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chapter 1

General Principles of Pharmacology

Key Terms

additive drug reaction
adverse reaction
agonist
allergic reaction
anaphylactic shock
angioedema
antagonist
antibodies
antigen
biotransformation
botanical medicine
controlled substances
cumulative drug effect
drug idiosyncrasy
drug tolerance
half-life
hypersensitivity
macromolecule
nonprescription drugs
pharmaceutic
pharmacodynamics
pharmacogenetic disorder
pharmacokinetics
pharmacology
physical dependency
polypharmacy
prescription drugs
psychological dependency
receptor
synergism
teratogen
toxic

Chapter Objectives

On completion of this chapter, the student will:

- Define pharmacology.
- Discuss drug development in the United States.
- Identify the different names assigned to drugs.
- Distinguish between prescription drugs, nonprescription drugs, and controlled substances.
- Discuss the laws governing the manufacture, distribution, and sale of drugs.
- Discuss the various types of drug reactions produced in the body.
- Identify factors that influence drug action.
- Define drug tolerance, cumulative drug effect, and drug idiosyncrasy.
- Discuss the types of drug interactions that may be seen with drug administration.
- Discuss the nursing implications associated with drug actions, interactions, and effects.
- Discuss the use of botanical medicines.

Pharmacology is the study of drugs and their action on living organisms. A sound knowledge of basic pharmacologic principles is essential if the nurse is to safely administer medications and to monitor patients who receive these medications. This chapter gives a basic overview of pharmacologic principles that the nurse must understand when administering medications. The chapter also discusses drug development, federal legislation affecting the dispensing and use of drugs, and the use of botanical medicines as they relate to pharmacology.

DRUG DEVELOPMENT

Drug development is a long and arduous process, taking anywhere from 7 to 12 years, and sometimes even longer. The United States Food and Drug Administration (FDA) has the responsibility of approving new drugs and monitoring drugs currently in use for adverse or toxic reactions. The development of a new drug is divided into the pre-FDA phase and the FDA phase (Fig. 1-1). During the pre-FDA phase, a manufacturer discovers a drug that looks promising. In vitro testing (testing in an artificial environment, such as a test tube) using animal and human cells is done. This testing is followed by studies in live animals. The manufacturer then makes application to the FDA for Investigational New Drug (IND) status.

With IND status, clinical testing of the new drug begins. Clinical testing involves three phases, with each phase involving a larger number of people. All effects, both pharmacologic and biologic, are noted. Phase I lasts 4 to 6 weeks and involves 20 to 100 individuals who are either "normal" volunteers or individuals in the intended treatment population. If Phase I studies are successful, the testing moves to Phase II, and if those results are positive, to Phase III. Each successive phase has a larger subject population. Phase III studies offer additional information on dosing and safety. The three phases last anywhere from 2 to 10 years, with the average being 5 years.

A New Drug Application (NDA) is submitted after the investigation of the drug in Phases I, II, and III is

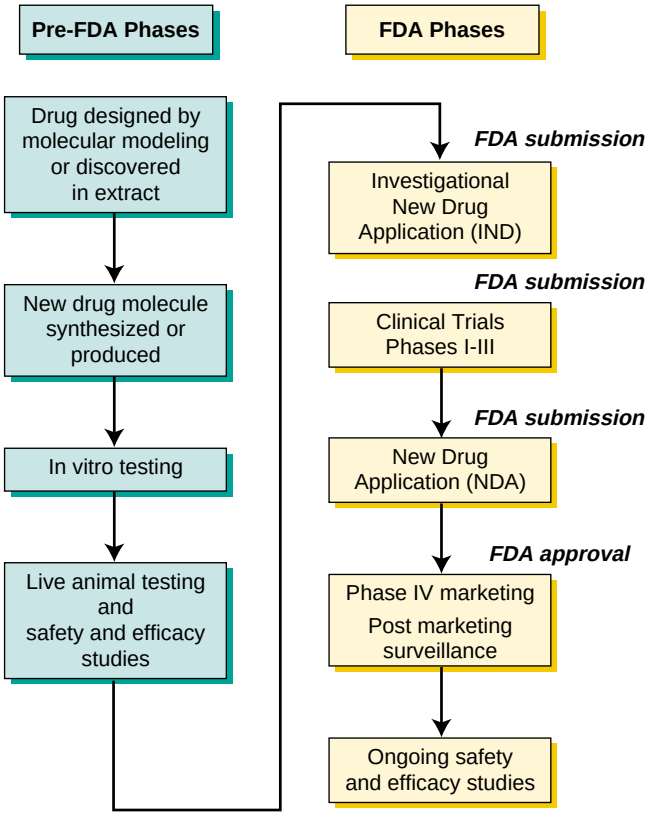


FIGURE 1-1 Phases of drug development. Adapted from (1997, Spring) *PharmPhax,* 3 (2), 2.

complete and the drug is found to be safe and effective. With the NDA, the manufacturer submits all data collected concerning the drug during the clinical trials. A panel of experts, including pharmacologists, chemists, physicians, and other professionals, reviews the application and makes a recommendation to the FDA. The FDA then either approves or disapproves the drug for use. This process of review takes approximately 2 years. After FDA approval, continued surveillance is done to ensure safety.

Postmarketing surveillance occurs after the manufacturer places the drug on the market. During this surveillance, an ongoing review of the drug occurs with particular attention given to adverse reactions. Health care professionals are encouraged to help with this surveillance by reporting adverse effects of drugs to the FDA by using MedWatch (see Display 1-1).

SPECIAL FDA PROGRAMS

Although it takes considerable time for most drugs to get FDA approval, the FDA has special programs to meet different needs. Examples of these special programs include the orphan drug program, accelerated programs for urgent needs, and compassionate use programs.

Orphan Drug Program

The Orphan Drug Act of 1983 was passed to encourage the development and marketing of products used to treat rare diseases. The act defines a "rare disease" as a condition affecting fewer than 200,000 individuals in the United States. The National Organization of Rare Disorders reports that there are more than 6000 rare disorders that affect approximately 25 million individuals. Examples of rare disorders include Tourette's syndrome, ovarian cancer, acquired immunodeficiency syndrome (AIDS), Huntington's disease, and certain forms of leukemia.

The act provides for incentives, such as research grants, protocol assistance by the FDA, and special tax credits, to encourage manufacturers to develop orphan drugs. If the drug is approved, the manufacturer has 7 years of exclusive marketing rights. More than 100 new drugs have received FDA approval since the law was passed. Examples of orphan drugs include thalidomide for leprosy, triptorelin pamoate for ovarian cancer, tetrabenazine for Huntington's disease, and zidovudine for AIDS.

Accelerated Programs

Accelerated approval of drugs is offered by the FDA as a means to make promising products for life-threatening diseases available on the market, based on preliminary evidence before formal demonstration of patient benefit.

DISPLAY 1-1 ● How to Report Adverse Reactions

A drug must be used and studied for many years before all of the adverse reactions are identified. To help in identifying adverse reactions the nurse must be aware of reporting mechanisms. The FDA established a reporting program called MedWatch by which nurses or other health care professionals can report observations of serious adverse drug effects by using a standard form (see Appendix A). The FDA protects the identity of those who voluntarily report adverse reactions. This form also is used to report an undesirable experience associated with the use of medical products (eg, latex gloves, pacemakers, infusion pumps, anaphylaxis, blood, blood components, etc.). It is important to submit reports, even if there is uncertainty about the cause-effect relationship.

Nurses play an important role in monitoring for adverse reactions. The FDA considers serious adverse reactions those that may result in death, life-threatening illness, hospitalization, or disability or those that may require medical or surgical intervention.

Adverse drug reactions may be reported to the FDA by completing the MedWatch form and sending it to:
MedWatch
5600 Fishers Lane
Rockville, MD 20852-9787

Reports may be faxed to the following number:
1-800-FDA-0178

Forms are available online and can be downloaded, completed, and returned via mail, fax, or electronic mail. See the following website:
www.fda.gov/medwatch/index.html

The approval that is granted is considered a "provisional approval," with a written commitment from the pharmaceutical company to complete clinical studies that formally demonstrate patient benefit. This program seeks to make life-saving investigational drugs available before granting final approval to treat diseases that pose a significant health threat to the public. One example of a disease that qualifies as posing a significant health threat is AIDS. Because AIDS is so devastating to the individuals affected and because of the danger the disease poses to public health, the FDA and pharmaceutical companies are working together to shorten the IND approval process for some drugs that show promise in treating AIDS. This accelerated process allows primary care providers to administer medications that indicate positive results in early Phase I and II clinical trials, rather than wait until final approval is granted. If the drug continues to prove beneficial, the process of approval is accelerated.

Compassionate Access to Unapproved Drugs

The compassionate access program allows patients to receive drugs that have not yet been approved by the FDA. This program provides experimental drugs for patients who could benefit from new treatments but whose conditions are such that they most probably would die before the drug is approved for use. These patients are often too sick to participate in the controlled studies. Drug manufacturers make a proposal to the FDA to target patients with the disease and, at the pharmaceutical company's expense, provide the drug free to patients. The pharmaceutical company analyzes and presents to the FDA data on the treatment. This program is not without problems. Because the drug is not in full production, quantities may be limited, so the number of patients may be limited, and patients may be selected at random. Because patients receiving compassionate access often are sicker, they are at increased risk for toxic reactions. This results in the newly developed drug running the risk of obtaining a "bad reputation," even before marketing begins.

DRUG NAMES

Throughout the process of development, drugs may have several names assigned to them: a chemical name, a generic (nonproprietary) name, an official name, and a trade or brand name. This is confusing unless the nurse has a clear understanding of the different names used. Table 1-1 identifies the different names and provides an explanation of each.

DRUG CATEGORIES

After approval of a drug, the FDA assigns the drug to one of the following categories: prescription, nonprescription, or controlled substance.

Prescription Drugs

Prescription drugs are drugs that the federal government has designated to be potentially harmful unless their use is supervised by a licensed health care provider, such as a nurse practitioner, physician, or dentist. Although these drugs have been tested for safety and therapeutic effect, prescription drugs may cause different reactions in some individuals.

In institutional settings the nurse administers the drug and monitors the patient for therapeutic effect and adverse reactions. Some drugs have the potential to be **toxic** (harmful). The nurse plays a critical role in evaluating the patient for toxic effects. When these drugs are prescribed to be taken at home, the nurse provides patient and family education about the drug.

TABLE 1-1 Drug Names

DRUG NAME AND EXAMPLE	EXPLANATION
Chemical name Example: ethyl 4-(8-chloro-5,6-dihydro-11*H*-benzo[5,6] cycloheptal[1,2-b]-pyridin-11-ylidene)-1-piperidinecardisplayylate	Gives the exact chemical makeup of the drug and placing of the atoms or molecular structure; it is not capitalized.
Generic name (nonproprietary) Example: loratadine	Name given to a drug before it becomes official; may be used in all countries, by all manufacturers; it is not capitalized.
Official name Example: loratadine	Name listed in *The United States Pharmacopeia-National Formulary;* may be the same as the generic name.
Trade name (brand name) Example: Claritin©	Name that is registered by the manufacturer and is followed by the trademark symbol; the name can be used only by the manufacturer; a drug may have several trade names, depending on the number of manufacturers; the first letter of the name is capitalized.

DEA # _____

CHARLES FULLER M.D.
SUSAN LUNGLEY R.N., A.N.
1629 TREASURE HILLS
HOUSTON, TX 79635

NAME _____

ADDRESS _____ DATE _____

R_x

☐ Label

Refill _____ times PRN NR

_____ M.D.

To ensure brand name dispensing, prescriber must write 'Dispense As Written' on the prescription.

FIGURE 1-2. Example of a prescription form.

Prescription drugs, also called legend drugs, are the largest category of drugs. Prescription drugs are prescribed by a licensed health care provider. The prescription (see Fig. 1-2) contains the name of the drug, the dosage, the method and times of administration, and the signature of the licensed health care provider prescribing the drug.

Nonprescription Drugs

Nonprescription drugs are drugs that are designated by the FDA to be safe (if taken as directed) and obtained without a prescription. These drugs are also referred to as over-the-counter (OTC) drugs and may be purchased in a variety of settings, such as a pharmacy, drugstore, or in the local supermarket. OTC drugs include those given for symptoms of the common cold, headaches, constipation, diarrhea, and upset stomach.

These drugs are not without risk and may produce adverse reactions. For example, acetylsalicylic acid, commonly known as aspirin, is potentially harmful and can cause gastrointestinal bleeding and salicylism (see Chap. 17). Labeling requirements give the consumer important information regarding the drug, dosage, contraindications, precautions, and adverse reactions. Consumers are urged to read the directions carefully before taking OTC drugs.

Controlled Substances

Controlled substances are the most carefully monitored of all drugs. These drugs have a high potential for abuse and may cause physical or psychological dependence. **Physical dependency** is a compulsive need to use a substance repeatedly to avoid mild to severe withdrawal symptoms; it is the body's dependence on repeated administration of a drug. **Psychological dependency** is a compulsion to use a substance to obtain a pleasurable experience; it is the mind's dependence on the repeated administration of a drug. One type of dependency may lead to the other type.

The Controlled Substances Act of 1970 regulates the manufacture, distribution, and dispensing of drugs that have abuse potential (see information under "Federal Drug Legislation and Enforcement" in this chapter). Drugs under the Controlled Substances Act are divided into five schedules, based on their potential for abuse and physical and psychological dependence. Display 1-2 describes the five schedules.

Prescriptions for controlled substances must be written in ink and include the name and address of the patient and the Drug Enforcement Agency number of the primary health care provider. Prescriptions for these drugs cannot be filled more than 6 months after the prescription

DISPLAY 1-2 ● Schedules of Controlled Substances

SCHEDULE I (C-I)
- High abuse potential
- No accepted medical use in the United States
- Examples: heroin, marijuana, LSD (lysergic acid diethylamide), peyote

SCHEDULE II (C-II)
- Potential for high abuse with severe physical or psychological dependence
- Examples: narcotics such as meperidine, methadone, morphine, oxycodone; amphetamines; and barbiturates

SCHEDULE III (C-III)
- Less abuse potential than schedule II drugs
- Potential for moderate physical or psychological dependence
- Examples: nonbarbiturate sedatives, nonamphetamine stimulants, limited amounts of certain narcotics

SCHEDULE IV (C-IV)
- Less abuse potential than schedule III drugs
- Limited dependence potential
- Examples: some sedatives and anxiety agents, nonnarcotic analgesics

SCHEDULE V (C-V)*
- Limited abuse potential
- Examples: small amounts of narcotics (codeine) used as antitussives or antidiarrheals

*Under federal law, limited quantities of certain schedule V drugs may be purchased without a prescription directly from a pharmacist if allowed under state law. The purchaser must be at least 18 years of age and must furnish identification. All such transactions must be recorded by the dispensing pharmacist.

was written or be refilled more than five times. Under federal law, limited quantities of certain schedule C-V drugs may be purchased without a prescription, with the purchase recorded by the dispensing pharmacist. In some cases state laws are more restrictive than federal laws and impose additional requirements for the sale and distribution of controlled substances. In hospitals or other agencies that dispense controlled substances, the scheduled drugs are counted every 8 to 12 hours to account for each ampule, tablet, or other form of the drug. Any discrepancy in the number of drugs must be investigated and explained immediately.

FEDERAL DRUG LEGISLATION AND ENFORCEMENT

Many laws have been enacted over the last century that affect drug distribution and administration. Those included here are the Pure Food and Drug Act; Harrison Narcotic Act; Pure Food, Drug, and Cosmetic Act; and the Comprehensive Drug Abuse Prevention and Control Act. These laws control the use of the three categories of drugs in the United States (prescription, nonprescription, and controlled substances).

Pure Food and Drug Act

This act, passed in 1906, was the first attempt by the government to regulate and control the manufacture, distribution, and sale of drugs. Before 1906, any substance could be called a drug, and no testing or research was required before placing the drug on the market. Before this time, drug potency and the purity of many drugs were questionable, and some were even dangerous for human use.

Harrison Narcotic Act

This law, passed in 1914, regulated the sale of narcotic drugs. Before the passage of this act, any narcotic could be purchased without a prescription. This law was amended many times. In 1970, the Harrison Narcotic Act was replaced with the passage of the Comprehensive Drug Abuse Prevention and Control Act.

Pure Food, Drug, and Cosmetic Act

In 1938, Congress passed this law that gave the FDA control over the manufacture and sale of drugs, food, and cosmetics. Before the passage of this act, some drugs, as well as foods and cosmetics, contained chemicals that were often harmful to humans. This law requires that these substances are safe for human use. It also requires pharmaceutical companies to perform toxicology tests before a new drug is submitted to the FDA for approval. Following FDA review of the tests performed on animals and other research data, approval may be given to market the drug (see sections on “Drug Development”).

Comprehensive Drug Abuse Prevention and Control Act

Congress passed this act in 1970 because of the growing problem of drug abuse. It regulates the manufacture, distribution, and dispensation of drugs that have the potential for abuse. Title II of this law, the Controlled Substances Act, deals with control and enforcement. The Drug Enforcement Agency within the US Department of Justice is the leading federal agency responsible for the enforcement of this act.

Drug Enforcement Administration

The Drug Enforcement Administration (DEA) within the US Department of Justice is the chief federal agency responsible for enforcing the Controlled Substances Act. Failure to comply with the Controlled Substances Act is punishable by fine and/or imprisonment. With drug abuse so prevalent, nurses must diligently adhere to the regulation imposed by the FDA and the Nurse Practice Act of their state. Any violation may result in the loss of the nurse’s license to practice. Nurses must also report any misuse or abuse of these substances by other nurses to their State Board of Nursing. Most states have provisions within their Nurse Practice Act to assist nurses who have problems with drug abuse.

DRUG USE AND PREGNANCY

The use of any medication—prescription or nonprescription—carries a risk of causing birth defects in the developing fetus. Drugs administered to pregnant women, particularly during the first trimester (3 months), may cause teratogenic effects. A **teratogen** is any substance that causes abnormal development of the fetus leading to a severely deformed fetus. Drugs are one type of teratogen.

In an effort to prevent teratogenic effects, the FDA has established five categories suggesting the potential of a drug for causing birth defects (Display 1-3). Information regarding the pregnancy category of a specific drug is found in reliable drug literature, such as the inserts accompanying drugs and approved drug references. In general, most drugs are contraindicated during pregnancy or lactation unless the potential benefits of taking the drug outweigh the risks to the fetus or the infant.

DISPLAY 1-3 ● Pregnancy Categories

PREGNANCY CATEGORY A
- Controlled studies show no risk to the fetus.
- Adequate well-controlled studies in pregnant women have not demonstrated risk to the fetus.

PREGNANCY CATEGORY B
- There is no evidence of risk in humans.
- Animal studies show risk, but human findings do not.
- If no adequate human studies have been done, animal studies are negative.

PREGNANCY CATEGORY C
- Risk cannot be ruled out.
- Human studies are lacking, and animal studies are either positive for fetal risk or lacking.
- The drug may be used during pregnancy if the potential benefits of the drug outweigh its possible risks.

PREGNANCY CATEGORY D
- There is positive evidence of risk to the human fetus.
- Investigational or postmarketing data show risk to the fetus.
- However, potential benefits may outweigh the risk to the fetus. If needed in a life-threatening situation or a serious disease, the drug may be acceptable if safer drugs cannot be used or are ineffective.

PREGNANCY CATEGORY X
- Use of the drug is contraindicated in pregnancy.
- Studies in animals or humans or investigational or postmarketing reports, have shown fetal risk that clearly outweighs any possible benefit to the patient.

Regardless of the pregnancy category or the presumed safety of the drug, no drug should be administered during pregnancy unless it is clearly needed and the potential benefits outweigh potential harm to the fetus.

During pregnancy, no woman should consider taking any drug, legal or illegal, prescription or nonprescription, unless the drug is prescribed or recommended by the primary health care provider. Smoking or drinking any type of alcoholic beverage also carries risks, such as low birth weight, premature birth, and fetal alcohol syndrome. Children born of mothers using addictive drugs, such as cocaine or heroin, often are born with an addiction to the drug abused by the mother.

DRUG ACTIVITY WITHIN THE BODY

Drugs act in various ways in the body. Oral drugs go through three phases: the pharmaceutic phase, pharmacokinetic phase, and pharmacodynamic phase. Liquid and parenteral drugs (drugs given by injection) go through the later two phases only.

Pharmaceutic Phase

The **pharmaceutic** phase of drug action is the dissolution of the drug. Drugs must be in solution to be absorbed. Drugs that are liquid or drugs given by injection (parenteral drugs) do not go through the pharmaceutic phase. A tablet or capsule (solid forms of a drug) goes through this phase as it disintegrates into small particles and dissolves into the body fluids within the gastrointestinal tract. Tablets that are enteric-coated do not disintegrate until reaching the alkaline environment of the small intestine.

Pharmacokinetic Phase

Pharmacokinetics refers to activities within the body after a drug is administered. These activities include absorption, distribution, metabolism, and excretion (ADME). Another pharmacokinetic component is the half-life of the drug. **Half-life** is a measure of the rate at which drugs are removed from the body.

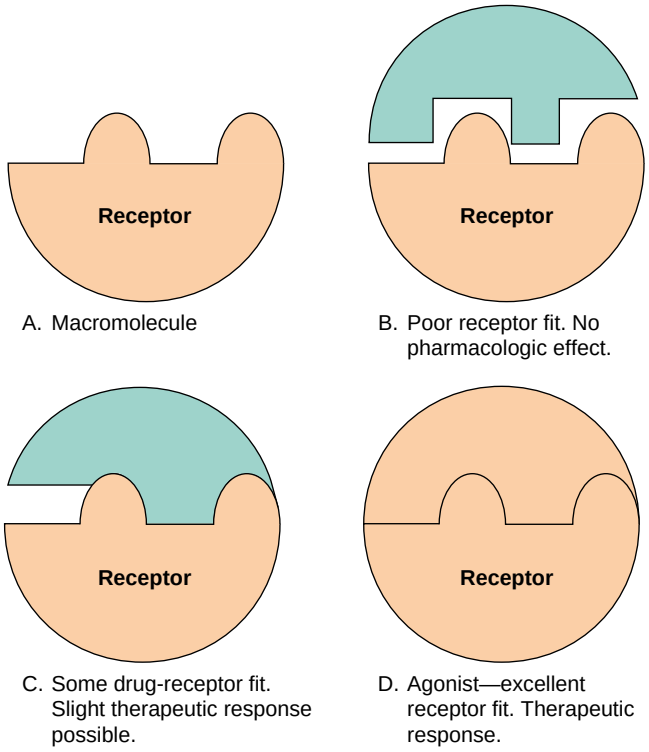
Absorption

Absorption follows administration and is the process by which a drug is made available for use in the body. It occurs after dissolution of a solid form of the drug or after the administration of a liquid or parenteral drug. In this process the drug particles within the gastrointestinal tract are moved into the body fluids. This movement can be accomplished in several ways: active absorption, passive absorption, and pinocytosis. In active absorption a carrier molecule such as a protein or enzyme actively moves the drug across the membrane. Passive absorption occurs by diffusion (movement from a higher concentration to a lower concentration). In pinocytosis cells engulf the drug particle causing movement across the cell.

As the body transfers the drug from the body fluids to the tissue sites, absorption into the body tissues occurs. Several factors influence the rate of absorption, including the route of administration, the solubility of the drug, and the presence of certain body conditions. Drugs are most rapidly absorbed when given by the intravenous route, followed by the intramuscular route, the subcutaneous route, and lastly, the oral route. Some drugs are more soluble and thus are absorbed more rapidly than others. For example, water-soluble drugs are readily absorbed into the systemic circulation. Bodily conditions, such as the development of lipodystrophy (atrophy of the subcutaneous tissue) from repeated subcutaneous injections, inhibit absorption of a drug given in the site of lipodystrophy.

Distribution

The systemic circulation distributes drugs to various body tissues or target sites. Drugs interact with specific receptors (see Fig. 1-3) during distribution. Some drugs travel by binding to protein (albumin) in the blood. Drugs bound to protein are pharmacologically inactive. Only when the protein molecules release the drug can the drug diffuse into the tissues, interact with receptors, and produce a therapeutic effect.



A. Macromolecule
B. Poor receptor fit. No pharmacologic effect.
C. Some drug-receptor fit. Slight therapeutic response possible.
D. Agonist—excellent receptor fit. Therapeutic response.

FIGURE 1-3. Drug-receptor interactions. (Adapted from Reiss & Evans, *Pharmacological Aspects of Nursing Care,* 3rd ed.)

As the drug circulates in the blood, a certain blood level must be maintained for the drugs to be effective. When the blood level decreases below the therapeutic level, the drug will not produce the desired effect. Should the blood level increase significantly over the therapeutic level, toxic symptoms develop. Specific therapeutic blood levels are discussed in the subsequent chapters when applicable.

Metabolism

Metabolism, also called **biotransformation,** is the process by which a drug is converted by the liver to inactive compounds through a series of chemical reactions. Patients with liver disease may require lower dosages of a drug detoxified by the liver, or the primary care provider may select a drug that does not undergo a biotransformation by the liver. Frequent liver function texts are necessary when liver disease is present. The kidneys, lungs, plasma, and intestinal mucosa also aid in the metabolism of drugs.

Excretion

The elimination of drugs from the body is called excretion. After the liver renders drugs inactive, the kidney excretes the inactive compounds from the body. Also, some drugs are excreted unchanged by the kidney without liver involvement. Patients with kidney disease may require a dosage reduction and careful monitoring of kidney function. Children have immature kidney function and may require dosage reduction and kidney function tests. Similarly, older adults have diminished kidney function and require careful monitoring and lower dosages. Other drugs are eliminated by sweat, breast milk, breath, or by the gastrointestinal tract in the feces.

Half-Life

Half-life refers to the time required for the body to eliminate 50% of the drug. Knowledge of the half-life of a drug is important in planning the frequency of dosing. For example, drugs with a short half-life (2–4 hours) need to be administered frequently, whereas a drug with a long half-life (21–24 hours) requires less frequent dosing. It takes five to six half-lives to eliminate approximately 98% of a drug from the body. Although half-life is fairly stable, patients with liver or kidney disease may have problems excreting a drug. Difficulty in excreting a drug increases the half-life and increases the risk of toxicity. For example, digoxin (Lanoxin) has a long half-life (36 hours) and requires once-daily dosing. However, aspirin has a short half-life and requires frequent dosing. Older patients or patients with impaired kidney or liver function require frequent diagnostic tests measuring renal or hepatic function.

PHARMACODYNAMIC PHASE

Pharmacodynamics deals with the drug's action and effect within the body. After administration, most drugs enter the systemic circulation and expose almost all body tissues to possible effects of the drug. All drugs produce more than one effect in the body. The primary effect of a drug is the desired or therapeutic effect. Secondary effects are all other effects, whether desirable or undesirable, produced by the drug.

Most drugs have an affinity for certain organs or tissues and exert their greatest action at the cellular level on those specific areas, which are called target sites. There are two main mechanisms of action:

1. Alteration in cellular environment
2. Alteration in cellular function

Alteration in Cellular Environment

Some drugs act on the body by changing the cellular environment, either physically or chemically. Physical changes in the cellular environment include changes in osmotic pressures, lubrication, absorption, or the conditions on the surface of the cell membrane. An example of a drug that changes osmotic pressure is mannitol, which produces a change in the osmotic pressure in brain cells, causing a reduction in cerebral edema. A

drug that acts by altering the cellular environment by lubrication is sunscreen. An example of a drug that acts by altering absorption is activated charcoal, which is administered orally to absorb a toxic chemical ingested into the gastrointestinal tract. The stool softener docusate is an example of a drug that acts by altering the surface of the cellular membrane. Docusate has emulsifying and lubricating activity that causes a lowering of the surface tension in the cells of the bowel, permitting water and fats to enter the stool. This softens the fecal mass, allowing easier passage of the stool.

Chemical changes in the cellular environment include inactivation of cellular functions or the alteration of the chemical components of body fluid, such as a change in the pH. For example, antacids neutralize gastric acidity in patients with peptic ulcers.

Alteration in Cellular Function

Most drugs act on the body by altering cellular function. A drug cannot completely change the function of a cell, but it can alter its function. A drug that alters cellular function can increase or decrease certain physiologic functions, such as increase heart rate, decrease blood pressure, or increase urine output.

Receptor-Mediated Drug Action

The function of a cell alters when a drug interacts with a receptor cell. A **receptor** is a specialized **macromolecule** (a large group of molecules linked together) that attaches or binds to the drug molecule. This alters the function of the cell and produces the therapeutic response of the drug. For a drug–receptor reaction to occur, a drug must be attracted to a particular receptor. Drugs bind to a receptor much like a piece of a puzzle. The closer the shape, the better the fit, and the better the therapeutic response. The intensity of a drug response is related to how good the "fit" of the drug molecule is and the number of receptor sites occupied.

Agonists are drugs that bind with a receptor to produce a therapeutic response. Drugs that bind only partially to the receptor will most probably have some, although slight, therapeutic response. Figure 1-3 identifies the different drug–receptor interactions. Partial agonists are drugs that have some drug receptor fit and produce a response but inhibit other responses.

Antagonists join with a receptor to prevent the action of an agonist. When the antagonist binds more tightly than the agonist to the receptor, the action of the antagonist is strong. Drugs that act as antagonists produce no pharmacologic effect. An example of an antagonist is Narcan, a narcotic antagonist that completely blocks the effects of morphine, including the respiratory depression. This drug is useful in reversing the effects of an overdose of narcotics.

Receptor-Mediated Drug Effects

The number of available receptor sites influences the effects of a drug. If only a few receptor sites are occupied, although many sites are available, the response will be small. If the drug dose is increased, more receptor sites are used and the response increases. If only a few receptor sites are available, the response does not increase if more of the drug is administered. However, not all receptors on a cell need to be occupied for a drug to be effective. Some extremely potent drugs are effective even when the drug occupies few receptor sites.

DRUG REACTIONS

Drugs produce many reactions in the body. The following sections discuss adverse drug reactions, allergic drug reactions, drug idiosyncrasy, drug tolerance, cumulative drug effect, and toxic reactions. Pharmacogenetic reactions can also occur. A pharmacogenetic reaction is a genetically determined adverse reaction to a drug.

Adverse Drug Reactions

Patients may experience one or more **adverse reactions** (side effects) when they are given a drug. Adverse reactions are undesirable drug effects. Adverse reactions may be common or may occur infrequently. They may be mild, severe, or life threatening. They may occur after the first dose, after several doses, or even after many doses. An adverse reaction often is unpredictable, although some drugs are known to cause certain adverse reactions in many patients. For example, drugs used in the treatment of cancer are very toxic and are known to produce adverse reactions in many patients receiving them. Other drugs produce adverse reactions in fewer patients. Some adverse reaction is predictable, but many adverse drug reactions occur without warning.

Some texts use both terms *side effect* and *adverse reactions.* These texts distinguish between the two terms by using *side effects* to explain mild, common, and nontoxic reactions; *adverse reaction* is used to describe more severe and life-threatening reactions. For the purposes of this text only the term *adverse reaction* is used, with the understanding that these reactions may be mild, severe, or life threatening.

Allergic Drug Reactions

An **allergic reaction** also is called a **hypersensitivity** reaction. Allergy to a drug usually begins to occur after more than one dose of the drug is given. On occasion, the nurse may observe an allergic reaction the first time a drug is given because the patient has received or taken the drug in the past.

A drug allergy occurs because the individual's immune system views the drug as a foreign substance or **antigen.** The presence of an antigen stimulates the antigen–antibody response that in turn prompts the body to produce **antibodies.** If the patient takes the drug after the antigen–antibody response has occurred, an allergic reaction results.

Even a mild allergic reaction produces serious effects if it goes unnoticed and the drug is given again. Any indication of an allergic reaction is reported to the primary health care provider before the next dose of the drug is given. Serious allergic reactions require contacting the primary health care provider immediately because emergency treatment may be necessary.

Some allergic reactions occur within minutes (even seconds) after the drug is given; others may be delayed for hours or days. Allergic reactions that occur immediately often are the most serious.

Allergic reactions are manifested by a variety of signs and symptoms observed by the nurse or reported by the patient. Examples of some allergic symptoms include itching, various types of skin rashes, and hives (urticaria). Other symptoms include difficulty breathing, wheezing, cyanosis, a sudden loss of consciousness, and swelling of the eyes, lips, or tongue.

Anaphylactic shock is an extremely serious allergic drug reaction that usually occurs shortly after the administration of a drug to which the individual is sensitive. This type of allergic reaction requires immediate medical attention. Symptoms of anaphylactic shock are listed in Table 1-2.

All or only some of these symptoms may be present. Anaphylactic shock can be fatal if the symptoms are not identified and treated immediately. Treatment is to raise the blood pressure, improve breathing, restore cardiac function, and treat other symptoms as they occur. Epinephrine (adrenalin) 0.1 to 0.5 mg may be given by subcutaneous or intramuscular injection. Hypotension and shock may be treated with fluids and vasopressors. Bronchodilators are given to relax the smooth muscles of the bronchial tubes. Antihistamines may be given to block the effects of histamine.

TABLE 1-2 Symptoms of Anaphylactic Shock

Respiratory	Bronchospasm Dyspnea (difficult breathing) Feeling of fullness in the throat Cough Wheezing
Cardiovascular	Extremely low blood pressure Tachycardia (heart rate > 100 bpm) Palpations Syncope (fainting) Cardiac arrest
Integumentary	Urticaria Angioedema Pruritus (itching) Sweating
Gastrointestinal	Nausea Vomiting Abdominal pain

Angioedema (angioneurotic edema) is another type of allergic drug reaction. It is manifested by the collection of fluid in subcutaneous tissues. Areas that are most commonly affected are the eyelids, lips, mouth, and throat, although other areas also may be affected. Angioedema can be dangerous when the mouth is affected because the swelling may block the airway and asphyxia may occur. Difficulty in breathing or swelling to any area of the body is reported immediately to the primary health care provider.

Drug Idiosyncrasy

Drug idiosyncrasy is a term used to describe any unusual or abnormal reaction to a drug. It is any reaction that is different from the one normally expected of a specific drug and dose. For example, a patient may be given a drug to help him or her sleep (eg, a hypnotic). Instead of falling asleep, the patient remains wide awake and shows signs of nervousness or excitement. This response is an idiosyncratic response because it is different from what the nurse expects from this type of drug. Another patient may receive the same drug and dose, fall asleep, and after 8 hours be difficult to awaken. This, too, is abnormal and describes an overresponse to the drug.

The cause of drug idiosyncrasy is not clear. It is believed to be due to a genetic deficiency that makes the patient unable to tolerate certain chemicals, including drugs.

Drug Tolerance

Drug tolerance is a term used to describe a decreased response to a drug, requiring an increase in dosage to achieve the desired effect. Drug tolerance may develop when a patient takes certain drugs, such as the narcotics and tranquilizers, for a long time. The individual who takes these drugs at home increases the dose when the expected drug effect does not occur. The development of drug tolerance is a sign of drug dependence. Drug tolerance may also occur in the hospitalized patient. When the patient receives a narcotic for more than 10 to 14 days, the nurse suspects drug tolerance (and possibly drug dependence). The patient may also begin to ask for the drug at more frequent intervals.

Cumulative Drug Effect

A **cumulative drug effect** may be seen in those with liver or kidney disease because these organs are the major sites for the breakdown and excretion of most

drugs. This drug effect occurs when the body is unable to metabolize and excrete one (normal) dose of a drug before the next dose is given. Thus, if a second dose of this drug is given, some drug from the first dose remains in the body. A cumulative drug effect can be serious because too much of the drug can accumulate in the body and lead to toxicity.

Patients with liver or kidney disease are usually given drugs with caution because a cumulative effect may occur. When the patient is unable to excrete the drug at a normal rate the drug accumulates in the body, causing a toxic reaction. Sometimes, the primary health care provider lowers the dose of the drug to prevent a toxic drug reaction.

Toxic Reactions

Most drugs can produce **toxic** or harmful reactions if administered in large dosages or when blood concentration levels exceed the therapeutic level. Toxic levels build up when a drug is administered in dosages that exceed the normal level or if the patient's kidneys are not functioning properly and cannot excrete the drug. Some toxic effects are immediately visible; others may not be seen for weeks or months. Some drugs, such as lithium or digoxin, have a narrow margin of safety, even when given in recommended dosages. It is important to monitor these drugs closely to avoid toxicity.

Drug toxicity can be reversible or irreversible, depending on the organs involved. Damage to the liver may be reversible because liver cells can regenerate. However, hearing loss due to damage to the eighth cranial nerve caused by toxic reaction to the anti-infective streptomycin may be permanent. Sometimes drug toxicity can be reversed by the administration of another drug that acts as an antidote. For example, in serious instances of digitalis toxicity, the drug Digibind may be given to counteract the effect of digoxin toxicity.

Nurses must carefully monitor the patient's blood levels of drugs to ensure that they remain within the therapeutic range. Any deviation should be reported to the primary health care provider. Because some drugs can cause toxic reactions even in recommended doses, the nurse should be aware of the signs and symptoms of toxicity of commonly prescribed drugs.

Pharmacogenetic Reactions

A **pharmacogenetic disorder** is a genetically determined abnormal response to normal doses of a drug. This abnormal response occurs because of inherited traits that cause abnormal metabolism of drugs. For example, individuals with glucose-6-phosphate dehydrogenase (G6PD) deficiency have abnormal reactions to a number of drugs. These patients exhibit varying degrees of hemolysis (destruction of red blood cells) if these drugs are administered. More than 100 million people are affected by this disorder. Examples of drugs that cause hemolysis in patients with a G6PD deficiency include aspirin, chloramphenicol, and the sulfonamides.

DRUG INTERACTIONS

It is important for the nurse administering medications to be aware of the various drug interactions that can occur, most importantly drug–drug interactions and drug–food interactions. The following section gives a brief overview of drug interactions. Specific drug–drug and drug–food interactions are discussed in subsequent chapters.

Drug—Drug Interactions

A drug–drug interaction occurs when one drug interacts with or interferes with the action of another drug. For example, taking an antacid with oral tetracycline causes a decrease in the effectiveness of the tetracycline. The antacid chemically interacts with the tetracycline and impairs its absorption into the bloodstream, thus reducing the effectiveness of the tetracycline. Drugs known to cause interactions include oral anticoagulants, oral hypoglycemics, anti-infectives, antiarrhythmics, cardiac glycosides, and alcohol. Drug–drug interactions can produce effects that are additive, synergistic, or antagonistic.

ADDITIVE DRUG REACTION. An **additive drug reaction** occurs when the combined effect of two drugs is equal to the sum of each drug given alone. For example, taking the drug heparin with alcohol will increase bleeding. The equation one + one = two is sometimes used to illustrate the additive effect of drugs.

SYNERGISTIC DRUG REACTION. Drug **synergism** occurs when drugs interact with each other and produce an effect that is greater than the sum of their separate actions. The equation one + one = four may be used to illustrate synergism. An example of drug synergism is when a person takes both a hypnotic and alcohol. When alcohol is taken simultaneously or shortly before or after the hypnotic is taken, the action of the hypnotic increases. The individual experiences a drug effect that is greater than if either drug was taken alone. On occasion, the occurrence of a synergistic drug effect is serious and even fatal.

ANTAGONISTIC DRUG REACTION. An antagonistic drug reaction occurs when one drug interferes with the action of another, causing neutralization or a decrease in

the effect of one drug. For example, protamine sulfate is a heparin antagonist. This means that the administration of protamine sulfate completely neutralizes the effects of heparin in the body.

Drug–Food Interactions

When a drug is given orally, food may impair or enhance its absorption. A drug taken on an empty stomach is absorbed into the bloodstream at a faster rate than when the drug is taken with food in the stomach. Some drugs (eg, captopril) must be taken on an empty stomach to achieve an optimal effect. Drugs that should be taken on an empty stomach are administered 1 hour before or 2 hours after meals. Other drugs, especially drugs that irritate the stomach, result in nausea or vomiting, or cause epigastric distress, are best given with food or meals. This minimizes gastric irritation. The nonsteroidal anti-inflammatory drugs and salicylates are examples of drugs that are given with food to decrease epigastric distress. Still other drugs combine with a drug forming an insoluble food–drug mixture. For example, when tetracycline is administered with dairy products, a drug–food mixture is formed that is unabsorbable by the body. When a drug is unabsorbable by the body, no pharmacologic effect occurs.

FACTORS INFLUENCING DRUG RESPONSE

Certain factors may influence drug response and are considered when the primary health care provider prescribes and the nurse administers a drug. These factors include age, weight, gender, disease, and route of administration.

Age

The age of the patient may influence the effects of a drug. Infants and children usually require smaller doses of a drug than adults do. Immature organ function, particularly the liver and kidneys, can affect the ability of infants and young children to metabolize drugs. An infant's immature kidneys impair the elimination of drugs in the urine. Liver function is poorly developed in infants and young children. Drugs metabolized by the liver may produce more intense effects for longer periods. Parents must be taught the potential problems associated with administering drugs to their children. For example, a safe dose of a nonprescription drug for a 4-year-old child may be dangerous for a 6-month-old infant.

Elderly patients may also require smaller doses, although this may depend on the type of drug administered. For example, the elderly patient may be given the same dose of an antibiotic as a younger adult. However, the same older adult may require a smaller dose of a drug that depresses the central nervous system, such as a narcotic. Changes that occur with aging affect the pharmacokinetics (absorption, distribution, metabolism, and excretion) of a drug. Any of these processes may be altered because of the physiologic changes that occur with aging. Table 1-3 summarizes the changes that occur with aging and the possible pharmacokinetic effect.

Polypharmacy is the taking of numerous drugs that can potentially react with one another. When practiced by the elderly, polypharmacy leads to an increase in the number of potential adverse reactions. Although multiple drug therapy is necessary to treat certain disease states, it always increases the possibility of adverse reactions. The nurse needs good assessment skills to detect any problems when monitoring the geriatric patient's response to drug therapy.

TABLE 1-3 Factors Altering Drug Response in the Elderly

AGE-RELATED CHANGES	EFFECT ON DRUG THERAPY
Decreased gastric acidity; decreased gastric motility	Possible decreased or delayed absorption
Dry mouth and decreased saliva	Difficulty swallowing oral drugs
Decreased liver blood flow; decreased liver mass	Delayed and decreased metabolism of certain drugs; possible increased effect, leading to toxicity
Decreased lipid content of the skin	Possible decrease in absorption of transdermal drugs
Increased body fat; decreased body water	Possible increase in toxicity of water-soluble drugs; more prolonged effects of fat-soluble drugs
Decreased serum proteins	Possible increased effect and toxicity of highly protein-bound drugs
Decreased renal mass, blood flow, and glomerular filtration rate	Possible increased serum levels, leading to toxicity of drugs excreted by the kidney
Changes in sensitivity of certain drug receptors	Increase or decrease in drug effect

Adapted from Eisenhauer, L., Nichols, L., Spencer, R., & Bergan, F. (1998). *Clinical pharmacology and nursing management* (5th ed., p. 189). Philadelphia: Lippincott-Raven. Used with permission.

Weight

In general, dosages are based on a weight of approximately 150 lb, which is calculated to be the "average" weight of men and women. A drug dose may sometimes be increased or decreased because the patient's weight is significantly higher or lower than this average. With narcotics, for example, higher or lower than average dosages may be necessary to produce relief of pain, depending on the patient's weight.

Gender

The gender of an individual may influence the action of some drugs. Women may require a smaller dose of some drugs than men. This is because many women are smaller than men and have a body fat-and-water ratio different from that of men.

Disease

The presence of disease may influence the action of some drugs. Sometimes disease is an indication for not prescribing a drug or for reducing the dose of a certain drug. Both hepatic (liver) and renal (kidney) disease can greatly affect drug response.

In liver disease, for example, the ability to metabolize or detoxify a specific type of drug may be impaired. If the average or normal dose of the drug is given, the liver may be unable to metabolize the drug at a normal rate. Consequently, the drug may be excreted from the body at a much slower rate than normal. The primary health care provider may then decide to prescribe a lower dose and lengthen the time between doses because liver function is abnormal.

Patients with kidney disease may exhibit drug toxicity and a longer duration of drug action. The dosage of drugs may be reduced to prevent the accumulation of toxic levels in the blood or further injury to the kidney.

Route of Administration

Intravenous administration of a drug produces the most rapid drug action. Next in order of time of action is the intramuscular route, followed by the subcutaneous route. Giving a drug orally usually produces the slowest drug action.

Some drugs can be given only by one route; for example, antacids are given only orally. Other drugs are available in oral and parenteral forms. The primary health care provider selects the route of administration based on many factors, including the desired rate of action. For example, the patient with a severe cardiac problem may require intravenous administration of a drug that affects the heart. Another patient with a mild cardiac problem may experience a good response to oral administration of the same drug.

NURSING IMPLICATIONS

Many factors can influence drug action. The nurse should consult appropriate references or the hospital pharmacist if there is any question about the dosage of a drug, whether other drugs the patient is receiving will interfere with the drug being given, or whether the oral drug should or should not be given with food.

Drug reactions are potentially serious. The nurse should observe all patients for adverse drug reactions, drug idiosyncrasy, and evidence of drug tolerance (when applicable). It is important to report all drug reactions or any unusual drug effect to the primary health care provider.

The nurse must use judgment about when adverse drug reactions are reported to the primary health care provider. Accurate observation and evaluation of the circumstances are essential; the nurse should record all observations in the patient's record. If there is any question regarding the events that are occurring, the nurse can withhold the drug but must contact the primary health care provider.

HERBAL THERAPY AND NUTRITIONAL SUPPLEMENTS

Botanical medicine or herbal therapy is a type of complementary/alternative therapy that uses plants or herbs to treat various disorders. Individuals worldwide use both herbal therapy and nutritional supplements extensively. According to the World Health Organization (WHO), 80% of the world's population relies on herbs for a substantial part of their health care. Herbs have been used by virtually every culture in the world throughout history, from the beginning of time until now. For example, Hippocrates prescribed St. Johns Wort, currently a popular herbal remedy for depression. Native Americans used plants such as coneflower, ginseng, and ginger for therapeutic purposes. Herbal therapy is part of a group of nontraditional therapies commonly known as complementary/alternative medicine (CAM). Unfortunately, CAM therapies are not widely taught in medical schools. A 1998 survey revealed that 75 of 117 US medical schools offered elective courses in CAM or included CAM topics in required courses. Complementary therapies are therapies such as relaxation techniques, massage, dietary supplements, healing touch, and herbal therapy that can be used to "complement" traditional health care. Alternative therapies, on the other hand, are therapies used in place of or instead of conventional or Western medicine. The term *complementary/alternative therapy* often is used as an umbrella term for many therapies from all over the world.

Although herbs have been used for thousands of years, most of what we know has been from observation. Most herbs have not been scientifically studied for safety and efficacy (effectiveness). Much of what we know about herbal therapy has come from Europe, particularly Germany. During the last several decades, European scientists have studied botanical plants in ways that seek to identify how they work at the cellular level, what chemicals are most effective, and adverse effects related to their use. Germany has compiled information on 300 herbs and made recommendations for their use.

Dietary Supplement Health and Education Act

Because herbs cannot be sold and promoted in the United States as drugs, they are regulated as nutritional or dietary substances. *Nutritional* or *dietary substances* are terms used by the federal government to identify substances not regulated as drugs by the FDA but that are purported to be effective for use to promote health. Herbs, as well as vitamins and minerals, are classified as dietary or nutritional supplements. Because natural products cannot be patented in the United States, it is not profitable for drug manufacturers to spend the millions of dollars and the 8 to 12 years to study and develop these products as drugs. In 1994, the US government passed the Dietary Supplement Health and Education Act (DSHEA). This act defines substances such as herbs, vitamins, minerals, amino acids, and other natural substances as "dietary supplements." The act permits general health claims such as "improves memory" or "promotes regularity" as long as the label also has a disclaimer stating that the supplements are not approved by the FDA and are not intended to diagnose, treat, cure, or prevent any disease. The claims must be truthful and not misleading and be supported by scientific evidence. Some have abused the law by making exaggerated claims, but the FDA has the power to enforce the law, which it has done, and these claims have decreased.

Center for Complementary and Alternative Health

In 1992, the National Institutes of Health established an Office of Alternative Medicine to facilitate the study of alternative medical treatments and to disseminate the information to the public. In 1998, the name was changed to National Center for Complementary and Alternative Medicine (NCCAM). This office was established partly because of the increased interest and use of these therapies in the United States. It has been estimated that approximately 40% of all individuals in the United States use some form of complementary/alternative therapy. In 1997, Americans spent more that $27 billion on these therapies. Among the various purposes of the NCCAM, one is to evaluate the safety and efficacy of widely used natural products, such as herbal remedies and nutritional and food supplements. Although the scientific study of CAM is relatively new, the Center is dedicated to developing programs and encouraging scientists to investigate CAM treatments that show promise. The NCCAM budget has steadily grown from $2 million in 1993 to more than $68.7 million in 2000. This funding increase reflects the public's interest and need for CAM information that is based on rigorous scientific research.

Educating the Client on the Use of Herbs and Nutritional Supplements

The use of herbs and nutritional supplements to treat various disorders is common. Herbs are used for various effects, such as to boost the immune system, treat depression, and for relaxation. Individuals are becoming more aware of the benefits of herbal therapies and nutritional supplements. Advertisements, books, magazines, and Internet sites abound concerning these topics. People, eager to cure or control various disorders, take herbs, teas, megadoses of vitamins, and various other natural products. Although much information is available on nutritional supplements and herbal therapy, obtaining the correct information sometimes is difficult. Medicinal herbs and nutritional substances are available at supermarkets, pharmacies, health food stores, specialty herb stores, and through the Internet. The potential for misinformation abounds. Because these substances are "natural products," many individuals may incorrectly assume that they are without adverse effects. When any herbal remedy or dietary supplement is used, it should be reported to the nurse and the primary health care provider. Many of these botanicals have strong pharmacological activity, and some may interact with prescription drugs or be toxic in the body. For example, comfrey, an herb that was once widely used to promote digestion, can cause liver damage. Although it may still be available in some areas, it is a dangerous herb and is not recommended for use as a supplement.

When obtaining the drug history, the nurse must always question the patient about the use of herbs, teas, vitamins, or other nutritional or dietary supplements. Many patients consider herbs as natural and therefore safe. It is also difficult for some to report the use of an herbal tea as a part of the health care regimen. Display 1-4 identifies teaching points to consider when discussing the use of herbs and nutritional supplements with patients. Although a complete discussion about the use of herbs is beyond the scope of this book, it is important to remember that the use of herbs and nutritional supplements is commonplace in many areas of the country. To help the student become more aware of herbal therapy and nutritional supplements, Appendix B gives

DISPLAY 1-4 ● Teaching Points When Discussing the Use of Herbal Therapy

- If you regularly use herbal therapies, invest in a good herbal reference book such as *Guide to Popular Natural Products,* edited by Ara DerMarderosian (Facts and Comparisons Publishing Group, 2001).
- Store clerks are not experts in herbal therapy. Your best choice is to select an herbal product manufactured by a reputable company.
- Check the label for the word "standardized." This means that the product has a specific percentage of a specific chemical.
- Some herbal tinctures are 50% alcohol, which could pose a problem to individuals with a history of alcohol abuse.
- Use products with more than six herbs cautiously. It is generally better to use the single herb than to use a diluted product with several herbs.
- Do not overmedicate with herbs. The adage "If one is good, two must be better" is definitely not true. Take only the recommended dosage.
- Herbs are generally safe when taken in recommended dosages. However, if you experience any different or unusual symptoms, such as heart palpitations, headaches, rashes, or difficulty breathing, stop taking the herb and contact your health care provider.
- Inform your primary health care provider of any natural products that you take (eg, herbs, vitamins, minerals, teas, etc.). Certain herbs can interact with the medications that you take, causing serious adverse reactions or toxic effects.
- Allow time for the herb to work. Generally, 30 days is sufficient. If your symptoms have not improved within 30 to 60 days, discontinue use of the herb.

Adapted from Fontaine, K. L. (2000). *Healing practices: Alternative therapies for nursing* (pp. 126–127). Upper Saddle River, NJ: Prentice Hall. Used with permission.

an overview of selected common herbs and nutritional supplements. In addition, Herbal Alerts are placed in various chapters throughout the book, giving the student valuable information or warnings about the use of herbs.

● *Critical Thinking Exercises*

1. *Judy Martin, a student nurse, has just administered an antibiotic to Mr. Green. When she returns to the room about 30 minutes later, she finds Mr. Green flushed, reporting a lump in his throat, and experiencing difficulty breathing. Determine what actions the student nurse should take.*
2. *Jenny Davis, age 25, is pregnant. Jenny's primary health care provider tells her that she may not take any medication without first checking with the health care provider during the pregnancy. Jenny is puzzled and questions you about this. Discuss how you would address Jenny's concerns.*
3. *Ms. James, an 80-year-old woman, is receiving a lower dose of Demerol, a narcotic analgesic, postoperatively for pain. Her family questions the use of a lower dose. Determine what information you would give her family when they voice concerns that the dosage will not adequately relieve their mother's pain. Analyze what patient assessment, if any, you would need to make before talking with the family.*

● *Review Questions*

1. Mr. Carter has a rash and pruritus. You suspect an allergic reaction and immediately assess him for other more serious symptoms of an allergic reaction. What question would be most important to ask Mr. Carter?
   - **A.** Are you having any difficulty breathing?
   - **B.** Have you noticed any blood in your stool?
   - **C.** Do you have a headache?
   - **D.** Are you having difficulty with your vision?
2. Mr. Jones, a newly admitted patient, has a history of liver disease. In planning Mr. Jones' care the nurse must consider that liver disease may result in a (an) _____.
   - **A.** increase in the excretion rate of a drug
   - **B.** impaired ability to metabolize or detoxify a drug
   - **C.** necessity to increase the dosage of a drug
   - **D.** decrease in the rate of drug absorption
3. Oxycodone is prescribed for a patient on the unit where you work. To safely administer oxycodone the nurse knows that this drug is regulated by the Controlled Substance Act, which classifies this drug as a Schedule _____.
   - **A.** drug with a high abuse potential
   - **B.** drug with the potential for high abuse with severe dependency
   - **C.** drug with moderate abuse potential
   - **D.** drug with limited abuse potential
4. A patient asks the nurse to define a hypersensitivity reaction. The nurse begins by telling the patient that a hypersensitivity reaction is also called a _____.
   - **A.** synergistic reaction
   - **B.** antagonistic reaction
   - **C.** drug idiosyncrasy
   - **D.** drug allergy
5. If a patient takes a drug on an empty stomach, the nurse is aware that the drug will be _____.
   - **A.** absorbed more slowly
   - **B.** neutralized by pancreatic enzymes
   - **C.** affected by enzymes in the colon
   - **D.** absorbed more rapidly
6. In monitoring drug therapy, the nurse is aware that a synergistic drug effect may be defined as _____.
   - **A.** an effect greater than the sum of the separate actions of two or more drugs
   - **B.** an increase in the action of one of the two drugs being given
   - **C.** a neutralizing drug effect
   - **D.** a comprehensive drug effect

chapter 2

The Administration of Drugs

Key Terms

buccal
drug errors
extravasation
infiltration
inhalation
intradermal
intramuscular
intravenous
parenteral
standard precautions
subcutaneous
sublingual
transdermal
unit dose
Z-track

Chapter Objectives

On completion of this chapter, the student will:

- Name the six rights of drug administration.
- Identify the different types of medication orders.
- Discuss once-a-week dosing of certain drugs.
- Describe the various types of medication dispensing systems.
- List the various routes by which a drug may be given.
- Discuss the administration of oral and parenteral drugs.
- Discuss Occupational Safety and Health Administration (OSHA) guidelines concerning needle stick injuries and precautions.
- Discuss the administration of drugs through the skin and mucous membranes.
- Discuss nursing responsibilities before, during, and after a drug is administered.

The administration of a drug is a fundamental responsibility of the nurse. An understanding of the basic concepts of administering drugs is critical if the nurse is to perform this task safely and accurately.

In addition to administering the drug, the nurse monitors the therapeutic response (desired response) and reports adverse reactions. In the home setting, the nurse is responsible for teaching the patient and family members the necessary information to administer drugs safely in an outpatient setting.

THE SIX RIGHTS AND DRUG ADMINISTRATION

The nurse preparing and administering a drug to a patient assumes responsibility for this procedure. Responsibility entails preparing and administering the prescribed drug. There are six "rights" in the administration of drugs:

- *Right* patient
- *Right* drug
- *Right* dose
- *Right* route
- *Right* time
- *Right* documentation

Right Patient

When administering a drug, the nurse must be certain that the patient receiving the drug is the patient for whom the drug has been ordered. This is accomplished by checking the patient's wristband containing the patient's name (see Fig. 2-1). If there is no written identification verifying the patient's name, the nurse obtains a wristband or other form of identification before administering the drug. In some instances the nurse may ask the patient to identify himself. However, the nurse should not ask, "Are you Mr. Jones?" Some patients, particularly those who are confused or have difficulty hearing, may respond by answering yes even though that is not their name.

Some nursing homes or extended care facilities have pictures of the patient available, which allows the nurse to verify the correct patient. If pictures are used to identify patients, it is critical that they are recent and bear a good likeness of the individual.

Right Drug

Drug names are often confused, especially when the names sound similar or the spellings are similar. Nurses who hurriedly prepare a drug for administration or who fail to look up questionable drugs are at increased risk for administering the wrong drug. Table 2-1 identifies examples of drugs that can easily be confused. The nurse should compare medication, container label, and medication record (see Fig. 2-2).

TABLE 2-1 Examples of Drugs That Are Easily Confused

Accupril	Accutane
albuterol	atenolol
Alupent	Atrovent
Amikin	Amicar
Bentyl	Aventyl
Capitrol	captopril
Cefzil	Ceftin
Celebrex	Celexa
DiaBeta	Zebeta
dobutamine	dopamine
Elavil	Mellaril
Eurax	Serax
Flomax	Fosamax
Inderal	Isordil
K-Dur	Imdur
Klonopin	clonidine
Lodine	codeine
Nicobid	Nitro-Bid
nifedipine	nicardipine
prednisolone	prednisone
Prilosec	Prozac
Retrovir	ritonavir
Taxol	Paxil
TobraDex	Tobrex
Versed	VePesid
Zocor	Zoloft
Zyvox	Vioxx

Right Dose, Route, and Time

The nurse should obtain a primary care provider's written order for the administration of all drugs. The primary care provider's order must include the patient's name, the drug name, the dosage form and route, the dosage to be administered, and the frequency of administration. The primary care provider's signature must follow the drug order. In an emergency, the nurse may administer a drug with a verbal order from the primary care provider. However, the primary care provider must write and sign the order as soon as the emergency is over.

It is important to question any order that is unclear. This includes unclear directions for the administration of the drug, illegible handwriting on the primary care provider's order sheet, or a drug dose that is higher or lower than the dosages given in approved references.

Right Documentation

After the administration of any drug, the nurse records the process immediately (see Fig. 2-3). Immediate documentation is particularly important when drugs are given on an as-needed basis (PRN drugs). For example, most analgesics require 20 to 30 minutes before the drug begins to relieve pain. A patient may forget that he or she received a drug for pain, may not have been told that the administered

drug was for pain, or may not know that pain relief is not immediate and may ask another nurse for drugs. If the administration of the analgesic were not recorded, the patient might receive a second dose of the analgesic shortly after the first dose. This kind of situation can be extremely serious, especially when narcotics or other central nervous system depressants are administered. Immediate documentation prevents accidental administration of a drug by another individual. Proper documentation is essential to the process of administering drugs correctly.

CONSIDERATIONS IN DRUG ADMINISTRATION

Drug Errors

Drug errors can be defined as any occurrence that can cause a patient to receive the wrong dose, the wrong drug, an incorrect dosage of the drug, a drug by the wrong route, or a drug given at the incorrect time. Errors may occur in transcribing drug orders, when the drug is dispensed, or in administration of the drug. Nurses serve as the last defense against detecting drug errors. When a drug error occurs, it must be reported immediately so that any necessary steps to counteract the action of the drug or any observation can be made as soon as possible. In most institutions, the nurse must complete an incident report and notify the primary care provider. It is important to report errors even if the patient suffers no harm.

Drug errors occur when one or more of the six "rights" has not been followed. Each time a drug is prepared and administered, the six rights must be a part of the procedure. In addition to consistently practicing the six rights, the nurse should adhere to the following precautions to help prevent drug errors:

- Confirm any questionable orders.
- When calculations are necessary, verify them with another nurse.
- Listen to the patient when he or she questions a drug, the dosage, or the drug regimen. Never administer the drug until the patient's questions have been adequately researched.
- Concentrate on only one task at a time.

Most errors are made during administration of the drug. Errors most commonly occur because of a failure to administer a drug that has been ordered, administration of the wrong dose or strength of a drug, or administration of the wrong drug. Two drugs often associated with errors are insulin and heparin.

The United States Pharmacopeia (USP) in cooperation with the Institute of Safe Medication Practices instituted a program called Medication Errors Reporting Program. This program is designed to identify the number and type of drug errors occurring around the country. The goal of this voluntary reporting system is to collect data and disseminate information that will prevent such errors in the future. A copy of the report form is included in Appendix C. Nurses are urged to participate in this important program as a means of protecting the public by identifying ways to make drug administration safer.

The Medication Order

Before a medication can be administered in a hospital or other agency the nurse must have a physician's order. Medications are ordered by the primary health care provider such as a physician, dentist, or in some cases a nurse practitioner.

Common orders include the standing order, the single order, the PRN order, and the STAT order. See Display 2-1 for an explanation of each.

DISPLAY 2-1 ● Types of Medication Orders

Standing Order: This type of order is given when the patient is to receive the drug as prescribed on a regular basis. The drug is administered until the physician discontinues the drug's use. Occasionally a drug may be ordered for a specified number of days, or in some cases a drug can only be given for a specified number of days before the order needs to be renewed.
Example: Lanoxin 0.25 mg PO QD.
Single order: An order to administer the drug one time only.
Example: Valium 10 mg IVP @ 10:00 AM.
PRN order: An order to administer the drug as needed.
Example: Demerol 100 mg IM q4h PRN for pain.
STAT order: A one-time order given as soon as possible.
Example: Morphine 10 mg IV STAT.

Once-a-Week Drugs

Soon many drugs will be available for once-a-week, or even twice-a-month, administration. The doses are designed to replace daily doses of drugs. One of the first is alendronate (Fosamax), a drug used to treat osteoporosis (see Chapter 21). In 2001, the FDA approved two new strengths for this drug to be given once a week: 70-mg and 35-mg tablets. The 70-mg tablet is used to treat postmenopausal osteoporosis, and the 35-mg tablet for prevention of osteoporosis in postmenopausal osteoporosis. In clinical trials the once-a-week dosing showed no greater adverse reactions than the once-daily regimen. Once-a-week dosing may prove beneficial for those experiencing mild adverse reactions in that the reactions would be experienced once a week, rather than every day.

Drug Dispensing Systems

There are a number of drug dispensing systems for the nurse to use to dispense medication after it has been ordered for the patient. A brief description of three methods is given below.

Computerized Dispensing System

Automated or computerized dispensing systems are used in many hospitals or agencies dispensing drugs. Drugs are dispensed in the pharmacy from drug orders that are sent from the individual floors or units. Each floor or unit has a medication cart in which medications are placed for individual patients. Medication orders are filled in the hospital pharmacy and are placed in the drug dispensing cart. When orders are filled, the cart is delivered to the unit. To administer the drugs, nurses enter the patient's name and the drug to be administered. The drug is dispensed and automatically recorded into the computerized system. After drugs are dispensed and the cart is almost empty, it goes back to the pharmacy to be refilled and for new drug orders to be placed.

Unit Dose System

The **unit dose** system is a method of dispensing medications in which drug orders are filled and medications dispensed to fill each patient's medication order(s) for a 24-hour period. The pharmacist dispenses each dose (unit) in a package that is labeled with the drug name and dosage. The drug(s) are placed in drawers in a special portable medication cart with a drawer for each patient. Many drugs are packaged by their manufacturers in unit doses. That is, each package is labeled by the manufacturer and contains one tablet or capsule, a premeasured amount of a liquid drug, a prefilled syringe, or one suppository. Hospital pharmacists also may prepare unit doses. The pharmacist restocks the cart each day with the drugs needed for the next 24-hour period. The nurse takes the drug cart into each patient's room (Figure 2-4).

Some hospitals are using a bar code scanner in the administration of unit dose drugs. To use this system, a bar code is placed on the patient's hospital identification band when the patient is admitted to the hospital. The bar codes, along with bar codes on the drug unit dose packages, are used to identify the patient and to record and charge routine and PRN drugs. The scanner also keeps an ongoing inventory of controlled substances, which eliminates the need for narcotic counts at the end of each shift.

Floor Stock

Some agencies, such as nursing homes or small hospitals, use a floor stock method to dispense drugs. Some special units in hospitals, such as the emergency department, may use this method. In this situation, drugs most frequently prescribed are kept on the unit in containers in a designated medication room or at the nurses' station. The nurse takes the medication from the appropriate container and administers the drug to the patient and records the drug in the patient's administration record.

General Principles of Drug Administration

The nurse must have factual knowledge of each drug given, the reasons for use of the drug, the drug's general action, the more common adverse reactions associated

with the drug, special precautions in administration (if any), and the normal dose ranges.

Some drugs may be given frequently; the nurse becomes familiar with pharmacologic information about a specific drug. Other drugs may be given less frequently, or a new drug may be introduced, requiring the nurse to obtain information from reliable sources, such as the drug package insert or the hospital department of pharmacy. *It is of utmost importance to check current and approved references for all drug information.*

It also is important for the nurse to take patient considerations, such as allergy history, previous adverse reactions, patient comments, and change in patient condition, into account before administering the drug. Before giving any drug for the first time, the nurse should ask the patient about any known allergies and any family history of allergies. This not only includes allergies to drugs but also to food, pollen, animals, and so on. Patients with a personal or family history of allergies are more likely to experience additional allergies and must be monitored closely.

If the patient makes any statement about the drug or if there is any change in the patient, these situations are carefully considered before the drug is given. Examples of situations that require consideration before a drug is given include:

- Problems that may be associated with the drug, such as nausea, dizziness, ringing in the ears, and difficulty walking. Any comments made by the patient may indicate the occurrence of an adverse reaction. The nurse should withhold the drug until references are consulted and the primary caregiver contacted. The decision to withhold the drug must have a sound rationale and must be based on knowledge of pharmacology.
- Comments stating that the drug looks different from the one previously received, that the drug was just given by another nurse, or that the patient thought the primary care provider discontinued the drug therapy.
- A change in the patient's condition, a change in one or more vital signs, or the appearance of new symptoms. Depending on the drug being administered and the patient's diagnosis, these changes may indicate that the drug should be withheld and the primary care provider contacted.

Preparing a Drug for Administration

When preparing a drug for administration, the nurse should observe the following guidelines:

- Always check the health care provider's written orders and verify any questions with the primary health care provider.
- Prepare drugs for administration in a quiet, well-lit area.
- Always check the label of the drug three times: (1) when the drug is taken from its storage area, (2) immediately before removing the drug from the container, and (3) before returning the drug to its storage area.
- Never remove a drug from an unlabeled container or from a container whose label is illegible.
- Wash hands immediately before preparing a drug for administration.
- Do not let hands touch capsules or tablets. To remove an oral drug from the container, the correct number of tablets or capsules is shaken into the cap of the container and from there into the medicine cup.
- Always observe aseptic technique when handling syringes and needles.
- Be alert for drugs with similar names. Some drugs have names that sound alike but are very different. To give one drug when another is ordered could cause serious consequences. For example, digoxin and digitoxin sound alike but are different drugs.
- Replace the caps of drug containers immediately after the drug is removed.
- Return drugs requiring special storage to the storage area immediately after they are prepared for administration. This rule applies mainly to the refrigeration of drugs but may also apply to drugs that must be protected from exposure to light or heat.
- Never crush tablets or open capsules without first checking with the pharmacist. Some tablets can be crushed or capsules can be opened and the contents added to water or a tube feeding when the patient cannot swallow a whole tablet or capsule. Some tablets have a special coating that delays the absorption of the drug. Crushing the tablet may destroy this drug property and result in problems such as improper absorption of the drug or gastric irritation. Capsules are gelatin and dissolve on contact with a liquid. The contents of some capsules do not mix well with water and therefore are best left in the capsule. If the patient cannot take an oral tablet or capsule, consult the primary care provider because the drug may be available in liquid form.
- Never give a drug that someone else has prepared. The individual preparing the drug must administer the drug.
- When using a unit dose system, do not remove the wrappings of the unit dose until the drug reaches the bedside of the patient who is to receive it. After administering the drug, the nurse charts immediately on the unit dose drug form. The method of administering drugs by the unit dose system is widely used.

ADMINISTRATION OF DRUGS BY THE ORAL ROUTE

The oral route is the most frequent route of drug administration and rarely causes physical discomfort in patients. Oral drug forms include tablets, capsules, and liquids. Some capsules and tablets contain sustained-release drugs, which dissolve over an extended period of time. Administration of oral drugs is relatively easy for patients who are alert and can swallow.

Nursing Responsibilities

The nurse should observe the following points when giving an oral drug:

- Place the patient in an upright position. It is difficult, as well as dangerous, to swallow a solid or liquid when lying down.
- Make sure that a full glass of water is readily available.
- Assess the patient's need for assistance in removing the tablet or capsule from the container, holding the container, holding a medicine cup, or holding a glass of water. Some patients with physical disabilities cannot handle or hold these objects and may require assistance.
- Advise the patient to take a few sips of water before placing a tablet or capsule in the mouth.
- Instruct the patient to place the pill or capsule on the back of the tongue and tilt the head back to swallow a tablet or slightly forward to swallow a capsule. Encourage the patient first to take a few sips of water to move the drug down the esophagus and into the stomach, and then to finish the whole glass.
- Give the patient any special instructions, such as drinking extra fluids or remaining in bed, that are pertinent to the drug being administered.
- Never leave a drug at the patient's bedside to be taken later unless there is a specific order by the primary care provider to do so. A few drugs (eg, antacids and nitroglycerin tablets) may be ordered to be left at the bedside.
- Patients with a nasogastric feeding tube may be given their oral drugs through the tube. Dilute and flush liquid drugs through the tube. However, crush tablets and dissolve them in water before administering them through the tube. Before administration, check the tube for placement. Flush the tube with water after the drugs are placed in the tube to completely clear the tubing.
- Instruct the patient to place **buccal** drugs against the mucous membranes of the cheek in either the upper or lower jaw. These drugs are given for a local, rather than systemic, effect. They are absorbed slowly from the mucous membranes of the mouth. Examples of drugs given buccally are lozenges and troches.
- Certain drugs are also given by the **sublingual** (placed under the tongue) route. These drugs must not be swallowed or chewed and must be dissolved completely before the patient eats or drinks. Nitroglycerin is commonly given sublingually.

ADMINISTRATION OF DRUGS BY THE PARENTERAL ROUTE

Parenteral drug administration means the giving of a drug by the subcutaneous (SC), intramuscular (IM), intravenous (IV), or intradermal route (Fig. 2-5). Other routes of parenteral administration that may be used by the primary care provider are intralesional (into a lesion), intra-arterial (into an artery), intracardiac (into the heart), and intra-articular (into a joint). In some instances, intra-arterial drugs are administered by a nurse. However, administration is not by direct arterial injection but by means of a catheter that has been placed in an artery.

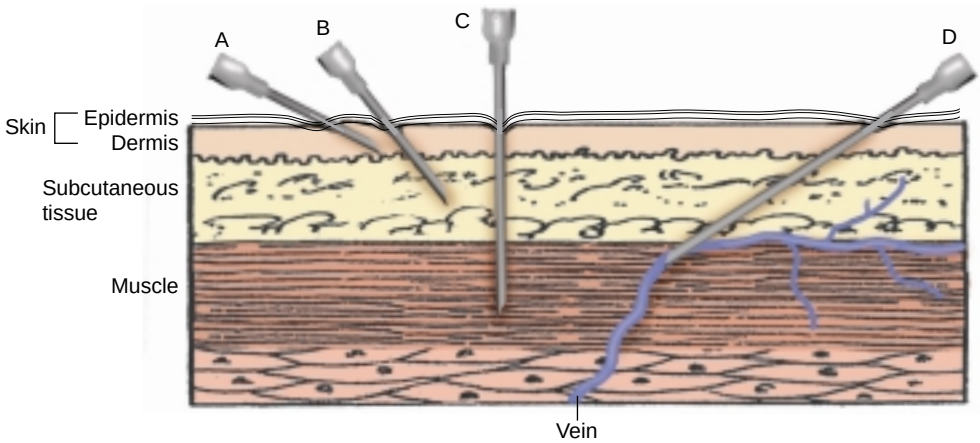


FIGURE 2-5. Needle insertion for parenteral drug: (**A**) Intradermal injection: a 26-guage, ⅜-inch long needle is inserted at a 10-degree angle. (**B**) Subcutaneous injection: a 25-guage, ½-inch long needle is inserted at an angle that depends on the size of the patient. (**C**) Intramuscular injection: a 20-gauge to 23-gauge, 1-inch to 3-inch long needle is inserted into the relaxed muscle at a 90-degree angle with a dart-throwing type of hand movement. (**D**) Intravenous injection: the diameter and length of the needle used depend on the substance to be injected and on the site of injection.

Nursing Responsibilities

The nurse should observe the following points when giving a drug by the parenteral route:

- Wear gloves for protection from the potential of a blood spill when giving parenteral drugs. The risk of exposure to infected blood is increasing for all health care workers. The Centers for Disease Control and Prevention (CDC) recommends that gloves be worn when touching blood or body fluids, mucous membranes, or any broken skin area. This recommendation is referred to as **Standard Precautions,** which combine the Universal Precautions for Blood and Body Fluids with Body Substance Isolation guidelines.
- After selecting the site for injection, cleanse the skin. Most hospitals have a policy regarding the type of skin antiseptic used for cleansing the skin before parenteral drug administration. Cleanse the skin with a circular motion, starting at an inner point and moving outward.
- After inserting the needle for IM administration, pull back the syringe barrel to aspirate the drug. If blood appears in the syringe, remove the needle so the drug is not injected. Discard the drug, needle, and syringe and prepare another injection. If no blood appears in the syringe, inject the drug. Aspiration is not necessary when giving an intradermal or SC injection.
- After inserting a needle into a vein for IV drug administration, pull back the syringe barrel. Blood should flow back into the syringe. After a backflow of blood is obtained, it is safe to inject the drug.
- After removing the needle from an IM, SC, or IV injection site, place pressure on the area. Patients with blooding tendencies often require prolonged pressure on the area.
- Do not recap syringes and dispose of them according to agency policy. Discard needles and syringes into clearly marked, appropriate containers. Most agencies have a "sharp" container located in each room for immediate disposal of needles and syringes after use.
- Most hospitals use needles designed to prevent sticks. This needle has a plastic guard that slips over the needle as it is withdrawn from the injection site. The guard locks in place and eliminates the need to recap. Other models are available as well. These newer types of methods for administering parenteral fluids provide a greater margin of safety for nurses. (See OSHA Guidelines below.)

Occupational Safety and Health Administration Guidelines

Each year between 600,000 and 1 million health care workers experience sticks from conventional needles and sharps. Needle exposures can transmit hepatitis B, hepatitis C, and human immunodeficiency virus. Other infections, such as tuberculosis, syphilis, and malaria, also can be transmitted through needle sticks. More than 80% of needle stick injuries could be prevented with the use of safer needle devices. Nurses working at the bedside are the largest group of health care workers sustaining needle stick and sharps injuries.

Effective April 2001, the Occupational Safety and Health Administration (OSHA) announced new guidelines on needle stick prevention. Under the theory that "prevention is the best medicine," revisions were made in the Bloodborne Pathogens Standard. The revisions clarify the need for employers to select safer needle devices as they become available and to involve employees in identifying and choosing the devices. Employers with 11 or more employees must also maintain a Sharps Injury Log to include (at least) the following components:

- Type and brand of device involved in the incident (if known)
- Location of the incident
- Description of the incident

The needle stick log will help both employees and employers track all needle sticks to help identify problem areas. The log must be maintained to protect the confidentiality of the injured employee. In addition, employers must have a written Exposure Control Plan that is updated annually. During the annual review, inquiries must be made about new or prospective safer options. If new safer devices are available, they should be adopted for use in the agency. The new guidelines will help reduce needle stick injuries among health care workers and others who handle medical sharps. Safety engineered devices such as self-sheathing needles and needleless systems can be used.

Administration of Drugs by the Subcutaneous Route

A **subcutaneous** (SC) injection places the drug into the tissues between the skin and the muscle (see Fig. 2-5B). Drugs administered in this manner are absorbed more slowly than are intramuscular injections. Heparin and insulin are two drugs most commonly given by the SC route.

Nursing Responsibilities

The nurse should observe the following points when giving a drug by the SC route:

- A volume of 0.5 to 1 mL is used for SC injection. Larger volumes (eg, >1 mL) are best given as IM

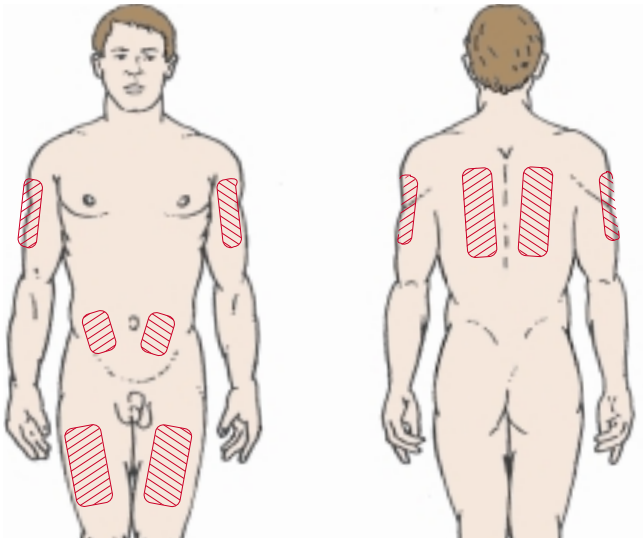


FIGURE 2-6. Sites on the body at which subcutaneous injections can be given.

injections. If a volume larger than 1 mL is ordered through the SC route, the injection is given in two sites, with separate needles and syringes.

- The sites for SC injection are the upper arms, the upper abdomen, and the upper back (Fig. 2-6). Rotate injection sites to ensure proper absorption and to minimize tissue damage.
- When giving a drug by the SC route, insert the needle at a 45-degree angle. However, to place the drug in the SC tissue, select the needle length and angle of insertion based on the patient's body weight. Obese patients have excess SC tissue, and it may be necessary to give the injection at a 90-degree angle. If the patient is thin or cachectic, there usually is less SC tissue. For such patients, the upper abdomen is the best site for injection. Generally, a syringe with a 23- to 25-gauge needle that is ½ to ⅝ inches in length is most suitable for an SC injection.

Administration of Drugs by the Intramuscular Route

An **intramuscular** (IM) injection is the administration of a drug into a muscle (see Fig. 2-5C). Drugs that are irritating to SC tissue can be given via IM injection. Drugs given by this route are absorbed more rapidly than drugs given by the SC route because of the rich blood supply in the muscle. In addition, a larger volume (1–3 mL) can be given at one site.

Nursing Responsibilities

The nurse should observe the following points when giving a drug by the IM route:

- If an injection is more that 3 mL, divide the drug and give it as two separate injections. Volumes larger than 3 mL will not be absorbed properly.
- A 22-gauge needle that is 1½ inches in length is most often used for IM injections.
- The sites for IM administration are the deltoid muscle (upper arm), the ventrogluteal or dorsogluteal sites (hip), and the vastus lateralis (thigh; Fig. 2-7). The vastus lateralis site is frequently used for infants and small children because it is more developed than the gluteal or deltoid sites. In children who have been ambulating for more than 2 years the ventrogluteal site may be used.
- When giving a drug by the IM route, insert the needle at a 90-degree angle. When injecting a drug into the ventrogluteal or dorsogluteal muscles, it is a good idea to place the patient in a comfortable position, preferably in a prone position with the toes pointing inward. When injecting the drug into the deltoid, a sitting or lying down position may be used. Place the patient in a recumbent position for injection of a drug into the vastus lateralis.

Z-Track Technique

The **Z-track** method of IM injection is used when a drug is highly irritating to SC tissues or has the ability to permanently stain the skin. The nurse should adhere to the following procedure when using the Z-track technique (Fig. 2-8):

- Draw the drug up into the syringe.
- Discard the needle and place a new needle on the syringe. This prevents any solution that may remain in the needle (that was used to draw the drug into the syringe) from contacting tissues as the needle is put into the muscle.
- Pull the plunger down to draw approximately 0.1 to 0.2 mL of air into the syringe. The air bubble in the syringe follows the drug into the tissues and seals off the area where the drug was injected, thereby preventing oozing of the drug up through the extremely small pathway created by the needle.
- Place the patient in the correct position for administration of an IM injection.
- Cleanse the skin.
- Pull the skin, SC tissues, and fat (that are over the injection site) laterally, displacing the tissue to the side.
- While holding the tissues in the lateral position, insert the needle and inject the drug.

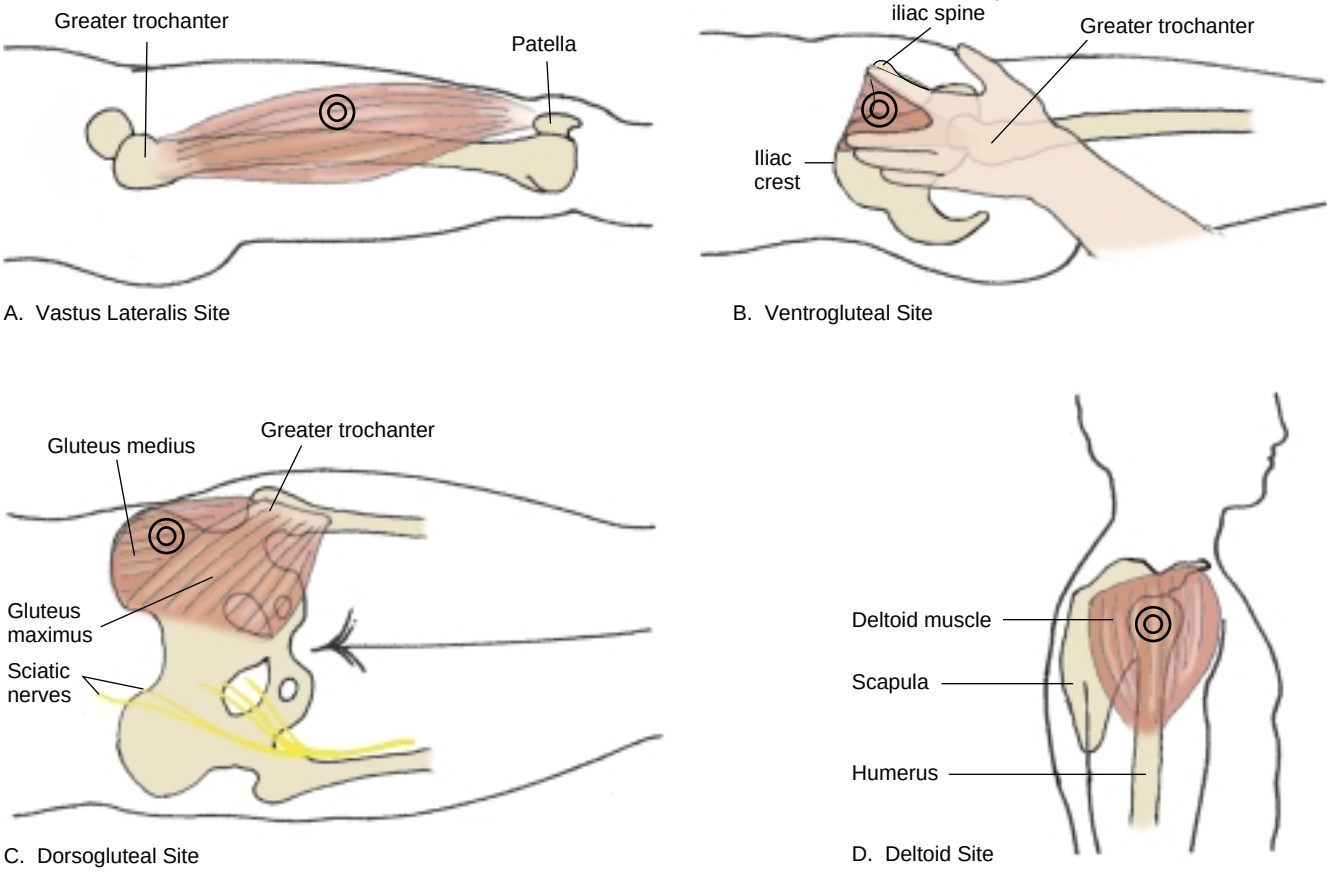


FIGURE 2-7. Sites for intramuscular administration. (**A**) Vastus lateralis site: the patient is supine or sitting. (**B**) Ventrogluteal site: the nurse's palm is placed on the greater trochanter and the index finger is placed on the anterior superior iliac spine; the injection is made into the middle of the triangle formed by the nurse's fingers and the iliac crest. (**C**) Dorsogluteal site: to avoid the sciatic nerve and accompanying blood vessels, an injection site is chosen above and lateral to a line drawn from the greater trochanter to the posterior superior iliac spine. (**D**) Deltoid site: the mid-deltoid area is located by forming a rectangle, the top of which is at the level of the lower edge of the acromion, and the bottom of which is at the level of the axilla; the sides are one third and two thirds of the way around the outer aspect of the patient's arm.

- After the drug is injected, release the tissues and withdraw the needle. This technique prevents the backflow of drug into the SC tissue.

Administration of Drugs by the Intravenous Route

A drug administered by the **intravenous** (IV) route is given directly into the blood by a needle inserted into a vein. Drug action occurs almost immediately.

Drugs administered via the IV route may be given:

- Slowly, over 1 or more minutes
- Rapidly (IV push)
- By piggyback infusions (drugs are mixed with 50–100 mL of compatible IV fluid and administered during a period of 30–60 minutes piggybacked onto the primary IV line)
- Into an existing IV line (the IV port)
- Into an intermittent venous access device called a heparin lock (a small IV catheter in the patient's vein connected to a small fluid reservoir with a rubber cap through which the needle is inserted to administer the drug)
- By being added to an IV solution and allowed to infuse into the vein over a longer period

When administering a drug into a vein by a venipuncture, the nurse should place a tourniquet above the selected vein. It is important to tighten the tourniquet so that venous blood flow is blocked but arterial blood flow is not. The nurse should allow the veins to fill (distend) and then should pull the skin taut (to anchor the vein and the skin) and insert the needle into the vein, bevel up, and at a short angle to the skin. Blood should immediately flow into the syringe if the needle is properly inserted into the vein.

Performing a venipuncture requires practice. A suitable vein for venipuncture may be hard to find, and some

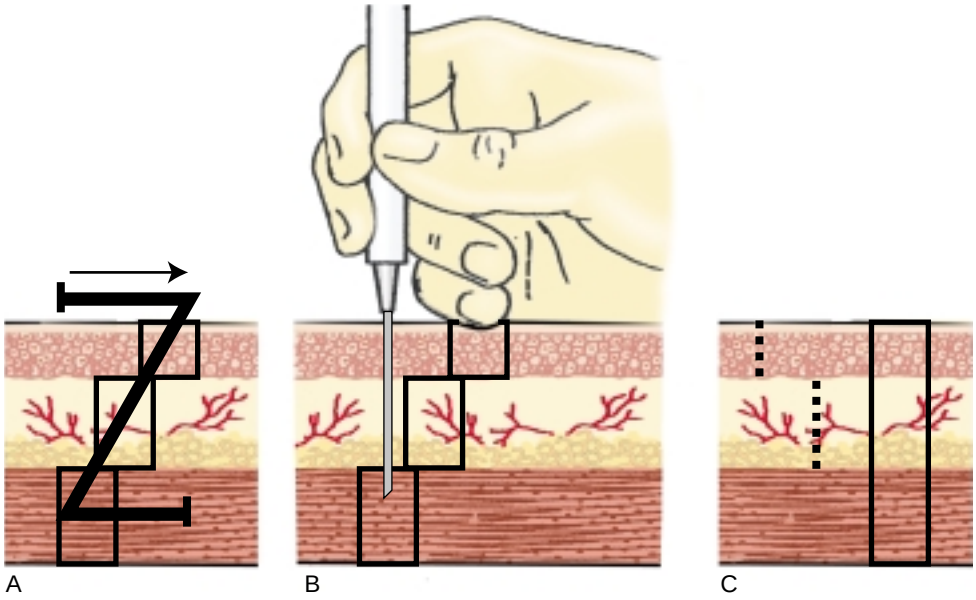


FIGURE 2-8. Z-track injection: (**A**) The tissue is tensed laterally at the injection site before the needle is inserted. This pulls the skin, subcutaneous tissue, and fat planes into a Z formation. (**B**) After the tissue has been displaced, the needle is thrust straight into the muscular tissue. (**C**) After injection, tissues are released while the needle is withdrawn. As each tissue plane slides by the other, the track is sealed.

veins are difficult to enter. The nurse should never repeatedly and unsuccessfully attempt a venipuncture. Depending on clinical judgment, three unsuccessful attempts on the same patient warrant having a more skilled individual attempt the procedure.

Some drugs are added to an IV solution, such as 1000 mL of dextrose 5% and water. The drug is usually added to the IV fluid container immediately before adding the fluid to the IV line. Whenever a drug is added to an IV fluid, the bottle must have a label attached indicating the drug and drug dose added to the IV fluid. In some hospitals, a pharmacist is responsible for adding specific drugs to IV fluids.

Intravenous Infusion Controllers and Pumps

Electronic infusion devices are classified as either infusion controllers or infusion pumps. The primary difference between the two is that an infusion pump adds pressure to the infusion, whereas an infusion controller does not. An infusion pump may be used to deliver the desired number of drops per minute. An alarm is set to sound if the IV is more than or less than the preset rate.

Controllers and pumps have detectors and alarms that alert the nurse to various problems, such as air in the line, an occlusion, low battery, completion of an infusion, or an inability to deliver the preset rate. When any problem is detected by the device, an alarm is activated to alert the nurse. Potential complications in IV therapy are the same as those with peripheral line.

Nursing Responsibilities

After the start of an IV infusion, the nurse records on the patient's chart the type of IV fluid and, when applicable, the drug added to the IV solution. It is important to check the infusion rate every 15 to 30 minutes. At this time, the nurse also inspects the needle site for signs of redness, swelling, or other problems. Swelling around the needle may indicate one of two things: extravasation or infiltration. **Extravasation** refers to the escape of fluid from a blood vessel into surrounding tissues while the needle or catheter is in the vein. **Infiltration** is the collection of fluid in tissues (usually SC tissue) when the needle or catheter is out of the vein. Both events necessitate discontinuation of the infusion and insertion of an IV line in another vein. Some drugs are capable of causing severe tissue damage if extravasation or infiltration occurs.

If extravasation or infiltration occurs, the IV must be stopped and restarted in another vein. The primary

Nursing Alert

Use of an infusion pump or controller still requires nursing supervision and frequent monitoring of the IV infusion. Infiltration can progress rapidly because the increased pressure will not slow the infusion until considerable edema has occurred. Therefore, it is important to monitor frequently for signs of infiltration, such as edema or redness at the site. Careful monitoring of the pump or controller is also necessary to make sure the flow rate is correct.

care provider should be contacted if a drug capable of causing tissue damage (eg, norepinephrine [Levophed]) has escaped into the tissues surrounding the needle insertion site.

Administration of Drugs by the Intradermal Route

Drugs given by the intradermal route are usually those for sensitivity tests (eg, the tuberculin test or allergy skin testing) (see Fig. 2-5A). Absorption is slow and allows for good results when testing for allergies or administering local anesthetics.

Nursing Responsibilities

The nurse observes the following points when administering drugs by the intradermal route:

- The inner part of the forearm and the upper back may be used for intradermal injections. The area should be hairless; areas near moles, scars, or pigmented skin areas should be avoided. The nurse should cleanse the area in the same manner as for SC and IM injections.
- A 1-mL syringe with a 25- to 27-gauge needle that is ¼ to ⅝ inch long is best suited for intradermal injections. Small volumes (usually <0.1 mL) are used for intradermal injections and administered with the bevel up.
- The nurse should insert the needle at a 15-degree angle between the upper layers of the skin. The nurse should not aspirate the syringe or massage the area. Injection produces a small wheal (raised area) on the outer surface of the skin. If a wheal does not appear on the outer surface of the skin, there is a good possibility that the drug entered the SC tissue, and any test results would be inaccurate.

Other Parenteral Routes of Drug Administration

The primary care provider may administer a drug by the intracardial, intralesional, intra-arterial, or intra-articular routes. The nurse may be responsible for preparing the drug for administration. The nurse should ask the primary care provider what special materials will be required for administration.

Venous access ports are totally implanted ports with a self-sealing septum that is attached to a catheter leading to a large vessel, usually the vena cava. These devices are most commonly used for chemotherapy or other long-term therapy and require surgical insertion and removal. Drugs are administered through injections made into the portal through the skin. These drugs are administered by the primary care provider or a registered nurse.

ADMINISTRATION OF DRUGS THROUGH THE SKIN AND MUCOUS MEMBRANES

Drugs may be applied to the skin and mucous membranes using several routes: topically (on the outer layers of skin), transdermally through a patch on which the drug has been implanted, or inhaled through the membranes of the upper respiratory tract.

Administration of Drugs by the Topical Route

Most topical drugs act on the skin but are not absorbed through the skin. These drugs are used to soften, disinfect, or lubricate the skin. A few topical drugs are enzymes that have the ability to remove the superficial debris, such as the dead skin and purulent matter present in skin ulcerations. Other topical drugs are used to treat minor, superficial skin infections. The various forms of topical applications and locations of use are described in Display 2-2.

Nursing Responsibilities

The nurse considers the following points when administering drugs by the topical route:

- The primary care provider may write special instructions for the application of a topical drug. For example, to apply the drug in a thin, even layer or to cover the area after application of the drug to the skin.
- Other drugs may have special instructions provided by the manufacturer, such as to apply the drug to a

DISPLAY 2-2 ● Topical Applications and Locations of Use

- Creams, lotions, or ointments applied to the skin with a tongue blade, gloved fingers, or gauze
- Sprays applied to the skin or into the nose or oral cavity
- Liquids inserted into body cavities, such as fistulas
- Liquids inserted into the bladder or urethra
- Solids (eg, suppositories) or jellies inserted into the urethra
- Liquids dropped into the eyes, ears, or nose
- Ophthalmic ointments applied to the eyelids or dropped into the lower conjunctival sac
- Solids (eg, suppositories, tablets), foams, liquids, and creams inserted into the vagina
- Continuous or intermittent wet dressings applied to skin surfaces
- Solids (eg, tablets, lozenges) dissolved in the mouth
- Sprays or mists inhaled into the lungs
- Liquids, creams, or ointments applied to the scalp
- Solids (eg, suppositories), liquids, or foams inserted into the rectum

clean, hairless area or to let the drug dissolve slowly in the mouth. All of these instructions are important because drug action may depend on correct administration of the drug.

Administration of Drugs by the Transdermal Route

Drugs administered by the **transdermal** route are readily absorbed from the skin and provide systemic effects. This type of administration is called transdermal drug delivery system. The drug dosages are implanted in a small patch-type bandage. The backing is removed, and the patch is applied to the skin where the drug is gradually absorbed into the systemic circulation. This type of drug system maintains a relatively constant blood concentration and reduces the possibility of toxicity. In addition, the use of drugs transdermally causes fewer adverse reactions, and administration is less frequent than when the drugs are given by another route. Nitroglycerin (used to treat cardiac problems) and scopolamine (used to treat dizziness and nausea) are two drugs given frequently by the transdermal route.

Nursing Responsibilities

The nurse observes the following points when administering drugs by the transdermal route:

- Apply transdermal patches to clean, dry, nonhairy areas of intact skin.
- Remove the old patch when the next dose is applied in a new site.
- Rotate sites for transdermal patches to prevent skin irritation. The chest, flank, and upper arm are the most commonly used sites. Do not shave the area to apply the patch; shaving may cause skin irritation.
- Ointments are sometimes used and come with a special paper marked in inches. Measure the correct length (onto the paper), place the paper with the drug ointment side down on the skin, and secure it with tape. Before the next dose, remove the paper and tape and cleanse the skin.

Administration of Drugs Through Inhalation

Drug droplets, vapor, or gas are administered through the mucous membranes of the respiratory tract with the use of a face mask, a nebulizer, or a positive-pressure breathing machine. Examples of drugs administered through **inhalation** include bronchodilators, mucolytics, and some anti-inflammatory drugs. These drugs produce, primarily, a local effect in the lungs.

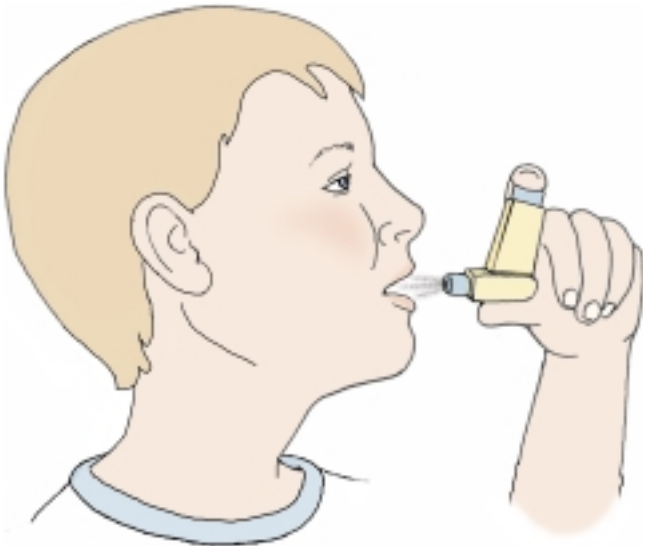


FIGURE 2-9. A respiratory inhalant is used to deliver a drug directly into the lungs. To deliver a dose of the drug, the patient takes a slow, deep breath while depressing the top of the canister. (See Chapter 37 for more information on drugs given by inhalation.)

Nursing Responsibilities

The primary nursing responsibility is to provide the patient with proper instructions for administering the drug. For example, many patients with asthma use a metered-dose inhaler to dilate the bronchi and make breathing easier. Without proper instruction on how to use the inhaler, much of the drug can be deposited on the tongue, rather than in the respiratory tract. This decreases the therapeutic effect of the drug. Instructions may vary with each inhaler. To be certain that the inhaler is used correctly, the patient is referred to the instructions accompanying each device. Figure 2-9 illustrates the proper use of one type of inhaler.

NURSING RESPONSIBILITIES AFTER DRUG ADMINISTRATION

After the administration of any type of drug, the nurse is responsible for the following:

- Recording the administration of the drug. The nurse should complete this task as soon as possible. This is particularly important when PRN drugs (especially narcotics) are given.
- Recording (when necessary) any information concerning the administration of the drug. This includes information such as the IV flow rate, the site used for parenteral administration, problems

Home Care Checklist

ADMINISTERING DRUGS SAFELY IN THE HOME

For most patients, drugs will be prescribed after discharge to be taken at home. Because the home is not as controlled an environment as a health care facility, the nurse should assess the patient's home environment carefully to ensure complete safety. It is important to keep in mind the following when making a home safety assessment:

- ☑ Does the home have a space that is relatively free of clutter and easily accessible to the patient or a caregiver?
- ☑ Do any small children live in or visit the home? If so, is there a place where drugs can be stored safely out of their reach?
- ☑ Does the drug require refrigeration? If so, does the refrigerator work?
- ☑ Does the patient need special equipment, such as needles and syringes? If so, where and how can the equipment be stored for safety and convenience? Does the patient have an appropriate disposal container? Will the refuse be safe from children and pets?
- ☑ If the patient needs several drugs, can the patient or caregiver identify which drugs are used and when? Do they know how to use them and why?
- ☑ Suggest using plastic storage containers with snap-on lids or clean, dry glass jars with screw tops for needle disposal.
- ☑ Advise the patient to use an impervious container with a properly fitting lid, such as a coffee can, for safe disposal of needles. A plastic milk jug with a lid or a heavy-duty, clean, cardboard milk or juice carton may be used if necessary.
- ☑ Explain the importance of taking precautions to make sure discarded needles do not puncture the container.

with administration (if any), and vital signs taken immediately before administration.

- Evaluating and recording the patient's response to the drug (when applicable). Evaluation may include such facts as relief of pain, decrease in body temperature, relief of itching, and decrease in the number of stools passed.
- Observing the adverse reactions. The frequency of these observations will depend on the drug administered. The nurse must record all suspected adverse reactions and report them to the primary care provider. The nurse must immediately report serious adverse reactions to the primary care provider.

ADMINISTRATION OF DRUGS IN THE HOME

Many times drugs are not administered by the nurse but in the home setting by the patient or family members serving as caregivers. When this is the case, it is important that the patient or caregivers understand the treatment regimen and are given an opportunity to ask questions concerning the drug therapy, such as why the drug was prescribed, how to administer the drug, and adverse reactions of the drug (see Chap. 5 for information concerning patient and family education). The Home Care Checklist: Administering Drugs Safely in the Home gives some guidelines to follow when drugs are administered in the home by the patient or caregiver, rather than by the nurse.

● *Critical Thinking Exercises*

1. *Ms. Benson, a nurse on your clinical unit, tells you that the head nurse is upset with her because she has not been recording the administration of narcotics immediately after they are given. Discuss the rationales you could give to Ms. Benson to stress the importance of recording the administration of narcotics immediately after they are given.*
2. *A nurse is to give an SC injection of heparin to a patient. Determine what information the nurse needs to know about the patient before preparing the injection. Discuss how this information would affect the preparation of the injection and the technique used to give the SC injection.*
3. *After administering a drug to a patient you find that the incorrect dosage was given. The dose that you administered was two times the correct dosage. Analyze what action, if any, you would take.*

4. *Discuss why the sixth right, right documentation, is important in drug administration.*
5. *Discuss the importance in participating in the MedWatch programs and the Medication Errors Reporting Program.*

● Review Questions

1. The nurse correctly administers an intramuscular injection by _____.
   - **A.** displacing the skin to the side before making the injection
   - **B.** using a 1-inch needle
   - **C.** inserting the needle at a 90-degree angle
   - **D.** using a 25-gauge needle
2. When preparing a drug for SC administration, the nurse is aware that the usual volume of a drug injected by the SC route is _____.
   - **A.** 2 to 5 mL
   - **B.** 3 to 4 mL
   - **C.** 0.5 to 1 mL
   - **D.** <0.5 mL
3. The nurse explains to the patient receiving an IV injection that the action of the drug occurs _____.
   - **A.** in 5 to 10 minutes
   - **B.** in 15 to 20 minutes
   - **C.** within 30 minutes
   - **D.** almost immediately
4. When administering a drug the nurse _____.
   - **A.** checks the drug label two times before administration
   - **B.** is alert for any drugs with a similar name
   - **C.** may administer a drug prepared by another nurse
   - **D.** may crush any tablet that the patient is unable to swallow
5. When monitoring a patient with an IV, the nurse observes the area around the needle insertion site is swollen and red. The first action of the nurse is to _____.
   - **A.** check the patient's blood pressure and pulse
   - **B.** check further for possible extravasation
   - **C.** ask the patient if the IV site has been accidentally injured
   - **D.** immediately notify the primary health care provider

chapter 3

Review of Arithmetic and Calculation of Drug Dosages

Key Terms

apothecaries' system
Celsius (C)
centigrade
decimal
decimal fraction
denominator
diluent
dimensional analysis
dividend
divisor
dram
Fahrenheit (F)
fluid dram
fluid ounce
grain
gram
household measurements
improper fraction
liter
metric system
mixed decimal fraction
minim
mixed number
numerator
ounce
proper fraction
quotient
remainder
solute
solvent

Chapter Objective

On completion of this chapter, the student will:

- Accurately perform mathematical calculations when they are necessary to compute drug dosages.

REVIEW OF ARITHMETIC

Fractions

The two parts of a fraction are the **numerator** and the **denominator.**

$$\frac{2}{3}$$

2 ← numerator
3 ← denominator

A **proper fraction** may be defined as a part of a whole or any number less than a whole number. An **improper fraction** is a fraction having a numerator the same as or larger than the denominator.

proper fraction $\frac{1}{2}$

improper fraction $\frac{7}{3}$

The numerator and the denominator *must be of like entities or terms,* that is:

Correct (like terms)	Incorrect (unlike terms)
$\frac{2 \text{ acres}}{3 \text{ acres}}$	$\frac{2 \text{ acres}}{3 \text{ miles}}$
$\frac{2 \text{ grams}}{3 \text{ grams}}$	$\frac{2 \text{ grams}}{5 \text{ milliliters}}$

Mixed Numbers and Improper Fractions

A **mixed number** is a whole number and a proper fraction. A whole number is a number that stands alone; 3, 25, and 117 are examples of whole numbers. A proper fraction is a fraction whose numerator is *smaller than* the denominator; 1/8, 2/5, and 3/7 are examples of proper fractions.

These are mixed numbers:

2 2/3 2 is the whole number and 2/3 is the proper fraction

3 1/4 3 is the whole number and 1/4 is the proper fraction

When doing certain calculations, it is sometimes necessary to change a mixed number to an improper fraction or change an improper fraction to a mixed number. An improper fraction is a fraction whose numerator is *larger than* the denominator; 5/2, 16/3, and 12 3/2 are examples of improper fractions.

To change a *mixed number to an improper fraction,* multiply the denominator of the fraction by the whole number, add the numerator, and place the sum over the denominator.

EXAMPLE Mixed number 3 3/5

1. Multiply the denominator of the fraction (5) by the whole number (3) or $5 \times 3 = 15$:

$$3 \times \frac{3}{5}$$

2. Add the result of multiplying the denominator of the fraction (15) to the numerator (3) or $15 + 3 = 18$:

$$3 \times \frac{3}{5}$$

3. Then place the sum (18) over the denominator of the fraction:

$$\frac{18}{5}$$

To change an *improper fraction to a mixed number,* divide the denominator into the numerator. The **quotient** (the result of the division of these two numbers) is the whole number. Then place the remainder over the denominator of the improper fraction.

EXAMPLE Improper fraction 15/4

$$\frac{15 \leftarrow \text{numerator}}{4 \leftarrow \text{denominator}}$$

1. Divide the denominator (4) into the numerator (15) or 15 divided by 4 (15 ÷ 4):

$$4\overline{)15}$$

3 ← quotient

12

3 ← remainder

2. The **quotient** (3) becomes the whole number:

$$\mathbf{3}\frac{3}{4}$$

3. The **remainder** (3) now becomes the numerator of the fraction of the mixed number:

$$3\frac{\mathbf{3}}{}$$

4. And the denominator of the improper fraction (4) now becomes the denominator of the fraction of the mixed number:

$$3\frac{3}{\mathbf{4}}$$

Adding Fractions With Like Denominators

When the denominators are the *same,* fractions can be added by adding the numerators and placing the sum of the numerators over the denominator.

EXAMPLES

$$2/7 + 3/7 = 5/7$$
$$1/10 + 3/10 = 4/10$$
$$2/9 + 1/9 + 4/9 = 7/9$$
$$1/12 + 5/12 + 3/12 = 9/12$$
$$2/13 + 1/13 + 3/13 + 5/13 = 11/13$$

When giving a final answer, fractions are *always* reduced to the lowest possible terms. In the examples above, the answers of 5/7, 7/9, and 11/13 cannot be reduced. The answers of 4/10 and 9/12 can be reduced to 2/5 and 3/4.

To reduce a fraction to the lowest possible terms, determine if any number, which always must be the same, can be divided into both the numerator and the denominator.

4/10: the numerator *and* the denominator can be divided by 2

9/12: the numerator *and* the denominator can be divided by 3

$$\text{For example: } \frac{4}{10} \div \frac{2}{2} = \frac{2}{5}$$

If when adding fractions the answer is an improper fraction, it may then be changed to a mixed number.

2/5 + 4/5 = 6/5 (improper fraction)
6/5 changed to a mixed number is 1 1/5

Adding Fractions With Unlike Denominators

Fractions with *unlike denominators* cannot be added until the denominators are changed to like numbers or numbers that are the same. The first step is to find the *lowest common denominator,* which is the lowest number divisible by (or that can be divided by) all the denominators.

EXAMPLE Add 2/3 and 1/4

$\frac{2}{3} \leftarrow$
$\frac{1}{4} \leftarrow$

The lowest number that can be divided by these two denominators is 12; therefore, 12 is the lowest common denominator.

1. Divide the lowest common denominator (which in this example is 12) by each of the denominators in the fractions (in this example 3 and 4):

$$\frac{2}{3} = \frac{\quad}{12} \qquad (12 \div 3 = 4)$$
$$\frac{1}{4} = \frac{\quad}{12} \qquad (12 \div 4 = 3)$$

2. Multiply the results of the divisions by the numerator of the fractions ($12 \div 3 = 4 \times$ the numerator $2 = 8$ and $12 \div 4 = 3 \times$ the numerator $1 = 3$) and place the results in the numerator:

$$\frac{2}{3} = \frac{\quad}{12} \qquad \frac{\mathbf{8}}{12}$$
$$\frac{1}{4} = \frac{\quad}{12} \qquad \frac{\mathbf{3}}{12}$$

3. Add the numerators ($8 + 3$) and place the result over the denominator (12):

$$\frac{8}{12}$$
$$\frac{3}{12}$$
$$\frac{11}{12}$$

Adding Mixed Numbers or Fractions With Mixed Numbers

When adding two or more mixed numbers or adding fractions and mixed numbers, the mixed number is first changed to an improper fraction.

EXAMPLE Add 3 3/4 and 3 3/4

$3\frac{3}{4}$ changed to an improper fraction $\rightarrow \frac{15}{4}$

$3\frac{3}{4}$ changed to an improper fraction $\rightarrow \frac{15}{4}$

The numerators are added $\rightarrow \frac{30}{4} = 7\ 2/4 = 7\ 1/2$

The improper fraction (30/4) is changed to a mixed number (7 2/4) and the fraction of the mixed number (2/4) changed to the lowest possible terms (1/2).

EXAMPLE Add 2 1/2 and 3 1/4

$2\frac{1}{2}$ changed to an improper fraction $\frac{5}{2}$

$3\frac{1}{4}$ changed to an improper fraction $\frac{13}{4}$

In the example above, 5/2 and 13/4 cannot be added because the denominators are not the same. It will be necessary to find the lowest common denominator first.

$\frac{5}{2}$ the lowest common denominator is 4 → $\frac{10}{4}$

$\frac{13}{4}$ → $\frac{13}{4}$

$\frac{23}{4}$ changed to a mixed number $= 5\frac{3}{4}$

Comparing Fractions

When fractions with *like* denominators are compared, the fraction with the *largest numerator* is the *largest* fraction.

EXAMPLES

Compare: 5/8 and 3/8 Answer: **5**/8 is larger than **3**/8.
Compare: 1/4 and 3/4 Answer: **3**/4 is larger than **1**/4

When the denominators are *not* the same, for example, comparing 2/3 and 1/10, the lowest common denominator must first be determined. The same procedure is followed when adding fractions with unlike denominators (see above).

EXAMPLE Compare 2/3 and 1/10 (fractions with unlike denominators)

$\frac{2}{3} = \frac{20}{30}$ ← lowest common denominator

$\frac{1}{10} = \frac{3}{30}$ ←

The largest numerator in these two fractions is 20; therefore, 2/3 is larger than 1/10.

Multiplying Fractions

When fractions are multiplied, the numerators are multiplied *and* the denominators are multiplied.

EXAMPLES

$$\frac{1}{8} \times \frac{1}{4} = \frac{1}{32} \qquad \frac{1}{2} \times \frac{2}{3} = \frac{2}{6} = \frac{1}{3}$$

In the above examples, it was necessary to reduce one of the answers to its lowest possible terms.

Multiplying Whole Numbers and Fractions

When whole numbers are multiplied with fractions, the numerator is multiplied by the whole number and the product is placed over the denominator. When necessary, the fraction is reduced to its lowest possible terms. If the answer is an improper fraction, it may be changed to a mixed number.

EXAMPLES

$2 \times \frac{1}{2} = \frac{2}{2} = 1$ (answer reduced to lowest possible terms)

$2 \times \frac{3}{8} = \frac{6}{8} = \frac{3}{4}$ (answer reduced to lowest possible terms)

$4 \times \frac{2}{3} = \frac{8}{3} = 2\frac{2}{3}$ (improper fraction changed to a mixed number)

Multiplying Mixed Numbers

To multiply mixed numbers, the mixed numbers are changed to *improper fractions* and then multiplied.

EXAMPLES

$$2\frac{1}{2} \times 3\frac{1}{4} = \frac{5}{2} \times \frac{13}{4} = \frac{65}{8} = 8\frac{1}{8}$$

$$3\frac{1}{3} \times 4\frac{1}{2} = \frac{10}{3} \times \frac{9}{2} = \frac{90}{6} = 15$$

Multiplying a Whole Number and a Mixed Number

To multiply a whole number and a mixed number, *both* numbers must be changed to improper fractions.

EXAMPLES

$$3 \times 2\frac{1}{2} = \frac{3}{1} \times \frac{5}{2} = \frac{15}{2} = 7\frac{1}{2}$$

$$2 \times 4\frac{1}{2} = \frac{2}{1} \times \frac{9}{2} = \frac{18}{2} = 9$$

A whole number is converted to an improper fraction by placing the whole number over 1. In the above examples. 3 becomes 3/1 and 2 becomes 2/1.

Dividing Fractions

When fractions are divided, the *second* fraction (the divisor) is inverted (turned upside down) and then the fractions are multiplied.

EXAMPLES

$$\frac{1}{3} \div \frac{3}{7} = \frac{1}{3} \times \frac{7}{3} = \frac{7}{9}$$

$$\frac{1}{8} \div \frac{1}{4} = \frac{1}{8} \times \frac{4}{1} = \frac{4}{8} = \frac{1}{2}$$

$$\frac{3}{4} \div \frac{1}{2} = \frac{3}{4} \times \frac{2}{1} = \frac{6}{4} = 1\frac{1}{2}$$

In the above examples, the second answer was reduced to its lowest possible terms and the third answer, which was an improper fraction, was changed to a mixed number.

Dividing Fractions and Mixed Numbers

Some problems of division may be expressed as (1) fractions and mixed numbers, (2) two mixed numbers, (3) whole numbers and fractions, or (4) whole numbers and mixed numbers.

MIXED NUMBERS AND FRACTIONS. When a mixed number is divided by a fraction, the whole number is first changed to a fraction.

EXAMPLES

$$2\frac{1}{3} \div \frac{1}{4} = \frac{7}{3} \div \frac{1}{4} = \frac{7}{3} \times \frac{4}{1} = \frac{28}{3} = 9\frac{1}{3}$$

$$2\frac{1}{2} \div \frac{1}{2} = \frac{5}{2} \div \frac{1}{2} = \frac{5}{2} \times \frac{2}{1} = \frac{10}{2} = 5$$

MIXED NUMBERS. When two mixed numbers are divided, they are both changed to improper fractions.

EXAMPLE

$$3\frac{3}{4} \div 1\frac{1}{2} = \frac{15}{4} \div \frac{3}{2} = \frac{15}{4} \times \frac{2}{3} = \frac{30}{12} = 2\frac{6}{12} = 2\frac{1}{2}$$

WHOLE NUMBERS AND FRACTIONS. When a whole number is divided by a fraction, the whole number is changed to an improper fraction by placing the whole number over 1.

EXAMPLE

$$2 \div \frac{2}{3} = \frac{2}{1} \div \frac{2}{3} = \frac{2}{1} \times \frac{3}{2} = \frac{6}{2} = 3$$

WHOLE NUMBERS AND MIXED NUMBERS. When whole numbers and mixed numbers are divided, the whole number is changed to an improper fraction and the mixed number is changed to an improper fraction.

EXAMPLE

$$4 \div 2\frac{2}{3} = \frac{4}{1} \div \frac{8}{3} = \frac{4}{1} \times \frac{3}{8} = \frac{12}{8} = 1\frac{4}{8} = 1\frac{1}{2}$$

Ratios

A ratio is a way of expressing *a part of a whole* or *the relation of one number to another.* For example, a ratio written as 1:10 means 1 in 10 parts, or 1 to 10. A ratio may also be written as a fraction; thus 1:10 can also be expressed as 1/10.

EXAMPLES

1:1000 is 1 part in 1000 parts, or 1 to 1000, or 1/1000

1:250 is 1 part in 250 parts, or 1 to 250, or 1/250

Some drug solutions are expressed in ratios, for example 1:100 or 1:500. These ratios mean that there is 1 part of a drug in 100 parts of solution or 1 part of the drug in 500 parts of solution.

Percentages

The term *percentage* or *percent* (%) means *parts per hundred.*

EXAMPLES

25% is 25 parts per hundred
50% is 50 parts per hundred

A percentage may also be expressed as a fraction.

EXAMPLES

25% is 25 parts per hundred or 25/100
50% is 50 parts per hundred or 50/100
30% is 30 parts per hundred or 30/100

The above fractions may also be reduced to their lowest possible terms:

$25/100 = 1/4, \quad 50/100 = 1/2, \quad 30/100 = 3/10.$

Changing a Fraction to a Percentage

To change a fraction to a percentage, divide the denominator by the numerator and multiply the results (quotient) by 100 and then add a percent sign (%).

EXAMPLES

Change 4/5 to a percentage

$$4 \div 5 = 0.8$$
$$0.8 \times 100 = 80\%$$

Change 2/3 to a percentage

$$2 \div 3 = 0.666$$
$$0.666 \times 100 = 66.6\%$$

Changing a Ratio to a Percentage

To change a ratio to a percentage, the ratio is first expressed as a fraction with the first number or term of the ratio becoming the numerator and the second number or term becoming the denominator. For example, the ratio 1:500 when changed to a fraction becomes 1/500. This fraction is then changed to a percentage by the same method shown in the preceding section.

EXAMPLE

Change 1:125 to a percentage

1:125 written as a fraction is 1/125

$$1 \div 125 = 0.008$$
$$0.008 \times 100 = 0.8$$
adding the percent sign = 0.8%

Changing a Percentage to a Ratio

To change a percentage to a ratio, the percentage becomes the numerator and is placed over a denominator of 100.

EXAMPLES

Changing 5% and 10% to ratios

$$5\% \text{ is } \frac{5}{100} = \frac{1}{20} \text{ or } 1{:}20$$
$$10\% \text{ is } \frac{10}{100} = \frac{1}{10} \text{ or } 1{:}10$$

Proportions

A proportion is a method of expressing equality between two ratios. An example of two ratios expressed as a proportion is: 3 is to 4 as 9 is to 12. This may also be written as:

3:4 as 9:12

or

3:4::9:12

or

$$\frac{3}{4} = \frac{9}{12}$$

Proportions may be used to find an unknown quantity. The unknown quantity is assigned a letter, usually X. An example of a proportion with an unknown quantity is 5:10::15:X.

The first and last terms of the proportion are called the *extremes.* In the above expression 5 and X are the extremes. The second and third terms of the proportion are called the *means.* In the above proportion, 10 and 15 are the means.

means
↙ ↘
5:10::15:X
↖ ↗
extremes

$$\underset{\text{mean}}{\text{extreme}}\ \frac{5}{10} = \frac{15}{X}\ \underset{\text{extreme}}{\text{mean}}$$

To solve for X:

1. Multiply the extremes and place the product (result) to the *left* of the equal sign.

5:10::15:X
5X =

2. Multiply the means and place the product to the *right* of the equal sign.

5:10::15X
5X = 150

3. Solve for *X* by dividing the number to the right of the equal sign by the number to the left of the equal sign (150 ÷ 5).

5X = 150
X = 30

4. To prove the answer is correct, substitute the answer (30) for X in the equation.

$$5:10::15:X$$
$$5:10::15:30$$

Then multiply the means and place the product to the left of the equal sign. Then multiply the extremes and place the product to the right of the equal sign.

$$5:10::15:30$$
$$150 = 150$$

If the numbers are the same on both sides of the equal sign, the equation has been solved correctly.

If the proportion has been set up as a fraction, cross multiply and solve for X.

$$\frac{5}{10} = \frac{15}{X}$$
$$5 \text{ times } X = 5X \text{ and } 10 \text{ times } 15 = 150$$
$$5X = 150$$
$$X = 30$$

To set up a proportion, remember that a *sequence must be followed.* If a sequence is not followed, the proportion will be stated incorrectly.

EXAMPLES

If a man can walk 6 *miles* in 2 *hours,* how many *miles* can he walk in 3 *hours?*

miles is to *hours* and *miles* is to *hours*

or

miles:*hours*::*miles*:*hours*

or

$$\frac{\text{miles}}{\text{hours}} = \frac{\text{miles}}{\text{hours}}$$

The unknown fact is the number of miles walked in 3 hours:

$$6 \text{ miles}:2 \text{ hours}::X \text{ miles}:3 \text{ hours}$$
$$2X = 18$$
$$X = 9 \text{ miles (he can walk 9 miles in 3 hours)}$$

If there are 15 *grains* in 1 *gram,* 30 *grains* equals how many *grams?*

$$15 \text{ grains}:1 \text{ gram}::30 \text{ grains}:X \text{ grams}$$
$$15X = 30$$
$$X = 2 \text{ grams (30 grains equals 2 grams)}$$

Decimals

Decimals are used in the metric system. A **decimal** is a fraction in which the denominator is 10 or some power of 10. For example, 2/10 (read as two tenths) is a fraction with a denominator of 10; 1/100 (read as one one hundredth) is an example of a fraction with a denominator that is a power of 10 (ie, 100).

A power (or multiple) of 10 is the *number 1 followed by one or more zeros.* Therefore, 100, 1000, 10,000 and so on are powers of 10 because the number 1 is followed by two, three, and four zeros, respectively. Fractions whose denominators are 10 or a power of 10 are often expressed in decimal form.

Parts of a Decimal

There are three parts to a decimal:

1	·	25
number(s)	**d**	number(s)
to the	**e**	to the
left of	**c**	right of
the	**i**	the
decimal	**m**	decimal
	a	
	l	

Types of Decimals

A decimal may consist only of numbers to the right of the decimal point. This is called a **decimal fraction.** Examples of decimal fractions are 0.05, 0.6, and 0.002.

A decimal may also have numbers to the *left* and *right* of the decimal point. This is called a **mixed decimal fraction.** Examples of mixed decimal fractions are 1.25, 2.5, and 7.5.

Both decimal fractions and mixed decimal fractions are commonly referred to as decimals. When there is no number to the left of the decimal, a zero may be written, for example, 0.25. Although in general mathematics the zero may not be required, it should be used in the writing of drug doses in the metric system. *Use of the zero lessens the chance of drug errors,* especially when the dose of a drug is hurriedly written and the decimal point is indistinct. For example, a drug order for dexamethasone is written as dexamethasone .25 mg by one physician and written as dexamethasone 0.25 by another. If the decimal point in the first written order is indistinct, the order might be interpreted as 25 mg, which is 100 times the prescribed dose!

Reading Decimals

To read a decimal, the position of the number to the left or right of the decimal point indicates how the decimal is to be expressed.

hundred thousands	ten thousands	thousands	hundreds	tens	units	DECIMAL POINT	tenths	hundredths	thousandths	ten thousandths	hundred thousandths
0	0	0	0	0	0	.	0	0	0	0	0

Adding Decimals

When adding decimals, place the numbers in a column so that the whole numbers are aligned to the left of the decimal and the decimal fractions are aligned to the right of the decimal.

EXAMPLE

20.45 + 2.56 is written as: 2 + 0.25 is written as:

$$\begin{array}{r} 20.45 \\ +2.56 \\ \hline 23.01 \end{array} \qquad \begin{array}{r} 2.00 \\ +0.25 \\ \hline 2.25 \end{array}$$

Subtracting Decimals

When subtracting decimals, the numbers are aligned to the left and right of the decimal in the same manner as for the addition of decimals.

EXAMPLE

20.45 − 2.56 is written as: 9.74 − 0.45 is written as:

$$\begin{array}{r} 20.45 \\ -2.56 \\ \hline 17.89 \end{array} \qquad \begin{array}{r} 9.74 \\ -0.45 \\ \hline 9.29 \end{array}$$

Multiplying a Whole Number by a Decimal

To multiply a whole number by a decimal, move the decimal point of the product (answer) as many places to the left as there are places to the right of the decimal point.

EXAMPLE

$$\begin{array}{r} 500 \\ \times .05 \\ \hline 2500. \end{array} \leftarrow$$

there are two places to the right of the decimal
the decimal point is moved two places to the left

After moving the decimal point, the answer reads 25.

$$\begin{array}{r} 250 \\ \times .3 \\ \hline 750. \end{array} \leftarrow$$

there are two places to the right of the decimal
the decimal point is moved two places to the left

After moving the decimal point, the answer reads 75.

Multiplying a Decimal by a Decimal

To multiply a decimal by a decimal, move the decimal point of the product (answer) as many places to the left as there are places to the right in *both* decimals.

EXAMPLE

$$\begin{array}{r} 2.75 \leftarrow \\ \times 0.5 \leftarrow \\ \hline 1375. \end{array}$$

there are two places to the right of the decimal
plus one place to the right of the decimal move the decimal point three places to the left

After moving the decimal point, the answer reads 1.375.

Dividing Decimals

The **divisor** is a number that is divided into the **dividend.**

EXAMPLE

$$\begin{array}{c} 0.69 \div 0.3 \\ \uparrow \quad \uparrow \\ \text{dividend} \quad \text{divisor} \end{array} \qquad \begin{array}{c} 0.3\overline{)0.69} \\ \uparrow \quad \uparrow \\ \text{divisor} \quad \text{dividend} \end{array}$$

This may be written or spoken as 0.69 divided by 0.3. To divide decimals:

1. The *divisor* is changed to a whole number. In this example, the decimal point is moved one place to the right so that 0.3 now becomes 3, which is a whole number.

$$0.\underset{\smile}{3}\overline{)0.69}$$

2. The decimal point in the *dividend* is now moved the *same number of places* to the right. In this example, the decimal point is moved one place to the right, the same number of places the decimal point in the divisor was moved.

$$0.3\overline{)0.\underset{\smile}{6}9}$$

3. The numbers are now divided.

$$3\overline{)6.9}\ \ 2.3$$

When only the dividend is a decimal, the decimal point is carried to the quotient (answer) in the same position.

EXAMPLES

$$2\overline{)0.750}\ \ .375 \qquad 2\overline{)3.472}\ \ 1.736$$

To divide when only the divisor is a decimal, for example,

$$.3\overline{)66}$$

1. The divisor is changed to a whole number. In this example the decimal point is moved one place to the right.

$$.\underset{\smile}{3}\overline{)66}$$

2. The decimal point in the dividend must also be moved one place to the right.

$$.3\overline{)66.\underset{\smile}{0}}$$

3. The numbers are now divided.

$$3\overline{)660}\ \ 220$$

Whenever the decimal point is moved in the dividend *it must also be moved* in the divisor, and whenever the

decimal point in the divisor is moved *it must be moved* in the dividend.

Changing a Fraction to a Decimal

To change a fraction to a decimal, divide the numerator by the denominator.

EXAMPLE

$$\frac{1}{5} = 5\overline{)1.0}^{\,.2} \qquad \frac{3}{4} = 4\overline{)3.00}^{\,.75} \qquad \frac{1}{6} = 6\overline{)1.000}^{\,.166}$$

Changing a Decimal to a Fraction

To change a decimal to a fraction:

1. Remove the decimal point and make the resulting whole number the numerator: 0.2 = 2.
2. The denominator is stated as 10 or a power of 10. In this example, 0.2 is read as two *tenths*, and therefore the denominator is 10.

$0.2 = \frac{2}{10}$ reduced to the lowest possible number is $\frac{1}{5}$

ADDITIONAL EXAMPLES

$$0.75 = \frac{75}{100} = \frac{3}{4} \qquad 0.025 = \frac{25}{1000} = \frac{1}{40}$$

CALCULATION OF DRUG DOSAGES

Although most hospital pharmacies dispense drugs as single doses or in a unit dose system, on occasion the nurse must compute a drug dosage because it differs from the dose of the drug that is available. This is particularly true of small hospitals, nursing homes, physicians' offices, and outpatient clinics that may not have a complete range of all available doses for a particular drug. Because certain situations may require computing the desired amount of drug to be given, nurses must be familiar with the calculation of all forms of drug dosages.

Systems of Measurement

There are three systems of measurement of drug dosages: the **metric system,** the **apothecaries' system,** and **household measurements.** The metric system is the most commonly used system of measurement in medicine. A physician may prescribe a drug dosage in the apothecaries' system, but for the most part this ancient system of measurements is only occasionally used. The household system is rarely used in a hospital setting but may be used to measure drug dosages in the home.

DISPLAY 3-1 ● Metric Measurements

WEIGHT
The unit of weight is the gram.
1 kilogram (kg) = 1000 grams (g)
1 gram (g) = 1000 milligrams (mg)
1 milligram (mg) = 1000 micrograms (mcg)

VOLUME
The unit of volume is the liter.
1 decaliter (dL) = 10 liters (L)
1 liter (L) = 1000 milliliters (mL)
1 milliliter (mL) = 0.001 liter (L)

LENGTH
The unit of length is the meter.
1 meter (m) = 100 centimeters (cm)
1 centimeter (cm) = 0.01 meter (m)
1 millimeter (mm) = 0.001 meter (m)

The Metric System

The metric system uses decimals (or the decimal system). In the metric system, the **gram** is the unit of weight, the **liter** the unit of volume, and the **meter** the unit of length.

Display 3-1 lists the measurements used in the metric system. The abbreviations for the measurements are given in parentheses.

The Apothecaries' System

The apothecaries' system uses whole numbers and fractions. Decimals are *not* used in this system. The whole numbers are written as lowercase Roman numerals, for example, x instead of 10, or v instead of 5.

The units of weight in the apothecaries' system are **grains, drams,** and **ounces.** The units of volume are **minims, fluid drams,** and **fluid ounces.** The units of measurement in this system are not based on exact measurements.

Display 3-2 lists the measurements used in the apothecaries' system. The abbreviations (or symbols) for the measurements are given in parentheses.

DISPLAY 3-2 ● Apothecaries' Measurements

WEIGHT
The units of weight are grains, drams, and ounces.
60 grains (gr) = 1 dram (ʒ)
1 ounce (℥) = 480 grains (gr)

VOLUME
The units of volume are minims, fluid drams, and fluid ounces.
1 fluid dram = 60 minims (♏)
1 fluid ounce = 8 fluid drams

DISPLAY 3-3 ● Household Measurements

3 teaspoons (tsp) = 1 tablespoon (tbsp)
2 tablespoons (tbsp) = 1 ounce (oz)
2 pints (pt) = 1 quart (qt)
4 quarts (qt) = 1 gallon (gal)

Household Measurements

When used, household measurements are for volume only. In the hospital, household measurements are rarely used because they are inaccurate when used to measure drug dosages. On occasion, the nurse may use the pint, quart, or gallon when ordering, irrigating, or sterilizing solutions or stock solutions. For the ease of a patient taking a drug at home, the physician may order a drug dosage in household measurements.

Display 3-3 lists the more common household measurements, with abbreviations in parentheses.

Conversion Between Systems

To convert between systems, it is necessary to know the equivalents, or what is equal to what in each system. Table 3-1 lists the more common equivalents.

TABLE 3-1 Approximate Equivalents

METRIC	APOTHECARIES	HOUSEHOLD
Weight		
0.1 mg	gr 1/600	
0.15 mg	gr 1/400	
0.2 mg	gr 1/300	
0.3 mg	gr 1/200	
0.4 mg	gr 1/150	
0.6 mg	gr 1/100	
1 mg	gr 1/60	
2 mg	gr 1/30	
4 mg	gr 1/15	
6 mg	gr 1/10	
8 mg	gr 1/8	
10 mg	gr 1/6	
15 mg	gr 1/4	
20 mg	gr 1/3	
30 mg	gr ss (1/2)	
60 mg	gr 1	
100 mg	gr i ss (1 1/2)	
120 mg	gr ii	
1 g (1000 mg)	gr xv	
Volume		
0.06 mL	min (ɱ) i	
1 mL	min (ɱ) xv or xvi	
4 mL	fluidram i	1 teaspoon (tsp)
15 mL	fluidrams iv	1/2 ounce (oz)
30 mL	fluid ounce i	1 ounce (oz)
500 mL	1 pint (pt)	1 pint (pt)
1000 mL (1 liter)	1 quart (qt)	1 quart (qt)

These equivalents are only *approximate* because the three systems are different and are not truly equal to each other.

Several methods may be used to convert from one system to another using an equivalent, but most conversions can be done by using proportion.

EXAMPLES

Convert 120 mg (metric) to grains (apothecaries')

Using proportion and the known equivalent 60 mg = gr i (1 grain)

$$1\text{ gr}:60\text{ mg}::X\text{ gr}:120\text{ mg}$$
$$60X = 120$$
$$X = 2\text{ gr (grains or gr ii)}$$

Note the use of the abbreviations gr and mg when setting up the proportion. This shows that the proportion was stated correctly and helps in identifying the answer as 2 *grains*.

Convert gr 1/100 (apothecaries') to mg (metric)

Using proportion and the known equivalent 60 mg = 1 gr:

If there are 60 mg in 1 gr, there are X mg in 1/100 gr

$$60\text{ mg}:1\text{ gr}::X\text{ mg}:1/100\text{ gr}$$
$$X = 60 \times \frac{1}{100} = \frac{60}{100} = \frac{3}{5}$$
$$X = \frac{3}{5}\text{ mg}$$

or

$$\frac{60\text{ mg}}{1\text{ gr}} = \frac{X\text{ mg}}{1/100}\text{ gr}$$
$$X = 60 \times \frac{1}{100} = \frac{60}{100} = \frac{3}{5}$$
$$X = \frac{3}{5}\text{ mg}$$

Fractions are *not* used in the metric system; therefore, the fraction must be converted to a decimal by dividing the denominator into the numerator, or $3 \div 5 = 0.6$ or

$$5\overline{)3.0}\quad .6$$

Therefore, gr 1/100 is equal to 0.6 mg.

When setting up the proportion, the apothecaries' system was written in Arabic numbers instead of Roman numerals, and their order was reversed (1 gr instead of gr i) so that all numbers and abbreviations are uniform in presentation.

Convert 0.3 milligrams (mg) [metric] to grains (gr) [apothecaries']

Using proportion and the known equivalent 1 mg = gr 1/60

$$1/60 \text{ gr}:1 \text{ mg}::X \text{ gr}:0.3 \text{ mg}$$

$$X = \frac{1}{60} \times 0.3 = \frac{0.3}{60} = \frac{3}{600} = \frac{1}{200}$$

$$X = \frac{1}{200} \text{ grain}$$

or

$$\frac{1/60}{} = \frac{X \text{ gr}}{}$$

or

$$\frac{1/60}{1 \text{ mg}} = \frac{X \text{ gr}}{0.3 \text{ mg}}$$

$$X = \frac{1}{60} \times 0.3 = \frac{0.3}{60} = \frac{3}{600} = \frac{1}{200}$$

$$X = \frac{1}{200 \text{ gr}}$$

Therefore, 0.3 mg equals gr 1/200.

There is no rule stating which equivalent must be used. In the above problem, another equivalent (60 mg = 1 gr) also could have been used. If 60 mg = 1 gr is used, the proportion would be:

$$60 \text{ mg}:1 \text{ gr}::0.3 \text{ mg}:X$$

$$60X = 0.3$$

$$X = 0.005$$

or

$$\frac{60 \text{ mg}}{1 \text{ gr}} = \frac{0.3 \text{ mg}}{X \text{ gr}}$$

$$60X = 0.3$$

$$X = 0.005$$

Therefore, 0.3 mg equals 0.005 gr.

Because decimals are not used in the apothecaries' system, this decimal answer must be converted to a fraction: 0.005 is 5/1000, which, when reduced to its lowest terms, is 1/200. The final answer is now 0.3 mg = gr 1/200.

Converting Within a System

Sometimes it is necessary to convert within the same system, for example, changing grams (g) to milligrams (mg) or milligrams to grams. Proportion and a known equivalent also may be used for this type of conversion.

EXAMPLE

Convert 0.1 gram (g) to milligrams (mg)

Using proportion and the known equivalent 1000 mg = 1g

$$1000 \text{ mg}:1 \text{ g}::X \text{ mg}:0.1 \text{ g}$$

$$X = 1000 \times 0.1$$

$$X = 100 \text{ mg}$$

or

$$\frac{1000 \text{ mg}}{1 \text{ g}} = \frac{X \text{ mg}}{0.1 \text{ g}}$$

$$X = 1000 \times 0.1$$

$$X = 100 \text{ mg}$$

Therefore, 0.1 gram (g) equals 100 milligrams (mg).

Solutions

A **solute** is a substance dissolved in a **solvent.** A solvent may be water or some other liquid. Usually water is used for preparing a solution unless another liquid is specified. Solutions are prepared by using a solid (powder, tablet) and a liquid, or a liquid and a liquid. Today, most solutions are prepared by a pharmacist and not by the nurse.

Examples of how solutions may be labeled include:

- 10 mg/mL–10 mg of the drug in each milliliter
- 1:1000–a solution denoting strength or 1 part of the drug per 1000 parts
- 5 mg/teaspoon–5 mg of the drug in each teaspoon (home use)

Reading Drug Labels

Drug labels give important information the nurse must use to obtain the correct dosage. The unit dose is the most common type of labeling seen in hospitals. The unit dose is a method of dispensing drugs in which each capsule or tablet is packaged separately. At times the drug will come to the nursing unit in a container with a number of capsules or tablets or as a solution. The nurse must then determine the number of capsules/tablets or the amount of solution to administer.

Drug labels usually contain two names: the trade (brand) name and the generic or official name (see Chap. 1). The trade name is capitalized, written first on the label, and identified by the registration symbol. The official or generic name is written in smaller print and usually located under the trade name. Although the drug has only one official name, several companies may manufacture the drug, with each manufacturer using a different trade name. Sometimes the generic or official name is so widely known that all manufacturers will simply use that name. For example, atropine sulfate is a widely used drug that is so well known that all manufacturers use the official name. In this case only the official name, atropine sulfate, will be found on the label. Drugs may be prescribed by either the trade name or the official or generic name. See Figure 3-1 for an example of a drug label showing the trade and generic names.

The dosage strength is also given on the container. The dosage strength is the average strength given to a patient as one dose. If necessary, the dosage strength is used to calculate the number of tablets or the amount of

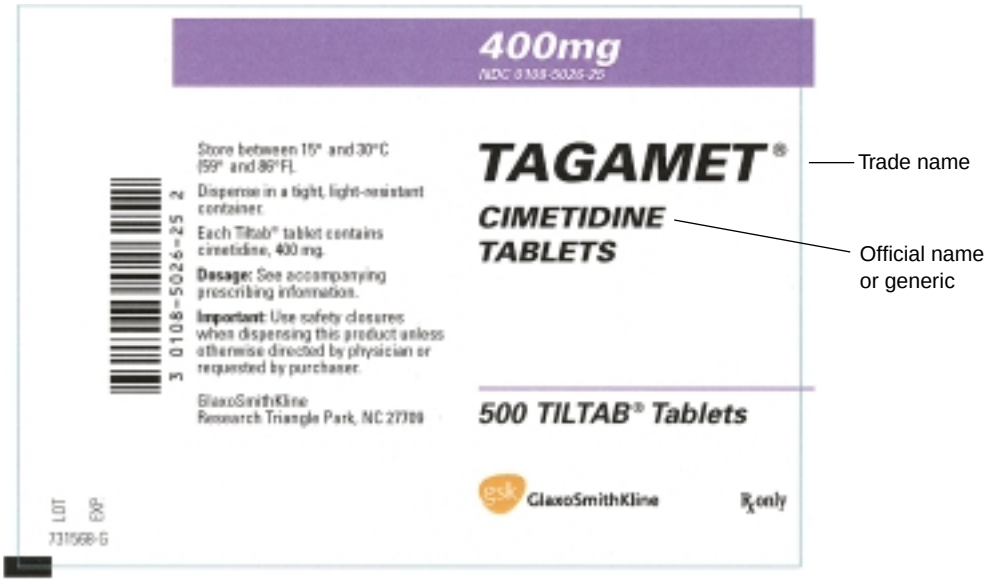


FIGURE 3-1. Drug label for Tagamet.

solution to administer. In liquid drugs there is a specified amount of drug in a given volume of solution, such as 50 mg in 2 mL.

Look at Figure 3-2. In this example, the dosage strength of the Augmentin is 125 mg/5 mL solution. If the physician orders 125 mg Augmentin, the nurse would administer 5 mL. More information on calculating drug dosages is given in the following section.

Oral Dosages of Drugs

Under certain circumstances, it may be necessary to compute an oral drug dosage because the dosage ordered by the physician may not be available, or the dosage may have been written in the apothecaries' system and the drug or container label is in the metric system.

Tablets and Capsules

To find the correct dosage of a solid oral preparation, the following formula may be used:

$$\frac{\text{dose desired}}{\text{dose on hand}} = \text{dose administered (the unknown or X)}$$

This formula may be abbreviated as

$$\frac{D}{H} = X$$

When the dose ordered by the physician (dose desired) is written in the *same system* as the dose on the drug container (dose on hand), these two figures may be inserted into the formula.

EXAMPLE

The physician orders ascorbic acid 100 mg (metric). The drug is available as ascorbic acid 50 mg (metric).

$$\frac{D}{H} = X$$

$$\frac{100 \text{ mg (dose desired)}}{50 \text{ mg (dose on hand)}} = 2 \text{ tablets of 50-mg ascorbic acid}$$

If the physician had ordered ascorbic acid 0.5 g and the drug container was labeled ascorbic acid 250 mg, a *conversion of grams to milligrams* (because the drug container is labeled in milligrams) would be necessary before this formula can be used. If the 0.5 g were *not*

FIGURE 3-2. Drug label for Augmentin.

converted to milligrams, the fraction of the formula would look like this:

$$\frac{0.5 \text{ grams}}{250 \text{ milligrams}}$$

A fraction *must* be stated in *like terms;* therefore, proportion may be used to convert grams to milligrams.

$$1000 \text{ mg}:1 \text{ g}::X \text{ mg}:0.5 \text{ g}$$
$$X = 1000 \times 0.5$$
$$X = 500 \text{ mg}$$

After changing 0.5 g to mg, use the formula:

$$\frac{D}{H} = X$$
$$\frac{500 \text{ mg}}{250 \text{ mg}} = 2 \text{ tablets of 250 mg ascorbic acid}$$

As with all fractions, the numerator and the denominator must be of like terms, for example, milligrams over milligrams or grams over grams. Errors in using this and other drug formulas, as well as proportions, will be reduced if the entire dose is written rather than just the numbers.

$$\frac{100 \text{ mg}}{50 \text{ mg}} \text{ rather than } \frac{100}{50}$$

This will eliminate the possibility of using *unlike* terms in the fraction.

Even if the physician's order was written in the apothecaries' system, the drug container most likely would be labeled in the metric system. A conversion of *apothecaries' to metric* will now be necessary because the drug label is written in the metric system.

EXAMPLE

The physician's order reads: codeine sulfate gr 1/4 (apothecaries'). The drug container is labeled: codeine sulfate 15 mg (metric). Grains must be converted to milligrams *or* milligrams converted to grains.

Grains to milligrams:

$$60 \text{ mg}:1 \text{ gr}::X \text{ mg}:1/4 \text{ gr}$$
$$X = 60 \times \frac{1}{4}$$
$$X = 15 \text{ mg}$$

or

$$\frac{60 \text{ mg}}{1 \text{ gr}} = \frac{X \text{ mg}}{1/4 \text{ gr}}$$
$$X = 60 \times \frac{1}{4}$$
$$X = 15 \text{ mg}$$

Therefore, 1/4 grain is approximately equivalent to 15 mg.

Milligrams to grains:

$$60 \text{ mg}:1 \text{ gr}::15 \text{ mg}:X \text{ gr}$$
$$60X = 15$$
$$X = 1/4 \text{ gr}$$

or

$$\frac{60 \text{ mg}}{1 \text{ gr}} = \frac{15 \text{ mg}}{X \text{ gr}}$$
$$60X = 15$$
$$X = \frac{1}{4} \text{ grain}$$

Therefore, 15 mg is approximately equivalent to 1/4 grain.

$$\text{The formula } \frac{D}{H} = X \text{ can now be used}$$
$$\frac{D}{H} = X$$
$$\frac{15 \text{ mg}}{15 \text{ mg}} = 1 \text{ tablet}$$

or

$$\frac{1/4 \text{ gr}}{1/4 \text{ gr}} = 1 \text{ tablet}$$

Liquids

In liquid drugs, there is a specific amount of drug in a given volume of solution. For example, if a container is labeled as 10 mg per 5 mL (or 10 mg/5 mL), this means that for every 5 mL of solution there is 10 mg of drug.

As with tablets and capsules, the prescribed dose of the drug may not be the same as what is on hand (or available). For example, the physician may order 20 mg of an oral liquid preparation and the bottle is labeled as 10 mg/5 mL.

The formula for computing the dosage of oral liquids is:

$$\frac{\text{dose desired}}{\text{dose on hand}} \times \text{quantity} = \text{volume administered}$$

This may be abbreviated as

$$\frac{D}{H} \times Q = X$$

The quantity (or Q) in this formula is the amount of liquid in which the available drug is contained. For example, if the label states that there is 15 mg/5 mL, 5 mL is the *quantity* (or volume) in which there is 15 mg of this drug.

EXAMPLE

The physician orders oxacillin sodium 125 mg PO oral suspension. The drug is labeled as 250 mg/5 mL.The 5 mL is the amount (quantity or Q) that contains 250 mg of the drug.

$$\frac{D}{H} \times Q = X \text{ (the liquid amount to be given)}$$

$$\frac{125 \text{ mg}}{250 \text{ mg}} \times 5 = X$$

$$\frac{1}{2} \times 5 = 2.5 \text{ mL}$$

Therefore, 2.5 mL contains the desired dose of 125 mg of oxacillin oral suspension.

Liquid drugs may also be ordered in drops (gtt) or minims. With the former, a medicine dropper is usually supplied with the drug and is always used to measure the ordered dosage. Eye droppers are not standardized, and therefore the size of a drop from one eye dropper may be different than one from another eye dropper.

To measure an oral liquid drug in minims, a measuring glass *calibrated in minims* must be used.

Parenteral Dosages of Drugs

Drugs for parenteral use must be in liquid form before they are administered. Parenteral drugs may be available in the following forms:

1. As liquids in disposable cartridges or disposable syringes that contain a specific amount of a drug in a specific volume, for example, meperidine 50 mg/mL. After administration, the cartridge or syringe is discarded.
2. In ampules or vials that contain a specific amount of the liquid form of the drug in a specific volume. The vials may be single-dose vials or multidose vials. A multidose vial contains more than one dose of the drug.
3. In ampules or vials that contain powder or crystals, to which a liquid (called a **diluent**) must be added before the drug can be removed from the vial and administered. Vials may be single dose or multidose vials.

Parenteral Drugs in Disposable Syringes or Cartridges

In some instances a specific dosage strength is not available and it will be necessary to administer less than the amount contained in the syringe.

EXAMPLE

The physician orders diazepam 5 mg IM. The drug is available as a 2-mL disposable syringe labeled 5 mg/mL.

$$\frac{D}{H} \times Q = X$$

$$\frac{5 \text{ mg}}{10 \text{ mg}} \times 2 \text{ mL} = X$$

$$X = \frac{1}{2} \times 2 = 1 \text{ mL}$$

Note that since the syringe contains 2 mL of the drug and that *each* mL contains 5 mg of the drug, there is a total of 10 mg of the drug in the syringe. Because there is 10 mg of the drug in the syringe, half of the liquid in the syringe (1 mL) is discarded and the remaining half (1 mL) is administered to give the prescribed dose of 5 mg.

Parenteral Drugs in Ampules and Vials

If the drug is in liquid form in the ampule or vial, the desired amount is withdrawn from the ampule or vial. In some instances, the entire amount is used; in others, only part of the total amount is withdrawn from the ampule or vial and administered.

Whenever the dose to be administered is different from that listed on the label, the volume to be administered must be calculated. To determine the volume to be administered, the formula for liquid preparations is used. The calculations are the same as those given in the preceding section for parenteral drugs in disposable syringes or cartridges.

EXAMPLES

The physician orders chlorpromazine 12.5 mg IM.

The drug is available as chlorpromazine 25 mg/mL in a 1-mL ampule.

$$\frac{D}{H} \times Q = X$$

$$\frac{12.5 \text{ mg}}{25 \text{ mg}} \times 1 \text{ mL} = X$$

$$\frac{1}{2} \times 1 \text{ mL} = \frac{1}{2} \text{ mL (or 0.5 mL) volume to be administered.}$$

The physician orders hydroxyzine 12.5 mg. The drug is available as hydroxyzine 25 mg/mL in 10-mL vials.

$$\frac{D}{H} \times Q = X$$

$$\frac{12.5 \text{ mg}}{25 \text{ mg}} \times 1 \text{ mL} = \frac{1}{2} \text{ mL (or 0.5 mL)}$$

Therefore, 0.5 mL is withdrawn from the 10-mL multidose vial and administered. In this example, the amount

in this or any multidose vial is *not* entered into the equation. What is entered into the equation as quantity (Q) is the amount of the available drug that is contained in a specific volume.

When the dose is less than 1 mL, it may be necessary, in some instances, to convert the answer to minims. A conversion factor of 15 or 16 minims/mL may be used.

EXAMPLES

The physician orders chlorpromazine 10 mg IM. The drug is available as chlorpromazine 25 mg/mL.

$$\frac{10\text{ mg}}{25\text{ mg}} \times 1\text{ mL} = X$$

$$\frac{2}{5} \times 1\text{ mL} = \frac{2}{5}\text{ mL}$$

$$\frac{2}{5} \times 15\text{ minims} = 6\text{ minims}$$

In this example 15 minims = 1 mL is used because 15 can be divided by 5.

The physician's order reads methadone 2.5 mg IM. The drug is available as methadone 10 mg/mL.

$$\frac{2.5\text{ mg}}{10\text{ mg}} \times 1\text{ mL} = X$$

$$\frac{1}{4} \times 1\text{ mL} = X$$

$$\frac{1}{4} \times 16\text{ minims} = 4\text{ minims}$$

Because 16 (and not 15) minims can be divided by 4, the conversion factor of 16 is used.

WARNING: ALWAYS CHECK DRUG LABELS CAREFULLY. Some may be labeled in a manner different from others.

EXAMPLE

a **2**-mL ampule labeled: **2** mL = 0.25 mg
a **2**-mL ampule labeled: **1** mL = 5 mg

In these two examples, one manufacturer states the entire dose contained in the ampule: 2 mL = 0.25 mg. The other manufacturer gives the dose per milliliter: 1 mL = 5 mg. In this 2-mL ampule, there is a total of 10 mg.

Parenteral Drugs in Dry Form

Some parenteral drugs are available as a crystal or a powder. Because these drugs have a short life in liquid form, they are available in ampules or vials in dry form and must be made a liquid (reconstituted) before they are removed and administered. Some of these products have directions for reconstitution on the label or on the enclosed package insert. The manufacturer may give either of the following information for reconstitution: (1) the name of the diluent(s) that must be used with the drug, or (2) the amount of diluent that must be added to the drug.

In some instances, the manufacturer supplies a diluent with the drug. If a diluent is supplied, no other stock diluent should be used. Before a drug is reconstituted, the label is carefully checked for instructions.

EXAMPLES

Methicillin sodium: To reconstitute 1 g vial add 1.5 mL of sterile water for injection or sodium chloride injection. Each reconstituted mL contains approximately 500 mg of methicillin.

Mechlorethamine: Reconstitute with 10 mL of sterile water for injection or sodium chloride injection. The solution now contains 1 mg/mL of mechlorethamine.

If there is any doubt about the reconstitution of the dry form of a drug and there are no manufacturer's directions, the hospital pharmacist should be consulted.

Once a diluent is added, the volume to be administered is determined. In some cases, the entire amount is given; in others, a part (or fraction) of the total amount contained in the vial or ampule is given.

After reconstitution of any multidose vial, the following information *must* be added to the label:

- Amount of diluent added
- Dose of drug in mL (500 mg/mL, 10 mg/2 mL, etc.)
- The date of reconstitution
- The expiration date (the date after which any unused solution is discarded)

Calculating Intravenous Flow Rates

When the physician orders a drug added to an intravenous (IV) fluid, the amount of fluid to be administered over a specified period, such as 125 mL/h or 1000 mL over 8 hours, must be included in the written order. If no infusion rate had been ordered, 1 L (1000 mL) of IV fluid should infuse over 6 to 8 hours.

To allow the IV fluid to infuse over a specified period, the IV flow rate must be determined. Before using one of the methods below, the drop factor must be known. Drip chambers on the various types of IV fluid administration sets vary. Some deliver 15 drops/mL and others deliver more or less than this number. This is called the *drop factor*. The drop factor (number of drops/mL) is given on the package containing the drip chamber and IV tubing. Three methods for determining the IV infusion rate follow. Methods 1 and 2 can be used when the known factors are the total amount of solution, the drop factor, and the number of hours over which the solution is to be infused.

METHOD 1

Step 1. Total amount of solution ÷ number of hours = number of mL/h

Step 2. mL/h ÷ 60 min/h = number of mL/min
Step 3. mL/min × drop factor = number of drops/min

EXAMPLE

1000 mL of an IV solution is to infuse over a period of 8 hours. The drop factor is 14.
Step 1. 1000 mL ÷ 8 hours = 125 mL/h
Step 2. 125 ÷ 60 minutes = 2.08 mL/min
Step 3. 2.08 × 14 = 29 drops/min

METHOD 2

Step 1. Total amount of solution ÷ number of hours = number of mL/h
Step 2. mL/h × drop factor ÷ 60 = number of drops/min

EXAMPLE

1000 mL of an IV solution is to infuse over a period of 6 hours. The drop factor is 12.
Step 1. 1000 mL ÷ 6 = 166.6 mL/h
Step 2. 166.6 × 12 ÷ 60 = 33.33 (33 to 34) drops/min

METHOD 3

This method may be used when the desired amount of solution to be infused in 1 hour is known or written as a physician's order.

$$\frac{\text{drops/mL of given set (drop factor)}}{\text{60 (minutes in an hour)}} \times \text{total hourly volume} = \text{drops/min}$$

EXAMPLE

If a set delivers 15 drops/min and 240 mL is to be infused in 1 hour:

$$\frac{15}{60} \times 240 = \frac{1}{4} \times 240 = 60 \text{ drops/min}$$

Oral or Parenteral Drug Dosages Based on Weight

The dosage of an oral or parenteral drug may be based on the patient's weight. In many instances, references give the dosage based on the weight in kilograms (kg) rather than pounds (1b). There are 2.2 1b in 1 kg.

When the dosage of a drug is based on weight, the physician, in most instances, computes and orders the dosage to be given. However, errors can occur for any number of reasons. The nurse should be able to calculate a drug dosage based on weight to detect any type of error that may have been made in the prescribing or dispensing of a drug whose dosage is based on weight.

To convert a known weight in kilograms to pounds, multiply the known weight by 2.2.

EXAMPLES

Patient's weight in kilograms is 54

$$54 \times 2.2 = 118.8 \text{ (or 119) lb}$$

Patient's weight in kilograms is 61.5

$$61.5 \times 2.2 = 135.3 \text{ (or 135) lb}$$

To convert a known weight in pounds to kilograms, divide the known weight by 2.2.

EXAMPLES

Patient's weight in pounds is 142

$$142 \div 2.2 = 64.5 \text{ kg}$$

Child's weight in pounds is 43

$$43 \div 2.2 = 19.5 \text{ kg}$$

Once the weight is converted to pounds or kilograms, this information is used to determine drug dosage.

EXAMPLES

A drug dose is 5 mg/kg/d. The patient weighs 135 1b, which is converted to 61.2 kg.

$$61.2 \text{ kg} \times 5 \text{ mg} = 306.8 \text{ mg}$$

Proportions also can be used:

$$5 \text{ mg:1 kg::X mg:61.2 kg}$$
$$X = 306.8 \text{ mg}$$

A drug dose is 60 mg/kg/d IV in three equally divided doses.

The patient weighs 143 Ib, which is converted to 65 kg.

$$65 \text{ kg} \times 60 \text{ mg} = 3900 \text{ mg/day}$$
$$3900 \text{ mg} \div 3 \text{ (dosess per day)} = 1300 \text{ mg each dose}$$

If the drug dose is based on body surface area (m^2) the same method of calculation may be used.

EXAMPLE

A drug dose is 60 to 75 mg/m^2 as a single IV injection.

The body surface area (BSA) of a patient is determined by means of a nomogram for estimating BSA (see Appendix E) and is found to be 1.8 m^2. The physician orders 60 mg/m^2.

$$60 \text{ mg} \times 1.8 \text{ m}^2 = 108 \text{ mg}$$

Proportion can also be used:

$$60 \text{ mg: } 1 \text{ m}^2\text{::X mg:1.8 m}^2$$
$$X = 108 \text{ mg}$$

Dosage Calculation Using Dimensional Analysis (DA)

When using DA to calculate dosage problems, dosages are written as common fractions. For example:

$$\frac{1 \text{ mL}}{4 \text{ mg}} \quad \frac{5 \text{ mL}}{10 \text{ mg}} \quad \frac{1 \text{ tablet}}{100 \text{ mg}}$$

When written as common fractions the numerator is the top number. In the example above, 1 mL, 5 mL, and 1 tablet are the numerators.

The numbers on the bottom are called denominators. In the example above, 4 mg, 10 mg, and 100 mg are denominators.

EXAMPLE

The physician orders 10 mg of diazepam. The drug comes in dosage strength of 5 mg/mL. How many mL would the nurse administer?

Step 1. To work this problem using DA, always begin by identifying the unit of measure to be calculated. The unit to be calculated will be mL or cc if the drug is to be administered parenterally. Another drug form is the solid and the unit of measure would be a tablet or capsule. In the problem above, the unit of measure to be calculated is mL. If the drug is an oral liquid drug, the measurement might be ounces.

Step 2. Write the identified unit of measure to be calculated, followed by an equal sign. In the problem above, mL is the unit to be calculated, so the nurse writes:

$$\text{mL} =$$

Step 3. Next, the dosage strength is written, with the numerator *always expressed in the same unit that was identified before the equal sign.* For example:

$$\text{mL} = \frac{1\ \text{mL}}{5\ \text{mg}}$$

Step 4. Continue by writing the next fraction with the numerator having the same unit of measure as the denominator in the previous fraction.
For example, our problem continues:

$$\text{mL} = \frac{1\ \text{mL}}{5\ \text{mg}} \times \frac{10\ \text{mg}}{\text{X mL}}$$

Step 5. The problem is solved by multiplication of the two fractions.

$$\text{mL} = \frac{1\ \text{mL}}{5\ \text{mg}} \times \frac{10\ \text{mg}}{\text{X mL}} = \frac{10\ \text{mg}}{5\text{X mL}} = 2\ \text{mL}$$

NOTE: Each alternate denominator and numerator cancel, with only the final unit remaining.

EXAMPLE

Ordered: 200,000 U
On hand: Drug labeled 400,000 U/mL

$$\text{mL} = \frac{1\ \text{mL}}{400{,}000\ \text{U}} \times \frac{200{,}000\ \text{U}}{\text{X mL}} = \frac{1}{2}\ \text{mL or } 0.5\ \text{mL}$$

Metric Conversions Using Dimensional Analysis

Occasionally the physician may order a drug in one unit of measure, whereas the drug is available in another unit of measure.

EXAMPLE

The physician orders 0.4 mg of atropine. The drug label reads 400 mcg per 1 mL. This dosage problem is solved by expanding the DA equation by adding one step to the equation.

Step 1. As above, begin by writing the unit of measure to be calculated, followed by an equal sign.

Step 2. Next, express the dosage strength as a fraction with the numerator having the same unit of measure as the number before the equal sign.

Step 3. Continue by writing the next fraction with the numerator having the same unit of measure as the denominator in the previous fraction.

$$\text{mL} = \frac{1\ \text{mL}}{400\ \text{mcg}} \times \frac{\text{mcg}}{\text{mg}}$$

Step 4. Expand the equation by filling in the missing numbers using the appropriate equivalent. In this problem, the equivalent would be 100 mcg = 1 mg. This will convert mcg to mg.

$$\text{mL} = \frac{1\ \text{mL}}{400\ \text{mcg}} \times \frac{1000\ \text{mcg}}{1\ \text{mg}}$$

Repeat Steps 3 and 4. Continue with the equation by placing the next fraction beginning with the unit of measure of the denominator of the previous fraction.

$$\text{mL} = \frac{1\ \text{mL}}{400\ \text{mcg}} \times \frac{1000\ \text{mcg}}{1\ \text{mg}} \times \frac{0.4\ \text{mg}}{\text{X mL}}$$

When possible, cancel out the units, leaving only mL.

Step 5. Solve the problem by multiplication. Cancel out the numbers when possible.

$$\text{mL} = \frac{1\ \text{mL}}{400\ \text{mcg}} \times \frac{1000\ \text{mcg}}{1\ \text{mg}} \times \frac{0.4\ \text{mg}}{\text{X mL}} = \frac{400}{400\ \text{X}} = 1\ \text{mL}$$

Solve the following problems using DA. Refer to the equivalent table if necessary. (See Table 3-1.)

EXAMPLE

Ordered: 250 mg.
On hand: Drug labeled 1 gram per 1 mL

$$\text{mL} = \frac{1\ \text{mL}}{1\ \text{g}} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{250\ \text{mg}}{\text{X mL}} = \frac{1\ \text{mL}}{4} \text{ or } 0.25\ \text{mL}$$

Temperatures

Two scales used in the measuring of temperatures are **Fahrenheit (F)** and **Celsius (C)** (also known as **centigrade**). On the Fahrenheit scale, the freezing point of water is 32° F and the boiling point of water is 212° F. On the Celsius scale, 0° C is the freezing point of water and 100° C is the boiling point of water.

To convert from Celsius to Fahrenheit, the following formula may be used: F = 9/5 C + 32 (9/5 times the temperature in Celsius, then add 32).

EXAMPLE

Convert 38° C to Fahrenheit:

$$F = \frac{9}{5} \times 38° + 32$$
$$F = 68.4° + 32$$
$$F = 100.4°$$

To convert from Fahrenheit to Celsius, the following formula may be used: C = 5/9 (F−32) (5/9 times the temperature in Fahrenheit minus 32).

EXAMPLE

Convert 100° F to Celsius:

$$C = \frac{5}{9} \times (100 - 32)$$
$$C = \frac{5}{9} \times 68$$
$$C = 37.77 \text{ or } 37.8°$$

(See Appendix D for Celsius (Centigrade) and Fahrenheit temperatures chart.)

Pediatric Dosages

The dosages of drugs given to children are usually less than those given to adults. The dosage may be based on age, weight, or BSA.

Body Surface Area

Charts are used to determine the BSA (see Appendix D) in square meters according to the child's height and weight. Once the BSA is determined, the following formula is used:

$$\frac{\text{surface area of the child in square meters}}{\text{surface area of an adult in square meters*}} \times \text{usual adult dose} = \text{pediatric dose}$$

(See Appendix E for Body Surface Area Nomograms.)

Weight

Pediatric as well as adult dosages may also be based on the patient's weight in pounds or kilograms. The method of converting pounds to kilograms or kilograms to pounds is explained in a previous section.

EXAMPLE

5 mg/kg
0.5 mg/lb

Today, most pediatric dosages are clearly given by the manufacturer, thus eliminating the need for formulas, except for determining the dose of some drugs based on the child's weight or BSA.

* The figure for the average BSA of an adult in square meters is 1.7.

chapter 4

The Nursing Process

Key Terms

assessment
evaluation
expected outcomes
implementation
independent nursing actions
initial assessment
nursing diagnosis
nursing process
objective data
ongoing assessment
planning
subjective data

Chapter Objectives

On completion of this chapter, the student will:

- List the five phases of the nursing process.
- Discuss assessment, nursing diagnosis, planning, implementation, and evaluation as they apply to the administration of drugs.
- Differentiate between objective and subjective data.
- Discuss how the nursing process may be used in daily life, as well as when administering drugs.
- Identify common nursing diagnoses used in the administration of drugs and nursing interventions related to each diagnosis.

The **nursing process** is a framework for nursing action consisting of problem-solving steps that help members of the health care team provide effective patient care. It is both a specific and orderly plan used to identify patient problems, develop and implement a plan of action, and then evaluate the results of nursing activities, including the administration of drugs.

The five phases of the process are used not only in nursing, but also in daily life. For example, when buying a computer one may first think about whether it is really needed, shop in several different stores to find out more about computers, and then determine what each store has to offer (**assessment**). At this point, one decides exactly what computer to buy and how to pay for the computer (**planning**); then the computer is purchased (**implementation**). After purchase and use, the computer is evaluated (**evaluation**).

Using the nursing process requires practice, experience, and a constant updating of knowledge. The nursing process is used in this text only as it applies to drug administration. It is not within the scope of this textbook to list all of the assessments, plans, implementations, and evaluations for the medical diagnosis that requires the administration of a specific drug.

THE FIVE PHASES OF THE NURSING PROCESS

Although the nursing process can be described in various ways, it generally consists of five phases: assessment, nursing diagnosis, planning, implementation, and evaluation. Each part is applicable, with modification, to the administration of medications. Figure 4-1 relates the nursing process to administration of medications.

Assessment

Assessment involves collecting objective and subjective data. **Objective data** are facts obtained by means of a physical assessment or physical examination. **Subjective data** are facts supplied by the patient or the patient's family.

Assessments are both initial and ongoing. An **initial assessment** is made based on objective and subjective data collected when the patient is first seen in a hospital, outpatient clinic, health care provider's office, or other type of health care facility. The initial assessment usually is more thorough and provides a database (sometimes called baseline) from which later data can be compared and decisions made. The initial assessment provides information that is analyzed to identify

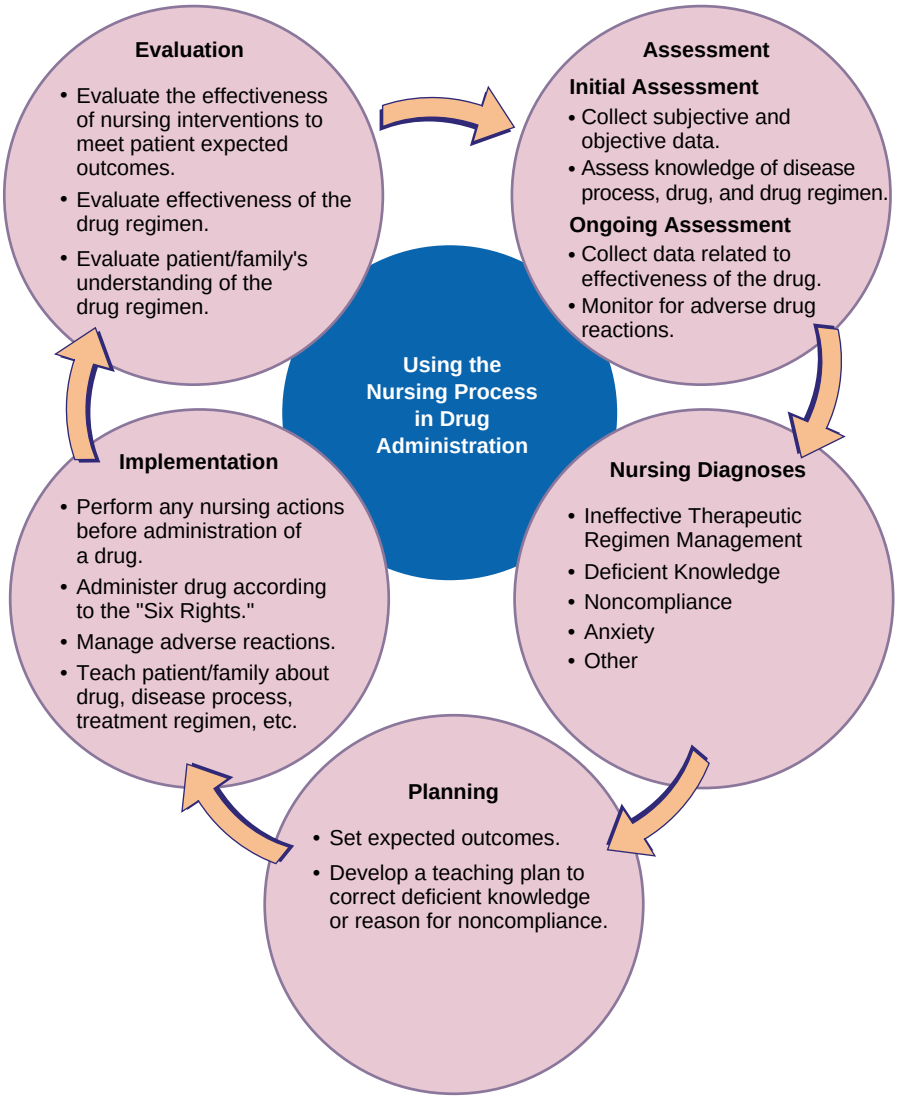


FIGURE 4-1. The nursing process as it relates to administration of medication.

problems that can be resolved or alleviated by nursing actions.

Objective data are obtained during an initial assessment through activities, such as examining the skin, obtaining vital signs, palpating a lesion, and auscultating the lungs. A review of the results of any recent laboratory tests and diagnostic studies also is part of the initial physical assessment. Subjective data are acquired during an initial assessment by obtaining information from the patient, such as a family history of disease, allergy history, occupational history, a description (in the patient's own words) of the current illness or chief complaint, a medical history, and a drug history. In addition to the prescription drugs that the patient may be taking, it is important to know any over-the-counter drugs, vitamins, or herbal therapies. For women of childbearing age the nurse needs to ask about the woman's pregnancy status and whether or not she is breastfeeding.

An **ongoing assessment** is one that is made at the time of each patient contact and may include the collection of objective data, subjective data, or both. The scope of an ongoing assessment depends on many factors, such as the patient's diagnosis, the severity of illness, the response to treatment, and the prescribed medical or surgical treatment.

The assessment phase (including the initial and ongoing assessment) of the nursing process can be applied to the administration of drugs, with objective and subjective data collected before and after to obtain a thorough baseline or initial assessment. This allows subsequent assessments to be compared with the baseline information. This comparison helps to evaluate the effectiveness of the drug and the presence of any adverse reactions. Ongoing assessments of objective and subjective data are equally important when administering drugs. Important objective data include blood pressure, pulse, respiratory rate,

temperature, weight, examination of the skin, examination of an intravenous infusion site, and auscultation of the lungs. Important subjective data include any statements made by the patient about relief or nonrelief of pain or other symptoms after administration of a drug.

The extent of the assessment and collection of objective and subjective data before and after a drug is administered will depend on the type of drug and the reason for its use.

Nursing Diagnosis

After the data collected during assessment are analyzed, the nurse identifies the patient's needs (problems) and formulates one or more nursing diagnoses. A **nursing diagnosis** is not a medical diagnosis; rather, it is a description of the patient's problems and their probable or actual related causes based on the subjective and objective data in the database. A nursing diagnosis identifies problems that can be solved or prevented by **independent nursing actions**—actions that do not require a physician's order and may be legally performed by a nurse. Nursing diagnoses provide the framework for selections of nursing interventions to achieve expected outcomes.

The North American Nursing Diagnosis Association (NANDA) was formed to standardize the terminology used for nursing diagnosis. NANDA continues to define, explain, classify, and research summary health statements about health problems related to nursing. NANDA has approved a list of diagnostic categories to be used in formulating a nursing diagnosis. This list of diagnostic categories is periodically revised and updated. In some instances, nursing diagnoses may apply to a specific group or type of drug or a particular patient. One example is Deficient Fluid Volume related to active fluid volume loss (diuresis) secondary to administration of a diuretic. Specific drug-related nursing diagnoses are highlighted in each chapter. However, it is beyond the scope of this book to discuss all possible nursing diagnoses related to a drug or a drug class.

Some of the nursing diagnoses developed by NANDA may be used to identify patient problems associated with drug therapy and are more commonly used when administering drugs. The most frequently used nursing diagnoses related to the administration of drugs include:

- Effective Therapeutic Regimen Management
- Ineffective Therapeutic Regimen Management
- Deficient Knowledge
- Noncompliance
- Anxiety

Because the above nursing diagnoses are commonly used for the administration of all types of drugs, they will not be repeated for each chapter. The nurse should keep these nursing diagnoses in mind when administering any drug.

Planning

After the nursing diagnoses are formulated, the nurse develops expected outcomes, which are patient oriented. An expected outcome is a direct statement of nurse–patient goals to be achieved. The **expected outcome** describes the maximum level of wellness that is reasonably attainable for the patient. For example, common expected patient outcomes related to drug administration, in general, include:

- The patient will effectively manage the therapeutic regimen.
- The patient will understand the drug regimen.
- The patient will comply with the drug regimen.

The expected outcomes define the expected behavior of the patient or family that indicates the problem is being resolved or that progress toward resolution is occurring.

The nurse selects the appropriate interventions on the basis of expected outcomes to develop a plan of action or patient care plan. Planning for nursing actions specific for the drug to be administered can result in greater accuracy in drug administration, patient understanding of the drug regimen, and improved patient compliance with the prescribed drug therapy after discharge from the hospital. For example, during the initial assessment interview, the patient may report an allergy to penicillin. This information is important, and the nurse must now plan the best methods of informing all members of the health care team of the patient's allergy to penicillin.

The **planning** phase plans the steps for carrying out nursing activities or interventions that are specific and that will meet the expected outcomes. Planning anticipates the implementation phase or the carrying out of nursing actions that are specific for the drug being administered. If, for example, the patient is to receive a drug by the intravenous route, the nurse must plan the materials needed and the patient instruction for administration of the drug by this route. In this instance, the planning phase occurs immediately before the implementation phase and is necessary to carry out the technique of intravenous administration correctly. Failing to plan effectively may result in forgetting to obtain all of the materials necessary for drug administration.

Expected outcomes define the expected behavior of the patient or family that indicates that the problem is being resolved or that progress toward resolution is occurring. Expected outcomes serve as a basis for evaluating the effectiveness of nursing interventions. For example, if the nursing intervention is to "monitor the blood pressure every hour," the expected outcome is that "the patient experiences no further elevation in blood pressure."

Implementation

Implementation is the carrying out of a plan of action and is a natural outgrowth of the assessment and planning phases of the nursing process. When related to the administration of drugs, implementation refers to the preparation and administration of one or more drugs to a specific patient. Before administering a drug, the nurse reviews the subjective and objective data obtained on assessment and considers any additional data, such as blood pressure, pulse, or statements made by the patient. The decision of whether to administer the drug is based on an analysis of all information. For example, a patient is hypertensive and is supposed to receive a drug to lower the blood pressure. Objective data obtained at the time of admission included a blood pressure of 188/110. Additional objective data obtained immediately before the administration of the drug included a blood pressure of 182/110. A decision was made by the nurse to administer the drug because the change in the patient's blood pressure was only minimal. However, if the patient's blood pressure was 132/84, and this was only the second dose of the drug, the nurse could decide to withhold the drug and contact the primary health care provider. Giving or withholding a drug or contacting the patient's health care provider are nursing activities related to the implementation phase of the nursing process.

The more common nursing diagnoses used when administering drugs are Effective Therapeutic Regimen Management, Ineffective Therapeutic Regimen Management, Deficient Knowledge, and Noncompliance. Nursing interventions applicable to each of these nursing diagnoses are discussed in the following sections. However, each patient is an individual, and nursing care must be planned on an individual basis after a careful collection and analysis of the data. In addition, each drug is different and may have various effects within the body. (For drugs discussed in subsequent chapters, some possible nursing diagnoses related to that specific drug are discussed.)

Effective Therapeutic Regimen Management

This nursing diagnosis takes into consideration that the patient is willing to regulate and integrate into daily living the treatment regimen such as the self-administration of medications. For this nursing diagnosis to be used the patient verbalizes the desire to manage the medication regimen. When the patient is willing and able to manage the treatment regimen, he or she may simply need information concerning the drug, method of administration, what type of reactions to expect, and what to report to the primary health care provider. A patient willing to take responsibility may need the nurse to develop a teaching plan that gives the patient the information needed to properly manage the therapeutic regimen (see Chap. 5 for more information on educating patients).

Ineffective Therapeutic Regimen Management

NANDA defines "ineffective therapeutic regimen management" as "a pattern of regulating and integrating into daily living a program for treatment of illness and the sequelae of illness that is unsatisfactory for meeting specific health goals." In the case of medication administration, the patient may not be taking the medication correctly or following the medication regimen prescribed by the health care provider.

The reasons for not following the drug regimen vary. For example, some people do not fill their prescriptions. Other patients skip doses, take the drug at the wrong times, or take an incorrect dose. Some may simply forget to take the drug; others take a drug for a few days, see no therapeutic effect, and quit. Some find the adverse effects so bothersome that they discontinue taking the drug without notifying the health care provider. Display 4-1 identifies some reasons for this ineffective therapeutic regimen management.

When working with a patient who is not managing the drug regimen correctly, the nurse must ensure that the patient understands the drug regimen. It is essential to provide written instructions. If possible, the nurse should allow the patient to administer the drug before he or she is dismissed from the health care facility. The nurse should determine if adequate funds are available to obtain the drug and any necessary supplies. For example, when a bronchodilator is administered by inhalation, a spacer or extender may be required for proper administration. This device is an additional expense. A referral to the social services department of the institution may help when finances are a problem.

For those who forget to take the drug, the nurse should suggest the use of small compartmentalized boxes marked with the day of the week or time the drug

DISPLAY 4-1 ● Possible Causes of Ineffective Management of Health Care Regimen

Extended therapy for chronic illness causes patient to become discouraged
Troublesome adverse reactions
Lack of understanding of the purpose for the drug
Forgetfulness
Misunderstanding of oral or written instructions on how to take the drug
Weak nurse–patient relationships
Lack of funds to obtain drug
Mobility problems
Lack of family support
Cognitive deficits
Visual or hearing defects
Lack of motivation

From: Carpenito, L. J. (1995). *Nursing diagnosis: Application to clinical practice* (6th ed., pp. 601–602). Philadelphia: Lippincott-Raven; Hussar, D. A. (1995, October). *Nursing95*, pp. 62–64.

FIGURE 4-2. Various types of drug containers may be used to help individuals remember to take their medication at the correct time.

is to be taken (see Fig. 4-2). These containers can be obtained from the local pharmacy.

It is important to discuss the drug regimen with the patient, including the reason the drug is to be taken, the times, the amount, adverse reactions to expect, and reactions that should be reported. The patient needs a thorough understanding of the desired or expected therapeutic effect and the approximate time expected to attain that effect. For example, a patient may become discouraged after taking an antidepressant for 5 to 7 days and seeing no response. An explanation that 2 to 3 weeks is required before the depression begins to lift will, in many cases, promote compliance.

It is important to provide ways to minimize adverse reactions if possible. For example, many anticholinergic drugs cause dry mouth. The nurse instructs the patient to take frequent sips of water or suck on hard candy to help minimize the discomfort of a dry mouth.

Frequent follow-up sessions are needed to determine compliance with the drug regimen. If a follow-up visit is not feasible, the nurse considers a telephone call or home visit. It is vital that the nurse strive to develop a caring and nurturing relationship with the patient. Compliance is enhanced when a patient trusts the nurse and feels comfortable confiding any problem encountered during drug therapy.

Deficient Knowledge

Deficient knowledge is the absence or deficiency of cognitive information to a specific subject. In the case of self-administration of drugs the patient lacks sufficient knowledge to administer the drug regimen correctly. It may also relate to a lack of interest in learning, cognitive limitation, or the inability to remember.

Most patients, at least in the initial treatment stages, have a lack of knowledge about the drug, its possible adverse reactions, and the times and method of administration. At times, the patient may have a lack of knowledge about the disease condition. In these situations, the nurse addresses the specific deficient knowledge (ie, adverse reactions, disease process, method of administration, and so on) in words that the patient can understand. It is important for the nurse to first determine what information the patient is lacking and then plan a teaching session that directly pertains to the specific area of need. (See Chap. 5 for more information on patient education.) If the patient lacks the cognitive ability to learn the information concerning self-administration of drugs, then one or more of the caregivers should be taught to administer the proper treatment regimen.

Noncompliance

Noncompliance is defined as behavior of the patient or caregiver that fails to coincide with the therapeutic plan agreed on by the patient and the health care provider. Patients are noncompliant for various reasons, such as a lack of information about the drug, the reason the drug is prescribed, or the expected or therapeutic results. Noncompliance also can be the result of anxiety or bothersome side effects. The nurse can relieve anxiety by allowing the patient to express feelings or concerns, by actively listening as the patient verbalizes feelings, and by providing information so that the patient can be fully informed about the drug. Many patients have a tendency to discontinue use of the drug once the symptoms have been relieved. It is important to emphasize the importance of completing the prescribed course of therapy. For example, failure to complete a course of antibiotic therapy may result in recurrence of the infection. To combat noncompliance the nurse finds out the exact reason for the noncompliance, if possible. Factors related to noncompliance are similar to those listed in Display 4-1.

Anxiety

Anxiety is a vague uneasiness or apprehension that manifests itself in varying degrees from expressions of concern regarding drug regimen to total lack of compliance with the drug regimen. When anxiety is high, the ability to focus on details is reduced. If the patient or caregiver is given information concerning the medication regimen during a high anxiety state, the patient may not remember the information. This could lead to noncompliance. The anxiety experienced during drug administration depends on the severity of the illness, the occurrence of adverse reactions, and the knowledge level of the patient. Anxiety is decreased with understanding of the therapeutic regimen. To decrease anxiety before discussing the treatment regimen with the patient, the nurse takes time to talk with and actively

listen to the patient. This helps to build a caring relationship and decrease patient anxiety. It is critical for the nurse to allow time for a thorough explanation and to answer all questions and concerns in language the patient can understand.

It is important to identify and address the specific fear and, if possible, reassure the patient that the drug will alleviate the symptoms or, if possible, cure the disorder. The nurse thoroughly explains any procedure. The nurse actively listens and provides encouragement as the patient expresses fears and concerns. Reassurance and understanding on the part of the nurse are required; the amount of reassurance and understanding depends on the individual patient.

Evaluation

Evaluation is a decision-making process that involves determining the effectiveness of the nursing interventions in meeting the expected outcomes. When related to the administration of a drug, this phase of the nursing process is used to evaluate the patient's response to drug therapy. The evaluation is positive if the expected outcomes have been accomplished or if progress has occurred. If the outcomes have not been accomplished, different interventions are needed. During the administration of the drug the expected response is alleviation of specific symptoms or the presence of a therapeutic effect. Evaluation also may be used to determine if the patient or family member understands the drug regimen.

To evaluate the patient's response to therapy, and depending on the drug administered, the nurse may check the patient's blood pressure every hour, inquire whether pain has been relieved, or monitor the pulse every 15 minutes. After evaluation, certain other decisions may need to be made and plans of action implemented. For example, the nurse may need to notify the primary health care provider of a marked change in a patient's pulse and respiratory rate after a drug was administered, or the nurse may need to change the bed linen because sweating occurred after a drug used to lower the patient's elevated temperature was administered.

The nurse can evaluate the patient's or family's understanding of the drug regimen by noting if one or both appear to understand the material that has been presented. Facial expression may indicate that one or both do or do not understand what has been explained. The nurse also may ask questions about the information that has been given to further evaluate the patient's or family's understanding.

● Critical Thinking Exercises

1. *Mr. Hatfield, age 69 years, confides to you that he is not taking the drug prescribed by his primary health care provider. He states he took the drug for a while and then quit. Explain some possible reasons Mr. Hatfield could have for not taking his drug. Discuss questions you could ask to assess the reason for Mr. Hatfield's noncompliance.*
2. *Ms. Heggan is 82 years old and lives alone. She is prescribed several drugs by the primary health care provider but is worried about taking the drugs and the side effects that might occur. She comes to the outpatient clinic after 1 week, and you learn that she has not filled her prescription and is not taking the drugs. Your nursing diagnosis is Ineffective Management of the Therapeutic Regimen related to anxiety about taking the prescribed drugs. Determine what information you would seek to obtain from Ms. Heggan. Identify important nursing interventions for this diagnosis.*
3. *Ms. Taylor is receiving three drugs for the treatment of difficulty breathing and swelling of her legs. You are giving these drugs for the first time. Discuss what questions you would ask Ms. Taylor to obtain subjective data.*

● Review Questions

1. A patient states that he does not understand why he had to take a specific medication. The most accurate nursing diagnosis for this man would be _____.
   - **A.** ineffective management of therapeutic regimen
   - **B.** anxiety
   - **C.** noncompliance
   - **D.** deficient knowledge
2. When the nurse enters subjective data in the patient's record, this information is obtained from _____.
   - **A.** the primary care provider
   - **B.** other members of the health care team
   - **C.** the patient or family
   - **D.** laboratory and x-ray reports
3. During the evaluation phase of the nursing process the nurse makes _____.
   - **A.** decisions regarding the effectiveness of nursing interventions
   - **B.** sure nursing procedures have been performed
   - **C.** notations regarding the patient's response to medical treatment
   - **D.** a list of all adverse reactions the patient has experienced while taking the drug

chapter 5

Patient and Family Teaching

Key Terms

affective domain
cognitive domain
learning
motivation
psychomotor domain
teaching

Chapter Objectives

On completion of this chapter, the student will:

- Identify important aspects of the teaching/learning process.
- Discuss the three domains of learning.
- Discuss important aspects of adult learning.
- Explain how the nursing process can be used to develop a teaching plan.
- Identify basic information to consider when developing a teaching plan.
- Discuss suggestions the nurse can make to the patient to modify drug administration in the home.

Patient teaching is an integral part of nursing. When a drug is prescribed, the patient and the family must be made aware of all information concerning the drug. The nurse is responsible for supplying the patient with accurate and up-to-date information about the drugs prescribed. The teaching/learning process is the means through which the patient is made aware of the drug regimen.

THE TEACHING/LEARNING PROCESS

Teaching is defined as an interactive process that promotes learning. Both the patient and the nurse must be actively involved if teaching is to be effective. **Learning** is acquiring new knowledge or skills. When learning occurs there is a change in the patient's behavior, thinking, or both.

A patient must have **motivation** (having the desire or seeing the need) to learn. Motivation depends on the patient's perception of the need to learn. Education concerning the disease process may be necessary for the patient to become motivated to learn. Encouraging patient participation in planning realistic and attainable goals also promotes motivation. If the patient has no motivation, he or she is likely to be noncompliant.

Creating an accepting and positive atmosphere also enhances learning. Physical discomfort negatively affects the patient's concentration and, thus, the ability to learn. Making sure the patient is not in pain is vital to the teaching/learning process.

THE THREE DOMAINS OF LEARNING

Learning occurs in three domains: cognitive, affective, and psychomotor. When developing a teaching plan for the patient, the nurse must consider each domain.

Cognitive Domain

The **cognitive domain** refers to intellectual activities such as thought, recall, decision making, and drawing conclusions. In this domain the patient uses previous experiences, prior knowledge, and perceptions to give meaning to new information or to modify previous thinking. The nurse makes use of the patient's cognitive abilities when information is given to the patient or caregivers about the disease process, medication regimen, and adverse reactions. The patient uses the cognitive domain to process the information, ask questions, and make decisions.

Affective Domain

The **affective domain** includes the patient/caregiver's attitudes, feelings, beliefs, and opinions. Health care providers often ignore these aspects of patient teaching.

It is easy to pull a preprinted teaching outline off of the computer or obtain preprinted material. This type of material is often used as a checklist to teach the patient about a drug and the therapeutic regimen. Such checklists are useful in helping the nurse remember important aspects of the drug that should be covered when teaching the patients about the drug and to give to the patient for future reference. However, the use of such checklists fails to take into account the affective domain.

Perhaps the most important prerequisite to learning about the patient's affective behavior is to develop a therapeutic relationship with the patient (one that is based on trust and caring). When the nurse takes the time to develop a therapeutic relationship, the patient/family has confidence in the nurse and more confidence in the information to be taught. The nurse approaches the patient with respect and encourages the expression of thoughts and feelings. Exploring the patient's beliefs about health and illness enhances the nurse's understanding of the patient's affective behavior.

Psychomotor Domain

The **psychomotor domain** involves learning physical skills (such as injection of insulin) or tasks (such as performing a dressing change). The nurse teaches a task or skill using a step-by-step method. The patient is allowed hands-on practice under the supervision of the nurse. The nurse assesses the patient mastery of the skill by having the patient or caregiver perform a return demonstration under the watchful eye of the nurse.

ADULT LEARNING

Generally adults learn only what they feel they need to learn. Adults learn best when they have a strong inner motivation to learn a new skill or acquire new knowledge. They will learn less if they are passive recipients of "canned" educational content. Adults have a vast array of experiences and knowledge to bring to a new learning experience. Teachers who use this experience will bring about the greatest behavior change. While 83% of adults are visual learners, only 11% learn by listening. Most adults retain the information taught if they are able to "do" something with that new knowledge immediately. For example, in teaching a patient how to administer his/her own insulin, the nurse would demonstrate the technique, allow time for supervised practice, and as soon as the patient appears ready, allow the patient to prepare and inject the insulin. Most adults prefer an informal learning environment where there is mutual exchange and freedom of expression.

THE NURSING PROCESS AS A FRAMEWORK FOR PATIENT TEACHING

The nursing process is a systematic method of identifying patient health needs, devising a plan of care to meet the identified needs, initiating the plan, and evaluating its effectiveness. This process provides the necessary framework to develop an effective teaching plan. However, the teaching plan differs from the nursing process in that the nursing process encompasses all of the patient's health care needs, whereas the teaching plan focuses primarily on the patient's learning needs. Nurses must be actively involved in teaching if they are to educate their patients about the proper way to take their drugs, the possibility of adverse reactions, and the signs and symptoms of toxicity (if applicable).

Assessment

Assessment is the data-gathering phase of the nursing process. Assessment assists the nurse in choosing the best teaching methods and individualizing the teaching plan. To develop an effective teaching plan, the nurse must first determine the patient's needs. Needs stem from three areas: (1) information the patient or family needs to know about a particular drug; (2) the patient's or family member's ability to learn, accept, and use information; and (3) any barriers or obstacles to learning.

Some drugs have simple uses and, therefore, relatively little patient teaching is needed. For example, applying a nonprescription ointment to the skin requires only minimal teaching. Other drugs, such as insulin, require detailed information that may need to be given over several days.

Assessing an individual's ability to learn may be difficult. Not all adults have the same literacy level. The information to be taught should be geared to the patient's educational and reading level. When assessing language and literacy skills, it is important to remember that some patients do not have the ability to read well. The nurse must carefully assess the patient's ability to communicate. Without accurate communication, learning will not occur. If the patient has a learning impairment, a family member or friend should be included in the teaching process. Most people readily understand what is being taught, but some cannot. For example, a visually impaired patient may be unable to read a label or printed directions supplied by the primary health care provider, pharmacist, or nurse. Another means of teaching will have to be used.

Through assessment, the nurse determines what barriers or obstacles (if any) may prevent the patient or family member from fully understanding the material being presented. Taking into consideration the patient's

Nursing Diagnosis Checklist

- ☑ **Effective Therapeutic Regimen Management**
- ☑ **Risk for Ineffective Therapeutic Regimen Management** related to lack of knowledge, indifference, other factors
- ☑ **Noncompliance** with drug regimen related to indifference, lack of knowledge, other factors
- ☑ **Deficient Knowledge** related to the drug regimen, possible adverse reactions, disease process, other factors

cultural background is helpful when planning a teaching session. For example, for some patients an interpreter is needed. In other cultures a certain individual (for example, the mother or the grandmother) is the decision maker in the family. It is important for the nurse to include the decision maker and the patient in the teaching session.

Nursing Diagnoses

The nursing diagnosis is formulated after analyzing the information obtained during the assessment phase. Most often, nursing diagnoses related to the administration of drugs are associated with a risk for ineffective management, deficit knowledge, or noncompliance. Examples of nursing diagnoses related to the administration of drugs are listed in the Nursing Diagnosis Checklist.

Planning

Planning is the actual development of strategies to be used in the teaching plan and the selection of information to be taught. Planning begins with an expected outcome statement. The nurse develops a teaching plan based on the expected outcome using the information gained during the assessment. Display 5-1 identifies important information that the nurse should include in the teaching plan.

DISPLAY 5-1 ● Important Information to Include in the Teaching Plan

1. Therapeutic response expected from the drug
2. Adverse reactions to expect when taking the drug
3. Adverse reactions to report to the nurse or primary health care provider
4. Dosage and route
5. Any special considerations or precautions associated with the particular drug prescribed
6. Additional education regarding special considerations of certain drugs, such as techniques for giving injections, applying topical patches, or instilling eye drops

Developing an Individualized Teaching Plan

Teaching plans are individualized because patients' needs are not identical. Areas covered in an individualized teaching plan vary depending on the drug prescribed, the primary health care provider's preference for including or excluding specific facts about the drug, and what the patient needs to know to take the drug correctly. Teaching strategies must reflect individual learning needs and ability. For example, a patient who speaks and reads only Spanish will not benefit from discharge instructions given in English or from instructions written in English. Different strategies must be implemented, such as providing instructions written in Spanish or communicating through another nurse who is fluent in the Spanish language.

When developing an individualized teaching plan for patients and their families, the nurse must select information relevant to a specific drug, adapt teaching to the individual's level of understanding, and avoid medical terminology unless terms are explained or defined. Figure 5-1 is a sample form to use when developing a teaching plan. It is important to remember that repetition enhances learning. Several teaching sessions help the nurse to better assess what the patient is actually learning and provides time for clarification. The patient should be encouraged to ask questions and express feelings.

Basic Information to Consider When Developing a Teaching Plan

General material to consider when developing a teaching plan includes information on the dosage regimen, adverse reactions, family members, and basic information about drugs, drug containers, and drug storage.

DOSAGE REGIMEN. The dosage regimen is an important aspect of the teaching plan. The nurse must consider the following general points when teaching about the dosage regimen:

- Capsules or tablets should be taken with water unless the primary health care provider or pharmacist directs otherwise (eg, take with food, milk, or an antacid). Some liquids, such as coffee, tea, fruit juice, and carbonated beverages, may interfere with the action of certain drugs.
- A full glass of water is used when taking an oral drug. In some instances, it may be necessary to drink extra fluids during the day while taking certain drugs.
- It is important not to chew capsules before swallowing; they must be swallowed whole. The patient also should not chew tablets unless labeled as "chewable." Some tablets have special coatings that are required for specific purposes, such as

Patient: _____ Medical Diagnosis: _____

Nursing Diagnosis: _____

_____ Effective Therapeutic Regimen Management _____

_____ Ineffective Therapeutic Regimen Management related to _____

_____ Deficient Knowledge related to _____

Expected Outcome: Patient will _____

_____

Identified obstacles to learning: _____

_____

_____

Primary Language: _____

Cultural Considerations: _____

_____

_____

Information to include in teaching session:
Expected therapeutic drug response:

Dosage and route:

Possible adverse reactions:

Adverse reactions to report:

Special considerations:

Teaching session (s)

Date(s)	Present	Evaluation*	Comments
1.			
2.			
3.			

*return demonstration, verbalizes understanding of information, questioned by nurse, other (specify) _____.

FIGURE 5-1. Patient and family teaching.

proper absorption of the drug or prevention of irritation of the lining of the stomach.
- The dose of a drug or the time interval between doses is never increased or decreased unless directed by the primary health care provider.
- A prescription drug or nonprescription drug recommended by a primary health care provider is not stopped or omitted except on the advice of the primary health care provider.
- If the symptoms for which a drug was prescribed do not improve, or become worse, the primary health care provider must be contacted as soon as possible because a change in dosage or a different drug may be necessary.
- If a dose of a drug is omitted or forgotten, the next dose must not be doubled or the drug taken at more frequent intervals unless advised to do so by the primary health care provider.
- All health care workers, including physicians, dentists, nurses, and health personnel must always be informed of all drugs (prescription and nonprescription) currently being taken on a regular or occasional basis.
- The exact names of all prescription and nonprescription drugs currently being taken should be kept in a wallet or purse for instant reference when seeing a physician, dentist, or other health care provider.
- Check prescriptions carefully when obtaining refills from the pharmacy and report any changes in the prescription (eg, changes in color, size, shape) to the pharmacist or primary health care provider before taking the drug because an error may have occurred.
- Wear a Medic-Alert bracelet or other type of identification when taking a drug for a long time. This is especially important for drugs such as anticoagulants, steroids, oral hypoglycemic agents, insulin, or digitalis. In case of an emergency, the bracelet ensures that medical personnel are aware of health problems and current drug therapy.

ADVERSE DRUG EFFECTS. Information about adverse drug effects of the prescribed drug must be included when the nurse develops a teaching plan for the patient. The nurse should teach the patient the following general points about adverse drug effects:

- All drugs cause adverse reactions (side effects). Examples of some of the more common adverse reactions are nausea, vomiting, diarrhea, constipation, skin rash, dizziness, drowsiness, and dry mouth. Some may be mild and disappear with time or when the primary health care provider adjusts the dosage. In some instances, mild reactions, such as dry mouth, may have to be tolerated. Some adverse reactions are potentially serious and even life threatening.
- Adverse effects are always reported to the primary health care provider as soon as possible.
- Medical personnel must be informed of all drug allergies before any treatment or drug is given.

FAMILY MEMBERS. The nurse considers the following points concerning family members when developing a teaching plan:

- A drug prescribed for one family member is never given to another family member, relative, or friend unless directed to do so by the primary health care provider.
- The nurse makes sure that all family members or relatives are aware of all drugs, prescription and nonprescription, that are currently being taken by the patient.

DRUGS, DRUG CONTAINERS, AND DRUG STORAGE. The following are important facts about drugs, drug containers, and the storage of drugs that the nurse must consider when developing a teaching plan:

- The term *drug* applies to both nonprescription and prescription drugs.
- A drug must be kept in the container in which it was dispensed or purchased. Some drugs require special containers, such as light-resistant (brown) bottles to prevent deterioration that may occur on exposure to light.
- If any drug changes color or develops a new odor, a pharmacist must be consulted immediately about continued use of the drug.
- The original label on the drug container must not be removed while it is used to hold the drug.
- Two or more different drugs must never be mixed in one container, even for a brief time, because one drug may chemically affect another. Mixing drugs can also lead to mistaking one drug for another, especially when the size and color are similar.
- The lid or cap of the container must be replaced immediately after removing the drug from the container. The lid or cap must be firmly snapped or screwed in place because exposure to air or moisture shortens the life of most drugs.
- Drugs requiring refrigeration are so labeled. The container must be returned to the refrigerator immediately after removing the drug.
- All drugs must be kept out of the reach of children.
- Unless otherwise directed, drugs must be stored in a cool, dry place.
- Do not expose a drug to excessive sunlight, heat, cold, or moisture because deterioration may occur.

Home Care Checklist

MODIFYING DRUG ADMINISTRATION IN THE HOME

Once the patient is at home, some modifications may be necessary to ensure safe drug administration. The nurse provides written instructions, using large print (if necessary), nonglare paper, and words that the patient and caregiver can understand. In addition, it is important to modify your teaching by using the following suggestions:

- ☑ For patients taking more than one drug, develop a clear, easy-to-read drug schedule or a chart resembling a clock for the patient or caregiver to consult.
- ☑ Try using a daily calendar as an inexpensive, yet effective, means for scheduling.
- ☑ If the patient or caregiver has a problem with drug names, refer to the drug by shape or color. Another idea is to number bottles and use this number on the drug chart.
- ☑ If financially feasible, suggest the use of commercially available drug organizers. If the patient cannot afford drug organizers, egg cartons or a muffin tin can be labeled and used as drug organizers.
- ☑ If your patient finds it helpful to keep all drugs together, suggest using a bowl, tray, or small box to hold all the containers.
- ☑ If temporary refrigeration is necessary, suggest the use of a small cooler or insulated bag.
- ☑ If equipment items such as needles and syringes are used, suggest keeping all the supplies in one area.
- ☑ If the supplies came in a delivery box, suggest that the patient use it for storage. Other suggestions include using plastic storage containers with snap-on lids or clean, dry glass jars with screw tops.
- ☑ Advise the patient to use an impervious container with a properly fitting lid, such as a coffee can, for safe disposal. A plastic milk jug with a lid or a heavy-duty, clean, cardboard milk or juice carton may be used if necessary.
- ☑ Explain the importance of taking precautions to make sure discarded needles do not puncture the container.

- The entire label of the prescription or nonprescription drug container must be read, including the recommended dosage and warnings.
- All directions printed on the label (eg, “shake well before using,” “keep refrigerated,” “take before meals”) must be followed to ensure drug effectiveness.
- In some instances, especially when an ointment or liquid drug is prescribed, some drug may remain after it is used or taken for the prescribed time. Some drugs have a short life (a few weeks to a few months) and may deteriorate or change chemically after a time. A prescription must never be saved for later use unless the primary health care provider so advises.

Implementation

Implementation is the actual performance of the interventions identified in the teaching plan. Teaching at an appropriate time for each patient fosters learning. For example, patient teaching is not done when there are visitors (unless they are to be involved in the administration of the patient’s drugs), immediately before discharge from the hospital, or if the patient has been sedated or is in pain.

Teaching is begun a day or more before discharge, at a time when the patient is alone and alert, and continued each day until dismissal. The nurse gears teaching to the patient’s level of understanding and, when necessary, provides written as well as oral instructions. If much information is given, it is often best to present the material in two or more sessions. Drug administration modifications may be necessary once the patient is at home. The nurse keeps these modifications in mind when teaching the patient (see Home Care Checklist: Modifying Drug Administration in the Home).

Evaluation

To determine the effectiveness of patient teaching, the nurse evaluates the patient’s knowledge of the material presented. Evaluation can be done in several ways, depending on the nature of the information.

For example, if the patient is being taught to administer insulin, several demonstrations can be scheduled, followed by a return demonstration by the patient with the nurse observing to evaluate the patient's technique.

Questions such as "Do you understand?" or "Is there anything you don't understand?" should be avoided because the patient may feel uncomfortable admitting a lack of understanding. When factual material is being evaluated, the nurse should periodically ask the patient to list or repeat some of the information presented.

● Critical Thinking Exercises

1. *Locate the clinical educator in any health care agency in your community whose job it is to do patient education. Discuss with that person his or her thoughts and feelings on patient education, as well as any problems or pitfalls he or she has identified.*
2. *Interview friends or relatives about their knowledge of the drug(s) prescribed by their primary health care provider. Discuss with them the teaching they received from nurses or other health care providers before they began taking the drugs. Determine what areas could have been included that were not discussed. Analyze how the teaching/learning process was evaluated. Identify any areas that could be improved.*
3. *Using the form in Figure 5-1, develop a teaching plan for a patient.*

● Review Questions

1. An interactive process that promotes learning is defined as _____.
   - **A.** motivation
   - **B.** cognitive ability
   - **C.** the psychomotor domain
   - **D.** teaching
2. When developing a teaching plan the nurse assesses the affective learning domain, which means that the nurse considers the patient's _____.
   - **A.** attitudes, feelings, beliefs, and opinions
   - **B.** ability to perform a return demonstration
   - **C.** intellectual ability
   - **D.** home environment
3. Actual development of the strategies to be used in the teaching plan and selections of the information to be taught occur in the _____ phase of the nursing process.
   - **A.** assessment
   - **B.** planning
   - **C.** implementation
   - **D.** evaluation
4. Unless the primary health care provider or pharmacist directs otherwise, the nurse informs patient to take oral medications with _____.
   - **A.** fruit juice
   - **B.** milk
   - **C.** water
   - **D.** food