decrease during pregnancy and should be monitored closely. Safety and effectiveness in pediatric clients ages 12 years and older have been established.

Levetiracetam immediate release and levetiracetam solution can be used in clients as young as 1 month.

Levetiracetam should not be stopped abruptly, or withdrawal seizures may occur. Use with caution in clients with renal impairment.

Side Effects/Adverse Effects: Behavioral abnormalities, including psychotic symptoms, suicidal ideation, irritability, and aggressive behavior, have been observed; monitor clients for psychiatric signs and symptoms.

The most common adverse reactions are somnolence and irritability. 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.

Health Teaching & Health Promotion: Medications should be taken as directed and may cause increased dizziness and somnolence. Clients should be monitored carefully for suicidality during medication therapy.[6]

Now let's take a closer look at the medication grid for levetiracetam in Table 8.10b.[7]

Table 8.10b Levetiracetam Medication Grid

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Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anticonvulsant	levetiracetam	Taper dose; do not stop abruptly or seizures may occur Monitor plasma levels for pregnant women Use cautiously if renal impairment	Decrease seizure activity	Behavioral/ mood changes (psychotic symptoms, suicidal ideation, irritability, and aggressive behavior) Anaphylaxis or angioedema Somnolence, fatigue, and irritability Serious skin conditions Coordination difficulties Hematopoietic abnormalities

Gabapentin

Gabapentin is indicated as an adjunct treatment for partial seizures but is most commonly used to treat neuropathic pain. It is also used to treat substance withdrawal.

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.

Indications: Gabapentin is used for partial seizures and neuropathic pain.

Nursing Considerations: This drug can cause harm to the fetus of pregnant women.

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).

In elderly clients, peripheral edema and ataxia tended to increase in incidence with age. Fall precautions should be considered.

Antiepileptic drugs should not be abruptly discontinued because of the possibility of increasing seizure frequency.

Side Effects/Adverse Effects: Antiepileptic drugs, including gabapentin, increase the risk of suicidal thoughts or behavior in clients taking these drugs for any indication. Clients should be monitored for the emergence or worsening of depression, suicidal thoughts or behavior, and/or any unusual changes in mood or behavior.

Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS), also known as multiorgan hypersensitivity, has been reported in clients taking antiepileptic drugs, including gabapentin. Some of these events have been fatal or life-threatening. DRESS typically, although not exclusively, 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.

Gabapentin may cause dizziness, somnolence, and other symptoms and 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.

Health Teaching & Health Promotion: Clients receiving gabapentin therapy should take medication as directed and be careful to not exceed dosage recommendations. Clients should not take gabapentin within two hours of antacid medications. Additionally, gabapentin may cause increased drowsiness and dizziness. Clients should be monitored carefully for suicidality.[8]

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Now let's take a closer look at the medication grid for gabapentin in Table 8.10c.[9]

Table 8.10c Gabapentin Medication Grid

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anticonvulsant	gabapentin	Administer first dose at bedtime to decrease dizziness and drowsiness Monitor for worsening depression, suicidal thoughts or behavior, and/or any unusual changes in mood or behavior Taper dose; do not stop abruptly	Decreased neuropathic pain or seizures	Increased suicidal ideation Immediately report fever, rash, and/or lymphadenopathy CNS depression: Dizziness, somnolence, and ataxia

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Critical Thinking Activity 8.10

A 70-year-old 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 anti-seizure 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 Critical Thinking activities can be found in the “Answer Key” section at the end of the book.

8.11 Anti-Parkinson's 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, so drug therapies are aimed at increasing levels of dopamine and/or antagonizing the effects of acetylcholine. Drug therapy does not cure the disease but is used to slow the progression of symptoms. Common medications used to treat Parkinson’s disease are 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 presumably is converted to dopamine in the brain. Carbidopa is combined with levodopa to help stop the breakdown of levodopa before it is able to cross the blood-brain barrier. Additionally, the incidence of levodopa-induced nausea and vomiting is less when it is combined with carbidopa.

Indications: Carbidopa/levodopa is indicated for Parkinson’s disease. It is also used to treat restless leg syndrome.

Nursing Considerations: Carbidopa/levodopa is recommended for use in clients older than age 18. It can take several weeks to see positive effects, and this should be explained to clients and their caregivers.

The drug is contraindicated for use with MAOIs. All clients should be

observed carefully for the development of depression with concomitant suicidal tendencies.

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.

Sporadic cases of symptoms resembling neuroleptic malignant syndrome (NMS) have been reported in association with dose reductions or withdrawal of certain anti-Parkinsonian agents. Therefore, clients should be observed carefully when the dosage of levodopa is reduced abruptly or discontinued.

Periodic evaluations of hepatic, hematopoietic, cardiovascular, and renal functions are recommended during extended therapy. The most common adverse effect of carbidopa/levodopa is dyskinesia, which may require dosage reduction.

Clients should be instructed to plan their mealtimes around medication times to improve the ability to use their utensils and to avoid diets high in protein due to decreased absorption of the medication.

Side Effects/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, binge eating, and/or other intense urges, and the inability to control these urges. These urges stopped when the dosage was decreased or the medication discontinued.

A higher risk for melanoma has been reported. 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.

Health Teaching & Health Promotion: 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. Medications may cause increased drowsiness, dizziness, and orthostatic changes. Clients should carefully assess their skin to

monitor for new lesions, and any abnormality should be reported to the health care provider.[1]

Now let's take a closer look at the medication grid for carbidopa-levodopa in Table 8.11a.[2]

Table 8.11a Carbidopa-Levodopa Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anti-Parkinson's Agent	carbidopa/levodopa	Avoid high-protein diets due to decreased absorption Monitor for sudden somnolence and increased depression Contraindicated with MAOIs Periodically monitor hepatic, renal, and hematopoietic functions	Slow progression of symptoms of Parkinson's disease (tremors, rigidity, and mobility issues)	Depression, suicidal ideation, hallucinations, and intense urges with inability to control them Somnolence and fatigue NMS symptoms with dose reductions or when discontinued Dyskinesia Discolored body fluids Hypomobility with long-term use

Selegiline

Selegiline is often used conjunction with carbidopa-levodopa when clients

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demonstrate a deteriorating response to this treatment. It is helpful to control symptom fluctuations.

Mechanism of Action: Selegiline inhibits MAO-B, blocking the breakdown of dopamine.

Indications: Selegiline capsules are 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. There is no evidence from controlled studies that selegiline has any beneficial effect in the absence of concurrent levodopa therapy.

Nursing Considerations: Large doses of selegiline may inhibit MAO-A that promotes metabolism of tyramine in the GI tract, which can cause a hypertensive crisis.

Side Effects/Adverse Effects: Side effects are dose-dependent, with larger doses posing a hypertensive crisis risk if there is consumption of food or beverages with tyramine.

Health Teaching & Health Promotion: Clients should be advised to avoid foods high in tyramine. Additionally, medications may cause increased drowsiness, dizziness, and orthostatic changes. If clients experience abnormal behaviors such as hallucinations, sexual urges, gambling, etc., this should be reported promptly to the health care provider.

Now let's take a closer look at the medication grid for selegiline in Table 8.11b.[3]

Table 8.11b Selegiline Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Anti-Parkinson's Agent, MAO Type B Inhibitor	selegiline	Avoid food with tyramine if on a large dose (above 10mg/day)	Minimize progression of Parkinson's disease symptoms	Higher doses increase risk for hypertensive crisis

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Amantadine

Amantadine is used in early stages of Parkinson's disease but can be effective in moderate or advanced stages in reducing tremor and muscle rigidity.

Mechanism of Action: The exact mechanism of action is unknown. Amantadine is an antiviral drug that acts on dopamine receptors.

Indications: Amantadine is used for Parkinson's disease, medication-induced extrapyramidal symptoms, and influenza A.

Nursing Considerations: Use cautiously with renal impairment. This drug may cause suicidal ideation and should not be stopped abruptly or can cause Parkinsonian crisis. Neuroleptic malignant syndrome (NMS) has been reported in association with dose reduction or withdrawal of amantadine therapy.

Side Effects/Adverse Effects: Suicide ideation, congestive heart failure, and peripheral edema can occur. 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. There is an increased risk of melanoma.

Adverse reactions reported most frequently are nausea, dizziness (light-headedness), and insomnia. This drug can also cause anticholinergic side effects, impaired thinking, and orthostatic hypotension.

Health Teaching & Health Promotion: 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. Clients should avoid using this medication with OTC cold medications or alcoholic beverages. If clients, family, or caregivers note worsening depression or suicidality, this should be reported immediately to the health care provider.[4]

Now let's take a closer look at the medication grid for amantadine in Table 8.11c.[5]

Table 8.11c Amantadine Medication Grid

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Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anti-Parkinson Agent, Antiviral	amantadine	Monitor renal function Monitor mental state Assess blood pressure	Improve Parkinson's disease symptoms	Increased suicidal ideation and urges Congestive heart failure and peripheral edema Neuroleptic malignant syndrome (NMS) when dosage decreased Orthostatic hypotension Nausea, dizziness, and insomnia Anticholinergic side effects

Critical Thinking Activity 8.11

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 Critical Thinking activities can be found in the "Answer Key" section at the end of the book.

8.12 Learning Activities

Exercises

Case Study 1

Mrs. Jones is a 65-year-old woman who has been diagnosed with major depressive disorder. She has been prescribed venlafaxine, an antidepressant medication, by her psychiatrist. She presents to the outpatient clinic with complaints of headaches, nausea, and dizziness. She reports that she has been taking venlafaxine for two weeks.

Questions:

1. What is venlafaxine, and how does it work?
2. What are the common side effects of venlafaxine?
3. What are the potential drug interactions with venlafaxine?
4. What should be done if a client experiences side effects from venlafaxine?

Case Study 2

Mr. Harshung is a 70-year-old man who has been diagnosed with Parkinson's disease. He has been taking levodopa/carbidopa for the past year, but his symptoms have been worsening, and he has developed motor fluctuations. His neurologist has prescribed selegiline as an adjunct therapy to improve his symptoms.

Questions:

1. What is selegiline, and how does it work?
2. What are the common side effects of selegiline?
3. What are the potential drug interactions with selegiline?
4. What should be done if a client misses a dose of selegiline?

Note: Answers to the Case Studies can be found in the "Answer Key" sections 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://wtcs.pressbooks.pub/pharmacology2e/?p=362#h5p-30

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An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=362#h5p-31

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Test your clinical judgment with this NEXT GEN RN

- NCLEX Next Generation-style bowtie question: CNS Assignment 1.[1]

- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: CNS Assignment 2.[2]

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VIII. Glossary

Action potential: A change in voltage of a cell membrane in response to a stimulus that results in transmission of an electrical signal; unique to neurons and muscle fibers.

Acute dystonia: Painful muscle spasms.

Affective mood disorders: Mental health illness such as major depression.

Akathisia: Distressing motor restlessness.

Blood-brain barrier (BBB): A physiological barrier between the circulatory system and the central nervous system that establishes a privileged blood supply, restricting the flow of substances into the CNS.

Bradykinesia: Slowness in initiation and execution of voluntary movements.

Central nervous system (CNS): Anatomical division of the nervous system located within the cranial and vertebral cavities, namely the brain and spinal cord.

Chemical synapse: Connection between two neurons, or between a neuron and its target, where a neurotransmitter diffuses across a very short distance.

Drug reaction with eosinophilia and systemic symptoms (DRESS): A condition reported in clients taking antiepileptic drugs. Some of these events have been fatal or life-threatening. DRESS typically presents with fever, rash, lymphadenopathy, and/or facial swelling.

Dystonia: Inappropriate and continuous muscle contraction.

Electrical synapse: Connection between two neurons, or any two electrically active cells, where ions flow directly through channels spanning their adjacent cell membranes.

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). Often treated with anticholinergic medications such as benztropine and trihexyphenidyl.

Gait disturbance: An abnormal way of walking, such as shuffling feet.

Hypertensive crisis: 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. Seizures may also occur. Intracranial bleeding, sometimes fatal, has been reported in association with the increase in blood pressure.

Mania: Periods of extreme highs in bipolar disorder. Manic episodes may include these symptoms: rapid speech, hyperactivity, reduced need for sleep, flight of ideas, grandiosity, poor judgement, aggression/hostility, risky sexual behavior, neglected basic self-care, or decreased impulse control.

Nerve: Cord-like bundle of axons located in the peripheral nervous system that transmits sensory input and response output to and from the central nervous system.

Neuroleptic malignant syndrome (NMS): Potentially life-threatening adverse effect that includes high fever, unstable blood pressure, and myoglobinemia.

Neuron(s): Neural tissue cell that is primarily responsible for generating and propagating electrical signals into, within, and out of the nervous system.

Neurotransmitter: Chemical signal that is released from the synaptic end bulb of a neuron to cause a change in the target cell.

Ophthalmoplegia: Weakness in eye muscles.

Orthostatic hypotension: A significant change in blood pressure from lying to sitting to standing.

Peripheral nervous system (PNS): An anatomical division of the nervous system that is largely outside the cranial and vertebral cavities, namely all parts except the brain and spinal cord.

Postural instability: Abnormal fixation of posture (stoop when standing), problems with equilibrium, and righting reflex.

Rigidity: Increased muscle tone and increased resistance to movement. As severity increases, there may be cogwheel rigidity.

Serotonin syndrome: May occur when taking serotonin medications. Includes mental status changes (e.g., agitation, hallucinations, coma), autonomic instability (e.g., tachycardia, labile blood pressure, hyperthermia),

neuromuscular aberrations (e.g., hyperreflexia, incoordination) and/or gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea). Serotonin syndrome, in its most severe form, can resemble neuroleptic malignant syndrome, which includes hyperthermia, muscle rigidity, autonomic instability with possible rapid fluctuation of vital signs, and mental status changes.

Status epilepticus: A state of repeated or continuous seizures.

Tardive dyskinesia: Involuntary contraction of the oral and facial muscles (such as tongue thrusting) and wavelike movements of the extremities.

Thalamus: The region of the central nervous system that acts as a relay for sensory pathways.

Threshold: The membrane voltage at which an action potential is initiated.

Tremor: Usually tremor at rest; when person sits, the arms shake, but tremor stops when person attempts to grab something.

PART IX

ENDOCRINE SYSTEM

9.1 Endocrine Introduction

Learning Objectives

- Identify the classifications and actions of endocrine system drugs
- Give examples of when, how, and to whom endocrine system drugs may be administered
- Identify the side effects and special considerations associated with endocrine system drug therapy
- Identify the considerations and implications of using endocrine system medications across the life span
- Apply evidence-based concepts when using the nursing process
- Identify indications, side effects, and potential drug interactions associated with the use of herbal supplements
- Identify and interpret related laboratory tests
- Identify nursing responsibilities related to health teaching and health promotion

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. This chapter will discuss medications that affect three of the major endocrine glands: the adrenal glands, the pancreas, and the thyroid.

9.2 Basic Concepts of the Endocrine System

Before we discuss endocrine medications, let's review endocrine system anatomy and hormones to better understand the mechanism of action of endocrine medications.

Review of Anatomy and Physiology of the Endocrine System

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. See Figure 9.1 for an illustration of the endocrine system.[1] Some of these glands have both endocrine and nonendocrine functions. For example, the pancreas contains cells that function in digestion, as well as cells

1. "1801 The Endocrine System.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-1-an-overview-of-the-endocrine-system

that secrete the hormones insulin and glucagon, which regulate blood glucose levels.[2]

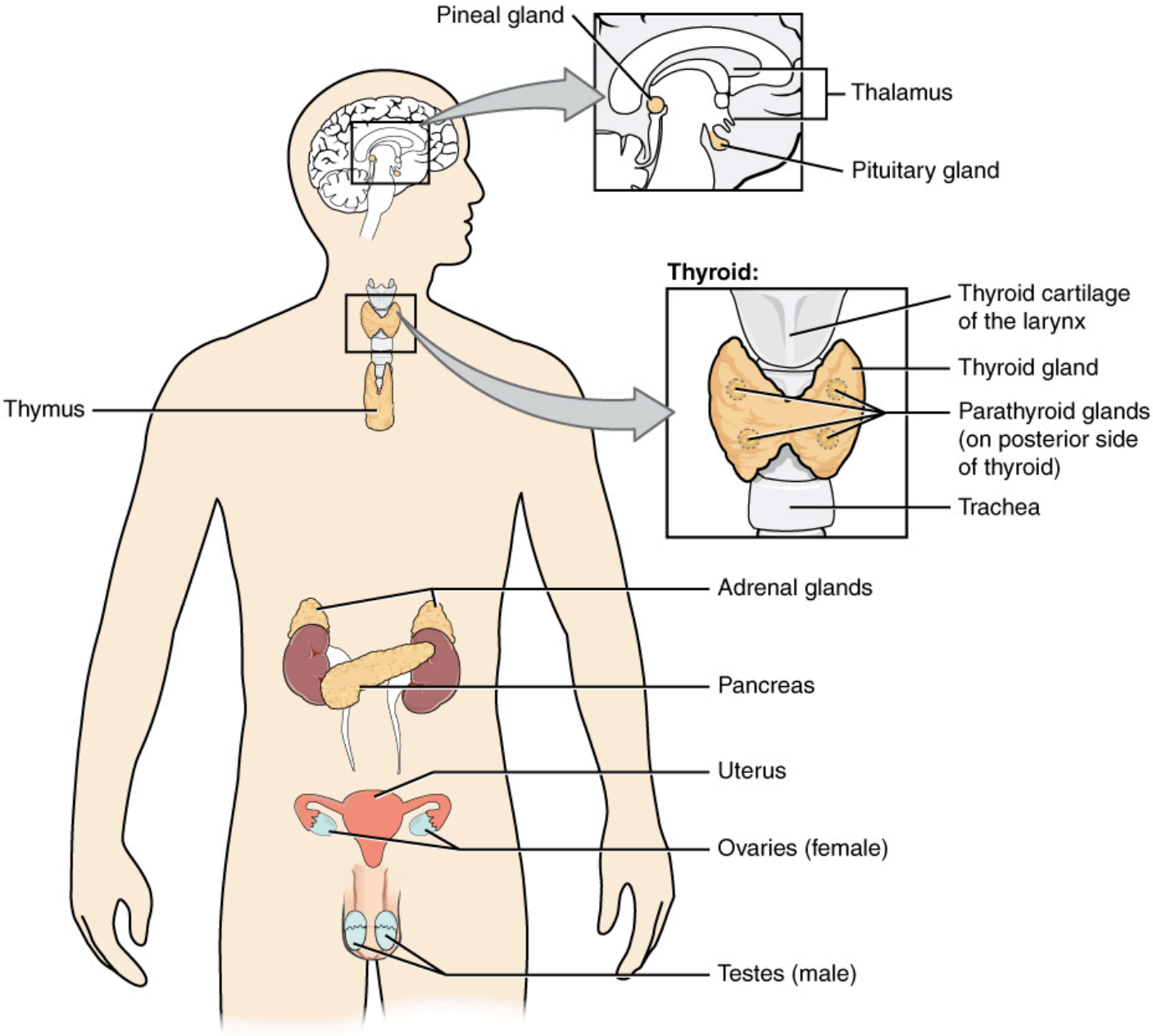

Figure 9.1 Overview of the Endocrine System

This chapter will discuss medications that affect three major endocrine

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glands and their hormones: the adrenal glands, the pancreas, and the thyroid. See Table 9.2 for a list of hormones associated with each of these glands and their effects.[3]

Table 9.2 Hormones Associated With Adrenal Glands, Pancreas, and Thyroid and Their Effects

Endocrine Gland	Hormone	Effect
Adrenal (cortex)	Aldosterone	Increases blood Na+ levels
Adrenal (cortex)	Cortisol	Increases blood sugar levels
Adrenal (medulla)	Epinephrine and norepinephrine	Stimulates fight-or-flight response
Pancreas	Insulin	Reduces blood glucose levels
Pancreas	Glucagon	Increases blood glucose levels
Thyroid	Thyroxine (T4) and triiodothyronine (T3)	Stimulates basal metabolic rate
Thyroid	Calcitonin	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

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hypothalamus and pituitary gland reduce their signaling to the adrenal glands to prevent additional glucocorticoid secretion.[4] See Figure 9.2 for an illustration of a negative feedback loop.[5]

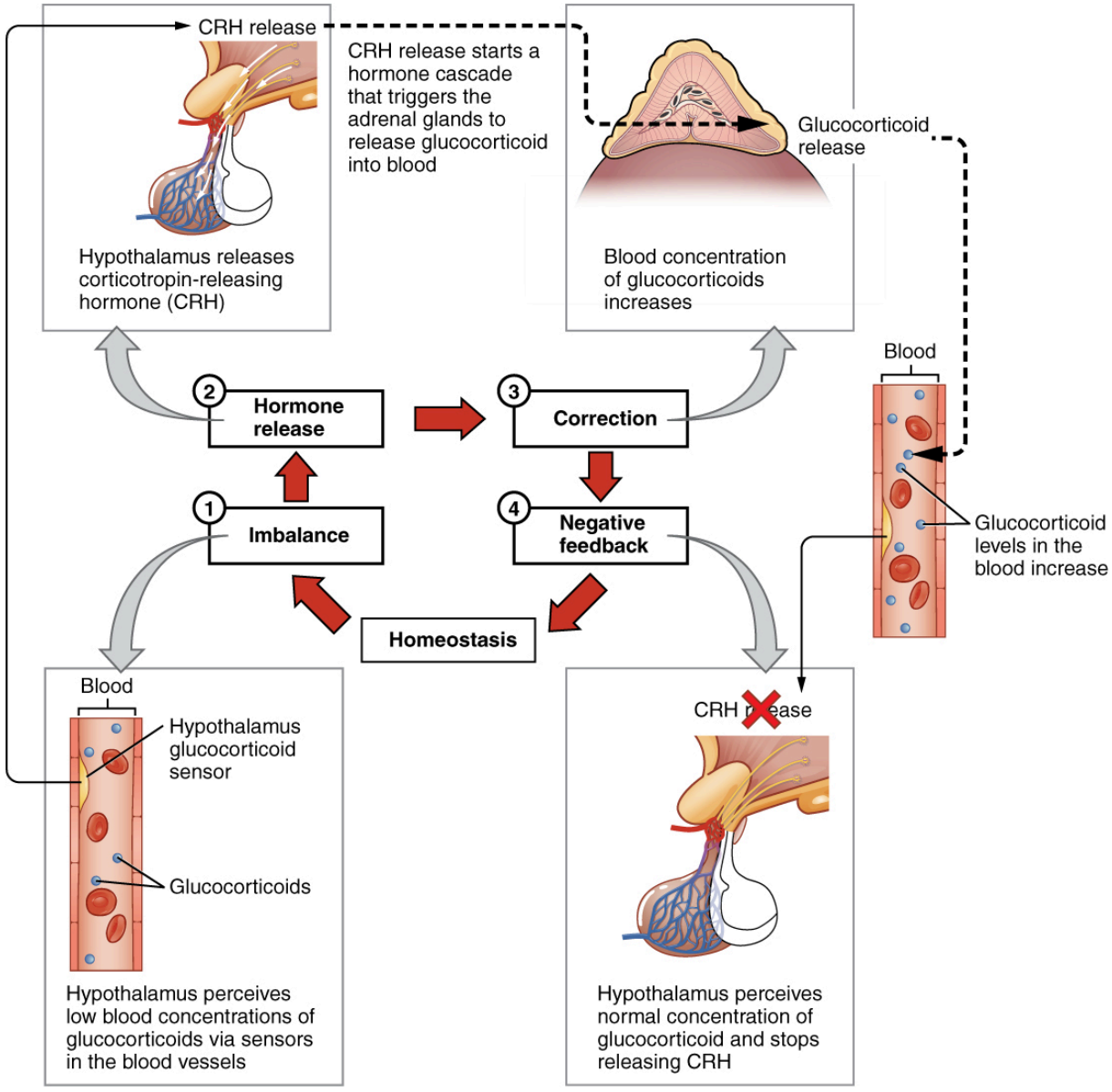

Figure 9.2 Negative Feedback Loop

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5. "1805 Negative Feedback Loop.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-2-hormones

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 nonhormone chemicals that cause the release or inhibition of a hormone to maintain homeostasis. For example, osmoreceptors in the hypothalamus detect changes in **blood osmolarity** (the concentration of solutes in the blood plasma). If blood osmolarity 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 osmolarity 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.[6]

Hypothalamus–Pituitary Complex

The **hypothalamus–pituitary complex** can be thought of as the "command

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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 9.3 for an illustration of the hypothalamus–pituitary complex.[7] 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.

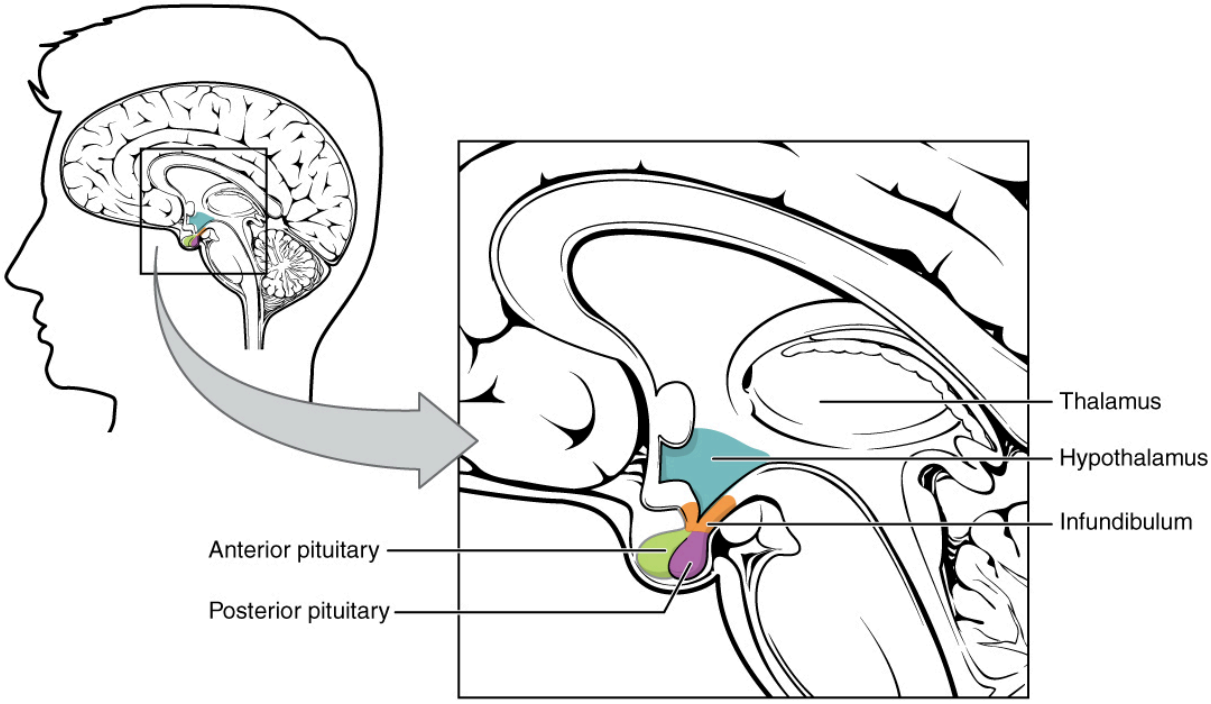

Figure 9.3 Illustration of the Hypothalamus–Pituitary Complex

Posterior Pituitary

The posterior pituitary gland does not produce hormones, but stores and

7. "1806 The Hypothalamus-Pituitary Complex.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-3-the-pituitary-gland-and-hypothalamus

secretes two hormones produced by the hypothalamus: oxytocin and antidiuretic hormone (ADH).

ANTIDIURETIC HORMONE (ADH)

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.[8]

Anterior Pituitary

In contrast to the posterior pituitary, the anterior pituitary does manufacture hormones. However, the secretion of hormones from the anterior pituitary is regulated by two classes of hormones secreted by the hypothalamus called

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releasing hormones. Releasing hormones then stimulate the secretion of hormones from the anterior pituitary (see Figure 9.4[9]). The anterior pituitary produces seven hormones. These are the growth hormone (GH), thyroid-stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), beta endorphin, and prolactin. 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. This module will focus on the effects of TSH and ACTH.

9. "1808 The Anterior Pituitary Complex.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-3-the-pituitary-gland-and-hypothalamus

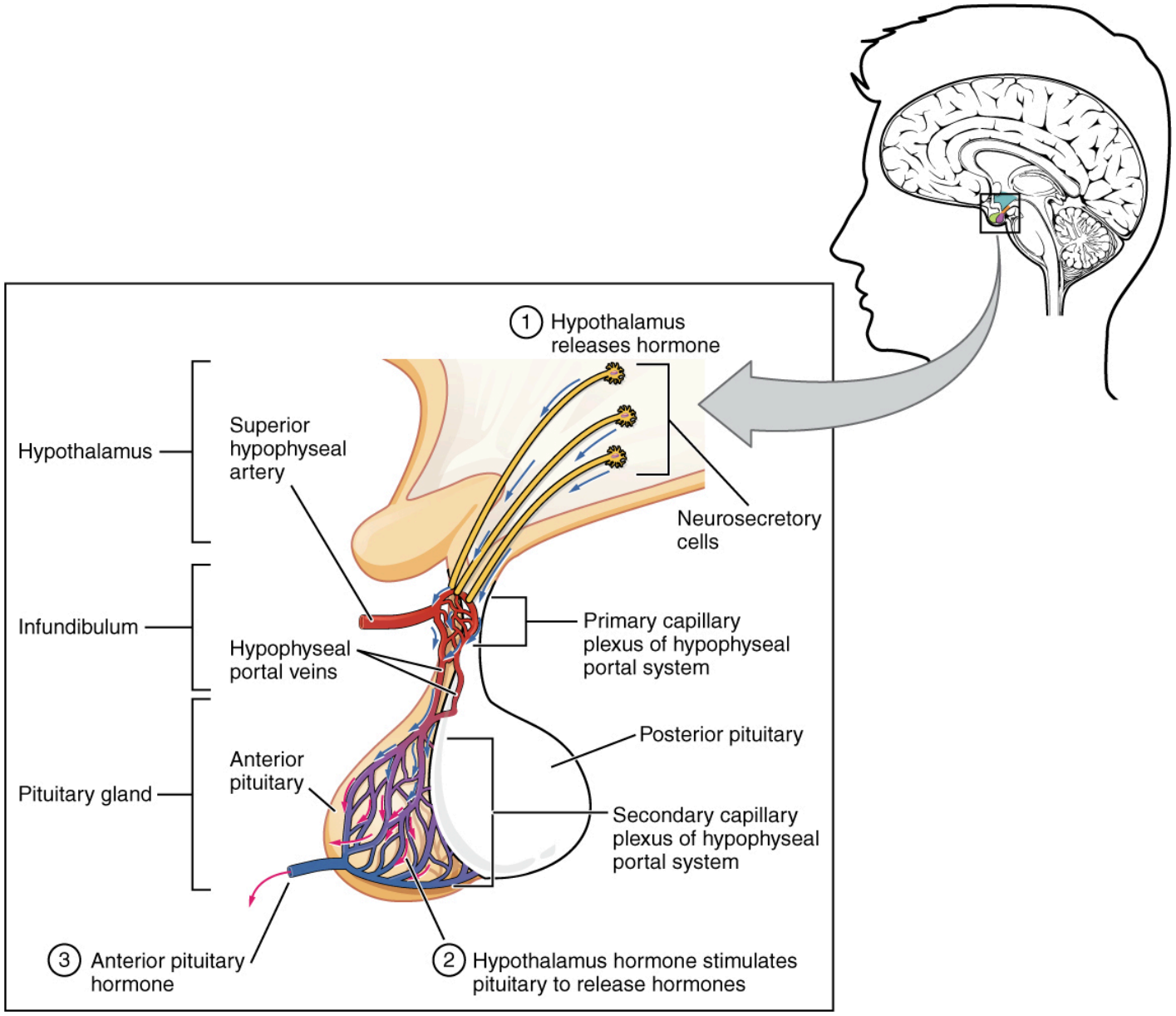

Figure 9.4 Hypothalamus Releases Hormones to Regulate Release of Hormones From Anterior Pituitary

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 Medications" section of this chapter.

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 "Corticosteroids" section of this chapter.[10]

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=373#h5p-32

"Endocrine gland match-up" by E. Christman for Open RN is licensed under CC BY 4.0

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9.3 Corticosteriods

This section will review the anatomy and physiology of the adrenal gland, outline common disorders affecting the adrenal gland, apply the nursing process to administering corticosteroids, and then discuss the medication classes of corticosteroids.

Review Anatomy and Physiology of the Adrenal Glands

The adrenal gland 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.

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 that are important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation.

The **adrenal medulla** is neuroendocrine tissue composed of postganglionic sympathetic nervous system (SNS) neurons that secrete the hormones epinephrine and norepinephrine. It is an extension of the autonomic nervous system, which regulates homeostasis in the body. See Figure 9.5[1] for an illustration of the adrenal gland and associated hormones.

1. "1818 The Adrenal Glands.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-6-the-adrenal-glands

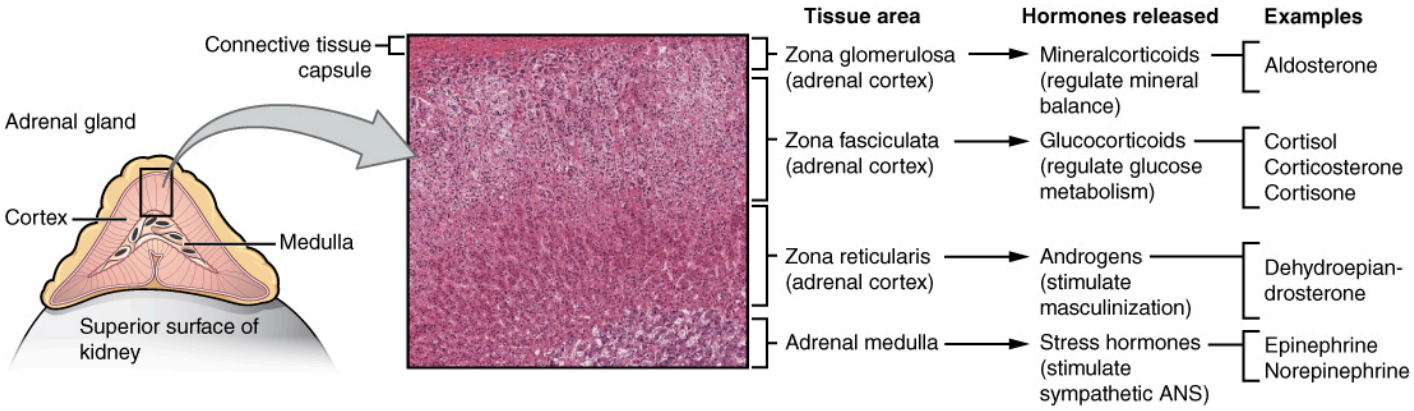

Figure 9.5 Adrenal Gland and Associated Hormones

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 nonstress-related functions, including the increase of blood sodium and glucose levels, which will be described in further detail below.

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. 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.

Aldosterone is also a key component of the renin-angiotensin-aldosterone system (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; and 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.

Glucocorticoids: Cortisol

The intermediate region of the adrenal cortex produces hormones called

glucocorticoids because of their role in glucose metabolism. 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.

Many medications contain glucocorticoids to treat various conditions, such as cortisone injections for inflamed joints; prednisone tablets, IV medications, and steroid-based inhalers to manage inflammation that occurs in asthma; and hydrocortisone creams that are applied to relieve itchy skin rashes.

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: 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.

Disorders Involving the Adrenal Glands

Several disorders are caused by the dysregulation of the hormones produced by the adrenal glands. For example, Cushing's disease is a disorder characterized by high blood glucose levels, the development of a moon-shaped face, a buffalo hump on the back of the neck, rapid weight gain, and hair loss. It is caused by hypersecretion of cortisol as the result of an ACTH-producing pituitary tumor. Cushing's syndrome can also be caused by long-term use of corticosteroid medications.

In contrast, the hyposecretion of corticosteroids can result in Addison's disease, a disorder that causes low blood glucose levels and low blood sodium levels. Addisonian crisis is a life-threatening condition due to severely low blood pressure resulting from a lack of corticosteroid levels.[2,3,4,5]

View a supplementary YouTube video about ACTH and the adrenal gland:

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3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
4. Nieman, L., Biller, B., Findling, J., Murad, M., Newell-Price, J., Savage, M., & Tabarin, A. (2015, August 1). Treatment of Cushing's syndrome: An endocrine clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism, 100*(8), 2807-2831. https://academic.oup.com/jcem/article/100/8/2807/2836065
5. Liu, D., Ahmet, A., Ward, L., et al. (2013). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology, 9*, 30. https://aacijournal.biomedcentral.com/articles/10.1186/1710-1492-9-30

ACTH and the Adrenal Gland[6]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/pharmacology2e/?p=379#oembed-1

Applying the Nursing Process to Corticosteroids

Assessment

Before initiating long-term systemic corticosteroid therapy, a thorough history and physical examination should be performed to assess for risk factors or preexisting conditions that may potentially be exacerbated by glucocorticoid therapy, such as diabetes, dyslipidemia, cerebrovascular disease (CVD), GI disorders, affective disorders, or osteoporosis. At a minimum, baseline measures of body weight, height, bone mineral density, and blood pressure should be obtained, along with laboratory assessments that include a complete blood count (CBC), blood glucose values, and lipid profile. In children, nutritional and pubertal status should also be examined. Symptoms of and/or exposure to serious infections should also be assessed as corticosteroids are contraindicated in clients with untreated systemic infections. Concomitant use of other medications should also be assessed before initiating therapy as significant drug interactions have been noted between glucocorticoids and several drug classes. Females of childbearing age should also be questioned about the possibility of pregnancy because use in pregnancy may increase the risk of cleft palate in offspring.[7]

6. 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.
7. Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August

Implementation

Long-term corticosteroid therapy should never be stopped abruptly due to the risk of Addisonian crisis. Instead, the dose should be tapered to allow the body to resume natural production of adrenal hormone levels. Addisonian crisis is a potentially life-threatening condition resulting from an acute insufficiency of adrenal hormones that can occur if chronic corticosteroid therapy is suddenly stopped.

Clients on long-term corticosteroid therapy who are also at high risk for fractures are recommended to receive concurrent pharmacological treatment for osteoporosis. 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.[8]

Evaluation

The lowest effective dose should be used for treatment of the underlying condition, and the dose should be reevaluated regularly to determine if further reductions can be instituted.

The parameters described under "Assessment" should be monitored regularly. Health care professionals should monitor for adrenal suppression in clients who have been treated with corticosteroids for greater than two weeks or in multiple short courses of high-dose therapy. 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.[9]

15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology, 9*(30). https://doi.org/10.1186/1710-1492-9-30

8. Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology, 9*(30). https://doi.org/10.1186/1710-1492-9-30
9. Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August

Corticosteroids

Mechanism of Action: Glucocorticoids cause profound and varied metabolic effects as described earlier in this section. In addition, they modify the body's immune responses.[10]

Indications: Corticosteroids are used as replacement therapy in adrenal insufficiency, as well as for the management of various dermatologic, ophthalmologic, rheumatologic, pulmonary, hematologic, and gastrointestinal (GI) disorders. In respiratory conditions, systemic corticosteroids are used for the treatment of acute exacerbations of chronic obstructive pulmonary disease (COPD) and severe asthma. Mineralocorticoids are primarily involved in the regulation of electrolyte and water balance. Glucocorticoids are predominantly involved in carbohydrate, fat, and protein metabolism and also have anti-inflammatory, immunosuppressive, anti-proliferative, and vasoconstrictive effects. Prednisone is perhaps the most widely used of the systemic corticosteroids. It is generally used as an anti-inflammatory and immunosuppressive agent. Hydrocortisone is a commonly used topical cream for itching, and its oral formulation is used to treat Addison's disease.[11] Methylprednisolone is a commonly used injectable corticosteroid. Fludrocortisone has much greater mineralocorticoid potency and, therefore, is commonly used to replace aldosterone in Addison's disease.[12] See Figure 9.6[13,14,15] for images of various formulations of corticosteroids.

15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology, 9*(30). https://doi.org/10.1186/1710-1492-9-30

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11. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
12. Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology, 9*(30). https://doi.org/10.1186/1710-1492-9-30
13. "Fluticasone.JPG" by James Heilman, MD is licensed under CC BY-SA 3.0
14. "Methylprednisolone vial.jpg" by Intropin is licensed under CC BY 3.0
15. "006035339lg Prednisone 20 MG Oral Tablet.jpg" by NLM is licensed under CC0



Figure 9.6 Examples of Corticosteroid Medications (fluticasone inhaler, intravenous methylprednisolone, and prednisone tablets)

Corticosteroids are used for a variety of disorders such as the following:

- 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[16]

Nursing Considerations: Despite their beneficial effects, long-term systemic use of corticosteroids is associated with well-known adverse events, including osteoporosis and fractures, adrenal suppression, hyperglycemia and diabetes, cardiovascular disease and dyslipidemia, dermatological and GI events, psychiatric disturbances, and immunosuppression. One side effect that is

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unique to children is growth suppression.[17] Therefore, the lowest possible dose of corticosteroid should be used to control the condition under treatment to avoid the development of these adverse effects. When reduction in dosage is possible, the reduction should be gradual and should not be stopped abruptly because of the associated HPA suppression that occurs with long-term administration. This hypothalamus-pituitary-adrenal (HPA) suppression can cause an impaired stress response, which may persist for months after discontinuation of therapy; therefore, in any situation of stress occurring during that period, hormone therapy should be reinstituted. 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.

Dosages are variable and tailored to the disease process and the individual.

Side Effects/Adverse Effects: Adverse/side effects of corticosteroids include fluid and electrolyte imbalances; muscle weakness; peptic ulcers; thin, fragile skin that bruises easily; poor wound healing; and the development of Cushing's syndrome. Corticosteroids may mask some signs of infection, and new infections may appear during their use. Psychic derangements may appear when corticosteroids are used, ranging from euphoria, insomnia, mood swings, and personality changes to severe depression.

Health Teaching & Health Promotion: 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.[18] Glucocorticoid medication can cause immunosuppression, which makes it more difficult to detect signs of infection. Clients should seek advice from health care providers regarding vaccination administration while on glucocorticoids. Clients should report unusual swelling, weight gain, fatigue, bone pain, bruising, nonhealing sores, and visual and behavioral disturbances to the provider.

17. Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology, 9*(30). https://doi.org/10.1186/1710-1492-9-30
18. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Use of glucocorticoid therapy may cause an increase in blood glucose levels. Clients should be advised to consume diets that are high in protein, calcium, and potassium.

Now let's take a closer look at the medication grid comparing different formulations of corticosteroids in Table 9.3.[19,20,21,22,23] Medication grids 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. Detailed information on a specific medication can be found for free at DailyMed. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also linked to a DailyMed page.

Table 9.3 Prednisone, Methylprednisolone, Hydrocortisone, and Fludrocortisone Medication Grid

19. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
20. AHFS Patient Medication Information [Internet]. Bethesda (MD): American Society of Health-System Pharmacists, Inc.; c2019. *Neomycin, Polymyxin, Bacitracin, and Hydrocortisone Topical;* [reviewed 2018 Jun 15]. https://medlineplus.gov/druginfo/meds/a601061.html
21. Bornstein, S., Allolio, B., Arlt., W., Barthel., A., Don-Wauchope, A., Hammer, G., Husebye, E., Merke, D., Murad, M., Stratakis, C., & Tropy, D. (2016, February 1). Diagnosis and treatment of primary adrenal insufficiency: An endocrine society clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism, 101*(2), 364-389. https://doi.org/10.1210/jc.2015-1710
22. Nieman, L., Biller, B., Findling, J., Murad, M., Newell-Price, J., Savage, M., & Tabarin, A. (2015, August 1). Treatment of Cushing's syndrome: An endocrine clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism, 100*(8), 2807-2831. https://academic.oup.com/jcem/article/100/8/2807/2836065
23. Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology, 9*(30). https://doi.org/10.1186/1710-1492-9-30

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adv Effects

Glucocorticoid	prednisone (PO) methylprednisolone (IV)	Never abruptly stop corticosteroid therapy Use the lowest dose possible to control disorder and taper when feasible May require concurrent treatment for osteoporosis or elevated blood glucose levels Regularly monitor for development of symptoms of adrenal suppression Contraindicated in clients with untreated systemic infections	Often used to reduce inflammation or for immunosuppression	Fluid and electrolyt imbalanc Increase blood glu Muscle weakness Peptic ulcers Thin, fr skin that bruises e Poor w healing Develo t of Cush syndrom May m some sig infection new infe may app Psychic deranger may app when corticoste are used, ranging f euphoria insomnia mood sw and personali changes severe depressio

Topical Glucocorticoid	hydrocortisone cream	Cream is only for use on the skin. Do not use in eyes Apply a small amount of medication to cover the affected area of skin with a thin, even film and rub in gently Do not wrap or bandage the treated area unless included in the prescription Symptoms should begin to improve during the first few days of treatment; do not use this medication longer than seven days unless directed	Cream: Topical relief of itching, redness, and swelling	Contact t provider improver within se days

Mineralocorticoid	fludrocortisone	Often administered in conjunction with cortisone or hydrocortisone Contraindicated if systemic fungal infection present Continually monitor for signs that indicate dosage adjustment is necessary, such as exacerbations of the disease or stress (surgery, infection, trauma)	Aldosterone replacement in Addison's disease	Potential adverse effects fr retention sodium a water: Hyperten edema, cardiac enlargem congestiv heart fail potassiur loss, and hypokale alkalosis

Critical Thinking Activity 9.3

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. The nurse is

concerned because the client requires assistance and is a fall risk, so 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, although she has no history of diabetes mellitus. 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?

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

9.4 Antidiabetics

This section will review the anatomy and physiology of the pancreas, discuss diabetes mellitus and insulin treatment, apply the nursing process to administering antidiabetics, and then discuss antihyperglycemic medications.

Review of Anatomy and Physiology of the Pancreas

The pancreas is a long, slender organ located near the stomach (see Figure 9.7).[1] Although it is primarily an **exocrine gland**, secreting a variety of digestive enzymes, the pancreas also has an endocrine function. Pancreatic islets, clusters of cells formerly known as the islets of Langerhans, secrete glucagon and insulin. Glucagon plays an important role in blood glucose regulation because low blood glucose levels stimulate its release. On the other hand, elevated blood glucose levels stimulate the release of insulin.

1. "1820 The Pancreas.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-9-the-endocrine-pancreas

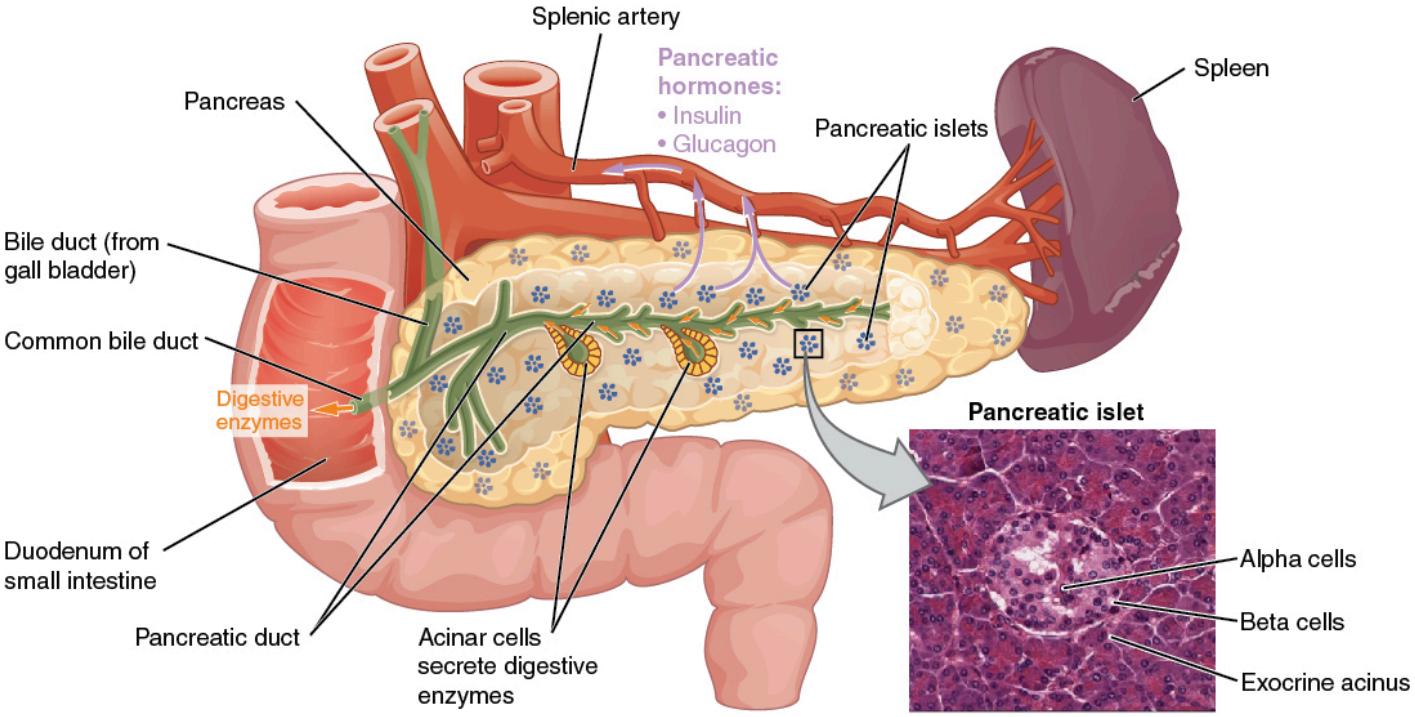


Figure 9.7 Pancreas

Regulation of Blood Glucose Levels by Insulin and Glucagon

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.

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 these 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. See Figure 9.8[2] for an illustration of homeostatic regulation of blood glucose levels.

2. "1822 The Homeostatic Regulation of Blood Glucose Levels.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at https://openstax.org/books/anatomy-and-physiology/pages/17-9-the-endocrine-pancreas

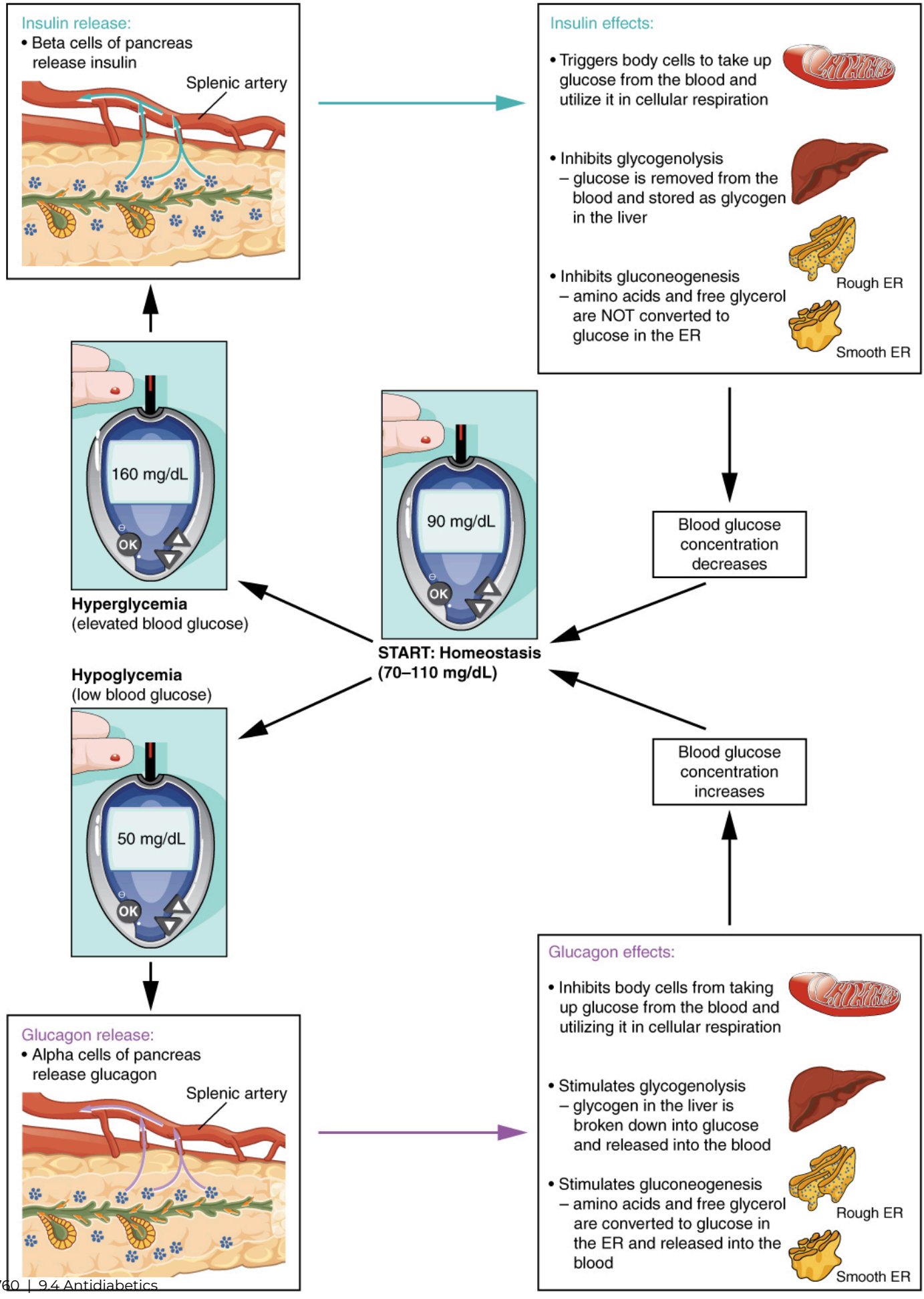

Insulin release:
• Beta cells of pancreas release insulin
Splenic artery
Insulin effects:
• Triggers body cells to take up glucose from the blood and utilize it in cellular respiration
• Inhibits glycogenolysis
– glucose is removed from the blood and stored as glycogen in the liver
• Inhibits gluconeogenesis
– amino acids and free glycerol are NOT converted to glucose in the ER
Rough ER
Smooth ER
160 mg/dL
OK
Hyperglycemia
(elevated blood glucose)
90 mg/dL
OK
START: Homeostasis
(70–110 mg/dL)
Blood glucose concentration decreases
Hypoglycemia
(low blood glucose)
50 mg/dL
OK
Blood glucose concentration increases
Glucagon release:
• Alpha cells of pancreas release glucagon
Splenic artery
Glucagon effects:
• Inhibits body cells from taking up glucose from the blood and utilizing it in cellular respiration
• Stimulates glycogenolysis
– glycogen in the liver is broken down into glucose and released into the blood
• Stimulates gluconeogenesis
– amino acids and free glycerol are converted to glucose in the ER and released into the blood
Rough ER
Smooth ER

Figure 9.8 Homeostatic Regulation of Blood Glucose Levels. Blood glucose concentration is tightly maintained between 70 mg/dL and 110 mg/dL. If blood glucose concentration rises above this range, insulin is released, which stimulates body cells to remove glucose from the blood. If blood glucose concentration drops below this range, glucagon is released, which stimulates body cells to release glucose into the blood.

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.

Common Disorder of the Pancreas: 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. **Type 2 diabetes** accounts for approximately 95 percent of all cases. It is acquired, and lifestyle factors such

as poor diet and inactivity greatly increase a person's risk. 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, oral diabetic medication is implemented, and eventually the type 2 diabetic may require insulin.

Diabetes is diagnosed when lab tests reveal that blood glucose levels are higher than normal, a condition called **hyperglycemia**.[3] According to the American Diabetes Association (ADA), normal fasting blood glucose levels for non-diabetic clients are 80-130 mg/dL. Glycosylated hemoglobin, also called A1C, is used to assess long-term blood glucose levels over three months. The ADA states that A1C target levels vary according to age and health, but the generalized A1C target is less than 7%, which equates to an average blood glucose level of 154.[4]

Insulin Treatment

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 from the American Diabetes Association (ADA) include the following:

- 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.

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
4. American Diabetes Association. (2019). *The big picture: Checking your blood glucose*. https://www.diabetes.org/diabetes/medication-management/blood-glucose-testing-and-control/checking-your-blood-glucose

- 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.

Basal insulin can be long-acting (insulin glargine or insulin detemir) or intermediate-acting (insulin isophane suspension [NPH]). **Prandial insulins** are used with meals and may be rapid-acting (insulin lispro, insulin aspart, or insulin glulisine) or short- acting (regular insulin).

According to the ADA, 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, most individuals with type 1 diabetes are treated with multiple daily injections of basal and mealtime insulin or continuous subcutaneous insulin infusion. Thus, health teaching for individuals with type 1 diabetes should include how to match mealtime insulin doses to carbohydrate intake, fat and protein content, as well as their anticipated physical activity. Ensuring that clients and/or caregivers understand correct insulin injection technique is also important to optimize glucose control and insulin use safety.[5]

Clients on insulin therapy are at risk for **hypoglycemia**. It is essential for the nurse to monitor for signs of hypoglycemia and to intervene appropriately. See Table 9.4a for symptoms of hypoglycemia. Hypoglycemia is defined as a blood glucose level below 70 mg/dL; severe hypoglycemia refers to a blood glucose level below 40 mg/dL.

Table 9.4a Hypoglycemia Symptoms

5. American Diabetes Association Professional Practice Committee. (2022). 9. Pharmacologic approaches to glycemic treatment: Standards of medical care in diabetes—2022. *Diabetes Care*. *45*(S1): S125–S143. https://doi.org/10.2337/dc22-S009

Mild-to-Moderate	Severe
• Shaky or jittery • Sweaty • Hungry • Headache • Blurred vision • Sleepy or tired • Dizzy or light-headed • Confused or disoriented • Pale • Uncoordinated • Irritable or nervous • Argumentative or combative • Changed behavior or personality • Trouble concentrating • Weak • Fast or irregular heartbeat	• Unable to eat or drink • Seizures or convulsions (jerky movements) • Unconsciousness

If a client with diabetes shows a sudden change in mood or mental status or other symptoms of hypoglycemia, the nurse should immediately check the blood glucose level. Health care agencies use hypoglycemia protocols so that the nurse can react quickly to episodes of hypoglycemia before they become severe. Hypoglycemia protocols contain orders for immediate treatment by the nurse. For instance, in clients who can tolerate oral intake, 15 grams of rapidly digested carbohydrates (such as 4 ounces of fruit juice) are recommended. In clients who are NPO or can't take oral treatment, dextrose 50% IV or glucagon IM or subcutaneously is administered. Clients who have had a hypoglycemic episode should be monitored 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 to discuss 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.[6]

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. The U.S. Food and Drug Administration has approved two hybrid closed-loop pump systems.[7] A hybrid closed-loop pump system automatically adjusts basal insulin delivery every five minutes based on sensor glucose to maintain blood glucose levels as close to a specific target as possible.[8]

According to the ADA, 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.

HYPOKALEMIA

All insulin products cause a shift in potassium from the extracellular to intracellular space, which can possibly lead to hypokalemia. Untreated hypokalemia may cause respiratory paralysis, ventricular arrhythmia, and death. Monitor potassium levels in clients at risk for hypokalemia due to other medications such as diuretics.

INSULIN PENS

Insulin pens are often used in inpatient settings, as well as for self-

6. Seggelke, S., & Everhart, B. (2012, September 11). Managing glucose levels in hospital patients. *American Nurse Today*. https://www.americannursetoday.com/managing-glucose-levels-in-hospital-patients/
7. American Diabetes Association Professional Practice Committee. (2022). 9. Pharmacologic approaches to glycemic treatment: Standards of medical care in diabetes—2022. *Diabetes Care*. *45*(S1): S125–S143. https://doi.org/10.2337/dc22-S009
8. Weaver, H., & Hirsch, I. (2018, June 6). The hybrid closed loop system: Evolution and practical applications. *Diabetes Technology & Therapeutics 20*(S2). https://www.liebertpub.com/doi/10.1089/dia.2018.0091

administration, to facilitate safe and accurate self-administration of insulin. See Figure 9.9[9] for an image of an insulin pen.



Figure 9.9 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 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 blood-borne 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.[10]

9. "Human insulin 100 IU-1ml pen yellow background (02).jpg" by Wesalius is licensed under CC BY 4.0
10. 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

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 client 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 mealtime.

In an inpatient setting, manifestations of poor glycemic control, including severe hypoglycemia and hyperglycemia, are deemed hospital-acquired conditions by the Centers for Medicare and Medicaid Services (CMS). CMS notes that poor glycemic control can be reasonably prevented with implementation of evidence-based guidelines; thus, the CMS denies payment for diabetic ketoacidosis, hypoglycemic coma, and other serious conditions related to poor glycemic control. Agency policies and procedures should be closely followed to avoid these errors and manifestations of poor glycemic control.

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[11]:

- Client-specific insulin pens are stored on clinical units in a manner that

11. 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

prevents their inadvertent use on more than one client.

- 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 nurse:
    - 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
- 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.
- 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 the following:
    - 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

LIFE SPAN CONSIDERATIONS

Elderly

Older adults are at higher risk for hypoglycemia episodes. The ADA has established the following evidence-based recommendations from well-conducted studies for older adult clients with diabetes[12]:

- Consider the assessment of medical, psychological, functional (self-management abilities), and social domains in older adults to provide a framework to determine targets and therapeutic approaches for diabetes management.
- Screen for geriatric syndromes (i.e., polypharmacy, cognitive impairment, depression, urinary incontinence, falls, persistent pain, and frailty) in older adults, as they may affect diabetes self-management and diminish quality of life.
- Screening for early detection of mild cognitive impairment or dementia should be performed for adults 65 years of age or older at the initial visit, annually, and as appropriate.
- Because older adults with diabetes have a greater risk of hypoglycemia than younger adults, episodes of hypoglycemia should be ascertained and addressed at routine visits.
- For older adults with type 1 diabetes, continuous glucose monitoring should be considered to reduce hypoglycemia.

12. American Diabetes Association Professional Practice Committee. (2022). 13. Older adults: Standards of medical care in diabetes—2022. *Diabetes Care 45*(S1). https://doi.org/10.2337/dc22-S013

- Optimal nutrition and protein intake is recommended for older adults; regular exercise, including aerobic activity, weight-bearing exercise, and/or resistance training, should be encouraged in all older adults who can safely engage in such activities.
- For older adults with type 2 diabetes, overweight/obesity, and capacity to safely exercise, an intensive lifestyle intervention focused on dietary changes, physical activity, and modest weight loss (e.g., 5–7%) should be considered for its benefits on quality of life, mobility and physical functioning, and cardiometabolic risk factor control.
- In older adults with type 2 diabetes 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 and polypharmacy, if it can be achieved within the individualized A1C target.
- Consider costs of care and insurance coverage rules when developing treatment plans in order to reduce risk of cost-related nonadherence.

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 childcare and school environment, neurological vulnerability to hypoglycemia and hyperglycemia in young children, as well as possible adverse neurocognitive effects of diabetic ketoacidosis (DKA). The ADA has established several evidence-based recommendations from well-conducted studies for children and adolescents with diabetes, including, but not limited to, the following[13]:

13. American Diabetes Association Professional Practice Committee. (2022). 14. Children and adolescents: Standards of medical care in diabetes—2022. *Diabetes Care 45*(S1). https://doi.org/10.2337/dc22-S014

- Youth with type 1 diabetes and their parents/caregivers (for clients aged <18 years) should receive culturally sensitive, developmentally appropriate, and individualized health teaching regarding diabetes self-management and support according to national standards at initial diagnosis and routinely thereafter.
- Individualized medical nutrition therapy is recommended for children and adolescents with type 1 diabetes as an essential component of the overall treatment plan.
- Monitoring carbohydrate intake, whether by carbohydrate counting or experience-based estimation, is a key component to optimizing glycemic management.
- Encourage developmentally appropriate family involvement in diabetes management tasks for children and adolescents, recognizing that premature transfer of diabetes care responsibility to the youth can result in diabetes burnout, suboptimal diabetes management, and deterioration in glycemic control.
- Providers should consider asking youth and their parents/caregivers about social adjustment (peer relationships) and school performance to determine whether further intervention is needed.
- Assess youth with diabetes for psychosocial and diabetes-related distress, generally starting at 7–8 years of age.
- Starting at puberty, preconception counseling should be incorporated into routine diabetes care for all girls of childbearing potential.
- Begin screening youth with type 1 diabetes for disordered eating between 10 and 12 years of age. The Diabetes Eating Problems Survey-Revised (DEPS-R) is a reliable, valid, and brief screening tool for identifying disturbed eating behavior.
- All children and adolescents with type 1 diabetes should monitor glucose levels multiple times daily (up to 6–10 times/day by blood glucose meter or continuous glucose monitoring), including prior to meals and snacks, at bedtime, and as needed for safety in specific situations such as exercise, driving, or the presence of symptoms of hypoglycemia.
- Real-time continuous glucose monitoring should be offered for diabetes management in youth with diabetes on multiple daily injections or

insulin pump therapy who are capable of using the device safely (either by themselves or with caregivers). The choice of device should be made based on client circumstances, desires, and needs.

- Automated insulin delivery systems or insulin pump therapy should be offered for diabetes management to youth with type 1 diabetes who are capable of using the device safely (either by themselves or with caregivers). The choice of device should be made based on client circumstances, desires, and needs.
- A1C goals must be individualized and reassessed over time. An A1C of <7% is appropriate for many children. Less stringent A1C goals (such as <7.5% or 8%) may be appropriate for clients who cannot articulate symptoms of hypoglycemia; have hypoglycemia unawareness; lack access to analog insulins, advanced insulin delivery technology, and/or continuous glucose monitoring; cannot check blood glucose regularly; or have nonglycemic factors that increase A1C (e.g., high glycators).
- Blood pressure should be measured at every routine visit. In youth with high blood pressure (blood pressure ≥90th percentile for age, sex, and height or, in adolescents aged ≥13 years, blood pressure ≥120/80 mmHg) on three separate measurements, ambulatory blood pressure monitoring should be strongly considered.
- In addition to lifestyle modification, ACE inhibitors or angiotensin receptor blockers should be started for treatment of confirmed hypertension (defined as blood pressure consistently ≥95th percentile for age, sex, and height or, in adolescents aged ≥13 years, ≥130/80 mmHg). Due to the potential teratogenic effects, females should receive reproductive counseling, and ACE inhibitors and angiotensin receptor blockers should be avoided in females of childbearing age who are not using reliable contraception.
- Elicit a smoking history at initial and follow-up diabetes visits; discourage smoking in youth who do not smoke and encourage smoking cessation in those who do smoke.
- All youth with type 2 diabetes and their families should receive comprehensive diabetes self-management teaching and support that is specific to youth with type 2 diabetes and is culturally appropriate.

- Nutrition for youth with prediabetes and type 2 diabetes, like for all children and adolescents, should focus on healthy eating patterns that emphasize consumption of nutrient-dense, high-quality foods and decreased consumption of calorie-dense, nutrient-poor foods, particularly sugar-added beverages.

Applying the Nursing Process to Administering Antidiabetics

Assessment

Clients with diabetes should be continuously monitored for signs of hypoglycemia and hyperglycemia. When a client with diabetes is experiencing stress or an infection, the nurse should plan to assess the blood glucose levels more frequently.

Implementation

The nurse should follow agency policy and ISMP guidelines for safe insulin administration. See the "Preventing Medication Errors" section in the "Legal/ Ethical" chapter for more information about ISMP guidelines regarding insulin as a "High-Alert Medication." Onset and peak times of insulin and sulfonylureas, in association with anticipated mealtimes, 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. Symptomatic hyperglycemia should be immediately reported to the provider. Health teaching should be provided to clients and their family members and/or caregivers according to ADA and ISMP guidelines.

Evaluation

The nurse should evaluate A1C levels to determine effectiveness (and compliance with) the treatment regimen.

Antihyperglycemic Medication: Insulins

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.

Rapid-Acting Insulin

Rapid-acting insulins include insulin lispro (Humalog) and insulin aspart (Novolog) and are also available via inhalation (Afrezza). See Figure 9.10[14] for an image of Novolog insulin.

14. "@dailyshoot-_2010-03-20-_Liquids_can_be_still_and_reflective_or_in_motion_and_chaotic._Make_a_photograph_of_something_liquid_today._-ds125_%284449910430%29.jpg" from cogdogblog website is licensed under CC BY 2.0



Figure 9.10 Novolog Insulin

Mechanism of Action: Insulins lower blood glucose by stimulating peripheral glucose uptake by skeletal muscle and fat and by inhibiting hepatic glucose production.

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.

Nursing Considerations: Humalog-100 (100 units per mL) and Humalog-200 (200 units per mL) are administered subcutaneously. Humalog-100 insulin can be administered intravenously under close supervision of blood glucose and potassium levels. Humalog-100 can be mixed with NPH insulin, but Humalog-200 should not be mixed with another insulin. Inspect insulin visually before use. It should appear clear and colorless; do not use if particulate matter or coloration is seen. Humalog-100 is available in vials, KwikPens, and cartridges; Humalog-200 is only available in KwikPens.

Administer subcutaneously into the outer lateral aspect of the upper arm, the abdomen (from below the costal margin to the iliac crest and more than two inches from the umbilicus), the anterior upper thighs, or the buttocks. Rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy. Lipodystrophy can be a lump or small dent in the skin that forms when a person performs injections repeatedly in the same spot.

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 minute and peaks in 30-60 minutes. Inhaled insulin is contraindicated in clients with chronic lung disease such as asthma or COPD.

Side Effects/Adverse Effects: Adverse effects of all insulins include hypoglycemia and hypokalemia. Inhaled insulin has a Boxed Warning for potentially causing acute bronchoconstriction.

Health Teaching & Health Promotion: See ISMP guidelines for client teaching in the previous "High-Alert Medication and Prevention of Errors" subsection.

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. See Figure 9.11[15] for an image of Humulin R insulin.

15. "Humulin R, Insulin, 1987" by National Museum of American History Smithsonian Institution is licensed under CC BY-NC-ND 2.0



Figure 9.11 Humulin R Insulin

Mechanism of Action: The primary activity of insulin is the regulation of glucose metabolism. Insulin lowers blood glucose by stimulating peripheral glucose uptake, especially by skeletal muscle and fat, and by inhibiting hepatic glucose production.

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.

Nursing Considerations: Regular insulin is generally administered subcutaneously. Regular insulin can be administered intravenously 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 outer lateral aspect of the upper arm, the abdomen (from below the costal margin to the iliac crest and more than two inches from the umbilicus), the anterior upper thighs, or the buttocks. 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.

Side Effects/Adverse Effects: Adverse effects of insulin include hypoglycemia and hypokalemia.

Health Teaching & Health Promotion: See IMSP guidelines for client teaching in the previous "High-Alert Medication and Prevention of Errors" subsection.

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.

Mechanism of Action: Insulins lower blood glucose by stimulating peripheral glucose uptake by skeletal muscle and fat and by inhibiting hepatic glucose production.

Indications: Intermediate insulins are administered once or twice daily to mimic endogenous basal insulin levels.

Nursing Considerations: NPH insulin is a white and cloudy suspension. Gently roll or invert vial/pen several times to resuspend 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 outer lateral aspect of the upper arm, the abdomen (from below the costal margin to the iliac crest and more than two inches from the umbilicus), the anterior upper thighs, or the buttocks. 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 is affected by the site of injection, physical activity level, and other variables, but the median peak level occurs in

four hours. See Figure 9.12[16] for an image of Novolin-N (a cloudy insulin) that can be mixed with Novolin R (a clear insulin).



Figure 9.12 Comparison of Novolin-N (a cloudy insulin) That Can Be Mixed With Novolin-R (a clear insulin)

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 two 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.

16. "The Gift of Life" by Melissa Johnson is licensed under CC BY 2.0

Side Effects/Adverse Effects: Adverse effects of insulin include hypoglycemia and hypokalemia.

Health Teaching & Health Promotion: See IMSP guidelines for client teaching in the previous "High-Alert Medication and Prevention of Errors" subsection.

Long-Acting Insulin

Insulin glargine (Lantus) and insulin detemir (Levemir) are long-acting insulins given once or twice daily. See Figure 9.13[17] for an image of a Levemir insulin pen.



Figure 9.13 Vial Used for Levemir Insulin Pen

Mechanism of Action: Insulins lower blood glucose by stimulating peripheral glucose uptake by skeletal muscle and fat and by inhibiting hepatic glucose production.

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.

Nursing Considerations: Long-acting insulin has a relatively constant concentration/time profile over 24 hours with no pronounced peak in

17. "Insulin analog 100 IU-1ml penfill levemir yellow background.jpg" by Wesalius is licensed under CC BY 4.0

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 outer lateral aspect of the upper arm, the abdomen (from below the costal margin to the iliac crest and more than two inches from the umbilicus), the anterior upper thighs, or the buttocks. Rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy.

Side Effects/Adverse Effects: Adverse effects of insulin include hypoglycemia and hypokalemia.

Health Teaching & Health Promotion: See ISMP guidelines for client teaching in the previous "High-Alert Medication and Prevention of Errors" subsection.

Glucagon

Mechanism of Action: Glucagon increases blood glucose concentration during an episode of hypoglycemia. See Figure 9.14[18] for an image of an emergency glucagon kit.

18. "Glucagon emergency rescue kit.JPG" by mbbradford is licensed under CC0



Figure 9.14 Emergency Glucagon Kit

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.

Nursing Considerations: Glucagon may be administered subcutaneously, intramuscularly (IM), or intravenously. Peak glucose levels occur within 13-20 minutes of subcutaneous or IM injection.

Side Effects/Adverse Effects: A side effect of glucagon is hyperglycemia.

Health Teaching & Health Promotion: Clients with type 1 diabetes may have less of an increase in blood glucose levels compared with clients with

stable type 2 diabetes, so a supplementary carbohydrate should be given as soon as possible, especially to a pediatric client.[19]

Now let's take a closer look at the medication grid comparing insulins in Table 9.4b.[20]

Table 9.4b Insulins and Glucagon Medication Grid

19. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.
20. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Onset/ Peak/ Duration	Nursing Considerations	Therapeutic Effects	Side/Ad Effects
Rapid-Acting Insulin	insulin lispro (Humalog) insulin aspart (Novolog) inhaled insulin (Afreeza)	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 clients with asthma or COPD	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypogly Hypokal Afrezz cause ac broncho
Short-Acting Insulin	Humulin R Novolin R	Onset: 30 minutes Peak effect: 3 hours Duration: 8 hours	Administer 30 minutes before a meal	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypogly Hypokal
Intermediate-Acting Insulin	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 Only administer subcutaneously Gently roll or invert vial/pen several times to resuspend the insulin before administration	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypogly Hypokal

Combination: Intermediate-Acting/ Rapid-Acting	Humalog Mix 50/50 Humalog Mix 75/25 Novolog Mix 70/30 *First number is % of intermediate-acting insulin; second number is % of rapid-acting insulin	Onset: 15-30 minutes Peak effect of Humalog 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 resuspend the insulin before administration	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypogly Hypokal
Combination: Intermediate-Acting/ Short-Acting	Humulin Mix 70/30 Novolin Mix 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 Only administer subcutaneously Gently roll or invert vial/pen several times to resuspend the insulin before administration Do not mix with other insulin	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypogly Hypokal

Long-Acting Insulin	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) Only administer subcutaneously Do not mix with other insulin	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypogly Hypokal
Hyperglycemic	glucagon		May be administered subcutaneously, IM, or IV Supplementary carbohydrate should be given as soon as possible, especially to a pediatric client	Used to reverse hypoglycemic episode if NPO administration is not appropriate	Hypergl

General administration considerations:

- Review orders closely because they may include a standard meal dose, a "sliding scale" dose, and a carb-related dose
- Always read drug labelling closely as there are several types of dosages and formulations
- See agency policies and ISMP guidelines for safe administration of insulin
- When administering with an insulin pen, after inserting the pen, count to five before removing the needle

General therapeutic effects:

- Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)

General side effects:

- Hypoglycemia and hypokalemia

Antihyperglycemic Medication: Oral Antihyperglycemics

There are several different classes of oral antihyperglycemic medications used in conjunction with a healthy diet and exercise for the management of type 2 diabetes. According to the American Diabetes Association, metformin is the preferred initial pharmacologic agent for the treatment of type 2 diabetes.[21] Other commonly used antihyperglycemic medications are glipizide and sitagliptin. The mechanism of action and administration considerations for these prototypes are described below.

Glipizide

Mechanism of Action: Glipizide is in the sulfonylurea class of antihyperglycemic medication. The mechanism of action is the stimulation of insulin secretion from the beta cells of pancreatic islet tissue and is thus dependent on functioning beta cells in the pancreatic islets. Peak plasma concentrations occur 1 to 3 hours after a single oral dose.

Indications: Glipizide is used to improve glycemic control in individuals with type 2 diabetes.

Nursing Considerations: All sulfonylurea drugs are capable of producing severe hypoglycemia. Hypoglycemia may be difficult to recognize in the elderly and in people who are taking beta-adrenergic blocking drugs. Sulfonylurea medications should be given 30 minutes before a meal due to hypoglycemic effects.

Glipizide is contraindicated in type 1 diabetics or for use of diabetic ketoacidosis; insulin should be used to treat this condition. Treatment of

21. American Diabetes Association Professional Practice Committee. (2022). 9. Pharmacologic approaches to glycemic treatment: Standards of medical care in diabetes—2022. Diabetes Care. *45* (S1): S125–S143. https://doi.org/10.2337/dc22-S009

clients with glucose 6-phosphate dehydrogenase (G6PD) deficiency with sulfonylurea agents can lead to hemolytic anemia.

Side Effects/Adverse Effects: The hypoglycemic action of sulfonylureas may be potentiated by certain drugs such as nonsteroidal anti-inflammatory agents and other drugs that are highly protein bound.

Health Teaching & Health Promotion: Clients should take the medication at the same time each day. 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.

Metformin

Mechanism of Action: Metformin is in the biguanide class of antihyperglycemics. It decreases hepatic glucose production, decreases intestinal absorption of glucose, and improves insulin sensitivity by increasing peripheral glucose uptake and utilization. Unlike sulfonylureas, metformin does not produce hypoglycemia. See Figure 9.15[22] for an image of a metformin tablet.

22. "Metformin 500mg Tablets.jpg" by User:Ash is licensed under CC0



Figure 9.15 Metformin

Indications: Metformin is an adjunct to diet and exercise to improve glycemic control in individuals with type 2 diabetes.

Nursing Considerations: Metformin hydrochloride should be given in divided doses with meals. 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, either when used as monotherapy or in combination with sulfonylurea or insulin.

Metformin is contraindicated in clients with kidney disease (e.g., serum creatinine levels ≥1.5 mg/dL [males] or ≥1.4 mg/dL [females]) and should be temporarily discontinued in clients undergoing radiologic studies involving intravascular administration of iodinated contrast materials because use of such products may result in acute alteration of renal function. It is also contraindicated in clients with metabolic acidosis.

Lactic acidosis is a rare, but serious, metabolic complication that can occur due to metformin accumulation during treatment with metformin; 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 should be promptly withheld 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. The onset of lactic acidosis often is subtle and accompanied only by nonspecific symptoms such as malaise, myalgias, respiratory distress, increasing somnolence, and nonspecific abdominal distress.

Side Effects/Adverse Effects: Common adverse effects include diarrhea, nausea/vomiting, weakness, flatulence, indigestion, abdominal discomfort, and headache.

Health Teaching & Health Promotion: Clients should take the medication at the same time each day. 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 client may be at risk for lactic acidosis and should report chills, low blood pressure, muscle pain, or dyspnea immediately to the health care provider. The use of medications like metformin can cause a metallic taste in the mouth.

Sitagliptin

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 and, thus, increases insulin release and decreases glucagon levels in the circulation. See Figure 9.16[23] for an image of sitagliptin.

23. "Januvia sitagliptin.jpg" by Kimivanil is licensed under CC BY-SA 4.0



Figure 9.16 Sitagliptin

Indications: It is used as an adjunct to diet and exercise to improve glycemic control in adults with type 2 diabetes.

Nursing Considerations: Sitagliptin is taken once daily and can be taken with or without food. It can cause hypoglycemia. Dose adjustment should occur for clients with kidney disease depending on their glomerular filtration rate. Report hypersensitivity reactions, blisters/erosions, headache, or symptoms of pancreatitis, heart failure, severe arthralgia, and upper respiratory infection.

Side Effects/Adverse Effects: Common side effects include hypoglycemia. Individuals may also experience hypersensitivity reactions, blisters/erosions, headache, or symptoms of pancreatitis, heart failure, severe arthralgia, or upper respiratory infection.

Health Teaching & Health Promotion: Clients should take the medication at the same time each day. 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. Clients should stop taking the medication if symptoms of

hypersensitivity occur and follow up immediately with their provider to determine the next course of treatment.

Now let's take a closer look at the medication grid comparing oral antihyperglycemics in Table 9.4c.[24]

Table 9.4c Oral Antihyperglycemics Medication Grid

24. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/ Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Sulfonylureas	glipizide	Time with meals; peak plasma concentrations occur 1 to 3 hours after administration	Reduce fasting blood sugar and glycosylated hemoglobin to near normal	Hypoglycemia; may be potentiated by nonsteroidal anti-inflammatory agents and other drugs that are highly protein bound
Biguanide	metformin	Contraindicated in renal and hepatic disease Should be temporarily discontinued in clients undergoing radiologic studies involving intravascular administration of iodinated contrast materials	Reduce fasting blood sugar and glycosylated hemoglobin to near normal	Stop immediately if signs of lactic acidosis or any condition associated with hypoxemia, dehydration, or sepsis occurs Common adverse effects: Diarrhea, nausea/vomiting, weakness, flatulence, indigestion, abdominal discomfort, and headache
DPP-4 Inhibitor	sitagliptin	Can be given with or without food	Reduce fasting blood sugar and glycosylated hemoglobin to near norm	Hypoglycemia Report hypersensitivity reactions, blisters/ erosions, headache, or symptoms of pancreatitis, heart failure, severe arthralgia, or upper respiratory infection

Critical Thinking Activity 9.4

A client with diabetes mellitus type 2 is admitted to the hospital for hip replacement surgery. The nurse reviews the following orders:

Diabetic diet with carb counting

Bedside blood glucose testing before meals and at bedtime with sliding scale Humalog insulin

Sliding scale Humalog insulin based on preprandial glucose level:

- 0-150: No coverage
- 151-175: 2 units
- 176-200: 4 units
- 201-225: 6 units
- 226-250: 8 units
- Over 250: call the provider

Insulin coverage per carbohydrate intake at meals: Humalog 2 units/carb

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 223 and he eats three carbs at breakfast. 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 1.8. 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 60. 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 glargine) therapy at home, based on the admitting A1C level. What patient teaching should the nurse plan to provide before discharge?

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

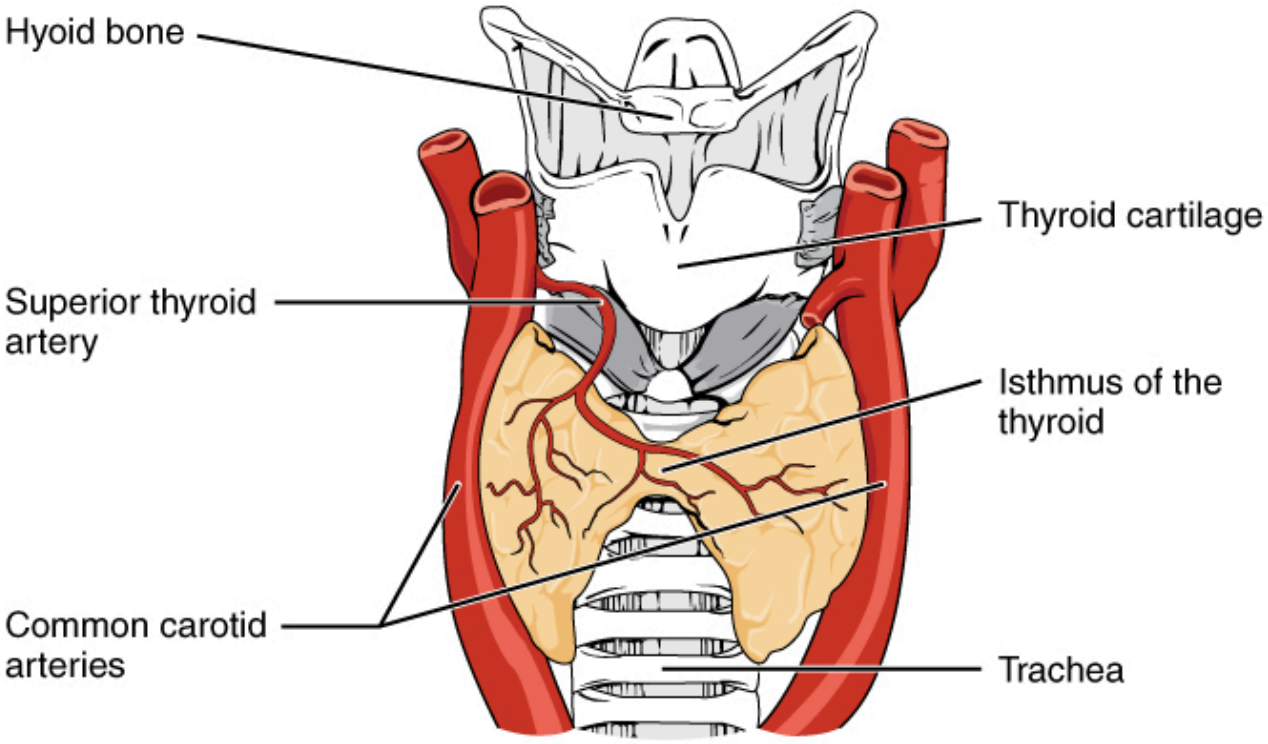
9.5 Thyroid Medications

This section will review the anatomy and physiology of the thyroid, outline common thyroid disorders, review the anatomy and physiology of the parathyroid gland, outline common parathyroid disorders, apply the nursing process to administering thyroid medications, and then discuss thyroid and osteoporosis medications.

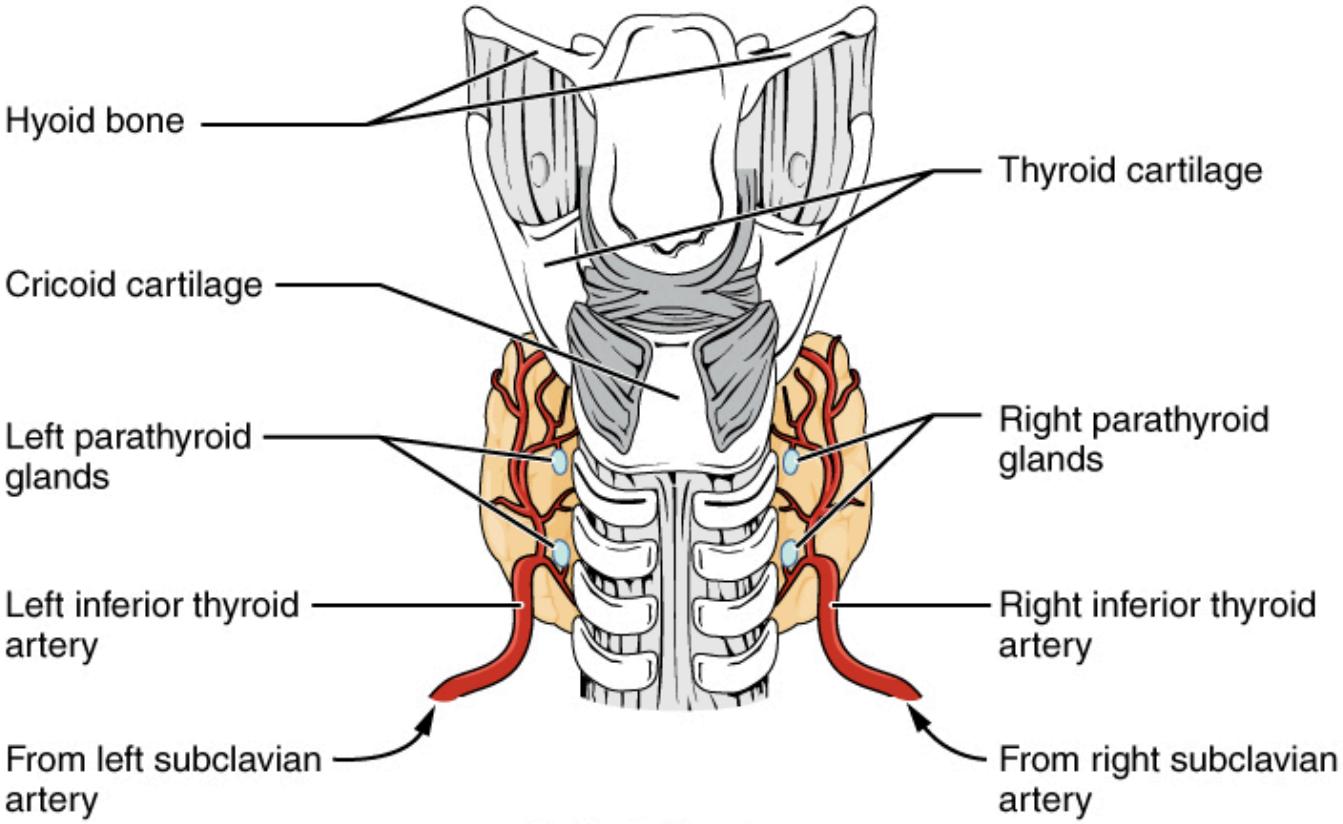
Review of Anatomy and Physiology of the Thyroid

The thyroid is a butterfly-shaped organ located anterior to the trachea, just inferior to the larynx (see Figure 9.17).[1] Each of the thyroid lobes is embedded with parathyroid glands.

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



a) Anterior view



b) Posterior view



Figure 9.17 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. 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 9.18,[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.

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

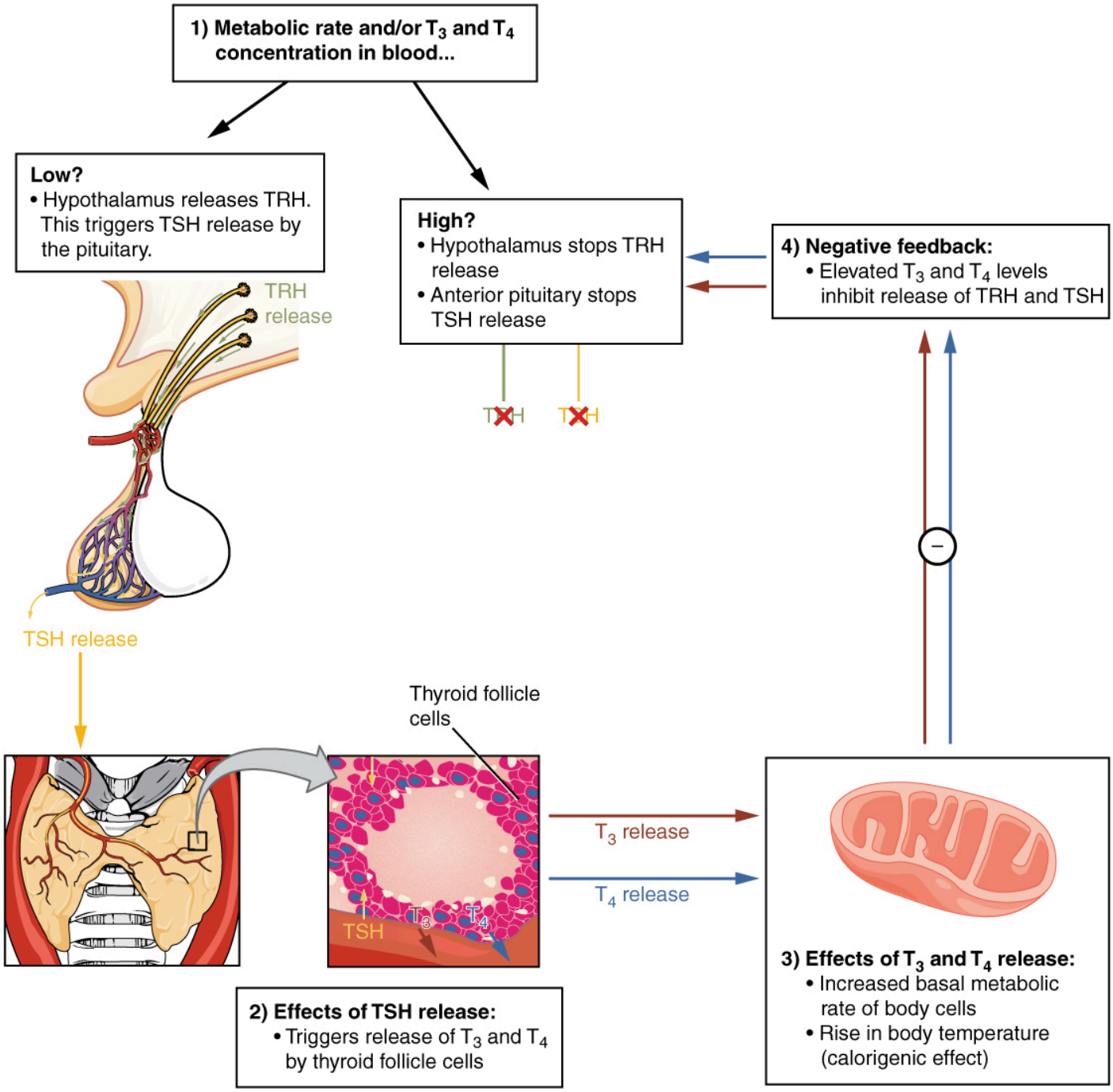


Figure 9.18 Negative Feedback Loop: Controls Regulation of Thyroid Hormone Levels

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 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.

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 in these ways:

- 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 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.

Disorders of the Thyroid Gland

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 began in the United States in 1924, and international efforts to iodize salt in the world's poorest nations continue today.

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 9.19[3]). 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

3. "Goitre.jpg" by Almazi is licensed under CC0

deficits, short stature, and sometimes deafness and muteness in children and adults born to mothers who were iodine-deficient during pregnancy.



Figure 9.19 Goiter

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. In contrast, **hyperthyroidism**—an abnormally elevated blood level of thyroid hormones—is often caused by a pituitary or thyroid 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.[4]

Review of Anatomy and Physiology of the Parathyroid Glands

The parathyroid glands are four tiny, round structures usually embedded in the posterior surface of the thyroid gland (see Figure 9.20).[5] 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.

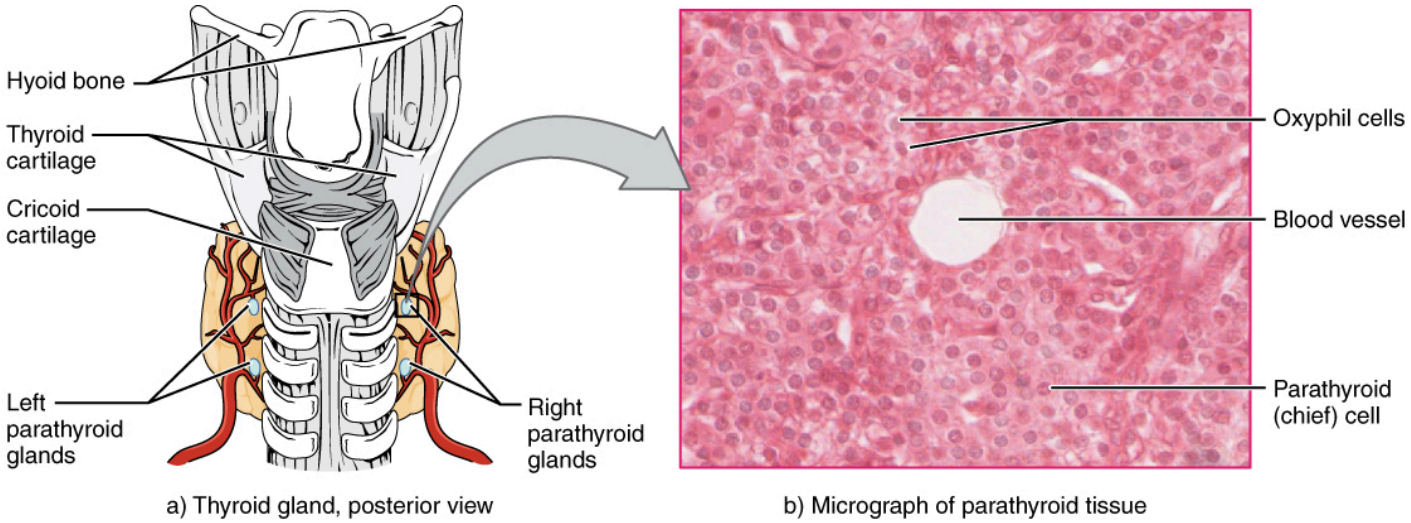


Figure 9.20 Parathyroid Glands

PTH secretion causes the release of calcium from the bones by stimulating

4. American Thyroid Association. (2019). *Radioactive iodine*. https://www.thyroid.org/radioactive-iodine/
5. "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

osteoclasts that degrade bone and then release calcium 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 9.21 for an illustration of the role of parathyroid hormone in maintaining blood calcium homeostasis.)[6]

6. "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

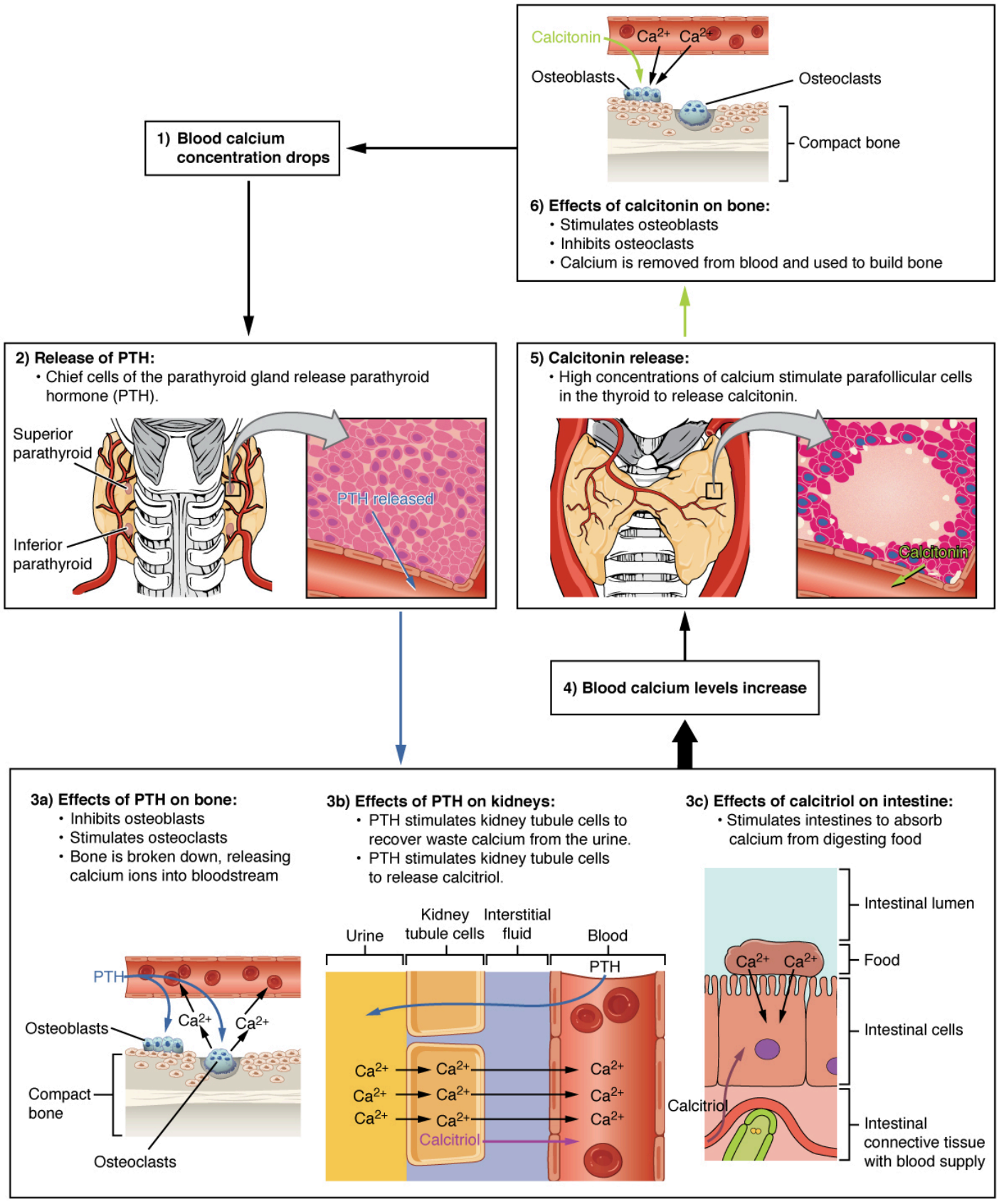


Figure 9.21 Parathyroid Hormone in Maintaining Blood Calcium Homeostasis

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.

Applying the Nursing Process to Administering Thyroid Medications

Assessment

When administering thyroid replacement medications, the nurse should plan to monitor TSH levels before and during therapy for effectiveness. Drug interactions may occur with several other medications, so review drug labeling information carefully before administering.

Implementation

Levothyroxine should be administered consistently every morning 30-60 minutes before a meal. For clients who are NPO, levothyroxine can also be given intravenously (IV).

Evaluation

Elevated levels of thyroid hormone can cause cardiac dysrhythmias; immediately report any symptoms of tachycardia, chest pain, or palpitations to the provider.

Thyroid and Osteoporosis Medication Classes

Thyroid Replacement Medication

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.

Indications: Levothyroxine is a thyroid replacement drug used to treat hypothyroidism. See Figure 9.22[7] for an image of levothyroxine.



Figure 9.22 Levothyroxine

7. "Levothyroxine 25mcg Tablets.jpg" by User:Ash is licensed under CC0

Nursing Considerations: Levothyroxine tablets should be taken with a full glass of water as the tablet may rapidly disintegrate. It should be administered as a single daily dose, on an empty stomach, one-half to one hour before breakfast, and at least four hours before or after drugs known to interfere with levothyroxine absorption. For clients who are NPO, levothyroxine can also be given intravenously (IV).

Levothyroxine is contraindicated for clients with hyperthyroidism and adrenal insufficiency until the condition is corrected. Many clients who undergo treatment for hyperthyroidism may develop hypothyroidism. Overtreatment with levothyroxine may cause symptoms of hyperthyroidism with increased heart rate, cardiac wall thickness, and cardiac contractility that may precipitate angina or arrhythmias, particularly in clients with cardiovascular disease and in older adults. Levothyroxine therapy in this population should be initiated at lower doses. If cardiac symptoms develop or worsen, the nurse should withhold the medication, contact the health care provider, and anticipate a lower dose prescribed or the medication to be withheld for one week and then restarted at a lower dose.

Addition of levothyroxine therapy in clients with diabetes mellitus may worsen glycemic control and result in the need for higher dosages of antidiabetic medication. Carefully monitor glycemic control, especially when thyroid therapy is started, changed, or discontinued.

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.

Levothyroxine can affect, or be affected by, several other medications, so carefully read drug label information when therapy is initiated.

Side Effects/Adverse Effects: There are risks to the mother and fetus associated with untreated hypothyroidism in pregnancy. Because TSH levels may increase during pregnancy, TSH should be monitored, and levothyroxine dosage may require adjustment during pregnancy.[8]

Health Teaching & Health Promotion: Clients should take thyroid

8. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

replacement medications at the same time each day. Clients should be aware that thyroid replacement medications do not cure hypothyroidism and therapy is lifelong. Clients should notify their health care provider if they experience signs of headache, diarrhea, sweating, 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 health care provider regarding their response to medication therapy and serum thyroid levels will be taken.[9]

Antithyroid Medication

Mechanism of Action: Propylthiouracil inhibits the synthesis of thyroid hormones.

Indications: Propylthiouracil (PTU) is an antithyroid medication used to treat hyperthyroidism or to ameliorate symptoms of hyperthyroidism in preparation for thyroidectomy or radioactive iodine therapy.

Nursing Considerations: Propylthiouracil is administered orally. The total daily dosage is usually given in three 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.

Side Effects/Adverse 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 three 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.

9. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

Propylthiouracil crosses the placenta and can cause fetal liver failure, a goiter, and cretinism if administered to a pregnant woman.

Health Teaching & Health Promotion: Clients should take the medication as directed at regular dosing intervals. They should monitor their weight 2-3 times per week. Additionally, 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

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.

Indications: Calcitonin is used to treat osteoporosis.

Nursing Considerations: Calcitonin is administered via nasal spray with one spray in one side of the nose daily. See Figure 9.23[10] 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.

Side Effects/Adverse Effects: Adverse effects include serious hypersensitivity reactions (bronchospasm, swelling of the tongue or throat, anaphylaxis and anaphylactic shock), hypocalcemia, nasal mucosa adverse events, and malignancy.

Calcitonin should not be used during pregnancy.

Health Teaching & Health Promotion: Clients should be advised to take medications as directed. They should report any signs of hypercalcemia or an allergic response. Clients should receive instruction on the process of self-injection. They should also be advised that they may experience flushing and warmth following injection. Post-menopausal women should adhere to a diet

10. "Nasal Spray" by NIAID is licensed under CC BY 2.0

high in calcium and vitamin D and should be educated regarding the importance of exercise for reversing bone loss.[11]



Figure 9.23 Administration of Calcitonin

Osteoporosis Medication: Alendronate

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.

Indications: Alendronate is used for the prevention and treatment of osteoporosis in postmenopausal women, to increase bone mass in men with osteoporosis, and for glucocorticoid-induced osteoporosis.

Nursing Considerations: Check dosages carefully because some

11. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

formulations are administered daily, whereas others are administered weekly. Alendronate should be taken after 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. 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.

Alendronate is contraindicated in the following conditions: pregnancy, hypocalcemia, the inability to sit or stand for 30 minutes after swallowing, esophageal abnormalities that delay emptying, and clients at risk for aspiration. Alendronate is not recommended for clients with kidney disease with creatinine clearance less than 35 mL/min.

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.

Side Effects/Adverse Effects: Side effects include upper GI disturbances, severe musculoskeletal pain, and risk of osteonecrosis of the jaw.

Health Teaching & Health Promotion: Clients should take medication as directed at the same time each day, first thing in the morning. 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 health care provider regarding supplementation with calcium and vitamin D. Clients should participate in regular exercise to help increase bone strength.[12]

Osteoporosis: Calcium + Vitamin D

Mechanism of Action: Calcium and vitamin D are essential nutrients that play a vital role in bone health. Calcium is necessary for the formation and

12. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

maintenance of healthy bones, while vitamin D helps the body absorb and use calcium.

Indications: Calcium and vitamin D supplements are often prescribed to prevent and treat osteoporosis, as they help maintain bone density and strength.

Nursing Considerations: The therapeutic effects of calcium and vitamin D supplements may vary depending on the individual's health status and the presence of any underlying medical conditions.

Side Effects/Adverse Effects: Side effects include hypercalcemia, kidney stones, and gastrointestinal problems such as constipation, bloating, and abdominal discomfort.

Health Teaching & Health Promotion: Clients should take with food to enhance absorption and monitor for signs of hypercalcemia such as kidney stones and gastrointestinal upset.

Now let's take a closer look at the medication grid comparing thyroid and osteoporosis medications in Table 9.5.[13] Medication grids 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. Detailed information on a specific medication can be found for free at DailyMed. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also linked to a DailyMed page.

Table 9.5 Thyroid and Osteoporosis Medications Grid

13. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effe

Thyroid Replacement	levothyroxine	Take levothyroxine sodium tablets with a full glass of water as the tablet may rapidly disintegrate Administer levothyroxine as a single daily dose, on an empty stomach, one-half to one hour before breakfast Administer levothyroxine at least four hours before or after drugs known to interfere with levothyroxine sodium tablets absorption Anticipate lower dosages in elderly clients with preexisting cardiac disease May interact with several medications, so read drug label thoroughly on initial administration	Increases T4 levels in hypothyroidism	Hypersensitivity reactions Cardiac dysrhythmias

		for potential effects		
Antithyroid	propylthiouracil (PTU)	Usually administered every eight hours May cause hypothyroidism, so TSH and T4 levels should be monitored If a client becomes pregnant, immediately notify health care provider because it can cause fetal harm	Inhibit production of T4	Hypothyroidism Liver failure Agranulocytosis Vasculitis Fetal harm
Calcium Regulator	calcitonin	Administer nasal spray with one spray in one side of the nose daily Contraindicated during pregnancy Discard unrefrigerated bottle after 30 days of opening May store unopened bottles in refrigerator until expiration date	Treats osteoporosis	Serious hypersensitivity reactions (bronchospasm, swelling of the tongue or throat, anaphylaxis, and anaphylactic shock Hypocalcemia Nasal mucosa adverse effects Malignancy

Bisphosphonates	alendronate	Administered on rising and at least one-half hour before the first food, beverage, or medication of the day with plain water only The client should sit or stand for 30 minutes after administration Contraindicated in pregnancy, hypocalcemia, and kidney disease Concurrent calcium and vitamin D supplements may be required	Enhances bone mineral density in osteoporosis	Upper GI tract adverse events Severe musculoskeletal pa Risk of osteonecrosis of th jaw
Herbal	calcium – vitamin D	Supplement should be taken with meal, as it is better absorbed with food	Improve calcium absorption and bone health	Constipation, bloating, and abdominal discomfort. High doses may lead to hypercalcemia Use with caution in clients with kidney stone, hyperparathyroidis or those with vitam D toxicity

Critical Thinking Activity 9.5

A client has been diagnosed with hypothyroidism and receives a prescription for levothyroxine.

What health teaching should the nurse provide regarding this medication?

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

9.6 Hormonal Contraceptives

This section will introduce classes of common hormonal contraceptives. Hormonal methods of contraception use hormones to prevent pregnancy. These methods work by preventing ovulation, thickening cervical mucus, and altering the lining of the uterus. Hormonal methods of birth control include combined and progestin only medication options. Contraceptive medications are available in various forms, including pills, patches, rings inserted into the vagina, injections, intrauterine devices, and implants inserted under the skin.

Combined Hormonal Contraceptives

Combined hormonal contraceptives (CHCs) are a type of birth control that contain estrogen and progestin hormones. These hormonal contraceptives are widely available in various forms such as pills, patches, vaginal rings, and injections. Ortho Tri-Cyclen is a popular prototype contraceptive.

Mechanism of Action: CHCs, such as Ortho Tri-Cyclen, prevent ovulation while thickening mucus to prevent the sperm from reaching the egg and thicken the lining of the uterus to prevent implantation of the fertilized egg.

Indications: These medications are used to prevent pregnancy.

Nursing Considerations: Clients should be monitored for adverse effects such as hypertension, thromboembolic events, and abnormal vaginal bleeding.

Side Effects/Adverse Effects: Common side effects of Ortho Tri-Cyclen include nausea, breast tenderness, and mood changes. Adverse effects include thromboembolic events, especially in clients who smoke.

Health Teaching & Health Promotion: Clients should take the medication at the same time every day. They must adhere to dosing schedule in order to ensure optimal contraceptive efficacy. Clients should be educated that although CHCs prevent pregnancy, they do not prevent sexually transmitted

diseases. Many medications also decrease effectiveness of CHCs, and clients should be instructed to use back-up contraception when on certain medications such as antibiotics.[1]

Progestin-Only Contraceptive

Progestin-only contraceptives only contain progestin rather than combined estrogen and progestin. An example of a progestin only contraceptive is norethindrone, also known as a mini-pill.

Mechanism of Action: The mini-pill works by thickening the cervical mucus, which makes it difficult for sperm to enter the uterus, and by thinning the lining of the uterus, which makes it less receptive to implantation of a fertilized egg.

Indications: This medication prevents pregnancy.

Nursing Considerations: The mini-pill is commonly prescribed for women who cannot tolerate estrogen or those who are breast feeding. It does not impact milk production.

Side Effects/Adverse Effects: Common side effects include irregular menstrual bleeding or spotting, headache, breast tenderness, nausea, weight gain, and mood changes. Adverse effects of the mini-pill include potential ectopic pregnancy, thrombosis, and liver problems.

Health Teaching & Health Promotion: It must be taken at the same time each day, without interruption. It may not be as effective as combined hormonal contraceptives due to the challenges many clients have with taking the medication at the same time every day.[2]

Now let's take a closer look at the contraceptive medication grid in Table 9.6.[3]

Table 9.6 Contraceptive Medication Grid

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3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Combined Hormonal Contraceptives	Ortho Tri-Cyclen	Clients should take the medication at the same time every day. They must adhere to dosing schedule in order to ensure optimal contraceptive efficacy. Clients should be educated that although CHCs prevent pregnancy, they do not prevent sexually transmitted diseases Many medications also decrease effectiveness of CHCs, and clients should be instructed to use back-up contraception when on certain medications such as antibiotics	Prevents pregnancy	Nausea, breast tenderness, and mood changes Thromboembolic events, especially in clients who smoke

Progestin Only Contraceptives	norethindrone (mini-pill)	It may not be as effective as combined hormonal contraceptives due to the challenges many clients have in taking the medication at the same time every day It does not impact milk production	Prevents pregnancy	Irregular menstrual bleeding or spotting, headache, breast tenderness, nausea, weight gain, and mood changes Potential ectopic pregnancy, thrombosis, and liver problems

9.7 Learning Activities

Exercises

Case Study 1

Ms. J.S. is a 45-year-old woman who was admitted to the hospital with a diagnosis of severe asthma exacerbation. She has a history of asthma and has been using her inhaler more frequently in the past week due to worsening symptoms. Upon admission, she was started on prednisone therapy.

1. What is prednisone, and how does it work?
2. What are the potential side effects of prednisone therapy?
3. How should prednisone therapy be administered?
4. What monitoring should be done during prednisone therapy?
5. What health teaching should be provided regarding prednisone therapy?

Case Study 2

Mr. D.K. is a 65-year-old male who has a long-standing history of type 2 diabetes mellitus. He is currently being managed with both metformin and insulin therapy. He presents to the clinic for a routine follow-up appointment.

1. What is the role of metformin in diabetes management?
2. What is the role of insulin in diabetes management?

3. What are the potential side effects of metformin and insulin therapy?
4. How should Mr. D.K. be monitored while taking both metformin and insulin therapy?
5. What health teaching should be provided regarding these medications?

Note: Answers to the Case Studies can be found in the "Answer Key" sections 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://wtcs.pressbooks.pub/pharmacology2e/?p=402#h5p-33

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An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wtcs.pressbooks.pub/pharmacology2e/?p=402#h5p-34

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- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Endocrine Assignment 1.[1]



- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Endocrine Assignment 2.[2]



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2. "Endocrine Assignment 2" by Open RN is licensed under CC BY 4.0

IX. Glossary

A1C: A lab test used to assess long-term blood glucose levels over three months. The general A1C target level is less than 7%.

Adrenal cortex: A component of the hypothalamic-pituitary-adrenal (HPA) axis that produces the steroid hormones important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation.

Adrenal medulla: Neuroendocrine tissue composed of postganglionic sympathetic nervous system (SNS) neurons that are stimulated by the autonomic nervous system to secrete hormones epinephrine and norepinephrine.

Aldosterone: A mineralocorticoid released by the adrenal cortex that controls fluid and electrolyte balance through the regulation of sodium and potassium.

Antidiuretic hormone (ADH): ADH is released by the posterior pituitary in response to stimuli from osmoreceptors indicating high blood osmolarity. Its effect is to cause increased water reabsorption by the kidneys. As more water is reabsorbed by the kidneys, the greater the amount of water that is returned to the blood, thus causing a decrease in blood osmolarity. ADH is also known as vasopressin because, in very high concentrations, it causes constriction of blood vessels, which increases blood pressure by increasing peripheral resistance.

Basal insulin: Long-acting (insulin glargine or insulin detemir) or intermediate-acting (NPH) insulin.

Basal metabolic rate: The amount of energy used by the body at rest.

Blood osmolarity: The concentration of solutes (such as sodium and glucose) in the blood.

Diabetes insipidus (DI): A disease characterized by underproduction of ADH that causes chronic dehydration.

Endocrine gland: Gland that secretes hormones that target other organs.

Exocrine gland: Gland that secretes digestive enzymes.

General adaptation syndrome (GAS): The pattern in which the body responds in different ways to stress: the alarm reaction (otherwise known as the fight-or-flight response), the stage of resistance, and the stage of exhaustion.

Glycolysis: Stimulated by insulin, the metabolism of glucose for generation of ATP.

Goiter: A visible enlargement of the thyroid gland when there is hyperstimulation of TSH due to deficient levels of T3 and T4 hormones in the bloodstream or an autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland, causing hyperthyroidism.

Hormones: Chemical signals sent by the endocrine organs and transported via the bloodstream throughout the body where they bind to receptors on target cells and induce a characteristic response.

Humoral stimuli: Changes in blood levels of nonhormone chemicals that cause an endocrine gland to release or inhibit a hormone to maintain homeostasis. For example, high blood sugar causes the pancreas to release insulin.

Hyperglycemia: Elevated blood glucose levels.

Hyperparathyroidism: A disorder caused by an overproduction of PTH that results in excessive calcium resorption from bone, causing significantly decreased bone density and spontaneous fractures, decreased responsiveness of the nervous system, and calcium deposits in the body's tissues and organs, impairing their functioning.

Hyperthyroidism: Abnormally elevated blood level of thyroid hormones T3 and T4, often caused by a pituitary tumor, thyroid tumor, or autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland.

Hypoglycemia: A blood glucose level below 70 mg/dL; severe hypoglycemia refers to a blood glucose level below 40.

Hypoparathyroidism: Abnormally low blood calcium levels caused by parathyroid hormone deficiency, which may develop following thyroid surgery. Low blood calcium can cause muscle twitching, cramping, spasms, or convulsions; severe deficits can paralyze muscles, including those involved in breathing, and can be fatal.

Hypothalamic-pituitary-adrenal (HPA) axis: The hypothalamus stimulates the release of ACTH from the pituitary, which then stimulates the adrenal cortex to produce the hormone cortisol and steroid hormones important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation.

Hypothalamus–pituitary complex: The "command center" of the endocrine system that 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.

Hypothyroidism: Abnormally low blood levels of thyroid hormones T3 and T4 in the bloodstream.

Insulin: A hormone that facilitates the uptake of glucose into skeletal and adipose body cells.

Mineralocorticoids: Hormones released by the adrenal cortex that regulate body minerals, especially sodium and potassium, that are essential for fluid and electrolyte balance. Aldosterone is the major mineralocorticoid.

Negative feedback loop: Characterized by the inhibition of further secretion of a hormone in response to adequate levels of that hormone.

Neural stimuli: Released in response to stimuli from the nervous system. For example, the activation of the release of epinephrine and norepinephrine in the fight-or-flight response is stimulated by the sympathetic nervous system.

Osmoreceptors: Specialized cells within the hypothalamus that are sensitive to the concentration of sodium ions and other solutes in the bloodstream.

Parathyroid hormone (PTH): The hormone released by parathyroid glands and is involved in the regulation of blood calcium levels.

Prandial insulins: During or relating to the eating of food.

Tropic hormones: Hormones that turn on or off the function of other endocrine glands, including ACTH, FSH, LH, and TSH.

Type 1 diabetes: An autoimmune disease that affects the beta cells of the pancreas so they do not produce insulin; thus, synthetic insulin must be administered by injection or infusion.

Type 2 diabetes: A condition where the body's cells become resistant to the effects of insulin. Over time, the beta cells become exhausted and if blood glucose levels cannot be controlled through a healthy diet and exercise, then oral diabetic medication must be implemented and eventually insulin administration may be required.

PART X

ANALGESICS & MUSCULOSKELETAL SYSTEM

10.1 Analgesics and Musculoskeletal Introduction

Learning Objectives

- Identify the classifications and actions of analgesics
- Identify the classifications and actions of musculoskeletal system drugs
- Give examples of when, how, and to whom analgesics and musculoskeletal system drugs may be administered
- Identify the side effects and special considerations associated with administering analgesics
- Identify the side effects and special considerations associated with administering musculoskeletal system drugs
- Identify the considerations and implications of using analgesics across the life span
- Identify the considerations and implications of using musculoskeletal system medications across the life span
- Apply evidence-based concepts when using the nursing process
- Identify nursing responsibilities related to health teaching and health promotion

Complaints of pain are one of the most common reasons individuals seek 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 management are a part of nurses' daily work. It is essential for nurses to understand the physiology of pain and the pharmacological and nonpharmacological treatment methods available to effectively manage pain.

10.2 Basic Concepts of Analgesics and the Musculoskeletal System

Before we discuss medications used to treat pain and musculoskeletal conditions, let's review the physiology of pain, as well as the anatomy and physiology of the musculoskeletal system.

Review of the Physiology of Pain

Knowledge about the transmission and the processing of pain has greatly expanded in recent years due to a multidisciplinary approach. Although pain is considered something to be avoided, pain impulses are necessary for maintaining the integrity of our bodies and survival. Interactions between the nervous and immune systems are closely linked through cellular interactions in processing and transmitting pain sensation. However, prolonged or chronic pain can cause secondary symptoms, such as anxiety and depression, and can decrease an individual's overall quality of life.[1]

The transmission of pain is linked to **nociceptors**, specialized sensory neurons in the central nervous system (CNS) that respond to painful stimuli. Nociceptors respond to harmful or potential tissue-damaging stimuli and transmit stimuli from the skin, muscles, joints, and viscera. The most nociceptor-rich tissue is the skin, which contains several different types of nociceptors. Nociceptors are further divided according to the type of stimuli they respond to (e.g., mechanical, chemical, thermal, or noxious stimuli).[2]

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Nociceptor activation is determined by the pain stimulus and depends on the site of generation and mode of activation. The site of the stimulus is important because it can influence the intensity of the nociceptor response. An interesting example is corneal nociceptors, which are activated by weaker stimuli than skin nociceptors. The nature of the stimulus is also important. Stimuli brought about by cutting or crushing, for example, activate most skin nociceptors but do not activate nociceptor in the joints, muscles, or viscera, which instead quickly respond to other types of mechanical forces, such as rotation and distention. In addition to cutting and crushing injuries, harmful stimuli that are able to activate nociceptors in the skin also include chemical, thermal, and mechanical damage.[3]

A property of nociceptors is their ability to cause sensitization, a process that reduces the threshold of activation and an increased response rate to stimulation. Sensitization typically results from tissue injury and inflammation and can result in chronic pain.[4]

The pain sensation, transmitted by neurons in the central nervous system, is influenced by the immune system through the release of molecular mediators. These substances activate pain receptors, increase the sensitivity of pain receptors, and stimulate the release of inflammatory substances called **prostaglandins**.[5]

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 (A-delta and C fibers). 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

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perceived.[6] See Figure 10.1[7] for an illustration of how the pain signal is transmitted from peripheral tissues to the spinal cord and then to the brain.

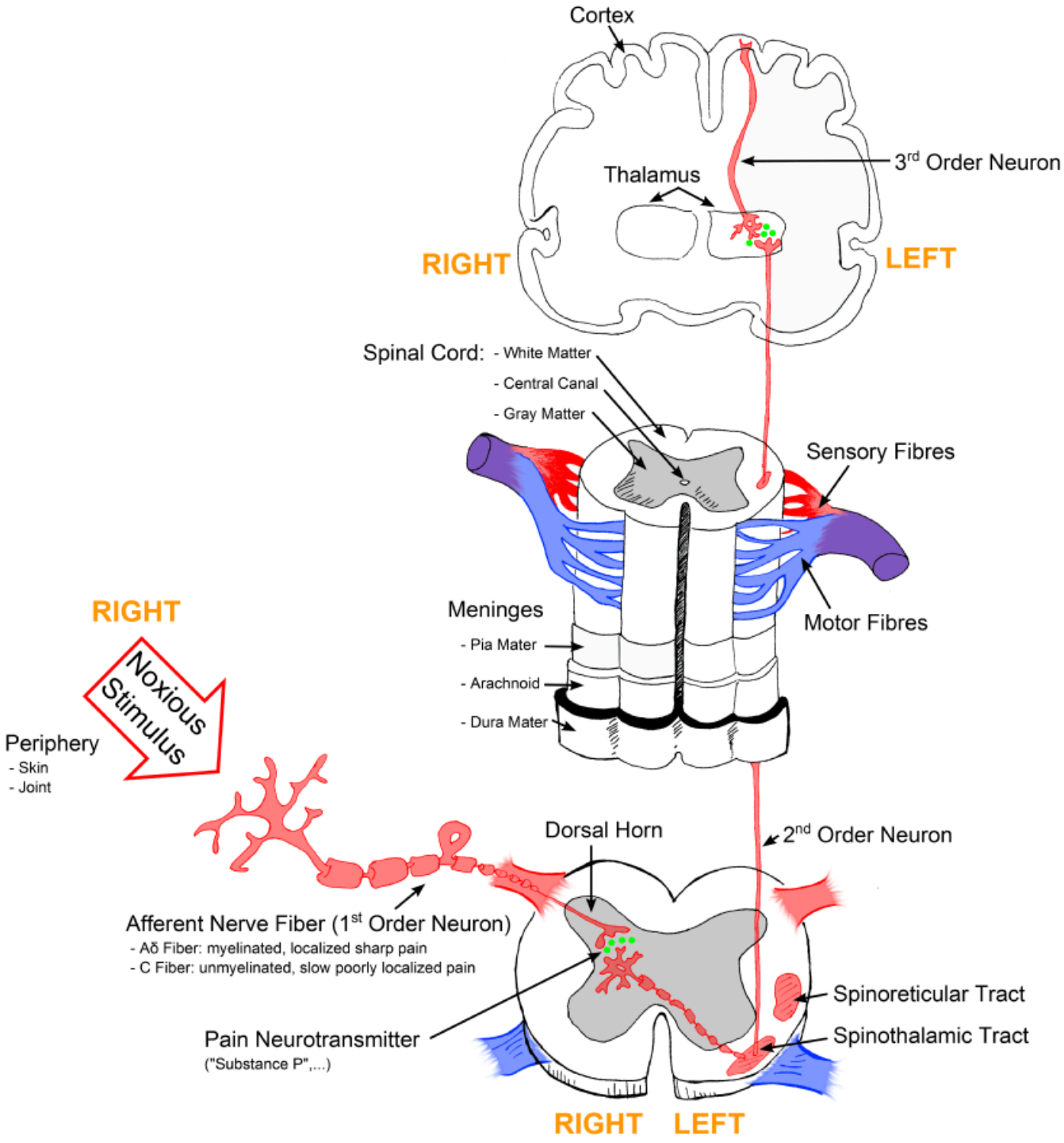


Figure 10.1 Transmission of Pain from Peripheral Tissues to the Brain

6. . Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pp. 305, 310, 952-953, 959-960. Wolters Kluwer.
7. "Sketch colored final.png" by Bettina Guebeli is licensed under CC BY-SA 4.0

Endogenous Pain Relief

The CNS has an endogenous (i.e., internal) system for relieving pain. The CNS can suppress pain signals from the peripheral nerves by using endogenous opioid peptides that interact with opioid receptors to inhibit perception and transmission of pain signals. These endogenous opioid peptides are endorphins, enkephalins, and dynorphins.[8]

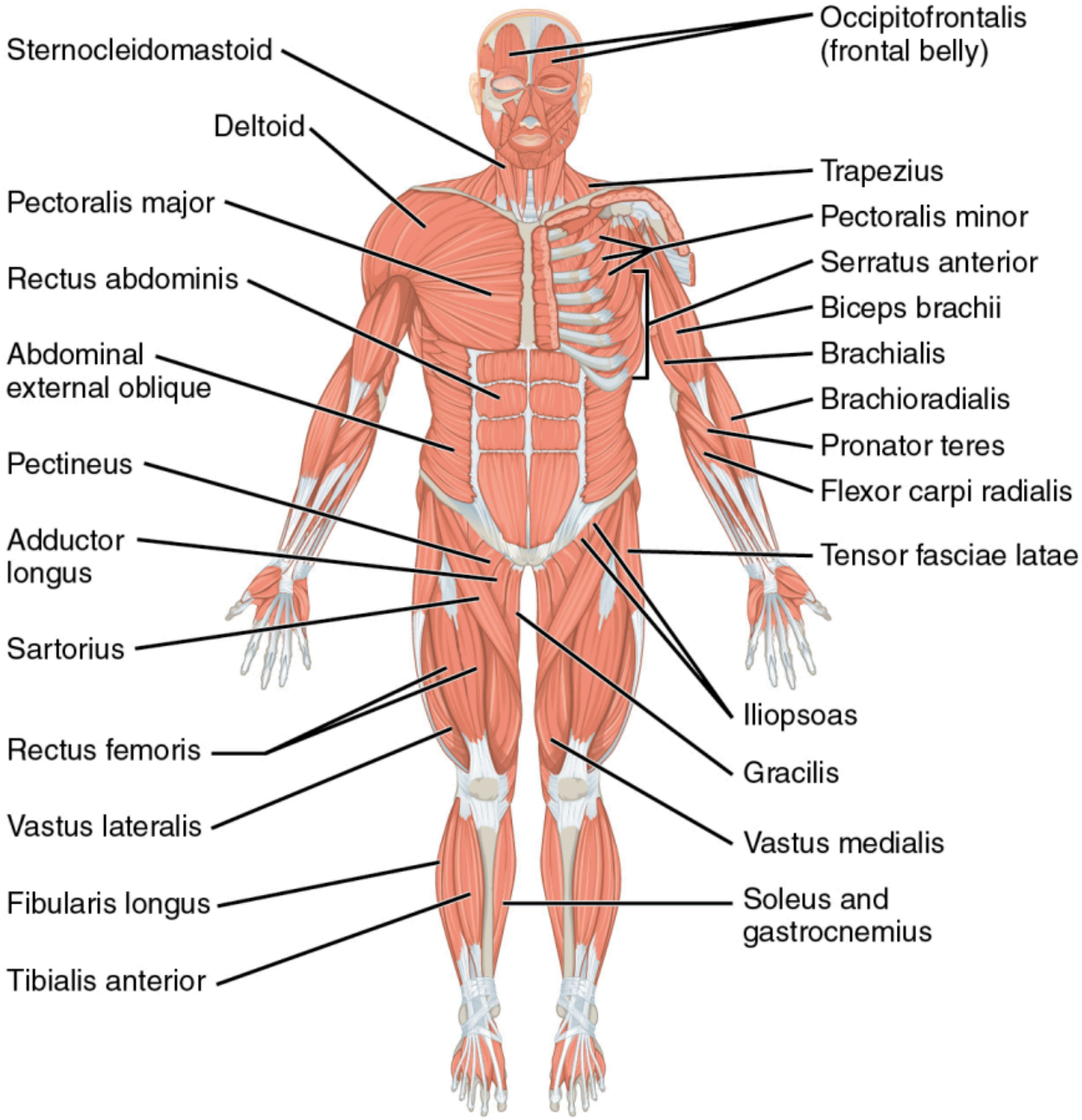
Visit the YouTube video below for more information about how pain relievers work.

How Do Pain Relievers Work? by George Zaidan[9]

Review of Anatomy and Physiology of the Musculoskeletal System

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.[10] See Figure 10.2[11] for an illustration of the musculoskeletal system.

8. . Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pp. 305, 310, 952-953, 959-960. Wolters Kluwer.
9. Ted-Ed. (2012, June 26). *How do pain relievers work? - George Zaidan* [Video]. YouTube. All rights reserved. https://youtu.be/9mcuIc5O-DE
10. Khan Academy. (n.d.). *The musculoskeletal system review.* https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-musculoskeletal-system/a/hs-the-musculoskeletal-system-review
11. This image is a derivative of "1105 Anterior and Posterior Views of Muscles.jpg" by CFCF licensed under CC BY 4.0



Major muscles of the body. Right side: superficial; left side: deep (anterior view)

Figure 10.2 Musculoskeletal System

Muscles

The body contains three types of muscle tissue: skeletal muscle, smooth

muscle, and cardiac muscle. See Figure 10.3[12] for images of different types of muscle.

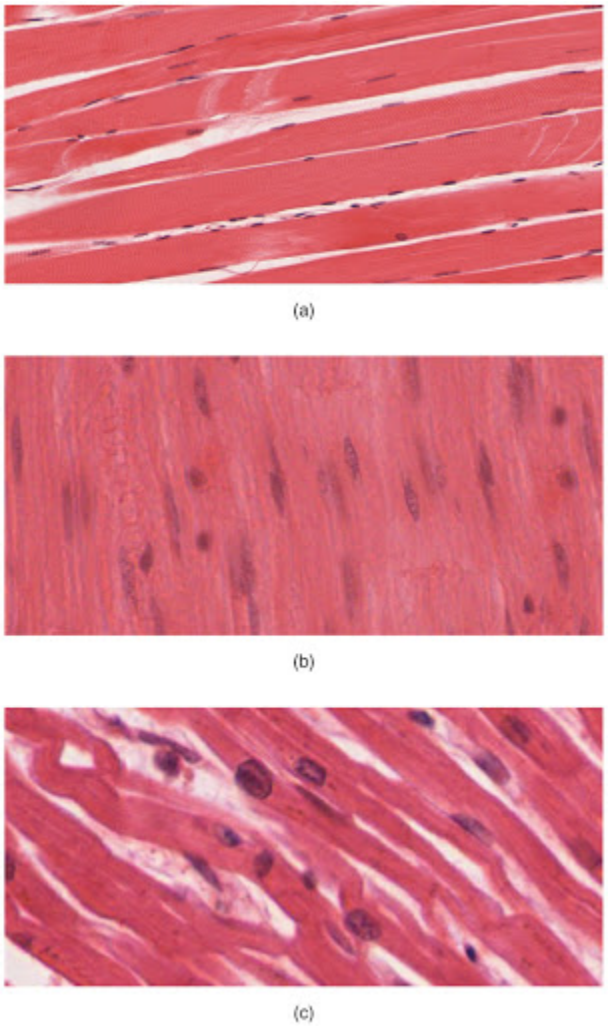


Figure 10.3 (a) Skeletal muscle; (b) Smooth muscle; (c) Cardiac muscle

Skeletal muscle is voluntary and striated. These are the muscles that attach to bones and control conscious movement. Smooth muscle is involuntary and nonstriated. It is found in the hollow organs of the body, such as the stomach, intestines, and around blood vessels. Cardiac muscle is involuntary and

12. "414 Skeletal Smooth Cardiac.jpg" by OpenStax College is licensed under CC BY 4.0

striated. It is found only in the heart and is specialized to help pump blood throughout the body.[13]

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.[14]

13. Khan Academy. (n.d.). *The musculoskeletal system review.* https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-musculoskeletal-system/a/hs-the-musculoskeletal-system-review
14. Khan Academy. (n.d.). *The musculoskeletal system review.* https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-musculoskeletal-system/a/hs-the-musculoskeletal-system-review

10.3 Acute Pain, Chronic Pain, and Musculoskeletal Disorders

Acute pain, chronic pain, and common musculoskeletal disorders are reviewed in this section.

Acute Pain

Acute pain usually comes on suddenly and is caused by something specific like an injury or surgery. It lasts less than three months and usually goes away when there is no longer an underlying cause for the pain. Examples of acute pain include the following[1]:

- Surgery
- Broken bones
- Dental work
- Burns or cuts
- Labor and childbirth

Chronic Pain

Chronic pain is pain that is ongoing and usually lasts longer than six 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 many conditions, including these conditions:

1. Cleveland Clinic. (2020). *Acute vs. chronic pain*. https://my.clevelandclinic.org/health/articles/12051-acute-vs-chronic-pain

- Headache
- Arthritis
- Cancer
- Nerve pain
- Back pain
- Fibromyalgia pain

People who have chronic pain can have 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.[2]

Fibromyalgia

Fibromyalgia is a condition that causes pain all over the body (also referred to as 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.[3]

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

2. Cleveland Clinic. (2017, January 26). *Acute vs. chronic pain.* https://my.clevelandclinic.org/health/articles/12051-acute-vs-chronic-pain
3. Centers for Disease Control and Prevention. (2017, October 11). *Arthritis, Fibromyalgia.* https://www.cdc.gov/arthritis/basics/fibromyalgia.htm

Other symptoms may present, including these symptoms:

- 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)

These are the known risk factors:

- 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 onset of fibromyalgia are as follows:

- 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.[4]

4. Centers for Disease Control and Prevention. (2017, October 11). *Arthritis, Fibromyalgia*. https://www.cdc.gov/arthritis/basics/fibromyalgia.htm

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.[5]

Symptoms in the affected joint(s) may include the following:

- Pain, usually intense
- Swelling
- Redness
- Heat

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.

The following make it more likely that you will develop hyperuricemia, which causes gout:

- Being male
- Being obese

5. Centers for Disease Control and Prevention. (2019, January 28). *Arthritis, Gout*. https://www.cdc.gov/arthritis/basics/gout.html

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

Additional 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

A medical doctor diagnoses gout by assessing your symptoms and the results of your physical examination, X-rays, and lab tests. Gout can be diagnosed only during a flare when a joint is hot, swollen, and painful and when a lab test finds uric acid crystals in the affected joint.[6]

Muscle Spasm

Spasms of skeletal muscles are most common and are often due to overuse and muscle fatigue, dehydration, and electrolyte abnormalities. The spasm occurs abruptly, is painful, and is usually short-lived. It may be relieved by gently stretching the muscle.[7] Diseases such as multiple sclerosis can also cause chronic muscle spasms.

6. Centers for Disease Control and Prevention. (2019, January 28). *Arthritis, Gout.* https://www.cdc.gov/arthritis/basics/gout.html
7. Wedro, B. (2019, July 18). *Muscle spasms.* https://www.medicinenet.com/muscle_spasms/article.htm

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.

These are some symptoms of MS:

- 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.[8]

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 jaw and problems chewing, swallowing, and holding up the head. MG is treatable with drugs that suppress the immune system or boost the signals between nerves and muscles.[9] The group of drugs used to control MG is called acetylcholinesterase (ACh) 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 parasympathomimetic. Pyridostigmine is an example of an ACh inhibitor.

Overdosing with ACh inhibitors can cause a complication called cholinergic crisis, which is an acute exacerbation of symptoms. A cholinergic crisis usually occurs 30-60 minutes after taking cholinergic medication with severe muscle weakness that can lead to respiratory paralysis and death.[10]

8. National Multiple Sclerosis Society. (2018, March 8). *What is MS?* [Video]. YouTube. All rights reserved. https://youtu.be/geQP_zYS-6s
9. Muscular Dystrophy Association. (n.d.). *Myasthenia gravis*. https://www.mda.org/disease/myasthenia-gravis
10. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 268-270, 324, 332. Elsevier.

10.4 Applying the Nursing Process to Pain Management

Now that we have reviewed basic concepts related to pain and several disorders requiring analgesic or musculoskeletal medication, let's consider the nursing process and how it applies to administering these medications.

Assessment

Asking a patient to rate the severity of their pain on a scale from 0 to 10, with "0" being no pain and "10" being the worst pain imaginable is a common question used to screen patients for pain. However, according to The Joint Commission requirements, this question can be used to initially screen a patient for pain, but a comprehensive pain assessment is required for adequate pain management.

Nurses perform comprehensive pain assessments before and after administering analgesics. Many mnemonics are used to guide comprehensive pain assessment. See Figure 10.4[1] for common nursing mnemonics for comprehensive pain assessment.

1. "Mnemonics for Pain Assessment" by Julie Teeter is licensed under CC BY-SA 4.0

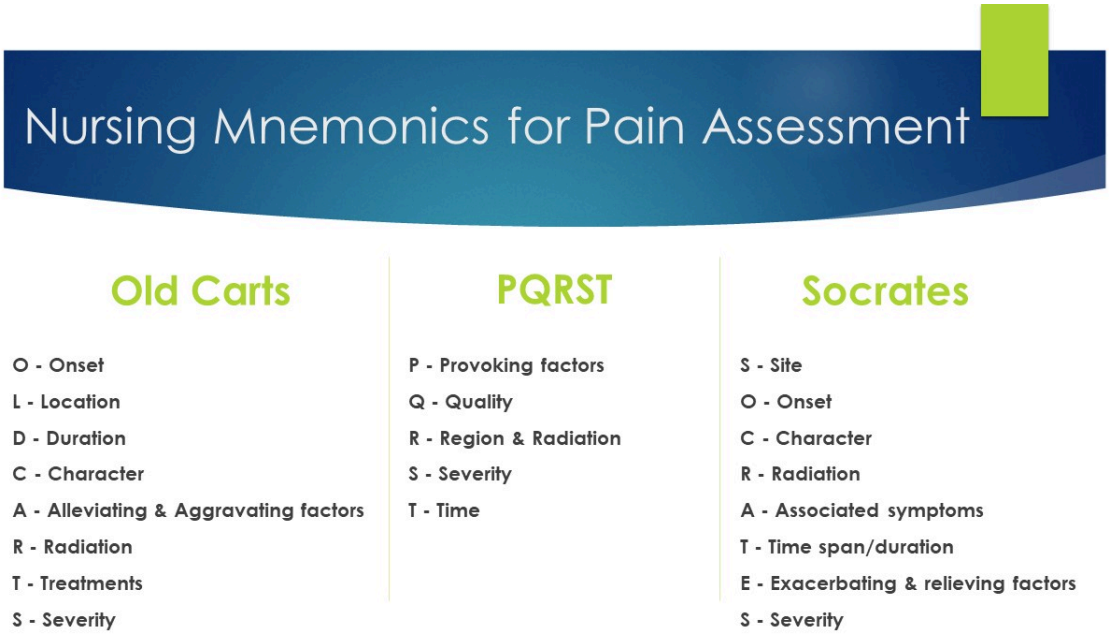


Figure 10.4 Mnemonics for Pain Assessment

To adequately manage a client's pain, it is important to also assess potential barriers that may contribute to inaccurate reports of the severity pain by individuals. Optimal pain management can be achieved by gathering subjective and objective data to accurately measure the severity of an individual's pain. A person's health can be negatively impacted if they under-rate or over-rate their pain level. Under-rated severe pain can interfere with an individual's ability to complete activities of daily life and can contribute to anorexia, insomnia, and feelings of depression and anxiety. Additionally, some clients are not able to adequately communicate their pain. For example, for older adults with cognitive impairment, caregivers play an important role in documenting and communicating pain assessments to nurses and health care providers to ensure adequate treatment of pain.[2,3]

2. Boring, B. L., Walsh, K. T., Nanavaty, N., Ng, B. W., & Mathur, V. A. (2021). How and why patient concerns influence pain reporting: A qualitative analysis of personal accounts and perceptions of others' use of numerical pain scales. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.663890
3. Horgas, A. L., Bruckenthal, P., Chen, S., Herr, K. A., Young, H. M., & Fishman, S. (2022). Assessing pain in older adults. *American Journal of Nursing 122(12)*, 42-48. https://doi.org/10.1097/01.NAJ.0000904092.01070.20

Visual Pain Rating Scales

Visual pain scales are commonly used as tools for assessing pain, especially with children and adults who have difficulty using the numerical pain rating scale. See Figure 10.5[4] for the FACES Pain Rating Scale. To apply this scale, use the following evidence-based instructions. Explain to the client that each face represents a person who has no pain (hurt), some, or a lot of pain. "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." Ask the person to choose the face that best represents the pain they are feeling.



Figure 10.5 Wong-Baker FACES Pain Rating Scale. Used with permission from http://www.WongBakerFACES.org.

Additional baseline information to collect prior to administration of analgesic or musculoskeletal medication includes obtaining a history of allergies or previous adverse response to medications. Additionally, nurses

4. Wong-Baker FACES Foundation. (2020). *Wong-Baker FACES® pain rating scale*. Retrieved [2020] with permission from http://www.WongBakerFACES.org

ask clients to describe their preferred acceptable pain level while also considering the potential side effects of analgesics.

> Read additional information about pain assessment and pain scales in the "Comfort" chapter of Open RN *Nursing Fundamentals*.

Implementation

As with all medications, nurses check the rights of medication administration and 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.

When administering opioids, the nurse considers if the prescribed medication is appropriate for the client's current level of pain. If there are concerns about appropriateness of the medication based on the client's current status, the prescribing provider should be notified. See Table 10.4 for a list of common opioid medications used to treat moderate to severe pain.[5] Notice that many opioids are combined with acetaminophen, so the maximum daily dosage of acetaminophen must be monitored.

Table 10.4 Common Opioid Analgesics Used to Treat Mild to Severe Pain

5. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Generic Name	Brand Name(s)	Pain Level	Route	Adult Dosage
Codeine/Acetaminophen	Tylenol #3	Mild	PO	30 mg/ 300 mg
Fentanyl	Duragesic Sublimaze	Severe	Transdermal IM IV	12 mcg-100 mcg/hr 0.5-1 mcg/ kg 0.5-1 mcg/kg
Hydrocodone/ Acetaminophen	Lortab Norco Vicodin	Moderate	PO PO PO	5 mg/300 mg or 325 mg 10 mg/320 mg or 325 mg
Hydromorphone	Dilaudid	Severe	PO Rectal SubQ, IM, & IV	4-8 mg 3 mg 1.5 mg (may be increased)
Morphine	Duramorph, MS Contin, Oramorph SR, & Roxanol-T	Severe	PO & Rectal SubQ, IM, & IV	30 mg (may be increased) 4-10 mg (may be increased)

Oxycodone **Oxycodone/Acetaminophen**	Oxy IR, Oxycontin, & Oxy-FAST Percocet & Roxicet	Severe	PO PO	5 mg-10 mg (may be increased) 5 mg/325 mg

WHO Ladder

A general rule of thumb when administering analgesics is pain control should be based on the pain level reported by the client and the least invasive medication with the least side effects should be used to treat that level of pain. The WHO ladder was originally developed for selection of analgesics for clients with cancer. It illustrates the concept that pain control should be based on the level indicated by the client. See Figure 10.6[6] for an image of the original WHO ladder.

6. World Health Organization. (1996). *Cancer pain relief* (2nd ed.). Geneva.

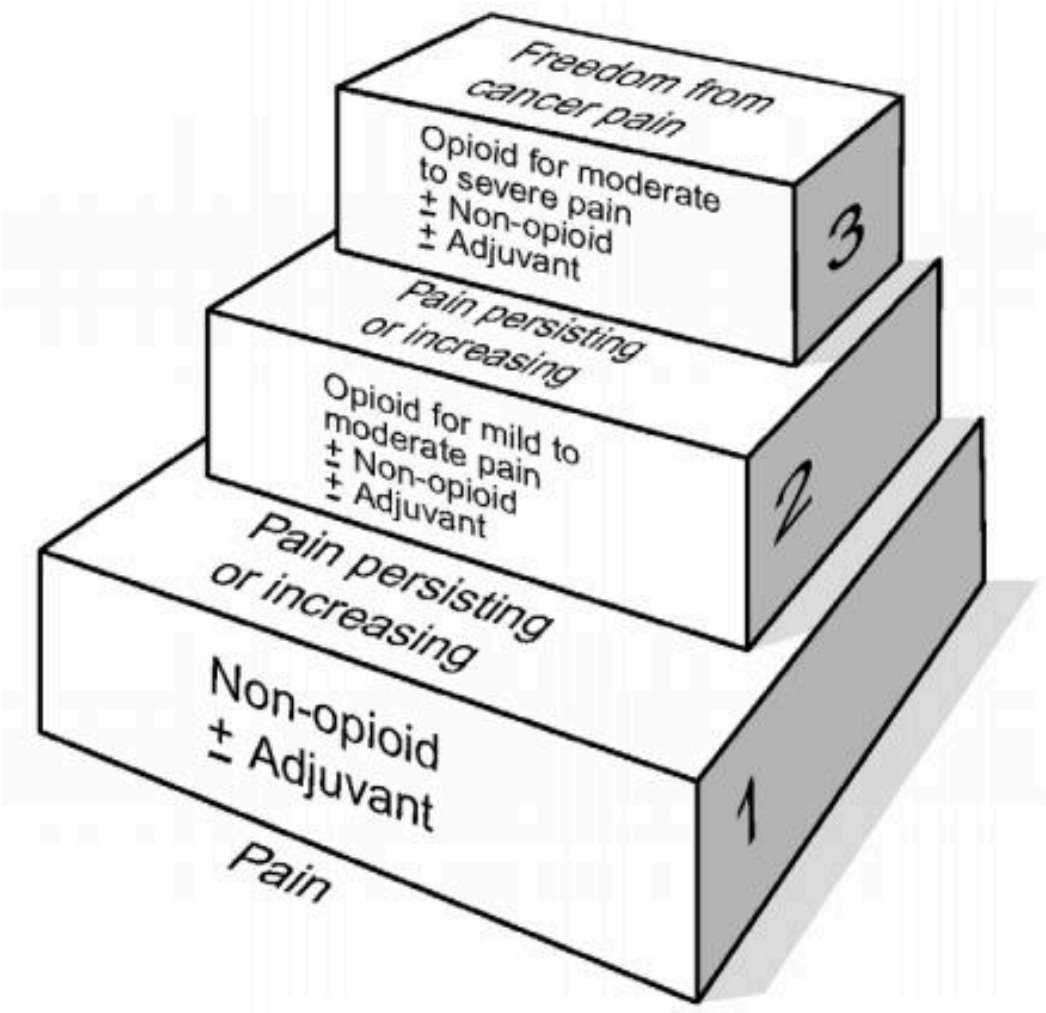


Figure 10.6 WHO Pain Ladder. This diagram below shows the stepwise approach to cancer pain management recommended by the World Health Organization (WHO)

The original WHO ladder consisted of three steps[7]:

- First Step – Mild pain: Non-opioid analgesics such as nonsteroidal anti-inflammatory drugs (NSAIDs) or acetaminophen are administered with or without adjuvants
- Second Step – Moderate pain: Weak opioids (hydrocodone, codeine,

7. Anekar, A.A., Hendrix, J.M., & Cascella, M. (2023). WHO Analgesic Ladder. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK554435/

tramadol) with or without non-opioid analgesics are administered with or without adjuvants
- Third Step – Severe and/or persistent pain: Potent opioids (morphine, methadone, fentanyl, oxycodone, buprenorphine, hydromorphone, oxymorphone) are administered with or without non-opioid analgesics, and with or without adjuvants

Adjuvant refers to medications typically used for indications other than pain but can be help in various painful conditions. Adjuvants include antidepressants (including tricyclic antidepressants [TCAs]), serotonin-norepinephrine reuptake inhibitors (SNRIs), anticonvulsants such as gabapentin and pregabalin, topical anesthetics such as a lidocaine patch), topical therapies such as capsaicin, corticosteroids, bisphosphonates, and cannabinoids.[8]

The fundamental concept of the WHO ladder is that it is essential to thoroughly assess pain in each individual and then manage that pain by using appropriate medications. For clients receiving opioids, the optimum dosage for pain relief must be balanced with the side effects of the drug. Additionally, clients should receive health teaching about the uses and side effects of pain medications to avoid misuse without compromising their benefits.[9]

The WHO ladder has undergone several modifications over the years and is currently used to manage other types of acute and chronic pain. A limitation of the original scale was the absence of nonpharmacological treatments in the pain management path. Consequently, a fourth step was added to the ladder. This fourth step includes numerous nonpharmacological procedures used for treating persistent pain, such as epidural analgesia, intrathecal administration of analgesic and local anesthetic drugs, neurosurgical procedures, and nerve blocks.[10]

8. Anekar, A.A., Hendrix, J.M., & Cascella, M. (2023). WHO Analgesic Ladder. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK554435/
9. Anekar, A.A., Hendrix, J.M., & Cascella, M. (2023). WHO Analgesic Ladder. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK554435/
10. Anekar, A.A., Hendrix, J.M., & Cascella, M. (2023). WHO Analgesic Ladder. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK554435/

The updated WHO analgesic ladder focuses on the quality of life and extends the strategy to treat pain. For acute pain, the strongest analgesic (indicated for the reported severity of pain) is the initial therapy and later toned down, whereas, for chronic pain, a stepwise approach from bottom to top may be employed.[11]

For example, if a client reports acute pain rated as "2," then it is appropriate to start at the lowest rung of the ladder and administer a prescribed NSAID. However, it may be clinically indicated to start at "Level 3" on the WHO ladder for clients who present with severe, acute pain and administer a potent opioid like morphine.

Managing Side Effects

In addition to administering analgesics, nurses anticipate side effects/adverse effects and plan appropriate monitoring, as well as administering additional medication if needed. For example, an adverse effect of opioid analgesics is respiratory depression. After administering an opioid medication, the nurse plans to monitor the client's respiratory rate and pulse oximetry level. Other common side effects of opioids include constipation or nausea, so the nurse anticipates administering medications such as stool softeners or antiemetics.

Health Teaching and Health Promotion

Nurses teach clients, their family members, and caregivers about appropriate pain management, pain medications, and symptoms to report that may indicate side effects/adverse effects. In addition to medication teaching, nurses also provide information about nonpharmacological therapy, including physical treatments (e.g., heat or cold therapy, exercise therapy, weight loss) and cognitive-behavioral treatments (e.g., distraction/diversion and cognitive behavioral therapy).

Controlled substances like opioids also have special regulations regarding

11. Anekar, A.A., Hendrix, J.M., & Cascella, M. (2023). WHO Analgesic Ladder. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK554435/

storage, auditing counts, and disposal or wasting of medication. See more information about controlled substances in the "Legal/Ethical" chapter. If a nurse has a concern that a client or one of their family members is misusing controlled substances, the provider should be notified. **Misuse** refers to using illegal drugs and/or prescription drugs in a manner other than directed by the provider, such as using in greater amounts, more often, or longer than prescribed, or using someone else's prescription.

Evaluation

Nurses evaluate and document the client's response to the administered analgesics based on the medication's onset and peak. With analgesic medications, the nurse typically evaluates the client for a decreased level of pain 30 minutes after IV administration and 60 minutes after oral medication. If the client's pain level is not acceptable at that time, the nurse investigates alternate pharmacological and nonpharmacological treatments, such as aromatherapy, repositioning, hot or cold treatments, and listening to music.

Because the nurse is the client's advocate, the health care provider should be notified if the client's pain is not being adequately managed by the prescribed analgesics.

10.5 Analgesic and Musculoskeletal Medications

Analgesics used to treat pain are categorized as nonopioid, opioid, and adjuvant medications. Nonopioid medications include acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDs). There are several types of opioids, as listed in Table 10.4 in the previous "Applying the Nursing Process to Pain Management" section.

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.[1] Each of these classes will be discussed in more detail, along with antigout medications and a brief overview of anesthetic medication.

Analgesic and Musculoskeletal Medication Classifications

Let's take a closer look at different classes of analgesics and musculoskeletal medications with specific administration considerations, therapeutic effects, side effects/adverse effects, and health teaching needed for each class of medications. Keep in mind that analgesic and musculoskeletal medications are available in many different forms, such as oral tablets, oral liquids, injections, inhalation, and transdermal patches. Some products contain more than one medication (for example, oxycodone and acetaminophen) to synergistically enhance pain relief.

1. Lussier, D., Huskey, A., & Portenoy, R. (2004). Adjuvant analgesics in cancer pain management. *Oncologist, 9*(5), 571-91. https://www.ncbi.nlm.nih.gov/pubmed/15477643

10.6 Nonopioid Analgesics

Nonopioid analgesics include acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDS).

Acetaminophen

Mechanism of Action: Acetaminophen inhibits the synthesis of prostaglandins that may serve as mediators of pain and fever primarily in the CNS.[1]

Indications: Acetaminophen is used to treat mild pain and fever; however, it does not have anti-inflammatory properties.

Nursing Considerations: Acetaminophen is safe for all ages and can be administered using various routes.

Geriatric populations should not exceed 3,000 mg in 24 hours, and chronic alcoholics should not exceed 2,000 mg in 24 hours due to the risk for hepatoxicity.

Side Effects/Adverse Effects: Adverse effects include skin reddening, blisters, rash, and hepatotoxicity.

Severe liver damage may occur if a client does the following:

- Takes more than 4,000 mg of acetaminophen in 24 hours (3,200 mg for geriatric adults, 2,000 mg for chronic alcoholics)
- Takes with other drugs containing acetaminophen
- Consumes three or more alcoholic drinks every day while using this product[2]

Some medications are combined with acetaminophen and are prescribed “as needed,” so the nurse must calculate the cumulative dose of acetaminophen

1. Frandsen, G., & Pennington S. (2018). *Abrams’ clinical drug: Rationales for nursing practice* (11th ed.). pp. 305, 310, 952-953, 959-960. Wolters Kluwer.
2. Vallerand, A., & Sanoski, C. A. (2019). *Davis’s drug guide for nurses* (16th ed.). F. A. Davis Company.

over the previous 24-hour period. For example, 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 two tablets are truly administered every 4 hours over a 24-hour period, this would add up to 3,900 mg of acetaminophen, which would exceed the recommended guidelines for a geriatric client and could cause liver damage.

If overdose occurs, the antidote is acetylcysteine.

Health Teaching & Health Promotion: Medications should be taken as directed and the dosing schedule should be adhered to appropriately. Clients should not take the medication for greater than ten days. Additionally, clients should avoid taking alcohol while using these medications. If a rash occurs, this should be reported to the health care provider, and the medication should be promptly stopped. Use of medications may interfere with blood glucose monitoring. If a fever lasts longer than three days or exceeds 39.5° C, this should be reported to the health care provider.[3]

Now let's take a closer look at the medication grid on acetaminophen in Table 10.6a.[4]

Medication grids 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 medications. Basic information related to each class of medication is outlined below. Detailed information on a specific medication can be found for free at DailyMed. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also linked to a DailyMed page.

Table 10.6a Acetaminophen Medication Grid

3. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
4. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/ Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Nonopioid Analgesic Antipyretic	acetaminophen	Can be given orally, rectally, and IV Assess pain prior to and after administration Administer with a full glass of water Maximum dose over 24-hour period: -4,000 mg for adults -3,200 mg for geriatric clients -2,000 mg for clients with chronic alcoholism	Relief of mild pain and fever	Skin reddening Blisters Rash Hepatic failure (liver damage)

Critical Thinking Activity 10.6a



A client is admitted to the hospital with acute liver failure due to acetaminophen toxicity. The client reveals 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 health teaching about acetaminophen should be provided?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” section at the end of the book.

Nonsteroidal Anti-Inflammatories (NSAIDs)

Nonsteroidal anti-inflammatories have an analgesic effect, as well as antipyretic and anti-inflammatory actions. Some, such as aspirin, also have an antiplatelet effect. Aspirin and other NSAIDs relieve pain by inhibiting the biosynthesis of prostaglandin by different forms of the COX enzyme. COX2 inhibitors are selective and only inhibit the COX-2 enzyme. As a result of the inhibition of COX1 by an NSAID, there is decreased protection of the stomach lining and gastric irritation, and bleeding may occur. This section will discuss the following NSAIDs: aspirin, ibuprofen, ketorolac, and celecoxib.[5]

Aspirin

Mechanism of Action: Aspirin produces analgesia and reduces inflammation and fever by inhibiting the production of prostaglandins. It also decreases platelet aggregation.

Indications: Aspirin is used for the treatment of mild pain and fever. Once daily dosages are also used to reduce the risk of heart attack and stroke.

Nursing Considerations: Aspirin is safe for adults and children older than 12 years of age.

5. McCuiston, L., E., Vuljoin-DiMaggio, K., Winton, M., B., & Yeager, J. (2018). *Pharmacology: A patient centered nursing process approach*. pp. 268-270, 324, 332. Elsevier.

Side Effects/Adverse Effects: Adverse effects include GI upset, GI bleed, and tinnitus (ringing of the ears).

Boxed Warning: Children or teenagers should not take aspirin to treat chicken pox or flu-like symptoms because of the risk of Reye's syndrome. Reye's syndrome primarily occurs in children in conjunction with a viral illness; it can cause symptoms such as persistent vomiting, confusion, or loss of consciousness and requires immediate medical attention.

Allergy Alert: Aspirin may cause a severe allergic reaction, which may include the following:

- Hives
- Facial swelling
- Shock
- Asthma (wheezing)

Stomach Bleeding Warning: This product contains an NSAID, which may cause severe stomach 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
- Has three or more alcoholic drinks every day while using this product

Aspirin is contraindicated if the client has a bleeding disorder such as hemophilia or a recent history of bleeding in the stomach or intestine.

Health Teaching & Health Promotion: Clients should avoid concurrent use of alcohol while taking medication to avoid gastric irritation. Additionally, they should report tinnitus, unusual bleeding, or fever lasting greater than three days to the health care provider.

Now let's take a closer look at the medication grid on aspirin in Table 10.6b.[6]

Table 10.6b Aspirin Medication Grid

6. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass</th	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects

Nonopioid Analgesic (NSAID) Antipyretic	aspirin	Give orally Assess pain prior to and after administration Children under 12 years: Do not use unless directed by a provider Take with a full glass of water and sit upright for 15-30 minutes after administration Take with food if the client reports that aspirin upsets their stomach Do not crush, chew, break, or open an enteric-coated or delayed-release pill; it should be swallowed whole The chewable tablet form must be chewed before swallowing Should be stopped seven days prior to surgery due to the risk of	Treatment of mild pain and fever Reduces the risk of heart attack and stroke	GI upset GI bleeding Tinnitus

		postoperative bleeding		

Critical Thinking Activity 10.6b

A client asks why aspirin is given to prevent a heart attack or stroke.

What is the nurse's response?

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

Ibuprofen

Mechanism of Action: Ibuprofen inhibits prostaglandin synthesis.

Indications: Ibuprofen is used to treat mild to moderate pain and fever; inflammatory disorders, including rheumatoid arthritis and osteoarthritis; and pain associated with dysmenorrhea.

Nursing Considerations: Ibuprofen is safe for infants six months or older. It is especially important not to use ibuprofen during the last three months of pregnancy unless directed to do so by a doctor because it may cause complications during delivery or in the unborn child.

Side Effects/Adverse Effects: Adverse effects include headache, GI bleed, constipation, dyspepsia, nausea, vomiting, Steven-Johnson syndrome, and renal failure.

Allergy Alert: Ibuprofen may cause a severe allergic reaction, especially in people allergic to aspirin. Symptoms may include the following:

- Hives

- Facial swelling
- Asthma (wheezing)
- Shock
- Skin reddening
- Rash
- Blisters

Stomach Bleeding Warning: This product contains a nonsteroidal anti-inflammatory drug (NSAID), which may cause severe stomach bleeding. The chance for bleeding is higher if the client:

- Is age 60 or older
- Has had stomach ulcers or bleeding problems
- Takes a blood-thinning (anticoagulant) or steroid drug
- Takes other drugs containing prescription or nonprescription NSAIDs (aspirin, ibuprofen, naproxen, or others)
- Has three or more alcoholic drinks every day while using this product
- Takes more or for a longer time than directed

Heart Attack and Stroke Warning: All NSAIDs, except aspirin, increase the risk of heart attack, heart failure, and stroke. These can be fatal. The risk is higher if the client takes more than is directed or takes it for longer than directed.

Boxed Warning: Ibuprofen is contraindicated for the treatment of perioperative pain after coronary artery bypass graft.

Health Teaching & Health Promotion: Clients should consume the medication with a full glass of water and remain upright for 30 minutes following medication administration. They should avoid the use of alcohol while taking this medication. Clients should be advised to not take the medication for longer than ten days. If the client notices rash, visual changes, tinnitus, weight gain, or influenza-like symptoms, these should be reported to the health care provider immediately.[7]

7. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

Now let's take a closer look at the medication grid on ibuprofen in Table 10.6c.[8]

Table 10.6c Ibuprofen Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Nonopioid Analgesic NSAID Antipyretic	ibuprofen	Given parenterally and orally Assess pain prior to and after administration May take with food or milk if stomach upset occurs Stay well-hydrated to prevent renal failure Assess client for signs of GI bleed Assess for skin rash Monitor BUN, serum creatinine, CBC, and liver function test Do not administer to clients who are allergic to aspirin or other NSAIDs	To relieve mild pain and to reduce fever	Headache GI bleed Constipation Dyspepsia Nausea Vomiting Steven-Johnson syndrome Renal failure

8. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Critical Thinking Activity 10.6c



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?

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

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.

Mechanism of Action: Ketorolac inhibits prostaglandin synthesis.

Indications: Ketorolac is indicated for the short-term (up to five days in adults) management of moderate to severe acute pain that requires analgesia at the opioid level.

Nursing Considerations: Ketorolac is safe for adults. This dose should be reduced for clients ages 65 and over.

Side Effects/Adverse Effects: Adverse effects include drowsiness, headache, GI bleed, abnormal taste, dyspepsia, nausea, Steven-Johnson syndrome, edema, and renal failure.

Gastrointestinal Risk: Ketorolac tromethamine (IV form) can cause peptic ulcers, gastrointestinal bleeding, and/or perforation of the stomach or intestines, which can be fatal. These events can occur at any time during use

and without warning symptoms. Therefore, ketorolac tromethamine is contraindicated in clients with active peptic ulcer disease, in clients with recent gastrointestinal bleeding or perforation, and in clients with a history of peptic ulcer disease or gastrointestinal bleeding. Elderly clients are at greater risk for serious gastrointestinal events.

Cardiovascular Thrombotic Events: Nonsteroidal anti-inflammatory drugs (NSAIDs) cause an increased risk of serious cardiovascular thrombotic events, including myocardial infarction and stroke, which can be fatal. This risk may occur early in treatment and may increase with duration of use.

Ketorolac tromethamine is contraindicated for clients who have recently received coronary artery bypass graft (CABG) surgery.

Renal Risk: Ketorolac tromethamine is contraindicated in clients with advanced renal impairment and in clients at risk for renal failure due to volume depletion.

Risk of Bleeding: Ketorolac tromethamine inhibits platelet function and is, therefore, contraindicated in clients with suspected or confirmed cerebrovascular bleeding, hemorrhagic diathesis, incomplete hemostasis, and a high risk of bleeding. Ketorolac tromethamine is contraindicated as a prophylactic analgesic before any major surgery.

Hypersensitivity Reactions: Hypersensitivity reactions ranging from bronchospasm to anaphylactic shock have occurred, and appropriate counteractive measures must be available when administering the first dose of ketorolac. Ketorolac tromethamine is contraindicated in clients with previously demonstrated hypersensitivity to ketorolac tromethamine or who have had allergic manifestations to aspirin or other nonsteroidal anti-inflammatory drugs (NSAIDs).

Health Teaching & Health Promotion: The use of ketorolac may cause dizziness of drowsiness. Clients should also avoid alcohol or other aspirin-containing products unless directed by their health care provider. If the client notices rash, visual changes, tinnitus, weight gain, or influenza-like symptoms, these should be reported to the health care provider immediately.[9]

9. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

Now let's take a closer look at the medication grid on ketorolac in Table 10.6d.[10]

Table 10.6d Ketorolac Medication Grid

10. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Nonopioid Analgesic NSAID	ketorolac	Given orally, parenterally, and as an ophthalmic solution Assess pain prior to and after administration Therapy should always be given initially by the IM or IV route; then use the oral route as a continuation of parenteral therapy Stay well-hydrated to prevent renal failure Assess for signs of GI bleeding Assess for skin rash Monitor BUN, serum creatinine, CBC, and liver function tests Do not administer before any major surgery Do not administer to clients who are allergic to aspirin or other NSAIDs	To relieve moderate pain short-term (not to exceed five days)	Drowsiness Headache GI bleed Abnormal taste Dyspepsia Nausea Steven-Johnson syndrome Edema Renal failure

Critical Thinking Activity 10.6d

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?

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

Celecoxib

Celecoxib is a COX-2 inhibitor.

Mechanism of Action: Celecoxib specifically inhibits the enzyme COX-2 that is required for the synthesis of prostaglandins.

Indications: 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 safe for children two years or older. There is a Boxed Warning for required dosage adjustment for clients with hepatic impairment.

Side Effects/Adverse Effects: Adverse effects include hypertension, peripheral edema, increased liver enzymes, abdominal pain, dyspepsia, gastroesophageal reflux disease, vomiting, and diarrhea.

Boxed Warnings: There are Boxed Warnings for increased risk of cardiovascular (CV) events and gastrointestinal bleeding, ulceration, and perforation. See more information about each condition below.

Cardiovascular Thrombotic Events: Nonsteroidal anti-inflammatory drugs (NSAIDs) 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.

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. Elderly clients and clients with a prior history of peptic ulcer disease and/or GI bleeding are at greater risk for serious (GI) events.

Health Teaching & Health Promotion: 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 health care provider.[11]

Now let's take a closer look at the medication grid on celecoxib in Table 10.6e.[12]

Table 10.6e Celecoxib Medication Grid

11. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
12. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects

NSAIDs COX-2 Inhibitor	celecoxib	May be given with or without food May sprinkle capsules on applesauce and ingest immediately with water Monitor clients for signs and symptoms of Steven-Johnson syndrome Monitor for signs and symptoms of GI bleed, hypertension, and heart failure Monitor liver enzymes. Boxed Warning for dosage adjustment for hepatic impairment Boxed Warnings for increased risk of cardiovascular (CV) events and gastrointestinal bleeding,	To decrease pain and inflammation caused by arthritis or spondylitis	Hypertension Peripheral edema Increased liver enzymes Abdominal pain, dyspepsia, gastroesophageal reflux disease, vomiting, and diarrhea Cardiovascular thrombotic events GI bleeding, ulceration and perforation Hepatotoxicity Hypertension Heart failure and edema Renal toxicity and hyperkalemia Anaphylactic reactions Serious skin reactions Hematologic toxicity

		ulceration, and perforation		

Critical Thinking Activity 10.6e

A client has been prescribed celecoxib for their arthritic pain.

What patient teaching does the nurse plan to provide?

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

- Test your knowledge with this NCLEX Next Generation style bowtie question: Acetaminophen.

10.7 Opioid Analgesics and Antagonists

Opioid analgesics are prescribed for moderate and severe pain. There are several types of opioids, as listed in Table 10.4 in the previous "Applying the Nursing Process to Pain Management" section. Before discussing morphine, the prototype opioid analgesic, and its antagonist, naloxone, let's discuss the opioid epidemic in the United States, efforts to stop this epidemic, and the dangers of drug diversion.

Understanding the Opioid Epidemic

The drug overdose epidemic continues to worsen in the United States. Overdose deaths remain a leading cause of injury-related death. In the United States, drug overdoses have claimed over 932,000 lives over the past 21 years. The majority of overdose deaths involve opioids. Deaths involving synthetic opioids (i.e., illicitly made fentanyl) have increased in recent years, especially during the COVID-19 pandemic.[1]

The rise in opioid overdose deaths can be outlined in three distinct waves. See Figure 10.7[2] for a graphic representation of the waves of opioid deaths.

1. Centers for Disease Control and Prevention. (2022). *Understanding drug overdoses and deaths.* https://www.cdc.gov/drugoverdose/epidemic/index.html
2. "3 Waves of the Rise of Opioid Overdose Deaths" by National Vital Statistics System, CDC is licensed under CC0

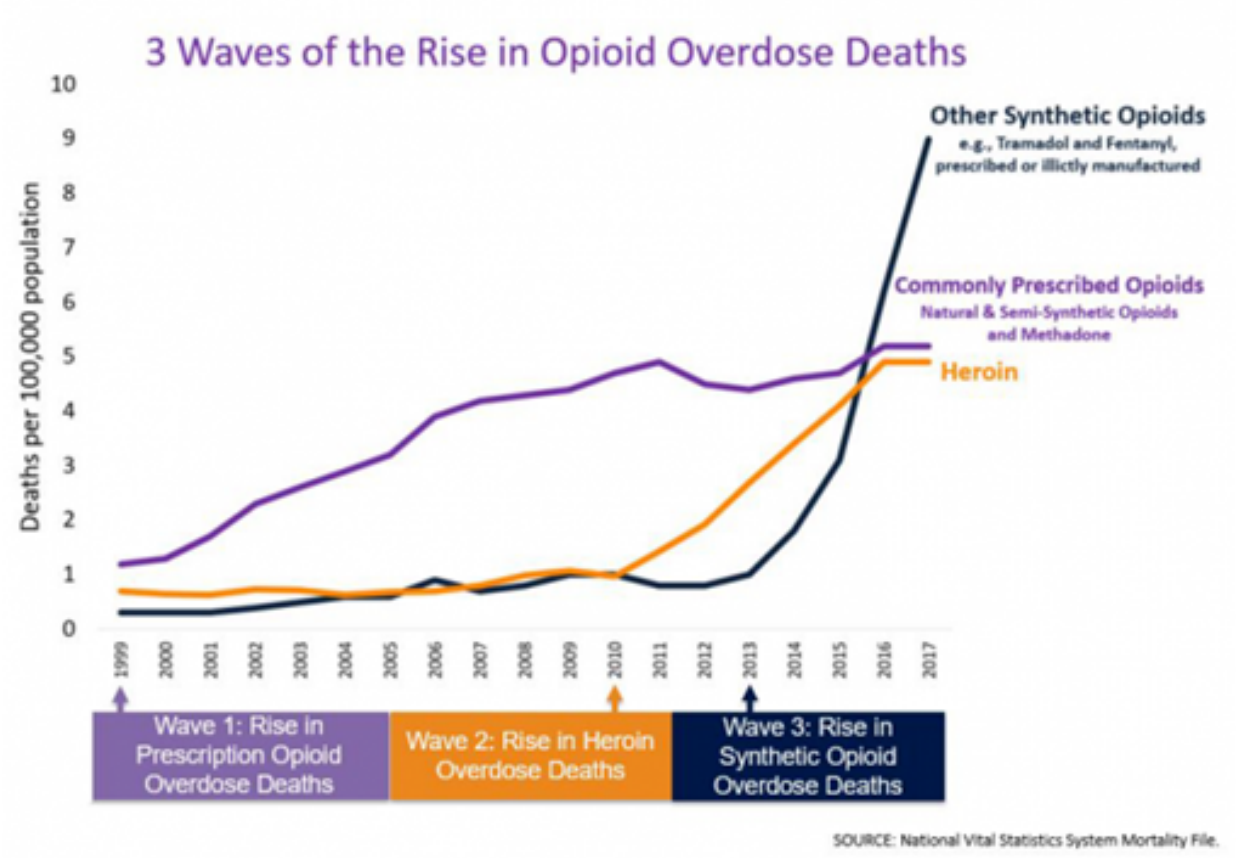


Figure 10.7 Three Waves of Opioid Overdose Deaths

The first wave began with increased prescribing of opioids in the 1990s, with overdose deaths involving prescription opioids (natural and semi-synthetic opioids and methadone). The second wave began in 2010 with rapid increases in overdose deaths involving heroin. The third wave began in 2013, with significant increases in overdose deaths involving synthetic opioids, especially those involving illicitly manufactured fentanyl.[3]

CDC's Educational Campaigns

To save lives from drug overdose, the Centers for Disease Control and Prevention (CDC) launched four education campaigns to reach young adults (ages 18-34). The campaigns provide information that can save the lives and

3. Centers for Disease Control and Prevention. (2018, December 19). *Opioid overdose, Understanding the epidemic.* https://www.cdc.gov/drugoverdose/epidemic/index.html

highlight actions the public can take to help prevent overdose. Specifically, the campaigns provide critical information about these topics[4]:

- Dangers of fentanyl
- Risks and consequences of mixing drugs
- Life-saving power of naloxone to reverse an opioid overdose
- Importance of reducing stigma to support treatment and recovery

> Read more information about the CDC campaigns to stop overdose deaths.

CDC Guidelines for Prescribing Opioids for Chronic Pain

In addition to establishing educational campaigns to prevent opioid deaths, the CDC has also established new clinical practice guidelines regarding the prescription of opioids to ensure clients have access to safer, effective pain treatment while also reducing the number of people who misuse or overdose from these drugs. The CDC's *Clinical Practice Guidelines for Prescribing Opioids – United States, 2022* was developed for the prescribing of opioid pain medication for clients 18 and older in primary care settings. Recommendations focus on the use of opioids in treating acute pain (pain lasting less than one month), subacute pain (pain lasting one to three months, and chronic pain (pain lasting longer than three months). This clinical practice guideline is intended to improve communication between clinicians and clients about the benefits and risks of pain treatments, including opioid therapy; improve the effectiveness and safety of pain treatment; mitigate pain; improve function and quality of life for clients with pain; and reduce risks associated with opioid pain therapy, including opioid

4. Centers for Disease Control and Prevention. (2022). *Understanding drug overdoses and deaths.* https://www.cdc.gov/drugoverdose/epidemic/index.html

use disorder, overdose, and death.[5] Nurses also play an important component in advocating for these outcomes.

Four key areas are covered in the CDC's *Clinical Practice Guidelines for Prescribing Opioids*[6]:

1. Determining whether or not to initiate opioids for pain
2. Selecting opioids and determining opioid dosages
3. Deciding duration of initial opioid prescription and conducting follow-up
4. Assessing risk and addressing potential harms of opioid use

In addition, five guiding principles were identified[7]:

1. Appropriate treatment of pain
2. Flexibility to meet the care needs and clinical circumstances of each client
3. A multimodal and multidisciplinary approach to pain management
4. Avoiding misapplication of the clinical practice guideline beyond its intended use
5. Vigilance in attending to health inequities and ensuring access to appropriate, affordable, diversified, coordinated, and effective nonpharmacologic and pharmacologic pain treatment for all persons

Improving the way opioids are prescribed through clinical practice guidelines can ensure clients have access to safer, more effective pain treatment while also reducing the risk of opioid use disorder, overdose, and death.

Drug Diversion and Impaired Health Care Workers

Drug diversion is a potential threat to patient safety in every health care

5. Centers for Disease Control and Prevention. (2022). *Clinical practice guidelines for prescribing opioids - United States, 2022*. https://www.cdc.gov/mmwr/volumes/71/rr/rr7103a1.htm?s_cid=rr7103a1_w
6. Centers for Disease Control and Prevention. (2022). *Clinical practice guidelines for prescribing opioids - United States, 2022*. https://www.cdc.gov/mmwr/volumes/71/rr/rr7103a1.htm?s_cid=rr7103a1_w
7. Centers for Disease Control and Prevention. (2022). *Clinical practice guidelines for prescribing opioids - United States, 2022*. https://www.cdc.gov/mmwr/volumes/71/rr/rr7103a1.htm?s_cid=rr7103a1_w

organization. Drug diversion involves the transfer of any legally prescribed controlled substance from the individual for whom it was prescribed to another person for illicit use. The most commonly diverted substances in health care facilities are opioids.

Risks to clients from drug diversion include inadequate pain relief compounded by potentially unsafe care due to the health care worker's impaired performance.[8] More information about drug diversion and substance use disorder in health care professionals is discussed in the "Legal Foundations and National Guidelines for Safe Medication Administration" section of the "Legal/Ethical" chapter.

Opioid Medication Class

See Table 10.4 in the "Nursing Process for Analgesics and Musculoskeletal Medications" section of this chapter for a list of common opioid medications used to treat moderate to severe pain. As discussed in that section, morphine is at the top of the WHO ladder and is used to treat severe pain. It is also commonly used to treat cancer pain and for pain at end of life because there is no "ceiling effect," meaning the higher the dose, the higher the level of analgesia. Morphine is also commonly used in **patient-controlled analgesia (PCA)**; other medications administered via PCA include hydromorphone or fentanyl. To receive the opioid using a PCA device, the patient pushes a button, which releases a specific dose but also has a lockout mechanism to prevent an overdose.[9]

Morphine

Morphine is an example of a potent opioid used to treat severe pain.

Mechanism of Action: Morphine binds to opioid receptors in the CNS and

8. The Joint Commission, Division of Healthcare Improvement. (2019). Drug diversion and impaired health care workers. *Quick Safety (48).* https://www.jointcommission.org/resources/news-and-multimedia/newsletters/newsletters/quick-safety/quick-safety-48-drug-diversion-and-impaired-health-care-workers/#.ZDh5THbMI2w
9. McCuistion, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach.* pp. 268-270, 324, 332. Elsevier.

alters the perception of and response to painful stimuli while producing generalized CNS depression.

Indications: Morphine is indicated for the relief of moderate to severe acute and chronic pain and for pulmonary edema.

Nursing Considerations: Morphine is safe for all ages. Use cautiously with clients with liver and renal impairment.

Side Effects/Adverse Effects: Adverse effects include respiratory depression, hypotension, light-headedness, dizziness, sedation, constipation, nausea, vomiting, and sweating.

Health Teaching & Health Promotion: Clients should be advised regarding the risks associated with opioid analgesic use. Please see the outlined "Special Considerations" for usage below.[10]

Boxed Warning: 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. Naloxone is used to reverse opioid overdose. There is also a risk of drug abuse and dependence with morphine.

Special Considerations

Respiratory Depression: Respiratory depression is the primary risk of morphine sulfate. Respiratory depression occurs more frequently in elderly or debilitated clients and in 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 preexisting 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 nonopioid analgesics and use morphine sulfate only under careful medical supervision at the lowest effective dose in such clients.

Misuse, Abuse, and Diversion of Opioids: Morphine sulfate is an opioid agonist and a Schedule II controlled substance. Such drugs are sought by

10. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

drug abusers and people with addiction disorders. Diversion of Schedule II products is an act subject to criminal penalty.

Morphine can be abused in a manner similar to other opioid agonists, legal or illicit. This should be considered when prescribing or dispensing morphine sulfate in situations where there is increased risk of misuse, abuse, or diversion. Morphine may be abused by crushing, chewing, snorting, or injecting the product. These practices pose a significant risk to the abuser that could result in overdose and death.

Interactions With Alcohol and Drugs of Abuse: Morphine has addictive effects when used in conjunction with alcohol, other opioids, or illicit drugs that cause central nervous system depression and respiratory depression, hypotension, profound sedation, coma, or death may result.

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.

Gastrointestinal Effects: Do not administer morphine to clients with gastrointestinal obstruction, especially paralytic ileus because morphine diminishes 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 morphine with caution in clients with biliary tract disease, including acute pancreatitis, as morphine

sulfate may cause spasming and diminished biliary and pancreatic secretions.

Special Risk Groups: Use morphine with caution and in reduced dosages in clients with severe renal or hepatic impairment, Addison's disease, hypothyroidism, prostatic hypertrophy, urethral stricture, and in elderly or debilitated clients. Exercise caution in the administration of morphine sulfate to clients with CNS depression, toxic psychosis, acute alcoholism, and delirium tremens.

All opioids may aggravate convulsions in clients with convulsive disorders, and all opioids may induce or aggravate seizures.

Driving and Operating Machinery: Caution clients that morphine sulfate could impair the mental and/or physical abilities needed to perform potentially hazardous activities such as driving a car or operating machinery.

Caution clients about the potential combined effects of morphine sulfate with other CNS depressants, including other opioids, phenothiazines, sedative/hypnotics, and alcohol.

Now let's take a closer look at the medication grid on morphine in Table 10.7a.[11,12,13]

Table 10.7a Morphine Medication Grid

11. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pp. 305, 310, 952-953, 959-960. Wolters Kluwer.
12. Vallerand, A., & Sanoski, C. A. (2019). *Davis's drug guide for nurses* (16th ed.). F. A. Davis Company.
13. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Opioid Analgesic	morphine	Given parenterally and orally Assess pain prior to and after administration Monitor respiratory status Monitor blood pressure Assess pediatric and geriatric clients frequently Assess bowel function Use cautiously with antidepressants and other CNS depressants Naloxone is used to reverse opioid overdose	Relieves severe pain	Respiratory depression Confusion Hypotension Light-headedness Dizziness Sedation Constipation Nausea and vomiting Sweating

Critical Thinking Activity 10.7a

Oral morphine was administered to a client for rib pain (rated as "6") from metastatic lung cancer.

When should the effectiveness of the medication be evaluated?

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

Naloxone (Narcan)

Mechanism of Action: Naloxone reverses analgesia and the CNS and respiratory depression caused by opioid agonists. It competes with opioid receptor sites in the brain and, thereby, prevents binding with receptors or displaces opioids already occupying receptor sites.

Indications: Naloxone is indicated for the complete or partial reversal of opioid depression, including respiratory depression induced by natural and synthetic opioids.

Nursing Considerations: Naloxone is safe for all ages.

Side Effects/Adverse Effects: Adverse effects include tremors, drowsiness, sweating, decreased respirations, hypertension, nausea, and vomiting.

Health Teaching & Health Promotion: Clients should be advised regarding the risks associated with opioid analgesic use and the need for opioid antagonists. Please see the outlined "Special Considerations" for usage below.[14]

Special Considerations

Postoperative: The following adverse events have been associated with the use of naloxone hydrochloride injection in postoperative clients: hypotension,

14. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

hypertension, ventricular tachycardia and fibrillation, dyspnea, pulmonary edema, and cardiac arrest. Death, coma, and encephalopathy have been reported as results of these events. Excessive doses of naloxone in postoperative clients may result in significant reversal of analgesia and may cause agitation.

Opioid Depression: Abrupt reversal of opioid depression may result in nausea, vomiting, sweating, tachycardia, increased blood pressure, tremulousness, seizures, ventricular tachycardia and fibrillation, pulmonary edema, and cardiac arrest, which may result in death.

Opioid Dependence: Abrupt reversal of opioid effects in persons who are physically dependent on opioids may precipitate an acute withdrawal syndrome, which may include, but not limited to, the following signs and symptoms: body aches, fever, sweating, runny nose, sneezing, piloerection, yawning, weakness, shivering or trembling, nervousness, restlessness or irritability, diarrhea, nausea or vomiting, abdominal cramps, increased blood pressure, and tachycardia. In the neonate, opioid withdrawal may also include convulsions, excessive crying, and hyperactive reflexes.

Now let's take a closer look at the medication grid on naloxone in Table 10.7b.[15,16]

Table 10.7b Naloxone Medication Grid

15. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pp. 305, 310, 952-953, 959-960. Wolters Kluwer.
16. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Opioid Antagonist	naloxone	Given parenterally and inhaled Assess for reversal of opioid effect Assess for hypertension Assess for return of pain Naloxone has a shorter duration of action than opioids, and repeated doses are usually necessary	Blocks the effects of opioid CNS and respiratory depression	Agitation Tremors Drowsiness Sweating Decreased respirations Hypertension Nausea and vomiting

Critical Thinking Activity 10.7b

A postoperative client just received naloxone for respiratory depression.

When should the client's respiratory status be reassessed?

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

10.8 Adjuvant Analgesics

Adjuvant analgesics are medications that were developed for other purposes but were later found to be effective to treat pain. Examples of adjuvant medications include gabapentin (an anticonvulsant) and amitriptyline (a tricyclic antidepressant). Additional information about these specific adjuvant medications can be found in the "Central Nervous System" chapter. Muscle relaxants are also considered an adjuvant analgesic and are used for various musculoskeletal disorders such as multiple sclerosis. Three different types of muscle relaxants will be discussed below: baclofen, cyclobenzaprine, and tizanidine.

Baclofen

Mechanism of Action: Baclofen inhibits reflexes at the spinal level.

Indications: Baclofen is used to treat muscle symptoms, such as spasm, pain, and stiffness, caused by multiple sclerosis, spinal cord injuries, or other spinal cord disorders.

Nursing Considerations: Baclofen is safe for clients 12 years and older.

Side Effects/Adverse Effects: Adverse effects include drowsiness, dizziness or light-headedness, confusion, nausea, constipation, and muscle weakness.

Abrupt Drug Withdrawal: Hallucinations and seizures have occurred on abrupt withdrawal of baclofen. Therefore, except for serious adverse reactions, the dose should be reduced slowly when the drug is discontinued.

Impaired Renal Function: Because baclofen is primarily excreted unchanged through the kidneys, it should be given with caution, and it may be necessary to reduce the dosage.

Signs and symptoms of overdose include vomiting, muscular hypotonia, drowsiness, accommodation disorders of the eye, coma, respiratory depression, and seizures.

Health Teaching & Health Promotion: The medication should be taken as directed and abrupt withdrawal of the medication should be avoided. It may cause dizziness or drowsiness. Clients should be advised to change positions

slowly because of the potential orthostatic changes that may occur. Additionally, clients should avoid concurrent use with alcohol or other CNS depressants.[1]

Now let's take a closer look at the medication grid on baclofen in Table 10.8a.[2,3]

Table 10.8a Baclofen Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/ Adverse Effects
Skeletal Muscle Relaxant and Antispasticity Agent	baclofen	Given parentally and orally Administer orally with milk or food to minimize gastric upset Assess for muscle spasticity before and during therapy Observe for drowsiness For intrathecal administration monitor client closely during test dose and titration and have resuscitative equipment available	To relieve muscle spasms and spasticity	Drowsiness Confusion Dizziness or light-headedness Nausea Constipation Muscle weakness

1. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
2. Vallerand, A., & Sanoski, C. A. (2019). *Davis's drug guide for nurses* (16th ed.). F. A. Davis Company.
3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Critical Thinking Activity 10.8a

A client just started taking baclofen for muscle spasticity due to multiple sclerosis.

What teaching should the nurse provide?

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

Cyclobenzaprine

Mechanism of Action: Cyclobenzaprine reduces tonic somatic muscle activity at the level of the brain stem. It is structurally similar to tricyclic antidepressants.

Indications: Cyclobenzaprine is used to treat acute muscle spasms.

Nursing Considerations: Cyclobenzaprine is safe for clients 15 years and older. Use cautiously with elderly clients, clients with hepatic impairment, and those who take antidepressants and other CNS depressants.

In the elderly, the frequency and severity of adverse events associated with the use of cyclobenzaprine, with or without concomitant medications, are increased. In elderly clients, cyclobenzaprine should be initiated with a 5 mg dose and titrated slowly upward.

Side Effects/Adverse Effects: Adverse effects include dizziness, drowsiness, dry mouth, urinary retention, serotonin syndrome with antidepressant use, or increased sedation with other CNS depressants.

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 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). Treatment with cyclobenzaprine hydrochloride and any concomitant serotonergic agents should be discontinued immediately 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.

General: Because of its atropine-like action, cyclobenzaprine hydrochloride should be used with caution in clients with a history of urinary retention, angle-closure glaucoma, increased intraocular pressure, and in those taking anticholinergic medication.

Impaired Hepatic Function: The plasma concentration of cyclobenzaprine is increased in clients with hepatic impairment.

Cyclobenzaprine, especially when used with alcohol or other CNS depressants, may impair mental and/or physical abilities required for performance of hazardous tasks, such as operating machinery or driving a motor vehicle.

Health Teaching & Health Promotion: The medication should be taken as directed. It may cause dizziness or drowsiness. Clients should be advised to change positions slowly because of the potential orthostatic changes that may occur. Additionally, clients should avoid concurrent use with alcohol or other CNS depressants. Clients should be aware that constipation may occur as a side effect of medication therapy and increased fluid intake may assist in preventing complications.[4]

4. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

Now let's take a closer look at the medication grid on cyclobenzaprine in Table 10.8b.[5,6]

Table 10.8b Cyclobenzaprine Medication Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Skeletal Muscle Relaxant	cyclobenzaprine	May be administered with meals to minimize GI upset Assess for pain and muscle stiffness Use cautiously with antidepressants and other CNS depressants	Reduction of muscle spasms	Dizziness Drowsiness Dry mouth Urinary retention Serotonin syndrome

Critical Thinking Activity 10.8b

A client asks if they can drive their car while taking cyclobenzaprine.

What is the nurse's best response?

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

5. Vallerand, A., & Sanoski, C. A. (2019). *Davis's drug guide for nurses* (16th ed.). F. A. Davis Company.
6. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Tizanidine

Mechanism of Action: Tizanidine acts as an agonist at central alpha-adrenergic receptor sites. It reduces spasticity by increasing presynaptic inhibition of motor neurons.

Indications: Tizanidine is used to treat increased muscle tone, spasms, and spasticity.

Nursing Considerations: Tizanidine is safe for adults. Dosage adjustment may be required for the geriatric population.

Side Effects/Adverse Effects: Adverse effects include somnolence, dry mouth, hypotension, bradycardia, dizziness, fatigue, weakness or asthenia, hallucinations, liver function test abnormality, and hepatotoxicity.

Health Teaching & Health Promotion: The medication should be taken as directed. It may cause dizziness or drowsiness. Clients should be advised to change positions slowly because of the potential orthostatic changes that may occur. Additionally, clients should avoid concurrent use with alcohol or other CNS depressants.[7]

Now let's take a closer look at the medication grid on tizanidine in Table 10.8c.[8,9,10]

Table 10.8c Tizanidine Medication Grid

7. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral
8. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pp. 305, 310, 952-953, 959-960. Wolters Kluwer.
9. Vallerand, A., & Sanoski, C. A. (2019). *Davis's drug guide for nurses* (16th ed.). F. A. Davis Company.
10. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Antispasticity	tizanidine	Given orally May be given with or without food Assess muscle spasticity before and during therapy Assess blood pressure and pulse Monitor for sedation Assess liver function	Reduction of muscle spasms and spasticity	Somnolence Dry mouth Hypotension Bradycardia Dizziness Fatigue Weakness or asthenia Hallucinations Liver function test abnormality and hepatotoxicity

Critical Thinking Activity 10.8c

A client asks, "Why should I not drink alcohol with tizanidine?"

What is the nurse's best response?

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

10.9 Antigout Medications

Antigout medications are used to treat gout, a musculoskeletal disorder. Allopurinol is commonly used to prevent gout from recurring. Colchicine, classified as anti-inflammatory medication, is used to prevent and treat acute gout flares.

Allopurinol

Mechanism of Action: Allopurinol blocks the production of uric acid by inhibiting the action of xanthine oxidase.

Indications: Allopurinol is used for the prevention of gouty arthritis and for the treatment of secondary hyperuricemia.

Nursing Considerations: Allopurinol is safe for all ages. For clients with renal impairment, the dose will be reduced.

Side Effects/Adverse Effects: Adverse effects include hypotension, flushing, drowsiness, nausea and vomiting, diarrhea, hepatitis, renal failure, drug rash with eosinophilia and systemic symptoms (DRESS) syndrome, or drug hypersensitivity syndrome.[1]

Health Teaching & Health Promotion: The medication should be taken as directed. An alkaline diet may be ordered for the client, and they may be advised to increase fluid intake to prevent kidney stone formation. The medication may cause dizziness or drowsiness. Clients who consume large amounts of alcohol may increase uric acid concentrations and decrease the effectiveness of the medication. If a client develops a rash or blood in the urine, these new symptoms should be reported promptly to the health care provider.[2]

1. Cleveland Clinic. (2017, January 26). *Acute vs. chronic pain.* https://my.clevelandclinic.org/health/articles/12051-acute-vs-chronic-pain
2. uCentral from Unbound Medicine. https://www.unboundmedicine.com/ucentral

Colchicine

Mechanism of Action: Colchicine has primarily anti-inflammatory properties.

Indications: Colchicine is indicated for prophylaxis and the treatment of acute gout flares.

Nursing Considerations: The recommended dosage of colchicine depends on the client's age, renal function, hepatic function, and use of co-administered drugs. Colchicine is not an analgesic medication and should not be used to treat pain from other causes. It is administered orally without regard to meals.

Side Effects/Adverse Effects: The most commonly reported side effect of colchicine is diarrhea. Life-threatening and fatal drug interactions have been reported in clients treated with colchicine given with P-gp and strong CYP3A4 inhibitors. Myelosuppression, leukopenia, granulocytopenia, thrombocytopenia, pancytopenia, and aplastic anemia have been reported with colchicine used in therapeutic doses. Colchicine-induced neuromuscular toxicity and rhabdomyolysis have been reported in elderly clients and those with renal dysfunction.

Health Teaching & Health Promotion: Clients should be instructed to take colchicine as prescribed, even if they are feeling better. Clients should not alter the dose or discontinue treatment without consulting with their provider. They should report to their health care provider all of the current medications they are taking and check before starting any new medications, particularly antibiotics, as well as nonprescription medication or herbal products. Grapefruit and grapefruit juice may also interact and should not be consumed during colchicine treatment. Clients should be informed to seek medication evaluation immediately if muscle pain or weakness, tingling, or numbness in fingers or toes occur.

Now let's take a closer look at the medication grid on antigout medication in Table 10.9.[3]

Table 10.9 Antigout Medication Grid

3. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
allopurinol	May be given with milk or meals to decrease stomach upset Give with plenty of water May be crushed Monitor intake and output Monitor hematologic, renal, and liver functions before and during therapy If rash occurs, notify health care provider	Prevention of gout Treatment of secondary hyperuricemia	Hypotension Flushing Hypertension Drowsiness Nausea and vomiting Diarrhea Hepatitis Rash Renal failure	
Antigout Agent	colchicine	Monitor hematologic, renal, and liver functions	Treatment of acute gout flares	Diarrhea Neuromuscular toxicity Rhabdomyolysis Myelosuppression, leukopenia, granulocytopenia, thrombocytopenia, pancytopenia, and aplastic anemia

10.10 Antimigraine Medications

Migraines are a neurological disorder characterized by severe and recurring headaches and other symptoms such as sensitivity to light, sound, and smells, and nausea. The treatment of migraines includes both acute and preventative medications. The following is a list of some common medications used to treat migraines.

Triptans

Mechanism of Action: Triptans bind to serotonin (5-HT) receptors, specifically the 5-HT1B and 5-HT1D receptors. Activation of these receptors leads to vasoconstriction of the dilated blood vessels in the brain, which is thought to be one of the key factors involved in migraines.

Indication: Triptans inhibit the release of pro-inflammatory neuropeptides, such as substance P and calcitonin gene-related peptide (CGRP), which are involved in the pain and inflammation associated with migraines. In addition, they may also reduce the sensitivity of the trigeminal nerve, which is a major source of pain in migraines.

Nursing Considerations: Triptans can be administered orally, subcutaneously, or as a nasal spray. The medication should be administered at the onset of the migraine and may be repeated once after two hours, but not to exceed 200 mg/per day.

Side Effects/Adverse Effects: Adverse effects of triptans include dizziness, vertigo, somnolence, nausea, vomiting, chest discomfort, and angina.

Health Teaching & Health Promotion: Advise the client to take the medication as soon as possible after the onset of the migraine symptoms. Additionally, it is important to acknowledge lifestyle changes that may be of benefit to help prevent migraine attacks such as stress management techniques, exercise, and avoidance of triggers.

Now let's take a closer look at sumatriptan in the medication grid Table 10.10a.[1]

Table 10.10a Sumatriptan Grid

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Triptans	sumatriptan	Administer at onset of migraine, may repeat once after 2 hours, but not to exceed 200 mg/day. May be administered PO, nasal spray, or injection	Relieves symptoms of migraine headaches, including pain, nausea, and sensitivity to light and sound	Dizziness, vertigo, somnolence, nausea, vomiting, chest discomfort, and angina. Can cause a severe allergic reaction

Ergot Alkaloids

Mechanism of Action: Ergot alkaloids work by narrowing the blood vessels within the brain.

Indication: Ergot alkaloids are used for the acute treatment of migraines.

Nursing Considerations: Ergot alkaloid medications may be administered orally, rectally, sublingually, or as a nasal spray.

Side Effects/Adverse Effects: Side effects may include nausea, vomiting, and abdominal pain.

Health Teaching & Health Promotion: Medication should be taken exactly as prescribed by the health care provider. Do not exceed the prescribed dose or take the medication for longer than prescribed. Clients should avoid the use of alcohol while taking the medications. Abrupt cessation of medication may elicit withdrawal symptoms such as headache, nausea, vomiting, and muscle pain.

1. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Now let's take a closer look at ergotamine in the medication grid Table 10.10b.[2]

Table 10.10b Ergotamine

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Ergot Alkaloid	ergotamine	These medications should not be used in clients with coronary artery disease, peripheral vascular disease, hypertension, or renal or hepatic dysfunction	Narrow blood vessels within the brain reducing pressure	Nausea Vomiting Abdominal pain

2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

10.11 Anesthetics

As a nurse, you may care for clients prior to surgery (preoperative), during surgery (perioperative), or after surgery (postoperative). One of your roles is to monitor the effects of anesthetics on your client's vital signs, paying close attention to respiratory status (respiratory rate, depth, quality, and SpO2), as well as their level of consciousness and pain level.

There are three categories of anesthetics:

- **Local:** Local anesthetic is when a medication (e.g., lidocaine) is injected into the skin at the site of the procedure to achieve numbness for procedures like suturing. EMLA cream is a combination of lidocaine and prilocaine used before procedures such as starting intravenous (IV) access, especially for children. Read more information about lidocaine and EMLA cream in Table 10.11.
- **Conscious Sedation:** Conscious sedation is a combination of medications that allow the client to be relaxed (midazolam) and free of pain (e.g., fentanyl) during a medical procedure (e.g., colonoscopy). This allows the client to remain awake and aware, without feeling discomfort. The client may or may not be able to speak or respond in this state.
- **General Anesthesia:** General anesthesia is a medication-induced reversible unconsciousness with loss of protective reflexes. Arousal, even to painful stimuli, cannot occur. General anesthesia requires the establishment and maintenance of airway control.[1] Propofol is an example of an intravenous general anesthetic. The intravenous (IV) injection of propofol induces anesthesia within 40 seconds from the start of injection.[2]

Table 10.11 Local Anesthetics

1. Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pp. 305, 310, 952-953, 959-960. Wolters Kluwer.
2. This work is a derivative of DailyMed by U.S. National Library of Medicine in the Public Domain.

Class/Subclass	Prototype/Generic	Nursing Considerations	Therapeutic Effects	Side/Adverse Effects
Anesthetics	lidocaine	Note that lidocaine is indicated for anesthesia, as well as other indications such as analgesia and cardiac dysrhythmias The appropriate dosage of lidocaine varies depending on the indication being treated, client age, weight, and other factors Can be administered topically, or via transdermal patch, injection, or other routes, depending on the specific indication	Used to numb a specific area of the body before a medical procedure or provide analgesia	Dizziness, nausea, and numbness

	▸ lidocaine and prilocaine (EMLA cream)[3]	Dosage is based on age, medical condition, and weight Use only on normal skin Wear gloves and apply directly onto the skin but do not rub in. Cover with airtight dressing if directed. Remove the dressing and cream prior to the procedure	Used to numb a specific area of the body before a medical procedure Considered a standard of care for nonemergent, invasive pediatric treatments such as IV starts and lab draws	Protect area from injury because it may be numb for several hours Do not expose area to heat or cold until feeling returns

3. WebMD. (n.d.). EMLA *2.5% topical cream*. https://www.webmd.com/drugs/2/drug-2358-8170/emla-topical/lidocaine-prilocaine-cream-topical/details

10.12 Learning Activities

Light Bulb Moment

Now let's apply what you have learned!

Your 82-year-old postoperative client is hard to arouse 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.

1. Administer oxygen
2. Administer naloxone
3. Insert a Foley catheter
4. Increase IV fluid rate
5. Raise the head of the bed

Note: Answers to the Light Bulb Moment can be found in the "Answer Key" section at the end of the book.

Case Study 1

Mrs. Penja is a 65-year-old female who has been admitted to the hospital for a left hip fracture. She has a history of hypertension and osteoarthritis. Mrs. Penja reports severe pain in her left hip, which is affecting her ability to move and sleep. She is currently being treated with acetaminophen and ibuprofen, but the pain persists. The health care provider prescribes toradol as an additional analgesic.

1. What is toradol, and how does it work?
2. What are the side effects of toradol?
3. How should toradol be administered?
4. What precautions should be taken when using toradol?
5. How long should toradol be used for pain relief?
6. What alternative analgesics could be used instead of toradol?

Case Study 2

Mr. Johnson is a 40-year-old male who has been brought to the emergency department by ambulance. He was found unresponsive in his home with shallow breathing and pinpoint pupils. He has a history of opioid addiction and has recently relapsed. The health care provider suspects an opioid overdose and orders Narcan.

1. What is Narcan, and how does it work?
2. How should Narcan be administered?
3. What are the potential side effects of Narcan?
4. What precautions should be taken when using Narcan?
5. What is the expected outcome after administering Narcan in an opioid overdose?

Note: Answers to the Case Studies can be found in the "Answer Key" 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://wtcs.pressbooks.pub/pharmacology2e/?p=434#h5p-36

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https://wtcs.pressbooks.pub/pharmacology2e/?p=434#h5p-37

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https://wtcs.pressbooks.pub/pharmacology2e/?p=434#h5p-38

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Test your clinical judgment with this NEXT GEN RN

- NCLEX Next Generation-style bowtie question: Analgesics & Musculoskeletal Assignment 1.[1]

- Test your clinical judgment with this NCLEX Next Generation-style bowtie question: Analgesics and Musculoskeletal Assignment 2.[2]

1. "Analgesics & Musculoskeletal Assignment 1" by Open RN is licensed under CC BY 4.0
2. "Analgesics & Musculoskeletal Assignment 2" by Open RN is licensed under CC BY 4.0

X. Glossary

Acute pain: Pain that usually starts suddenly and has a known cause, like an injury or surgery. It normally gets better as your body heals and lasts less than three months.

Adjuvant analgesics: Drugs with a primary indication other than pain that have analgesic properties in some painful conditions. The group includes numerous drugs in diverse classes such as gabapentin (an anticonvulsant) or amitriptyline (a tricyclic antidepressant).

Chronic pain: Pain that lasts six months or more and can be caused by a disease or condition, injury, medical treatment, inflammation, or an unknown reason.

Immune-mediated disease process: Occurs when the body's immune system attacks the central nervous system.

Misuse: The use of illegal drugs and/or the use of prescription drugs in a manner other than as directed by a provider, such as using in greater amounts, more often, or longer than told to take a drug or using someone else's prescription.

Muscle spasticity: Condition in which certain muscles are continuously contracted. This contraction causes stiffness or tightness of the muscles and can interfere with normal movement, speech, and gait. Spasticity is usually caused by damage to the portion of the brain or spinal cord that controls voluntary movement.

Nociceptors: Nerve endings that selectively respond to painful stimuli and send pain signals to the brain and spinal cord.

Nonpharmacologic therapy: Treatments that do not involve medications, including physical treatments (e.g., heat or cold therapy, exercise therapy, weight loss) and cognitive-behavioral treatments (e.g., distractions/diversions and cognitive behavioral therapy).

Patient-controlled analgesia (PCA): To receive the opioid, the patient pushes a button on the PCA device, which releases a specific dose but also

has a lockout mechanism to prevent an overdose. Included with hydromorphone or fentanyl.

Prostaglandins: Produced in nearly all cells and are part of the body's way of dealing with injury and illness. Prostaglandins act as signals to control several different processes depending on the part of the body in which they are made. Prostaglandins are made at the sites of tissue damage or infection, where they cause inflammation, pain, and fever as part of the healing process.

Vertigo: A sense of spinning dizziness. It is a symptom of a range of conditions. It can happen when there is a problem with the inner ear, brain, or sensory nerve pathway.

PART XI

ANSWER KEY

Answer keys for the Critical Thinking Activities and Light Bulb Moments in each chapter are provided in the following sections.

1. Chapter 1

Answer Key to Chapter 1

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 1.5

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.

Critical Thinking Activity Section 1.6

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.

Critical Thinking Activity Section 1.7

An antagonist medication blocks a specific action at a receptor site.

Critical Thinking Activities Section 1.9

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 client 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 client'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 client 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 client's blood sugar reading and consider withholding the medication if the client continues to refuse food over the next few hours to avoid causing hypoglycemia. The provider may also need to be notified of the client's change in condition and, a change in the medication order may be required.

Critical Thinking Activity Section 1.10

The normal lab values of gentamicin are 5 to 10 mcg/mL (or 10.45 to 20.90 micromol/L), so 30 mcg/mL is too high. This abnormal result could indicate the client has renal impairment affecting metabolism and excretion of this medication. The provider and pharmacist should be notified to adjust the next dose of gentamycin before it is administered.

Section 1.12 Light Bulb Moment

1. The nurse should select the rectal route due to the client'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 client'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 client.

4. Sam should evaluate the client's vital signs, specifically the apical pulse and blood pressure, to be sure they are within normal range for this client 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 expected actions of the medication and the client'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 hydrocodone/acetaminophen will peak in approximately one hour. The client will likely require another dose of medication for acute, severe pain that accompanies a knee replacement in approximately four hours.

2. Chapter 2

Answer Key to Chapter 2

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 2.2a

Before administering the medications with similar mechanisms of action, the nurse should notify both providers to clarify the orders and advocate for patient safety.

Critical Thinking Activity Section 2.2b

The nurse should provide health teaching regarding when to take medication, side effects to watch for, and potential adverse effects. The client should also be educated on any restrictions related to diet, over-the-counter medications, and herbal supplements.

Critical Thinking Activity Section 2.3a

The nurse should clarify the medication order with the provider before administration because pneumonia is not listed as an indication for levofloxacin in the Boxed Warning. Notification of the provider and the provider's response should be recorded in the client's medical record.

Critical Thinking Activity Section 2.3b

1. The nurse should educate the client 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 client, 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 clients 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.

Critical Thinking Activities Section 2.3c

1. The rights of medication administration the nurse checks before administering any medication include right patient, right medication, right dose, right route, right time, right documentation, right reason, and right response. Checking allergies and the expiration date of the medication are also included when checking the rights of medication administration.

2. Nurses confirm patient identification prior to administering medication by asking the client their name and date of birth, checking the client's identification band, and by scanning barcodes on the medication and client's armband. In long-term care settings where clients 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 client's picture in the medication record or asking another staff member to confirm the client's identity.

3. Prior to the administration of morphine, an opioid medication, the nurse should assess the client's pain level, level of consciousness, respiratory rate, and oxygenation status. If the client 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 the respiratory rate, oxygenation level, and sedation status.

5. The nurse should teach the client about common side effects, such as constipation and drowsiness.

6. The shift handoff report should include the location of the client's pain, the reported pain level, pain medications administered during the shift, the time of medication administration, and the client's response to the medication.

Critical Thinking Activity Section 2.3d

The colleague can share information about the Professional Assistance Procedure in Wisconsin that provides support to nurses who are committed to their own recovery. It is important to emphasize that the nurse jeopardizes patient safety when practicing under the influence of a substance.

Critical Thinking Activity Section 2.4

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 home to administer medication.

Critical Thinking Activity Section 2.5a

The nurse can use alternative sources of medication information when the client cannot recall their home medication and it is not available in the electronic medical health records. A common intervention is to ask the client 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 client's permission. After determining the client's current medications, the nurse should print a copy of the list of medications and instruct the client to bring it with them to all of the health care providers and update it as needed.

Critical Thinking Activity Section 2.5b

In addition to verifying the five 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. Chapter 3

Answer Key to Chapter 3

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 3.2

Health teaching regarding the importance of adhering to the prescribed medication regimen is vital for preventing drug resistance. During health teaching, the nurse should emphasize the need to complete the full course of medication, in the dosages and frequencies prescribed, to treat the infection and prevent the dangers of drug resistance. In addition to health teaching, 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.

Critical Thinking Activity Section 3.5

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.

Critical Thinking Activity Section 3.6

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.

Critical Thinking Activity Section 3.7

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.

Critical Thinking Activity Section 3.8

Monobactams are narrow-spectrum antibacterial medications used primarily to treat gram-negative bacteria like *Pseudomonas aeruginosa*. However, MRSA is a gram-positive bacterium, 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 aztreonam.

Critical Thinking Activity Section 3.9

The nurse should review the other medications the client is taking. Trimethoprim-sulfamethoxazole has many significant drug interactions, including oral diabetics. 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.

Critical Thinking Activity Section 3.10

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.

Critical Thinking Activity Section 3.11

The nurse should notify the provider of the client's change condition because it may indicate an adverse effect of liver damage is occurring.

Critical Thinking Activity Section 3.12

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.

Critical Thinking Activity Section 3.13

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.

Critical Thinking Activity Section 3.14

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.

Critical Thinking Activity Section 3.15

If there are no signs of improvement from the prescribed medication therapy, the nurse should notify the provider.

Critical Thinking Activity Section 3.16

In order to prevent malaria, the CDC recommends clients should take antimalarial medications for four weeks after leaving the infected area. The nurse should provide additional health teaching regarding this recommendation and evaluate for client understanding.

Critical Thinking Activity Section 3.17

Metronidazole is commonly used to treat C-diff. The medication must be given by mouth for the indication of a gastrointestinal infection like C-diff.

Critical Thinking Activity Section 3.18

The nurse should provide health teaching regarding the use of the medication, as well as ways to prevent reinfection. 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.

Critical Thinking Activity Section 3.19

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.

Critical Thinking Activity Section 3.20

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.

Section 3.21 Case Study 1

1. In the presence of *Staphylococcus aureus*, the health care provider would likely prescribe penicillin intravenously to treat the bacterial infection.
2. Prior to administering the medication, the nurse should ensure the client has no allergies to the medication. Additionally, the client will need instruction regarding the importance of completing the full prescribed regimen of therapy.
3. Side effects such as gastrointestinal upset and rash should be reported to the provider.

Section 3.21 Case Study 2

1. Miss Iso would likely be prescribed tetracycline 500 mg twice daily to treat her acne.

2. Miss Iso should receive health teaching regarding common gastrointestinal side effects and photosensitivity associated with the medication. Additionally, it will be critical to ensure that Miss Iso understands that tetracycline poses risk to a developing fetus; therefore, pregnancy should be avoided.
3. Due to the gastrointestinal side effects associated with tetracycline usage, Miss Iso should be instructed to take the medication with food. She should also be advised to use sunscreen and wear protective clothing when in direct sunlight because of the increased photosensitivity that she may experience while taking the medication.

4. Chapter 4

Answer Key to Chapter 4

Section 4.17 Light Bulb Moment

1. A potential side effect of nicotine is the activation of the sympathetic nervous system that causes an increased heart rate. Nausea and weakness are potential side effects that can indicate nicotine overdose. The nurse should provide health teaching 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 Receptor Agonists" 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 cause 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 albuterol 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.

Section 4.17 Case Study 1

1. The preferred treatment for hypertension and ADHD is clonidine.
2. Prior to administering clonidine, the nurse should collect vital signs, including heart rate and blood pressure. It is also important to ensure that the client does not have any allergies to the medication.
3. Mr. Lao should be encouraged to begin an exercise regimen gradually. Individuals receiving clonidine are more susceptible to hypotension with exercise, especially in environments of extreme heat.

Section 4.17 Case Study 2

1. Mrs. Anton would likely be prescribed propranolol.
2. For any ER (extended-release) medication, clients must be aware that the medication cannot be crushed.
3. Mrs. Anton should recheck her blood pressure and heart rate. Once she has confirmed the findings, she should phone her provider to report the findings. The medication dosage may require an adjustment.

5. Chapter 5

Answer Key to Chapter 5

Section 5.15 Light Bulb Moment Case Study 1 (Asthma Scenario)

1. The correct answer is c) Albuterol. Albuterol is a Beta-2 agonist that relaxes smooth muscle to cause bronchodilation and assists 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 "Common Respiratory Disorders" section and albuterol in the "Beta-2 Agonists" section of this chapter.

Section 5.15 Light Bulb Moment Case Study 2 (Allergy Scenario)

1. The correct answer is b) Epinephrine. Epinephrine is used to rapidly treat severe allergic reactions.

You can review additional information about epinephrine and the use of EpiPens in the "Alpha- and Beta-Receptor Agonists (Catecholamines)" section of the "Autonomic Nervous System" chapter.

Section 5.15 Light Bulb Moment Case Study 3 (Rheumatoid Arthritis Scenario)

1. The common side effects of prednisone use include insomnia, increased appetite, weight gain, fluid retention, increased thirst, and mood changes.
2. The nurse can suggest nonpharmacologic approaches such as practicing good sleep hygiene, using relaxation techniques, and establishing a consistent sleep routine. Additionally, the nurse can also talk to the health care provider about adjusting the timing or dosage of prednisone to help reduce the client's insomnia.
3. The nurse can advise the client to increase her fluid intake with noncaffeinated drinks, such as water and herbal tea. The nurse should also encourage the client to avoid salty and processed foods. The nurse can also educate the client on the importance of regular monitoring of her blood sugar levels, as increased thirst can be a sign of hyperglycemia.
4. The nurse should educate the client on the possible side effects of prednisone use, including the potential for increased appetite, fluid retention, and mood changes. The nurse should also emphasize the importance of taking the medication as prescribed, not discontinuing it suddenly, and discussing any concerns or questions about prednisone use with the health care provider. The client should also be advised to follow a healthy diet, engage in regular physical activity, and get enough rest to minimize the potential side effects of prednisone.

6. Chapter 6

Answer Key to Chapter 6

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 6.6

1. A nurse should assess the heart rate, blood pressure, and QTc interval before and after sotalol administration. Additionally, the nurse should assess for the presence and occurrence of cardiac arrythmias.

Critical Thinking Activity Section 6.7

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.

Critical Thinking Activity Section 6.8

The nurse should monitor the client's blood pressure and heart rate. After five 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.

Critical Thinking Activity Section 6.9

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.
3. The normal range for serum potassium is 3.5-5.0 mEq/L.
4. Furosemide (Lasix) is a loop diuretic.
5. 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.
6. 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.
7. 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.
8. Furosemide can deplete potassium levels, which then increases the risk for developing digoxin toxicity.

Critical Thinking Activity Section 6.10

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 fluid retention and blood pressure through vasodilation. 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.
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.

Critical Thinking Activity Section 6.12

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. Health teaching 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.

Section 6.14 Case Study 1

1. Spironolactone is a medication used to treat high blood pressure, heart failure, and certain types of hormonal imbalances. It works by blocking the action of aldosterone, a hormone that regulates the balance of salt and water in the body.
2. Spironolactone has been prescribed to Ms. Hernandez to help manage her symptoms of heart failure by reducing the amount of fluid in her body and preventing the buildup of excess fluid around her heart and lungs.
3. The potential side effects of spironolactone include dizziness, nausea, vomiting, headache, and diarrhea. In some cases, spironolactone can cause hyperkalemia, a condition where there is too much potassium in the blood.
4. Potential drug interactions with spironolactone include other medications that affect potassium levels, such as ACE inhibitors, angiotensin receptor blockers, and potassium-sparing diuretics. Ms. Hernandez's health care provider will need to monitor her potassium levels carefully and adjust her dosage as needed.
5. Ms. Hernandez's health care provider will need to monitor her kidney function, electrolyte levels, and potassium levels regularly while she is taking spironolactone.
6. Ms. Hernandez should avoid a high-potassium diet while taking spironolactone. This includes foods such as bananas, oranges, potatoes, tomatoes, and spinach.

Section 6.14 Case Study 2

1. Warfarin is an anticoagulant medication used to prevent blood clots that can lead to a stroke or other serious medical conditions.
2. Warfarin has been prescribed to Mr. Johnson to prevent blood clots caused by his atrial fibrillation.
3. Warfarin works by inhibiting the formation of certain clotting factors in the blood, which prevents blood clots from forming.
4. The potential risks of taking warfarin include bleeding, bruising, and gastrointestinal complications. In rare cases, warfarin can cause life-threatening bleeding, and it can also increase the risk of osteoporosis and bone fractures.
5. The optimal therapeutic range for warfarin is typically an international normalized ratio (INR) between 2.0 and 3.0.
6. Laboratory tests required to monitor the effects of warfarin include regular INR tests and blood tests to monitor liver and kidney function.
7. Potential drug interactions with warfarin include other anticoagulants, antibiotics, anti-inflammatory drugs, and some herbal supplements.
8. Mr. Johnson should be aware of the vitamin K content in his diet, as vitamin K can interfere with the effects of warfarin. He should avoid drastic changes in his diet while taking warfarin and should talk to his health care provider before making any significant changes.
9. If Mr. Johnson misses a dose of warfarin, he should take it as soon as he remembers. If it is almost time for his next dose, he should skip the missed dose and continue with his regular dosing schedule.
10. Mr. Johnson should see his health care provider regularly while taking warfarin to monitor his INR levels and adjust his dosage as needed. The frequency of visits will depend on his individual needs and medical history.

7. Chapter 7

Answer Key to Chapter 7

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 7.3

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.

Critical Thinking Activity Section 7.4a

1. The client may be experiencing increased heart rate as a symptom of dehydration associated with water loss from the diarrhea. Additionally, a Boxed 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.

Critical Thinking Activity Section 7.4b

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 increasing fluid and fiber intake and walking.
2. Docusate softens the stool and improves the regularity of bowel

movements.

3. Docusate usually works within 12-72 hours. If it is not effective in creating a bowel movement with soft stool, the client should be instructed to notify the nurse and additional laxatives can be administered.
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 stepwise approach to constipation. Docusate or polyethylene glycol 3350 is often used preventively, but if a bowel movement does not occur within the expected time frame, additional laxatives such as bisacodyl or 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.

Critical Thinking Activity Section 7.5

1. 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.
2. 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.
3. 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.

Section 7.6 Case Study 1

1. Proton pump inhibitors (PPIs) are a class of drugs that reduce the production of stomach acid. They work by blocking the proton pump in the parietal cells of the stomach that produces acid. Examples of PPIs include omeprazole, esomeprazole, lansoprazole, pantoprazole, and rabeprazole.
2. PPIs work by irreversibly binding to the proton pump, which is responsible for the final step in acid production in the stomach. By blocking the proton pump, PPIs reduce the production of stomach acid.
3. The most common side effects of PPIs include headache, diarrhea, abdominal pain, and nausea. Long-term use of PPIs has been associated with an increased risk of osteoporosis-related fractures, kidney disease, and infections such as pneumonia and *Clostridioides difficile* (C. difficile) infection.
4. The nurse should monitor Mrs. Jones for relief of her GERD symptoms, as well as any adverse effects of omeprazole, such as headache, diarrhea, abdominal pain, and nausea. The nurse should also monitor Mrs. Jones' electrolyte levels, particularly magnesium and potassium, as long-term use of PPIs can lead to electrolyte imbalances. Additionally, the nurse should monitor Mrs. Jones for signs and symptoms of C. difficile infection, such as diarrhea and abdominal pain.
5. The nurse should instruct Mrs. Jones to take omeprazole once a day, preferably in the morning before breakfast. Omeprazole should be taken at the same time each day to maintain a consistent blood level. The nurse should also instruct Mrs. Jones not to crush, chew, or break the capsules, but to swallow them whole. If Mrs. Jones has difficulty swallowing the capsule, the nurse may suggest opening the capsule and mixing the contents with applesauce or water.
6. Omeprazole can interact with other drugs that are metabolized by the liver, such as warfarin, diazepam, and phenytoin. Omeprazole can increase the effects of these drugs, leading to a higher risk of bleeding or sedation. Additionally, omeprazole can decrease the absorption of certain drugs, such as ketoconazole and atazanavir, so it is important to separate the administration of these drugs from omeprazole by several hours.
7. The nurse should instruct Mrs. Jones to follow up with her health care

provider if her GERD symptoms do not improve or if she experiences any adverse effects of omeprazole. The nurse should also instruct Mrs. Jones to follow up with her health care provider if she experiences any signs or symptoms of C. difficile infection, such as diarrhea and abdominal pain.

Section 7.6 Case Study 2

1. Loperamide is an antidiarrheal medication that works by slowing down the movement of the intestines and reducing the frequency of bowel movements.
2. Loperamide works by binding to opioid receptors in the gut, which decreases the activity of the intestinal muscles and reduces the speed at which food moves through the digestive tract. This results in decreased diarrhea and increased water absorption.
3. The most common side effects of loperamide include constipation, abdominal cramping, and bloating. In rare cases, loperamide can cause severe constipation, which can lead to intestinal obstruction.
4. The nurse should monitor Mr. Lopez's bowel movements and symptoms of dehydration, such as thirst, dry mouth, and decreased urine output. The nurse should also monitor Mr. Lopez's electrolyte levels, particularly potassium, as loperamide can cause electrolyte imbalances. Additionally, the nurse should monitor Mr. Lopez's pain level and bowel sounds, as severe constipation can lead to abdominal pain and distension.
5. The nurse should instruct Mr. Lopez to take loperamide as directed by his health care provider. Typically, the initial dose is two capsules (4 mg) followed by one capsule (2 mg) after each loose stool, up to a maximum of eight capsules (16 mg) per day. The nurse should also instruct Mr. Lopez to drink plenty of fluids to prevent dehydration and to avoid alcohol and caffeine, as they can worsen diarrhea.
6. Loperamide can interact with other drugs that slow down the movement of the intestines, such as opioids and anticholinergics. Loperamide can increase the effects of these drugs, leading to constipation and other adverse effects. Additionally, loperamide can decrease the absorption of certain drugs, such as digoxin and quinidine, so it is important to separate

the administration of these drugs from loperamide by several hours.

7. The nurse should instruct Mr. Lopez to follow up with his health care provider if his diarrhea persists for more than two days, if he experiences severe constipation or abdominal pain, or if he develops a fever or bloody stools. The nurse should also instruct Mr. Lopez to follow up with his health care provider if he experiences any adverse effects of loperamide, such as severe constipation or bloating.

8. Chapter 8

Answer Key to Chapter 8

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 8.5

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.

Critical Thinking Activity Section 8.6

Health teaching 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 Boxed 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.

Critical Thinking Activity Section 8.7

1. A client taking an SSRI medication like fluoxetine is at risk for developing serotonin syndrome if they have liver dysfunction or are taking other CNS medications. SSRIs are contraindicated with MAOIs due to the risk of developing serotonin syndrome. Symptoms of serotonin syndrome include confusion, elevated temperature, and rapidly changing levels of blood pressure.

2. 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.
3. 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.
4. 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.

Critical Thinking Activity Section 8.8

1. The nurse should explain 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 0.8 to 1.2 mEq/L.
3. The nurse should advise the client that lithium reaches therapeutic range within 1 to 3 weeks.

Critical Thinking Activity Section 8.10

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.

Critical Thinking Activity Section 8.11

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.

Section 8.12 Case Study 1

1. Venlafaxine is a serotonin-norepinephrine reuptake inhibitor (SNRI) that is used to treat depression, anxiety, and other mood disorders. It works by increasing the levels of serotonin and norepinephrine in the brain, which help to regulate mood.
2. The common side effects of venlafaxine include nausea, vomiting, constipation, diarrhea, dry mouth, dizziness, headache, blurred vision, increased sweating, decreased appetite, and sexual dysfunction.
3. Venlafaxine can interact with other medications, such as MAO inhibitors, other SNRIs, SSRIs, tricyclic antidepressants, and medications that affect blood clotting. Clients should inform their health care provider of all medications, supplements, and herbal remedies they are taking before

starting venlafaxine.
4. If a client experiences side effects from venlafaxine, they should inform their health care provider. Depending on the severity of the side effects, the health care provider may adjust the dosage, switch to a different medication, or suggest other treatments to alleviate the side effects. It is important for clients to continue taking venlafaxine as prescribed unless instructed otherwise by their health care provider.

Section 8.12 Case Study 2

1. Selegiline is a monoamine oxidase inhibitor (MAOI) that is used to treat Parkinson's disease. It works by blocking the enzyme monoamine oxidase, which breaks down dopamine in the brain. By blocking this enzyme, selegiline helps to increase the levels of dopamine in the brain, which helps to improve Parkinson's symptoms.
2. The common side effects of selegiline include nausea, vomiting, dizziness, headache, dry mouth, and sleep disturbances.
3. Selegiline can interact with other medications, such as other MAOIs, selective serotonin reuptake inhibitors (SSRIs), tricyclic antidepressants, and meperidine. Clients should inform their health care provider of all medications, supplements, and herbal remedies they are taking before starting selegiline.
4. If a client misses a dose of selegiline, they should take it as soon as they remember. However, if it is almost time for the next dose, they should skip the missed dose and resume their regular dosing schedule. Clients should not take a double dose to make up for a missed dose. If a client misses multiple doses, they should inform their health care provider.

9. Chapter 9

Answer Key to Chapter 9

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 9.3

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.
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. Although the client has no history of diabetes, the increased blood glucose levels may require the temporary use of insulin.
5. Signs of adrenal suppression include severe fatigue, gastrointestinal upset, and a suppressed immune response that places the client at risk for developing infections.

Critical Thinking Activity Section 9.4

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.

2. 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.
3. The nurse should administer 12 units of Humalog insulin, along with the scheduled 20 units of Humulin-N insulin at breakfast.
4. Metformin may be discontinued because it is contraindicated in clients with kidney disease (e.g., serum creatinine levels ≥1.5 mg/dL [males] or ≥1.4 mg/dL [females]).
5. The client is displaying signs of hypoglycemia. A supplementary carbohydrate, such as four ounces of orange juice, should be administered as soon as possible. However, if the client seems confused or unable to swallow, glucagon should be administered.
6. The client has hypoglycemia because the peak effect of Humulin-N is about six hours. Because the medication is peaking between mealtimes, 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 mealtime maintains a normal blood sugar as long as the meals and the insulin administration are matched.
7. 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 health teaching regarding diabetes management, to avoid the development of long-term complications of diabetes.

8. 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.

Critical Thinking Activity Section 9.5

The client should be advised to take levothyroxine at the same time every morning, before eating or drinking. It should not be taken with other medications that may interfere with its absorption and should be taken at least 30 minutes before eating or two hours after eating. The client should monitor for signs of hypothyroidism from too low of a dose of levothyroxine, such as constipation, weight gain, and fatigue. It is also important to watch for signs of too high of a dose of levothyroxine, such as rapid or irregular heart rate.

Section 9.7 Case Study 2

1. Prednisone is a synthetic corticosteroid medication that is commonly used to treat a variety of inflammatory conditions, including asthma exacerbations. Prednisone works by suppressing the immune system and reducing inflammation in the body.
2. Common side effects of prednisone therapy include increased appetite, weight gain, fluid retention, mood changes, and difficulty sleeping. Other possible side effects include increased blood sugar levels, high blood pressure, decreased bone density, increased risk of infection, and increased risk of stomach ulcers.
3. Prednisone therapy is typically administered orally in the form of tablets or capsules. The dosage and duration of treatment depend on the condition being treated and the client's response to the medication. In the case of asthma exacerbation, a typical course of prednisone therapy may involve a high-dose regimen for several days, followed by a gradual

tapering of the dose.

4. During prednisone therapy, clients should be monitored for potential side effects, including changes in blood sugar levels, blood pressure, and bone density. Regular blood tests may also be done to monitor for any signs of infection. Clients should also be monitored for any signs of adrenal suppression, which can occur if the medication is stopped abruptly.
5. Clients should be educated on the potential side effects of prednisone therapy and instructed to report any new or worsening symptoms to their health care provider. Clients should also be advised to take the medication with food to reduce the risk of stomach upset and to avoid abruptly stopping the medication. Clients should also be instructed to avoid exposure to individuals with infectious illnesses while on prednisone therapy.
6. Metformin is a medication commonly used in the management of type 2 diabetes. It works by reducing the amount of glucose produced by the liver and increasing the body's sensitivity to insulin. It is typically used in combination with other diabetes medications, such as insulin.
7. Insulin is a hormone that is essential for the regulation of blood sugar levels. In individuals with type 2 diabetes, insulin therapy may be necessary to help manage blood sugar levels. Insulin can be administered via injection or through an insulin pump.
8. Common side effects of metformin include gastrointestinal symptoms such as diarrhea, nausea, and abdominal discomfort. More serious side effects can include lactic acidosis, a rare but potentially life-threatening condition. Common side effects of insulin therapy include hypoglycemia, weight gain, and injection site reactions.
9. Mr. D.K. should be monitored regularly to assess his blood sugar levels and ensure that they are within the target range. He should also be monitored for any signs of hypoglycemia, including confusion, sweating, and tremors. Regular kidney function tests should also be performed to monitor for any adverse effects of metformin on kidney function.
10. Mr. D.K. should be educated on the importance of adhering to his medication regimen and monitoring his blood sugar levels regularly. He should also be instructed on how to recognize and manage episodes of

hypoglycemia. Mr. D.K. should also be advised to report any new or worsening symptoms to his health care provider. Finally, he should be encouraged to follow a healthy diet and exercise regularly to help manage his diabetes.

10. Chapter 10

Answer Key to Chapter 10

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 10.6a

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 3,200 mg for geriatric adults, and less than 2,000 mg for clients with alcoholism. Fewer than three alcoholic drinks should be consumed daily while using acetaminophen.

Critical Thinking Activity Section 10.6b

The client should be advised that aspirin has an antiplatelet 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.

Critical Thinking Activity Section 10.6c

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 an 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

Critical Thinking Activity Section 10.6d

The nurse should evaluate the effectiveness of ketorolac IV in relieving the client's pain 30 minutes after administration.

Critical Thinking Activity Section 10.6e

The nurse should provide the following health teaching regarding 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 hand or feet, or notice yellowing of your skin.

Critical Thinking Activity Section 10.7a

Oral drops of morphine, commonly used for clients with metastatic cancer, should be effective within one hour of administration.

Critical Thinking Activity Section 10.7b

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.

Critical Thinking Activity Section 10.8a

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.

Critical Thinking Activity Section 10.8b

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 to not drive when taking cyclobenzaprine.

Critical Thinking Activity Section 10.8c

The client should be advised that tizanidine can cause drowsiness and dizziness, and concurrent use with alcohol can worsen these effects. Tizanidine can damage the liver, so alcohol should be avoided to prevent additional damage.

Section 10.12 Light Bulb Moment

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 client's respiratory status after naloxone is administered because repeated doses may be required.

Section 10.12 Case Study 1

1. Toradol is a nonsteroidal anti-inflammatory drug (NSAID) that works by blocking the production of prostaglandins, which are chemicals that cause pain, inflammation, and fever. It is used to treat moderate to severe pain, such as postoperative pain or pain associated with musculoskeletal

injuries.

2. The side effects of toradol can include nausea, vomiting, constipation, diarrhea, dizziness, headache, drowsiness, and stomach pain. More serious side effects can include stomach ulcers, bleeding, and kidney problems. It can also increase the risk of heart attack and stroke, especially with long-term use or in clients with preexisting cardiovascular disease.
3. Toradol can be administered orally, intramuscularly, or intravenously. The recommended dose for oral and intramuscular administration is 10 mg every 4 to 6 hours, not to exceed 40 mg per day. For intravenous administration, the recommended dose is 30 mg as a single dose or 15 mg every 6 hours, not to exceed 60 mg per day.
4. Toradol should be used with caution in clients with a history of gastrointestinal bleeding or ulcers, kidney disease, heart disease, or bleeding disorders. It should not be used in clients who are allergic to NSAIDs or aspirin, or who have a history of asthma, hives, or other allergic reactions to these drugs. It should also be avoided in pregnant women and nursing mothers.
5. Toradol should be used for the shortest duration possible, typically no more than five days, due to the risk of serious side effects with prolonged use. It should not be used for chronic pain management.
6. Alternative analgesics that could be used instead of toradol include acetaminophen, opioids, and other NSAIDs such as ibuprofen or naproxen. The choice of analgesic should be based on the client's individual needs and medical history.

Section 10.12 Case Study 2

1. Narcan (naloxone) is an opioid antagonist that works by blocking the effects of opioids on the central nervous system. It quickly reverses the effects of an opioid overdose, including respiratory depression and sedation.
2. Narcan can be administered intravenously, intramuscularly, subcutaneously, or intranasally. The route of administration will depend

on the client's condition and the available equipment. The dose of Narcan will also depend on the client's weight and the severity of the overdose.

3. The potential side effects of Narcan can include nausea, vomiting, sweating, tremors, anxiety, and irritability. In some cases, Narcan can cause rapid and severe withdrawal symptoms, which can include seizures, hypertension, tachycardia, and pulmonary edema.
4. When using Narcan, health care providers should take precautions to ensure that the client's airway is protected and that they receive adequate oxygenation and ventilation. Narcan should be used with caution in clients with a history of cardiac disease, hypertension, or seizures. It should also be used with caution in clients who are pregnant or nursing.
5. The expected outcome after administering Narcan in an opioid overdose is rapid reversal of respiratory depression and sedation. The client should be monitored closely for signs of withdrawal and respiratory depression, as additional doses of Narcan may be necessary. The health care provider should also address the underlying opioid addiction and provide appropriate treatment and resources to prevent future overdose.

Appendix A - Additional Information Related to the NCLEX Test Plan

The 2023 NCLEX-PN and NCLEX-RN Test Plans contain a Client Need category entitled "Pharmacological and Enteral Therapies." To assist students in preparing for the NCLEX based on the Activity Statements provided for this category, in addition to the content contained in this book, links to related content in the series of Open RN OER textbooks are provided below.

- Administer blood products and evaluate client response: "Administer Blood Products" chapter in Open RN *Advanced Skills*
- Access and/or maintain central venous access devices: "Manage Central Lines" chapter in Open RN *Advanced Skills*
- Perform calculations need for medication administration: "Math Calculations" chapter in Open RN *Nursing Skills*
- Prepare and administer medications using the rights of medication administration: "Administration of Enteral Medications" chapter in Open RN *Nursing Skills*
- Monitor intravenous infusion and maintain site: "IV Therapy Management" chapter in Open RN *Nursing Skills*
- Administer parenteral nutrition and evaluate client response: "Applying the Nursing Process" section in the Nutrition chapter of Open RN *Nursing Fundamentals*

Appendix B - Overall Glossary

This section contains an overall glossary of terms used in this book and the location where the content can be found.

A

A1C: A lab test used to assess long-term blood glucose levels over three months. The general A1C target level is less than 7%. (Chapter 9.4)

Absorption: The first stage of pharmacokinetics where medications enter the body and travel from site of administration into the body's circulation. (Chapter 1.2, Chapter 1.3)

Acetylcholine (ACh): Binds to both nicotinic receptors and muscarinic receptors in the PNS. (Chapter 4.2)

Action potential: A change in voltage of a cell membrane in response to a stimulus that results in transmission of an electrical signal; unique to neurons and muscle fibers. (Chapter 8.2)

Acute dystonia: Painful muscle spasms. (Chapter 8.9)

Acute pain: Pain that usually starts suddenly and has a known cause, like an injury or surgery. It normally gets better as your body heals and lasts less than three months. (Chapter 10.3)

ADME: Four basic stages of pharmacokinetics a medication goes through within the human body: absorption, distribution, metabolism, and excretion. (Chapter 1.2)

Adjuvant analgesics: Drugs with a primary indication other than pain that have analgesic properties in some painful conditions. The group includes numerous drugs in diverse classes such as gabapentin (an anticonvulsant) or amitriptyline (a tricyclic antidepressant). (Chapter 10.5)

Adrenal cortex: A component of the hypothalamic-pituitary-adrenal (HPA) axis that produces the steroid hormones important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation. (Chapter 9.2)

Adrenal medulla: Neuroendocrine tissue composed of postganglionic sympathetic nervous system (SNS) neurons that are stimulated by the autonomic nervous system to secrete hormones epinephrine and norepinephrine. (Chapter 9.3)

Adrenergic: Postganglionic neuron where neurotransmitters norepinephrine and epinephrine are released. Includes alpha (α)-receptors and beta (β)-receptors. (Chapter 4.2)

Adrenergic agonist: Mimics the effects of the body's natural SNS stimulation on alpha (α)- and beta (β)-receptors. Also called sympathomimetics. (Chapter 4.2)

Adrenergic antagonist: Blocks the effects of the SNS receptors. (Chapter 4.2)

Adsorption: The adhesion of molecules to a surface. For example, bismuth salicylate coats the walls of the GI tract and binds the causative bacteria or toxin for elimination from the GI tract through the stool. (Chapter 7.4)

Adverse effect: An unintended and potentially dangerous pharmacological effect that occurs when a medication is administered correctly. (Chapter 1.11)

Affective mood disorders: Mental health illness such as major depression. (Chapter 8.3)

Affinity: The strength of binding between drug and receptor. (Chapter 1.2)

Afterload: The tension that the ventricles must develop to pump blood effectively against the resistance in the vascular system. (Chapter 6.2)

Agonist: A drug that binds to a "receptor" and produces an effect. (Chapter 1.7)

Akathisia: Distressing motor restlessness. (Chapter 8.9)

Aldosterone: A mineralocorticoid released by the adrenal cortex that controls fluid and electrolyte balance through the regulation of sodium and potassium. (Chapter 9.3)

Allergies: Allergies occur when the immune system reacts to a foreign substance and makes antibodies that identify a particular allergen as harmful, even though it is not. (Chapter 5.3)

American Nurses Association (ANA): The professional organization that represents the interests of the nation's four million registered nurses. (Chapter 2.2)

Anaphylaxis: A severe, potentially life-threatening allergic reaction. It can occur within seconds or minutes of exposure to something you are allergic to, such as peanuts or bee stings. (Chapter 5.3)

Antacids: Used to neutralize stomach acid and reduce the symptoms of heartburn. (Chapter 7.3)

Antagonist: A molecule that prevents the action of other molecules, often by competing for a cellular receptor; opposite of agonist. (Chapter 1.7)

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. (Chapter 3.3)

Anticholinergics: Inhibit acetylcholine (ACh), which allows the SNS to dominate. Also called parasympatholytics or muscarinic antagonists. Overall use is to relax smooth muscle. (Chapter 4.2)

Anticoagulant: Any substance that opposes coagulation. (Chapter 6.12)

Antidiarrheals: Relieve the symptoms of diarrhea, such as an increased frequency and urgency when passing stools, but do not eliminate the cause of it. (Chapter 7.4)

Antidiuretic hormone (ADH): ADH is released by the posterior pituitary in response to stimuli from osmoreceptors indicating high blood osmolarity. Its effect is to cause increased water reabsorption by the kidneys. As more water is reabsorbed by the kidneys, the greater the amount of water that is returned to the blood, thus causing a decrease in blood osmolarity. ADH is also known as vasopressin because, in very high concentrations, it causes constriction of blood vessels, which increases blood pressure by increasing peripheral resistance. (Chapter 9.2)

Antifungal: Medications that are used to treat fungal infections. For example, nystatin is used to treat *Candida albicans*, a fungal infection. (Chapter 3.2)

Antimotility medications: Medications that help to treat diarrhea by slowing peristalsis. (Chapter 7.4)

Antiviral: Medications used to treat viral infections. For example, Tamiflu is used to treat influenza. (Chapter 3.2)

Area postrema: A structure in the medulla oblongata in the brain stem that controls vomiting. Its location in the brain also allows it to play a vital role in the control of autonomic functions by the central nervous system. (Chapter 7.5)

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. (Chapter 6.3)

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. (Chapter 6.3)

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). (Chapter 6.2)

Atherosclerosis: A buildup, called plaque, that can narrow arteries enough to impair blood flow. (Chapter 6.3)

Autonomic nervous system: Controls cardiac and smooth muscle, as well as glandular tissue; associated with involuntary responses. (Chapter 4.2)

B

Bactericidal: Antimicrobial drugs that kill their target bacteria. (Chapter 3.2)

Bacteriostatic: Antimicrobial drugs that cause bacteria to stop reproducing but may not ultimately kill the bacteria. (Chapter 3.2)

Basal insulin: Long-acting (insulin glargine or insulin detemir) or intermediate-acting (NPH) insulin. (Chapter 9.4)

Basal metabolic rate: The amount of energy used by the body at rest. (Chapter 9.2)

Beneficence: To “do good.” (Chapter 2.2)

Bioavailability: The presence of a drug in the bloodstream after it is administered. (Chapter 1.2)

Blood-brain barrier (BBB): A nearly impenetrable barricade that is built

from a tightly woven mesh of capillaries cemented together to protect the brain from potentially dangerous substances such as poisons or viruses. (Chapter 1.4, Chapter 8.11)

Blood osmolarity: The concentration of solutes (such as sodium and glucose) in the blood. (Chapter 9.2)

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. (Chapter 6.2)

Boxed Warnings: The strongest warnings issued by the Federal Drug Association (FDA) that signify a drug carries a significant risk of serious or life-threatening adverse effects. (Chapter 2.3)

Bradykinesia: Slowness in initiation and execution of voluntary movements. (Chapter 8.3)

Broad-spectrum antimicrobial: An antibiotic that targets a wide variety of bacterial pathogens, including both gram-positive and gram-negative species. (Chapter 3.2)

C

Capillaries: Smallest arteries where nutrients and wastes are exchanged at the cellular level. (Chapter 6.2)

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: $CO = HR \times SV$. (Chapter 6.2)

Catecholamines: Include norepinephrine, epinephrine, and dopamine. Stimulate the adrenergic receptors. (Chapter 4.15)

Central nervous system (CNS): Anatomical division of the nervous system located within the cranial and vertebral cavities, namely the brain and spinal cord. (Chapter 4.2, Chapter 8.2)

Cerebrovascular accident (CVA): Lack of blood flow to the brain that can cause irreversible brain damage, often referred to as a “stroke.” (Chapter 6.3)

Chemical synapse: Connection between two neurons, or between a neuron and its target, where a neurotransmitter diffuses across a very short distance. (Chapter 8.2)

Chemoreceptor trigger zone (CTZ): Area in the brain that responds directly

to toxins in the bloodstream and also receives stimuli from several other locations in the body that stimulate the vomiting center. (Chapter 7.5)

Cholinergic: Postganglionic neuron where acetylcholine (ACh) is released that stimulates nicotinic receptors and muscarinic receptors. Also relating to drugs that inhibit, enhance, or mimic the action of ACh. (Chapter 4.2)

Chronic pain: Pain that lasts six months or more and can be caused by a disease or condition, injury, medical treatment, inflammation, or an unknown reason. (Chapter 10.3)

Chronotropic: Drugs may change the heart rate and rhythm by affecting the electrical conduction system of the heart and the nerves that influence it, such as by changing the rhythm (increasing) produced by the sinoatrial node. Positive chronotropes increase heart rate; negative chronotropes decrease heart rate. (Chapter 4.2)

Clostridium difficile (C-diff): Causes pseudomembranous colitis, a superinfection that can be caused by broad-spectrum antibiotic therapy. (Chapter 3.2)

Coagulation: The formation of a blood clot. (Chapter 6.2)

Code of Ethics for Nurses: Developed by the American Nurses Association as a guide for carrying out nursing responsibilities in a manner consistent with quality in nursing care and the ethical obligations of the profession. (Chapter 2.2)

Complementary and alternative medications (CAM): Therapies that are commonly used in conjunction with, or as an alternate to, traditional medical therapies such as vitamins, herbs, and other supplements. These substances are not regulated by the FDA, and most have not undergone rigorous scientific testing for safety for the public. (Chapter 1.8)

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. (Chapter 6.2)

Contractility: The force of contraction of the heart. (Chapter 6.2)

Culture: A test performed on various body substances for the presence of bacteria or fungus. (Chapter 3.2)

Cultural competence: The process by which nurses demonstrate culturally congruent practice. (Chapter 2.2)

Cultural humility: A humble and respectful attitude toward individuals of other cultures that pushes one to challenge their own cultural biases, realize they cannot possibly know everything about other cultures, and approach learning about other cultures as a lifelong goal and process. (Chapter 2.4)

Culturally congruent practice: The application of evidence-based nursing that is in agreement with the preferred cultural values, beliefs, worldview, and practices of the health care consumer and other stakeholders. (Chapter 2.2)

Cyanotic: A bluish or purplish discoloration (as of skin) due to deficient oxygenation of the blood. (Chapter 5.3)

Cytochrome P-450 enzymes: Enzymes produced from the cytochrome P450 genes involved in the formation (synthesis) and breakdown (metabolism) of various molecules, chemicals, and medications within cells. (Chapter 7.3)

D

Defecation: The digestive process where undigested materials are removed from the body as feces. (Chapter 7.4)

Diabetes insipidus (DI): A disease characterized by underproduction of ADH that causes chronic dehydration. (Chapter 9.2)

Diarrhea: The passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual). (Chapter 7.4)

Diastole: The period of relaxation that occurs as the chambers fill with blood. (Chapter 6.2)

Distribution: The second stage of pharmacokinetics where medication is dispersed throughout the body via the bloodstream. (Chapter 1.2, Chapter 1.4)

Do Not Crush list: A list of medications that should not be crushed, often due to a sustained-release formulation. (Chapter 2.2)

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. (Chapter 3.3)

Dose-response: The dose of medication required to achieve the desired response to the medication. (Chapter 1.9)

Dromotropic: Stimulation causes speed of conduction between SA and AV node. (Chapter 4.2)

Drug diversion: The transfer of any legally prescribed controlled substance from the individual for whom it was prescribed to another person for any illicit use. (Chapter 2.3)

Drug reaction with eosinophilia and systemic symptoms (DRESS): A condition reported in clients taking antiepileptic drugs. Some of these events have been fatal or life-threatening. DRESS typically presents with fever, rash, lymphadenopathy, and/or facial swelling. (Chapter 8.10)

Drugs: Medications or other substances that have a physiological effect when introduced to the body. (Chapter 1.2)

Duration: The length of time that a medication is producing its desired therapeutic effect. (Chapter 1.9)

Dystonia: Inappropriate and continuous muscle contraction. (Chapter 8.3)

E

Edema: The presence of excess tissue fluid around the cells. (Chapter 6.2)

Efficacy: The maximum effect of which the drug is capable. (Chapter 1.9)

Electrical synapse: Connection between two neurons, or any two electrically active cells, where ions flow directly through channels spanning their adjacent cell membranes. (Chapter 8.2)

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. (Chapter 6.3)

Emesis: The forceful oral expulsion of gastric contents. (Chapter 7.5)

Endocrine gland: Gland that secretes hormones that target other organs. (Chapter 9.2)

Error-prone abbreviations: Abbreviations, symbols, and dose designations

that are frequently misinterpreted and involved in harmful medication errors. (Chapter 2.5)

Excretion: The final stage of pharmacokinetics where drug byproducts and metabolites are eliminated from the body. (Chapter 1.2, Chapter 1.6)

Exocrine gland: Gland that secretes digestive enzymes. (Chapter 9.4)

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). Often treated with anticholinergic medications such as benztropine and trihexyphenidyl. (Chapter 8.9)

F

Fibrillation: An uncoordinated beating of the heart, which if serious and untreated, can lead to decreased cardiac output and death. (Chapter 6.3)

Fibrinolysis: The gradual degradation of a clot. (Chapter 6.2)

Fight-or-flight response: The response when the SNS is stimulated, causing the main effects of increased heart rate, increased blood pressure, and bronchodilation. (Chapter 4.2)

First-pass effect: The inactivation of orally or enterally administered drugs in the liver and intestines. (Chapter 1.3)

Five rights of medication administration: Standards of practice that require the following information is confirmed prior to each administration of medication: right patient, right drug, right dose, right time, and right route. (Chapter 2.3)

G

Gait disturbance: An abnormal way of walking, such as shuffling feet. (Chapter 8.3)

Gas exchange: The process at the alveoli level where blood is oxygenated and carbon dioxide, the waste product of cellular respiration, is removed from the body. (Chapter 5.2)

Gastroenteritis: Infection of the intestines. (Chapter 7.5)

Gastroesophageal reflux disease (GERD): Caused by excessive hydrochloric acid that tends to back up, or reflux, into the lower esophagus. (Chapter 7.3)

General adaptation syndrome (GAS): The pattern in which the body responds in different ways to stress: the alarm reaction (otherwise known as the fight-or-flight response), the stage of resistance, and the stage of exhaustion. (Chapter 9.3)

Glycogenolysis: The breakdown of glycogen into glucose, causing elevated blood glucose. (Chapter 4.2)

Glycolysis: Stimulated by insulin, the metabolism of glucose for generation of ATP. (Chapter 9.4)

Goiter: A visible enlargement of the thyroid gland when there is hyperstimulation of TSH due to deficient levels of T3 and T4 hormones in the bloodstream or an autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland, causing hyperthyroidism. (Chapter 9.5)

Gram-negative: Gram-negative bacteria are classified by the color they turn after a chemical called gram stain is applied to them. *Escherichia Coli* (also known as E. Coli) is an example of a gram-negative infection. (Chapter 3.2)

Gram-positive: Gram-positive bacteria are classified by the color they turn after a chemical called gram stain is applied to them. Infections caused by *Streptococcus* and *Staphylococcus* bacteria are examples of gram-positive infections. (Chapter 3.2)

Gram stain: A test used to quickly diagnose types of bacterial infection. Gram-positive and gram-negative bacteria stain differently because their cell walls are different. Identification of bacteria as gram-positive or gram-negative assists the health care provider in selecting an appropriate antibiotic to treat the infection. (Chapter 3.2)

H

Half-life: The rate at which 50% of a drug is eliminated from the bloodstream. (Chapter 1.5, Chapter 3.3)

Health literacy: The degree to which individuals have the capacity to obtain, process, and understand basic health information needed to make appropriate health decisions. (Chapter 2.4)

Hematemesis: Blood in the vomit. (Chapter 7.5)

Hemostasis: The process by which the body temporarily seals a ruptured blood vessel and prevents further loss of blood. (Chapter 6.2)

High-risk medications: Drugs that bear a heightened risk of causing significant client harm when they are used in error. (Chapter 2.5)

Homeostasis (in ANS): 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. (Chapter 4.2)

Hormones: Chemical signals sent by the endocrine organs and transported via the bloodstream throughout the body where they bind to receptors on target cells and induce a characteristic response. (Chapter 9.2)

Humoral stimuli: Changes in blood levels of nonhormone chemicals that cause an endocrine gland to release or inhibit a hormone to maintain homeostasis. For example, high blood sugar causes the pancreas to release insulin. (Chapter 9.2)

Hypercalcemia: Elevated levels of calcium in the bloodstream. (Chapter 7.3)

Hyperglycemia: Elevated blood glucose levels. (Chapter 9.4)

Hyperlipidemia: Elevated cholesterol levels in the blood that increase a client's risk for heart attack and stroke. (Chapter 4.2, Chapter 6.3)

Hyperparathyroidism: A disorder caused by an overproduction of PTH that results in excessive calcium resorption from bone, causing significantly decreased bone density and spontaneous fractures, decreased responsiveness of the nervous system, and calcium deposits in the body's tissues and organs, impairing their functioning. (Chapter 9.5)

Hypertension: Chronically elevated blood pressure. (Chapter 6.10)

Hypertensive crisis: 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. Seizures may also occur. Intracranial bleeding, sometimes fatal, has been reported in association with the increase in blood pressure. (Chapter 8.7)

Hyperthyroidism: Abnormally elevated blood level of thyroid hormones T3 and T4, often caused by a pituitary tumor, thyroid tumor, or autoimmune

reaction in which antibodies overstimulate the follicle cells of the thyroid gland. (Chapter 9.5)

Hypervolemia: Excessive fluid volume caused by retention of water and sodium, as seen in clients with heart failure, liver cirrhosis, and some forms of kidney disease. (Chapter 6.2)

Hypoglycemia: A blood glucose level below 70 mg/dL; severe hypoglycemia refers to a blood glucose level below 40. (Chapter 9.4)

Hypoparathyroidism: Abnormally low blood calcium levels caused by parathyroid hormone deficiency, which may develop following thyroid surgery. Low blood calcium can cause muscle twitching, cramping, spasms, or convulsions; severe deficits can paralyze muscles, including those involved in breathing, and can be fatal. (Chapter 9.5)

Hypothalamic-pituitary-adrenal (HPA) axis: The hypothalamus stimulates the release of ACTH from the pituitary, which then stimulates the adrenal cortex to produce the hormone cortisol and steroid hormones important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation. (Chapter 9.3)

Hypothalamus–pituitary complex: The "command center" of the endocrine system that 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. (Chapter 9.2)

Hypothyroidism: Abnormally low blood levels of thyroid hormones T3 and T4 in the bloodstream. (Chapter 9.5)

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. (Chapter 6.2)

I

Immune-mediated disease process: Occurs when the body's immune system attacks the central nervous system. (Chapter 10.3)

Inappropriate polypharmacy: Present when one or more medicines are prescribed that are not or no longer needed. (Chapter 2.5)

Indications: The use of a drug for treating a particular condition or disease. The FDA determines if there is enough evidence for a labeled indication of a drug. Providers may also prescribe medications for off-label indications if there is reasonable scientific evidence that the drug is effective, but these uses have not been approved by the FDA. (Chapter 3.5)

Inotropic: Stimulation causes increased force of contraction. (Chapter 4.2)

Insulin: A hormone that facilitates the uptake of glucose into skeletal and adipose body cells. (Chapter 9.4)

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. (Chapter 6.12)

Intrinsic factor: Necessary for the absorption of vitamin B12 in the small intestine. (Chapter 7.3)

Involuntary responses: Responses that the brain controls without the need for conscious thought. (Chapter 4.1)

Ischemia: Reduced blood flow to the tissue region "downstream" of the narrowed vessel. (Chapter 6.3)

L

Look-alike and sound-alike (LASA) drugs: Medications that require special safeguards to reduce the risk of errors and minimize harm. (Chapter 2.5)

Loop of Henle: A component of the nephron where loop diuretics act to eliminate sodium and water. (Chapter 6.2)

M

Maleficence: Causing harm to patients. (Chapter 2.2)

Mania: Periods of extreme highs in bipolar disorder. Manic episodes may include these symptoms: rapid speech, hyperactivity, reduced need for sleep, flight of ideas, grandiosity, poor judgment, aggression/hostility, risky sexual behavior, neglected basic self-care, or decreased impulse control. (Chapter 8.3)

Mechanism of action: How a medication works at a cellular level within the body. (Chapter 1.7, Chapter 3.2)

Metabolism: The third stage of pharmacokinetics that involves the breakdown of a drug so that it can be excreted by the body. (Chapter 1.2, Chapter 1.5)

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. (Chapter 3.2)

Mineralocorticoids: Hormones released by the adrenal cortex that regulate body minerals, especially sodium and potassium, that are essential for fluid and electrolyte balance. Aldosterone is the major mineralocorticoid. (Chapter 9.3)

Misuse: The use of illegal drugs and/or the use of prescription drugs in a manner other than as directed by a provider, such as using in greater amounts, more often, or longer than told to take a drug or using someone else's prescription. (Chapter 10.4)

Motor neurons: Consist of the somatic nervous system that stimulates voluntary movement of muscles and the autonomic nervous system that controls involuntary responses. (Chapter 4.2)

Muscarinic agonists: Also called parasympathomimetics. Primarily cause smooth muscle contraction, resulting in decreased HR, bronchoconstriction, increased gastrointestinal/genitourinary tone, and pupil constriction. (Chapter 4.2)

Muscle spasticity: Condition in which certain muscles are continuously contracted. This contraction causes stiffness or tightness of the muscles and can interfere with normal movement, speech, and gait. Spasticity is usually caused by damage to the portion of the brain or spinal cord that controls voluntary movement. (Chapter 10.3)

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. (Chapter 6.3)

N

Narrow-spectrum antimicrobial: An antibiotic that targets only specific subsets of bacterial pathogens. (Chapter 3.2)

National Patient Safety Goals (NPSGs): Goals established by The Joint Commission to help accredited organizations address specific areas of concern related to patient safety. (Chapter 2.3)

Negative feedback loop: Characterized by the inhibition of further secretion of a hormone in response to adequate levels of that hormone. (Chapter 9.2)

Negative inotropic factors: Factors that decrease contractility. (Chapter 6.2)

Nerve: Cord-like bundle of axons located in the peripheral nervous system that transmits sensory input and response output to and from the central nervous system. (Chapter 8.8)

Neural stimuli: Released in response to stimuli from the nervous system. For example, the activation of the release of epinephrine and norepinephrine in the fight-or-flight response is stimulated by the sympathetic nervous system. (Chapter 9.2)

Neuroleptic malignant syndrome (NMS): Potentially life-threatening adverse effect that includes high fever, unstable blood pressure, and myoglobinemia. (Chapter 8.7)

Neuron(s): Neural tissue cell that is primarily responsible for generating and propagating electrical signals into, within, and out of the nervous system. (Chapter 4.2, Chapter 8.2)

Neurotransmitter: Chemical signal that is released from the synaptic end bulb of a neuron to cause a change in the target cell. (Chapter 8.2)

Nociceptors: Nerve endings that selectively respond to painful stimuli and send pain signals to the brain and spinal cord. (Chapter 10.2)

Nonpharmacologic therapy: Treatments that do not involve medications, including physical treatments (e.g., heat or cold therapy, exercise therapy, weight loss) and cognitive-behavioral treatments (e.g., distractions/diversions and cognitive behavioral therapy). (Chapter 10.4)

Nonselective beta-blockers: Medications that block both Beta-1 and Beta-2 receptors, thus affecting both the heart and lungs. (Chapter 4.2)

Nursing: The protection, promotion, and optimization of health and abilities, prevention of illness and injury, facilitation of healing, alleviation of

suffering through the diagnosis and treatment of human response, and advocacy in the care of individuals, families, groups, communities, and populations, as defined by the American Nurses Association. (Chapter 2.2)

Nursing process: Standards of Practice that include Assessment, Diagnosis, Outcome Identification, Planning, Implementation, and Evaluation components of providing client care. (Chapter 2.3)

Nursing Scope and Standards of Practice: A document created by the American Nurses Association that outlines professional nursing performance according to national standards. (Chapter 2.2)

O

Onset: When a medication first begins to work and exerts a therapeutic effect. (Chapter 1.9)

Ophthalmoplegia: Weakness in eye muscles. (Chapter 8.3)

Orthostatic hypotension: A significant change in blood pressure from lying to sitting to standing. (Chapter 8.7)

Osmoreceptors: Specialized cells within the hypothalamus that are sensitive to the concentration of sodium ions and other solutes in the bloodstream. (Chapter 9.2)

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. (Chapter 7.4)

P

Pallor: A deficiency of color especially of the face; paleness. (Chapter 5.4)

Paradoxical effect: An effect that is opposite to what is expected. (Chapter 5.6)

Parasympathetic nervous system (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. (Chapter 4.2)

Parasympatholytics: Inhibit acetylcholine (ACh), which allows the SNS to

dominate. Also called anticholinergics or muscarinic antagonists. (Chapter 4.2)

Parasympathomimetics: Also called muscarinic agonists. Primarily cause smooth muscle contraction, resulting in decreased HR, bronchoconstriction, increased GI/GU tone, and pupil constriction. (Chapter 4.2)

Parathyroid hormone (PTH): The hormone released by parathyroid glands and is involved in the regulation of blood calcium levels. (Chapter 9.5)

Parietal cells: Cells in the gastric glands that produce and secrete hydrochloric acid (HCl) and intrinsic factor. (Chapter 7.3)

Partial thromboplastin time (PTT): A blood test used to monitor how long it takes for a client's blood to clot. PTT is used for clients 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. (Chapter 6.12)

Pathogen: An organism causing disease to its host. (Chapter 3.2)

Patient-controlled analgesia (PCA): To receive the opioid, the patient pushes a button on the PCA device, which releases a specific dose but also has a lockout mechanism to prevent an overdose. Included with hydromorphone or fentanyl. (Chapter 10.7)

Peak: When the maximum concentration of a drug is in the bloodstream. (Chapter 1.9, Chapter 1.10)

Pepsin: A digestive enzyme. (Chapter 7.3)

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. (Chapter 7.3)

Peripheral nervous system (PNS): An anatomical division of the nervous system that is largely outside the cranial and vertebral cavities, namely all parts except the brain and spinal cord. (Chapter 4.2, Chapter 8.2)

Pharmacodynamics: The effects of drugs in the body and the mechanism of their action. (Chapter 1.2, Chapter 1.7)

Pharmacogenetics: The study of how a person's genetic makeup affects their response to medicines. (Chapter 1.2)

Pharmacokinetics: The study of how the body absorbs, distributes, metabolizes, and eliminates drugs. (Chapter 1.2)

Pharmacology: The science dealing with actions of drugs on the body. (Chapter 1.1)

Pharmacy: The science of the preparation of drugs.

Polypharmacy: The concurrent use of multiple medications. (Chapter 2.5)

Positive inotropic factors: Factors that increase contractility. (Chapter 6.2)

Postganglionic neurons: Differ for the SNS and PNS branches. Postganglionic neurons of the autonomic system are classified as either cholinergic, meaning that acetylcholine (ACh) is released, or adrenergic, meaning that norepinephrine is released. (Chapter 4.2)

Postural instability: Abnormal fixation of posture (stoop when standing), problems with equilibrium, and righting reflex. (Chapter 8.3)

Potency: The drug dose required to produce a specific intensity of effect. (Chapter 1.11)

Prandial insulins: During or relating to the eating of food. (Chapter 9.4)

Preganglionic neurons: Release acetylcholine (ACh). (Chapter 4.2)

Preload: The amount of blood in the atria just prior to atrial contraction. (Chapter 6.2)

Prescription Drug Monitoring Programs (PDMP): A statewide electronic database that collects designated data on substances dispensed in a state to address prescription drug abuse, addiction, and diversion. (Chapter 2.3)

Probiotics: Used for the prevention and treatment of diarrhea by restoring normal bacteria flora in the gastrointestinal tract. (Chapter 7.4)

Professional assistance procedure: A voluntary nondisciplinary program to provide support for credentialed professionals in Wisconsin with a substance abuse disorder who are committed to their own recovery. (Chapter 2.3)

Prokinetic: Medications used to promote peristalsis to empty the gastrointestinal tract and reduce nausea. (Chapter 7.5)

Prostaglandins: Produced in nearly all cells and are part of the body's way of dealing with injury and illness. Prostaglandins act as signals to control several different processes depending on the part of the body in which they are made. Prostaglandins are made at the sites of tissue damage or infection,

where they cause inflammation, pain, and fever as part of the healing process. (Chapter 10.2)

Prothrombin time (PT): A blood test that measures how long it takes for a client's blood to clot. PT is used to monitor the effects of warfarin in preventing clot formation. (Chapter 6.12)

Proton pump inhibitors (PPIs): Bind to the hydrogen-potassium ATPase enzyme system of the parietal cell and inhibit the release of hydrogen ions into the stomach. (Chapter 7.3)

Prototype: A common individual drug that represents a drug class or group of medications having similar chemical structures, mechanisms of action, and modes of action. (Chapter 3.5)

R

Rebound hyperacidity: A side effect of medication causing elevated levels of hydrochloric acid in the stomach after the medication is discontinued. (Chapter 7.3)

Registered Nurse (RN): An individual who is educationally prepared and licensed by a state to practice as a registered nurse. (Chapter 2.2)

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. (Chapter 6.2)

Resistance: A characteristic of bacteria when sensitivity analysis is performed demonstrating lack of effective treatment by a particular antibiotic. (Chapter 3.2)

Respiratory rate: The total number of breaths, or respiratory cycles, that occur each minute. 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. (Chapter 5.2)

Rigidity: Increased muscle tone and increased resistance to movement. As severity increases, there may be cogwheel rigidity. (Chapter 8.3)

Root cause analysis: An analysis after an error occurs 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. (Chapter 2.3)

S

Safety culture: The culture of a health care agency that empowers staff to speak up about risks to clients and to report errors and near misses, all of which drive improvement in client care and reduce the incident of client harm. (Chapter 2.3)

Scheduled medications: The Controlled Substances Act (CSA) places all substances that are regulated under existing federal law into one of five schedules, ranging from Schedule I drugs with a high potential for abuse and the potential to create severe psychological and/or physical dependence, to Schedule V drugs with the least potential for abuse. (Chapter 2.3)

Selective beta-blocker: Medications that mostly inhibit B1-receptors. (Chapter 4.2)

Selectivity: The separation between the desired and undesired effects of a drug. (Chapter 1.11)

Sensitivity analysis: A test performed in addition to a culture to select an effective antibiotic to treat a microorganism. (Chapter 3.2)

Sensory neurons: Sense the environment and conduct signals to the brain that become a conscious perception of that stimulus. (Chapter 4.2)

Serotonin syndrome: May occur when taking serotonin medications. Includes mental status changes (e.g., agitation, hallucinations, coma), autonomic instability (e.g., tachycardia, labile blood pressure, hyperthermia), neuromuscular aberrations (e.g., hyperreflexia, incoordination) and/or gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea). Serotonin syndrome, in its most severe form, can resemble neuroleptic malignant

syndrome, which includes hyperthermia, muscle rigidity, autonomic instability with possible rapid fluctuation of vital signs, and mental status changes. (Chapter 7.5, Chapter 8.7)

Side effect: Effect of a drug, other than the desired effect, sometimes in an organ other than the target organ. (Chapter 1.11)

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. (Chapter 6.2)

Sinus rhythm: Normal electrical pattern followed by contraction of the heart. (Chapter 6.2)

"SLUDGE": Mnemonic for the effects of anticholinergics: Salivation decreased, Lacrimation decreased, Urinary retention, Drowsiness/dizziness, GI upset, Eyes (blurred vision/dry eyes). (Chapter 4.2)

Social determinants of health (SDOH): Conditions in the places where people live, learn, work, and play that can affect a wide range of health risks and outcomes. (Chapter 2.2, Chapter 2.4)

Somatic nervous system: Causes contraction of skeletal muscles; associated with voluntary responses. (Chapter 4.2)

Sputum: Matter expectorated from the respiratory system and especially the lungs that is composed of mucus but may contain pus, blood, fibrin, or microorganisms (such as bacteria) in diseased states. (Chapter 5.4)

Standards of practice: Authoritative statements of duties by the American Nursing Association that all registered nurses, regardless of role, population, or specialty, are expected to perform competently. Standards of Practice include Assessment, Diagnosis, Outcome Identification, Planning, Implementation, and Evaluation components of providing client care. (Chapter 2.2)

Standards of professional performance: Describe a competent level of behavior in the professional role, including activities related to ethics, culturally congruent practice, communication, collaboration, leadership, education, evidence-based practice, and quality of practice as defined by the American Nursing Association. (Chapter 2.2)

State Board of Nursing: A group of officials who enforce the State Nurse Practice Act. (Chapter 2.3)

State Nurse Practice Act: Law enacted by state legislatures setting professional standards of nursing care to which nurses are held accountable by the State Board of Nursing. (Chapter 2.2)

Status epilepticus: A state of repeated or continuous seizures. (Chapter 8.3)

Steady state: The point at which the amount of drug entering the body is equal to the amount of drug being eliminated, resulting in a stable drug concentration. (Chapter 1.9)

Stimulants: Laxatives that cause the intestines to contract, inducing stool to move through the colon. (Chapter 7.4)

Stool softeners: Laxatives that facilitate movement of water and fats into stool to make it soft and improve regularity of bowel movements. (Chapter 7.4)

Stress-related mucosal damage: A common condition in hospitalized clients that can lead to peptic ulcer disease (PUD). (Chapter 7.3)

Stress ulcer prophylaxis: Medication to prevent the formation of stress ulcers. (Chapter 7.3)

Stroke volume (SV): The amount of blood that both ventricles pump during each contraction, normally in the range of 70–80 mL. (Chapter 6.2)

Substance use disorder: A pattern of behaviors that ranges from misuse to dependency or addiction, whether it is alcohol, legal drugs, or illegal drugs. Addiction is a complex disease with serious physical, emotional, financial, and legal consequences. (Chapter 2.3)

Superinfection: A secondary infection in a client having a preexisting infection. C-diff and yeast infections as a result of antibiotic therapy are examples of superinfections. (Chapter 3.2)

Surface epithelium cells: Cells found within the lining of the stomach that secrete mucus as a protective coating. (Chapter 7.3)

Sympathetic nervous system (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. (Chapter 4.2)

Sympathomimetics: Mimic the effects of the body’s natural SNS stimulation of adrenergic receptors. Also called adrenergic agonists. (Chapter 4.2)

Synapse: The connection between the neuron and its target cell. (Chapter 4.2)

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). (Chapter 3.3)

Systole: The period of contraction that the heart undergoes while it pumps blood into circulation. (Chapter 6.2)

T

Tardive dyskinesia: Involuntary contraction of the oral and facial muscles (such as tongue thrusting) and wavelike movements of the extremities. (Chapter 8.9)

Thalamus: The region of the central nervous system that acts as a relay for sensory pathways. (Chapter 8.2)

THC: Tetrahydrocannabinols found in marijuana. (Chapter 7.5)

The Joint Commission: A national organization that accredits and certifies health care organizations in the United States. (Chapter 2.3)

Therapeutic index: A quantitative measurement of the relative safety of a drug that compares the amount of drug that produces a therapeutic effect versus the amount of drug that produces a toxic effect. Medication with a large therapeutic index is safer than a medication with a small therapeutic index. (Chapter 1.10)

Therapeutic window: The dosing window in which the safest and most effective treatment will occur. (Chapter 1.10)

Threshold: The membrane voltage at which an action potential is initiated. (Chapter 8.2)

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. (Chapter 6.2)

Time dependent: Time dependency occurs when greater therapeutic effects are seen with lower blood levels over a longer period of time. (Chapter 3.3)

Titration: The process of adjusting a medication dose to achieve a desired therapeutic effect for the client. (Chapter 1.10)

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. (Chapter 6.3)

Tremor: Usually tremor at rest; when person sits, the arms shake, but tremor stops when person attempts to grab something. (Chapter 8.3)

Tropic hormones: Hormones that turn on or off the function of other endocrine glands, including ACTH, FSH, LH, and TSH. (Chapter 9.2)

Trough: A drug level drawn from the bloodstream when the drug is at its lowest concentration, typically right before the next scheduled dose is given. (Chapter 1.10)

Type 1 diabetes: An autoimmune disease that affects the beta cells of the pancreas so they do not produce insulin; thus, synthetic insulin must be administered by injection or infusion. (Chapter 9.4)

Type 2 diabetes: A condition where the body's cells become resistant to the effects of insulin. Over time, the beta cells become exhausted and if blood glucose levels cannot be controlled through a healthy diet and exercise, then oral diabetic medication must be implemented and eventually insulin administration may be required. (Chapter 9.4)

V

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. (Chapter 3.2)

Veins: Blood vessels that conduct blood toward the heart (except for pulmonary veins that carry deoxygenated blood from the heart to the lungs). (Chapter 6.2)

Venous reserve: Volume of blood located in venous networks within the liver, bone marrow, and integument. (Chapter 6.2)

Vertigo: A sense of spinning dizziness. It is a symptom of a range of conditions. It can happen when there is a problem with the inner ear, brain, or sensory nerve pathway. (Chapter 10.3)

Vestibular system: An area located within the inner ear that gives a sense of

balance and spatial orientation for the purpose of coordinating movement with balance. (Chapter 7.5)

Vomiting center (VC): An area in the brain that 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. (Chapter 7.5)

Appendix C - Virtual Simulation

Practice your clinical judgment as you apply nursing knowledge gained from this book in a virtual simulation as you care for six virtual patients in a long term care setting.

Access the free online virtual simulation using this link: https://cvtc.h5p.com/content/1292014892726649668