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# Textbook of Nursing Foundation-II

*As Per Revised INC Syllabus for BSc Nursing*

**Semester-II**





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Chapter

# 9 Administration of Medications

## Learning Objectives

**On completion of this chapter, the students will be able to:**

- Enumerate the concept of medication/drugs and drug nomenclature.
- Describe different forms of medications.
- Write the classification of medication based on action.
- Explain the types of medication action/effects of medications.
- Discuss different types of side effects/reactions of drugs.
- Define and differentiate pharmacokinetics and pharmacodynamics.
- Write main routes of drug excretion.
- Describe different systems of drug measurement.
- Perform medication dose calculation.
- Enumerate classification of medication based on action.
- Describe medication orders and prescriptions.
- Elaborate topical routes of administration.
- Demonstrate application of medication to skin and mucous membrane.
- Discuss about topical application of liquids and gargling.
- Demonstrate eye instillation procedure.
- Perform ear irrigation procedure.
- Demonstrate procedures for inhalation of medications.
- Administer enema and suppositories.
- Provide IM, IV and intradermal injections.
- Prepare tray for intra-articular, intraosseous and other form of injection.
- Store and maintain the drugs properly.

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## INTRODUCTION

Medications are the drugs that are used in the treatment of illness or injury. A medication administration route is often classified by the location at which the drug is applied, such as oral, topical or parenteral. Understanding the different routes of medication administration is essential for effective treatment and patient safety. Each route has specific considerations and potential contraindications based on the medication's properties and the patient's condition. The choice of routes in which the medications are applied depends not only on convenience but also on the drug's properties and pharmacokinetics. Therefore, it is crucial to understand the characteristics of the various routes and associated techniques. Each route has its own set of considerations, including absorption rates, potential side effects, and patient-specific factors. Routes of administration are generally classified by the location at which the substance is applied. Common examples include oral and intravenous administration. Routes can also be classified based on where the target of action is. Action may be topical (local), enteral for system-wide effect, but delivered through the gastrointestinal tract or parenteral (systemic action, but is delivered by routes other than the GI tract). Route of administration and dosage form are aspects of drug delivery. Many interprofessional healthcare team members are involved in administering medications to patients and understanding the characteristics and techniques associated with each route is essential for them. The healthcare team members need to decide the proper route for administration of medication. Beside that institutional policies and procedures for administration of

medications may be present at hospital and there may have specific protocols in place for medication administration.

## CONCEPT OF DRUGS, MEDICATIONS AND THEIR ADMINISTRATION

### Drug

A drug is a substance which alters physiological function with the potential of affecting health.

A drug is any chemical substance (other than food) that, when introduced into the body, causes a physiological effect. This produces a measurable physiological change when it enters the body. This broad definition covers not only compounds used to treat or prevent diseases but also substances that can alter mood, behavior, or bodily functions for nonmedical or recreational purposes. In fact, the World Health Organization defines a drug as "any substance or product that is used or intended to be used to modify or explore physiological systems or pathological states for the benefit of the recipient". This inclusive term therefore spans everything from clinically approved compounds to substances that are misused.

### Medication

A medication is a substance used in the diagnosis, treatment, cure, relief or prevention of health alteration.

A medication is a specific subset of drugs—one that is formulated, prescribed, and administered with the intent of diagnosing, treating, or preventing disease. Medications are rigorously tested for safety, efficacy, and quality before they are approved by regulatory bodies, and they are typically supplied in precise dosages (for example, in pill, liquid, or injection form) to manage health conditions effectively. In other words, while all medications are drugs, they always carry a therapeutic purpose and are intended to improve health outcomes all medications are drugs, but not every drug qualifies as a medication. While medications have clear and positive therapeutic objectives, the term "drug" can also refer to substances used recreationally or even those associated with adverse effects when misused.

"A fundamental rule of safe drug administration is never administer an unfamiliar medication".

The administration of medication is a critical component of patient care. It involves several key steps to ensure that the medication is given safely and effectively. Medications can be dangerous, though, even when they're meant to improve our health. Taking them correctly and understanding the right way to administer them can reduce the risks. There are several different ways drugs can be administered. Administration of medication requires thorough understanding the drug, including how it moves through the body, when it needs to be administered, possible side effects and dangerous reactions, proper storage, handling, and disposal. Health care professional are well trained on this. Even though the common people are taking medication in home with physician order, they should be well trained regarding the route, doses, time of self-administration of drugs and it is adverse effects. They should know when they have to consult a doctor. There are several different routes through which drugs can be administered which will be explained later.

## DRUG NOMENCLATURE

Drug nomenclature is the systematic naming of drugs, especially pharmaceutical drugs using different types of names to identify them. These names include chemical names, generic names (also known as international nonproprietary names or INNs), and brand names (also known as proprietary names). The INN system, managed by the World Health Organization, aims to provide a unique, globally recognized name for each drug, promoting clarity and safety in healthcare.

### Chemical Name

The chemical name provides a precise description of a drug's chemical composition and molecular structure. It details the exact arrangement of atoms and the chemical bonds within the molecule. Due to its complexity, the chemical name is generally not used in everyday prescriptions.

It represents the drug's molecular structure and chemical properties in a detailed manner. Chemical names are often lengthy and intricate, making them cumbersome for routine use in clinical settings.

*Examples:* Acetylsalicylic Acid is the chemical name for aspirin. This name reflects the molecular structure of the drug. Similarly, N-Acetyl-p-Aminophenol is the chemical name for paracetamol (also known as acetaminophen). This name describes the chemical structure of paracetamol. Because of its complexity, the chemical name is primarily used in scientific and research contexts rather than in clinical practice.

### Nonproprietary Name

The nonproprietary name, commonly referred to as the generic name, is a standard name assigned to a drug by a competent scientific body or authority. For example, the United States adopted names (USAN) Council in the US is responsible for assigning these name. It is uniform throughout the world and denotes the active pharmaceutical ingredient. The generic name is used internationally and is consistent across different countries and manufacturers.

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This uniformity helps in maintaining clarity and reducing confusion in drug prescribing and administration. The generic name specifically refers to the active pharmaceutical ingredient (API) in the drug, distinguishing it from other drugs with different active components. Ideally generic name should be used in prescriptions because it is generally uniform all over the world than the branded counterparts. Using the generic name helps in standardizing drug information and improves safety by ensuring that healthcare professionals and patients are discussing the same substance.

*Acetaminophen:* The generic name for the drug known by brand names like Tylenol.

*Ibuprofen:* The generic name for the drug marketed under brand names such as Advil and Motrin.

While chemical names provide detailed descriptions of a drug's molecular structure, they are too complex for routine use in prescriptions. Generic names offer a simpler, universally accepted way to identify drugs.

### Proprietary Name/Trade/Brand Name

It is the name given by the drug manufacturers. Brand names are designed to be catchy, short, easy to remember and often suggestive (e.g., Lopresor suggesting drug for lowering BP) one drug may have multiple brand names. It may have different names within a country and in different countries Brand names can also be used in prescriptions, e.g., disprin is a brand name of aspirin. Crocin is a brand name of paracetamol.

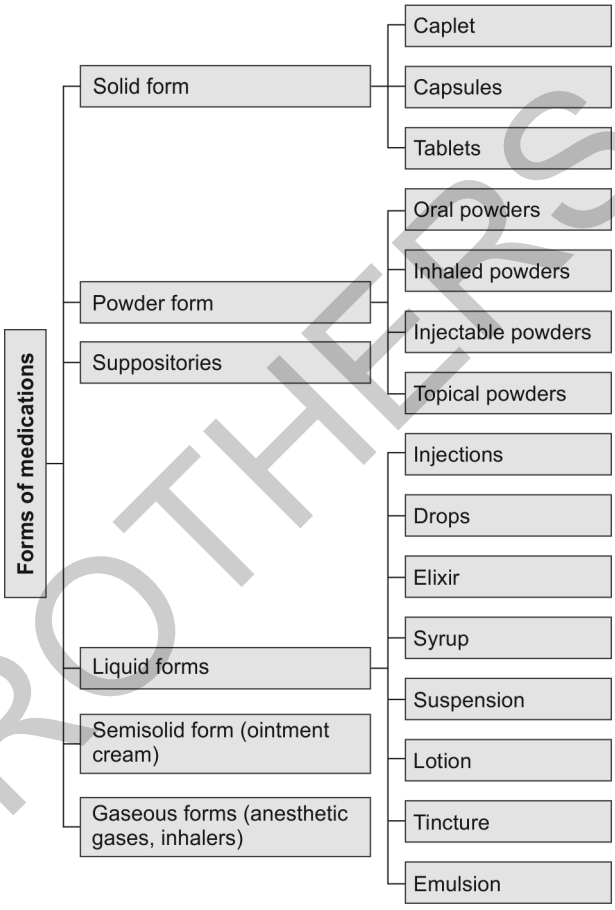


**Fig. 9.1:** Forms of medications.

## FORMS OF MEDICATIONS

Described in **Figure 9.1**.

### Solid Form

#### *Caplet*

Caplets are smooth-coated tablets that are shaped like capsules. Caplets are an easier-to-swallow alternative to traditional tablets. But they are absorbed in the body similarly to tablets. Common caplet examples—the pain reliever naproxen (Aleve) and diarrhea medication bismuth subsalicylate (Pepto-Bismol).

#### *Capsules*

This solid form contains the medicine in a soft or hard gelatin shell. The shell breaks down in the digestive tract and releases the active substance.

Advantages include a possibly palatable taste for some and relatively fast action. Disadvantages of a capsule are that it is more expensive to manufacture, less stable with unfavorable storage conditions, and has a shorter shelf life. These products may contain animal products.

Medication encased in a gelatin shell.

#### *Tablets*

This solid dosage form is the most common form of oral medication. The active pharmaceutical ingredient is bound into a solid form (pill) with one or more inactive substances. Tablets or pills are available in different shapes and sizes. There are different types of oral tablets, such as:

*Enteric coated tablets*

These are coated with special polymers that prevent them from dissolving in stomach acid and allow them to be absorbed in the small intestine. Examples include certain antibiotics and proton pump inhibitors to treat gastroesophageal reflux disease.

*Sublingual tablets*

A sublingual tablet is placed under the tongue, where it dissolves and is absorbed into the blood via the oral mucosa.

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Examples include sublingual nitroglycerine used to treat angina chest pain.

*Chewable tablets*

This form of medicine is chewed and then swallowed. It is often considered the best form of oral medication for children and elderly people. Advantages of chewable tablets include:

- **Orally disintegrating tablets:** These pills dissolve on the tongue, become liquified, are swallowed subconsciously, and then the tiny pieces of the drug travel to the stomach and intestines, where the absorption occurs. Pros of this method of administering medication include ease of use and quick onset of action. Cons are that they may be more expensive and not as stable as other solid dosage forms.
- **Effervescent tablets:** These are dissolved in water and then drunk. Pros are ease of use, better absorption, and a reasonably quick action onset. Cons: they are relatively more expensive, depending on the type of drug. You should pay attention to what type of liquid this tablet can be dissolved in, as water and juice are acceptable depending on the type of medication.
- **Lozenges:** Also called troches, pastilles, or cough drops, lozenges are medicated tablets that dissolve slowly in the mouth and lubricate or soothe irritated tissues in patients with sore throats. They offer local pain relief and ease of use for children and adults who have difficulty swallowing pills.

## Powder Form

A powder form of medication refers to a pharmaceutical product that has been processed into a fine, dry powder rather than a liquid or solid form like tablets or capsules. These powders typically require reconstitution (mixing with a liquid) before they can be consumed or applied, but some are designed to be used directly. Powders are mixtures of active drug and excipients that usually are sold in the form of powder papers

- **Oral powders:** These are often mixed with water or other liquids before consumption. Examples include antibiotics like amoxicillin and antacids like calcium carbonate. This form allows for easy administration, particularly for individuals who have difficulty swallowing pills or who need a specific dose that is more easily measured in powder form. In the form of electrolyte replenishment oral powders designed to help rehydrate and restore electrolyte balance in the body, particularly useful during dehydration or in conditions like diarrhea.
- **Inhaled powders:** These are used in the treatment of respiratory conditions like asthma or chronic obstructive pulmonary disease (COPD). Medications like inhaled corticosteroids or bronchodilators are often delivered in powder form using specialized inhalers (e.g., Advair, Symbicort).
- **Injectable powders:** Some medications, especially those for more severe conditions, come in a powdered form that is reconstituted with a specific liquid before being injected. This includes many biologics, vaccines, and certain antibiotics (e.g., vancomycin, erythromycin).
- **Topical powders:** These are applied directly to the skin and can be used for conditions like fungal infections or to absorb moisture. Examples include antifungal powders (Candid) or talcum powder.

## Suppositories

Suppositories are solid, medication-filled forms that are intended to be inserted into the body through specific openings, most commonly the rectum, vagina, or urethra. Once inserted, the suppository melts, dissolves, or is absorbed into the body to deliver medication locally or systemically. The active part of the medicine is combined with another substance and pressed into a 'bullet shape' so it can be inserted into the bottom. Suppositories must not be swallowed.

The action of suppositories depends on the type of medication and the location of the suppository.

- **Local effect:** Some medications are designed to act locally at the site of insertion. For instance, a rectal suppository with an anti-inflammatory drug can treat hemorrhoids or inflammation in the intestines.
- **Systemic effect:** Other medications are absorbed into the bloodstream from the rectum, vagina, or urethra, providing a systemic effect. This is often used when oral medication is not effective or suitable, such as for nausea, seizures, or when a patient cannot take medications orally.

### *Advantages of Suppositories*

- **Bypass the digestive system:** Suppositories can be useful when oral administration is not possible due to nausea, vomiting, difficulty swallowing, or digestive issues (like when a person is unconscious).
- **Faster absorption:** The medications in suppositories are absorbed directly into the bloodstream via the mucous membranes, potentially allowing for faster effects than oral medications, which have to go through the digestive system first.

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- **Targeted treatment:** Suppositories can provide targeted therapy for localized conditions (e.g., rectal suppositories for hemorrhoids or vaginal suppositories for infections).
- **Reduced side effects:** Since suppositories are absorbed directly, they may have fewer gastrointestinal side effects compared to oral medications.

***Common Medications in Suppository Form***

- **Pain and fever relievers:** Acetaminophen (Tylenol) or ibuprofen for fever or pain.
- **Laxatives:** Glycerin, bisacodyl (Dulcolax).
- **Anti-nausea drugs:** Prochlorperazine or ondansetron.
- **Hormonal therapy:** Progesterone or estrogen.
- **Antifungal treatments:** Miconazole, clotrimazole (for vaginal yeast infections).
- **Erectile dysfunction treatments:** Alprostadil.

### Liquid Form

- **Injections:** There are different types of injection, in how and where they are injected. Subcutaneous or SC injections are given just under the surface of the skin. Intramuscular or IM injections are given into a muscle. Intrathecal injections are given into the fluid around the spinal cord. Intravenous or IV injections are given into a vein. Some injections can be given at home but most are given at your doctor's surgery or in hospital.
- **Drops:** These are often used where the active part of the medicine works best if it reaches the affected area directly. These drugs are used for instillation in eyes, ears, nose.
- **Elixir:** Clear fluid containing water and alcohol, usually has sweetener for easy swallowing. Typically, alcohol and water are used as solvents when the drug will not dissolve in water alone. In addition to active drug, they usually contain flavoring and coloring agents to improve patient acceptance.
- **Syrup:** Drug dissolved in concentrated sugar solution. Medicinal syrup is a nearly saturated aqueous solution in which the medicinal substance or drug is dissolved.
- **Suspension:** A pharmaceutical suspension is a heterogeneous system in which finely divided solid particles are dispersed in a liquid medium.
- **Lotion:** Drug in liquid suspension used externally onto the skin.
- **Tincture:** Water or alcohol drug solution. Tinctures are medicinal formulations in the form of alcoholic and aqueous/alcoholic extracts of medicinal plant materials (1:5 or 1:10) produced without heating or removal of the extractant.
- **Emulsion:** Mixture of two liquids uniformly dispersed throughout each other.

### Semisolid Form

- **Ointment:** Preparation made for external use usually containing one or more drugs.
- **Paste:** Thick and stiff preparation absorbed through skin more slowly than ointment.
- **Cream:** A nongreasy semisolid preparation used onto the skin.

They come in tubs, bottles or tubes depending on the type of medicine. The active part of the medicine is mixed with another substance, making it easy to apply to the skin.

### Gaseous Forms

Medical gases are pharmaceutical gaseous molecules which offer solutions to medical needs. Anesthetic gases (nitrous oxide, halothane, isoflurane, desflurane, sevoflurane), also known as inhaled anesthetics, are administered as primary therapy for preoperative sedation.

***Inhalers***

The active part of the medicine is released under pressure directly into the lungs. Young children may need to use a 'spacer' device to take the medicine properly.

## CLASSIFICATION OF MEDICATION BASED ON ACTION

Medication with similar characteristics are grouped into classification. It indicates effect of medication on body system, the symptoms it relieves and desired effects, e.g., oral hypoglycemic, analgesics, antibiotics and antipyretics.

- **Analgesics:** Drug used to relieve pain.
- **Anesthesia:** A drug which causes loss of sensation, e.g., ketamine, propofol.
- **Anthelmintics:** Drug which expels and destroys the worms.
- **Antipyretics:** Drug used to reduce fever.
- **Anti-infective:** Drugs used to inhibit or kill or retard growth of microorganism.
- **Antidotes:** Substance used to counteract the effect of toxin/poison.
- **Anti-inflammatory:** Drugs helps to reduce inflammation.
- **Anticoagulants:** Drugs which inhibits or decrease blood clotting process.
- **Antipruritic:** Drugs which relieve itching.
- **Antifungal:** Medications used to treat and prevent fungal infections.

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- **Antispasmodics:** Relieve spasmodic pain of muscles.
- **Antiemetics:** Relieve nausea and vomiting.
- **Antitubercular:** Used for treatment of tuberculosis.
- **Antirheumatic:** Used for treatment of rheumatoid arthritis.
- **Anticonvulsants:** These drugs are used to control convulsion.
- **Antidepressants:** These drugs are used to treat depression
- **Antidiarrheals:** These drugs are used to control diarrhea.
- **Antihistamines:** These drugs are used to compete with histamine for its receptor site and to overcome allergic conditions.
- **Antineoplastics:** These drugs are used to interfere with o reproduction or replication at some point in cell cycle reduce the production of tumor cells. Medications used to treat cancer.
- **Antiparasitic:** Used to treat parasitic infections by either killing the parasites or inhibiting their growth and reproduction.
- **Antipyretics:** These drugs are used to relieve or reduce fever.
- **Antianxiety:** These drugs are used to treat anxiety disorders.
- **Antiemetics:** These drugs are used to control vomiting.
- **Anticoagulants:** These drugs are used to prevent blood clot
- **Antacids:** These drugs are used to reduce gastric acidity
- **Astringent:** Cause muscular contraction and shrinks or constricts body tissues.
- **Bronchodilator:** Relax muscles of bronchus.
- **Coagulants:** Used for clotting of blood.
- **Carminatives:** Used for expulsion of gas from stomach intestine. Examples include Ajowan and Ginger.
- **Cathartics:** Causes intestinal evacuation. It induce a more rapid and complete evacuation of the bowel, potentially leading to watery, unformed stools.
- **Laxative:** Laxatives generally ease the passage of stool, often by softening it.
- **Purgative:** Purgatives are a type of laxative that are considered moderate in their effect, meaning their action is less potent than a cathartic and more moderate than a simple laxative.
- **Hydra gouge:** Induces a watery evacuation of the bowels. It is a type of cathartic or purgative that promotes the discharge of watery stools.
- **Corticosteroid:** Hormonal drug extracted from adrenal cortex.
- **Glucocorticoids:** Stimulates the conversion of glucose from protein.
- **Mineralocorticoids:** Which regulates the sodium and mineral metabolism.
- **Androgens:** To develop secondary male characteristics.
- **Diaphoretics:** Increase action of sweat gland.
- **Diuretics:** Increase flow of urine.
- **Digestant:** Drug which promotes digestion.
- **Emetics:** A medicine or other substance which causes vomiting.
- **Oxytocics:** Stimulates uterine contraction, e.g., syntocinon.
- **Expectorants:** Aid expulsion of bronchial secretion, e.g., mucinex.
- **Emollients:** Substance that smoothens, soften and protects the skin.
- **Galactagogue:** A substance that helps to increase breast milk production.
- **Hypnotics:** Drugs that induces sleep.
- **Hemostatics:** Refer to agents or processes that arrest or slow down bleeding.
- **Hypotensive:** Lower blood pressure.
- **Hematinics:** Increase hemoglobin level.
- **Hypoglycemic:** Lower blood sugar level.
- **Inotropes:** Increase cardiac muscle contractility.
- **Keratolytic:** Soften horny layer of skin and helps in removal, e.g., Salicylic acid.
- **Mydriatics:** Dilates pupil, e.g., cyclopentolate, phenylephrine.
- **Myotics:** Constricts pupil, e.g., pilocarpine
- **Nasal decongestants:** Causes shrinkage of inflamed nasal mucosa, e.g., oxymetazoline, ephedrine.
- **Narcotics:** Produce complete insensibility, e.g., Morphine.
- **Sedatives:** Slow down brain activity, leading to relaxation, reduced anxiety.
- **Stimulants:** A substance that raises levels of physiological or nervous activity in the body.
- **Tranquilizer:** Calm down the nervous system, e.g., Chlordiazepoxide, Diazepam
- **Vasodilators:** Dilates blood vessels. Nitroglycerine, SNP.
- **Vasoconstrictor:** Constricts blood vessels, e.g., Epinephrine, vasopressin.
- **Cholagogues:** These drugs are used to increase the excretion of bile.

### Purpose of Drug Administration

The purposes of drug administration can be classified into prophylactic, therapeutic, and diagnostic categories, each serving specific functions in medical care shown in **Figure 9.2**.

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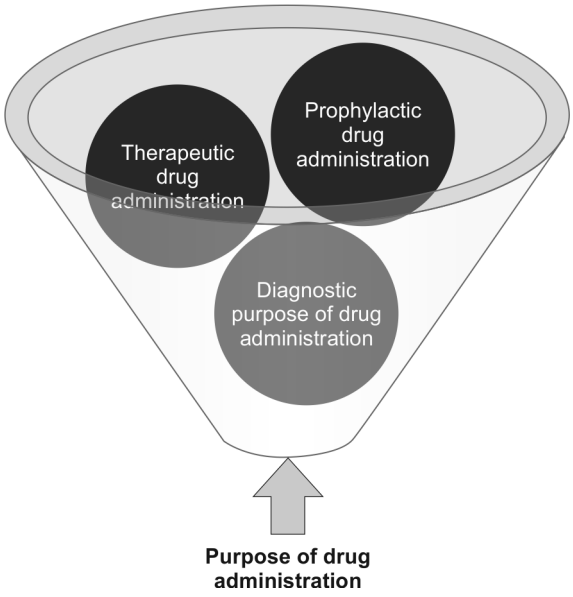


**Fig. 9.2:** Purpose of drug administration.

### *Prophylactic Drug Administration*

- **Preventing disease:** Administering vaccines to prevent infectious diseases (e.g., influenza or measles vaccines) or giving medications to reduce the risk of specific conditions (e.g., antimalarials for travelers to endemic areas).
- **Reducing risk of complications:** Providing medications to prevent complications in at-risk individuals, such as anticoagulants to prevent blood clots in patients undergoing surgery or with a history of thrombosis.
- **Preventing disease recurrence:** Using medications to prevent the recurrence of chronic diseases or conditions, such as prophylactic antibiotics to prevent infections in patients with compromised immune systems or those undergoing certain medical treatments. Prophylactic antibiotics, for instance, cefazolin might be administered prior to a surgical procedure to reduce the risk of surgical site infections.

### *Therapeutic Drug Administration*

Therapeutic drug administration focuses on treating existing conditions and managing symptoms.

- **Treating active disease:** Administering medications to cure or alleviate symptoms of active diseases or conditions, such as antibiotics for bacterial infections or antihypertensives for managing high blood pressure.
- **Managing chronic conditions:** Providing ongoing treatment to control chronic conditions, like insulin for diabetes, to stabilize the condition and prevent deterioration.
- **Relieving symptoms:** Using medications to manage and alleviate symptoms associated with various conditions, such as analgesics for pain relief or antipyretics for fever reduction.
- **Supporting recovery:** Administering drugs to aid in the recovery process after illness, injury, or surgery, such as anti-inflammatory medications to reduce inflammation and promote healing.
- **Modulating physiological functions:** Using drugs to correct physiological imbalances or deficiencies, such as hormone replacement therapy for thyroid or adrenal insufficiency.

### *Diagnostic Purpose of Drug Administration*

These drugs aid in the diagnosis of medical conditions or facilitate diagnostic procedures. Some of the examples are:

- **Contrast agents:** Used in imaging studies to enhance the visibility of structures or fluids. For instance, iodine-based contrast media is used in CT scans to better visualize blood vessels and organs.
- **Radioactive tracers:** Administered for imaging procedures such as PET scans (positron emission tomography) where radioactive glucose is used to assess metabolic activity and detect cancer.
- **Functional tests:** Medications like dexamethasone are used in tests to diagnose conditions like Cushing's syndrome by assessing adrenal function.
- **Diagnostic breath tests:** Medications or substances, such as lactulose, are used in breath tests to diagnose conditions like small intestinal bacterial overgrowth (SIBO) or lactose intolerance.

## Types of Medication Action/Effects of Medications

Medication action refers to how a drug produces its effects within the body. Understanding various types of medication actions helps in selecting the right therapy, anticipating interactions, and managing side effects effectively shown in **Figure 9.3**.

### *Therapeutic Action*

This is the desired, intended effect of a medication. The therapeutic action of a drug is to treat or cure a disease and relief of distressing symptoms. It is the reason the medication is prescribed, such as pain relief from an analgesic or blood sugar control from an antidiabetic drug. Similarly, nitroglycerin to reduce chest pain. One drug may have multiple action. Nurse must know the intended action of a drug, so that can evaluate the effectiveness of a drug.

### *Side Effect*

These are unintended effects that occur alongside the therapeutic effect. They can be minor and not harmful, like

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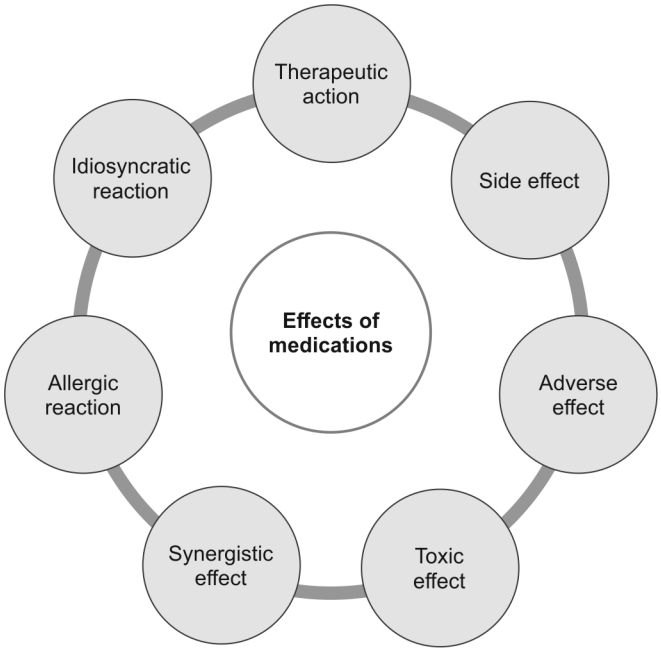


**Fig. 9.3:** Effects of medications.

dry mouth from antihistamines, or more bothersome but not life-threatening. Side effects are generally predictable based on the medication's action and often unavoidable secondary effect produced at a usual therapeutic dose. Most common side effects are anorexia, vomiting, constipation, diarrhea. Sometimes side effects make discontinuation of medications.

### *Adverse Effect*

An adverse effect is a harmful or unintended response to a medication that occurs at normal doses used for treatment. It is more serious than a side effect and can lead to significant health problems. For example, liver damage from high doses of acetaminophen. It is the undesired, unintended and often unpredicted response to medication.

The risk people are women, elderly (60-year-old or more), very young (1–4 year), patients taking more than one drug.

### *Toxic Effect*

This occurs when a medication is taken in doses that are too high, either accidentally or intentionally, leading to harmful effects. It also develop after prolong use of medication or when medication accumulated in blood because of impaired metabolism or excretion. This toxicity sometime requires antidote, e.g., morphine causes severe respiratory depression. Toxicity can result in severe damage to organs or systems, like kidney failure from an overdose of certain antibiotics.

### *Synergistic Effect*

Synergistic effect occurs when a combination of medications is given. In synergistic effect, the combined effect of two or more drugs is different from the effect of each drug when taken alone. The combined effect may be less than what would be expected or greater than the effect of each drug. Synergism may be a desired therapeutic effect or an undesirable complication, e.g., alcohol and barbiturates are potentially lethal; Phenytoin (Dilantin) has an inhibitory effect upon digitalis.

### *Idiosyncratic Reaction*

This is an unusual or unexpected reaction to a medication that occurs in a small number of people, often due to genetic differences. For instance, some individuals might have an unexpected severe reaction to a medication that most people tolerate well. In this type of reaction patient may overreact or underreact to a medication or a reaction different from what is expected, e.g., a child receiving Benadryl becomes agitated instead of drowsy.

### *Allergic Reaction*

This is an immune system response to a medication that the body mistakenly identifies as a harmful substance. It can range from mild symptoms like rash and itching to severe reactions like anaphylaxis, which is a medical emergency. These patients are immunologically sensitized to a medication after taking the first dose. Allergic response occurs to medications, its preservatives or metabolites which act as an antigen and that triggers for antibody formation.

### Different Types of Side Effects/Reactions of Drugs

- **Anaphylaxis:** This is an immediate and severe reaction marked by a decreased blood pressure, local oedema, prickling feeling in the throat, oedema of the face and hands, cyanosis, choking cough, dyspnea and wheezing due to accumulated fluids and oedema in the respiratory tissues. This is an emergency. Unless acted quickly death may follow within few minutes. Sera and Penicillin, etc., should be administered only after a sensitivity test has been done to prevent such reactions.
- **Skin rashes (urticaria):** Edematous pinkish elevations with itching may occur due to the reaction of a drug. Rash is usually generalized over the body.
- **Pruritus:** Itching of the skin with or without a rash.
- **Angioedema:** Edema due to increased permeability of the blood capillaries.

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- **Rhinitis:** Excessive watery discharge from the nose.
- **Lacrimal tearing:** Excessive tears from the eyes.
- **Nausea and vomiting:** Due to stimulation of the centers in the brain.
- **Diarrhea:** Irritation of the mucosa of the intestines.
- **Shortness of breath and wheezing:** Due to laryngeal edema.
- **Atropine like side effects:** Certain drugs cause dryness of the mouth and nose, flushing and dryness of the skin, tachycardia, urinary retention and blurring of vision. The patient may need to be reassured that the effects will disappear when the drug is withdrawn. Patients after taking drugs, producing these side effects should not operate dangerous machinery.
- **Liver damage:** This is characterized by jaundice especially in the sclera of the eyes, hemorrhages under the skin, dark urine and pruritus. Since many drugs are detoxicated by the liver and may become harmful, if liver damages are present for any reason.

### *Side Effects/Reactions of Drugs on the Cardiovascular System*

- **Arrhythmias:** Any change in the rate, rhythm, volume or character of the pulse. Counting pulse for one minute will reveal such irregularities.
- **Hypotension:** It is characterized by decrease in blood pressure, dizziness, syncope and shock. Cheak BP before and after the administration of drug is indicated. The patient should be warned about post hypotension.
- **Hypertension:** This is characterized by elevated blood pressure epistaxis, emotional irritability, headache and dizziness.

### *Side Effects/Reactions on the Blood Dyscrasias*

Drug-induced blood dyscrasias are adverse reactions that can affect any component of the blood, including red blood cells, white blood cells, and platelets. These reactions can manifest as various conditions such as anemia, leukopenia, thrombocytopenia, and agranulocytosis, among others.

- **Anemia:** This involves a reduction in red blood cells, leading to fatigue, shortness of breath, and pale skin. Drugs can cause anemia through various mechanisms, including interfering with red blood cell production in the bone marrow or inducing red blood cell destruction.
- **Leukopenia:** A decrease in white blood cells, particularly neutrophils, can increase the risk of infections. Certain drugs like carbamazepine and clozapine have been linked to drug-induced leukopenia.
- **Thrombocytopenia:** This refers to a low platelet count, which can lead to increased bleeding and bruising. Medications like heparin and certain antibiotics are known to cause thrombocytopenia.
- **Agranulocytosis:** A severe form of leukopenia affecting granulocytes (a type of white blood cell), agranulocytosis can result in life-threatening infections.
- **Aplastic anemia:** This condition involves the bone marrow's failure to produce sufficient blood cells, leading to pancytopenia (deficiency of all blood cell types).
- **Drug reaction with eosinophilia and systemic symptoms (DRESS):** This is a severe hypersensitivity reaction characterized by skin rash, fever, organ involvement, and blood abnormalities including eosinophilia and atypical lymphocytosis.

### *Side Effects/Reactions on the Nervous System*

- **Abnormal involuntary movements:** Tremor, chores dystonia, alterations in the muscle tone, difficulty in pre serving equilibrium in erect and sitting positions.
- **Stimulations of the central nervous system:** These are characterized by anxiety, nervousness, insomnia, headache, double vision, etc. Stimulation of the nervous system may precipitate convulsions if the patient has the history of epilepsy.
- **Depression of the central nervous system:** It is characterized by dizziness, vertigo, drowsiness, fatigue and ataxia. Restriction of ambulation and use of bed rails may be necessary. The persons taking such medications should not operate car or machinery.

### *Side Effects/Reactions on the Gastrointestinal System*

- **Irritation of the gastric mucosa:** This is characterized by nausea, vomiting, anorexia. This can be prevented to some extent by not giving the drug in an empty stomach. Give the drug with or after the meals or it should be given along with one glass of milk or an antiacid. These drugs are contraindicated if the patient has a history of peptic ulcer.
- **Small bowel ulceration:** It is characterized by abdominal pain, melena, distension and diarrhea.
- **Constipation.**

### *Side Effects/Reactions on the Urinary System*

Certain drugs may cause renal damage which is characterized by anuria, oliguria, hematuria, crystalluria, albuminuria, etc. Accurate, recording and intelligent observation of the intake and output is indicated. Frequent urine analysis and blood chemistry studies can prevent such occurrences. Patients should be asked to take plenty of fluids to prevent stone formations.

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## PHARMACOKINETICS

Pharmacokinetics (PK) is derived from Greek word pharmakon "drug" and kinetikos "moving, putting in motion". This is a branch of pharmacology dedicated to determining the fate of drug administered to a living organism (the moment that it is administered up to the point at which it is completely eliminated from the body).

Pharmacokinetics is the branch of pharmacology that focuses on the study of the absorption, distribution, metabolism, and excretion (ADME) of drugs within the body shown in **Figure 9.4**. It describes the journey of a drug from its administration to its eventual elimination, and how the body affects the drug over time. Understanding pharmacokinetics is essential for determining the appropriate dosages, frequency of administration, and potential side effects of medications. Clinical pharmacokinetics is the application of pharmacokinetic principles to the safe and effective therapeutic management of drugs in an individual patient. Primary goals of clinical pharmacokinetics include enhancing efficacy and decreasing toxicity of a patient's drug therapy. The development of strong correlations between drug concentrations and their pharmacologic responses has enabled clinicians to apply pharmacokinetic principles to actual patient situations.

### Absorption

Drug absorption refers to the way a drug is absorbed from a pharmaceutical formulation into the bloodstream. It is the process by which a drug enters the bloodstream after it has been administered. The rate and extent of absorption depend on the drug's form (e.g., oral, intravenous, topical), its solubility, and its ability to pass through biological membranes. Several factors can affect the absorption of a drug into the body. These include:

- **Route of administration:** Oral drugs need to pass through the gastrointestinal (GI) tract, whereas intravenous (IV) drugs are directly introduced into the bloodstream, bypassing absorption.
- **Drug formulation:** Solid forms like tablets may be slower to absorb than liquid forms.
- **pH and ionization:** The ionization of a drug can affect its ability to be absorbed. Drugs that are ionized are generally less able to pass through cell membranes.
- **Blood flow and surface area:** Areas with rich blood flow (e.g., the small intestine) and large surface areas (e.g., lung alveoli) tend to absorb drugs more efficiently.
- Physicochemical properties (e.g., solubility) and the rate of gastric emptying.

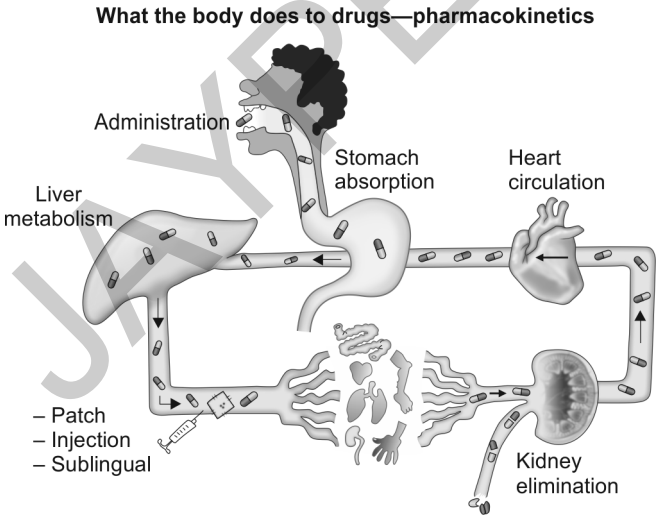


**Fig. 9.4:** Absorption, distribution, metabolism, and excretion of drugs.

### Distribution

The distribution of drugs refers to the process by which a drug moves from the bloodstream into various tissues and organs of the body after it has been absorbed. This process is crucial because it determines where and how much of the drug reaches its target site(s), where it can exert its therapeutic effects or cause side effects. The rate and extent of distribution are influenced by several factors, including the drug's chemical properties, the physiological conditions of the body, and the characteristics of the tissues and organs involved.

#### *Factors Affecting Distribution*

*Blood flow*

- **Organs with high blood flow:** Drugs are delivered more quickly to organs with high blood flow, such as the liver, kidneys, brain, and heart. These organs receive a significant portion of the cardiac output, so drugs distributed to these areas are generally absorbed faster.
- **Organs with low blood flow:** Drugs are distributed more slowly to tissues like fat and muscle, which have lower blood flow. As a result, it may take longer for the drug to reach these areas in effective concentrations.

*Plasma protein binding*

Many drugs bind to plasma proteins like albumin in the blood. Only the unbound (free) drug is pharmacologically active and capable of crossing cell membranes to reach its target tissues. Drugs that are highly protein-bound may have a reduced effect in tissues until they are released from the proteins.

For example, warfarin is highly bound to albumin in the bloodstream, and only the unbound fraction is available to exert its anticoagulant effect.

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*Lipophilicity vs hydrophilicity*

Lipophilic (fat-soluble) drugs tend to accumulate in fatty tissues, as they can easily cross lipid membranes. These drugs are often distributed widely throughout the body and can cross the blood-brain barrier, making them effective for central nervous system (CNS) treatments.

Hydrophilic (water-soluble) drugs are more likely to stay in the extracellular fluid or blood plasma, as they have difficulty crossing lipid membranes. These drugs are generally more concentrated in organs like the kidneys or liver, which have a high-water content.

*Molecular size*

Smaller molecules are generally distributed more easily across biological membranes, while larger molecules (like protein-based drugs or biologics) may have difficulty penetrating tissues and are often confined to the blood-stream or extracellular fluid.

For example, insulin is a peptide hormone that remains largely in the extracellular space and does not easily cross cell membranes.

*Tissue permeability*

The ability of a drug to pass through cell membranes or capillaries depends on the permeability of the tissues or organs involved. Some tissues, such as the brain and placenta, have protective barriers (e.g., the blood-brain barrier and placental barrier) that limit drug distribution.

- **Blood-brain barrier:** This selectively prevents certain drugs from entering the central nervous system. Lipophilic drugs or those that actively cross the blood-brain barrier are more likely to exert effects on the brain.
- **Placental barrier:** Many drugs can pass through the placenta and potentially affect the developing fetus. Pregnant women need careful consideration when taking medications due to potential risks to fetal development.

*pH and ionization*

The ionization state of a drug influences its ability to cross membranes. Drugs that are nonionized (neutral) can more easily cross cell membranes compared to ionized drugs. The pH of the environment plays a significant role in determining whether a drug is ionized or nonionized.

For instance, in the stomach (which is acidic), weak acidic drugs tend to remain nonionized and are better absorbed, whereas weak basic drugs may be ionized and less readily absorbed.

## Metabolism

Drug metabolism refers to the chemical modification of a drug by the body, primarily in the liver, but also in other tissues. This process is crucial for transforming drugs into forms that are easier for the body to eliminate. Metabolism generally results in the inactivation of the drug, although in some cases, it can convert a drug into an active form (a prodrug). The metabolic process is typically divided into two phases—phase I and phase II, which work together to modify and prepare drugs for excretion.

### *Phases of Metabolism*

In phase I, enzymes modify the drug molecule to introduce or expose functional groups (such as –OH, –NH2, –COOH). This phase involves a group of enzymes known as cytochrome P450 enzymes (CYP450). Phase I metabolism can have various outcomes:

- **Activation:** Some prodrugs are metabolized in Phase I to form active metabolites. For example, the prodrug codeine is metabolized to its active form, morphine, through phase I metabolism.
- **Inactivation:** Many drugs are made less active in phase I as they are converted to metabolites that are easier to excrete.
- **Drug interactions:** Certain drugs can inhibit or induce CYP450 enzymes, affecting the metabolism of other drugs that rely on these enzymes. For example, grapefruit juice inhibits CYP3A4, which can increase the concentration of drugs metabolized by this enzyme. Phase II (conjugation): Involves attaching a larger molecule (e.g., glucuronic acid, sulfate, or glycine) to make the drug more water-soluble, thus enhancing its elimination.

### *Factors Affecting Metabolism*

- **Genetic factors:** Variations in genes that code for metabolic enzymes (especially CYP450 enzymes) can lead to differences in how people metabolize drugs. For example, some individuals are "rapid metabolizers", while others are "slow metabolizers". This genetic variation can affect drug efficacy and the risk of side effects. Some individuals may lack the enzyme responsible for metabolizing a particular drug, leading to accumulation and toxicity.
- **Age:** Newborns and infants have immature liver enzyme systems, so they may metabolize drugs more slowly. Dosing adjustments are often needed.

  Older adults may have reduced liver function, leading to slower metabolism of certain drugs and an increased risk of drug toxicity.
- **Liver function:** Impaired liver function (e.g., due to cirrhosis or hepatitis) can slow down drug metabolism, causing drugs to accumulate in the body and increase the risk of adverse effects.

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- Hepatic enzyme induction (e.g., by certain drugs like phenytoin) can increase the rate of metabolism, reducing the effectiveness of other drugs.
- **Drug-drug interactions:** One drug can inhibit the metabolism of another drug by inhibiting the enzymes responsible for metabolizing it. For example, ketoconazole (an antifungal) inhibits CYP3A4 and can increase the concentration of drugs metabolized by this enzyme.

  Some drugs can induce enzymes (e.g., rifampin, which induces CYP3A4), speeding up the metabolism of other drugs and potentially reducing their therapeutic effects.
- **Diet and environmental factors:** Certain foods (e.g., grapefruit juice) can inhibit drug-metabolizing enzymes, particularly CYP3A4, while others (e.g., charbroiled meats) can induce these enzymes.
- **Smoking:** Smoking can increase the activity of certain drug-metabolizing enzymes, leading to faster clearance of some medications.

## Excretion of Drugs

Excretion of drugs refers to the process by which the body eliminates drugs and their metabolites, ultimately removing them from circulation. Excretion is a crucial phase in the pharmacokinetics of drugs because it ensures that drugs do not accumulate in the body to toxic levels, and that therapeutic effects are properly regulated. The primary organs involved in drug excretion are the kidneys, but other routes include feces, lungs, sweat, and saliva **(Fig. 9.5)**. The efficiency and manner in which a drug is excreted depend on various factors, including the drug's chemical properties and the excretory pathways involved.

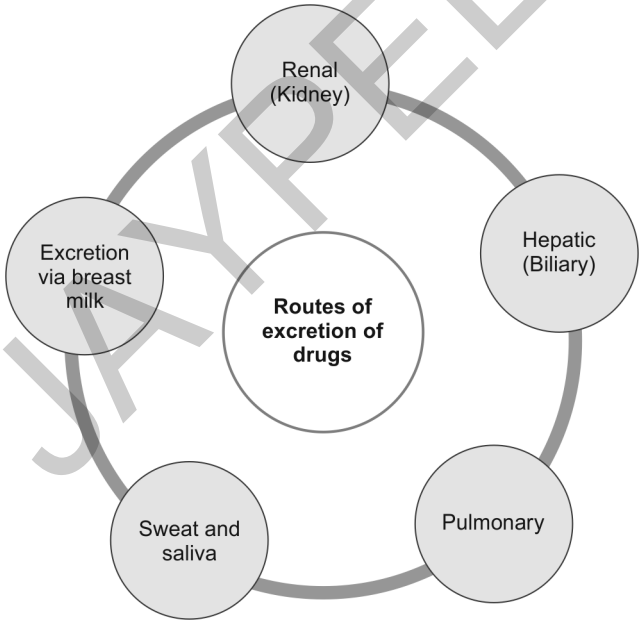


**Fig. 9.5:** Routes of excretion of drugs.

### *Main Routes of Drug Excretion*

*Renal (kidney) excretion*

Kidneys are the primary organs responsible for the excretion of drugs and their metabolites. Drugs are eliminated through the urine after being filtered by the kidneys.

- **Filtration:** The first step in renal excretion is the filtration of drugs from the blood into the renal tubules. The glomerulus filters the blood, allowing water-soluble (polar) drugs and metabolites to pass into the urine. Nonpolar drugs are usually reabsorbed in the tubules and are less likely to be excreted.
- **Secretion:** Some drugs are actively secreted from the blood into the renal tubules by transporters in the proximal tubule. This process allows the body to eliminate drugs that might not be efficiently filtered by the glomerulus.
- **Reabsorption:** After filtration, a portion of the drug may be reabsorbed from the renal tubules back into the blood, particularly if the drug is lipid-soluble. This process occurs mainly in the distal tubules of the kidney. The amount of drug reabsorbed depends on the drug's characteristics, such as its lipid solubility and ionization.
- **Excretion:** The final amount of drug excreted in the urine is determined by the balance between filtration, secretion, and reabsorption. Acidic drugs tend to be excreted more efficiently in an alkaline urine, while basic drugs are excreted more effectively in acidic urine.

*Hepatic (biliary) excretion*

The liver also plays a role in the excretion of some drugs through bile, which is then stored in the gallbladder or directly released into the small intestine. From there, the drug can be excreted in feces.

- **Biliary secretion:** After metabolism in the liver (often through Phase II conjugation reactions), drugs and their metabolites (such as glucuronides or sulfates) can be excreted into the bile. These conjugated metabolites are usually more water-soluble and thus more easily excreted through the bile.
- **Enterohepatic recirculation:** Some drugs that are excreted into the bile may undergo enteric reabsorption (known as enterohepatic recycling). This process involves the drug being reabsorbed from the intestines back into the bloodstream, which can prolong its effect. For example, bile acids and some antibiotics undergo enterohepatic recirculation.

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*Pulmonary excretion*

The lungs excrete gases and volatile substances, including inhaled anesthetics and alcohol (ethanol). Drugs that are volatile or gaseous are excreted primarily through the lungs in expired air. Ethanol is an example of a drug that is excreted through the lungs. Breathalyzer tests measure ethanol concentrations in the breath to estimate blood alcohol levels. General anesthetics like nitrous oxide are excreted via the lungs as well.

*Excretion through sweat and saliva*

Some drugs are excreted through the skin in sweat or through the salivary glands. These routes are less significant in drug elimination but can still contribute to drug clearance. Drugs excreted through the sweat glands are usually lipid-soluble compounds, although this is not a primary route of excretion. Drugs in the saliva can be swallowed or absorbed back into the bloodstream. In certain cases, salivary drug concentrations can be measured as a noninvasive means of drug monitoring.

*Excretion via breast milk*

Drugs can also be excreted into breast milk, especially lipophilic drugs. This is an important consideration for breastfeeding mothers, as drugs in the milk can affect the nursing infant. Many medications, including antibiotics and antidepressants, can pass into breast milk, which may lead to adverse effects in the infant.

### *Factors Affecting Drug Excretion*

Several factors influence the efficiency and rate of drug excretion, including:

*Renal function*

- **Kidney disease:** It can reduce the ability of the kidneys to excrete drugs, potentially leading to drug accumulation and toxicity. Drugs that rely heavily on renal excretion may require dose adjustments in patients with impaired renal function.
- **Age:** Newborns and the elderly often have reduced renal clearance, making them more susceptible to drug accumulation.

*Urine pH*

The pH of the urine can significantly influence the excretion of certain drugs. For example—acidic drugs (e.g., aspirin) are excreted more quickly in alkaline urine. Basic drugs (e.g., ammonium chloride) are excreted more effectively in acidic urine.

*Liver function*

If liver function is impaired (e.g., due to cirrhosis), the ability to metabolize and excrete drugs via the biliary route can be reduced.

*Drug interactions*

Some drugs may interfere with the excretion of other drugs, either by inhibiting renal transporters or by affecting bile secretion. For example, probenecid is used to inhibit renal secretion of penicillin, extending its half-life in the body.

*Body fat and lipophilicity*

Drugs that are highly lipophilic (fat-soluble) tend to accumulate in adipose tissue and may have a longer half-life because they are slowly released into the bloodstream over time. These drugs may have a prolonged elimination phase due to their storage in fat.

## PHARMACOKINETIC PARAMETERS

Pharmacokinetic parameters refer to the assessment of drug behavior in the body by monitoring drug and metabolite concentrations in easily accessible physiological fluids like plasma and urine. These parameters are key quantitative measures used to describe the absorption, distribution, metabolism, and excretion (ADME) of drugs in the body and help in understanding how a drug behaves in the body over time and are crucial for determining appropriate dosing regimens, drug efficacy, and safety. The main pharmacokinetic parameters include:

### Absorption-related Parameters

#### *Bioavailability (F)*

Bioavailability refers to the fraction of an administered drug that reaches the systemic circulation in its active form. For intravenous (IV) administration, bioavailability is 100% (F = 1), as the drug is directly injected into the bloodstream. For other routes (oral, sublingual, etc.), the bioavailability is less than 100% due to factors like incomplete absorption and first-pass metabolism in the liver.

$$F = \frac{\text{Amount of drug reaching systemic circulation}}{\text{Amount of drug administered}}$$

- **F = 1 (or 100%)** means that all of the drug administered reaches systemic circulation. This is typically the case with intravenous (IV) administration, as the drug bypasses the gastrointestinal system and liver metabolism.
- **F < 1** means that some of the drug is lost before it reaches the bloodstream, which happens with oral drugs due to factors like absorption inefficiency or first-pass metabolism in the liver.

**Example:**

If 100 mg of a drug is administered orally and only 50 mg reaches the systemic circulation (due to absorption

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limitations and first-pass metabolism), the bioavailability (F) would be:

$$F = \frac{50\ mg}{100\ mg} = 0.5$$

This means that only 50% of the drug administered orally reaches the bloodstream in an active form.

*Absorption rate (Ka)*

The absorption rate constant (Ka) refers to the rate at which a drug is absorbed from the site of administration into the bloodstream. It is commonly used to describe how quickly the drug reaches its peak concentration after administration.

*Time to peak concentration ($T_{max}$)*

"Time to peak concentration" ($T_{max}$) refers to the amount of time it takes for a drug or substance to reach its highest concentration in the bloodstream after administration. This is a crucial pharmacokinetic parameter, especially when evaluating the efficacy and safety of medications.

*Peak plasma concentration ($C_{max}$)*

The maximum concentration of a drug in blood plasma represents a drug's peak effect. $C_{max}$ is one of the primary pharmacokinetic measures for evaluating how the body acts upon a drug. $C_{max}$ is the highest concentration of a drug in the plasma after administration. It is useful for assessing how much of the drug reaches systemic circulation.

### Distribution-related Parameters

*Volume of distribution (Vd)*

The volume of distribution (*Vd*) is a pharmacokinetic parameter that quantifies the extent to which a drug disperses throughout the body's tissues. A large *Vd* indicates that a drug is widely distributed throughout the body's tissues, while a small *Vd* suggests it is confined to the bloodstream. It is defined as the theoretical volume in which the total amount of drug would need to be evenly distributed to result in the observed plasma concentration.

$$Vd = \frac{\text{Amount of drug in body}}{\text{Plasma drug concentration}}$$

Alternatively, it can also be written as:

$$Vd = \frac{\text{Plasma drug concentration}}{\text{Amount of drug in body}}$$

*Plasma protein binding*

Plasma protein binding (PPB) is the extent to which a drug attaches to proteins in the blood plasma. It is an important factor in drug distribution and can affect a drug's efficacy, metabolism, clearance, and elimination half-life. Many drugs bind to plasma proteins (such as albumin), and only the unbound (free) drug can exert a therapeutic effect or be excreted. Drugs that are highly protein-bound typically have a low *Vd*, as they remain largely in the bloodstream.

### Metabolism-related Parameters

*Half-life (t½)*

The half-life (t½) of a drug is the time required for the concentration of the drug in plasma to decrease by 50%. It provides information about the duration of action of a drug and how long it will take to be eliminated from the body. Drugs with longer half-lives require less frequent dosing, while drugs with shorter half-lives may need more frequent dosing. For drugs following first-order elimination (where the rate of elimination is proportional to the drug concentration), the half-life is given by the following equation:

$$t_{1/2} = \frac{0.693}{K_e}$$

where

$t_{1/2}$ is the half-life of the drug.

$k_e$ is the elimination rate constant, which represents the rate at which the drug is eliminated from the body.

*Elimination rate constant ($k_e$)*

The elimination rate constant ($k_e$) describes the rate at which a drug is eliminated from the body. It is related to the drug's half-life and clearance (Cl), and it helps to estimate how quickly the drug concentration decreases in the plasma.

### Excretion-related Parameters

*Clearance (Cl)*

Clearance refers to the volume of plasma from which a drug is completely removed per unit of time (usually in milliliters per minute or liters per hour). It is an important measure of how efficiently the body eliminates a drug and is influenced by processes such as renal excretion, hepatic metabolism, and biliary excretion.

Formula for clearance (Cl):

$$Cl = \frac{\text{Rate of elimination of drug}}{\text{Plasma drug concentration}}$$

*Renal clearance ($Cl_{renal}$)*

Renal clearance refers specifically to the rate at which a drug is cleared by the kidneys, and it depends on the drug's ability to be filtered, secreted, and reabsorbed by the kidneys. It is defined as the volume of plasma that is cleared of a drug by the kidneys per unit of time.

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$$Cl_{renal} = \frac{\text{Urinary excretion rate}}{\text{Plasma drug concentration}}$$

It represents the efficiency of the kidneys in eliminating a drug. Drugs that are eliminated primarily by the kidneys will have a high renal clearance.

*Hepatic Clearance ($Cl_{hepatic}$)*

Hepatic clearance refers to the rate at which the liver removes the drug from the bloodstream, typically via metabolism and biliary excretion. The liver plays a major role in the metabolism of many drugs, and hepatic clearance can be significantly reduced in cases of liver disease, affecting the overall clearance of the drug from the body.

## Pharmacokinetic Models

*One-compartment model*

In a one-compartment model, the body is treated as a single, uniform compartment. Drugs are assumed to distribute rapidly and evenly throughout the body. The drug follows first-order kinetics in this model, where a constant fraction of the drug is eliminated per unit time.

Key components of the one-compartment model:

- **Instantaneous distribution:** The drug is assumed to distribute instantly and evenly throughout the body after administration.
- **First-order kinetics:** The drug follows first-order kinetics, meaning the rate of drug elimination is directly proportional to the drug concentration in the body.
- **Homogeneity:** The body is treated as a single compartment, meaning that the drug concentration is the same throughout the entire body at any given time.
- **No active metabolites or accumulation:** The model assumes that the drug is eliminated without the formation of active metabolites or any significant accumulation.
- **Linear elimination:** The drug is eliminated at a constant fraction of its concentration over time (first-order elimination), so the rate of elimination decreases as the drug concentration decreases.

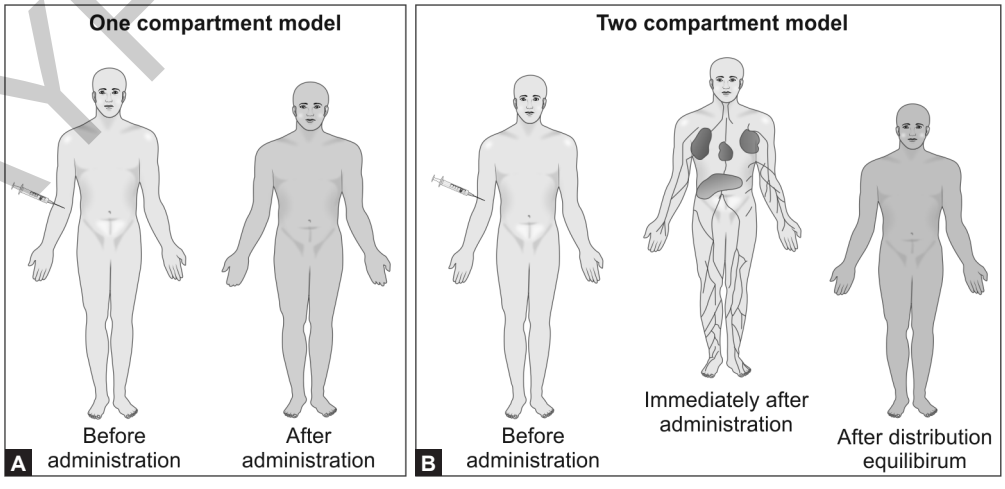
*Two-compartment model*

The two-compartment model accounts for a central compartment (blood and highly perfused tissues) and a peripheral compartment (less-perfused tissues). In this model, drugs are initially distributed rapidly to the central compartment before slowly redistributing to the peripheral compartment. This model is often used for drugs with complex distribution patterns. The two-compartment model is a more complex pharmacokinetic model used to describe the behavior of drugs that do not distribute instantly or uniformly throughout the body. It is often used for drugs that have distinct phases of distribution and elimination.

The model assumes the body consists of two compartments **(Figs. 9.6A and B):**

1. **Central compartment (C.):** This represents the blood and well-perfused organs such as the heart, liver, and kidneys. The central compartment is where the drug initially enters the bloodstream.
2. **Peripheral compartment (C.):** This includes less well-perfused tissues such as fat, muscle, and skin, where the drug may distribute after being absorbed into the central compartment.

After the drug is administered, it initially distributes rapidly into the central compartment. Over time, the drug slowly moves from the central compartment into the peripheral compartment. This is known as the distribution




**Figs. 9.6A and B:** Distribution of drugs in one-compartment and two-compartment model.

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phase. Once the drug has distributed throughout the body, it starts to be eliminated. This elimination occurs through the central compartment, as drugs are primarily cleared by organs like the liver and kidneys.

## PHARMACODYNAMICS

Pharmacodynamics refers to the relationship between drug concentration at the site of action and the resulting effect, including the time course and intensity of therapeutic and adverse effects. In simpler terms, it explains how a drug works to produce its therapeutic effects and how the body responds to it. The effect of a drug present at the site of action is determined by that drug's binding with a receptor. Receptors may be present on neurons in the central nervous system (i.e., opiate receptors) to depress pain sensation, on cardiac muscle to affect the intensity of contraction, or even within bacteria to disrupt maintenance of the bacterial cell wall. For most drugs, the concentration at the site of the receptor determines the intensity of a drug's effect. However, other factors affect drug response as well. Density of receptors on the cell surface, the mechanism by which a signal is transmitted into the cell by second messengers (substances within the cell), or regulatory factors that control gene translation and protein production may influence drug effect. Pharmacodynamics is the branch of pharmacology that deals with the effects of drugs on the body and the mechanisms by which these effects occur **(Fig. 9.7)**.

Key components of pharmacodynamics include:

### Drug-receptor Interaction

Drug-receptor interaction is a fundamental concept in pharmacodynamics that explains how a drug exerts its effects on the body by interacting with specific receptors. A receptor is typically a protein molecule found on the surface of cells or within cells that binds to a drug (or endogenous substance like a neurotransmitter or hormone) to trigger a biological response. Most drugs exert their effects by binding to specific receptors on cells, tissues, or organs. These receptors can be proteins, enzymes, ion channels, or other molecules that mediate the drug's effect. The binding of a drug to its receptor can either activate or block the receptor, leading to a physiological response (e.g., increased heart rate, pain relief, etc.).

Drug-receptor interaction is a molecular process that occurs when a drug molecule binds to a specific receptor protein on a cell's surface. The interaction is highly specific, similar to a lock and key mechanism, where the drug fits into the receptor with precision. The result of this interaction can activate or inhibit the receptor's function, which can lead to a physiological effect.

Receptors are typically proteins or glycoproteins found on cell membranes, in the cytoplasm, or in the nucleus of cells. They are proteins that play a key role in transmitting signals within the body, such as those that regulate hormones, neurotransmission, and the immune response and drugs are designed to interact with specific receptors to produce a desired therapeutic effect. There is a process of ligand binding. Where a drug acts as a ligand, it binds to a receptor site on a target cell. The binding of a drug to its receptor is often compared to a "lock and key" mechanism: the drug (key) binds specifically to a receptor (lock) due to its molecular shape, size, and charge The binding of a drug to a receptor can be modelled mathematically and obeys the Law of Mass Action.

#### *Types of Drug-receptor Interactions*

- **Agonists:** A drug that binds to a receptor and activates it, producing a biological response. Agonists can be classified into:

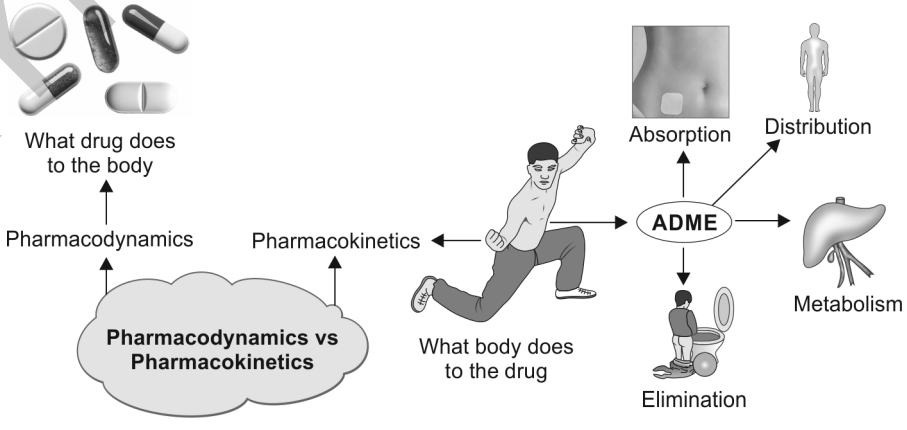


**Fig. 9.7:** Pharmacokinetic vs pharmacodynamics.

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### *Regular Audits*

Nurses may participate in or assist with regular audits of drug storage areas to ensure compliance with institutional policies, safety standards, and legal requirements. Audits help identify any potential problems (e.g., expired medications, improper storage, security concerns) and allow corrective action to be taken.

### *Controlled Drugs*

Drugs of addiction is supplied only against the signature of a ward in-charge of the ward. The requisition must have the name, form, strength and quantity of drug required, e.g., morphine, pethidine, etc. The nurse in-charge should have control on other drugs such as night sedatives, tranquillizers, antidepressants, etc., and should take due precautions while ordering those drugs.

## Chapter Summary

- The administration of medication is a critical component of patient care. It involves several key steps to ensure that the medication is given safely and effectively. There are several different ways drugs can be administered. Administration of medication requires thorough understanding the drug, including how it moves through the body, when it needs to be administered, possible side effects and dangerous reactions, proper storage, handling, and disposal.
- Drug nomenclature is the systematic naming of drugs, especially pharmaceutical drugs. There are different types of nomenclature for the drugs like chemical name nonproprietary name, proprietary name otherwise known as trade/brand name. The chemical name provides a precise description of a drug's chemical composition and molecular structure. The nonproprietary name, commonly referred to as the generic name, is a standard name assigned to a drug by a competent scientific body or authority, similarly trade name is given by the drug manufacturers.
- Drugs are also available in different forms. Solid forms (tablet, capsule), liquid form (drops, syrups, tonics, injections), semi-solid form (ointment, powder, suppositories, cream) and gaseous forms like anesthetic gases, different types of drugs in gashouse forms used by inhalation or volatile substances, etc. Medication with similar characteristics are grouped into classification. It indicates effect of medication on body system, the symptoms it relieves and desired effects.
- Pharmacokinetics (PK) is the branch of pharmacology that focuses on the study of the absorption, distribution, metabolism, and excretion (ADME) of drugs within the body. Pharmacodynamics refers to the relationship between drug concentration at the site of action and the resulting effect, including the time course and intensity of therapeutic and adverse effects. In simpler terms, it explains how a drug works to produce its therapeutic effects and how the body responds to it.
- The term prescription refers to a medication order on a prescription blank to be filled in an outpatient or ambulatory care setting often abbreviated ℞ or Rx. Prescriptions are often referred to as orders in clinical practice. There are several types of orders, such as routine orders, PRN orders, standing orders, one-time orders, STAT orders, and titration orders.
- The nurses need to know mathematics in order to administer the drugs safely by following ten rights. She should know how to prepare solutions of correct strength from the stock solutions. There are various routes for drug administration. A route of administration is the path by which a drug, fluid or other substance is brought into contact with the body. Every route has specific mode of action and absorption capabilities. The purposes of drug administration can be classified into prophylactic, therapeutic, and diagnostic categories, each serving specific functions in medical care.
- A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Storing medicines properly can help to ensure the nurse that medicines are working properly as well as prevent poisoning accidents of medications. Controlled drugs must be stored in a double locked container.
- Nurses play a crucial role in the storage and maintenance of drugs to ensure that medications are stored properly, remain effective, and are administered safely. Proper handling, storage, and maintenance of drugs are essential to ensure patient safety, maintain drug efficacy, and comply with legal and institutional regulations.

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## Multiple Choice Questions

1. **While administering cleansing enema the height of enema can need to be raised to a height of _____ to allow the solution to flow in by gravity**
   a. 20–25 cm b. 50–60 cm
   c. 30–45 cm d. 15–20 cm

2. **The maximum amount of medicine can be injected into gluteus muscle is:**
   a. Up to 3 mL b. Up to 5 mL
   c. Up to 7 mL d. Up to 10 mL

3. **The most common site for intradermal injections is:**
   a. Inner aspect of lower arm
   b. Inner aspect of upper arm
   c. Between scapula
   d. Upper chest

4 **Which of the following best describes a Z-track injection?**
   a. A method of injection that allows a relatively slow uptake of the drug
   b. A method of injecting medication into a large muscle without causing irritation to skin or other tissue layers
   c. A method used to avoid hitting the sciatic nerve
   d. A method used to avoid accidentally giving the drug intravenously

5. **Which is the preferred site for intramuscular injection in infants?**
   a. Deltoid b. Rectus femoris
   c. Vastus lateralis d. Ventrogluteal

6. **The nonproprietary name of medication, commonly referred to as the:**
   a. Generic name of medication
   b. Chemical name of medication
   c. Trade name of medication
   d. Brand name of medication

7. **Which of the following medical procedure where medication is injected directly into the joint is called:**
   a. Intraosseous injection
   b. Intra-articular injection
   c. Intrathecal injection
   d. Intra-arterial injection

8. **When the administration of medication directly into the subarachnoid space of the spinal cord, it is called:**
   a. Intraosseous injection
   b. Intra-articular injection
   c. Intrathecal injection
   d. Intra-arterial injection

9. **Which of the following route of medication administration has First-pass effect?**
   a. Oral
   b. Topical
   c. Injectable
   d. Inhalation

10. **Which of the followings are portable devices that release a specific dose of medication in aerosol form with each puff?**
    a. Dry powder inhalers
    b. Metered-dose inhalers
    c. Nebulizer
    d. Nelson inhaler

11. **Which of the following form of the parental route of medication and are administered to the layer of skin just below the dermis and epidermis layers?**
    a. Intradermal
    b. Intrathecal
    c. Subcutaneous
    d. Intraosseous

12. **In sublingual mode of medication administration the medicine is placed:**
    a. Between gums and inner lining of the cheek
    b. Under the tongue
    c. On the tongue
    d. On the eye

## ANSWERS

| | | | | |
|---|---|---|---|---|
| 1. c | 2. b | 3. a | 4. b | 5. d |
| 6. a | 7. b | 8. c | 9. a | 10. b |
| 11. c | 12. b | | | |

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