Pharmacology for Nurses A Pathophysiologic Approach 7th Edition PDF

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Preface

When students are asked which subject in their nursing program is the most challenging, pharmacology always appears near the top of the list. The study of pharmacology demands that students apply knowledge from a wide variety of the natural and applied sciences. Successfully predicting drug action requires a thorough knowledge of anatomy, physiology, chemistry, and pathology as well as the social sciences of psychology and sociology. Lack of adequate pharmacology knowledge can result in immediate and direct harm to the patient; thus, the stakes in learning the subject are high.

Pharmacology cannot be made easy, but it can be made understandable when the proper connections are made to knowledge learned in these other disciplines. The vast majority of drugs in clinical practice are prescribed for specific diseases, yet many pharmacology textbooks fail to recognize the complex interrelationships between pharmacology and pathophysiology. When drugs are learned in isolation from their associated diseases or conditions, students have difficulty connecting pharmacotherapy to therapeutic goals and patient wellness. The pathophysiology focus of this textbook gives the student a clearer picture of the importance of pharmacology to disease and, ultimately, to patient care. The approach and rationale of this textbook focus on a holistic perspective to patient care which clearly shows the benefits and limitations of pharmacotherapy in curing or preventing illness. In addition to its pathophysiology focus, medication safety and interdisciplinary teamwork are consistently emphasized throughout the text. Although difficult and challenging, the study of pharmacology is truly a fascinating, lifelong journey.

New to This Edition

It is amazing how much pharmacology has changed in the past 4 years. The seventh edition of *Pharmacology for Nurses: A Pathophysiologic Approach* has been thoroughly updated to reflect these changes to current pharmacotherapeutics and advances in understanding disease.

- **NEW!** Pregnancy data for all prototype drugs have been completely updated and expanded to reflect FDA requirements implemented since the previous edition.
- **NEW!** The clinical judgment measurement model is now discussed and integrated into all appropriate medication chapters.
- **NEW!** The nursing practice application feature has been totally transformed into Nursing Clinical Judgement. Students will love this concise, one-column format that reinforces the clinical judgment measurement model.
- **NEW!** Emerging therapies for the prevention and treatment of COVID-19 infections have been added to the antiviral chapter.
- **NEW!** Coverage of emerging mechanisms in pharmacotherapy are discussed, including use of m-RNA vaccines to teat COVID-19 infections, SGLT2 inhibitors for diabetes, and CGRP inhibitors for migraine.
- **NEW!** Pharmacotherapy of cystic fibrosis, narcolepsy, and amyotrophic lateral sclerosis has been added.
- **EXPANDED!** Includes more than 120 new drugs, drug classes, indications, and therapies that have been approved since the last edition.
- **EXPANDED!** Includes new and updated information on the importance of biomarkers and pharmacogenetics in the diagnosis and treatment of disease.
- **EXPANDED!** All drug tables drugs have been revised to reflect changes in therapeutics.
- **UPDATED!** Includes new CDC recommendations of the prevention of HIV infection following occupational exposure, nonoccupational exposure, perinatal exposure, and preexposure prophylaxis.
- **UPDATED!** The latest black box warnings issued by the FDA are included for all appropriate drug prototypes.
- **UPDATED!** All references have been updated to reflect current pharmacotherapeutics.
- **UPDATED!** Ten new special features have been added in topics applying research to nursing practice, community-oriented practice, lifespan considerations, and patient safety.

Organization and Structure—A Pathophysiology Approach

It is not enough for nursing students to memorize names, doses, and actions of medications. Not only would this be overwhelming (and boring), but those who wish to enter nursing must develop higher levels of understanding and demonstrate analytical and evaluation skills. The authors created this text to assist students in reaching those levels.

Pharmacology for Nurses: A Pathophysiologic Approach is organized according to body systems (units) and

diseases (chapters). The pathophysiologic approach clearly places the drugs in context with how they are used therapeutically. The student is able to locate easily all relevant anatomy, physiology, pathology, and pharmacology in the same chapter in which the drugs are discussed. This approach provides the student with a clear view of the connection among pharmacology, pathophysiology, and the nursing care learned in other clinical courses.

PROTOTYPE APPROACH: The number of drugs available in clinical practice is staggering. To facilitate learning, this text uses drug prototypes in which the most representative drugs in each classification are introduced in detail. Students are less intimidated when they can focus their learning on one representative drug in each class.

Prototype Drug | Atenolol *(Tenormin)*

Therapeutic Class: Drug for angina, MI, and HTN **Pharmacologic Class:** Beta-adrenergic blocker

Actions and Uses

Atenolol is one of the most frequently prescribed drugs due to its relative safety and effectiveness in treating a number of chronic disorders, including HF, HTN, angina, and MI. The drug selectively blocks $beta_1$-adrenergic receptors in the heart. Its effectiveness in treating angina is attributed to its ability to slow heart rate and reduce contractility, both of which lower myocardial oxygen demand. As with other beta blockers, therapy generally begins with low doses, which are gradually increased until the therapeutic effect is achieved.

Administration Alerts

- Blood pressure and pulse should be assessed before, during, and after the dose is administered.
- Assess pulse and blood pressure before oral administration. Hold if the pulse is below 60 beats per minute or if the patient is hypotensive.
- Neonates born to women taking beta blockers may experience hypoglycemia and bradycardia. Atenolol should not be used during pregnancy or lactation unless the potential benefits justify the potential risks to the fetus and neonate.

PHARMACOKINETICS

Onset	Peak	Duration
1 h	2–4 h	12–24 h

Adverse Effects

Being a cardioselective $beta_1$-adrenergic blocker, atenolol has few adverse effects on the lung. The most frequently reported adverse effects of atenolol include fatigue, weakness, bradycardia, and hypotension. **Black Box Warning:** Abrupt discontinuation should be avoided in patients with ischemic heart disease; doses should be gradually reduced over a 1- to 2-week period. If angina worsens during the withdrawal period, the drug should be reinstituted.

Contraindications: Because atenolol slows heart rate, it should not be used in patients with severe bradycardia, atrioventricular (AV) heart block, cardiogenic shock, or decompensated HF. Due to its vasodilation effects, it is contraindicated in patients with severe hypotension.

Interactions

Drug–Drug: Concurrent use with CCBs may cause bradycardia. Use with digoxin may slow AV conduction, leading to heart block. Concurrent use of atenolol with other antihypertensives may result in additive hypotension. Anticholinergics may cause decreased absorption from the gastrointestinal (GI) tract.

Treatment of Overdose: The most serious symptoms of overdose are hypotension and bradycardia. Atropine or isoproterenol may be used to reverse bradycardia. Atenolol can be removed from the systemic circulation by hemodialysis.

Complementary and Alternative Therapies

COENZYME Q10 FOR HEART DISEASE

CoQ10 is a vitamin-like substance found in most animal cells where it serves as an essential component in the cell's mitochondrial production of ATP. Foods richest in this substance are pork, sardines, beef heart, salmon, broccoli, spinach, and nuts. Decreased blood levels of CoQ10 have been associated with several diseases, including fibromyalgia, migraines, diabetes, and heart failure.

Some research has confirmed that CoQ10 supplementation combined with standard therapy may reduce the risk of subsequent cardiovascular events and improve left-ventricular contractility. Some studies showed a potential role in migraine prophylaxis, lessening depression in bipolar disease, and improving morning fatigue in patients with fibromyalgia (Sood & Keenaghan, 2022). Considerable research has been conducted on this antioxidant; however, most evidence is weak or inconclusive (National Center for Complementary and Integrative Health, 2018).

Statins block an enzyme involved in the production of CoQ10, creating a deficiency of the antioxidant in patients taking statin medications. Supplementation with CoQ10 may improve myopathy symptoms in patients taking statins, although evidence for this action is weak.

CoQ10 is well tolerated, however, safety has not been demonstrated in pregnant patients or in those with serious kidney or liver disease. CoQ10 is structurally similar to vitamin K and thus should be avoided in patients taking warfarin.

Treating the Diverse Patient: Angioedema Associated with ACE Inhibitor Therapy

Angioedema is an adverse effect associated with several drugs, including ACE inhibitors. It is theorized that the angioedema is not an allergy but is possibly due to a buildup in bradykinin secondary to the ACE inhibitor's mechanism of action, leading to vasodilation of blood vessels (Bonner et al., 2017; Chandler & Banerji, 2022; Scalese & Reinaker, 2016). Symptoms include nonitchy swelling of the lips, face, tongue, and upper airway, and, on occasion, swelling of the gastrointestinal tract (Chandler & Banerji, 2022; Riha et al., 2017). Swelling usually develops over minutes to hours after ingestion, then resolves in 24 to 72 hours. A higher incidence of ACE inhibitor–associated angioedema has been noted in Blacks, women, smokers, adults over age 65, patients with a history of allergy to NSAIDs, and those patients who experience a cough as an adverse effect of their ACE inhibitor (Banerji et al., 2017; Bonner et al., 2017; Chandler & Banerji, 2022; Lawlor et al., 2018). Treatment includes discontinuing the ACE inhibitor, antihistamines, corticosteroids, and fresh frozen plasma. Two newer drug therapies are ecallantide (Kalbitor), which was approved in 2009 to treat hereditary angioedema, and icatibant (Firazyr) (Bonner et al., 2017; Chandler & Banerji, 2022; Riha et al., 2017).

A thorough health history is important in any drug therapy, but especially important when adverse drug reactions may result in serious consequences, such as respiratory arrest. The nurse should explore the existence of previous angioedema reactions, even in the absence of drug therapy, which may suggest a hereditary component. Carefully assessing at-risk populations during drug therapy with ACE inhibitors is also needed to detect reactions promptly. Patients who develop a cough during ACE inhibitor therapy should notify their healthcare provider so that early therapy may be started.

NURSING PRACTICE FEATURES: This text uses several strategies to connect pharmacology to nursing practice. Relevant features, such as Complementary and Alternative Therapies, Treating the Diverse Patient, Community-Oriented Practice, and Lifespan Considerations, place the drugs in context with their clinical applications. Applying Research to Nursing Practice features illustrate how current medical research is used to improve patient teaching.

Community-Oriented Practice

ADDRESSING PUBERTY IN PEDIATRIC PATIENTS

Puberty is the presence of secondary sexual characteristics: breast development in girls, pubic hair, and testicular and penile enlargement in boys. Although the exact mechanism that triggers puberty is not yet fully understood, sometime between the ages of 7 and 11 in girls, and 9½ to 13½ in boys, the pituitary gland releases hormones that signals ovaries to begin secreting estrogen and testes to start producing testosterone. Although almost everyone will experience body changes because of puberty, discussing it with pediatric and adolescent patients can cause much angst and discomfort, even when everything is "normal."

Precocious puberty is when a child's body begins changing too soon. It is defined as before the age of 8 in girls and 9 in boys (Mayo Clinic, 2021). Precocious puberty can be separated into central precocious puberty (CPP) and peripheral precocious puberty (PPP). In CPP, the likely culprit may be because of an abnormality in the pituitary gland or in the hypothalamus, and in PPP (less common), the gonads release estrogen or testosterone into the body too early (Mayo Clinic, 2021). Some of the puberty-blocking drugs used to treat precocious puberty are also used to treat gender dysphoria. In gender dysphoria, children experience gender incongruence between their biological sex and their gender identity. Precocious puberty and gender dysphoria require the nurse to have knowledge of pharmacological options for treatment, as they can come with significant emotional and social considerations (Meyer et al., 2020). For what is already a sensitive topic, additional care should be taken when addressing those of concern for precocious puberty or those with gender dysphoria.

Applying Research to Nursing Practice:

The HPV Vaccination for Cancer Prevention

Sexually transmitted HPV is spread through vaginal, anal, and oral sex and falls into low- and high-risk categories for causing cancer. Almost all people are infected with HPV within a few years of becoming sexually active and half of those infections are HPV of the high-risk type (National Cancer Institute, 2019). Worldwide, cervical cancer is the fourth most common cancer in females and nearly all cases are attributable to HPV (National Cancer Institute, 2019). Oropharyngeal cancer from HPV infection in both men and women are on the rise in the United States (Palefsky, 2022). The HPV vaccination has been demonstrated to be highly effective in preventing these cancers, and the vaccine is now recommended for most children of both sexes starting at age 11. The response rate to the vaccine remains less than desired and differences exist among different racial-ethnic and socioeconomic groups.

There is much misinformation and misconception about the HPV vaccine, perhaps even more so because it is associated with a sexually transmitted infection. Despite its effectiveness at preventing HPV-related cancers, vaccine adoption and completion rates are low in the United States, compared to other developed countries (Hawes, 2018).

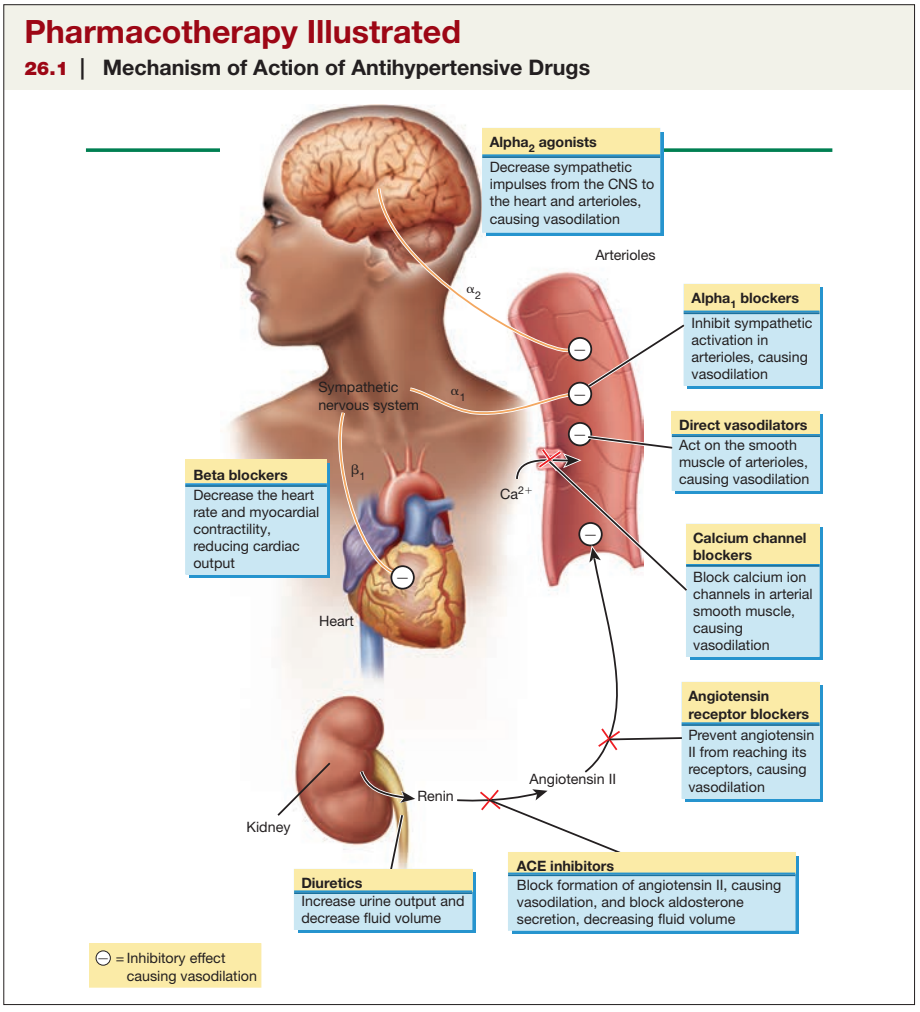
In one study conducted at a university in the United States, Oh et al. (2021) found that vaccination completion rates in college students was lower among students who were Black and those who did not speak English at home. Compliance was higher in students who received any recommendation for the HPV vaccine in their life, those with more knowledge about HPV and the HPV vaccine, and those who perceived benefits of vaccination. This study suggests that healthcare providers should seize every opportunity to educate adolescents, young adults, and families of the impact of HPV, the benefits of vaccination, and follow it up with a strong recommendation to be immunized. Working to increase access to primary care providers or health department providers so that all adolescents and young adults may obtain the HPV vaccine, even if they do not have insurance, is an important consideration. In a trusted profession, nurses can serve at the forefront of providing vital information and encouragement for the vaccine, particularly among groups not normally considered as being low responders. Providing evidence-based information to all families about healthy lifestyles and about the value of the vaccine is key to increasing the response rate.

PATIENT SAFETY: A prime responsibility of the nurse is to ensure medication is delivered in a safe and effective manner. Throughout the text, Patient Safety features illustrate potential pitfalls that can lead to medication errors.

Patient Safety: Medication Reconciliation Before Home Discharge for the Older Adult

Medication reconciliation is the process of comparing a patient's current medication orders with all of the medications that the patient has been taking to avoid duplications, omissions, dosage differences, or drug interactions. Because the older adult may be taking multiple medications prescribed by different healthcare providers, it is especially important that the nurse perform a medication reconciliation before discharging the patient from an acute care setting to the patient's home or other care facility. The nurse should review the patient's medications listed on admission, the patient's currently ordered medication prescriptions, and any special notations about which previously ordered medications should be continued and which should be stopped. If there are any discrepancies, omissions, duplications, or change in dosage noted, the nurse should contact the healthcare provider to verify the order.

LEARNING THROUGH VISUALS: Students learn better when supplied with accurate, attractive graphics and rich media resources. *Pharmacology for Nurses: A Pathophysiologic Approach* contains a generous number of figures, with an unequaled art program. Pharmacotherapy Illustrated features appear throughout the text, breaking down complex topics into easily understood formats.



Sertraline (Zoloft): Studies in pregnant laboratory animals showed delayed ossification and increased mortality. Human data on sertraline showed a small risk for cardiovascular malformations in infants whose mothers took the drug during the first trimester. If exposed during the third trimester, the neonate may show signs of distress upon delivery that resemble serotonin syndrome. SSRIs should be used during pregnancy and lactation only if the potential benefits to the patient justify the potential risks to the fetus and neonate.

PREGNANCY INFORMATION: NEW! Every prototype drug now includes updated pregnancy information. The FDA has replaced the old A-X rating system to include more relevant information for patients and their healthcare providers.

NURSING CLINICAL JUDGMENT: NEW! This is one of the most important additions in this edition of *Pharmacology for Nurses: A Pathophysiologic Approach.* Nursing Clinical Judgment provides a concise approach to patient assessment, planning prioritizing solutions, implementing patient-centered care, and evaluating the outcomes. This feature retains the essence of the nursing process, while moving forward to a clinical judgment measurement model.

NURSING CLINICAL JUDGMENT: LIPID-LOWERING PHARMACOTHERAPY

Recognize and Analyze Cues

- Obtain a complete health and drug history, including allergies, current prescription and OTC drugs; herbal preparations; and alcohol use. Be alert to possible drug interactions.
- Evaluate appropriate laboratory findings, especially liver function studies and lipid profiles.
- Assess the patient's ability to receive and understand instructions. Include family and caregivers as needed.

Prioritize and Generate Solutions

Goals and Outcomes

- Review medication administration guidelines and discuss desired therapeutic effect outcomes. Many of the lipid-lowering drugs have specific administration requirements. For best results, some should be taken at night when cholesterol biosynthesis is at its highest.

Take Action

- Follow appropriate administration guidelines. Continue to assess for adverse effects.
- Use opportunities during administration of medications and during assessments to provide patient education and instruct the patient or caregiver in proper self-administration of the drug. Using time during nursing care helps to optimize and reinforce key teaching areas.

Patient Teaching: Medication Adverse Effects

- Teach the patient the importance of reporting signs or symptoms related to adverse drug effects as follows:
  - *Statins.* Report unusual or unexplained muscle tenderness, increasing muscle pain, numbness or tingling of extremities, or effects that hinder normal activities of daily living (ADLs). **Lifespan:** The drug should not be taken during pregnancy, if pregnancy is suspected, or while breastfeeding.
  - *Bile acid sequestrants.* Report severe nausea, heartburn, constipation, or straining with passing stools. Any tarry stools or yellowing of sclera or skin should also be reported. **Lifespan:** The older adult may have an increased risk of bleeding due to drug-related changes with vitamin K synthesis.
  - *Niacin.* Report flank, joint, or stomach pain or yellowing of sclera or skin.
  - *Fibric acid drugs.* Report unusual bleeding or bruising, right upper quadrant pain, muscle cramping, or changes in the color of the stool. Patients with diabetes on PO medications may need a change in their dosage and should monitor their glucose more frequently in early therapy. **Lifespan & Safety:** Monitor the older adult for dizziness and assist with ambulation to prevent falls. **Diverse Patients:** Research has indicated that those who are Hispanic or American Indian may have a greater risk for development of gallbladder disease than other ethnic groups.
  - *PCSK9 drugs.* Teach the patient proper subcutaneous injection technique followed by teach-back. Report localized injection reactions or flulike symptoms.

Patient Teaching: Lifestyle Considerations

- Encourage the patient to adopt a healthy lifestyle of low-fat foods, increased exercise, decreased alcohol consumption, and smoking cessation and provide dietician consultation as needed
- Encourage increased intake of omega-3- and CoQ10-rich foods (e.g., fish such as salmon and sardines, nuts, extra-virgin olive and canola oils, beef and chicken). Supplementation may be needed; instruct the patient to seek the advice of a healthcare provider before supplements are taken.
- If long-term therapy is used, ensure adequate intake of fat-soluble vitamins (A, D, E, K) and folic acid in the diet or consider supplementation. (Lipid-lowering drugs may cause depletion or diminished absorption of these nutrients.)

Evaluate Outcomes

Medication Effectiveness

- Assess for desired therapeutic effects (e.g., lowered total cholesterol and LDL levels, increased HDL levels)
- Continue periodic monitoring of lipid profiles, liver function studies, creatine kinase, and uric acid levels. **Lifespan:** Monitor the older adult more frequently because age-related physiologic changes may affect the drug's metabolism or excretion. **Diverse Patients:** Because statins metabolize through the CYP450 system pathways, monitor ethnically diverse patients to ensure optimal therapeutic effects and to minimize adverse effects. Instruct the patient on the need to return periodically for laboratory work.
- Assess for adverse effects: musculoskeletal discomfort, nausea, vomiting, abdominal cramping, and diarrhea. Immediately report severe musculoskeletal pain, unexplained muscle tenderness accompanied by fever, inability to maintain ADLs due to musculoskeletal weakness or pain, unexplained numbness or tingling of extremities, yellowing of sclera or skin, severe constipation, or straining with passing of stools or tarry stools.

Patient Understanding

- The patient should be able to state the reason for the drug; appropriate dose and scheduling; what adverse effects to observe for and when to report them; and the anticipated length of medication therapy.
- The patient or caregiver is able to discuss appropriate dosing and administration needs.
- The patient takes the drug following appropriate guidelines:
  - *Statins.* Take with evening meal; avoid grapefruit and grapefruit juice, which could inhibit the drug's metabolism, leading to toxic levels.
  - *Bile acid sequestrants.* Take before meals with plenty of fluids, mixing powders or granules thoroughly with liquid. Take other medications 2 hours before or 4 hours after the bile acid sequestrant is taken.
  - *Niacin.* Take with cold water to decrease flushing. Take one aspirin tablet (81–325 mg) 30 minutes before the niacin dose.
  - *Fibric acid drugs.* Take with a meal.
  - *PCSK9 drugs.* Give the drug subcutaneously once every 2 weeks.

No pharmacology text is complete unless it contains a method of self-assessment by which students may gauge their progress. *Pharmacology for Nurses: A Pathophysiologic Approach* contains an end-of-chapter review of the major concepts. Review questions, a Patient-Focused Case Study, and an additional set of Critical Thinking questions allow students to check their retention of chapter material.

Chapter Review

KEY Concepts

The numbered key concepts provide a succinct summary of the important points from the corresponding numbered section within the chapter. If any of these points are not clear, refer to the numbered section within the chapter for review.

27.1 Heart failure is closely associated with coronary artery disease, mitral stenosis, myocardial infarction, chronic HTN, diabetes mellitus, dyslipidemia, and thyroid disorders. The body attempts to compensate for HF by increasing cardiac output. Preload and afterload are two primary factors determining cardiac output.

27.2 Heart failure is classified by patient symptoms. Choice of pharmacologic therapy depends on the stage of the disease.

27.3 ACE inhibitors reduce symptoms of HF by lowering blood pressure, reducing peripheral edema, and increasing cardiac output. They are preferred drugs for the treatment of HF.

27.4 Diuretics relieve symptoms of HF by reducing fluid overload and decreasing blood pressure.

27.5 Beta-adrenergic blockers slow the heart rate and decrease blood pressure. They can dramatically reduce hospitalizations and increase the survival of patients with HF.

27.6 Cardiac glycosides increase the force of myocardial contraction and were once preferred drugs for HF. Because of their narrow safety margin and the development of more effective drugs, their use has declined.

27.7 Vasodilators can relieve symptoms of HF by reducing preload and decreasing the cardiac workload. Positive inotropic drugs are used for the short-term treatment of advanced HF to increase the force of myocardial contraction and improve cardiac output.

REVIEW Questions

1. The patient is prescribed digoxin (Lanoxin) for treatment of heart failure. Which statement by the patient indicates the need for further teaching?
   1. "I may notice my heart rate decrease."
   2. "I may feel tired during early treatment."
   3. "This drug should cure my heart failure."
   4. "My energy level should gradually improve."
2. The patient is receiving hydralazine with isosorbide (BiDil) for heart failure. The nurse should monitor this patient for:
   1. Dizziness and rapid heart rate
   2. Bleeding
   3. Tingling or cramping in the legs
   4. Confusion and agitation

PATIENT-FOCUSED Case Study

Juniata Meeks is a 62-year-old female who has a long history of type 2 diabetes and HTN. She takes metformin and occasional insulin injections for her diabetes and has been taking chlorothiazide (Diuril) for HTN. Ms. Meeks tells you, her nurse, that last month she suffered from a particularly "bad bout" of the flu and has been feeling extremely tired since that time. She has also noticed that her ankles have been swelling and she becomes "easily winded" doing her chores. In the healthcare provider's office, Ms. Meeks is noted to have 1 + pitting ankle edema and has some fine crackles in the bases of her lungs bilaterally. She is started on lisinopril for mild HF.

1. What is the drug classification of lisinopril and why is it given in HF?
2. What other testing may be ordered for Ms. Meeks?
3. What teaching is important for this patient?

CRITICAL THINKING Questions

1. A patient is newly diagnosed with mild HF. The patient has been started on digoxin (Lanoxin). What objective evidence would indicate that this drug has been effective?
2. A 69-year-old patient has a sudden onset of acute pulmonary edema. The patient has no past cardiac history, is allergic to sulfa antibiotics, and routinely takes no medications. The healthcare provider orders furosemide (Lasix) to relieve the pulmonary congestion, along with digoxin (Lanoxin) to improve the patient's hemodynamic status. What interventions are essential in the care of this patient?

See Appendix A for answers and rationales for all activities.

Acknowledgments

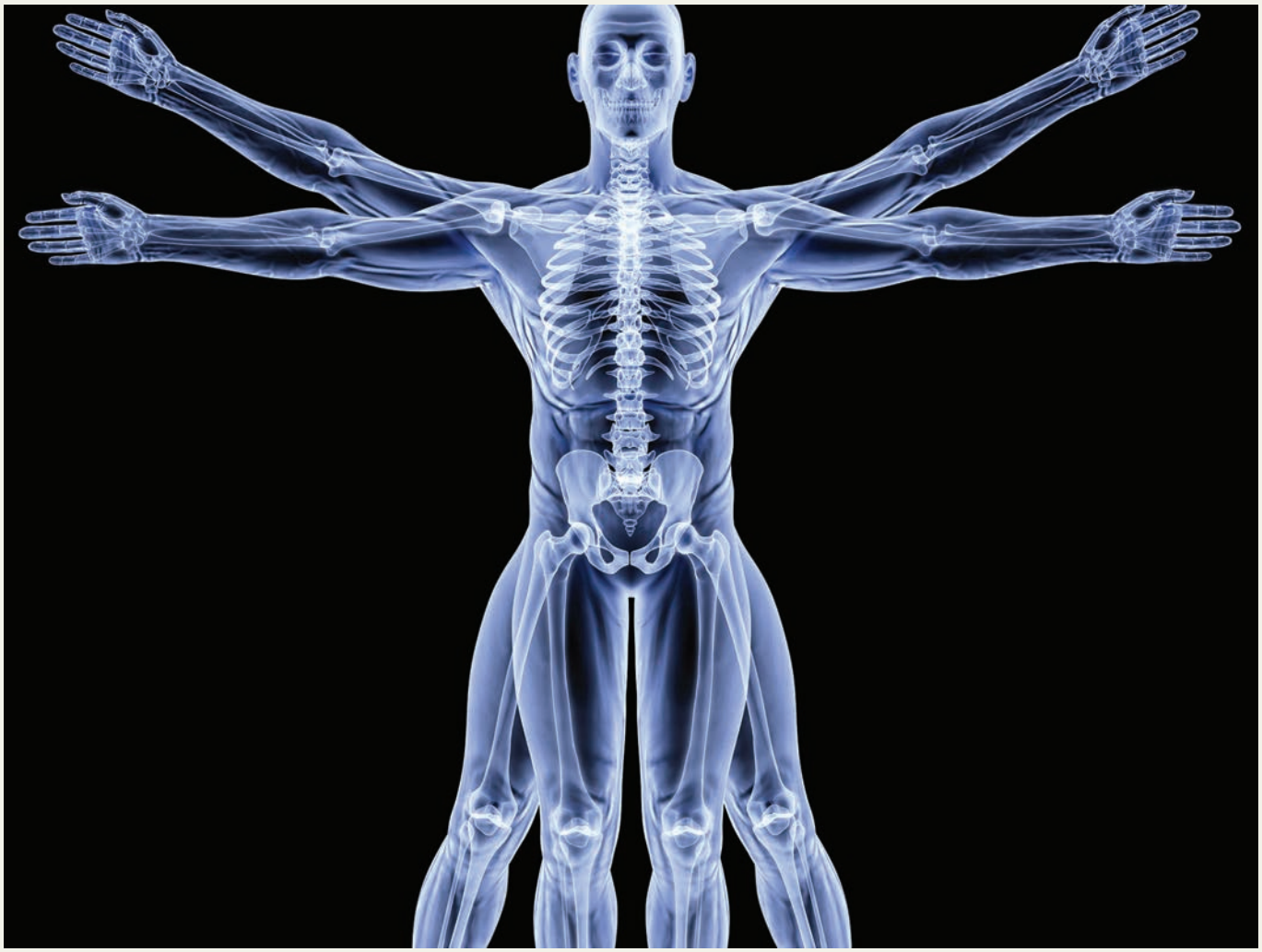
When authoring a textbook like this, many dedicated and talented professionals are needed to bring the vision to reality. Kevin Wilson, Content Manager-Health Sciences, and Michael Giacobbe, Program Manager, at Pearson were responsible for guiding the many details in the development and production of the seventh edition. Patty Donovan, Senior Project Manager for Health Sciences at Straive, provided expert professional guidance to keep everyone on track given a very challenging schedule.

Although difficult and challenging, the study of pharmacology is truly a fascinating lifelong journey. We hope we have succeeded in writing a textbook that makes that study easier and more understandable so that nursing students will be able to provide safe, effective nursing care to patients who are undergoing drug therapy. We hope students and faculty will share with us their experiences using this textbook and all its resources.

Contents

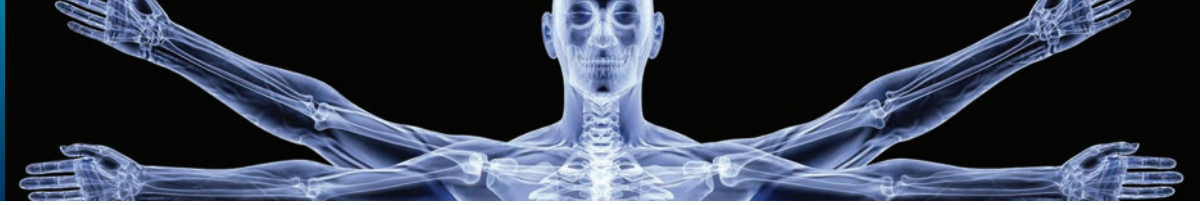
Unit 1

Core Concepts in Pharmacology



Core Concepts in Pharmacology

Chapter 1



Introduction to Pharmacology

Learning Outcomes

After reading this chapter, the student should be able to:

1. Identify key events in the history of pharmacology.
2. Explain the interdisciplinary nature of pharmacology, giving an example of how knowledge from different sciences impacts the nurse's role in drug administration.
3. Compare and contrast therapeutics and pharmacology.
4. Compare and contrast traditional drugs, biologics including biosimilars, and complementary and alternative medicine therapies.
5. Explain the basis for placing drugs into therapeutic and pharmacologic classes.
6. Discuss the prototype approach to drug classification.
7. Describe what is meant by a drug's mechanism of action.
8. Distinguish among a drug's chemical name, generic name, and trade name.
9. Outline the major differences between prescription and over-the-counter drugs.
10. Explain the differences between trade-name drugs and their generic equivalents.
11. Describe how decisions are made relative to drug therapy among groups of patients.

Key Terms

bioavailability, 7
biologics, 4
biosimilar drug, 4
biosimilar, 4
chemical name, 6
combination drug, 6
complementary and alternative medicine (CAM) therapies, 5
drug, 4
generic name, 6
mechanism of action, 5
medication, 4
pharmacoeconomics, 8
pharmacologic classification, 5
pharmacology, 3
pharmacotherapy, 4
prototype drug, 5
therapeutic classification, 5
therapeutics, 4
trade name, 6

When students begin the study of pharmacology, they are immediately confronted with new drug concepts and the many ways that drugs are identified. Hundreds of drugs have specific dosages, side effects, and various mechanisms of action. To prevent errors when administering drugs, the nurse must constantly check trade names, generic equivalents, correct name spelling, adverse drug reactions, warnings, contraindications, and other key facts. Without a means of organizing this information, students would be overwhelmed by the vast amounts of data. This chapter serves as a starting point for connecting introductory pharmacologic concepts to nursing practice. It discusses the methods for organizing drugs: by therapeutic or pharmacologic classification, by dispensing methods (prescription or over-the-counter), and whether dispensing trade-name drugs or generic equivalents should be appropriate. This chapter also introduces drug therapy for larger patient groups.

1.1 History of Pharmacology

The story of pharmacology is rich and exciting, filled with accidental discoveries and landmark events. Its history likely began when humans first used plants to relieve symptoms of disease. One of the oldest forms of healthcare, herbal medicine has been practiced in virtually every culture dating to antiquity. The Babylonians recorded the earliest surviving "prescriptions" on clay tablets in 3000 B.C. At about the same time, the Chinese recorded the *Pen Tsao* (Great Herbal), a 40-volume compendium of plant remedies dating to 2700 B.C. The Egyptians followed in 1500 B.C. by archiving their remedies on a document known as the Eber's Papyrus.

The first recorded reference to *pharmacology* is found in a text titled "Pharmacologia sen Manuductio and Materiam Medicum," by Samuel Dale, in 1693. Before this date, the study of herbal remedies was called "Materia Medica," a term that persisted into the early twentieth century (Figure 1.1).

Modern pharmacology began in the early 1800s. At that time, chemists were making remarkable progress in isolating specific substances from complex mixtures. Scientists isolated active drugs like morphine, colchicine, curare, cocaine, and other early pharmacologic agents from natural sources. Using standardized amounts, pharmacologists studied drug effects more precisely in animal models. Indeed, some of the early researchers used themselves as test subjects. Friedrich Serturner, who first isolated morphine from opium in 1805, injected himself and three friends with a huge dose (100 mg) of his new product. He and his colleagues suffered acute morphine intoxication for several days following.

Pharmacology as a distinct discipline was officially recognized when the first department of pharmacology was established in Estonia in 1847. John Jacob Abel, who is considered the father of American pharmacology because of his many contributions to the field, founded the first pharmacology department in the United States at the University of Michigan in 1890.

FIGURE 1.1 DE Materia Medica was written in the first century and was a source for medicines for about 500 years
The Picture Art Collection/Alamy Stock Photo.

In the twentieth century, the pace of change in all areas of medicine continued exponentially. Pharmacologists no longer needed to rely on the slow, laborious process of isolating active agents from scarce natural sources; they began to synthesize drugs in the laboratory. Hundreds of new drugs started to be synthesized and tested in a relatively short time. More importantly, pharmacologists embarked on a mission to understand how drugs produced their effects, down to their molecular mechanism of action.

The current practice of pharmacology is extremely complex and far advanced compared with its early, primitive history. The nurse who consults with a pharmacist in the use of medicines and other health professionals who practice it must never forget its early roots: the application of products to relieve human suffering. Whether a substance is extracted from the Pacific yew tree, isolated from a fungus, or created totally in a laboratory, pharmacology's central purpose is to focus on the patient and to improve the quality of life.

1.2 Pharmacology: The Study of Medicines

The word **pharmacology** is derived from two Greek words: *pharmakon*, which means "medicine," and *logos*, which means "study." Thus, pharmacology is most simply defined as the study of medicine. Pharmacology is an expansive subject ranging from understanding how drugs are administered, to where they travel in the body, to how the actual

responses are produced. To learn the discipline well, nursing students must acquire a broad knowledge base from various foundation areas, such as anatomy and physiology, chemistry, microbiology, and pathophysiology.

As an example, aminoglycosides are a class of antibiotics that are useful in the treatment of many infectious diseases. The mainstay of treatment for infective endocarditis is antibiotic therapy, which is instituted as soon as possible to minimize valvular damage. Caution must be used, however, because some aminoglycosides can cause inner ear toxicity and neuromuscular impairment, especially if furosemide (a loop diuretic) is administered at the same time. You can see how, in this case, concepts from multiple science disciplines are integrated. Knowledge of chemistry would be inferred by the terms *amino* and *glyco*. Further study about "infectives" would draw information from the subject of microbiology, including the use of antibiotics and sensitivities of gram-positive and gram-negative bacteria. The fields of anatomy and physiology would correlate much information with emphasis on ear anatomy and organs of the muscular, nervous, renal, and cardiovascular systems. "Endocarditis" would be the central pathophysiologic focus of treatment. Most of the time pharmacology incorporates knowledge from multiple areas, which healthcare providers must use in making decisions about drug administration.

More than 10,000 trade-name drugs, generic drugs, and combination drugs are currently available. Each has its own characteristic set of therapeutic applications, interactions, adverse effects, and mechanisms of action. Many drugs are prescribed for more than one disease, and most produce multiple effects within the body. Drugs may elicit different responses depending on individual patient factors, such as age, gender, body mass, health status, and genetics. Drug effects may be enhanced or reduced by combined factors. For example, patients with liver or chronic kidney disease may experience enhanced responses due to reduced clearance of drugs from the body. So, learning the applications of existing medications and staying current with new drugs introduced every year are among the formidable but necessary tasks of the nurse. These challenges are critical for both the patient and the healthcare provider. If applied properly, drugs can dramatically improve the quality of life; if administered improperly, drugs can produce devastating consequences.

1.3 Pharmacology and Therapeutics

A thorough study of pharmacology is essential for healthcare providers who prescribe drugs. The nurse is often the healthcare provider most directly involved with patient care and is active in educating, managing, and monitoring the proper use of drugs. This applies not only to nurses in clinics, hospitals, and home healthcare settings but also to nurses who teach and to students entering the nursing profession. As nursing students progress toward their chosen specialty, pharmacology is at the core of patient care and is integrated into every step of the nursing process. Indeed, learning pharmacology is a gradual, continuous process that does not end with graduation. A nurse never completely masters every facet of drug action and application, which is one of the motivating challenges of the nursing profession.

Another important area of focus for the nurse, sometimes challenging to distinguish from pharmacology, is therapeutics. As defined, therapeutics is slightly different from pharmacology, although the areas are closely connected. **Therapeutics** is concerned with the prevention of disease and treatment of suffering. **Pharmacotherapy**, or pharmacotherapeutics, is the application of drugs for the purpose of treating diseases and alleviating human suffering. Drugs are just one of many tools available to the nurse for these purposes.

1.4 Classification of Therapeutic Agents as Drugs, Biologics, Biosimilars, and Complementary and Alternative Medicine Therapies

Substances applied for therapeutic purposes fall into one of the following three general categories:

- Drugs or medications
- Biologics and biosimilar drugs
- Complementary and alternative medicine therapies.

A **drug** is a chemical agent capable of producing biologic responses within the body. These responses may be desirable (therapeutic) or undesirable (adverse). After a drug is administered, it is called a **medication**. Drugs and medications may be considered a part of the body's normal activities, from the essential gases that we breathe to the foods that we eat. Because drugs are defined so broadly, they must be clearly distinguished from other substances, such as foods, household products, and cosmetics. Many agents, such as antiperspirants, toothpastes, and shampoos, may alter the body's normal activities, but, unlike drugs, they are not necessarily considered medically therapeutic.

Although most modern drugs are synthesized in a laboratory, **biologics** are agents naturally produced by microorganisms, the cell's molecular machinery, tissues, or by organs within the body itself. Biologics are large, complex molecules or mixtures of molecules that may be composed of living material. Examples of biologics include hormones, monoclonal antibodies, natural blood products and components, interferons, and vaccines. In recent years, biologics have become important treatments for rheumatoid arthritis, multiple sclerosis, and cancer. However, while they are effective medications, they are usually very expensive. For example, some of the newer biologics for hepatitis C cost thousands of dollars per dose.

A **biosimilar drug** or **biosimilar** is a biological product that is highly similar to and has no meaningful clinical differences from an existing *reference product* already approved by the U.S. Food and Drug Administration (FDA). The reference product is the original biologic drug that underwent rigorous testing and was approved by the FDA

based upon a thorough evaluation of its safety and effectiveness. Biosimilars are not required to undergo the same rigorous preclinical and clinical testing. Biosimilars must have the same routes of administration, dosage forms, mechanisms of action, and clinical indications as the reference product. If a biosimilar undergoes a higher standard of additional testing, it is referred to as an *interchangeable product*. Testing must show that an interchangeable product produces the same therapeutic effectiveness as the reference product. More than 30 biosimilars have been approved. A list of approved biosimilars is found in the *Purple Book*, an online database that can be searched at the FDA website (*https://purplebooksearch.fda.gov*).

Other approaches for treatment include **complementary and alternative medicine (CAM) therapies**. These are natural plant extracts, herbs, vitamins, minerals, dietary supplements, and additional techniques considered by many to be outside mainstream Western healthcare practice. Such therapies include body-based practices, such as manipulations, massage, acupuncture, hypnosis, and biofeedback. Because of their great popularity, herbal and alternative therapies are featured throughout this text wherever they show promise in treating a disease or condition. CAM therapies are presented in Chapter 10.

1.5 Therapeutic and Pharmacologic Classification of Drugs

One useful method of organizing drugs is based on their usefulness in treating specific diseases or disorders. This is referred to as the drug's **therapeutic classification**. Drugs may also be organized by **pharmacologic classification**, which refers to the way a drug works at the molecular, cellular, tissue, or body system's level. Both types of classification are widely used in categorizing the thousands of available drugs.

Table 1.1 illustrates the method of therapeutic classification, using cardiac care as an example. Many different types of drugs affect cardiovascular function: Some drugs influence blood clotting, whereas others lower blood cholesterol or prevent the onset of stroke. Drugs may be used to treat elevated blood pressure, heart failure, abnormal rhythm, chest pain, heart attack, or circulatory shock. Thus, drugs that treat cardiac disorders may be placed in several therapeutic classes, for example, anticoagulants, antihyperlipidemics, and antihypertensives.

A therapeutic classification need not be complicated. For example, it is appropriate to simply classify a medication as a "drug used for stroke" or a "drug used for shock." The key to therapeutic classification is to clearly state what a particular drug does clinically. Other examples of therapeutic classifications include antidepressants, antipsychotics, drugs for erectile dysfunction, and antineoplastics.

The pharmacologic classification addresses a drug's **mechanism of action**, or how a drug produces its physiologic effect in the body. Table 1.2 shows a variety of pharmacologic classifications using hypertension as the therapeutic focus. A diuretic treats hypertension by lowering plasma volume. Calcium channel blockers treat this disorder by decreasing cardiac contractility. Other drugs block intermediates of the renin–angiotensin pathway. Notice that each example describes how hypertension is controlled. A drug's pharmacologic classification is more specific than a therapeutic classification and requires a more in-depth understanding of biochemistry and physiology. In addition, pharmacologic classifications may be described with varying degrees of complexity, sometimes taking into account the drugs' chemical names.

When classifying drugs, common practice is to select a single drug from a class and compare all other medications within the same representative group. Thus, a **prototype drug** is the well-understood drug model with which other drugs in its representative class are compared. By learning the characteristics of the prototype drug, students may predict the actions and adverse effects of other drugs in the same class. For example, by knowing the effects of penicillin V, students can extend this knowledge to the other drugs in the penicillin class of antibiotics. The original drug prototype is not always the most widely used drug in its class. Newer drugs in the same class may be more effective, have a more favorable safety profile, or have a longer duration of action. These factors may sway healthcare providers from using the original prototype drug. Becoming familiar with the drug prototypes and keeping up with newer drugs as they are developed is an essential part of mastering drugs and drug classes.

Table 1.1 Therapeutic Classification

Focus: Cardiovascular Function

Usefulness	Drug Classification
Influence blood clotting	Anticoagulant
Lower blood cholesterol	Antihyperlipidemic
Lower blood pressure	Antihypertensive
Restore normal cardiac rhythm	Antidysrhythmic
Treat angina	Antianginal

Table 1.2 Pharmacologic Classification

Focusing on Therapeutic Application: Pharmacotherapy for Hypertension

Mechanism of Action	Drug Classification
Lowers plasma volume	Diuretic
Blocks heart calcium channels	Calcium channel blocker
Blocks hormonal activity	Angiotensin-converting enzyme inhibitor
Blocks physiologic reactions to stress	Adrenergic antagonist
Dilates peripheral blood vessels	Vasodilator

1.6 Chemical, Generic, and Trade Names for Drugs

A major challenge in studying pharmacology is mastering the thousands of drug names. Adding to this difficulty is the fact that most drugs have multiple names. The three basic types of drug names are chemical, generic, and trade names.

A **chemical name** is assigned using standard nomenclature established by the International Union of Pure and Applied Chemistry. A drug has only one chemical name, which is sometimes helpful in predicting a substance's physical and chemical properties. Although chemical names convey a clear and concise meaning about the nature of a drug, they are often complicated and difficult to remember or pronounce. For example, few nurses know the chemical name for diazepam: 7-chloro-1,3-dihydro-1-methyl-5-phenyl-2H-1,4-benzodiazepin-2-one. In only a few cases, usually when the name is brief and easily remembered, will the nurse use chemical names. Examples of useful chemical names include lithium carbonate, calcium gluconate, and sodium chloride.

More practically, drugs are sometimes classified by a portion of their chemical structure, known as the chemical group name. Examples are antibiotics, such as the fluoroquinolones and cephalosporins. Other common examples include the phenothiazines, thiazides, and benzodiazepines. Although chemical group names may seem complicated when first encountered, knowing them will become invaluable as the nursing student begins to understand and communicate major drug actions and adverse side effects.

The **generic name** of a drug is assigned by the U.S. Adopted Name Council. With few exceptions, generic names are less complicated and easier to remember than chemical names. Many organizations, including the FDA, the U.S. Pharmacopeia, and the World Health Organization (WHO), routinely describe a medication by its generic name. Because there is only one generic name for each drug, using this name has value and students generally must memorize it. It's important to remember that biosimilars are not exact copies of original medications (recall *reference products*), so they should not be called generic medications. Instead, biosimilars use the generic name of the drug, followed by four lowercase letters approved by the FDA. The history of adopted names for biosimilars dates to guidelines finalized in January 2017. Examples of biosimilar names include infliximab-abda, bevacizumab-awwb, and adalimumab-atto.

A drug's **trade name** is usually short and easy to remember and is assigned by the company marketing the drug. The trade name is sometimes called the proprietary, product, or brand name. The term *proprietary* suggests ownership. In the United States, a drug developer is given exclusive rights to name and market a drug for 17 years after a New Drug Application is submitted to the FDA. Because it takes several years for a drug to be approved, the amount of time spent in approval is usually subtracted from the 17 years. For example, if it takes 7 years for a drug to be approved, competing companies will not be allowed to market a generic equivalent drug for another 10 years. The rationale is that the developing company is allowed sufficient time to recoup the millions of dollars in research and development costs in designing the new drug. After 17 years, competing companies may sell a generic equivalent drug, sometimes using a different name, which the FDA must approve.

Trade names may be a challenge for students to learn because of the dozens of products containing similar ingredients. A **combination drug** contains more than one active generic ingredient. This poses a problem in trying to match one generic name with one product name. As an example, Table 1.3 lists the drug diphenhydramine (generic name), also called Benadryl (one of the many trade names). Diphenhydramine is an antihistamine. Low doses of diphenhydramine may be purchased over the counter (OTC); higher doses require a prescription. When looking for diphenhydramine, the nurse may find it listed under many trade names, such as Allerdryl and Compoz, or provided alone or in combination with other active ingredients. Ibuprofen and aspirin are additional drug examples with different trade names. The rule of thumb is that the active ingredients in a drug are described by their generic name. The generic name of a drug is usually written in lowercase, whereas the trade name is capitalized.

1.7 Prescription and Over-the-Counter Drugs

Many drugs are obtained by prescription or OTC. To obtain prescription drugs, the person must receive a written order from someone with the legal authority to write such a prescription. The advantages to requiring this authorization are numerous. The healthcare provider has an opportunity to examine the patient and determine a specific diagnosis. The provider can maximize therapy by ordering the proper drug

Table 1.3 Examples of Trade-Name Products Containing Popular Generic Substances

Generic Substance	Trade Names
aspirin	Acuprin, Anacin, Bayer, Bufferin, Ecotrin, Empirin, Excedrin, Maprin, Norgesic, Salocol, Supac, Talwin, Triaphen-10, Vanquish, Verin, Zorprin
diphenhydramine	Allerdryl, Benadryl, Benahist, Bendylate, Caladryl, Compoz, Diahist, Diphenadril, Eldadryl, Fenylhist, Fynex, Hydramine, Hydril, Insomnal, Noradryl, Nordryl, Nytol, Tusstat, Wehdryl
ibuprofen	Advil, Amersol, Apsifen, Brufen, Haltran, Medipren, Midol 200, Motrin, Neuvil, Novoprofen, Nuprin, Pamprin-IB, Rufen, Trendar

for the patient's condition and by conveying the amount and frequency of drug to be dispensed. In addition, the healthcare provider has an opportunity to teach the patient the proper use of the drug and what adverse effects may occur. In a few instances, a high margin of safety observed over many years can prompt a change in the status of a drug from prescription to OTC.

In contrast to prescription drugs, OTC drugs do not require a healthcare provider's order. In most cases, patients may treat themselves safely if they carefully follow the instructions included with the medication. If patients do not follow these guidelines, OTC drugs can have serious adverse effects.

Patients prefer to take OTC drugs for a variety of reasons. They are obtained more easily than prescription drugs. No appointment with a healthcare provider is required, thus saving time and money. Without the assistance of a healthcare provider, however, choosing the proper drug for a specific complaint can be challenging for a patient. OTC drugs may react with foods, herbal products, prescription medications, or other OTC drugs. Patients may not be aware that some OTC drugs can impair their ability to function safely. Self-treatment is frequently ineffectual, and the potential for harm may increase if the disease is allowed to progress.

1.8 Differences Between Trade-Name Drugs and Their Generic Equivalents

During its 17 years of exclusive rights to a new drug, the pharmaceutical company determines the price of the medication. Because there is no competition, the price is generally quite high. The developing company sometimes uses legal tactics to extend its exclusive rights, since this can mean hundreds of millions of dollars per year in profits for a popular medicine. Once the exclusive rights end, competing companies market the generic drug for less money, and consumer savings may be considerable. In some instances, pharmacists may routinely substitute a generic drug when the prescription calls for a trade name. In other cases, the pharmacist must dispense drugs directly as written by a healthcare provider or obtain approval from the provider before giving a generic substitute. Drugs not approved are placed on a closed formulary or a list of drugs not covered for reimbursement.

Companies marketing trade-name drugs often lobby against laws restricting the routine use of their trade-name products. The lobbyists claim significant differences exist between a trade-name drug and its generic equivalent and switching to the generic drug may be harmful for the patient. Patients and consumer advocates, on the other hand, argue that generic substitutions should routinely be permitted because of the cost savings.

Are there really differences between a trade-name drug and its generic equivalent? The answer is unclear and depends on the situation. Even though the dosages may be identical, drug formulations are not always the same. The two drugs may have different inert ingredients. For example, if the drug is in tablet form, the active ingredients may be more tightly compressed in one of the preparations. Public information often focuses on generic drugs having the same active ingredients but different colors, flavors, and certain other filler ingredients. It is the "certain other filler ingredients" where the problem may occur. It is important that generic medications do not work differently from trade-name medications. The FDA provides electronic resources for searching out drug products by active ingredients, trade name, generic equivalents, and the manufacturer. One major source, the *Electronic Orange Book*, can be searched online. Since there is a lag time before generic products appear in the *Orange Book*, first-time generic drug approvals can also be searched online at the FDA website (*www.accessdata.fda.gov/scripts/cder/ob/index.cfm*).

The key to comparing trade-name drugs and their generic equivalents may lie in measuring the bioavailability of the two preparations. As shown in Figure 1.2, **bioavailability** is the physiologic ability of the drug to

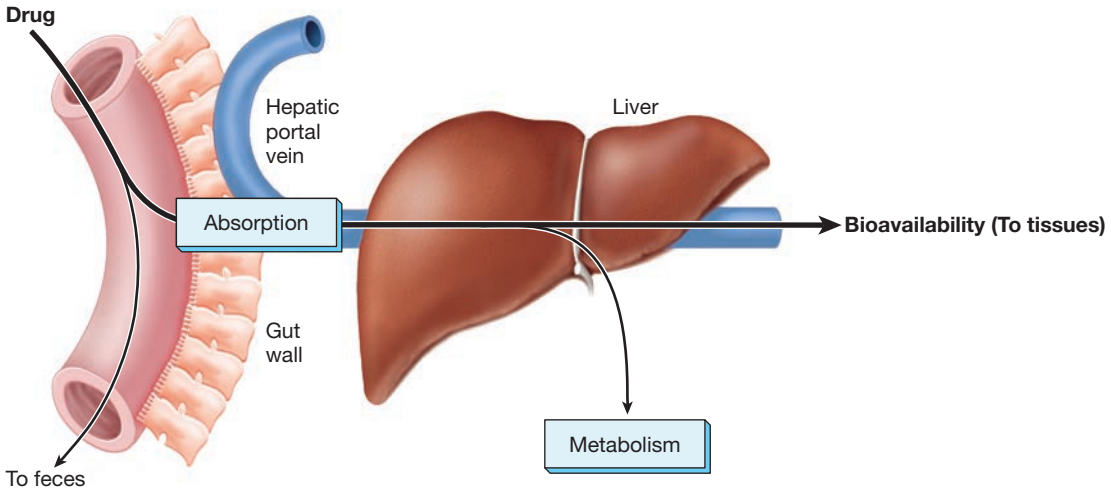


FIGURE 1.2 A drug's bioavailability will depend on the dosage form and how much actually reaches the target location

Patient Safety: Look-Alike Generic Drug Names

A student nurse is preparing medications for a patient. When checking the medication administration record against the drug found in the patient's medication cassette, the student nurse notes that hydroxyzine has been ordered for the patient, but hydralazine has been dispensed from the pharmacy. What should the student nurse do?

Answer to the Patient Safety Question can be found in Appendix A.

reach its target cells and produce its effect. Bioavailability may indeed be affected by inert ingredients and tablet compression. Anything that affects absorption of a drug, or its distribution to the target cells, can certainly affect drug action (see Chapters 4 and 5). Measuring how long a drug takes to exert its effect gives pharmacologists a crude measure of bioavailability. For example, if a patient is in circulatory shock and the generic-equivalent drug takes 5 minutes longer to produce its effect, this is indeed significant; however, if a generic medication for arthritis pain relief takes 45 minutes to act, compared with the trade-name drug, which takes 40 minutes, it probably does not matter which drug is prescribed.

To address issues of bioavailability, some states have compiled a negative formulary. A negative formulary is a list of trade-name drugs that pharmacists may not dispense as generic drugs. These drugs must be dispensed exactly as written on the prescription, using the trade-name drug the healthcare provider prescribed. Pharmaceutical companies and some healthcare providers have supported this action, claiming that generic drugs—even those that have small differences in bioavailability and bioequivalence—could adversely affect patient outcomes in those with critical conditions or illnesses. However, laws frequently change and, in many instances, the efforts of consumer advocacy groups have led to changes in or elimination of negative formulary lists.

Another widespread application of the negative formulary is used by managed care plans. In these cases, a negative formulary lists specific drugs that may not be dispensed to beneficiaries of the plan, usually because they are significantly more expensive than comparable medications. The managed care plans provide an appeal mechanism whereby a physician may provide a justification as to why their patient requires a medication on the negative formulary.

1.9 Decisions Relative to Proper Drug Choices

Lawmakers, manufacturers, nurses, and patients along with family members are often placed in the position of making difficult decisions about proper drug choices. **Pharmacoeconomics**, a subdiscipline of health economics, has helped in situations involving broader application of a particular type of drug therapy. For example, some groups of patients may benefit from the development of a particular class of drugs. Decisions are often based on costs (resources) and the outcomes considered not only for patient and family groups but also for the providers, lawmakers, and drug manufacturers. When making therapy- or production-related decisions, the following basic outcomes are generally considered: (1) benefit in dollars, (2) effectiveness in health improvement (e.g., variables of improved cardiovascular or nervous system benefit), (3) minimization in terms of the same benefit provided to other patients in a similar group, and (4) improved utility (both quantitative and qualitative benefits). You might imagine these factors being considered on a focused level, for example, if a single patient were in terrible pain and needed a strong narcotic medication. It is possible the nurse might deny the medication due to fear of possible addiction. Most nurses would probably not be as concerned about administering a potent pain medication if the patient were in acute pain.

More recent concerns involve groups of patients at the state and national levels debating the legalization of marijuana for the treatment of disorders such as epilepsy, amyotrophic lateral sclerosis (also called "Lou Gehrig's disease"), multiple sclerosis, glaucoma, AIDS, or other select conditions, such as pain. Marijuana legalization has been a passionate topic due to strong convictions among members of the U.S. population. Residents of Colorado and Washington were among the first to have marijuana approved for recreational use. Patients in about 21 states and the District of Columbia have been given ranges of approval for legal marijuana use. Citizens in other states continue to submit requests for legalization of marijuana, and these debates are expected to continue.

On a global scale the WHO, the Centers for Disease Control and Prevention, and the FDA have engaged in a series of public discussions, for example, on the outbreak of COVID-19 in December 2019. The questions of how to reduce the risk of viral transmission; how to effectively finance, develop, and distribute vaccines to the public; and how to plan appropriately for outbreaks and continuing drug development have been among the emerging twenty-first-century challenges. As primary healthcare providers, the work performed by nurses continues to be at the core of these challenges. Emergency preparedness and the general roles of nurses due to pandemic and global threats are covered more thoroughly in Chapter 11.

Chapter Review

KEY Concepts

The numbered key concepts provide a succinct summary of the important points from the corresponding numbered section within the chapter. If any of these points are not clear, refer to the numbered section within the chapter for review.

1.1 The history of pharmacology began thousands of years ago with the use of plant products to treat disease.

1.2 Pharmacology is the study of medicines, including the study of how drugs are administered and how the body responds.

1.3 The fields of pharmacology and therapeutics are closely connected. Pharmacotherapy is the application of drugs to treat disease and ease human suffering.

1.4 Therapeutic agents may be classified as drugs, biologics and biosimilar drugs, or complementary and alternative medicine (CAM) therapies.

1.5 Drugs may be organized by their therapeutic or pharmacologic classification.

1.6 Drugs have chemical, generic, and trade names. A drug has only one chemical or generic name but may have multiple trade names.

1.7 Drugs are available by prescription or over the counter (OTC). Prescription drugs require an order from a healthcare provider.

1.8 Generic drugs are less expensive than trade-name drugs, but they may differ in their bioavailability, which is the ability of the drug to reach its target cell and produce its action.

1.9 Group-based decisions for drug therapy center around cost benefit, effectiveness in health improvement, minimization of benefit to patients within a similar group, and improved quantitative and qualitative utility.

CRITICAL THINKING Questions

1. What is the difference between therapeutic and pharmacologic classifications? Identify the following classifications as therapeutic or pharmacologic: beta-adrenergic blocker, oral contraceptive, laxative, folic acid antagonist, and antianginal drug.
2. What is a prototype drug, and how does it differ from other drugs in the same class?
3. Explain why a patient might seek treatment from an OTC drug instead of a more effective prescription drug.
4. A generic-equivalent drug may be legally substituted for a trade-name medication unless the medication is on a negative formulary or requested by the prescriber or patient. What advantages does this substitution have for the patient? What disadvantages might be caused by the switch?
5. What are "biosimilar" drugs? How do they differ from generic drugs?

See Appendix A for answers and rationales for all activities.

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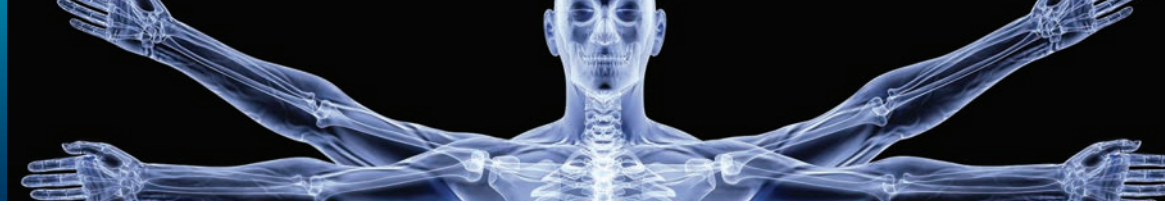
Chapter 2



Drug Approval and Regulation

Learning Outcomes

After reading this chapter, the student should be able to:

1. Identify key U.S. drug regulations that have provided guidelines for the safe and effective use of drugs and drug therapy.
2. Discuss the role of the U.S. Food and Drug Administration (FDA) in the drug approval process.
3. Explain the four phases of approval for therapeutic and biologic drugs.
4. Discuss how the FDA has increased the speed with which new drugs reach consumers.
5. Identify the advanced practice registered nurse's role in prescribing drugs.
6. Explain the U.S. Controlled Substance Act of 1970 and the role of the U.S. Drug Enforcement Administration in controlling drug abuse and misuse.
7. Discuss why drugs are sometimes placed on a restrictive list, and the controversy surrounding this issue.
8. Explain the meaning of a controlled substance and teratogenic risk in pregnancy.
9. Identify the five drug schedules and give examples of drugs at each level.

Key Terms

black box warnings, 14
clinical investigation, 14
clinical phase trials, 14
Center for Biologics Evaluation and Research (CBER), 14
Center for Drug Evaluation and Research (CDER), 13
Center for Food Safety and Applied Nutrition (CFSAN), 14
controlled substance, 17
dependence, 17
Drug Enforcement Administration (DEA), 17
formulary, 12
Investigational New Drug (IND), 15
National Center for Complementary and Integrative Health (NCCIH), 14
New Drug Application (NDA), 14
NDA review, 15
pharmacopeia, 12
postmarketing surveillance, 15
preclinical investigation, 14
scheduled drugs, 17
U.S. Department of Health and Human Services (DHHS), 13
U.S. Food and Drug Administration (FDA), 13
withdrawal, 17

Every year, the number of prescriptions dispensed in the United States increases. Prescription drugs account for more than 9% of national healthcare spending. About one-half of all Americans take at least one drug regularly and one out of six individuals takes at least three prescription drugs. Sources of safe drug information are wide and vast, from official pharmacopoeias to compendia such as drug guides, FDA publications, pharmaceutical package inserts, and various types of web- and software-based electronic data. Drug standards and schedules, are published for general regulation purposes and enforcement. This chapter discusses the role of government in ensuring that drugs, herbals, and supplements are safe and effective for the public.

2.1 Drug Regulations and Standards

Until the nineteenth century, there were few regulations or standards in place to protect the public from drug misuse. The archives of drug regulatory agencies are filled with examples of early medicines, including rattlesnake oil for rheumatism; epilepsy treatment for spasms, hysteria, and alcoholism; and fat reducers for a slender, healthy figure. Many of these early concoctions proved ineffective, though harmless. At their worst, some contained hazardous levels of dangerous or addictive substances. Over time it became clear that drug regulations were needed to protect the public.

The first standard commonly used by pharmacists was the **formulary**, or list of drugs and drug recipes. In the United States, the first comprehensive publication of drug standards, called the *U.S. Pharmacopeia* (USP), was established in 1820. A **pharmacopeia** is a medical reference summarizing standards of drug purity, strength, and directions for synthesis. In 1852, a national professional society of pharmacists called the American Pharmaceutical Association (APhA) was founded. From 1852 to 1975, two major compendia-maintained drug standards in the United States: the *U.S. Pharmacopeia* and the *National Formulary* (NF) established by the APhA. All drug products were covered in the USP; non-drug ingredients were covered in the NF. In 1975, the two entities merged into a single publication, the *U.S. Pharmacopeia–National Formulary* (USP-NF). Today, USP-NF is a resource of pharmacopoeia standards containing over 300 chapters and 4900 monographs that cover quality standards for drugs, inactive ingredients, and dietary supplements. The USP label can be found on many medication vials, verifying the purity and exact amounts of ingredients found within the container. Sample labels are illustrated in Figure 2.1.

To protect the public, in the early 1900s, the United States began to develop and enforce tougher drug legislation. In 1902, the Biologics Control Act helped to standardize the quality of serums and other blood-related products. The Pure Food and Drug Act of 1906 gave the government power to control the labeling of medicines. In 1912, the Sherley Amendment prohibited the sale of drugs labeled with false therapeutic claims that were intended to defraud the consumer. In 1938, Congress passed the Food, Drug, and Cosmetic Act. This was the first law preventing the sale of drugs that had not been thoroughly tested

PharmFacts

CONSUMER SPENDING ON PRESCRIPTION DRUGS AND DRUG DEVELOPMENT

- According to National Healthcare Expenditure data, the United States spent about $360 billion on prescription drugs in 2020, about 9% of $4 trillion in 2020 national healthcare spending.
- Specialty drugs account for approximately half of combined *gross* spending on retail, mail-order, and provider-administered drugs.
- Since the turn of the twenty-first century, the cost of drug invention in the United States has been rising dramatically, while the actual numbers of drugs developed have stabilized.
- Adult and older patients routinely do not fill or skip prescription doses due to cost.
- The Centers for Medicare and Medicaid Services (2022) forecasts that retail drug spending could grow 5.5% annually from 2020 through 2028.
- The FDA continues to accelerate development of COVID-19-related treatments. Publication of guidances and other information for industry will be ongoing.

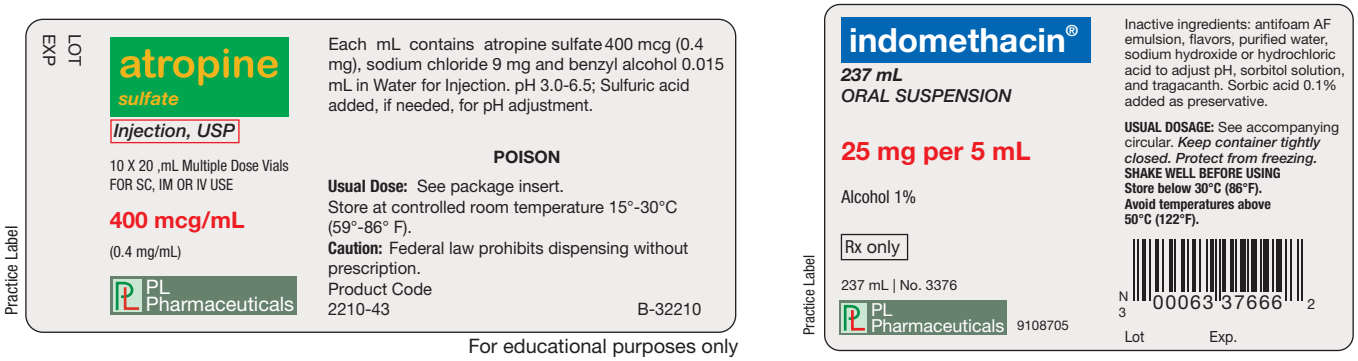


FIGURE 2.1 Medication with the USP label (left) and without the USP label (right). Practice Label "for educational purposes only."

before marketing. Later amendments to this law required drug companies to prove the safety and efficacy of any drug before it could be sold within the United States. In reaction to the rising popularity of dietary supplements in 1994, Congress passed the Dietary Supplement Health and Education Act in an attempt to control misleading industry claims. A brief timeline of major events in U.S. drug regulation is shown in Figure 2.2.

2.2 The Role of the Food and Drug Administration

Much has changed in the regulation of drugs in the past 100 years. In 1988, the **U.S. Food and Drug Administration (FDA)** was officially established as an agency of the **U.S. Department of Health and Human Services (DHHS)**. The **Center for Drug Evaluation and Research (CDER)**,

TIME LINE	REGULATORY ACTS, STANDARDS, AND ORGANIZATIONS
1820	A group of healthcare providers established the first comprehensive publication of drug standards called the ***U.S. Pharmacopoeia*** **(USP).**
1852	A group of pharmacists founded a national professional society called the **American Pharmaceutical Association (APhA).** The APhA then established the ***National Formulary*** **(NF),** a standardized publication focusing on pharmaceutical ingredients. The *USP* continued to catalogue all drug-related substances and products.
1862	This was the beginning of the **Federal Bureau of Chemistry,** established under the administration of President Lincoln. Over the years and with added duties, it gradually became the Food and Drug Administration (FDA).
1902	Congress passed the **Biologics Control Act** to control the quality of serums and other blood-related products.
1906	**The Pure Food and Drug Act** gave the government power to control the labeling of medicines.
1912	**The Sherley Amendment** made medicines safer by prohibiting the sale of drugs labeled with false therapeutic claims.
1938	Congress passed the **Food, Drug, and Cosmetic Act.** It was the first law preventing the marketing of drugs not thoroughly tested. This law now provides for the requirement that drug companies must submit a New Drug Application (NDA) to the FDA prior to marketing a new drug.
1944	Congress passed the **Public Health Service Act,** covering many health issues including biologic products and the control of communicable diseases.
1975	The *U.S. Pharmacopoeia* and *National Formulary* announced their union. The **USP-NF** became a single standardized publication.
1986	Congress passed the **Childhood Vaccine Act.** It authorized the FDA to acquire information about patients taking vaccines, to recall biologics, and to recommend civil penalties if guidelines regarding biologic use were not followed.
1988	The **FDA** was officially established as an agency of the **U.S. Department of Health and Human Services.**
1992	Congress passed the **Prescription Drug User Fee Act.** It required that nongeneric drug and biologic manufacturers pay fees to be used for improvements in the drug review process.
1994	Congress passed the **Dietary Supplement Health and Education Act** that requires clear labeling of dietary supplements. This act gives the FDA the power to remove supplements that cause a significant risk to the public.
1997	The **FDA Drug Modernization Act** reauthorized the Prescription Drug User Fee Act. This act represented the largest reform effort of the drug review process since 1938.
2002	The **Bioterrorism Act** implemented guidelines for registration of selected toxins that could pose a threat to human, animal, or plant safety and health.
2007	The **FDA Amendments Act** reviewed, expanded, and reaffirmed legislation to allow for additional comprehensive reviews of new drugs and medical products. This extended the reforms imposed from 1997. The **FDA's Critical Path Initiative** was a part of this reform.
2009	The **Biologics Price Competition and Innovation Act** created an approval pathway for biosimilar and interchangeable biologic products.
2012	The FDA Safety and Innovation Act reauthorizes the **Prescription Drug User Fee Act.** This requires the FDA to implement a structured benefit-risk framework in the new drug approval process.
2020	The **Over the Counter Monograph Safety, Innovation, and Reform Act** streamlines approval of OTC medications.

FIGURE 2.2 A historical timeline of regulatory acts, standards, and organizations

a branch of the FDA, exercises control over whether prescription and over-the-counter (OTC) drugs may be used for therapy. CDER's mission is facilitating the availability of safe, effective drugs; keeping unsafe or ineffective drugs off the market; improving the health of Americans; and providing clear, easily understandable drug information for safe and effective use. Any pharmaceutical laboratory, whether private, public, or academic, must solicit FDA approval before marketing a drug.

To address certain high risk medications, the FDA has created boxed warnings to alert physicians and the public to drugs with "special" issues. **Black box warnings**, named after the black box appearing around drug safety information located within package inserts, eventually became one of the primary alerts for identifying extreme adverse drug reactions discovered during and after the review process.

It would be ideal if all potential adverse effects were identified before a drug went on the market. Because this is not realistic, nurses must be increasingly mindful about the standards of care necessary to promote safety, including scanning of medications, medication reconciliation, and special alerts. Black box warnings are included throughout this text for all prototype drugs.

Another branch of the FDA, the **Center for Biologics Evaluation and Research (CBER)**, regulates the use of biologics, including serums, vaccines, blood products and gene therapies. One historical achievement involving biologics was the 1986 Childhood Vaccine Act. This act authorized the FDA to acquire information about patients taking vaccines, to recall biologics, and to recommend civil penalties if guidelines regarding biologics were not followed. In 1996, the Health Insurance Portability and Accountability Act required health-related organizations and schools to keep private all health information, including vaccinations. In 2016, the FDA granted 32 significant biologics licenses, including biosimilars. *Biosimilars* are biologic products similar to FDA-approved reference products (see Chapter 1). Three notable biosimilars are adalimumab-atto, or Amjevita (reference product: Humira); etanercept-szzs, or Erelzi (reference product: Enbrel); and infliximab-dyyb, or Inflectra (reference product: Remicade).

The FDA oversees administration of herbal products and dietary supplements through the **Center for Food Safety and Applied Nutrition (CFSAN)**. Herbal products and dietary supplements are regulated by the Dietary Supplement Health and Education Act of 1994 and its subsequent amendments. However, this act does not provide the same degree of protection for consumers as the Food, Drug, and Cosmetic Act of 1938. For example, herbal and dietary supplements can be marketed without prior approval from the FDA; however, all package inserts and information are monitored once products have gone to market. The Dietary Supplement Health and Education Act is discussed in detail in Chapter 10.

The **National Center for Complementary and Integrative Health (NCCIH)** is the federal government's lead agency for scientific research and information about complementary and alternative medicine (CAM) therapies. Its mission is to define, through rigorous scientific investigation, the usefulness and safety of complementary and integrative health interventions and their roles in improving health and healthcare. Among several areas of focus, this agency supports research and serves as a resource for nurses in establishing which CAM therapies are safe and effective.

2.3 Phases of Approval for Therapeutic and Biologic Drugs

The amount of time the FDA spends in the review and approval process for a particular drug depends on several checkpoints, along with a well-developed and organized plan. Therapeutic drugs and biologics are reviewed in four phases. Figure 2.3 summarizes these four phases as follows:

1. Preclinical investigation
2. Clinical investigation
3. Review of the New Drug Application
4. Postmarketing surveillance.

Preclinical investigation involves extensive laboratory research, in which scientists perform tests on human and microbial cells cultured in the laboratory. Studies are performed in several species of animals to examine the drug's effectiveness at different doses and to look for adverse effects. Extensive testing on cultured cells and in animals is essential because it allows the pharmacologist to predict whether the drug will cause harm to humans. Because laboratory tests do not accurately reflect the way the human body will respond to a substance, preclinical investigation results are always inconclusive. Animal testing, for example, may overestimate or underestimate the actual risk to humans.

Clinical investigation, the second phase of drug testing, takes place in three different stages termed **clinical phase trials**. Clinical phase trials are the longest part of the drug approval process. Clinical pharmacologists first perform tests on volunteers to determine proper dosage and to assess for adverse effects. Large groups of selected patients with the particular disease are then given the medication. Clinical investigators from different medical specialties address concerns such as whether the drug is effective, worsens other medical conditions, interacts unsafely with existing medications, or affects one type of patient more than others.

Clinical phase trials are an essential component of drug evaluations due to the variability of responses among patients. If a drug appears to be effective without causing serious side effects, approval for marketing may be accelerated, or the drug may be used immediately in special cases with careful monitoring. If the drug shows promise but precautions are noted, the process is delayed until the pharmaceutical company remedies the concerns. In any case, a **New Drug Application (NDA)** must be submitted before a

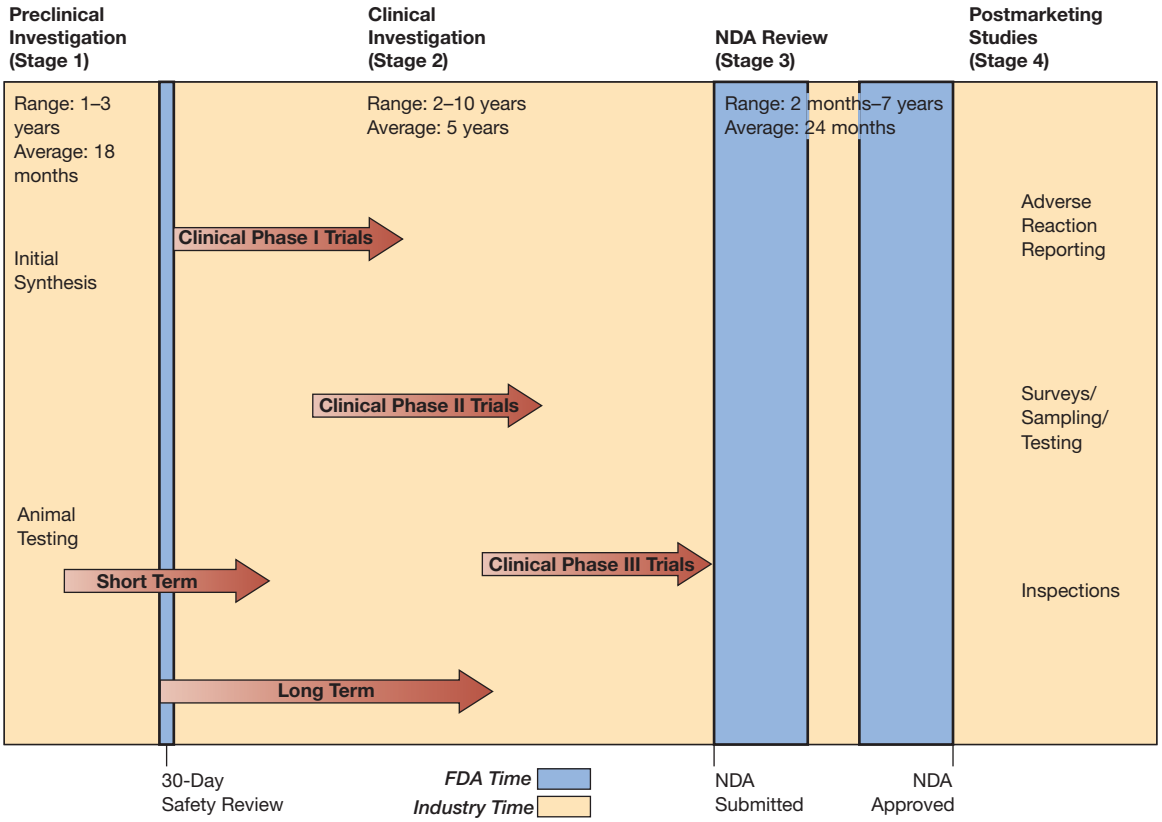


FIGURE 2.3 A new drug development timeline with the four phases of drug approval

drug is allowed to proceed to the next phase of the approval process. An **Investigational New Drug (IND)** application may be submitted for Phase I clinical trials when it is determined that there are significant therapeutic benefits and that the product is reasonably safe for initial use in humans.

The **NDA review** is the third phase of the drug approval process. During this phase, the drug's trade name is finalized. Clinical Phase III trials and animal testing may continue depending on the results obtained from preclinical testing. By law, the FDA is obligated to act on at least 90% of the NDAs for standard drugs within 10 months of submission. If the drug is determined to be "approvable," the process continues to the final phase. If the drug is determined to be "not approvable," the NDA likely has significant issues and the process is suspended until noted concerns are addressed by the pharmaceutical company.

Postmarketing surveillance, the final phase of the drug approval process, begins after clinical trials and the NDA review have been completed. The purpose of this phase is to survey for harmful drug effects in a larger population. Some adverse effects take longer to appear and are not identified until a drug is circulated to large numbers of people. Examples of successful postmarketing surveillance include the removal of two cholesterol-lowering drugs in 2016 because long-term clinical trials revealed that the medications were ineffective at reducing adverse cardiovascular events. In these cases, the withdrawals were not prompted by serious safety concerns. The benefits of the drugs were found to no longer outweigh their risks.

The FDA holds annual public meetings to receive feedback from patients and professional and pharmaceutical organizations regarding the effectiveness and safety of new drug therapies. If the FDA discovers a serious problem, it will mandate that the drug be withdrawn from the market. The FDA has a free email subscription service to alert the consumer regarding drugs and products withdrawn from the market. In addition, the FDA sponsors MedWatch and Drug Safety Communications, podcasts, and newsletters to alert patients, consumers, and healthcare providers of drug risks. They also provide safety sheets, press announcements, and other pertinent drug fact information.

2.4 Changes to the Drug Approval Process

The process of isolating or synthesizing a new drug and testing it in cells, experimental animals, and humans can take many years. The NDA can include dozens of volumes of experimental and clinical data that must be examined in the drug review process. Some NDAs contain more than 100,000 pages. Even after all experiments have been concluded and clinical data have been gathered, the FDA review process can take several years.

Expenses associated with development of a new drug can cost pharmaceutical manufacturers millions of dollars. Drug companies are often concerned about the regulatory process and are eager to get the drug marketed

Applying Research to Nursing Practice: Informed Consent Procedures

At some point in their career, nurses may care for a patient who is enrolled in, or considering participation in, a clinical drug research trial. The publication of the Belmont Report (DHHS, 2016) provides guidance and principles for obtaining informed consent from patients enrolled in clinical trials. The FDA has guidelines that include how to obtain informed consent from children and illiterate adults (FDA, 2019). Ultimately, providing information about the research trial is the responsibility of the researcher and healthcare provider, but nurses can participate by helping to ensure that they address any questions or concerns the patient has regarding participation before signing the informed consent document. Special populations—including children, patients with cognitive or mental impairments, and patients with sensory or language barriers—require careful assessment of the patient's ability to understand or make informed decisions about research participation. Other circumstances that may make obtaining informed consent for research participation more difficult include those in which the patient may be critically ill or suffering from a traumatic injury. Such situations may delay obtaining consent directly from the patient and result in the patient's exclusion from the clinical trial. Nurses should ensure that a patient, family, or legal guardian has the information necessary to make informed decisions when caring for patients who are considering or participating in a clinical research trial. By working collaboratively with the researcher and healthcare provider, the nurse can assist the patient to make informed decisions about participation in research trials.

to recoup their research and development expenses. The public is also eager to receive new drugs, particularly for diseases that have a high mortality rate. Although the criticisms from manufacturers and the public are certainly understandable—and sometimes justified—the FDA's fundamental priority is to ensure that drugs are safe. Without an exhaustive review of scientific data, the public could be exposed to dangerous or ineffectual medications.

In the early 1990s, due to pressure from organized consumer groups and various drug manufacturers, government officials created a plan to speed up the drug review process. In 1992 and in 2012, legislation was passed to allow the FDA to speed up the review and approval of drugs intended to treat serious conditions. The following are four strategies used by the FDA to accelerate the review process.

Fast Track: A fast track designation means that the developing drug has the *potential* to meet an unmet need for a condition in which there is no current therapy, or the drug may offer significant improvements over existing therapies. A fast-track drug must be reviewed by the FDA within 60 days.

Breakthrough Therapy: A breakthrough therapy means that trials suggest there is *clinical evidence* that the drug may demonstrate substantial improvement over existing therapies for a serious or life-threatening condition. Like the fast track, a breakthrough therapy drug must be reviewed by the FDA within 60 days.

Priority Review: When a NDA is received, the FDA makes a decision to perform a standard review (average 10 months) or a priority review (average 6 months). The decision is based on whether the new drug would offer a significant improvement over existing therapies for a serious condition.

Accelerated Approval: It may take many years to demonstrate that a drug provides real clinical benefit. In these cases, the FDA may approve the drug based on "intermediate clinical endpoints." The best example is a new anticancer drug. The new drug may show positive evidence of tumor shrinkage in early clinical trials and receive accelerated approval to be marketed. However, it may take several years before it is known whether the drug actually improved patient survival. The drug company can continue to market the new drug but must perform follow-up studies, known as *confirmatory trials*. If the confirmatory trials show the drug did not improve survival, the FDA may withdraw the accelerated approval.

2.5 Prescriptive Authority for Nurses

Advanced practice registered nurses are authorized to prescribe drugs under state regulations. Historically, prescribing drugs was the responsibility of the primary care provider or dentist. With the growth of advanced nursing degrees at the master's and doctoral levels, nurses began to specialize and to obtain certification as certified nurse midwives (CNMs), certified registered nurse anesthetists (CRNAs), nurse practitioners (NPs), and clinical nurse specialists (CNSs). These advanced practice registered nurses (APRNs) complete graduate-level education that includes advanced pharmacology content, and they obtain certification by exam in one of the four above specialties.

The ability to prescribe drugs is regulated by state law, and each state has different requirements for prescriptive authority. In approximately one-third of the United States, APRNs are authorized to prescribe drugs independently of primary care provider collaboration, delegation, or supervision. In approximately another third, the APRN must have some level of primary care provider collaboration or delegation and may not prescribe independently (National Council of State Boards of Nursing, 2021). The specialty of the APRN may also affect prescriptive authority, and there may be additional requirements for a CRNA rather than an NP, as an example. Controlled substance prescriptive authority may also vary from state to state. As the demand for primary care providers increases, and healthcare organizations such as the Veterans Health Administration recognize the full scope of practice for an APRN, the ability to practice independently is rapidly changing. The APRN is viewed as an essential member of the healthcare system's

PharmFacts

TIME LENGTH FOR NEW DRUG APPROVALS

- It takes about 11 years of research and development before a drug is submitted to the FDA for review.
- Phase I clinical trials take about 1 year and involve 20 to 80 normal, healthy volunteers.
- Phase II clinical trials last about 2 years and involve 100 to 300 volunteer patients with the disease.
- Phase III clinical trials take about 3 years and involve 1000 to 3000 patients in hospitals and clinic agencies.
- For every 5000 chemicals that enter preclinical testing, only five make it to human testing. Of these five potential drugs, only one is finally approved.

ability to deliver affordable care. The ability to prescribe drugs, a key component of most treatment plans, will ensure that patients are provided the best and most cost-effective care possible by APRNs and other healthcare providers.

2.6 Controlled Substances and Drug Schedules

Some drugs are frequently abused or have a high potential for addiction. Technically, addiction refers to the overwhelming feeling that drives someone to use a drug repeatedly despite harmful consequences. In recent years, the term addiction has been replaced by substance use disorder.

Dependence is a related term, often defined as a physiologic or psychologic need for a substance. *Physical dependence* refers to an altered physical condition caused by the adaptation of the nervous system to repeated drug use. In this case, when the drug is no longer available, the individual expresses physical signs of discomfort known as **withdrawal**. In contrast, when an individual is *psychologically dependent*, there are few signs of physical discomfort when the drug is withdrawn; however, the individual feels an intense, compelling desire to continue drug use. These concepts are discussed in detail in Chapter 22.

In the United States, a **controlled substance** is a drug whose use is restricted by the Controlled Substances Act of 1970 and later revisions. According to this law, drugs that have a significant potential for abuse are placed into five categories called schedules. These **scheduled drugs** are classified according to their potential for abuse: Schedule I drugs have the highest potential for abuse, and Schedule V drugs have the lowest potential for abuse. Schedule I drugs are restricted for use in situations of medical necessity, if at all. According to the FDA, they have little or no therapeutic value or are only intended for research purposes. Drugs in the other four schedules may be dispensed only in cases in which therapeutic value has been determined. Schedule V is the only category in which some drugs may be dispensed without a prescription because the quantities of the controlled drug are so low that the possibility of causing dependence is extremely remote. Table 2.1 gives the five drug schedules with examples. Not all drugs with an abuse potential are regulated or placed into schedules; tobacco, alcohol, and caffeine are significant examples.

The Controlled Substances Act is also called the Comprehensive Drug Abuse Prevention and Control Act. Hospitals and pharmacies must register with the **Drug Enforcement Administration (DEA)** and use their assigned

Table 2.1 U.S. Drug Schedules and Examples

Drug Schedule	Abuse Potential	Potential for Physical Dependency	Potential for Psychologic Dependency	Examples	Therapeutic Use
I	Highest	High	High	GHB, Heroin, LSD, marijuana (cannabis), methaqualone, methcathinone, peyote, and psilocybin	Limited without current therapeutic use
II	High	High	High	Hydromorphone, meperidine, methadone, morphine, and oxycodone; amphetamine, methamphetamine, methylphenidate, short-acting barbiturates, and pentobarbital	Used therapeutically with prescription
III	Moderate	Moderate	High	Combination products containing less than 15 mg of hydrocodone per dosage unit, products containing not more than 90 mg of codeine per dosage unit, anabolic steroids, buprenorphine products, phendimetrazine, ketamine, anabolic steroids, and intermediate-acting barbiturates	Used therapeutically with prescription; some drugs no longer routinely used
IV	Lower	Lower	Lower	Alprazolam, clonazepam, clorazepate, diazepam, lorazepam, midazolam, pentazocine, temazepam, tramadol, triazolam, and zolpidem	Used therapeutically with prescription
V	Lowest	Lowest	Lowest	Cough preparations containing not more than 200 mg of codeine per 100 mL or per 100 g	Used therapeutically without prescription

registration numbers to purchase scheduled drugs. The DEA is in charge of enforcing controlled substance laws in the United States. Hospitals and pharmacies must maintain complete records of all quantities purchased and sold. Healthcare providers, nurse practitioners, and others with prescriptive authority must also register with the DEA and receive an assigned number before prescribing these drugs. Drugs with higher abuse potential have more restrictions; for example, in many states, a special order form must be used to obtain Schedule II drugs, and orders must be written and signed by the healthcare provider. Telephone orders to a pharmacy are not permitted. Refills for Schedule II drugs are not permitted: patients must visit their healthcare provider first. Those convicted of unlawful manufacturing, distributing, or dispensing controlled substances face severe penalties.

Chapter Review

KEY Concepts

The numbered key concepts provide a succinct summary of the important points from the corresponding numbered section within the chapter. If any of these points are not clear, refer to the numbered section within the chapter for review.

2.1 Drug regulations were created to protect the public from drug misuse and to ensure continuous evaluation of safety and effectiveness.

2.2 The regulatory agency responsible for ensuring that drugs are safe and effective is the U.S. Food and Drug Administration (FDA).

2.3 There are four phases of approval for therapeutic and biologic drugs. The phases progress from cellular and animal testing to use of the experimental drug in patients with the disease.

2.4 Once criticized for being too slow, the FDA has streamlined the process to get new drugs to market more quickly.

2.5 Advanced practice registered nurses are allowed to prescribe drugs under state regulations.

2.6 Drugs with a potential for abuse are restricted by the Controlled Substances Act and are categorized into schedules. Schedule I drugs are the most tightly controlled; Schedule V drugs have less potential for addiction and are less tightly controlled.

CRITICAL THINKING Questions

1. How does the FDA ensure the safety and effectiveness of drugs? What types of drugs does the FDA regulate or control?
2. What is a black box warning? Why is it important for nurses to consider these when reading drug information materials?
3. Identify opportunities the nurse has in educating about, administering, and monitoring the proper use of drugs.
4. Why are certain drugs placed in schedules? What does the nurse need to know when a scheduled drug is ordered?
5. A nurse is preparing to give a patient a medication and notes that a drug to be given is marked as a Schedule III drug. What does this information tell the nurse about this medication?

See Appendix A for answers and rationales for all activities.

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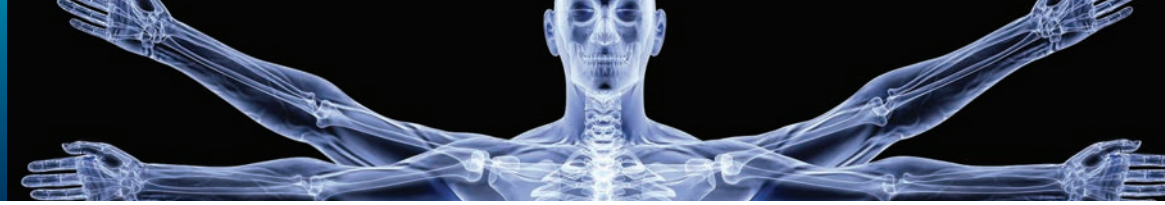
Chapter 3



Principles of Drug Administration

Learning Outcomes

After reading this chapter, the student should be able to:

1. Discuss drug administration as a component of safe, effective nursing care, using appropriate clinical judgment.
2. Describe the roles and responsibilities of nurses regarding safe drug administration.
3. Explain how the five rights of drug administration affect patient safety.
4. Give specific examples of how nurses can increase patient adherence in taking medications.
5. Interpret drug orders that contain abbreviations.
6. Compare and contrast the three systems of measurement used in pharmacology.
7. Explain the proper methods of administering enteral, topical, and parenteral drugs.
8. Compare and contrast the advantages and disadvantages of each route of drug administration.

Key Terms

adherence, 23
adverse effect, 22
adverse event (AE), 22
allergic reaction, 22
anaphylaxis, 23
apothecary system, 25
ASAP order, 24
astringent effect, 29
buccal route, 27
enteral route, 25
enteric-coated, 26
five rights of drug administration, 23
household system, 25
intradermal (ID), 31
intramuscular (IM), 32
intravenous (IV), 34
metric system of measurement, 25
orally disintegrating tablets (ODTs), 27
parenteral route, 31
PRN order, 24
routine orders, 24
side effect, 22
single order, 24
standing order, 24
STAT order, 24
subcutaneous, 31
sublingual route, 27
three checks of drug administration, 23

The primary role of the nurse in drug administration is to make sure that medications are delivered and tolerated in a safe manner. Drug administration is an important component of providing comprehensive nursing care. It incorporates all aspects of the nursing process and the clinical judgment measurement model (see Chapter 6). During drug administration, the nurse will collaborate closely with healthcare providers, pharmacists, and the patient. The purpose of this chapter is to introduce the roles and responsibilities of the nurse in delivering medications safely and effectively.

Responsibilities of the Nurse

3.1 Medication Knowledge and Understanding

Whether administering drugs to or supervising the use of drugs by their patients, nurses are expected to understand the pharmacotherapeutic principles for all medications. Given the variety and vast numbers of drugs, as well as the potential consequences of medication errors or problems with drug interactions, this is indeed an enormous task. The nurse's responsibilities include knowledge and understanding of the following:

- Which drug is ordered
- Name (generic and trade) and drug classification
- Intended or proposed use
- Expected effects on the body
- Contraindications
- Special considerations (e.g., how age, weight, body fat distribution, and individual pathophysiologic states affect pharmacotherapeutic response)
- Side effects
- How the medication is supplied by the pharmacy
- How the medication is to be administered, including dosage ranges

Before any drug is administered, the nurse must obtain and process pertinent information regarding the patient's medical history, physical assessment, disease processes, and learning needs and capabilities. Growth, developmental, and psychosocial factors must be considered. Nurses must remember that many variables influence a patient's response to medications. Having a firm understanding of these variables can increase the success of pharmacotherapy.

A major goal of studying pharmacology is to limit the number and severity of adverse drug events. Many adverse effects are preventable. The nurse can avoid many unfavorable drug effects in patients by applying clinical judgement and knowledge of pharmacotherapeutics to clinical practice. Some unfavorable effects, however, are not preventable. The nurse, as a result, should be prepared to recognize and respond to the potential harmful effects of medications.

An **adverse event (AE)**, or **adverse effect**, is any undesirable sign or symptom associated with the use of a medical product. AEs are generally described in terms of intensity (e.g., mild, moderate, severe, and life threatening). The term *serious adverse event* is used to define threat of permanent disability or immediate risk of death.

Adverse effects warrant either lowering the dosage or discontinuing the drug. A *side effect* is another term often associated with adverse effect. The difference is that **side effect** describes an unintended nontherapeutic reaction to a drug. Side effects may be transient, but this is not always the case. They may require nursing intervention, although most of the time they are perceived as tolerable. Both drug reactions have a nature and intensity that is documented and included in the published literature (e.g., drug guides, safety reports).

Allergic and anaphylactic reactions are particularly serious side effects that must be carefully monitored and prevented, when possible. An **allergic reaction** is a hyperresponse of body defenses to a foreign substance (allergen). Signs of allergic reactions vary in severity and include skin rash with or without itching, edema, runny nose, or reddened eyes with tearing. On discovering that the patient is allergic to a product, it is the nurse's responsibility to alert all personnel by documenting the allergy in the medical record and by appropriately labeling patient records and the medication administration record (MAR). An appropriate bracelet should be placed on the patient to alert all caregivers to the specific drug allergy. Information related to a drug allergy must be communicated to the healthcare provider and pharmacist so the medication regimen can be evaluated for cross-sensitivity among various pharmacologic products.

PharmFacts

POTENTIALLY FATAL DRUG REACTIONS

Toxic Epidermal Necrolysis (TEN)

- Severe and deadly drug-induced allergic reaction characterized by widespread epidermal sloughing caused by massive disintegration of the top layer of the skin and mucous membranes
- Involves multiple body systems and can cause death if not quickly diagnosed
- Occurs when the liver fails to properly break down a drug, which then cannot be excreted normally
- Associated with the use of some anticonvulsants (phenytoin, carbamazepine, the antibiotic trimethoprim/sulfamethoxazole) but can occur with the use of any prescription or over-the-counter (OTC) preparation, including ibuprofen
- Risk of death decreases if the offending drug is quickly withdrawn and supportive care is maintained

Stevens–Johnson Syndrome (SJS)

- Often prompted by the same or similar drugs as TEN, usually within 1 to 14 days of pharmacotherapy
- Start of SJS is usually signaled by nonspecific upper respiratory infection with chills, fever, and malaise
- Generalized blister-like lesions follow within a few days, and skin sloughing may occur on 10% of the body

Anaphylaxis is a severe type of allergic reaction that involves the massive, systemic release of histamine and other chemical mediators of inflammation that can lead to life-threatening shock. Symptoms such as acute dyspnea and the sudden appearance of hypotension or tachycardia following drug administration are indicative of anaphylaxis, which must receive immediate treatment. The pharmacotherapy of allergic reactions and anaphylaxis are presented in Chapters 39 and 29, respectively.

3.2 The Rights of Drug Administration

The traditional **five rights of drug administration** form the operational basis for the safe delivery of medications and are recognized by such organizations as the Institute for Safe Medication Practices. The five rights offer simple and practical guidance for nurses to use during drug preparation, delivery, and administration, and they focus on individual performance. The five rights are as follows:

1. Right patient
2. Right medication
3. Right dose
4. Right route of administration
5. Right time of delivery.

Additional rights have been added over the years. Additions to the original five rights include considerations such as the right to refuse medication, the right to receive drug education, the right preparation, and the right documentation, but deviations from the original five rights still account for most medication administration errors. If a patient refuses medication, it is the nurse's responsibility to educate the patient about drug benefits and risks and to assess for fears and reasons why the patient might refuse the medication. Ethical and legal considerations regarding the five rights are discussed in Chapter 7.

The **three checks of drug administration** that the nurse uses in conjunction with the five rights help to ensure patient safety and drug effectiveness. Traditionally these checks incorporate the following:

1. Checking the drug with the MAR or the medication information system when removing it from the medication drawer, refrigerator, or controlled substance locker
2. Checking the drug when preparing it, pouring it, taking it out of the unit-dose container, or connecting the IV tubing to the bag
3. Checking the drug before administering it to the patient.

Despite all attempts to provide safe drug delivery, medication errors continue to occur, some of which result in patient injury or death. Although the nurse is accountable for preparing and administering medications, the responsibility for safe and accurate administration of medications lies with multiple individuals, including prescribers, pharmacists, and other healthcare practitioners. The nurse who follows institutional policy and procedure when scanning is correctly checking the five rights three times. Unfortunately, when scanning is not done correctly, errors can occur. It should be noted that computerized scanning systems of medication administration do not relieve the healthcare provider of the responsibility to use the three checks and the five rights continuously. Factors contributing to medication errors and strategies for reducing their occurrence are presented in Chapter 7.

3.3 Patient Adherence and Successful Pharmacotherapy

Adherence, or compliance to the drug regimen, is a major factor affecting pharmacotherapeutic success. As it relates to pharmacology, **adherence** is taking a medication in the manner prescribed by the healthcare provider or, in the case of OTC drugs, following the instructions on the label. Patient nonadherence ranges from not taking the medication at all to taking it at the wrong time or in the wrong manner.

Applying Research to Nursing Practice: Off-Label Use of Medications in Pediatrics

Prescription and OTC medicines are used to treat many illnesses and diseases in childhood, yet many of the drugs have not been officially approved for children and are given off-label. Off-label is when a medication differs in dose or indication or route of administration from the published package insert and U.S. Food and Drug Administration (FDA) approval for that drug. Albuterol is a common example; although commonly used in infants and toddlers for reactive airway disease, albuterol is only FDA approved for children over 2 years old.

Currently, healthcare providers must prescribe many off-label prescriptions because with-holding those medications may be ethically more harmful than helpful. While providers do not wish to do anything unsafe intentionally, there is no FDA approval because the clinical trials have not been conducted by the drug manufacturer. Drug manufacturers have historically hesitated from pursuing clinical trials in the pediatric population due to financial and ethical concerns, so the FDA has recently increased its efforts to address this issue. As of April 2022, section 505A of the Federal Food, Drug, and Cosmetic Act approved pediatric exclusivity to 280 new drugs approved for pediatric use (FDA, 2022a). Pediatric exclusivity requires the FDA to develop, prioritize, and publish a list of approved drugs for which additional pediatric information may produce health benefits in the pediatric populations (FDA, 2022b).

Off-label prescribing is legal and common. It does not mean the healthcare provider is experimenting with the child, but it does come with the risk of possible therapeutic failure or adverse events. Off-label use is often necessary after careful consideration and evidentiary support for its use, but the lack of clinical trials and FDA approval for many drugs present a gap and an opportunity for further research and nurse advocacy.

3.4 Drug Orders and Time Schedules

Healthcare providers use accepted abbreviations to communicate the directions and times for drug administration. Table 3.1 lists common abbreviations that relate to universally scheduled times.

A **STAT order** refers to any medication that is needed immediately and is to be given only once. It is often associated with emergency medications that are needed for life-threatening situations. The term *STAT* comes from *statim*, the Latin word meaning "immediately." The healthcare provider normally notifies the nurse of any STAT order so it can be obtained from the pharmacy and administered immediately. The time between writing the order and administering the drug should be 5 minutes or less. Although not as urgent, an **ASAP order** (as soon as possible) should be available for administration to the patient within 30 minutes of the written order.

The **single order** is for a drug that is to be given only once and at a specific time, such as a preoperative order. A **PRN order** (Latin: *pro re nata*) is administered *as required* by the patient's condition. The nurse makes judgments, based on patient assessment, as to when such a medication is to be administered. Orders not written as STAT, ASAP, or PRN are called **routine orders**. These are usually carried out within 2 hours of the time the order is written by the healthcare provider. A **standing order** is written in advance of a situation that is to be carried out under specific circumstances. An example of a standing order is a set of postoperative PRN prescriptions that are written for all patients who have undergone a specific surgical procedure. A common standing order for patients who have had a tonsillectomy, for example, is "Tylenol elixir 325 mg PO every 6 hours PRN sore throat." Because of the legal implications of putting all patients into a single treatment category, standing orders are no longer permitted in some facilities.

Agency policies dictate that drug orders be reviewed by the attending healthcare provider within specific time frames, usually at least every 7 days. Prescriptions for narcotics and other scheduled drugs are often automatically discontinued after 72 hours, unless specifically reordered by the healthcare provider. Automatic stop orders do not generally apply when the number of doses or an exact period of time is specified.

Some medications must be taken at specific times. If a drug causes stomach upset, it is usually administered *with* meals to prevent epigastric pain, nausea, or vomiting. Other medications should be administered *between* meals because food interferes with absorption. Some central nervous system drugs and antihypertensives are best administered at *bedtime* because they may cause drowsiness. Sildenafil (Viagra) is unique in that it should be taken 30 to 60 minutes prior to expected sexual intercourse to achieve an effective erection. (*Note:* Sildenafil is also prescribed to hospitalized patients for pulmonary hypertension.) The nurse must pay careful attention to educating patients about the timing of their medications to enhance adherence to the drug regimen and to increase the potential for therapeutic success.

Table 3.1 Drug Administration Abbreviations

Abbreviation	Meaning
AM	morning
BID	twice a day
cap	capsule
gtt	drop
h or hr	hour
IM	intramuscular
IV	intravenous
PM	afternoon
PO	by mouth
PRN	as needed, when necessary
WID	four times per day
q2h	every 2 hours
q4h	every 4 hours
q6h	every 6 hours
q8h	every 8 hours
q12h	every 12 hours
Rx	"take," commonly used for prescriptions in written instructions
STAT	immediately; at once
tab	tablet
TID	three times a day

Note: For these and other recommendations, see The Joint Commission's official "Do Not Use List" at http://www.jointcommission.org/assets/1/18/dnu_list.pdf.

PharmFacts

GRAPEFRUIT JUICE AND DRUG INTERACTIONS

- Grapefruit juice may not be safe for people who take certain oral medications.
- Chemicals (most likely flavonoids) in grapefruit juice lower the activity of specific enzymes in the intestinal tract that normally break down medications. This allows a larger amount of medication to reach the bloodstream, resulting in increased drug activity.
- Drugs that may be affected by grapefruit juice include midazolam; cyclosporine (Sandimmune, Neoral); antihyperlipidemics, such as simvastatin (Zocor); calcium channel blockers, including nifedipine; certain antibiotics, such as erythromycin; and certain antifungals, such as itraconazole (Sporanox).
- Grapefruit juice should be consumed at least 2 hours before or 5 hours after taking an oral medication that may interact with it.
- Some drinks that are flavored with fruit juice could contain grapefruit juice, even if grapefruit is not part of the name of the drink. Check the ingredients label.

Once medications are administered, the nurse must correctly document that the medications have been given to the patient. This documentation is completed only *after* the medications have been given, not when they are prepared. The drug name, dosage, time administered, any assessments, and the nurse's signature should all be included. If a medication is refused or omitted, this fact must be recorded on the appropriate form within the medical record. It is customary to document the reason when possible. Should the patient voice any concerns or adverse effects about the medication, these should also be included.

3.5 Systems of Measurement

Dosages are labeled and dispensed according to their weight or volume. Three systems of measurement are used in pharmacology: metric, apothecary, and household.

The most common system of drug measurement uses the **metric system of measurement**. The volume of a drug is expressed in terms of liters (L) or milliliters (mL). The cubic centimeter (cc) is a measurement of volume that is equivalent to 1 mL of fluid, but the *cc* abbreviation is no longer used because it can be mistaken for the abbreviation for unit (u) and cause medication errors. The metric weight of a drug is stated in kilograms (kg), grams (g), milligrams (mg), or micrograms (mcg). Note that the abbreviation *μg* should not be used for microgram because it too can be confused with other abbreviations and cause a medication error.

The **apothecary system** and the **household system** are older systems of measurement. Although most healthcare providers and pharmacies use the metric system, these older systems are still encountered. In 2005, The Joint Commission, the accrediting organization for healthcare agencies, added "apothecary units" to its official "Do Not Use" list. However, because not all healthcare agencies are accredited by The Joint Commission and until the metric system totally replaces the other systems, the nurse must recognize dosages based on all three systems of measurement. Approximate equivalents among metric, apothecary, and household units of volume and weight are listed in Table 3.2.

Because Americans are very familiar with the teaspoon, tablespoon, and cup, the nurse must be able to convert between the household and metric systems of measurement. In the hospital, a glass of fluid is measured in milliliters—an 8-oz glass of water is recorded as 240 mL. If a patient being discharged is ordered to drink 2400 mL of fluid per day, the nurse may instruct the patient to drink 10 eight-oz glasses or 10 cups of fluid per day. Likewise, when a child is to be given a drug that is administered in elixir form, the nurse should explain that 5 mL of the drug is approximately the same as 1 teaspoon. The nurse should encourage the use of accurate medical dosing devices at home, such as oral dosing syringes, oral droppers, cylindrical spoons, and medication cups. Eating utensils that are commonly referred to as teaspoons or tablespoons often do not hold the volume that their names imply.

Table 3.2 Metric, Apothecary, and Household Approximate Measurement Equivalents

Metric	Apothecary	Household
1 mL	15–16 minims	15–16 drops
4–5 mL	1 fluid dram	1 teaspoon or 60 drops
15–16 mL	4 fluid drams	1 tablespoon or 3–4 teaspoons
30–32 mL	8 fluid drams or 1 fluid ounce	2 tablespoons
240–250 mL	8 fluid ounces (½ pint)	1 glass or cup
500 mL	1 pint	2 glasses or 2 cups
1 L	32 fluid ounces or 1 quart	4 glasses or 4 cups or 1 quart
1 mg	1/60 grain	-
60–64 mg	1 grain	-
300–325 mg	5 grains	-
1 g	15–16 grains	-
1 kg	-	2.2 pounds

Note: To convert grains to grams: Divide grains by 15 or 16. To convert grams to grains: Multiply grams by 15 or 16. To convert minims to milliliters: Divide minims by 15 or 16.

Because of the differences in volumes among standard teaspoons, dessert spoons, tablespoons, and "salt spoons," it is recommended that a measuring spoon used for cooking be used rather than household eating utensils if a more accurate dosing device is not available. Many OTC liquid medications come with a prepackaged medication cup to encourage correct dosing.

Routes of Drug Administration

The three broad categories of routes of drug administration are enteral, topical, and parenteral, and there are subsets within each of these. Each route has both advantages and disadvantages. Whereas some drugs are formulated to be given by several routes, others are specific to only one route. Pharmacokinetic considerations, such as how the route of administration affects drug absorption and distribution, are discussed in Chapter 4.

3.6 Enteral Drug Administration

The **enteral route** includes drugs given orally and those administered through nasogastric or gastrostomy tubes. Oral drug administration is the most common, most convenient, and usually the least costly of all routes. It is also considered the safest route because the skin barrier is not compromised. In cases of overdose, medications remaining in the stomach can be retrieved by inducing vomiting. Oral preparations are available in tablet, capsule, and liquid forms. Medications administered by the enteral route take advantage of the vast absorptive surfaces of the oral mucosa, stomach, or small intestine.

Tablets and Capsules

Tablets and capsules are the most common forms of drugs. Patients prefer tablets or capsules because of their ease of use. In some cases, tablets may be scored for more individualized dosing.

Some patients, particularly children, have difficulty swallowing tablets and capsules. Crushing tablets or opening capsules and sprinkling the drug over food or mixing it with juice will make it more palatable and easier to swallow. However, drugs should not be crushed or opened unless the manufacturer specifically states that this is permissible. Some drugs are inactivated by crushing or opening, whereas others severely irritate the stomach mucosa and cause nausea and/or vomiting. Occasionally, drugs should not be crushed because they irritate the oral mucosa, are extremely bitter, or contain dyes that stain the teeth. Most drug guides provide lists of drugs that may not be crushed. Guidelines for administering tablets or capsules are given in Table 3.3 (section A).

The strongly acidic contents within the stomach can present a destructive obstacle to the absorption of some medications. To overcome this barrier, tablets may have a hard, waxy coating that enables them to resist the acidity. These **enteric-coated** tablets are designed to dissolve in the alkaline environment of the small intestine. Enteric-coated tablets should not be crushed because the medication would then be directly exposed to the stomach environment.

Studies have clearly demonstrated that adherence to the drug regimen declines as the number of doses per day increases. Many drugs are available that have long durations of action that may be administered only once or twice daily. Sustained-release (SR), extended-release (XR), or long-acting (LA) tablets or capsules are designed to dissolve very slowly. This releases the medication over an extended time and results in a longer duration of action for the medication. These medications must not be crushed or opened.

Giving medications by the oral route has certain disadvantages. The patient must be conscious and able to swallow properly. Certain types of drugs, including proteins, are inactivated by digestive enzymes in the stomach and small intestine. Medications absorbed from the stomach and small intestine first travel to the liver, where they may be inactivated before they ever reach their target organs. This process, called *first-pass effect*, is discussed in Chapter 4. The significant variation in the motility of the gastrointestinal (GI) tract and in its ability to absorb medications can create differences in bioavailability. In addition, children and some adults have an aversion to swallowing large tablets and capsules or to taking oral medications that are distasteful.

Oral Transmucosal Drugs

The mucosa of the oral cavity contains a rich blood supply that provides an excellent absorptive surface for certain drugs. Medications given by this route are not subjected to destructive digestive enzymes, nor do they undergo hepatic first-pass effect.

Table 3.3 Enteral Drug Administration

Drug Form	Administration Guidelines
A. Tablet, capsule, or liquid (e.g., orally disintegrating tablets and soluble films are placed on the tongue and then swallowed.)	1. Assess that the patient is alert and is able to swallow. 2. Place the tablets or capsules into separate medication cups. 3. If the medication is in liquid form, shake the bottle to mix the agent and measure the dose into the cup at eye level. 4. Hand the patient the medication cup, one by one. 5. Offer a glass of water to facilitate swallowing the medication. Milk or juice may be offered if not contraindicated. 6. Remain with the patient until all the medication is swallowed.
B. Sublingual	1. Assess that the patient is alert and can hold the medication under the tongue. 2. Place the sublingual tablet under the tongue. 3. Instruct the patient not to chew or swallow the tablet or move the tablet around with the tongue. 4. Instruct the patient to allow the tablet to dissolve completely. 5. Remain with the patient to determine that all the medication has dissolved. 6. Offer a glass of water after the medication has dissolved if the patient desires.
C. Buccal	1. Assess that the patient is alert and can hold the medication between the gums and the cheek. 2. Place the buccal tablet between the gum line and the cheek. 3. Instruct the patient not to chew or swallow the tablet or move the tablet around with the tongue. 4. Instruct the patient to allow the tablet to dissolve completely. 5. Remain with the patient to determine that all of the medication has dissolved. 6. Offer a glass of water after the medication has dissolved if the patient desires.
D. Nasogastric and gastrostomy	1. Administer liquid forms, when possible, to avoid clogging the tube. Contact the pharmacist or healthcare provider if unsure if the medication may be given through the tube. 2. If the medication is solid, crush finely into a powder and mix thoroughly with at least 30 mL of warm water until dissolved. Enteric-coated, extended-release, and other dosage types may not be crushed. Always check the drug information before crushing. Each medication should go into a separate cup. 3. Assess and verify tube placement per agency protocol. 4. Turn off the enteric feeding, if applicable to the patient. 5. Aspirate stomach contents and measure the residual volume as per agency protocol. 6. Return the residual via gravity and flush with water. 7. Pour the medication into the syringe barrel and allow to flow into the tube by gravity. Give each medication separately, flushing between with water. 8. Keep the head of the bed elevated for 1 hour to prevent aspiration. 9. Reestablish continual feeding, as scheduled. Keep the head of the bed elevated 45° to prevent aspiration. 10. Keep in mind that the nurse should recognize cues of anything unexpected clinically through each step (i.e., during a nasogastric medication administration, greater than 100mL of volume is aspirated from the stomach).

For the **sublingual route**, the medication is placed under the tongue and allowed to dissolve slowly. Because of the rich blood supply in this region, the sublingual route results in a rapid onset of action. When multiple drugs have been ordered, the sublingual preparations should be administered after oral medications have been swallowed. The patient should be instructed not to move the drug with the tongue, nor to eat or drink anything until the medication has completely dissolved. The sublingual mucosa is not suitable for XR formulations because it is a relatively small area and is constantly being bathed by a substantial amount of saliva. Table 3.3 (section B) and Figure 3.1a present important points regarding sublingual drug administration.

To administer by the **buccal route**, the tablet or capsule is placed in the oral cavity between the gum and the cheek. The patient must be instructed not to manipulate the medication with the tongue; otherwise, it could get displaced to the sublingual area, where it would be more rapidly absorbed, or to the back of the throat, where it could be swallowed. The buccal mucosa is less permeable to most medications than the sublingual area, providing for slower absorption. The buccal route is preferred over the sublingual route for SR delivery because of the greater mucosal surface area of the former. Drugs formulated for buccal administration generally do not cause irritation and are small enough to not cause discomfort to the patient. Table 3.3 (section C) and Figure 3.1b provide important guidelines for buccal drug administration.

Orally disintegrating tablets (ODTs) and oral soluble films are newer drug delivery systems that allow for quick dissolving of medications without the need for an external source of water. Both forms are useful for children and for adults with adherence issues. These products usually contain a flavoring or sweetener to make the drug more palatable. ODTs are designed to dissolve in less than 30 seconds after placement on the tongue. The tablet is small and disintegrates upon contact with saliva. Once dissolved, the saliva containing the drug is swallowed.

The oral soluble film drug delivery system coats the drug on a polymer about the size of a postage stamp. The soluble strip of film is flexible and dissolves very quickly when placed on or under the tongue or on the buccal surface. Examples of drugs formulated as ODTs are ondansetron, clonazepam, and risperidone. Several pediatric medications are now available by this route.

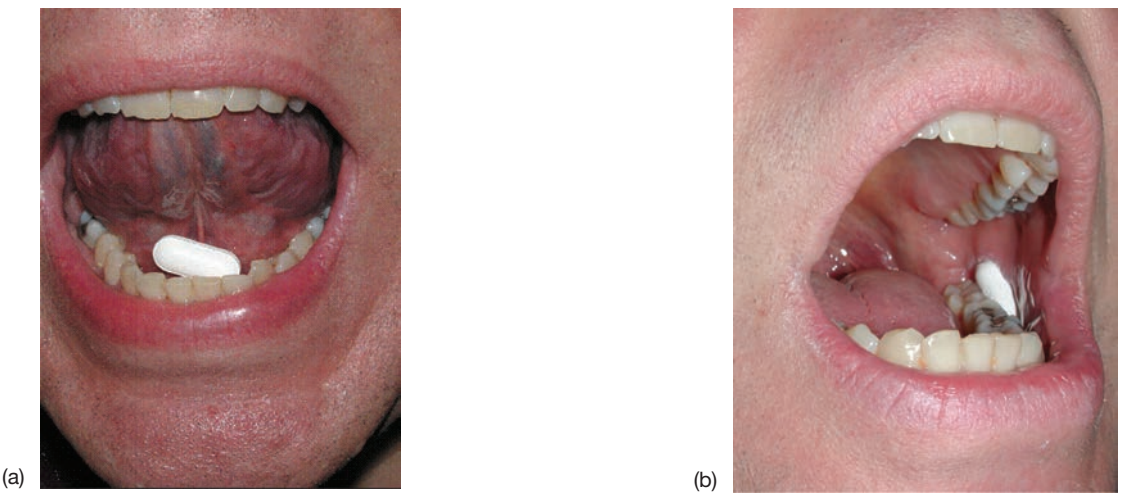
Nasogastric and Gastrostomy Drug Administration

Patients with a nasogastric tube or gastrostomy tube may have their medications administered through these devices. A nasogastric (NG) tube is a soft, flexible tube inserted by way of the nasopharynx with the tip lying in the stomach. A gastrostomy (G) tube is surgically placed directly into the patient's stomach. Generally, the NG tube is used for short-term treatment whereas the G tube is inserted for patients requiring long-term care. Drugs administered through these tubes are usually in liquid form. Although solid drugs can be crushed or dissolved, they tend to cause clogging within the tubes. SR drugs should not be crushed and administered through NG or G tubes. Drugs administered by this route are exposed to the same physiologic processes as those given orally. Table 3.3 (section D) gives important guidelines for administering drugs through NG or G tubes.

3.7 Topical Drug Administration

Topical drugs are those applied locally to the skin or the membranous linings of the eye, ear, nose, respiratory tract, urinary tract, vagina, and rectum. These applications include the following:

- *Dermatologic preparations.* Drugs applied to the skin. The topical route is most commonly used. Formulations include creams, lotions, gels, powders, and sprays.
- *Instillations and irrigations.* Drugs applied into body cavities or orifices. These routes may include the eyes, ears, nose, urinary bladder, rectum, and vagina.



(a) (b)

FIGURE 3.1 (a) Sublingual drug administration; (b) buccal drug administration
Pearson Education, Inc.

Treating the Diverse Patient: Religious Fasting and Adherence with Medication Administration

Religious fasting periods are a feature of many of the world's religions. During periods of religious fasting, such as Ramadan or Yom Kippur, patients observing a fast may not take their prescribed medications, including nonoral medications such as eyedrops, to avoid "breaking" the fast. Different religions and religious authorities may allow the taking of required medications during the fast, but patients may avoid all medications, depending on their own personal religious beliefs.

Nurses play an important role in assessing cultural or religious customs, serving as a patient advocate and increasing effective communication about relevant practices with the interdisciplinary team. By recognizing known periods of religious fasting and discussing the observance of fasting periods with the patient, nurses can explore opportunities to develop strategies for successful medication use. For example, an alternative form of the medication may be ordered, if available (e.g., a 12-hour dose that could be taken before, beginning, and after ending the fast rather than a 6-hour dose). If the patient is unable to adhere to medication administration during fasting periods due to religious beliefs, the prescribing healthcare provider should also be notified.

- *Inhalations.* Drugs applied to the respiratory tract by inhalers, nebulizers, or positive-pressure breathing apparatuses. The most common indication for inhaled drugs is bronchoconstriction due to bronchitis or asthma; however, a number of illegal, abused drugs are taken by this route because it provides a very rapid onset of drug action (see Chapter 22). Additional details on inhalation drug administration can be found in Chapter 40.

Many drugs are applied topically to produce a *local* effect. For example, antibiotics may be applied to the skin to treat skin infections. Antineoplastic agents may be instilled into the urinary bladder via catheter to treat tumors of the bladder mucosa. Corticosteroids are sprayed into the nostrils to reduce inflammation of the nasal mucosa due to allergic rhinitis. Local, topical delivery produces fewer side effects compared with oral or parenteral administration of the same drug. This is because topically applied drugs are absorbed very slowly, and amounts reaching the general circulation are minimal.

Some drugs are given topically to provide for slow release and absorption of the drug in the general circulation. These agents are administered for their *systemic* effects. For example, a nitroglycerin patch is applied to the skin, not to treat a local skin condition but to treat a systemic condition, such as coronary artery disease. Likewise, prochlorperazine (Compro) suppositories are inserted rectally, not to treat a disease of the rectum but to alleviate nausea.

The distinction between topical drugs given for local effects and those given for systemic effects is an important one for the nurse. In the case of local drugs, absorption is undesirable and may cause side effects. For systemic drugs, absorption is essential for the drug's therapeutic action. With either type of topical agent, drugs should not be applied to abraded or denuded skin, unless directed to do so.

Transdermal Delivery System

The use of transdermal patches provides an effective means of delivering certain medications. Examples include nitroglycerin for angina pectoris and scopolamine (Transderm-Scop) for motion sickness. Although transdermal patches contain a specific amount of drug, the rate of delivery and the actual dose received may be variable. Patches are changed on a regular basis, using a site rotation routine, which should be documented in the MAR. Before applying a transdermal patch, the nurse should verify that the previous patch has been removed and disposed of appropriately. Drugs to be administered by this route avoid the first-pass effect in the liver and bypass digestive enzymes. Table 3.4 (section A) and Figure 3.2 illustrate the major points of transdermal drug delivery.

Ophthalmic Administration

The ophthalmic route is used to treat local conditions of the eye and surrounding structures. Common indications include excessive dryness, infections, glaucoma, and dilation of the pupil during eye examinations. Ophthalmic drugs are available in the form of eye irrigations, drops, ointments, and medicated disks. In adults, only small amounts of these drugs reach the systemic circulation; thus, ophthalmic drugs cause few systemic adverse effects. In infants, however, the concentration of drugs reaching the systemic circulation is higher than in an adult, giving a greater risk for side effects. Figure 3.3 and Table 3.4 (section B) give guidelines for adult administration. Although the procedure is the same with a child, it is advisable to enlist the help of an adult caregiver.

Otic Administration

The otic route is used to treat local conditions of the ear, including infections and soft blockages of the auditory canal. Otic medications include eardrops and irrigations, which are usually ordered for cleaning purposes. Administration to infants and young children must be performed carefully to avoid injury to the sensitive structures of the ear. Figure 3.4 and Table 3.4 (section C) present key points in administering otic medications.

Nasal Administration

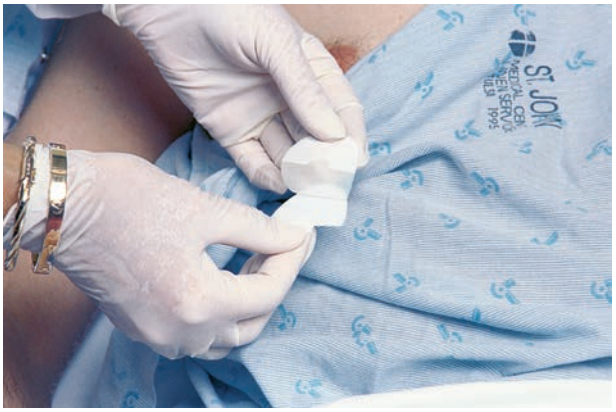
The nasal route is used for both local and systemic drug administration. The nasal mucosa provides an excellent absorptive surface for certain medications. Advantages of this route include ease of use and avoidance of the first-pass effect and digestive enzymes. For example, nasal spray formulations of corticosteroids are the preferred treatment of allergic rhinitis owing to their high safety margin.

Table 3.4 Topical Drug Administration

Drug Form	Administration Guidelines
A. Transdermal	1. Apply gloves before handling to avoid absorption of the agent by the nurse. 2. Label the patch with the date, time, and the nurse's initials. 3. Remove the previous medication or patch and cleanse the area. 4. If using a transdermal ointment, apply the ordered amount of medication in an even line directly on the premeasured paper that accompanies the medication tube. 5. Press the patch or apply the medicated paper to clean, dry, and hairless skin. Many transdermal patches have pressure-activated adhesive. The rate of drug release may also be altered by external factors, such as heat. Apply firm pressure to the patch without heat. 6. Rotate sites to prevent skin irritation.
B. Ophthalmic	1. Instruct the patient to lie supine or sit with the head slightly tilted back. 2. With the nondominant hand, pull the lower eyelid down gently to expose the conjunctival sac, creating a pocket. 3. Ask the patient to look upward. 4. Hold the eyedropper 1/4–1/8 inch above the conjunctival sac. Do not hold the dropper over the eye, as this may stimulate the blink reflex. 5. Instill the prescribed number of drops into the center of the pocket. Avoid touching the eye or conjunctival sac with the tip of the eyedropper. 6. If applying ointment, apply a thin line of ointment evenly along the inner edge of the lower lid margin, from inner to outer canthus. 7. Instruct the patient to close the eye gently. Apply gentle pressure with a finger to the nasolacrimal duct at the inner canthus for 1–2 minutes to avoid overflow drainage into the nose and throat, thus minimizing the risk of absorption into the systemic circulation. 8. With a tissue, gently blot or remove excess medication around the eye. 9. Replace the dropper into the bottle if it comes separately. Do not rinse the eyedropper.
C. Otic	1. Instruct the patient to lie on the opposite side of administration or to sit with the head tilted so that the affected ear is facing up. 2. If necessary, clean the pinna of the ear and the meatus with a clean washcloth or gauze to prevent any discharge from being washed into the ear canal during the instillation of the drops. 3. Hold the dropper 1/4 inch above the ear canal and instill the prescribed number of drops into the side of the ear canal, allowing the drops to flow downward. Avoid placing the drops directly on the tympanic membrane. 4. Gently apply intermittent pressure to the tragus of the ear three or four times. 5. Instruct the patient to remain in a side-lying position for up to 10 minutes to prevent loss of medication. 6. If a cotton ball is ordered, presoak with medication and insert it into the outermost part of the ear canal. 7. Wipe any solution that may have dripped from the ear canal with a tissue.
D. Nasal spray	1. Ask the patient to blow the nose to clear the nasal passages. 2. Insert the tip of the nozzle into the nostril, aiming the top of the nozzle toward the ear on the opposite side of the head. 3. Instruct the patient to inhale through the nostril as the top of the canister is pushed down to administer the medication. 4. Repeat these steps for the opposite nostril, as applicable. 5. Ask the patient to not blow the nose for at least 10 minutes after administration.
E. Vaginal	1. Instruct the patient to assume a supine position with knees bent and separated. 2. Place water-soluble lubricant into a medicine cup. 3. Apply gloves; open the suppository and lubricate the rounded end. 4. Expose the vaginal orifice by separating the labia with the nondominant hand. 5. Insert the rounded end of the suppository about 8–10 cm along the posterior wall of the vagina or as far as it will pass. 6. If using a cream, jelly, or foam, gently insert the applicator 5 cm along the posterior vaginal wall and slowly push the plunger until empty. Remove the applicator and place it on a paper towel. 7. Ask the patient to lower the legs and remain lying in the supine or side-lying position for 5–10 minutes following insertion. A sanitary pad may be required to prevent soiling of underclothes or bed.
F. Rectal suppositories	1. Instruct the patient to lie on the left side (Sims position). 2. Place water-soluble lubricant into a medicine cup. 3. Apply gloves; open the suppository and lubricate the blunt end. Suppositories are designed for the rounded end to be facing out to exert less pressure on the internal anal sphincter, thereby decreasing the patient's urge to push it out. 4. Lubricate the gloved forefinger of the dominant hand with water-soluble lubricant. 5. Inform the patient when the suppository is to be inserted; instruct the patient to take slow, deep breaths and deeply exhale during insertion to relax the anal sphincter. 6. Gently insert the lubricated end of the suppository into the rectum beyond the anal–rectal ridge to ensure retention. 7. Instruct the patient to remain in the Sims position or to lie supine to prevent expulsion of the suppository. 8. Instruct the patient to retain the suppository for at least 30 minutes to allow absorption to occur, unless the suppository is administered to stimulate defecation.

Although the nasal mucosa provides an excellent surface for drug delivery, there is the potential for damage to the cilia within the nasal cavity, and mucosal irritation is common. In addition, unpredictable mucus secretion among some individuals may affect drug absorption from this site. Drops or sprays are often used for their local **astringent effect**; that is, they shrink swollen mucous membranes or loosen secretions and facilitate drainage. This brings immediate relief from the nasal congestion caused by the common cold. The nose also provides the route to reach the nasal sinuses and the eustachian tube. Proper positioning of the patient prior to instilling nose drops for sinus disorders

(a)



(b)

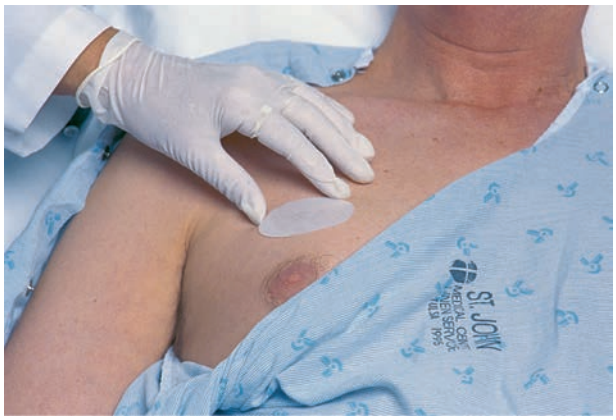


FIGURE 3.2 Transdermal patch administration: (a) protective coating removed from patch; (b) patch immediately applied to clean, dry, hairless skin and labeled with date, time, and initials
PH College photos/Pearson Education, Inc.

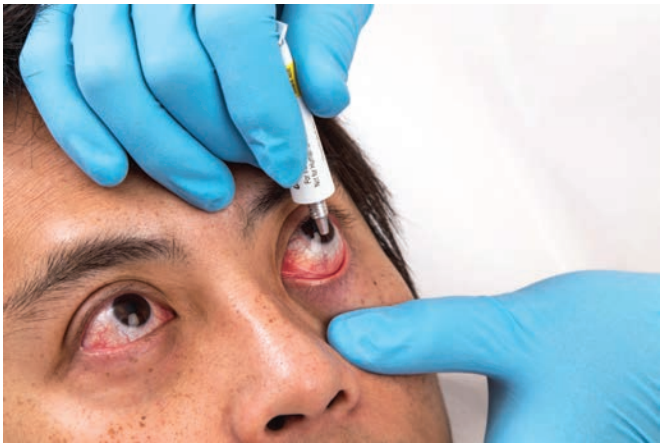


FIGURE 3.3 Instilling an eye ointment into the lower conjunctival sac
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FIGURE 3.4 Instilling eardrops
Ricky Brandy/Pearson Education, Inc.

depends on which sinuses are being treated. The same holds true for treatment of the eustachian tube. Table 3.4 (section D) and Figure 3.5 illustrate important facts related to nasal drug administration.

Vaginal Administration

The vaginal route is used to deliver medications for treating local infections and to relieve vaginal pain and itching. Vaginal medications are inserted as suppositories, creams, jellies, or foams. The vagina has a rich blood supply, and drugs may be absorbed to produce systemic effects. For example, vaginal creams containing estrogen not only produce local effects on the vagina but may also result in significant levels of this hormone in the circulation. The contraceptive NuvaRing, inserted into the vagina, contains estrogen and progestin, which are absorbed and provide contraception protection for a month. Table 3.4 (section E) and Figure 3.6 provide guidelines regarding vaginal drug administration.

Rectal Administration

The rectal route may be used for either local or systemic drug administration. It is a safe and effective means of delivering drugs to patients who are comatose or who are experiencing

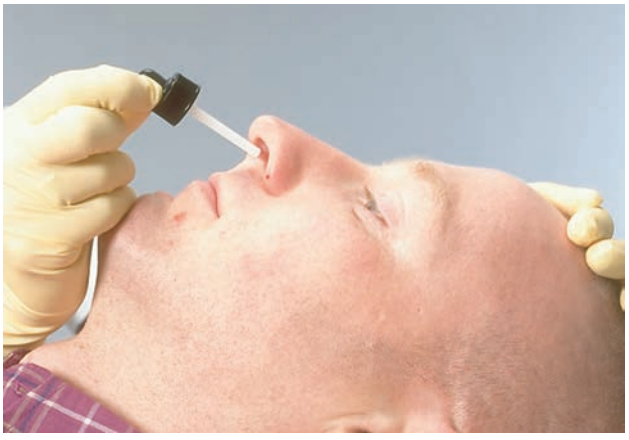

FIGURE 3.5 Nasal drug administration
PH College photos/Pearson Education, Inc.

nausea and vomiting. Rectal drugs are normally in suppository form, although a few laxatives and diagnostic agents are given via enema. Although absorption is slower than by other routes, it is steady and reliable provided the medication can be retained by the patient. Venous blood from the lower rectum is not transported by way of the liver;

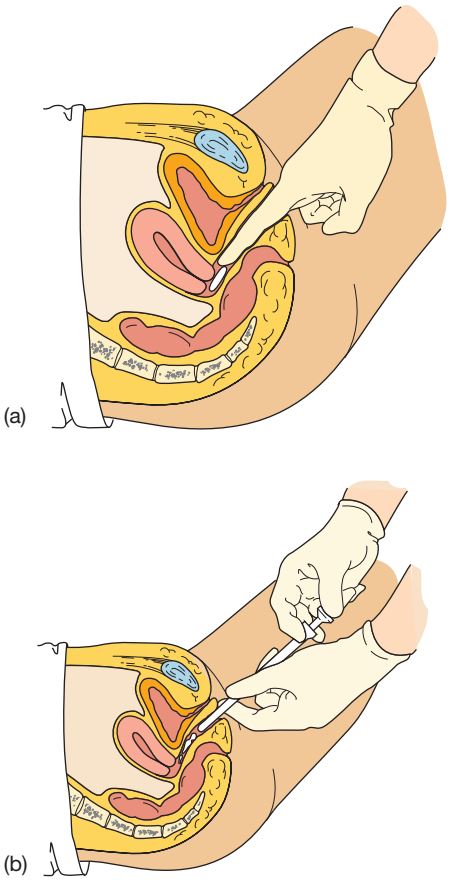

FIGURE 3.6 Vaginal drug administration: (a) instilling a vaginal suppository; (b) using an applicator to instill a vaginal cream

thus, the first-pass effect is avoided, as are the digestive enzymes of the upper GI tract. Table 3.4 (section F) gives selected details regarding rectal drug administration.

3.8 Parenteral Drug Administration

Parenteral administration refers to the dispensing of medications by routes other than oral or topical. The **parenteral route** delivers drugs via a needle into the skin layers, subcutaneous tissue, muscles, or veins. More advanced parenteral delivery includes administration into arteries, body cavities (intrathecal), and organs (such as intracardiac). Parenteral drug administration is much more invasive than topical or enteral. Because of the potential for introducing pathogenic microbes directly into the blood or body tissues, aseptic techniques must be strictly applied. The nurse is expected to identify and use appropriate materials for parenteral drug delivery, including specialized equipment and techniques involved in the preparation and administration of injectable products. The nurse must know the correct anatomic locations for parenteral administration and safety procedures regarding hazardous equipment disposal.

Intradermal and Subcutaneous Administration

Injection into the skin delivers drugs to the blood vessels that supply the various layers of the skin. Drugs may be injected either intradermally or subcutaneously. The major difference between these methods is the depth of injection. An advantage of both methods is that they offer a means of administering drugs to patients who are unable to take them orally. Drugs administered by these routes avoid the hepatic first-pass effect and digestive enzymes. Disadvantages are that only small volumes can be administered, and injections can cause pain and swelling at the injection site.

An **intradermal (ID)** injection is administered into the dermis layer of the skin. Because the dermis contains more blood vessels than the deeper subcutaneous layer, drugs are more easily absorbed. ID injection is usually employed for allergy and disease screening or for local anesthetic delivery prior to venous cannulation. ID injections are limited to very small volumes of drug, usually only 0.1 to 0.2 mL. The usual sites for ID injections are the nonhairy skin surfaces of the upper back, over the scapulae, the high upper chest, and the inner forearm. Guidelines for intradermal injections are given in Table 3.5 (section A) and Figure 3.7.

A **subcutaneous** injection is delivered to the deeper tissue layers associated with the skin. Insulin, heparin, vitamins, some vaccines, and other medications are given in this area because the sites are easily accessible and provide rapid absorption. Body sites that are ideal for subcutaneous injections include the following:

- Outer aspect of the upper arms, in the area above the triceps muscle
- Middle two-thirds of the anterior thigh area
- Subscapular areas of the upper back
- Upper dorsogluteal and ventrogluteal areas
- Abdominal areas, above the iliac crest and below the diaphragm, 1.5 to 2 inches out from the umbilicus.

Subcutaneous doses are small in volume, usually ranging from 0.5 to 1 mL. The needle size varies with the patient's quantity of body fat. The length is usually half the size of a pinched or bunched skinfold that can be grasped between the thumb and forefinger. It is important to rotate injection sites in an orderly and documented manner to promote absorption, minimize tissue damage, and alleviate discomfort. For insulin, however, rotation should be within an anatomic area to promote reliable absorption and maintain consistent blood glucose levels. When performing subcutaneous injections, it is usually not necessary to aspirate prior to the injection. It depends on what is being injected and the patient's anatomy. Aspiration might prevent inadvertent administration into a vein or artery in a thin person. If the medication should not be administered directly into a vessel, aspiration is recommended. For example, long-acting insulins should not be given IV; therefore, aspiration is justified. Heparin, on the other hand, can be safely administered IV and so aspiration is not required. Note that tuberculin syringes and insulin syringes are not interchangeable, so the nurse should not substitute one for the other. Table 3.5 (section B) and Figure 3.8 include important information regarding subcutaneous drug administration.

Table 3.5 Parenteral Drug Administration

Drug Form	Administration Guidelines
A. Intradermal route	1. Verify the order and prepare the medication in a tuberculin or 1-mL syringe with a preattached 26- to 27-gauge, 3/8- to 5/8-inch needle. 2. Apply gloves and cleanse the injection site with an antiseptic swab in a circular motion. Allow to air-dry. 3. With the thumb and index finger of the nondominant hand, spread the skin taut. 4. Insert the needle, with the bevel facing upward, at an angle of 10–15°. 5. Advance the needle until the entire bevel is under the skin; do not aspirate. 6. Withdraw the needle quickly and pat the site gently with a sterile 2×2 gauze pad. Do not massage the area. 7. Instruct the patient not to rub or scratch the area.
B. Subcutaneous route	1. Verify the order and prepare the medication in a 1- to 3-mL syringe using a 23- to 25-gauge, $^{1}/_{2}$- to $^{5}/_{8}$-inch needle. For heparin, the recommended needle is $^{3}/_{8}$ inch and 25–26 gauge. 2. Choose the site, avoiding areas of bony prominence, major nerves, and blood vessels. For heparin and other parenteral anticoagulants, check with agency policy for the preferred injection sites. 3. Check the previous rotation sites and select a new area for injection. 4. Apply gloves and cleanse the injection site with an antiseptic swab in a circular motion. 5. Allow to air-dry. 6. Pinch or bunch the skin between the thumb and index finger of the nondominant hand. 7. Insert the needle at a 45° or 90° angle depending on body size: 90° if obese, 45° if average weight. If the patient is very thin, gather the skin at the area of needle insertion and administer at a 90° angle. 8. Inject the medication slowly. 9. Remove the needle quickly and gently massage the site with an antiseptic swab. For heparin and other parenteral anticoagulants, do not massage the site, as this may cause increased bruising or bleeding.
C. Intramuscular route: ventrogluteal (different administration guidelines would apply to the dorsogluteal, vastus lateralis, and deltoid muscle sites)	1. Verify the order and prepare the medication using a 20- to 23-gauge, 5/8- to 2-inch needle. 2. Apply gloves and cleanse the ventrogluteal injection site with antiseptic swab in a circular motion. Allow to air-dry. 3. Locate the site by placing the hand with the heel on the greater trochanter and the thumb toward the umbilicus. Point to the anterior iliac spine with the index finger, spreading the middle finger to point toward the iliac crest (forming a V). Inject the medication within the V-shaped area of the index and third finger. (*Note:* This is how to locate the ventrogluteal site.) 4. Insert the needle with a smooth, dartlike movement at a 90° angle within the V-shaped area. 5. Depending on agency policy and type of drug, aspirate, and observe for blood. If blood appears, withdraw the needle, discard the syringe, and prepare a new injection. 6. Inject the medication slowly and with smooth, even pressure on the plunger. 7. Remove the needle quickly. 8. Apply pressure to the site with a dry, sterile 2×2 gauze and massage to promote absorption of the medication into the muscle.
D. Intravenous route: to add a drug to an IV fluid container (different administration guidelines for adding an IV bolus to an existing line)	1. Verify the order and compatibility of the drug with the IV fluid. 2. Prepare the medication in a 1- to 20-mL syringe using a 1- to 1.5-inch, 19- to 21-gauge needle from the original medication vial or ampule. If a needleless system is used, use the appropriate syringe or tip required per the system in use. 3. Apply gloves and assess the injection site for signs and symptoms of inflammation or extravasation. 4. Locate the medication port on the IV fluid container and cleanse with an antiseptic swab. 5. Carefully insert the needle or needleless access device into the port and inject the medication. 6. Withdraw the needle and mix the solution by rotating the container end to end. 7. Hang the container and check the infusion rate.

Intramuscular Administration

An **intramuscular (IM)** injection delivers medication directly into specific muscles. Because muscle tissue has a rich blood supply, medication moves quickly into blood vessels to produce a more rapid onset of action than with oral, ID, or subcutaneous administration. The anatomic structure of muscle permits this tissue to receive a larger volume of medication than the subcutaneous region. An adult with well-developed muscles can safely tolerate up to 3 mL of medication in a large muscle, although only 2 mL is recommended. The deltoid and triceps muscles should receive a maximum of 1 mL.

A major consideration for the nurse regarding IM drug administration is the selection of an appropriate injection site. Injection sites must be located away from bone, large blood vessels, and nerves. The size and length of the needle are determined by body size and muscle mass, the type of drug to be administered, the amount of adipose tissue overlying the muscle, and the age of the patient. Information regarding IM injections is given in Table 3.5 (section C) and Figure 3.9. The four common sites for intramuscular injections are as follows:

1. *Ventrogluteal site.* This is the preferred site for IM injections. This area provides the greatest thickness of gluteal muscles, contains no large blood vessels or nerves, is sealed off by bone, and contains less fat than the buttock area, thus eliminating the need to determine the depth of subcutaneous fat. It is a suitable site for children and infants over 7 months of age.
2. *Deltoid site.* This site is used in well-developed teens and adults for volumes of medication not to exceed 1 mL. Because the radial nerve lies in close proximity, the deltoid is not generally used, except for small-volume vaccines, such as for hepatitis B in adults.
3. *Dorsogluteal site.* This site is used for adults and for children who have been walking for at least 6 months. The site is rarely used due to the potential for damage to the sciatic nerve.

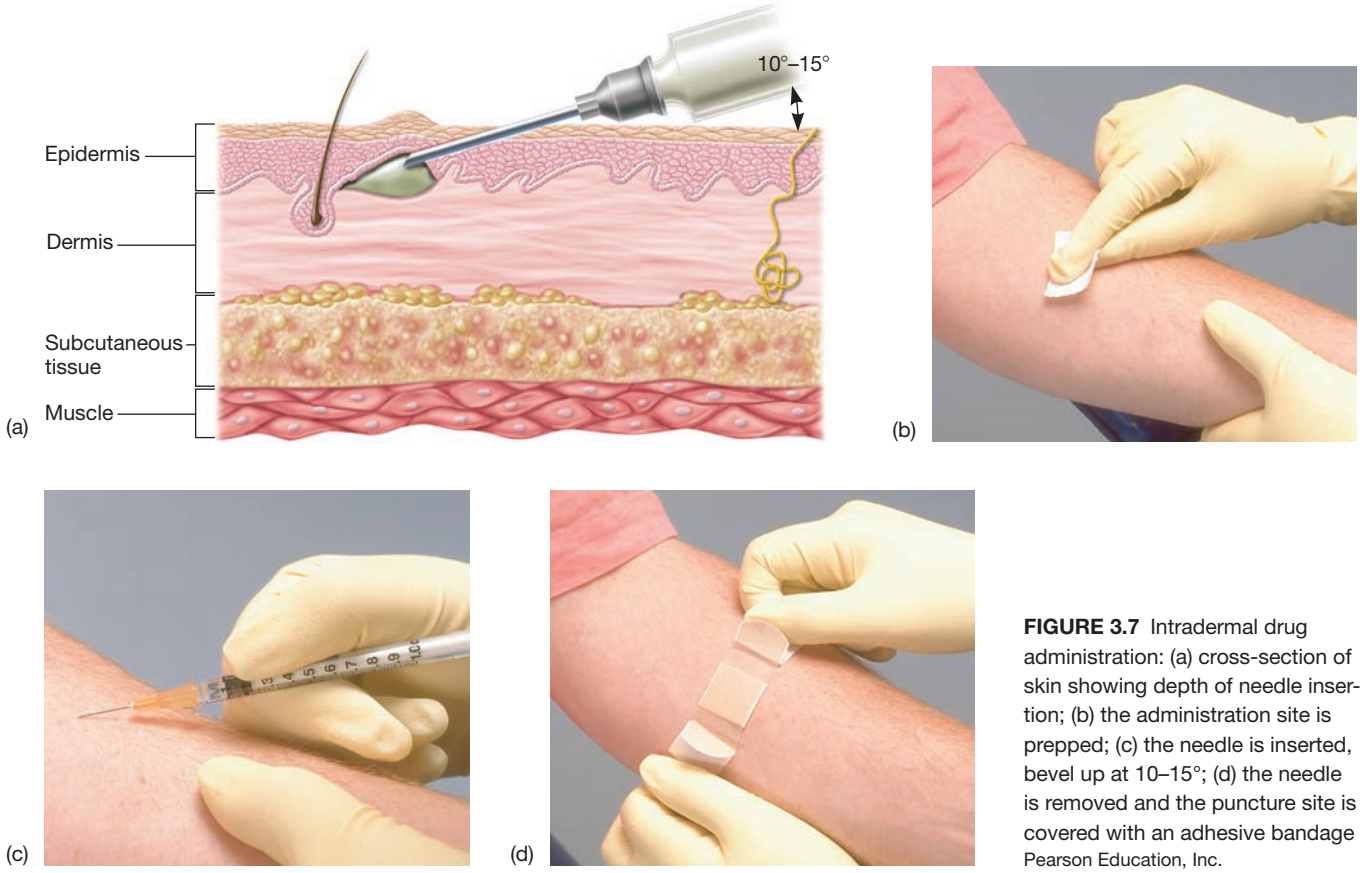

FIGURE 3.7 Intradermal drug administration: (a) cross-section of skin showing depth of needle insertion; (b) the administration site is prepped; (c) the needle is inserted, bevel up at 10–15°; (d) the needle is removed and the puncture site is covered with an adhesive bandage
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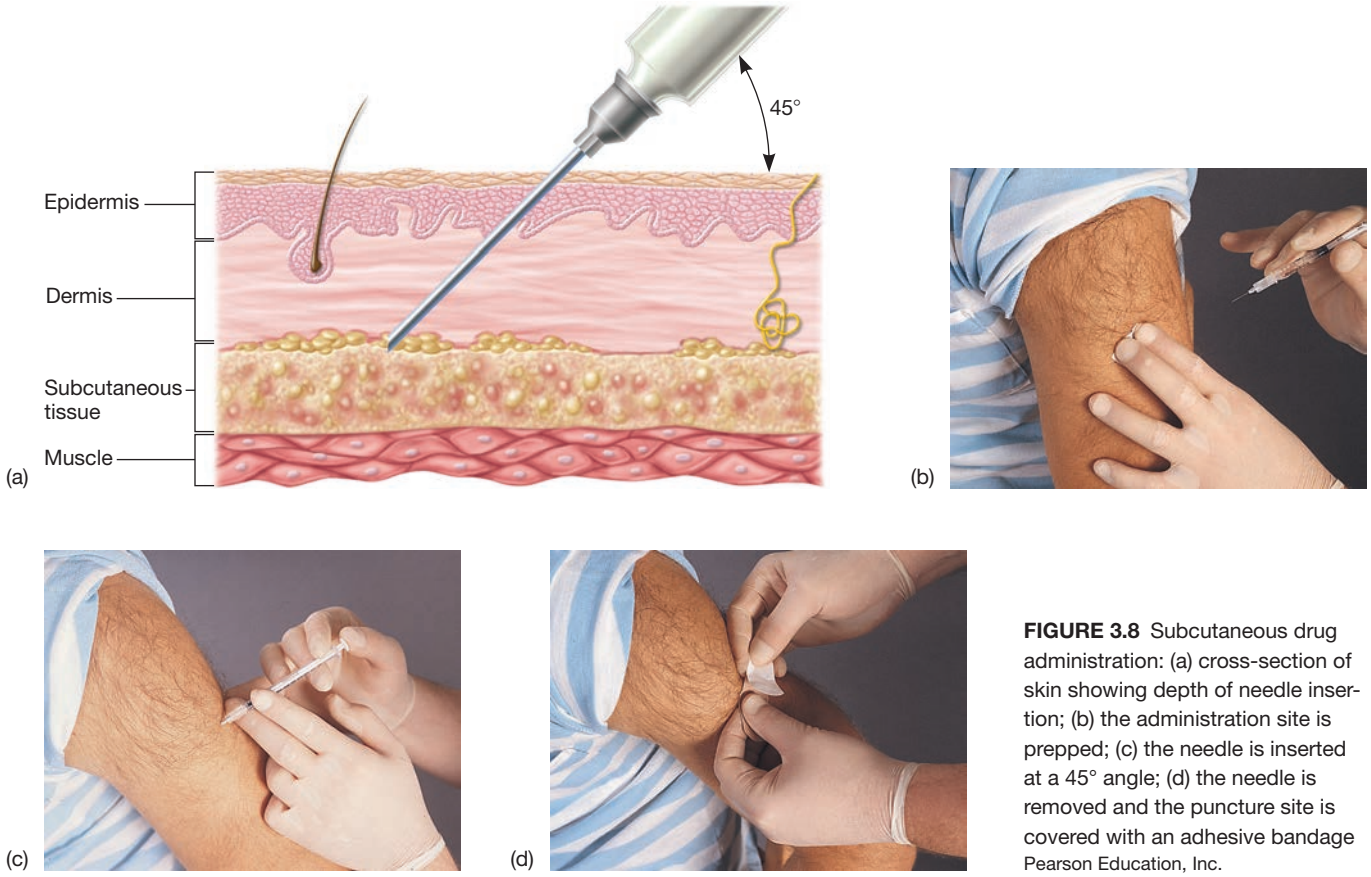

FIGURE 3.8 Subcutaneous drug administration: (a) cross-section of skin showing depth of needle insertion; (b) the administration site is prepped; (c) the needle is inserted at a 45° angle; (d) the needle is removed and the puncture site is covered with an adhesive bandage
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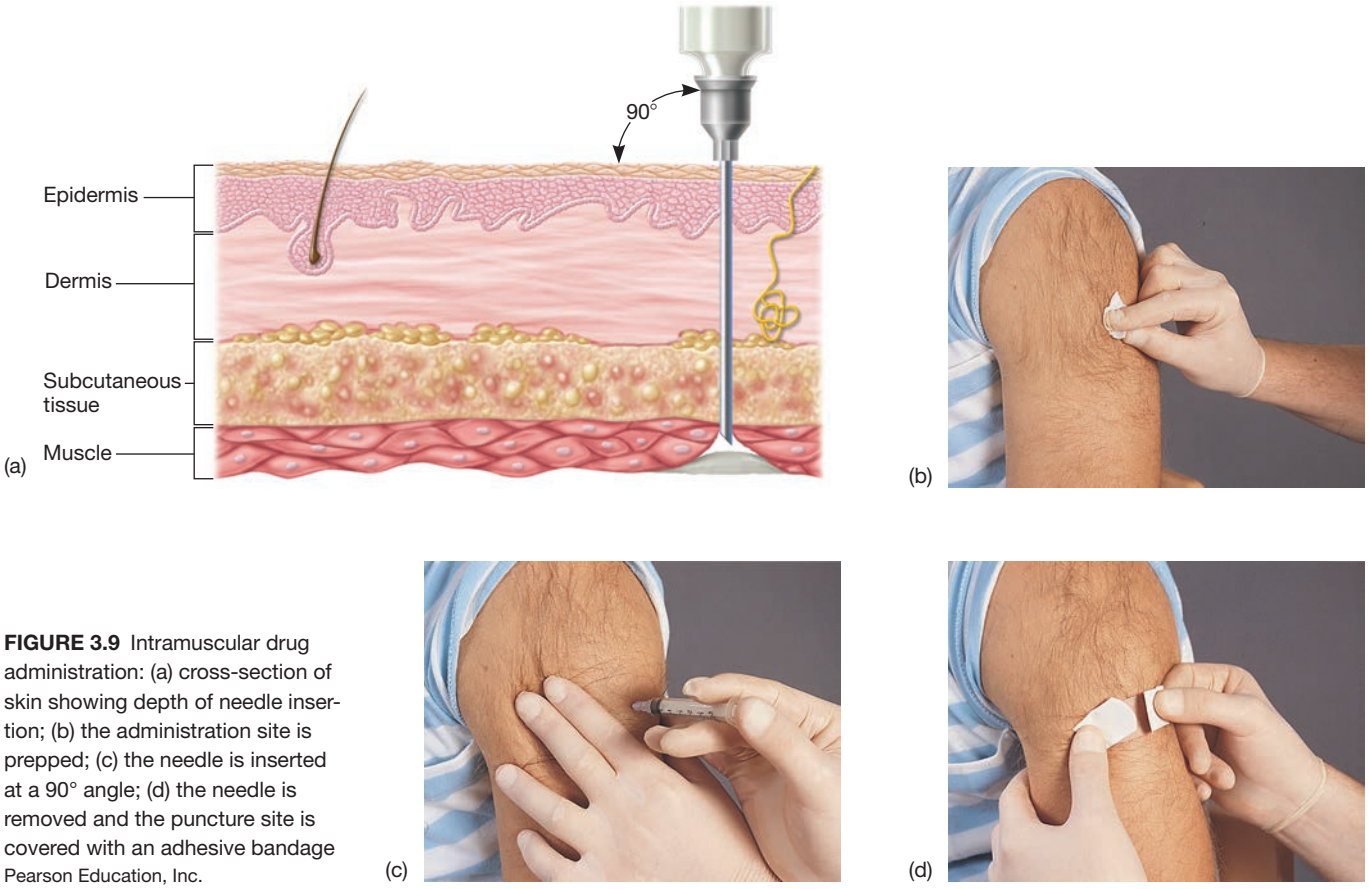

FIGURE 3.9 Intramuscular drug administration: (a) cross-section of skin showing depth of needle insertion; (b) the administration site is prepped; (c) the needle is inserted at a 90° angle; (d) the needle is removed and the puncture site is covered with an adhesive bandage
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4. *Vastus lateralis site.* The vastus lateralis is usually thick and well developed in both adults and children. The middle third of the muscle is the site for IM injections.

Intravenous Administration

Intravenous (IV) medications and fluids are administered directly into the bloodstream and are immediately available for use by the body. The IV route is used if a rapid onset of action is desired. As with other parenteral routes, IV medications bypass the enzymatic process of the digestive system and the first-pass effect of the liver. The three basic types of IV administration are as follows:

1. *Large-volume infusion.* This type of IV administration is for fluid maintenance, replacement, or supplementation. Compatible drugs may be mixed into a large-volume IV container with fluids such as normal saline or Ringer's lactate. Table 3.5 (section D) and Figure 3.10 illustrate this technique.
2. *Intermittent infusion.* This is a small amount of IV solution that is arranged in tandem with or piggybacked to the primary large-volume infusion (Figure 3.11). It is used to instill adjunct medications, such as antibiotics or analgesics, over a short time period.
3. *IV bolus (push) administration.* This is a concentrated dose delivered directly to the circulation via syringe to administer single-dose medications. Bolus injections may be given through an intermittent injection port or by direct IV push. Details on the bolus administration technique are given in Table 3.5 (section D).

The most common ways of securing access to administer IV medications or fluids are through central lines and peripheral IV sites; both include a catheter that is placed under the skin into the vein. Central lines, like implantable ports, are surgically implanted catheters into large veins. Implantable ports are typically found on the chest and commonly used for chemotherapy. Peripheral IVs are commonly placed at the bedside and go into much smaller veins, like the ones found in the antecubital fossa and hand. Peripherally inserted central lines (PICC lines) come out of the arm near the antecubital fossa as well but have a very long catheter so the opening goes into a large vein, making it a central line. It is important for nurses to know what types of IV access their patient has, and which medications prescribed must go into central lines (i.e., vasopressors are not allowed to go through peripheral lines).

Although the IV route offers the fastest onset of drug action, it is also the most dangerous. Once injected, the medication cannot be retrieved. If the drug solution or the needle is contaminated, pathogens have a direct route to the bloodstream and body tissues. Patients who are receiving IV injections must be closely monitored for adverse reactions. Some reactions occur immediately after injection; others may take hours or days to appear. Antidotes for drugs that can cause potentially dangerous or fatal reactions must always be readily available.

FIGURE 3.10 Injecting a medication by IV push to an existing IV using a needleless system
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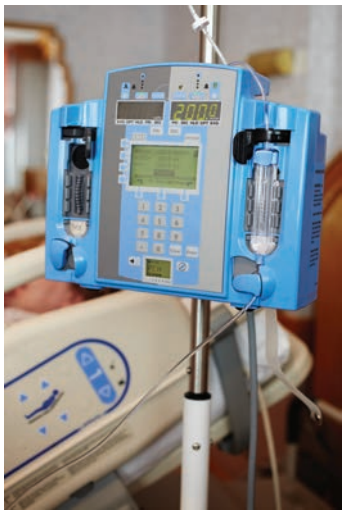

FIGURE 3.11 An infusion pump is used for both continuous and intermittent IV administration
Medicimage/UIG/Universal Images Group North America LLC/Alamy Stock Photo.

Chapter Review

KEY Concepts

The numbered key concepts provide a succinct summary of the important points from the corresponding numbered section within the chapter. If any of these points are not clear, refer to the numbered section within the chapter for review.

3.1 The nurse must have a comprehensive knowledge of the actions and side effects of drugs before they are administered to limit the number and severity of adverse drug reactions.

3.2 The five rights and three checks are guidelines for safe drug administration, which is a collaborative effort among the nurse, the healthcare provider, and other healthcare professionals.

3.3 For pharmacologic adherence, the patient must understand and personally accept the value associated with the prescribed drug regimen. When pharmacotherapy fails to produce the expected outcomes, nonadherence should be considered a possible explanation.

3.4 There are established orders and time schedules by which medications are routinely administered. Documentation of drug administration and reporting of side effects are important responsibilities of the nurse.

3.5 Systems of measurement used in pharmacology include the metric, apothecary, and household systems. Although the metric system is most commonly used, the nurse must be able to convert dosages among the three systems of measurement.

3.6 The enteral route includes drugs given orally and those administered through nasogastric or gastrostomy tubes. It also includes those administered by buccal, sublingual, and oral disintegrating tablet and film methods. This is the most common route of drug administration.

3.7 Topical drugs are applied locally to the skin or membranous linings of the eye, ear, nose, respiratory tract, urinary tract, vagina, and rectum.

3.8 Parenteral administration is the dispensing of medications via a needle, usually into the skin layers (ID), subcutaneous tissue, muscles (IM), or veins (IV).