

# Pharmacology in Radiology



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# Pharmacology in Radiology

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*Radiologic technologists need a basic understanding of pharmacology principles. This is particularly true during radiographic examinations involving contrast media administration. A fundamental knowledge of pharmacodynamics and pharmacokinetics can help radiologic technologists and radiologist assistants better understand how medications act, possible adverse reactions and the principles of drug administration.*

*This ASRT Directed Reading Classic was originally published in Radiologic Technology, July/August 2009, Vol. 80/No.6.*

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## After completing this article, the reader should be able to:

- Discuss the basic principles of pharmacology.
- Review pharmacokinetics and pharmacodynamics concepts.
- List the various routes for drug administration.
- Explain the pharmacology of radiographic contrast media.
- Describe the pharmacology of commonly used medications.

In many clinical settings it is common for radiologic technologists and radiologist assistants to administer pharmacologic agents during the course of a radiologic examination. According to the Practice Standards for Medical Imaging and Radiation Therapy developed by the American Society of Radiologic Technologists (ASRT), medication administration including the administration of contrast media is within the scope of practice for radiologic technologists with appropriate clinical and didactic education and where permitted by federal or state statutes and/or institutional policy.<sup>1</sup> Several other organizations (eg, the American College of Radiology, or ACR, and the Joint Review Committee on Educational Programs in Nuclear Medicine Technology) have echoed this position.<sup>2</sup>

It is important to note that medication administration by radiologic technologists is governed by state statute, regulation and institutional policy. For example, the Joint Commission

requires facilities to develop policies identifying who can administer medications, via which delivery method and under what supervisory level. The ASRT holds the position that “absent specific protocols, the parenteral injection of contrast media and other medications by radiologic technologists be performed only when a licensed independent practitioner or radiologist where required, is immediately available to ensure proper diagnosing of and treatment of possible allergic reaction.”<sup>1</sup> Nevertheless, it is important that medical imaging professionals have a fundamental understanding of pharmacology to provide optimal patient care.<sup>3</sup>

## Basic Principles of Pharmacology

Pharmacology is the study of drugs in living systems. Pharmaceutical agents are approved for use after both preclinical (animal) and clinical (human) studies are completed to demonstrate their safety and effectiveness. Once these studies are completed, the

company that manufactures the agent submits the data to the U.S. Food and Drug Administration (FDA) for approval. If approved, most drugs are given a patent life of approximately 10 years. Pharmacologic agents can be divided into prescription and nonprescription (over-the-counter) drugs. Certain prescription agents with potential for addiction are known as controlled substances. Drugs should not be prescribed or administered without proper training and authority.<sup>4,5</sup>

### **Nomenclature**

Drug nomenclature can be divided into several parts because each pharmacologic agent receives many names or designations. These names include the chemical name, proprietary or trade name and a generic or nonproprietary name.

The chemical name for a pharmacologic agent is the International Union of Pure and Applied Chemistry (IUPAC) designation that identifies the structure of the compound. This nomenclature seldom is used by clinicians.<sup>6</sup>

The agent's proprietary or trade name also is known as the brand name for the drug. This designation is selected by the manufacturer for marketing purposes. A generic name is the official nonproprietary designation for a pharmacologic agent. All pharmacologic agents in this article are referred to by their generic names. Most branded pharmacologic agents become generic at some point, often when the patent expires.<sup>7</sup>

The designations for pharmacologic agents can be demonstrated with the following example. The cholesterol-lowering medication simvastatin is marketed as ZOCOR (Merck & Co Inc, Whitehouse Station, New Jersey). Simvastatin is the generic name and ZOCOR is the proprietary name. The IUPAC chemical designation for simvastatin is 2,2-dimethyl-1,2,3,7,8,8a-hexahydro-3,7-dimethyl-8-[2-(tetrahydro-4-hydroxy-6-oxo-2H-pyran-2-yl)-ethyl]-1-naphthalenyl ester.<sup>8</sup>

### **Biopharmaceutics**

The area of pharmacology that studies the methods for achieving effective drug administration is known as biopharmaceutics.<sup>9</sup> Manufacturers place medications into vehicles such as tablets to help deliver them to the body. The combination of the pharmacologic agent and the vehicle is known as the dosage form. Common

dosage forms include tablets, capsules, solutions, suspensions and gases.

Orally delivered dosage forms include tablets, capsules, troches, solutions, emulsions and suspensions. Tablets and capsules consist of several components, including the active form of the pharmacologic agent, chemicals that aid in the disintegration process and fillers to help maintain the form of the medication. Substances to help mask the taste of the medication also may be added to the tablet or capsule.

Certain agents, such as antifungal medications, are presented in the form of troches or lozenges that are designed to dissolve in the mouth. Troches commonly are used to treat oral candida infections or thrush. Solid dosage forms such as suppositories can be used for rectal and vaginal administration.

Liquid dosage forms also are administered orally. Examples include solutions, emulsions and suspensions. A solution is any mixture of a solid, liquid or gas that is dissolved in a liquid. An emulsion is a mixture of 2 immiscible liquids (liquids that are incapable of mixing, such as oil and water). A suspension is the mixture of a solid medication into a liquid medium. Liquid dosage forms also can be delivered parenterally.

Inhaled medications such as anesthetics are presented in gas dosage forms. Other inhalants contain liquified medications that are dispersed in a gas propellant.<sup>7,9</sup>

### **Pharmacokinetics**

Pharmacokinetics is the process of absorption, distribution, metabolism and excretion of medications. Drug selection, dosing and administration schedule depend on the principles of pharmacokinetics.<sup>7,10</sup>

#### **Absorption and Distribution**

The body must absorb a medication before the drug can have an effect at its intended site. Drugs can be absorbed into the systemic circulation at various sites including the skin, gastrointestinal tract, lungs, subcutaneous tissue, muscle and mucous membranes.<sup>7,10</sup>

Several factors affect absorption. Parts of the body that contain the largest surface areas, such as the lungs and gastrointestinal tract, provide better absorption for a pharmacologic agent than those with less surface area. Increased circulation results in optimal absorption. A patient in shock has decreased circulation to the

gastrointestinal tract and thus can be expected to have a lower rate of absorption for an orally administered medication than a healthy patient. Drug concentration also affects medication absorption as medications tend to move from an area of higher concentration to an area of lower concentration. Some medications bind to carrier proteins that facilitate drug absorption and thus do not depend on concentration. The acid-base status and fat solubility of medications also affect how they are absorbed.<sup>10</sup>

After absorption, the bloodstream distributes the medication to the site of action. If the circulation is compromised, the ability of the bloodstream to distribute the medication to the intended target area also will be diminished. Similarly, certain medications have a tendency to accumulate in certain body tissues such as fat, which can prevent the medication from reaching its intended site of action.<sup>9,10</sup>

#### Metabolism

Medication metabolism encompasses the biochemical reactions that modify the drug and make it ready for use in the body. Several biochemical processes, including oxidation, reduction, glucuronidation and hydroxylation, occur during drug metabolism.<sup>10</sup>

Oxidation involves combining a substance with oxygen, increasing the electronegative charge of the compound. Reduction is a reaction that results in gaining electrons or the addition of hydrogen to an organic compound. Glucuronidation is a detoxification of most commonly prescribed drugs in which glucuronic acid is conjugated with toxins in the liver. Hydroxylation is a means of oxidizing a compound by introducing hydroxyl groups.

Most drugs are metabolized in the liver. Hepatic metabolism makes most drugs more water soluble, allowing for improved absorption and effectiveness. Metabolism also may reduce the activity of certain agents. Prodrugs are an important exception to this principle. These agents are pharmacologically inactive when initially administered but metabolism renders them active.<sup>10</sup>

#### Excretion

Most pharmacologic substances are excreted from the body following metabolism. The most common route of excretion is the kidney. Drugs metabolized in

the kidney are excreted as urine. As blood containing a pharmacologic agent is filtered through the kidney, the metabolized drug may be excreted or reabsorbed. Certain agents, such as aspirin, are both reabsorbed and excreted.<sup>10</sup> Some agents, such as certain types of radiographic contrast, can cause renal damage. The resulting damage can affect drug metabolism and excretion.<sup>7,10</sup>

The liver is another key organ involved in the excretion of certain pharmacologic agents. Some medications are excreted from the liver into urine and others into the bile; some agents are eliminated via the bile and reabsorbed in the intestine. These agents return to the liver and ultimately are excreted in the bile. This process is known as extrahepatic excretion. The cardiovascular medication digitoxin undergoes extrahepatic excretion.<sup>10</sup>

Other organs also are involved in excreting pharmacologic substances. The intestine can eliminate medications in the form of feces. Drugs also can be eliminated by saliva, sweat and breast milk.<sup>10</sup>

### Pharmacodynamics

Pharmacodynamics is the study of drugs' effects. A number of properties should be considered in the pharmacodynamics of each medication, including mechanism of action, dose response, half-life, drug interactions and adverse events.<sup>7,9,10</sup>

#### Mechanism of Action

A drug's mechanism of action is the way in which it interacts with the body to produce its intended effect. Many pharmacologic agents interact with receptors in the body; this triggers a cascade of events that results in a specific action. Other medications exert their effects by stimulating or inhibiting enzymes.<sup>7,10</sup>

Antihistamines are an example of a medication that binds to receptors. Histamine is a chemical compound that is naturally produced in the body. Allergic reactions occur in part when histamine binds to histamine receptors. Antihistamines can bind the receptors and thus prevent the histamine from binding to them. Antihistamines can compete with histamine for the cellular binding sites and reduce the allergic response.

Other medications actually can stimulate a receptor when they bind to it. This results in an exaggerated