PHARMACOLOGY

STUDENT BOOK SENIOR 4
ASSOCIATE NURSING PROGRAM

First Edition

FOREWORD

Dear Student

The Rwanda Basic Education Board is pleased to introduce this textbook of Pharmacology of the Associate Nursing Program. This resource is crafted to support competence-based teaching and learning, ensuring a uniform approach to mastering the Pharmacology. Our educational philosophy is designed to help you realize your full potential at each level of your education, equipping you to integrate effectively into society and seize career opportunities.

The Rwandan government emphasizes the alignment of educational materials with the syllabus to enhance your learning experience. Instructional materials, activities, and engagement play a crucial role in shaping how well you learn. This textbook focuses on activities that promote idea development and discovery, whether done individually or in groups.

In a competence-based curriculum, learning is an active process where knowledge, skills, and attitude and values are developed through practical activities and real-life scenarios. To fully benefit from this textbook, you should:

- Engage in activities and laboratory experiments to build your skills.
- Share information through presentations, discussions, and collaborative work.
- Take ownership of your learning and draw insights from your activities.

I extend my gratitude to all those who contributed to the creation of this book, including the Ministry of Health, University of Rwanda, and other institutions. Special thanks go to the dedicated faculty members, nurses, midwives, teachers, illustrators, and designers who worked diligently on this project.

Dr. MBARUSHIMANA Nelson

Director General, REB

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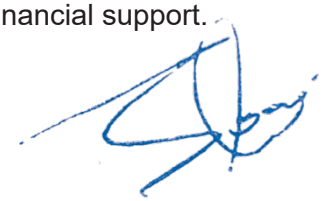

Ms. MURUNGI Joan

Head of Curriculum, Teaching, and Learning Resources Department / REB

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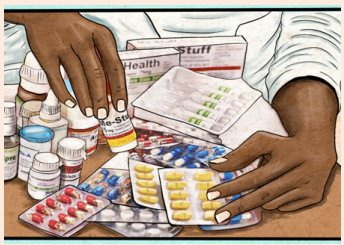
UNIT 1

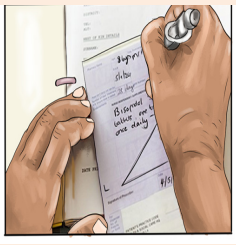
PRINCIPLES OF PHARMACOLOGY

Key Unit Competence

Apply fundamental principles of pharmacology during patient care

1.0 Introductory activity

A. 

B. 

C. 

D. 

E. 

F. 

Observe the images above and respond to the following questions:

1. What do you observe from the images above?
2. What do you think people on the images above (A, B, C, D, E, F) are doing?

1.1. History of pharmacology

Learning activity 1.1

Read the case study below and answer the questions related to it:

A student in O' level is concerned about different ways of managing illness. Therefore, he asked different ways, sources and reasons of using medications.

As a student who has chosen the associate nursing program, you know that a medicine is linked to the pharmacology science and you expect to use medicines to help persons who have diseases.

1. What do you think are the sources of medicines?
2. What is the purpose of using drug substances in human kind?

CONTENT SUMMARY

The story of pharmacology is rich and exciting, filled with accidental or unplanned discoveries and landmark events. Its history likely **began when a human first used a plant to relieve symptoms of disease**. One of the oldest forms of health care, herbal medicine has been practiced in virtually every culture dating to antiquity / ancient times.

The Babylonians recorded the earliest surviving prescriptions on clay tablets in **3000 Before Christ (BC)**, although magic and the art of reading omens were probably considered as legitimate to healing as the use of drug remedies.

At about the same time, the Chinese recorded the Pen Tsao (Great Herbal), a 40-volume compendium of plant remedies dating to 2700 BC. The Egyptians followed in 1500 BC by archiving their remedies on a document known as the Eber s papyrus, which contains over 700 magical formulas and remedies. Galen, the famous Greek physician, described over 1,000 healing preparations using plant products before his death in Dark Ages (AD) 201.

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

Drugs are substances that are used in the **diagnosis, prevention, treatment or cure of diseases**. In early times, these substances were derived from natural sources, of which plants took up the major share. With the introduction of technology, most drugs today are manufactured synthetically in the laboratory.

The major sources of drugs can be grouped into the following: **Plant, animal, mineral, marine, synthetic/chemical derivative, Semi-synthetic, Microbiological and Recombinant DNA technology/** Biosynthetic sources.

1. Plant source

It is the oldest source of drugs. Most of the drugs in ancient times were derived from plants. A number of plants have medicinal qualities and have been used for centuries as drugs or drug sources. Although the earliest plant source for drugs was the leaf, other parts of plants (e.g., barks, fruits, roots, stem, wood, seeds, blossoms, bulb etc.) Almost all parts of the plants are used i.e. leaves, stem, bark, fruits and roots.

Leaves: The leaves of Digitalis Purpurea are the source of Digitoxin and Digoxin, which are cardiac glycosides; used to treat HF (heart failure)

Leaves of Eucalyptus give oil of Eucalyptus, which is important component of cold & cough syrup

Flowers: Poppy papaver somniferous gives morphine (opoid), Vinca rosea gives vincristine and vinblastine and Rose gives rose water used as tonic.

Fruits: Senna pod gives anthracine, which is a purgative and Calabar beans Give physostigmine, which is cholinomimetic agent.

Seeds: Seeds of Nux Vomica give strychnine, which is a CNS stimulant and Castor seeds give castor oil.

Roots: Ipecacuanha root gives Emetine, used to induce vomiting as in accidental poisoning, it also has amoebicidal properties.

Ipecacuanha root gives Emetine, used to induce vomiting as in accidental poising, it also has ameobicidal properties.

Rauwolfia serpentina gives reserpine, a hypotensive agent. Reserpine was used for hypertension treatment.

Bark: Cinchona bark gives quinine and quinidine, which are antimalarial drugs. Quinidine also has antiarrhythmic properties.

Cinchona hark gives quinine and quinidine, which are antimalarial drugs

Atropa belladonna gives atropine, which is anticholinergic. Hyoscyamus Niger gives Hyosine, which is also anticholinergic.

Stem: Chondrodendron tomentosum gives tuboqurarine, which is skeletal muscle relaxant used in general anaesthesia.

2. Animal sources

Many important drugs are derived from animal source. In most instances, these medicinal substances are derived from the animal's body secretions, fluid or glands. Insulin, heparin, adrenaline, thyroxin, cod liver oil, musk, beeswax, enzymes, and antitoxins sera are some examples of drugs obtained from animal sources. Like plant products, drugs from animal sources may be crude (unrefined) or refined material.

Sources	Product	Used for disease
Pancreas	Insulin	Diabetes
Urine of pregnant women	HCG	Infertility
Sheep thyroid	Thyroxin	Hypertension
Cod liver	Vit-A and Vit-D	

3. Mineral sources

Minerals **(both metallic and non-metallic minerals)** have been used as drugs since ancient times. Our body requires trace elements of minerals in order to maintain homeostasis. Patients lacking an adequate level of these materials may take specific mineral-based drugs to raise the level of minerals.

Examples include ferrous sulfate in iron deficiency anemia; magnesium sulfate as purgative; magnesium trisilicate, aluminum hydroxide and sodium bicarbonate as antacids for hyperacidity and peptic ulcer; zinc oxide ointment as skin protectant, in wounds and eczema; gold salts as anti-inflammatory and in rheumatoid arthritis; selenium as anti-dandruff.

- **Metallic and non-metallic sources**: Iron is used in treatment of iron deficiency anemia, Mercurial salts are used in Syphilis (bacterial infection), Zinc is used as zinc supplement, Zinc oxide paste is used in wounds and in eczema, Iodine is antiseptic and Iodine supplements are also used and Gold salts are used in the treatment of rheumatoid arthritis
- Miscellaneous sources: Fluorine has antiseptic properties, Borax has antiseptic properties as well, Selenium as selenium sulphide is used in antidandruff shampoos and Petroleum is used in preparation of liquid paraffin.

4. Marine source (water source)

Bioactive compounds from marine flora and fauna have extensive past and present use in the prevention, treatment or cure of many diseases. Fish and

marine microorganisms produce biologically potent chemicals with interesting anti-inflammatory, anti-viral, and anticancer activity.

5. Synthetic /chemical derivative

A synthetic drug is produced using chemical synthesis, which rearranges chemical derivatives to form a new compound. The synthetic sources of drugs evolved with human skills in the laboratory and advanced knowledge and understanding of phytochemical investigation. When the nucleus of the drug from natural source as well as its chemical structure is altered, we call it synthetic. Examples include Emetine Bismuth Iodide. At present, majority of drugs used in clinical practice are exclusively prepared synthetically in pharmaceutical and chemical laboratory.

6. Semi-synthetic Sources

Semi-synthetic drugs are neither completely natural nor completely synthetic. They are a hybrid and are generally made by chemically modifying substances that are available from natural source to improve its potency, efficacy and/or reduce side effects. Sometimes, semi-synthetic processes are used to prepare drugs when the natural sources may yield impure compounds or when the synthesis of drugs (complex molecules) may be difficult, expensive, and commercially unviable. When the nucleus of drug obtained from natural source is retained but the chemical structure is altered, we call it semi - synthetic. E.g. Apomorphine, Diacetyl morphine, Ethinyl Estradiol, Homatropine, Ampicillin and Methyl testosterone.

7. Microbiological sources

Several life-saving drugs have been historically derived from microorganisms. Examples include penicillin produced by *Penicillium chrysogenum*, streptomycin from *Streptomyces griseus,* chloramphenicol from *Streptomyces venezuelae,* neomycin from *Streptomyces fradiae,* bacitracin from *Bacillus subtilis* etc.

PenicilliumNotatum is a fungus which gives penicillin, Actinobacteria gives Streptomycin, and Aminoglycosides such as gentamicin and tobramycin are obtained from streptomycis and micromonosporas.

8. Recombinant DNA technology/ Biosynthetic sources (genetically engineered drugs)

This is relatively a new field which is being developed by mixing discoveries from molecular biology, recombinant DNA technology, DNA alteration, gene splicing, immunology, and immune pharmacology. Drugs developed using living organisms with the help of biotechnology or genetic engineering are known as biologics, biopharmaceuticals, recombinant DNA expressed products, bioengineered, or genetically engineered drugs Examples include recombinant Hepatitis B vaccine,

recombinant insulin and others. Recombinant DNA technology involves cleavage of DNA by enzyme restriction endonucleases. The desired gene is coupled to rapidly replicating DNA (viral, bacterial or plasmid). The new genetic combination is inserted into the bacterial cultures which allow production of vast amount of genetic material. Advantages: Huge amounts of drugs can be produced, Drug can be obtained in pure form, and It is less antigenic (induce immune system). Disadvantages: Well-equipped lab is required, highly trained staff is required and it is a complex and complicated technique.

Self- assessment 1.1

1. The use of the drug started when?
2. What are the sources of drug?
3. Who first isolated morphine from opium in 1805?
4. Who is considered as the father of American pharmacology?

1.2 Definition of key concepts used in Pharmacology

Learning activity 1.2

As the new student admitted in Associate nurse program in senior 4, read the book of pharmacology and define the following common key terms used in pharmacology:

1. Pharmacology
2. Clinical pharmacology
3. Drugs
4. Adverse drug reaction and
5. Therapeutic effect

CONTENT SUMMARY

Pharmacology: The word pharmacology is derived from two Greek words, "**pharmakon**", which means **medicine or drug,** and **logos**, which means study. It is the study of medicines. It includes the study of how drugs are administered and how the body responds (Adams et all 2014).

It can be also defined as the study of drugs and their interactions with living systems.

Clinical pharmacology: is defined as the study of drugs in humans.

Drugs: chemicals that are introduced into the body to bring about some sort of change.

Adverse drug reaction: Any unexpected, unintended, undesired, or excessive response to a medication given at therapeutic dosages (Linder et al 2014).

Drug actions: The processes involved in the interaction between a drug and body cells (e.g., the action of a drug on a receptor protein); also called mechanism of action.

Drug classification: A method of grouping drugs; may be based on structure or therapeutic use.

Drug effects: The physiologic reactions of the body to a drug. They can be therapeutic or toxic and describe how the body is affected as a whole by the drug. The terms onset, peak, and duration are used to describe drug effects (most often referring to therapeutic effects).

Pharmacognosy The study of drugs that are obtained from natural plant and animal sources.

Therapeutic effect: The desired or intended effect of a particular medication.

Therapeutic index: The ratio between the toxic and therapeutic concentrations of a drug.

Tolerance: Reduced response to a drug after prolonged use.

Toxic: The quality of being poisonous (i.e., injurious to health or dangerous to life).

Toxicity: The condition of producing adverse bodily effects due to poisonous qualities.

Food and Drug Administration (FDA): federal agency responsible for the regulation and enforcement of drug evaluation and distribution policies

Self- assessment 1.2

Define the following terms:

1. Pharmacognosy
2. Therapeutic index
3. Tolerance

1.3 Chemical drug name

Learning activity 1.3

1. Read the book of pharmacology and explain chemical drug name (using library textbook)

CONTENT SUMMARY

Drugs are chemicals that are introduced into the body to bring about some sort of change. The drugs have several names, which may cause confusion. Each drug has three names: **a chemical name, a generic name, and a brand name.** The health care professionals have to study **pharmacology** which is the study of drugs and their interactions with living systems to know the exact medication to be used and to control the complication associated.

The chemical names are the scientific names, based on the molecular structure of the drug. There are various systems of chemical nomenclature and thus various chemical names for any one substance. The most important is the International Union of Pure and applied Chemistry **(IUPAC)** name. A drug has only **one chemical name**. Chemical names are typically very long and too complex to be commonly used in referring to a drug in speech or in prose documents. For example, "1-(isopropylamino)-3-(1-naphthyloxy) propan-2-ol" is a chemical name for propranolol. Sometimes, a company that is developing a drug might give the drug a company code, which is used to identify the drug while it is in development. This chemical name is sometimes helpful in **predicting a drug's physical and chemical properties**. Examples of chemical names of common drugs include lithium carbonate, calcium gluconate, and sodium chloride.

Self- assessment 1.3

1. A drug can have different name. Which one among the following drug name is chemical name?
   a. N-acetyl-p-aminophenl
   b. Paracetamol
   c. Tylenol
2. A drug has how many chemical name?
3. Give 3 examples of easy chemical names to remember of common drugs

1.4 Generic drug name

Learning activity 1.4

Your neighbour sent her child to the pharmacy to buy the Paracetamol tablets. The pharmacist gives the child the firm coated tablet labelled as PANADOL®. The neighbour becomes confused and returns to the pharmacy for clarification before taking the drug. The pharmacist tells the neighbour that, it is the same drug. One is generic name (Paracetamol) and the other is brand name (Panadol®)

1. Give the difference between generic name and brand name.

CONTENT SUMMARY

The generic name is simpler name, **less complicated and easier to remember than chemical names**. It may be used in any country and by any manufacturer. The first letter of the generic name is not capitalized. Students are strongly encouraged to learn and refer to drugs by their generic names because formularies (i.e., lists of medicines available through a pharmacy) are maintained by generic names. When a therapeutically equivalent drug becomes available in generic form, the generic medicine is routinely substituted for the brand-name medicine. Generic names are provided by the United States Adopted Names Council, which is an organization sponsored by the United States Pharmacopeial Convention, the American Medical Association, and the American Pharmacists Association. The official name, which is virtually always the generic name in the United States, is the name under which the drug is listed by the US Food and Drug Administration (FDA). The FDA is empowered by federal law to generically name the drugs for human use in the United States.

Food and Drug Administration (FDA) is federal agency responsible for the regulation and enforcement of drug evaluation and distribution policies. **Because there is only one generic name for each drug, health care providers often use this name and they must memorize it. Generic drugs are less expensive than brand-name drugs, but they may differ in bioavailability. Bioavailability** is defined by the Federal Food, Drug and Cosmetic Act as the rate and extent to which the active ingredient is absorbed from a drug product and becomes available at the site of drug action to produce its effect. Bioavailability may be affected by many factors, **including inert ingredients and tablet compression**. Anything that affects the absorption of a drug or its travel to the target cells can certainly affect drug action. Measuring how long a drug takes to exert its effect (onset time) gives pharmacologists a crude measure of bioavailability. If the trade and generic products have the same rate of absorption and have the same onset of therapeutic action, they are said to be bioequivalent.

Self- assessment 1.4

1. A patient/client tells to the nurse that is taking aspirin. Which type of drug name is this?
2. A drug can have different name. Which one among the following drug name is generic name:
   a. (RS)-2-(4-(2methylpropyl)phenyl) propanoic acid
   b. Ibuprofen
   c. Motrin
3. _____ means that the amount of active ingredient that reaches the patient's bloodstream for a generic drug must be equivalent to that of the branded drug.
   a. Bioequivalence
   b. Route of administration
   c. Monitoring of adverse events
   d. Biohazard labels
4. What does the term "Bioavailability" mean?
   a. Plasma protein binding degree of substance
   b. Permeability through the brain-blood barrier
   c. The rate and extent to which the active ingredient is absorbed
   d. Amount of a substance in urine relative to the initial dose

1.5 Trade drug name

Learning activity 1.5

Read the book of pharmacology and explain trade drug name (using library textbook)

A drugs trade name, sometimes called **the proprietary, product, or brand name**, is assigned by the pharmaceutical company marketing the drug and it is followed by the symbol ®. This symbol indicates that the name is registered and that the use of the name is restricted to the owner of the drug, which is usually the manufacturer. The trade name is intentionally selected to be short and easy to remember so that patients will remember it (and ask for it by name).

Drugs with more than one active generic ingredient are **called combination drugs**. Acetaminophen and aspirin are examples of agents that appear in many combination

drugs with dozens of different trade names. **To avoid this confusion, generic names should be used when naming the active ingredients in a combination drug**. When referring to a drug, it is conventional to write the generic name in lower case first, followed by the trade name in parentheses with the first letter capitalized. Examples include alprazolam (Xanax) and acetaminophen (Tylenol). (Cyton et al 2017).

The difference between trade name and trademark name is that a trade name refers to the company's official name, while a trademark provides a company's brand with legal protection.

The key to comparing brand-name drugs and their generic equivalents lies in measuring the bioavailability of the two agents. **Bioavailability** is defined by the Federal Food, Drug and Cosmetic Act as the rate and extent to which the active ingredient is absorbed from a drug product and becomes available at the site of drug action to produce its effect. Bioavailability may be affected by many factors, **including inert ingredients and tablet compression.** Anything that affects the absorption of a drug or its travel to the target cells can certainly affect drug action. Measuring how long a drug takes to exert its effect (onset time) gives pharmacologists a crude measure of bioavailability. If the trade and generic products have the same rate of absorption and have the same onset of therapeutic action, they are said to be bioequivalent.

The importance of bioavailability differences between a trade name drug and its generic equivalent depend on the specific circumstances of pharmacotherapy. For example, if a patient is in circulatory shock and the generic equivalent drug takes 5 minutes longer to produce its effect that may indeed be significant. However, if a generic medication for arthritis pain relief takes 45 minutes to act, compared to the brand-name drug that takes 40 minutes, it probably does not matter which drug is used, and the inexpensive product should be prescribed to provide cost savings to the consumer.

As a general rule, **bioavailability is of most concern when using critical care drugs and those with a narrow safety margin**. In these cases, the patient should continue taking the brand name drug and not switch to a generic equivalent, unless approved by the health care provider. For most other drugs, the generic equivalent may be safely substituted for the trade name drug.

In the age of Internet pharmacies, the issue of exclusive marketing rights has drastically changed. In some cases, they even sell the drug to consumers without a prescription. Other countries do not have the same quality control standards as the United States, and the patient may be purchasing a useless or even harmful product. Furthermore, although Internet sites may appear to be based in the United States, they may instead be obtaining their medications from unreliable sources.

Nurses must strongly urge their patients not to purchase drugs from overseas pharmacies because there is no assurance that the drugs are safe or effective.

Examples of Brand-Name Products Containing Popular Generic Substances

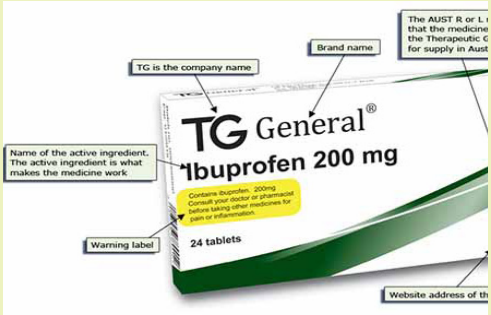
Generic substance	Brand names
Aspirin	There are several brand names which many exceed 50 e.g. Acuprin, Anacin, Aspergum,
Diphenhydramine	Allerdry, Benadryl, benahist, hydril
Ibuprofen	Pamprin, Motrin, Brufen, medipren, Rufen

Self- assessment 1.5

1. A drug can have different name. Which one among the following drug name is chemical name?
   a. N-acetyl-p-aminophenl
   b. Paracetamol
   c. Tylenol
2. What is the meaning of the symbol ® following drug name?

1.6. Label of drugs container

Learning activity 1.6

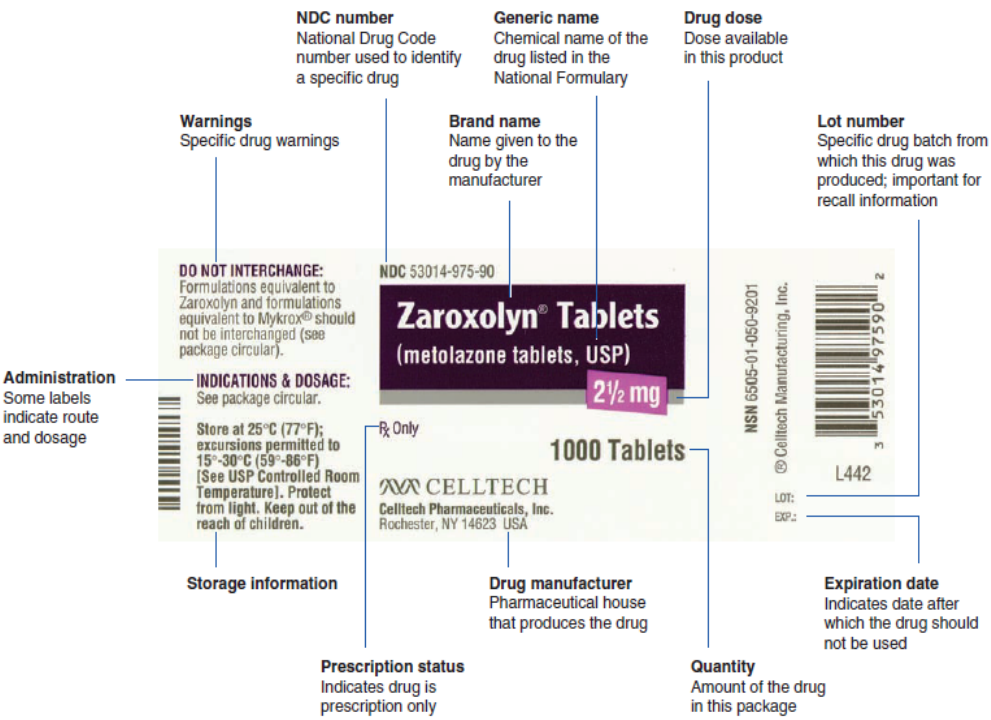


1. What do you observe on this image?
2. Explain why it is necessary to label the drug container?

The Food and Drug Administration have specific information that identifies a specific drug. It is important to obtain a thorough and accurate information from the drug containers regarding their labelling, as they can often provide valuable information.

The Drug label is a standardized label that appears on all over-the-counter (OTC) medicines approved by the Food and Drug Administration, it have specific information that identifies a specific drug. It is designed to tell the purpose of the medicine, who should take the medicine and how to take it safely. For example, a drug label identifies the brand and generic names for the drug, the drug dosage, the expiration date, and special drug warnings. Some labels also indicate the route and dose for administration. It's very important to read all the information on the label and current and approved references every time someone want to administer a medicine because labels change regularly. Nurses need to become familiar with each aspect of the label.

A lack of information on drug labelling can result in serious mistakes in the preparation of drugs which can place patients at risk. In all drug packaging of the chosen drug should contain; what drug is to be used, how the drug is taken, when the drug is to be administered, the importance of taking the drug (patient compliance) and information about what happens if it is not taken as prescribed (patient noncompliance), how long the drug is to be used, what adverse effects can be expected and the alternatives available. The term compliance is the extent to which patients follow instruction.



Numerous drug labels are used in the drug calculation problems to familiarize the nurse with important information on a drug label. This information is then used in correctly calculating the drug dose.

Self- assessment 1.6

1. Enumerate the necessary information which must be on the drug containers?
2. What is drug label?
3. During the drug administration the nurse found a drug container on which the label information is not clear?

1.7. Solid drug dosage forms

Learning activity 1.7

1. What do you observe on this image?
2. Are there any other solid forms of medication which are not on this image?
3. Why is it important for nurses to know different types of solid drug dosage form?

CONTENT SUMMARY

Solid dosage forms include tablets, capsules, Caplets, Lozenges/ troches, Powders and granules. The Tablets are available in variety of sizes, shapes, colors, and thicknesses, usually obtained by single or multiple compressions of powders or granules.

Most tablets and caplets are designed to be swallowed whole and dissolve in the gastrointestinal tract, but some are also made to be administered sublingually, buccally, or vaginally.

Tablets are normally right circular solid cylinders, the end surfaces of which are flat or convex and the edges of which may be beveled. They may have lines or break-marks (scoring), symbols or other markings.

1. **Uncoated tablets**: compressed tablet or core tablet formed by compression and contain no special coating. They are made from active ingredient in combination with excipients such as binders, diluents, etc. Example: Analgin, Paracetamol, Bactrim, etc

2. **Sugar-coated tablets:** are smooth, round or oval compressed tablets containing sugar coatings. Sugar coating provides both protection and sweet taste but the coating operations take a long time. Example: Neocodion, Paderyl, Aphatyl, Spasfon etc.

3. **Film-coated tablets:** are compressed tablets which are covered with a thin layer or a film of polymeric substances to protect their contents from moisture or to mask the taste of the ingredients. Example: Ibuprofen

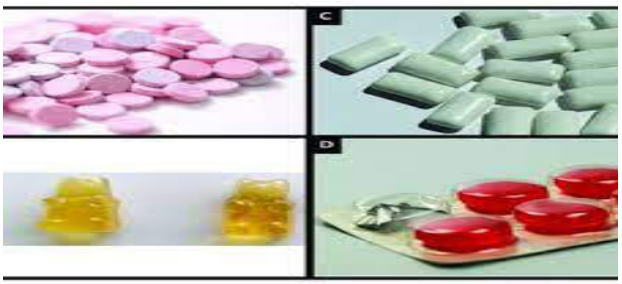
4. **Modified release tablets:** are coated, uncoated or matrix tablets containing excipients or prepared by procedures which, separately or together, are designed to modify the rate, the place or the time of release of the active ingredient(s) in the gastrointestinal tract. Sustained-release tablets (Extended/ Controlled/Prolonged-release): Sustained-release tablets are designed to slow the rate of release of the active ingredient(s) in the gastrointestinal tract.

   Example: Nifedipine. Delayed-release tablets (Entered-coated/Gastro-resistant tablets): are coated with substances that resist solution in gastric fluid but disintegrate in the alkaline contents of the intestine. Enteric coating is used for medicines with a gastric irritant action, for medicines which are unstable in the acid medium of the gastric contents or if the medicine should

act on the intestine. Example: Aspirin 81mg.

5. **Effervescent tablets:** Effervescent tablets are uncoated tablets generally containing acid substances and carbonates or hydrogen carbonates that react rapidly in the presence of water to release carbon dioxide. They are intended to be dissolved or dispersed in water before administration. Example: Efferalgan Vitamin C, Berroca Suppradine, etc

6. **Chewable tablets:** Chewable tablets are usually uncoated. They are intended to be chewed before being swallowed; however, where indicated on the label, they may be swallowed whole instead. They should be hard and large which difficult to swallow. Example : Maalox, Amoxicillin chewable zentel, etc



7. **Lozenge tablets (Troche):** Tablets containing palatable flavoring, indicated for a local (often soothing) effect on the throat and mouth. They are placed in the mouth where they slowly dissolve, liberating the active ingredient. The drug involved can be antiseptic, local anesthetic, antibiotic, or antitussive. Example: Lysopaine, Horf, Strepsil, Wood, Zecuf, etc. Patient is advised not to swallow a lozenge; it should be allowed to slowly dissolve in the mouth. Patient is also advised not to drink liquids for approximately 15 minutes after administration, to prevent washing of the lozenge contents from throat or mouth.

8. **Sublingual tablets:** Medicine is placed under the tongue and allows dissolving. It is absorbed into the circulation and provides the systemic effects. This medication form is suitable for the active ingredients which is destroyed or unstable in the gastrointestinal fluids. Example: Nitroglycerin

Capsules are solid dosage forms in which the drug substance is enclosed in either a hard or soft soluble container of suitable form of gelatin. They are intended to mask the smell and taste of the drug substances. Capsules are tasteless, easily administered and some patients prefer them to the tablets. They are of various shapes and sizes and contain a single dose of one or more active ingredients. Capsules may be Hard Gelatin Capsules, Soft Gelatin Capsules and Modified-Release Capsules:

1. **Hard Gelatin Capsules**: Hard capsules have shells consisting of two prefabricated cylindrical sections that fit together. One end of each section is shorter, larger rounded, and closed (cap) and the other is open, longer and smaller (body). The contents of hard capsules are usually in solid form (powder or granules). Example: Amoxicillin, Ampicillin, Cephalexin, etc.
2. **Gelatin Capsules**: Soft capsules have thicker shells than hard capsules and antimicrobial preservatives are usually added. The shells are of one piece and various shapes. They may be round, oval and oblong. The contents of soft capsules are usually solutions or suspensions of the active ingredient(s) in non-aqueous liquids. Example: Vitamin E, Vitamin A, Eugica, etc
3. **Modified-Release Capsules**: Modified-release capsules are hard or soft capsules in which the contents or the shell or both contain excipients or are prepared by special procedures such as micro-encapsulation which, separately or together, are designed to modify the rate, place or time of release of the active ingredient(s) in the gastrointestinal tract. **Sustained-release capsules** are designed to slow the rate of release of the active ingredient(s) in the gastrointestinal tract. Example: Cardene SR (nicardipine). **Delayed-release capsules** are hard or soft capsules prepared in such a manner that either the shell or the contents resist the action of gastric fluid but release the active ingredient(s) in the presence of intestinal fluid. Examplse: Casprin, Esomeprazole
4. The caplets/ Pills are small, round dosage forms for oral administration which are prepared by the pharmacist. They are rarely prescribed today. The powdered ingredients are mixed together with binding agents. The pill mass is rolled into spheres and coated with talc, gelatin, or sugar.

   Example: Oral contraceptive pills.
5. **Oral Powder**: oral powders are preparations consisting of solid, loose, dry particles of varying degrees of fineness. They contain one or more active ingredients, with or without excipients and, if necessary, authorized colouring

matter and flavouring substances. They are generally administered in or with water or another suitable liquid. They may also be swallowed directly. They are presented as single-dose or multidose preparations. Each dose of a single-dose powder is enclosed in an individual container, for example a packet, a sachet or a vial. Multidose oral powders require the provision of a measuring device capable of delivering the quantity prescribed.

Example: Clamoxyl 250mg, Dolipran, powder, Smecta, etc.

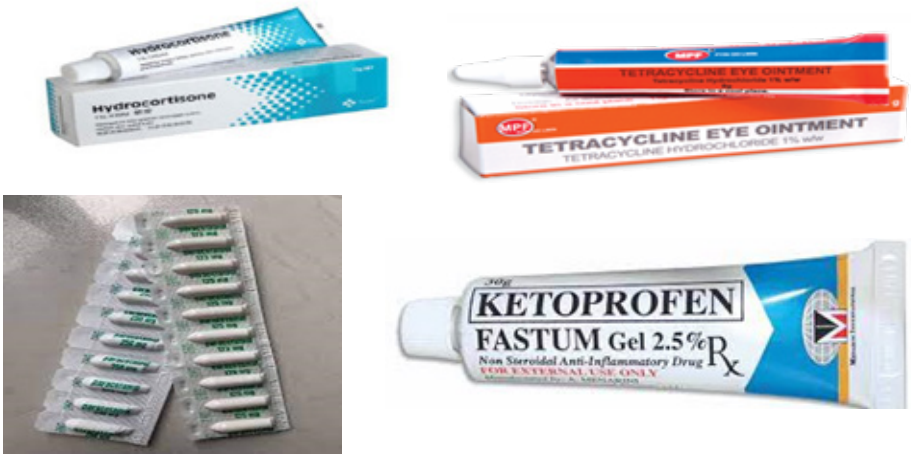
6. Granules are dosage forms related to powders. They are particularly suitable for the preparation of solutions or mixtures of medicines. Example: Montiget, Biorrhee, etc.

Self- assessment 1.7

1. The associate nurse students are reviewing principles of pharmacology, and are reading about different forms of drugs. Enumerate 6 solid drug dosage forms which can be used orally?
2. Some tablets to treat a headache must first be dissolved in water before swallowing. Which one of the following best describes this type of tablet?
   a. Modified release
   b. Oral disintegrating
   c. Effervescent
   d. Buccal
3. Capsules in which powders are enclosed are made up of …..
   a. Gelatine
   b. Rice flour
   c. Fructose
   d. Dextrose

1.8. Semisolid drug dosage forms

Learning activity 1.8



Semisolid Dosage Forms

1. What do you observe on this image?
2. Are there any other semisolid forms of medication which are not on this image?
3. Why is it important for nurses to know different types of semisolid drug dosage forms?

CONTENT SUMMARY

Semisolid dosage forms are normally presented in the form of creams, gels, ointments, pastes, suppository or patch. They contain one or more active ingredients dissolved or uniformly dispersed in a suitable base and any suitable excipients such as emulsifiers, viscosity-increasing agents, antimicrobial agents, antioxidants, or stabilizing agents. The choice of a base for semi-solid dosage forms depends on many factors: the therapeutic effect desired the nature of the active ingredient to be incorporated, the availability of the active ingredient at the site of action, the shelf-life of the finished product, and the environmental conditions in which the product is intended to be administered.

It should be smooth, inert, odorless, physically and chemically stable, and compatible with both the skin and the active ingredient(s) to be incorporated. It should normally be of such a consistency that it spreads and softens easily when stress is applied. It may be necessary for a topical semi-solid dosage form to be sterile, for example, when it is intended for use on large open wounds or severely injured skin.

Creams are homogenous, semisolid preparation that is usually white and no greasy and has a water base. Creams are intended for application to the skin or certain mucous membranes for therapeutic or protective purposes. The term “cream” is most frequently used to describe soft, cosmetically acceptable types of preparations.

Example: Hydrocortisone cream, Ketoconazole cream, etc

Ointments are homogeneous, semi-solid and greasy preparations intended for external application to the skin or mucous membranes for therapeutic or protective purposes.

Example: Tetracycline ointment.

Gels are usually homogeneous, clear, semi-solid, jelly- like preparations that may be used for topical medication. Gels are applied to the skin or certain mucous membranes for therapeutic, or protective purposes.

Example: Erythrogel, fastum gel, etc

Pastes are homogeneous, semi-solid preparations containing high concentrations of insoluble powdered substances (usually not less than 20%) dispersed in a suitable base. The pastes are usually less greasy, more absorptive, and stiffer in

consistency than ointments because of the large quantity of powdered ingredients present. Pastes adhere reasonably well to the skin and they are suited for application on and around moist lesions.

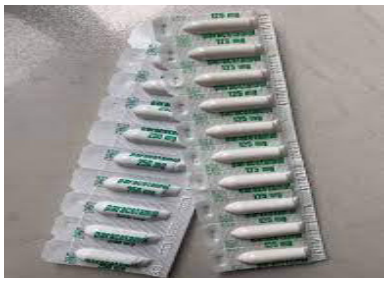
Example: Orrepaste, Anagelsic and anti-inflammatory containing dental paste, etc

Patched/Plasters are substances intended for external application made of such materials and of such consistency as to adhere to the skin. Inner surface of the patch contacts skin and allows transdermal absorption of lipid-soluble medicines. The total amount of medicine on the patch is very large, but typically only a small fraction is absorbed. Patch are convenient because they can be applied easily and minimize stomach upset. They can also improve compliance because there is no need for more frequent dosing like oral dosage forms.

Example: Dermal patches

Suppository are semisolid dosage forms to be inserted into body cavity-rectum or vagina, where medication is melt at the body temperature which provides local or systemic effects.

Example: paracetamol suppository, Flagyl suppository, etc



Advantage of semisolid dosage form are: It is used externally, the probability of side effects can be reduced, first-pass gut and hepatic metabolism is avoided, local action and site-specific action of the drug on the affected area, convenient for unconscious patients or patients to have difficulty in oral administration, suitable dosage form for bitter drugs and more stable than a liquid dosage form. The disadvantage of using semisolid drug forms are: The accuracy can't be measured, for the semisolid dosage form, may cause staining, they are bulky to handle, application with a finger may cause contamination, physico-chemical is less stable than a solid dosage form and may cause irritation or allergy to some patients. The ideal properties of semisolid dosage forms are smooth texture, elegant in appearance, non-dehydrating, non-gritty and non-greasy and non-staining and Non-hygroscopic.

Self- assessment 1.8

1. Enumerate the semisolid dosage forms.
2. Which of the following is not a semisolid dosage form
   a. Paste
   b. Cream
   c. Ointments
   d. Suspension
3. A semi-solid preparations containing high concentrations of insoluble powdered substances (usually not less than 20%) dispersed in a suitable base is known as:
   a. Paste
   b. Suppository
   c. Ointments
   d. Gels

1.9. Liquid drug dosage forms

Learning activity 1.9

1. What do you observe on this image?
2. Is there any other liquid form of medication which is not on this image?
3. Why is it important for the associate nurses to know different types of liquid drug dosage forms?

CONTENT SUMMARY

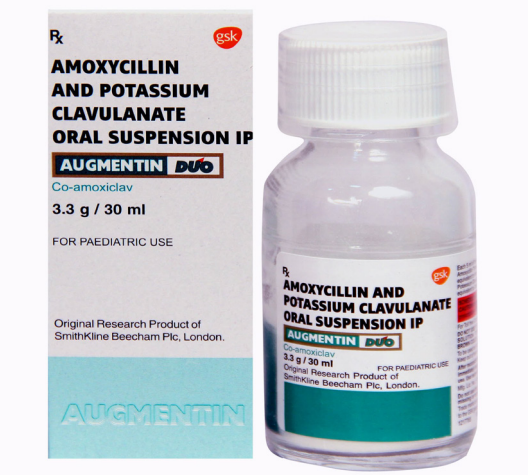
Liquid dosage forms are prepared by dissolving the active ingredient(s) in an aqueous or nonaqueous solvent, by suspending the drug in appropriate medium or by incorporating the drug substance, into one or two phases of an oil and water system. These forms can be formulated for different routes of administration: oral use, introduction into body cavities, or applied externally. Liquid drugs may also be administered systemically by mouth or by injection throughout the body.

The oral liquid forms can be readily administered to children or people unable to swallow tablets or capsules.

Syrup is a medicine dosage form that consists of a high concentration of a sugar in water. Flavors may be added to mask unpleasant taste of certain medication. Cherry, grape, strawberry syrup drug preparations are common for children.

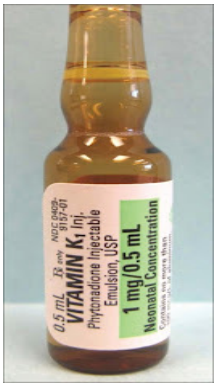
Example: Sara syrup, Ibuprofen syrup, Dalfagan syrup, etc.

Suspension is liquid form of medication that must be shaken well before administration because the medicine particles settle at the bottom of the bottle. The medicine is not evenly dissolved in the liquid (hydrophobic agents). Example: Cotrimoxazole suspension, Diaryl suspension, Amoxicillin suspension, Cefixim suspension, etc



Elixir is liquid medicine form for oral use that contain primarily water, alcohol and sugar. Their alcohol content makes elixir convenient liquid dosage form for many drugs that are only slightly soluble in water. Example: Hosolvan elixir, Terpin hydrate elixir, etc.

Emulsion is a pharmaceutical preparation in which two agents of oil and water that cannot ordinarily be combined are mixed. These forms can be administered orally, topically, or parenterally (intramuscularly). In order to prepare suitable emulsions and to have them remain stable for a suitable period of time, a number of emulsifying agents are used in their preparation. Example: Propofol (Diprivan), Metronidazole topical emulsion, etc.



Tincture is alcoholic or water- alcohol solution of medicines. It differs from elixir which is not sweet. Tincture can be used orally or externally. Example: Iodine tincture

Eye, Ear and Nose Drops are medicines in sterile water (purified water-deionized, demineralized water) to be applied by drops.

Example: Ciprofloxacin eye/ear drop, New V-rotho, Tear Natural II, Pyinchin, etc.

Mouth washes solution are aqueous solutions which are most often used for their deodorant, refreshing or antiseptic effect.

Example: Eludril, Septil, etc

Enema is a fluid injected into the lower bowel by way of the rectum and most frequent used as a cleansing enema which is given to relieve constipation or for bowel cleansing before a medical examination or procedure.

Example: Pata enema, etc

Douche solution is sterile solution, often a cleansing or antiseptic agent for part of the body or body cavity.

Example: Povidone iodine, H_2O_2

Liniment is the preparation for external use that is rubbed on the skin as a counterirritant. As such, the liniment creates a different sensation (e.g. tingling or burning) to mask pain in the skin, muscle or joint.

Example: Camphor liniment

Medications for injection: solution have a sterile water base and are thus referred to as aqueous solution. Some solutions have an oil base, which tends to cause a more prolonged absorption time. The oily nature of these solutions makes them thick, thus they are referred to viscous solution.

Example: Becozyme injection, Glucose 50% injection, Lactate ringer, NaCl 0.9%, etc

Intravenous fluids

In clinical practice, restoring and maintaining proper fluid volume, composition, and classification of intravenous fluids distribution is a significant problem in the treatment of seriously ill patients and those with or at risk of fluid and electrolytes imbalance. Nurses are in good position for the intravenous fluid administration and monitoring. Fluids are administered to refill total body water, restore blood volume and pressure and/or shift water from one fluid compartment to another, restore and maintain electrolyte and acid–base balance.

Classification of intravenous fluids

The IV fluids are classified considering the effect that they may cause to cells when reach human body. According to their tonicity, intravenous fluids are classified as **isotonic, hypertonic and hypotonic.**

Solutions that are **isotonic** have the same concentration of solutes (same osmolality) as plasma. **Hypertonic** solutions contain a greater concentration of solutes than plasma, whereas hypotonic solutions have a lesser concentration of solutes than plasma. If hypertonic solution is administered, the plasma gains more solutes than the interstitial fluid. Water will move, by osmosis, from the interstitial

fluid compartment to the plasma compartment. This type of fluid shift removes water from cells and can result in dehydration. Water will move in the opposite direction, from plasma to interstitial fluid, if a **hypotonic** solution is administered. This type of fluid shift could result in hypotension due to movement of water out of the vascular system. Isotonic solutions will produce no net fluid shift.

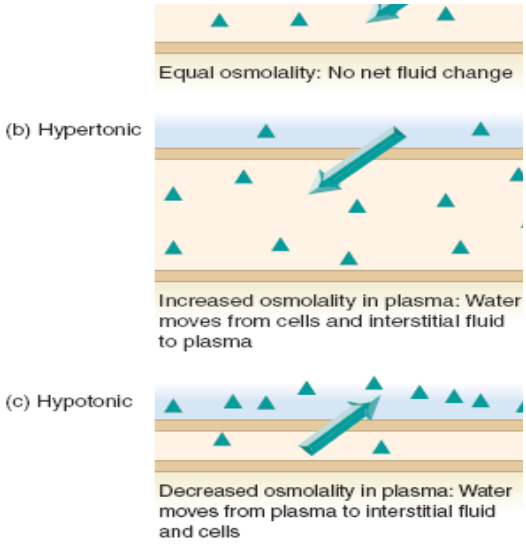


Figure: Movement of fluids

Another important classification considering the components of the IV fluid. There are **crystalloid and colloidal IV fluids.**

Crystalloids are IV solutions that contain electrolytes and other substances that closely mimic the body's ECF. They are used to replace depleted fluids and to promote urine output. Crystalloid solutions are capable of quickly diffusing across membranes, leaving the plasma and entering the interstitial fluid and ICF. It is estimated that two thirds of infused crystalloids will distribute in the interstitial space. Isotonic, hypotonic, and hypertonic solutions are available.

Table: CRYSTALLOID IV SOLUTIONS

INFUSION	TYPE/TONICITY
Normal saline (0.9% NaCl)	Isotonic
Lactated Ringer's	Isotonic
5% Dextrose in water (D5W)	Isotonic
5% Dextrose in normal saline	Hypertonic
5% Dextrose in lactated Ringer's	Hypertonic

Figure: Crystalloids

Note: 5% of dextrose in water (D5W) is quickly metabolized, it is considered as hypotonic solution.

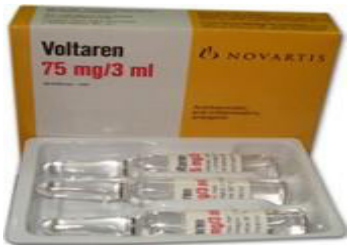
COLLOIDS IV FLUID

Colloids contain large molecules like proteins that remain in the blood for a long time because they are too large to easily cross the capillary membranes. When they are circulating, they have the same effect as hypertonic solutions. They pull water molecules from the cells and tissues into the plasma through their ability to increase plasma osmolality and osmotic pressure. They are plasma volume expanders that are used in treatment of hypovolemic shock due to burns, haemorrhage or after surgery.

Table: COLLOIDS IV FLUID

INFUSION	TONICITY	INDICATIONS
5% albumin	Isotonic	Shock
Dextran 40 in D5W	Isotonic	Double the plasma volume
Plasma protein fraction (83% albumin,17% globulins)	Isotonic	Hypoproteinemia

Figure: Colloids



Powder are dry particle of medicines. The powder itself cannot be injected. It must be mixed with a sterile diluting solution-solvent (sterile water or saline solution) to render an injectable solution. This is termed reconstitution of medicine. Medicines are supplied undiluted in powder form because of the short period of time they remain stable after dilution.

Example: Ampicillin, Ceftriaxone, etc

These products are packaged in ampoules, vials, bottles, plastic bags, and prefilled disposable syringes.

Self- assessment 1.9

1. Give the difference between suspension and emulsion
2. Which of the following formulations would not be applicable to ocular administration?

   A. Solution C. Suspension
   B. Liniment D. Ointment

3. The component present in solution in small quantity is known as…..

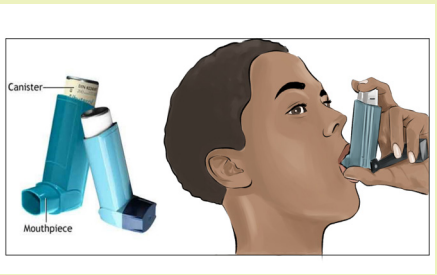
   A. Solvent C. Solute
   B. Solution D. Liquid

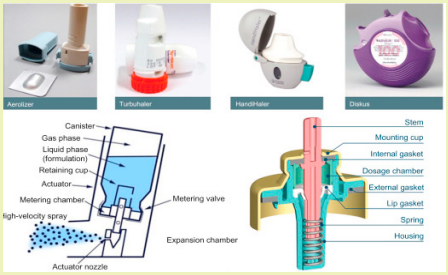
4. The component present in solution in large quantity is known as.

   A. Solvent
   B. Solution
   C. Solute
   D. Liquid

1.10. Gaseous drug dosage forms

Learning activity 1.10





1. What do you observe on this image?
2. Which form of medication that can be taken in this way?

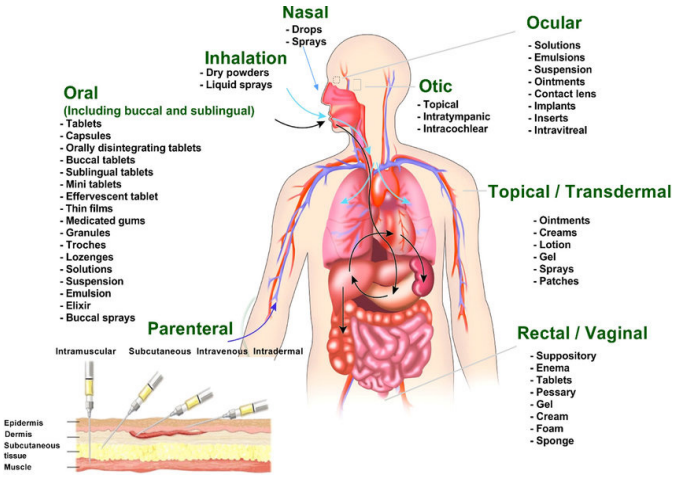
In gaseous dosage forms, the active pharmaceutical ingredients (API) are given in the form of gas, are packed in a special container which gets released upon applying pressure. It is used in the nose and mouth for local application or on the skin. This allows medicines to be delivered to and absorbed in the lungs, which provides the ability for targeted medical treatment to this specific region of the body, as well as a reduction in the side effects of oral medications.

E.g. Inhalers, aerosols, vaporizers, sprays, and nebulizers or atomizers

Aerosols are suspension of fine solid or liquid particles with gas used to apply drug to respiratory tract having atomizer with in device. **Inhalations** are internal liquid preparations containing medicaments dissolved in suitable solvent or if insoluble suspended in the propellant

Sprays are gaseous preparation of drugs containing alcohol applied to mucous membrane of nose or throat with atomizer or nebulizer.

Some Routes of Drug Administration

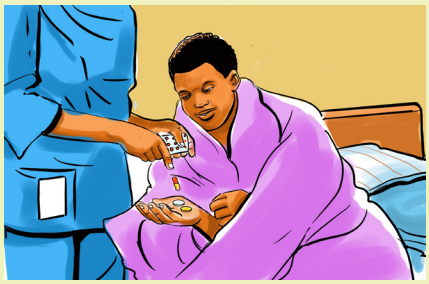


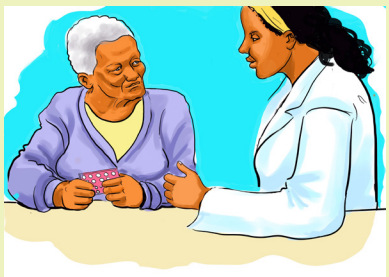
Self- assessment 1.10

1. Enumerate the routes of administration for the gaseous dosage forms
2. What are the difference between aerosol and spray drugs?

1.11 Doses and drug regimen

Learning activity 1.11





1. What do you observe on this image?
2. Explain the importance of taking the medication as prescribed?
3. What is the effective dose?
4. Based on this image what do thing you will learn in this unit?

The patient diagnosed with disease has to take the medications as prescribed by the authorised health professional. To avoid and to achieve desirable therapeutic effect, the patient has to take the correct dose. **A dose** refers to a specified amount of medication taken at one time while the **dosage** is the prescribed administration of a specific amount, number, and frequency of doses over a specific period of time. A dosage guides a drug regimen.

A drug regimen is a prescribed systematic form of treatment for a course of drug(s). Regimen is a treatment plan that specifies the dosage, the schedule, and the duration of treatment. Dose regimen includes the loading dose, maintenance dose, dose frequency, dose duration, and dose adjustments for special populations and for coadministration with other drugs.

The drugs dose can be given as **single dose, continuous administration and irregular or several doses administration. The Single dose:** After an intravenous injection, the drug enters the bloodstream directly and the concentration rises to its peak level almost immediately. Elimination and distribution will start immediately.

With intramuscular injection, the drug is absorbed over a longer period, and following oral administration, absorption takes even longer. The effect of a drug is usually fastest if the route of administration that leads most rapidly to a high concentration in the target organ is used.

Continuous administration: intravenous infusion if a drug is administered by a continuous intravenous infusion, the absorption phase will last as long as the infusion continues.

Irregular administration: several doses per day If a drug is administered in 'portions', or by several doses per day, the absorption and subsequent concentration of the drug in the blood will vary between each dose. Initially, the concentration increases for each new dose, if the time interval between the doses is so short that the drug is not totally eliminated before the next dose is taken.

This increase in concentration gradually diminishes, and steady state is eventually achieved, as the rate of elimination of drug increases with increased concentration of the drug. Once steady state is achieved, the concentration of the drug will only vary between doses. The concentration rises immediately after intake, reaches a peak level, and drops gradually until the next dose is taken.

Even though many people receive the same dose of a drug, not all of them will achieve the same effect. Some may have effect with a low dose, while others require a higher dose. Likewise, some notice adverse effects at lower doses than others.

The effective dose is the dose that produces the desired effect. Based on the amount the client received the dose can be effective, toxic and lethal dose. **The toxic dose** is the dose that produces a toxic effect. **The lethal dose** is the dose that results in death. This is an experimental term that can only be determined in animal experiments and estimated in humans taking high doses in attempting suicide.

Drug dosage errors can occur at any time from when the drug is prescribed to its administration and mistakes can place patients at risk; at worst, they can be fatal. The cause of drug dosage errors can be attributed to both the health professional and the patient. When using drugs with potent effects, it is even more important to have a raised awareness, to avoid potential dosage errors. The same applies when administering drugs to small children, the elderly and unconscious patients.

A loading dose is a higher amount of drug, often given only once or twice, that is administered to "prime" the blood-stream with a level sufficient to quickly induce a therapeutic response. Before plasma levels drop back toward zero intermittent maintenance doses are given to keep the plasma drug concentration in the therapeutic range. Although blood levels of the drug fluctuate with this approach, the equilibrium state can be reached almost as rapidly as with a continuous infusion.

When immediate drug response is desired, a large initial dose, known as the loading dose, of drug is given to achieve a rapid minimum effective concentration in the plasma. After a large initial dose, a prescribed dosage per day is ordered.

Loading doses are particularly important for drugs with prolonged half-lives and for situations in which it is critical to raise drug plasma levels quickly, as might be the case when administering an antibiotic for a severe infection. It took almost five doses (48 hours) to reach a therapeutic level using a routine dosing schedule. With a loading dose, a therapeutic level can be reached within 12 hours.

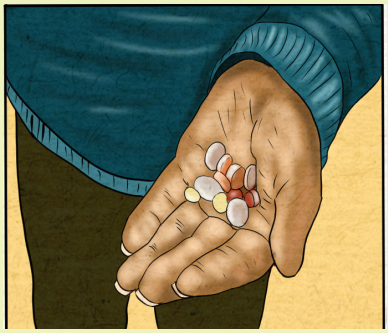
Maintenance doses are the dose taken to maintain the plasma concentration. During the long-term use of some drugs, it is customary to prescribe fixed doses with virtually identical long intervals between doses. With a dosage of 1×1, there will be 24 h between each dose. With a dosage of 1×3, there will be 8 h between each dose. With dosages that are more frequent than twice a day, the dosage intervals will, in practice, often vary during the course of the day. Maintenance dose can be also administered after loading dose to maintain the plasma concentration of the drug.

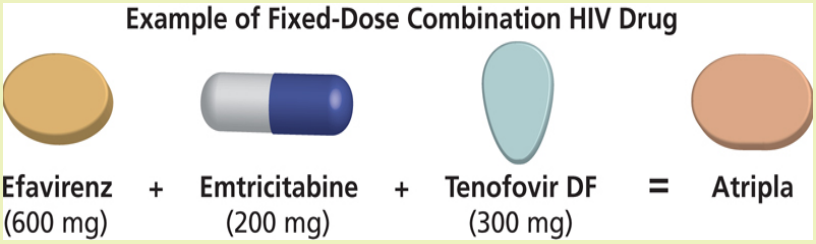
Self- assessment 1.11

1. Give the difference between the loading dose and maintenance dose
2. What are the difference between dose and dosage?
3. A client was diagnosed with malaria and is taking quinine by oral route. The medical prescription indicate that the patient will take 10mg per Kg per day in 3 times (every 8hours). Explain why the patient have to take the medication every 8 hours

1.12. Fixed dose combinations (FDCs)

Learning activity 1.12





1. What do you observe on this image?
2. Atripla is combination of which drug?

CONTENT SUMMARY

Good adherence to medication is one of the cornerstones of successful management of chronic diseases. Unfortunately, such adherence is often difficult to achieve and estimates suggest that only 50% of all chronic disease patients are able to adhere to treatment. Fixed dose combinations (FDCs) are defined as a combination of two or more active ingredients within a single form of pharmaceutical administration.

They have been shown to appreciably reduce the risk of medication non adherence, which is particularly important in patients with chronic diseases. An example of a fixed-dose combination (FDC) HIV drug is Atripla (a combination of efavirenz, emtricitabine, and tenofovir disoproxil fumarate) and Bactrim (sulfamethoxazole + trimethoprim). By reducing the number of pills a person must take each day, fixed-dose combination drugs can help improve adherence to treatment regimen.

It is widely accepted that most drugs should be formulated as single compounds. Fixed ratio combination products are acceptable only when the dosage of each ingredient meets the requirement of a defined population group and when the combination has a proven advantage over single compounds administered separately in therapeutic effect, safety or compliance

The rationality of FDCs should be based on certain aspects such as: The drugs in the combination should act by different mechanisms, the pharmacokinetics must not be widely different and the combination should not have supra-additive toxicity of the ingredients.

Table: Advantages and Disadvantages of FDCs

Advantages of FDCs	Disadvantages of FDCs
Decreased pill burden Better adherence Prescription errors less likely Patients unable to take partial regimen Experience of FDCs with other diseases such as tuberculosis, malaria etc. Practical for management in large programs (improved drug supply systems) Cheaper in generic form	Does not accommodate lead-in dose Difficult to use when dose adjustments are needed (ex, renal failure) Need to stop FDC for adverse drug reaction to one component Limited availability of pediatric formulations More expensive if generic version of one or more components available

1.13 Directly observed therapy (DOT)

Learning activity 1.13

1. What do you observe on this image?
2. Explain why it is necessary to take drug while the nurse is observing

CONTENT SUMMARY

Directly observed therapy (DOT) is used to ensure that the person receives and takes all medications as prescribed and to monitor response to treatment. DOT is widely used to manage tuberculosis (TB) disease. In HIV treatment, DOT is sometimes called directly administered antiretroviral therapy (DAART).

The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) recommend directly observed therapy (DOT) for TB treatment to monitor and provide treatment support for affected people whenever feasible. When implemented properly, DOT fosters high levels of treatment adherence and early detection of adherence problems, adverse drug reactions, and worsening TB symptoms.

Even if a proposed drug treatment is the optimal choice for a disease, it will not be effective without patient compliance (the extent to which patients follow instructions).

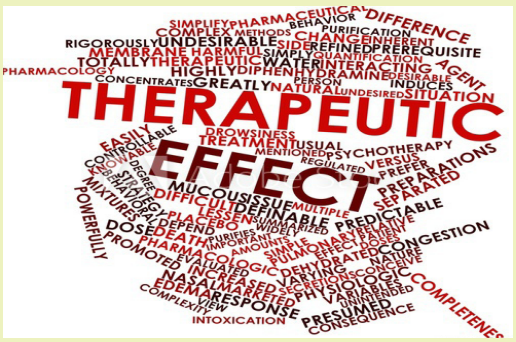
There are causes and many possible r**easons for patient noncompliance**: the patient suffers adverse effects, the patient does not think the drug is effective, the patient forgets to take the drug, the patient believes the disease is cured because the symptoms have abated, the patient has misunderstood the user instructions, the patient has run out of the drug, the patient does not master the administration technique, e.g. inhalation, the drug formulation is unsuitable, the drug is unacceptable, e.g. unpleasant taste, the patient uses many drugs simultaneously (polypharmacy), frequent dosages and the patient has other objections towards the use of a certain drug. In relation to drug therapy, the patient is compliant if he or she cooperates fully in taking a prescribed medication following medical recommendations.

Self- assessment 1.13

1. Why does WHO recommend Direct Observed Therapy (DOT) for patient taking anti-tuberculosis drugs?

1.14. Therapeutic effect

Learning activity 1.14



1. What do you observe on this image?
2. Discus the importance of taking the medication as prescribed?

CONTENT SUMMARY

The main purpose of taking the medication is to achieve the therapeutic effect. Therapeutic effect refers to the response after a treatment of any kind, the results of which are judged to be desirable and beneficial. Therapeutic effects vary with the nature of the medication, the length of time drugs was received and also vary with client physical condition and interaction other drugs.

The effect of a drug can be described at several levels: on the whole body, the organ system(s), targets cell or at molecular target within cells.

A single drug may have many effects other than its main therapeutic effect, and in some instances these secondary effects and the responses they produce may not be known in detail. Ideally, it is desirable that drugs should be as specific as possible. This means that they should produce effects in as few organ systems as possible other than those in which an effect is required. The treatment can then be controlled to achieve the desired effect.

Drug response can be impacted by several factors including diet, comorbidities, age, weight, drug–drug interactions, and genetics. Individual genetic variation in key genes involved in the metabolism, transport, or drug target can contribute to risk of adverse events or treatment failure.

Self- assessment 1.14

1. Explain therapeutic effect?
2. Enumerate the factors affecting therapeutic effect of drug?

1.15. Side effects

Learning activity 1.15

1. Read the book of pharmacology and explain side effects (using the library text books).

CONTENT SUMMARY

An undesirable secondary effect which occurs in addition to the desired therapeutic effect of a drug or medication is called side effect. It may vary for each individual depending on the person's disease state, age, weight, gender, ethnicity and general health. All drugs have desirable or undesirable side effects. Even with a correct drug dosage, side effects occur and are predicted.

The terms side effects and adverse reactions are sometimes used interchangeably in the literature and in speaking, but they are different. Some side effects are expected as part of drug therapy. The occurrence of these expected but undesirable side effects is not a reason to discontinue therapy.

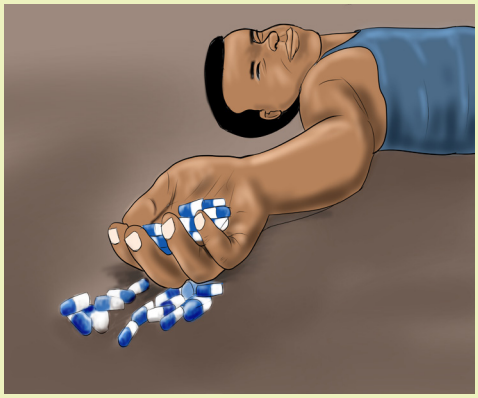
Side effects can occur when commencing, decreasing/increasing dosages, or ending a drug or medication regimen. Side effects may also lead to non-compliance with prescribed treatment. When side effects of a drug or medication are severe, the dosage may be adjusted or a second medication may be prescribed. Lifestyle or dietary changes may also help to minimize side effects.

Self- assessment 1.15

1. What a nurse can do if the patient develops the side effect after administrating the drug?
2. Give an example where side effects may be desirable?

1.16 Adverse reactions

Learning activity 1.16



1. What do you observe on this image?
2. What do you thing happened to this person?
3. What can you do in this situation?

CONTENT SUMMARY

When the patient is taking the medications he/she can develop some effect which is not desirable and severe which is called **adverse effects**. The adverse effects can be classified into dose-related and non-dose-related effects.

Dose-related adverse effects are associated with the drug's known pharmacological effects and occur when drugs are used in therapeutic doses. In principle, they are predictable. All users will experience these adverse effects if the dose is high enough. Often, an increase in the concentration of the drug due to reduced elimination, or drug interactions which potentiate the effect, can be responsible for such adverse effects. Toxic effects are included in this group.

Non-Dose-Related Adverse Effects: In principle, all effects of drugs depend on the dose that is taken (with a zero dose, there are no effects or adverse effects). When adverse effects are classified as nondose- related, this means that such effects occur at doses or concentrations that are considerably lower than the standard dose known to produce a therapeutic effect. Such adverse effects are not predictable, unless a patient has experienced them before. Typically, only a few individuals experience non-dose-related adverse effects. Allergic reactions are included in this group.

Adverse reactions:

Adverse reactions to medications can vary in severity and are more severe than typical side effects. These reactions are classified into several types to better understand their nature and origins.

1. Type A (Augmented) Reactions

Type A reactions are the most common, accounting for 80–90% of all adverse drug reactions. These reactions are dose-dependent and predictable based on the drug's pharmacological properties. They can range from mild to severe side effects, including life-threatening conditions such as anaphylaxis (cardiovascular collapse). Adverse reactions are always undesirable and must be reported and documented as they represent deviations from planned therapy.

2. Type B (Bizarre) Reactions

Type B reactions are less common and account for a smaller percentage of adverse drug reactions. These reactions are dose-independent and unpredictable, often resulting from hypersensitivity or allergic responses. Examples include anaphylaxis from penicillin or Stevens-Johnson syndrome from certain medications.

3. Type C (Chronic) Reactions

Type C reactions occur due to long-term drug use and are typically dose- and time-related. An example is adrenal suppression from prolonged corticosteroid use. These reactions develop over an extended period of time, and ongoing evaluation of long-term medication use is required to prevent chronic toxicity.

4. Type D (Delayed) Reactions

Type D reactions become apparent only after some time has passed since the drug was taken. They can include carcinogenic and teratogenic effects, such as cancer from certain chemotherapeutic agents. Long-term follow-up is necessary to detect these delayed effects.

5. Type E (End-of-use) Reactions

Type E reactions occur when a drug is stopped, especially if it is stopped suddenly. Examples include withdrawal symptoms from opioids or rebound hypertension after stopping clonidine. Gradual tapering of the drug dosage may be required to avoid withdrawal symptoms.

Toxic Effects (Toxicity)

Toxicity is an adverse drug reaction caused by excessive dosing. For drugs with a wide therapeutic index, the therapeutic ranges are seldom given. However, for drugs with a narrow therapeutic index, such as aminoglycoside antibiotics and

anticonvulsants, the therapeutic ranges are closely monitored. When the drug level exceeds the therapeutic range, toxic effects are likely to occur from overdosing or drug accumulation. Regular monitoring of drug levels is essential to prevent toxic effects, particularly for drugs with a narrow therapeutic index.

Manifestation of ADRs

Effects most often manifest as changes in organ function. These may include:

- Changes in the appearance of the skin.
- Changes in the function of the respiratory, cardiovascular, and nervous systems.
- Changes in bone marrow function and the gastrointestinal tract.

The liver and kidneys are particularly vulnerable due to high drug and metabolite concentrations during drug elimination.

Responsibility for Reducing ADRs

- **Pharmaceutical Industry**: Strive to produce the safest medicines possible.
- **Prescribers**: Select the least harmful medicine for a particular patient.
- **Nurses**: Evaluate patients for adverse reactions, educate patients on minimizing harm, and monitor for signs of adverse reactions.
- **Patients and Families**: Watch for signs of adverse reactions and seek medical attention if one appears.

Anticipation and Monitoring

Anticipating adverse reactions can help minimize them. Both healthcare providers and patients should be aware of the major adverse reactions a drug can produce. This knowledge allows early identification and timely intervention to minimize harm. Certain drugs are toxic to specific organs, requiring monitoring of the target organ's function.

- **Liver Toxicity**: Monitor for signs of liver damage (jaundice, dark urine, light-colored stools, nausea, vomiting, malaise, abdominal discomfort, loss of appetite) and perform periodic Liver Function Tests.
- **Kidney Toxicity**: Conduct routine urinalysis and measure serum creatinine; periodic tests of creatinine clearance should also be performed.
- **Bone Marrow Toxicity**: Periodic blood cell counts are required.

Individualizing Therapy

When choosing a drug, the prescriber must balance potential risks versus probable benefits. Drugs likely to harm a specific patient should be avoided. For example, avoiding penicillin in patients with a known allergy and selecting safe alternatives for pregnant patients to protect the fetus.

Vulnerable Populations

Patients with chronic disorders, such as hypertension, epilepsy, heart disease, and psychoses, are especially vulnerable to adverse reactions. Long-term drug use requires informing patients about potential adverse effects and monitoring for their appearance.

Adverse reactions to medications can be more severe and potentially harmful compared to typical side effects. These reactions are categorized into several types to better understand their nature and origins. Here are the classifications:

Table illustrating different Types adverse drug reactions to Medication

Type	ADRs (adverse reactions)	Definition	Example
Type A	**(Augmented) Reactions**	These are dose-dependent and predictable based on the drug's pharmacological properties.	Common examples include hypoglycemia from insulin or bleeding from anticoagulants.
Type B	**(Bizarre) Reactions**	These are dose-independent and unpredictable. They often result from hypersensitivity or allergic reactions.	Examples include anaphylaxis from penicillin or Stevens-Johnson syndrome from certain medications.
Type C	**(Chronic) Reactions**	These reactions occur due to long-term drug use and are typically dose- and time-related	An example is adrenal suppression from prolonged corticosteroid use.
Type D	**(Delayed) Reactions**	These reactions become apparent only after some time has passed since the drug was taken.	They can include carcinogenic and teratogenic effects, such as cancer from certain chemotherapeutic agents
Type E	**(End-of-use) Reactions:**	These reactions occur when the drug is stopped, especially if it is stopped suddenly.	Examples include withdrawal symptoms from opioids or rebound hypertension after stopping clonidine.

Self- assessment 1.16

1. What does the nurse have to do when the client develops allergic reaction to the drugs?
2. Discusses the concept of adverse drug reactions and drug side effects
3. 30-year-old women client came to the health post where you work. She is complaining hearing problem (tinnitus) 3 day ago after taking quinine. How will you explain to the client about the symptom she developed after taking quinine?
4. Adverse drug reactions (ADRs) are mainly classified into five categories. Describe the characteristics and differences between Type A and Type B adverse drug reactions. Include examples of each type and explain their predictability, dose-dependence, and potential severity?

	Type A (Augmented) Reactions	**Type B (Bizarre) Reactions**
Characteristics:		
Examples:		
Predictability:		
Dose-Dependence:		
Severity:		

1.17 Antidotes

Learning activity 1.17

1. Read the book of pharmacology and explain antidote (using library books)

CONTENT SUMMARY

During the drugs administration the patient can experience any unusual reaction which can be reversed by administering another drug that acts as an **antidote**. For example, when too much opiate is taken, the drug naloxone may be given to counteract the effect. It is very important to monitor the drugs closely to detect or to avoid any unusual reaction and have different antidotes at health facility which can be used in case of overdose to prevent the complication associated. **An antidote is a drug, chelating substance, or a chemical that counteracts (neutralizes) the effects of another drug or a poison.**

There are dozens of different antidotes; however, some may only counteract one particular drug, whereas others (such as charcoal) may help reduce the toxicity of numerous drugs. Antidotes mediate its effect either by preventing the absorption of the toxin, by binding and neutralizing the poison, antagonizing its end-organ effect, or by inhibition of conversion of the toxin to more toxic metabolites.

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 from damage to the eighth cranial nerve caused by toxic reaction to the anti-infective drug streptomycin may be permanent. Sometimes drug toxicity can be reversed by administering another drug that acts as an **antidote**. For example, when too much opiate is taken, naloxone may be given to counteract the effect.

The FDA encourages nurses and other health care providers to report medication errors to its database, which is used to assist other professionals in avoiding similar mistakes. Poisoning occurs when an overdose of a drug damages multiple body systems, leading to the potential for fatal reactions. Antidotes for drugs that can cause potentially dangerous or fatal reactions must always be readily available. Assessment parameters vary with the particular drug.

Treatment of drug poisoning also varies, depending on the drug. Emergency and life support measures often are needed in severe cases. Although some medication errors go unreported, it is always the nurse's legal and ethical responsibility to document all occurrences. In severe cases, adverse reactions caused by medication errors may require the initiation of lifesaving interventions for the patient, including available antidotes. After such an incident, the patient may require close supervision, and additional medical treatments may be warranted.

According to mode of action the antidote can be classified as physical, chemical and physiological and pharmacological. Physical antidote the agent use to interfere with poison through physical properties by adsorbing. Chemical antidote interacts specifically with a toxicant, or neutralize the toxicant. Physiological antidote act by producing opposite effect to that of poison. Pharmacological antidote counteracts the effects of a poison by producing the opposite pharmacological effects. They may neutralize or antagonize the effects of a toxicant.

According to site of action the antidote may act by preventing the formation of toxic metabolites, by facilitation of more rapid or complete elimination of toxicant, and by competing with the toxicant's action at a receptor site. For preventing the formation of toxic metabolites: more effective when given immediately before toxic metabolic activation. For facilitation of more rapid or complete elimination of toxicant: change the physiochemical nature of toxin, allowing better glomerular filtration and prohibit tubular reabsorption.

Self- assessment 1.17

1. Explain the mechanism of action of the antidote?
2. Give example of drug toxicity which can be reversible or irreversible, depending on the organs involved

1.18 Responsibilities of nurses regarding safe drug administration

Learning activity 1.18

1. What is the role of nurse and responsibilities in medication administration?

CONTENT SUMMARY

Nurses have a critical role in the safe administration of medications to patients. Their duties involve multiple aspects aimed at reducing adverse drug reactions and maintaining patient safety. Key responsibilities include:

Nurses have a unique and vital role in medication administration, often serving as the final checkpoint to verify that the medication is correctly prescribed and dispensed before it is administered.

1. Knowledge

- **Understanding Medications**: Nurses must have a thorough understanding of the medications they administer, including their therapeutic effects, potential side effects, and adverse reactions and engaging in ongoing education and training to stay updated on new medications, protocols, and best practices in drug administration.

2. Assessment and Monitoring

- **Patient Assessment**: Conducting comprehensive assessments of patients before administering medications. This includes reviewing medical history, current medications, allergies, and potential contraindications.
- **Monitoring**: Regularly monitoring patients for therapeutic effects and signs of adverse reactions or toxicity, and documenting these observations accurately.

3. Medication Administration

- **Following Protocols**: Adhering to established protocols and guidelines for medication administration, including the patient right in drug administration,
- **Dosage Calculation**: Accurately calculating and verifying medication dosages, particularly for high-risk drugs with narrow therapeutic indexes.

- **Proper Techniques**: Using proper techniques for different routes of administration (oral, intravenous, intramuscular, etc.) to ensure the effectiveness and safety of the medication.

4. Patient Education

- **Informing Patients**: Educating patients about the medications they are receiving, including the purpose, expected effects, potential side effects, and the importance of adherence to the prescribed regimen, where necessary Teaching the patients how to self-administer medications safely, if applicable, and providing instructions on recognizing and responding to adverse reactions.

5. Documentation and Reporting

- **Accurate Documentation**: Recording all administered medications accurately in the patient's medical record, including the time, dose, route, and any observations related to the administration.
- **Adverse Reaction Reporting**: Promptly reporting any adverse drug reactions or medication errors to the appropriate authorities and healthcare team members to ensure timely intervention and to contribute to safety monitoring efforts.

6. Collaboration and Communication

- **Interdisciplinary Collaboration**: Collaborating with other healthcare professionals, including physicians and pharmacists, to ensure comprehensive care and safe medication practices.
- **Clear Communication**: Communicating clearly and effectively with patients, their families, and the healthcare team regarding medication regimens, changes in therapy, and any observed reactions or concerns.

7. Medication Reconciliation

- **Verification**: Ensuring that the patient's medication list is accurate and up-to-date, especially during transitions of care (e.g., hospital admission, transfer, discharge).
- **Consistency**: Comparing the patient's current medication orders with the previous ones to avoid discrepancies and potential drug interactions.

8. Ethical and Legal Considerations

- **Patient Advocacy**: Advocating for patient safety by ensuring that medications are prescribed appropriately and questioning orders that appear unsafe or unclear.
- **Legal Compliance**: Adhering to legal requirements and institutional policies regarding medication administration and handling.

Self- assessment 1.18

1. How do you verify that the medication is correctly prescribed?
2. What steps do you take to ensure the medication is correctly dispensed?
3. How do you ensure that you are administering the right medication to the right patient?
4. What protocols do you follow to ensure the correct dosage is administered?
5. How do you confirm the right route of administration for a medication?

1.19. Food and drug administration (FDA) pregnancy risk categories

Learning activity 1.19

1. Read the book of pharmacology and explain why pregnant women cannot take any drugs without medical prescription (using library textbook).

CONTENT SUMMARY

Drugs used by pregnant women may reach the fetus through the placenta and lead to effects on the development, intellectual ability, birth defects, miscarriage and stillbirth. The Food and Drug Administration has established five categories (A, B, C, D & X) to indicate the potential for a systemically absorbed drug to cause birth defects. The key differentiation among the categories

Category A**: Adequate and well-controlled studies have failed to demonstrate a risk** to the fetus in the first trimester of pregnancy (and there is no evidence of risk in later trimesters). Example drugs or substances: levothyroxine, folic acid, liothyronine.

Category B: Animal reproduction studies have failed to demonstrate a risk to the fetus and there are no adequate and well-controlled studies in pregnant women. Example drugs: metformin, hydrochlorothiazide, cyclobenzaprine, amoxicillin.

Category C: Animal reproduction studies have shown an adverse effect on the fetus and there are no adequate and well-controlled studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks. Example drugs: gabapentin, amlodipine, trazodone.

Category D: There is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience or studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks. Example drugs: losartan.

Category X: Studies in animals or humans have demonstrated fetal abnormalities and/or there is positive evidence of human fetal risk based on adverse reaction data from investigational or marketing experience, and the risks involved in use of the drug in pregnant women clearly outweigh potential benefits. Example drugs: atorvastatin, simvastatin, methotrexate, finasteride

Regardless of the designated Pregnancy Category or presumed safety, no drug should be administered during pregnancy unless it is clearly needed.

Self- assessment 1.19

1. Describe FDA pregnancy risk categories?

End Unit assessment 1

1. Define pharmacology
2. List 4 drugs dosage forms
3. What are the sources of drug?
4. Give the difference between loading dose and maintenance dose
5. The nurse knows the importance of administering the right medication to the patient and that drugs have many names. It is therefore important that drugs be ordered by which name?
6. Explain the importance of directly observed therapy in patient care
7. Explain the importance of fixed dose combination in patient care
8. How medication administration errors can be prevented?
9. What are the responsibilities of the nurse during drug administration?
10. Clinical pharmacology is the study of

    A. The biological effects of chemicals.

    B. Drugs used to treat, prevent, or diagnose disease.

    C. Plant components that can be used as medicines.

    D. Binders and other vehicles for delivering medication.

11. The generic name of a drug is

    A. The name assigned to the drug by the pharmaceutical company developing it.

    B. The chemical name of the drug based on its chemical structure.

    C. The original name assigned to the drug at the beginning of the evaluation process.

    D. The name that is often used in advertising campaigns.

12. The Food and Drug Administration (FDA) pregnancy categories

    A. Indicate a drug's potential or actual teratogenic effects.

    B. Are used for research purposes only.

    C. List drugs that are more likely to have addicting properties.

    D. Are tightly regulated by the Drug Enforcement Agency (DEA).

13. Give the definition for a therapeutic dose:

A. The amount of a substance to produce the minimal biological effect

B. The amount of a substance to produce effects hazardous for an organism

C. The amount of a substance to produce the required effect in most patients

D. The amount of a substance to accelerate an increase of concentration of medicine in an organism

14. Pick out the correct definition of a toxic dose:

A. The amount of substance to produce the minimal biological effect

B. The amount of substance to produce effects hazardous for an organism

C. The amount of substance to produce the necessary effect in most of patients

D. The amount of substance to fast creation of high concentration of medicine in an organism

15. A rectal suppository is used to treat fever. This would represent what type of drug delivery?

A. Parenteral and local

B. Parenteral and systemic

C. Enteral and local

D. Enteral and systemic

16. Which of the following is not a semisolid dosage forms?

A. Solution

B. Cream

C. Paste

D. Gel

17. A suppository is generally intended for use in

A. Rectum

B. Ear

C. Nose

D. Mouth

18. Vaginal suppositories also called as

A. Simple suppositories

B. Bougies

C. Pessaries

D. Soft tablet

19. The nurse is reviewing the various forms of topical medications. Which of these are considered topical medications?

A. Tablets for oral route

B. Eye drops for inflammation

C. Sublingual tablet for chest pain

D. Intradermal injection for tuberculosis testing

20. An 82-year-old patient is admitted to the hospital after an episode of confusion at home. The nurse is assessing the current medications he is taking at home. Which method is the best way to assess his home medications?

A. Ask the patient what medications he takes at home.

B. Ask the patient's wife what medications he takes at home.

C. Ask the patient's wife to bring his medications to the hospital in their original containers.

D. Contact the patient's pharmacy for a list of the patient's current medications.

21. During the medication administration process, it is important that the nurse remembers which guideline?

A. When in doubt about a drug, ask a colleague about it before giving the drug.

B. Ask what the patient knows about the drug before giving it.

C. When giving a new drug, be sure to read about it after giving it.

D. If a patient expresses a concern about a drug, stop, listen, and investigate the concerns.

22. A patient's medical record includes an order that reads as follows: "Pacetamol 500 mg once daily at 09h00." Which action by the nurse is correct?

A. The nurse does not give the drug.

B. The nurse gives the drug orally.

C. The nurse gives the drug intravenously.

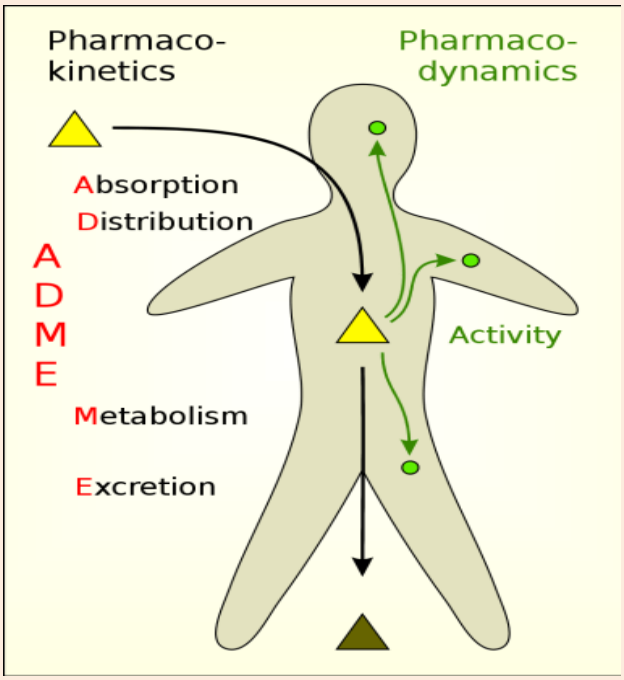
D. The nurse contacts the prescriber to clarify the dosage route.

UNIT 2 PHARMACOKINETICS AND PHARMACODYNAMICS

Key Unit Competence

Explain the application of pharmacokinetcs and pharmacodynamics during clinical practice

2.0 Introductory activity



1. That image above represents a patient who has ingested a drug. What do you think the arrows in the image indicate?
2. In your daily life, what do you think happens in the body after ingestion of medications (tablets)?

2.1 Introduction to Pharmacokinetics

Learning activity 2.1

You are placed at a health post in the clinical placement, and the patient consults for his medical condition follow up. As he has a chronic disease, you inquire about his health status, focusing on kidney function, bearing in mind that the drug is eliminated via the urinary system. Then your colleague says that he heard that pharmacokinetics of each needs to be taken into consideration while prescribing a drug. He is curious, and would like to get more explanations from you.

1. How can you briefly explain the word “pharmacokinetics” to your colleague?
2. Mention 4 phases/processes of pharmacokinetics.

CONTENT SUMMARY

Pharmacokinetics, sometimes described as what the body does to a drug, refers to the movement of drug into, through, and out of the body.

Pharmacokinetics involves the study of absorption, distribution, metabolism (biotransformation), and excretion of drugs. In clinical practice, pharmacokinetic considerations include the onset of drug action, drug half-life, timing of the peak effect, duration of drug effects, metabolism or biotransformation of the drug, and the site of excretion.

Critical Concentration

After a drug is administered, its molecules first must be absorbed into the body; then they make their way to the reactive tissues. If a drug is going to work properly on these reactive tissues, and thereby have a therapeutic effect, it must attain a sufficiently high concentration in the body. The amount of a drug that is needed to cause a therapeutic effect is called the critical concentration.

Drug evaluation studies determine the critical concentration required to cause a desired therapeutic effect. The recommended dose of a drug is based on the amount that must be given to eventually reach the critical concentration. Too much of a drug will produce toxic (poisonous) effects, and too little will not produce the desired therapeutic effects.

Loading Dose

Some drugs may take a prolonged period to reach a critical concentration. If their effects are needed quickly, a loading dose is recommended.

Dynamic Equilibrium

The actual concentration that a drug reaches in the body results from a dynamic equilibrium involving several processes:

1. Absorption from the site of entry
2. Distribution to the active site
3. Biotransformation (metabolism) in the liver
4. Excretion from the body

These processes are key elements in determining the amount of drug (dose) and the frequency of dose repetition (scheduling) required to achieve the critical concentration for the desired length of time. When administering a drug, the nurse needs to consider the phases of pharmacokinetics so that the drug regimen can be made as effective as possible.

Self- assessment 2.1

1. There are some drugs that may take a prolonged period to reach a critical concentration. If their effects are needed quickly, a maintenance dose is recommended. (True or False)
2. A right sequence of pharmacokinetic processes for a drug given by oral route is:

   A. Absorption, Distribution, Biotransformation and Excretion

   B. Distribution, Absorption, Biotransformation and Excretion

   C. Biotransformation, Absorption, Distribution, and Excretion

   D. Excretion, Absorption, Distribution, and Metabolism

Source: Library textbooks of pharmacology (Karch, A.M. (2013). Focus on Nursing Pharmacology): On chapter of pharmacokinetics and pharmacodynamics.

2.2 Absorption of drugs

Learning activity 2.2

A patient X was received at the health post presenting severe respiratory disease. An associate nurse student in clinical practice suggests administering a drug via oral route but the nurse tells him to administer injectable drug rather than oral drug, as the injectable form can work quickly.

1. Referring to drug absorption, explain why the nurse preferred injectable drug form.
2. List at least 3 factors that can affect absorption of drugs administered by oral route.

CONTENT SUMMARY

Absorption refers to what happens to a drug from the time it is introduced to the body until it reaches the circulating fluids and tissues. Drugs can be absorbed from many different areas in the body: through the GI tract either orally or rectally, through mucous membranes, through the skin, through the lung, or through muscle or subcutaneous tissues.

Drug absorption is influenced by the route of administration. Generally, drugs given by the oral route are absorbed more slowly than those given parentally. Of the parenteral route, IV administered drugs are absorbed the fastest.

Routes of Administration

The oral route is the most frequently used drug administration route in clinical practice. Oral administration is not invasive, and, as a rule, oral administration is less expensive than drug administration by other routes. It is also the safest way to deliver drugs. Patients can easily continue their drug regimen at home when they are taking oral medications. Oral administration subjects the drug to a number of barriers aimed at destroying ingested foreign chemicals. The acidic environment of the stomach is one of the first barriers to foreign chemicals.

The acid breaks down many compounds and inactivates others. This fact is taken into account by pharmaceutical companies when preparing drugs in capsule or tablet form. The binders that are used often are designed to break down in ascertain acidity and release the active drug to be absorbed.

When food is present, stomach acidity is higher and the stomach empties more slowly, thus exposing the drug to the acidic environment for a longer period. Certain foods that increase stomach acidity, such as milk products, alcohol, and protein, also speed the breakdown of many drugs.

Other foods may chemically bind drugs or block their absorption. To decrease the effects of this acid barrier and the direct effects of certain foods, oral drugs ideally are to be given 1 hour before or 2 hours after a meal.

Drugs that are injected IM (intramuscularly) are absorbed directly into the capillaries in the muscle and sent into circulation. This takes time because the drug must be picked up by the capillary and taken into the veins. Men have more vascular muscles than women do. As a result, drugs administered to men via the IM route reach a peak level faster than they do in women. Subcutaneous injections deposit the drug just under the skin, where it is slowly absorbed into circulation. Timing of absorption varies with subcutaneous injection, depending on the fat content of the injection site and the state of local circulation.

Absorption Processes: Drugs can be absorbed into cells through various processes, which include passive diffusion and filtration.

Passive diffusion is the major process through which drugs are absorbed into the body. Passive diffusion occurs across a concentration gradient.

When there is a greater concentration of drug on one side of a cell membrane, the drug will move through the membrane to the area of lower concentration. This process does not require any cellular energy. Unlike passive diffusion, active transport is a process that uses energy to actively move a molecule across a cell membrane. The molecule may be large, or it may be moving against a concentration gradient. This process is not very important in the absorption of most drugs, but it is often a very important process in drug excretion in the kidney.

Filtration involves movement through pores in the cell membrane, either down a concentration gradient or as a result of the pull of plasma proteins (when pushed by hydrostatic, blood, or osmotic pressure). Filtration is another process the body commonly uses in drug excretion.

TABLE 2.2 Factors that affect absorption of drugs

Factors That Affect Absorption of Drugs	
ROUTE	**FACTORS AFFECTING ABSORPTION**
Intravenous	None: Direct entry into the venous system
Intramuscular	• Perfusion or blood flow to the muscle • Fat content of the muscle • Temperature of the muscle: Cold causes vasoconstriction and decreases absorption; heat causes vasodilation and increases absorption

Subcutaneous	• Perfusion or blood flow to the tissue • Fat content of the tissue • Temperature of the tissue: cold causes vasoconstriction and decreases absorption; heat causes vasodilation and increases absorption
PO (oral)	• Acidity of stomach • Length of time in stomach • Blood flow to gastrointestinal tract • Presence of interacting foods or drugs
PR (rectal)	• Perfusion or blood flow to the rectum • Lesions in the rectum • Length of time retained for absorption
Mucous membranes (sublingual, buccal)	• Perfusion or blood flow to the area Integrity of the mucous membranes Presence of food or smoking Length of time retained in area
Mucous membranes (sublingual, buccal)	• Perfusion or blood flow to the area Integrity of the mucous membranes Presence of food or smoking Length of time retained in area
Topical (skin)	• Perfusion or blood flow to the area Integrity of skin
Inhalation	• Perfusion or blood flow to the area Integrity of lung lining Ability to administer drug properly

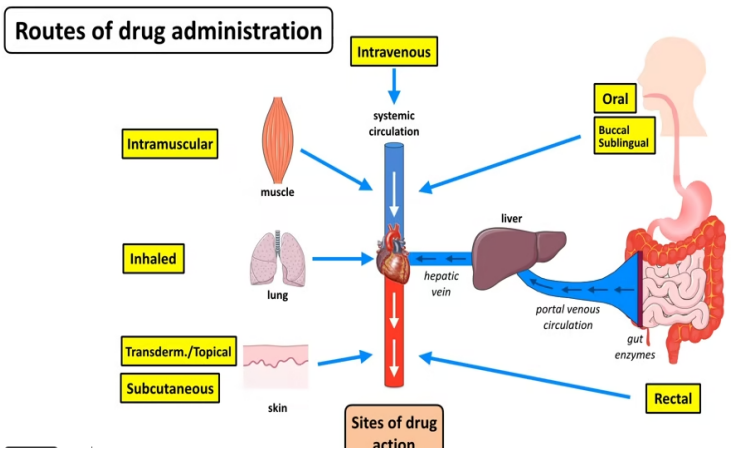


***Figure**: Drug absorption into the body*

Self- assessment 2.2

Multiple choice questions

1. Which of the following drug transport ways requires energy in drug movement in aqueous diffusion model?

   A. Active transport

   B. Facilitated transport

   C. Passive transport

   D. Filtration

2. Identify the factors that can affect the absorption of the drugs administered by the following routes:

   A. IM (Intramuscularly)

   B. SC (Subcutaneously)

   C. IV (Intravenously)

2.3 Distribution of drugs

Learning activity 2.3

Read the scenario below:

A 37-year-old female patient consults the health faciluty for her localized leg infection. She is known as a diabetic for the last 10 years, and has developed circulatory complications that affected different body parts including the lower limbs. This infection can be treated by drugs that can act by either topical way or systemic way. The nurse taking care of this patient is doubting the right mode to use, and she wants to get advice from you as a student associate nurse carrying out the clinical practice in her health post. You then advise him to choose the drug that will work topically rather than the one that acts systemically.

1. Referring to the process of drug distribiution, why did you advise the nurse to prescribe the drug that acts topically?
2. Name 2 organs with high blood flow that are first to accumulate drugs which are administered systemically?

CONTENT SUMMARY

Once a drug has been absorbed from the stomach and/or intestines (GI Tract) into the blood, it is circulated to some degree to all areas of the body to which there is blood flow. This is the process of **distribution**. Organs with high blood flow, i.e., brain, heart, liver, etc. are the first to accumulate drugs, while connective tissue and lesser-perfused organs are the last. The pattern of distribution of drug molecules by different tissues after the chemical enters the circulatory system varies.

Because of differences in pH, lipid content, cell membrane functions, and other individual tissue factors, most drugs are not distributed equally in all parts of the body. For example, the acidity of aspirin influences a distribution pattern that is different from that of an alkaline product such as amphetamine. In same context, tissue perfusion is a factor in treating a patient with diabetes who has a lower-leg infection and needs antibiotics to destroy the bacteria in the area. In this case, systemic drugs may not be effective because part of the disease process involves changes in the vasculature and decreased blood flow to some areas, particularly the lower limbs. If there is not adequate blood flow to the area, little antibiotic can be delivered to the tissues, and little antibiotic effect will be seen. In addition, patients in a cold environment may have constricted blood vessels (vasoconstriction) in the extremities, which would prevent blood flow to those areas. The circulating blood would be unable to deliver drugs to those areas, and the patient would receive little therapeutic effect from drugs intended to react with those tissues.

Many drugs are bound to plasma proteins such as albumin, and are not lipid soluble. These drugs cannot be distributed to the central nervous system (CNS) because of the effective blood–brain barrier (see later discussion), which is highly selective in allowing lipid-soluble substances to pass into the CNS. Since only drugs that are not bound are free to exert a pharmacologic effect, the ratio of “free” to “bound” drug is important in determining the onset and duration of action of drugs. Highly bound drugs are distributed less extensively throughout the body and are slower to act. By virtue of their high binding to plasma proteins, they also stay in the body for longer periods of time because the binding sites act as a sort of “reservoir” for the drug, releasing drug molecules slowly.

Protein Binding

Most drugs are bound to some extent to proteins in the blood to be carried into circulation. The protein–drug complex is relatively large and cannot enter into capillaries and then into tissues to react. The drug must be freed from the protein’s binding site at the tissues.

Some drugs are tightly bound and are released very slowly. These drugs have a very long duration of action because they are not free to be broken down or excreted. Therefore, they are released very slowly into the reactive tissue. Some

drugs are loosely bound; they tend to act quickly and to be excreted quickly. Some drugs compete with each other for protein binding sites, altering effectiveness or causing toxicity when the two drugs are given together.

Blood–Brain Barrier

The blood–brain barrier is a protective system of cellular activity that keeps many things (e.g., foreign invaders, poisons) away from the CNS. Drugs that are highly lipid soluble are more likely to pass through the blood–brain barrier and reach the CNS. Drugs that are not lipid soluble are not able to pass the blood–brain barrier. This is clinically significant in treating a brain infection with antibiotics. Almost all antibiotics are not lipid soluble and cannot cross the blood–brain barrier. Effective antibiotic treatment can occur only when the infection is severe enough to alter the blood–brain barrier and allow antibiotics to cross.

Although many drugs can cause adverse CNS effects, these are often the result of indirect drug effects and not the actual reaction of the drug with CNS tissue. For example, alterations in glucose levels and electrolyte changes can interfere with nerve functioning and produce CNS effects such as dizziness, confusion, or changes in thinking ability.

Placenta and Breast Milk

Many drugs readily pass through the placenta and affect the developing fetus in pregnant women. As it has been approved, it is best not to administer any drugs to pregnant women because of the possible risk to the fetus. Drugs should be given only when the benefit clearly outweighs any risk. Many other drugs are secreted into breast milk and therefore have the potential to affect the neonate. Because of this possibility, the nurse must always check the ability of a drug to pass into breast milk when giving a drug to a breast-feeding mother.

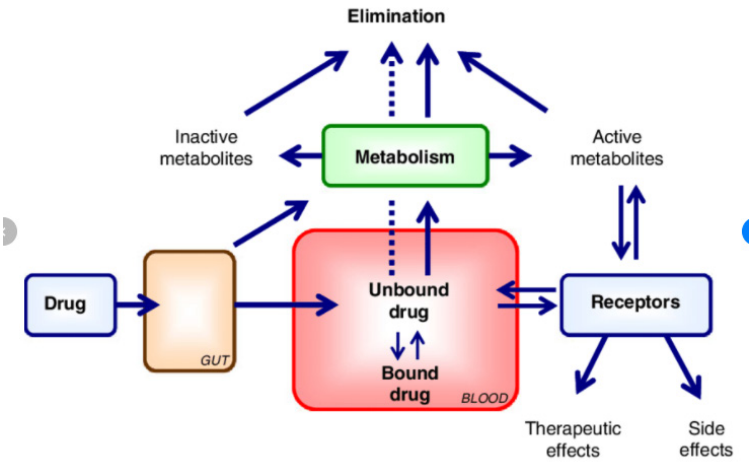


Figure: Distribution of the drug

Self- assessment 2.3

1. After absorption of the drug from the stomach and/or intestines (GI Tract) into the blood, the next pharmacokinetic step is:

   A. Absorption
   B. Excretion
   C. Distribution
   D. Metabolism

2. During drug distribution, the drugs are bound to which of the following?

   A. Proteins in the blood
   B. Lipids in blood
   C. Vitamins in blood
   D. Minerals in blood

2.4 Metabolism (Biotransformation) of drugs

Learning activity 2.4

Read the case study below and answer the questions related to it:

An 85-year-old male patient consults the health facility where you are placed as an associate nurse during the clinical placement. He also suffers from a a chronic liver disease, and he was prescribed the drugs that are metabolised in the liver. You then advise the prescribing team to inform the patient that as he is taking the drug, they need to advise adjust the dose and ensure that the patient comes for follow up at the health facility.

1. Referring to the metabolism of drugs, why did you advise the nurse to adjust the dose and follow the client up?
2. Name the main organ that is involved in metabolism of drugs.

CONTENT SUMMARY

Drugs in the blood and tissues must be inactivated and excreted from the body. This process is initiated by altering the chemical structure of the drug in such a way as to promote its excretion. The body is well prepared to deal with a myriad of foreign chemicals. Enzymes in the liver, in many cells, in the lining of the GI tract, and even circulating in the body detoxify foreign chemicals to protect the fragile homeostasis that keeps the body functioning. The transformation of the drug molecule into a chemically related substance that is more easily excreted

from the body is called **metabolism, biotransformation or detoxification**. Drug metabolism is the process by which the body breaks down and converts medication into active chemical substances. Drugs can interact with other drugs, foods, and beverages. Interactions can lessen or magnify the desired therapeutic effect of a drug, or may cause unwanted or unexpected side effects.

Exogenous compounds (xenobiotics) must be metabolized before they can be excreted. The biochemical transformation of xenobiotics, such as alcohol, nicotine and drugs is a prime activity of the liver. In addition to the liver, biotransformation processes occur in plasma, in the lungs, in the gastrointestinal tract and in the skin. The liver is the organ that plays a major role in metabolism, digestion, detoxification, and elimination of substances from the body. Think of the liver as a sewage treatment plant. Everything that is absorbed from the GI tract first enters the liver to be “treated.” The liver detoxifies many chemicals and uses others to produce needed enzymes and structures. Enzymes in the liver are responsible for chemically changing drug components into substances known as metabolites. Metabolites are then bound to other substances for excretion through the lungs, or bodily fluids such as saliva, sweat, breast milk, and urine, or through reabsorption by the intestines. The metabolic rate can vary significantly from person to person, and drug dosages that work quickly and effectively in one individual may not work well for another.

First-Pass Effect

Drugs that are taken orally are usually absorbed from the small intestine directly into the portal venous system (the blood vessels that flow through the liver on their way back to the heart). Aspirin and alcohol are two drugs that are known to be absorbed from the lower end of the stomach. The portal veins deliver these absorbed molecules into the liver, which immediately transforms most of the chemicals delivered to it by a series of liver enzymes. These enzymes break the drug into metabolites, some of which are active and cause effects in the body, and some of which are deactivated and can be readily excreted from the body. As a result, a large percentage of the oral dose is destroyed at this point and never reaches the tissues. This phenomenon is known as the first-pass effect. The portion of the drug that gets through the first pass effect is delivered to the circulatory system for transport throughout the body.

Injected drugs and drugs absorbed from sites other than the GI tract undergo a similar biotransformation when they pass through the liver. Because some of the active drug already has had a chance to reach the reactive tissues before reaching the liver, the injected drug is often more effective at a lower dose than the oral equivalent. Thus, the recommended dose for oral drugs can be considerably higher than the recommended dose for parenteral drugs, taking the first-pass effect into account

Factors that influence drug metabolism

These include:

- Genetics,
- Environment,
- Nutrition, and
- Age. **Infants** and **elderly** patients may have a reduced capacity to metabolize certain drugs, and may require adjustments in dosage.

Self- assessment 2.4

1. Which of the following factors may impact negatively the drug metabolism?

   A. Proper nutrition

   B. Advanced age (elderly)

   C. Healthy liver

   D. Healthy young person

2. Which of the following routes of drug administration would be more likely to make the drug subject to first-pass effect?

   A. Oral

   B. Intravenous

   C. Intraarterial

   D. Intranasal

2.5 Excretion of drugs

Learning activity 2.5

A patient known for chronic heart failure consults hospital for the appointment. The doctor decides to test kidney function and finds the client has developed also kidney failure. The doctor prescribes a drug eliminated by the kidneys, but reduces the dose. The client asks the doctor why to reduce the dose.

1. Referring to the excretion of the drug, what should the doctor tell the client?

CONTENT SUMMARY

Excretion is the removal of a drug from the body. The skin, saliva, lungs, bile, and feces are some of the routes used to excrete drugs. The kidneys, however, play the most important role in drug excretion. Drugs that have been made water soluble in the liver are often readily excreted from the kidney by glomerular filtration (the passage of water and water-soluble components from the plasma into the renal tubule).

Other drugs are secreted or reabsorbed through the renal tubule by active transport systems. The active transport systems that move the drug into the tubule often do so by exchanging it for acid or bicarbonate molecules. Therefore, the acidity of urine can play an important role in drug excretion.

This concept is important to remember when trying to clear a drug rapidly from the system or trying to understand why a drug is being given at the usual dose but is reaching toxic levels in the system. One should always consider the patient's kidney function and urine acidity before administering a drug. Kidney dysfunction can lead to toxic levels of a drug in the body because the drug cannot be excreted.

Half-Life

The half-life of a drug is the time it takes for the amount of drug in the body to decrease to one half of the peak level it previously achieved. For instance, if a patient takes 20 mg of a drug with a half-life of 2 hours, 10 mg of the drug will remain 2 hours after administration. Two hours later, 5 mg will be left (one half of the previous level); in 2 more hours, only 2.5 mg will remain. This information is important in determining the appropriate timing for a drug dose or determining the duration of a drug's effect on the body.

The absorption rate, the distribution to the tissues, the speed of biotransformation, and how fast a drug is excreted are all taken into consideration when determining the half-life of the drug. The half-life that is indicated in any drug monograph is the half-life for a healthy person.

Using this information, one can estimate the half-life of a drug for a patient with kidney or liver dysfunction (which could prolong the biotransformation and the time required for excretion of a drug), allowing the prescriber to make changes in the dosing schedule.

The timing of drug administration is important to achieve the most effective drug therapy. Nurses can use their knowledge of drug half-life to explain the importance of following a schedule of drug administration in the hospital or at home.

Self- assessment 2.5

1. The patient took 50 mg of drug with half-life of 2 hours at 8h00 AM. How many mgs will be remaining in the body at 12h00 PM?

   A. 25 mg
   B. 20 mg
   C. 12.5 mg
   D. 6.25 mg

2. Define what half-life is.
3. In the following organs, which one plays the most important role in excretion of a drug?

   A. The skin
   B. Saliva
   C. Lungs
   D. Kidney

2.6 Factors influencing drug effects

Learning activity 2.6

A patient is brought to the health post where you are placed as a student associate nurse, and you need to prescribe drugs for him.

It is a stunted kid who is brought by his parents, and he is aged 12 months.

1. Which factors influencing drug effects should you bear in mind for this specific patient?
2. Is it necessary to bear in mind factors that influence drug effects during its prescription?

CONTENT SUMMARY

When administering a drug to a patient, the nurse must be aware that the human factor has a tremendous influence on what actually happens to a drug when it enters the body. No two people react in exactly the same way to any given drug. Even though textbooks and drug guides explain the pharmacodynamics and pharmacokinetics of a drug, it must be remembered that such information usually is based on studies of healthy adult males. Things may be very different in the clinical setting. Consequently, before administering any drug, the nurse must consider a number of factors influencing drug effects as follows:

Weight

The recommended dose of a drug is based on drug evaluation studies and is targeted at a 150-pound (around 70 kilos) person. People who are much heavier may require larger doses to get a therapeutic effect from a drug because they have increased tissues to perfuse and increased receptor sites in some reactive tissue. People who weigh less than the norm may require smaller doses of a drug. Toxic effects may occur at the recommended dose if the person is very small.

Age

Age is a factor primarily in children and older adults. Children are not just little adults. Children metabolize many drugs differently than adults do, and they have immature systems for handling drugs. Many drugs come with recommended pediatric doses, and others can be converted to pediatric doses using one of several conversion formulas.

Elderly people undergo many physical changes that are a part of the aging process. Their bodies may respond very differently in all aspects of pharmacokinetics less effective absorption, less efficient distribution because of fewer plasma proteins and less efficient perfusion, altered biotransformation or metabolism of drugs because of age-related liver changes, and less effective excretion owing to less efficient kidneys. Many drugs now come with recommended doses for patients who are older. The doses of other drugs also may need to be decreased for the older adult.

When administering drugs to a patient at either end of the age spectrum, one should monitor the patient closely for the desired effects. If the effects are not what would normally be expected, one should consider the need for a dose adjustment.

Gender

Physiological differences between men and women can influence a drug's effect. When giving IM injections, for example, it is important to remember that men have more vascular muscles, so the effects of the drug will be seen sooner in men than in women. Women have more fat cells than men do, so drugs that deposit in fat may be slowly released and cause effects for a prolonged period. For example, gas anesthetics have an affinity for depositing in fat and can cause drowsiness and sedation sometimes weeks after surgery. Women who are given any drug should always be questioned about the possibility of pregnancy because, as stated previously, the use of drugs in pregnant women is not recommended unless the benefit clearly outweighs the potential risk to the fetus.

Physiological Factors

Physiological differences such as diurnal rhythm of the nervous and endocrine systems, acid–base balance, hydration, and electrolyte balance can affect the way

that a drug works on the body and the way that the body handles the drug. If a drug does not produce the desired effect, one should review the patient's acid–base and electrolyte profiles and the timing of the drug.

Pathological Factors

Drugs are usually used to treat disease or pathology. However, the disease that the drug is intended to treat can change the functioning of the chemical reactions within the body and thus change the response to the drug. Other pathological conditions can change the basic pharmacokinetics of a drug. For example, GI disorders can affect the absorption of many oral drugs. Vascular diseases and low blood pressure alter the distribution of drug, preventing it from being delivered to the reactive tissue, thus rendering the drug nontherapeutic. Liver or kidney diseases affect the way that a drug is biotransformed and excreted and can lead to toxic reactions when the usual dose is given.

Genetic Factors

Genetic differences can sometimes explain patients' varied responses to a given drug. Some people lack certain enzyme systems necessary for metabolizing a drug, whereas others have overactive enzyme systems that cause drugs to be broken down more quickly. Still others have differing metabolisms or slightly different enzymatic makeups that alter their chemical reactions and the effects of a given drug.

Immunological Factors

People can develop an allergy to a drug. After exposure to its proteins, a person can develop antibodies to a drug. With future exposure to the same drug, that person may experience a full-blown allergic reaction. Sensitivity to a drug can range from mild (e.g., dermatological reactions such as a rash) to more severe (e.g., anaphylaxis, shock, and death).

Psychological Factors

The patient's attitude about a drug has been shown to have an effect on how that drug works. A drug is more likely to be effective if the patient thinks it will work than if the patient believes it will not work. This is called the placebo effect.

The patient's personality also influences compliance with the drug regimen. Some people who believe that they can influence their health actively seek health care and willingly follow a prescribed regimen. These people usually trust the medical system and believe that their efforts will be positive. Other people do not trust the medical system. They may believe that they have no control over their health and may be unwilling to comply with any prescribed therapy. Knowing a patient's healthseeking history and feelings about health care is important in planning an

educational program that will work for that patient. It is also important to know this information when arranging for necessary follow-up procedures and evaluations. As the caregiver most often involved in drug administration, the nurse is in a position to influence the patient's attitude about drug effectiveness. Frequently, the nurse's positive attitude, combined with additional comfort measures, can improve the patient's response to a medication.

Environmental Factors

The environment can affect the success of drug therapy. Some drug effects are enhanced by a quiet, cool, non-stimulating environment. For example, sedating drugs are given to help a patient relax or to decrease tension. Reducing external stimuli to decrease tension and stimulation help the drug be more effective. Other drug effects may be influenced by temperature. For example, antihypertensives that work well during cold, winter months may become too effective in warmer environments, when natural vasodilation may lead to a release of heat that tends to lower the blood pressure. If a patient's response to a medication is not as expected, look for possible changes in environmental conditions.

Tolerance

The body may develop a tolerance to some drugs over time. Tolerance may arise because of increased biotransformation of the drug, increased resistance to its effects, or other pharmacokinetic factors. When tolerance occurs, the drug no long causes the same reaction. Therefore, increasingly larger doses are needed to achieve a therapeutic effect. An example is morphine, an opiate used for pain relief. The longer morphine is taken, the more tolerant the body becomes to the drug, so that larger and larger doses are needed to relieve pain. Clinically, this situation can be avoided by giving the drug in smaller doses or in combination with other drugs that may also relieve pain. Cross-tolerance or resistance to drugs within the same class may also occur in some situations.

Interactions

When two or more drugs or substances are taken together, there is a possibility that an interaction can occur, causing unanticipated effects in the body. Alternative therapies, such as herbal products, act as drugs in the body and can cause these same interactions. Certain foods can interact with drugs in much the same way. Usually this is an increase or decrease in the desired therapeutic effect of one or all of the drugs or an increase in adverse effects.

Self- assessment 2.6

1. List at least 5 factors that influence drug effects.
2. What is the ideal adult weight is considered while prescribing drugs?

2.7 Drug-drug interactions

Learning activity 2.7

Read the case study below and answer the question related to it:

A 40-year-old male patient was prescribed a penicillin G injection, and he is receiving concurrently tetracyclines taken by oral route. The symptoms of the disease for which penicillin G was given persisted after 5 days of the treatment, and the patient came back to the health facility where the drug was prescribed. The prescribing personnel decide that both penicillin G and tetracyclines are needed for this patient, and decides to increase the dose of penicillin G. After 2 days, the symptoms start to resolve until they completely disappear and the patient improves.

1. What do you think happened for this patient so that he did not improve with the first period, and improved after increasing the dose of penicillin G?

CONTENT SUMMARY

A drug-drug reaction is when there's an interaction between two or more prescription drugs. This can cause the medication to be less or more potent than intended or result in unexpected side effects.

Clinically significant drug-drug interactions occur with drugs that have small margins of safety. If there is very little difference between a therapeutic dose and a toxic dose of the drug, interference with the drug's pharmacokinetics or pharmacodynamics can produce serious problems. For example, drug-drug interactions can occur in the following situations:

At the site of absorption: One drug prevents or accelerates absorption of the other drug. For example, the antibiotic tetracycline is not absorbed from the GI tract if calcium or calcium products (milk) are present in the stomach.

During distribution: One drug competes for the protein-binding site of another drug, so the second drug cannot be transported to the reactive tissue. For example, aspirin competes with the drug methotrexate for protein-binding sites. Because aspirin is more competitive for the sites, the methotrexate is bumped off, resulting in increased release of methotrexate and increased toxicity to the tissues.

During biotransformation: One drug stimulates or blocks the metabolism of the other drug. For example, warfarin (Coumadin), an oral anticoagulant, is biotransformed more quickly if it is taken at the same time as barbiturates, rifampin, or many other drugs. Because the warfarin is biotransformed to an inactive state more quickly, higher doses will be needed to achieve the desired effect.

During excretion: One drug competes for excretion with the other drug, leading to accumulation and toxic effects of one of the drugs. For example, digoxin and quinidine are both excreted from the same sites in the kidney. If they are given together, the quinidine is more competitive for these sites and is excreted, resulting in increased serum levels of digoxin, which cannot be excreted.

At the site of action: One drug may be an antagonist of the other drug or may cause effects that oppose those of the other drug, leading to no therapeutic effect. This is seen, for example, when an antihypertensive drug is taken with an antiallergy drug that also increases blood pressure. The effects on blood pressure are negated, and there is a loss of the antihypertensive effectiveness of the drug.

If a patient is taking antidiabetic medication and also takes the herb ginseng, which lowers blood glucose levels, he or she may experience episodes of hypoglycemia and loss of blood glucose control.

Whenever two or more drugs are being given together, first consult a drug guide for a listing of clinically significant drug-drug interactions. Sometimes problems can be avoided by staggering the administration of the drugs or adjusting their doses. For example, when penicillin G and tetracyclines are taken concurrently, the effectiveness of penicillin G decreases. If this combination is used, the dose of the penicillin should be increased.

Drug-nonprescription treatment interaction refers the reaction between a drug and a nonprescription treatment. These include over-the-counter (OTC) medications, herbs, vitamins, or other supplements. An example of this type of interaction can occur between a diuretic, a drug that attempts to rid the body of excess water and salt taken with ibuprofen, as an non steroid anti-inflammatory drug. The ibuprofen may reduce the diuretic's effectiveness because ibuprofen often causes the body to retain salt and fluid.

Self- assessment 2.7

1. Referring to the lesson on drug-drug interactions, list the stages/sites at which drug-drug interactions may happen.
2. What do you understand by "drug-nonprescription treatment interaction"?

2.8 Drug-food/beverage interactions

Learning activity 2.8

Your relative consulted the health post complaining of the low abdominal pain and she has been prescribed medications. She was then told that she could not take grapefruit juice while she is taking a drug but she does not understand why. When she arrives home she asks you to give more explanation about why she was requested not to take the grapefruit juice.

1. With reference to the interactions between drugs and food or beverages, what will you tell to your sister?
2. Drug-food/beverage interactions always result in decreased serum levels of the concerned drugs. True or False

CONTENT SUMMARY

For the most part, a drug-food interaction occurs when the drug and the food are in direct contact in the stomach. Some foods increase acid production, speeding the breakdown of the drug molecule and preventing absorption and distribution of the drug. Some foods chemically react with certain drugs and prevent their absorption into the body. The antibiotic tetracycline cannot be taken with iron products for this reason. Tetracycline also binds with calcium to some extent and should not be taken with foods or other drugs containing calcium.

Grapefruit juice has been found to affect liver enzyme systems for up to 48 hours after it has been ingested. This can result in increased or decreased serum levels of certain drugs. Many drugs come with the warning that they should not be combined with grapefruit juice. This drug–food interaction does not take place in the stomach, so the grapefruit juice needs to be avoided the entire time the drug is being used, not just while the drug is in the stomach.

In most cases, oral drugs are best taken on an empty stomach. If the patient cannot tolerate the drug on an empty stomach, the food selected for ingestion with the drug should be something that is known not to interact with it. Drug monographs usually list important drug-food interactions and give guidelines for avoiding problems and optimizing the drug's therapeutic effects.

Self- assessment 2.8

A patient consults the health post for pain during urination. He was then prescribed antibiotic drugs. The associate nurse student in pharmacy of the health post dispenses the medications but indicates the patient that he needs to take drugs on the empty stomach.

1. Explain why it is better to take oral drugs on an empty stomach.
2. Drug-food/beverage interactions occur for drugs administered orally only. True or False

2.9 Time-Response Relationships: Drug Plasma Levels

Learning activity 2.9

An associate nurse prescribed the drug to the client to be taken in equal intervals of 4 hours a day. The first dose meant to achieve the target concentration rapidly has to be taken at the time he consults the health post at 3h00 PM. The following doses must then follow the first dose later on., respecting the intervals This means that the second dose should be taken at 9.00 PM, third dose at 11 h00 PM. The client tells the associate nurse that he is going to take 2nd dose and 3 doses at the same time because he goes to bed at 8 h00'.

1. What should the associate nurse should the patient to understand the reason of respecting the doses interval?
2. Differentiate the loading dose from the maintenance dose.

CONTENT SUMMARY

Drugs are used for the treatment of diseases but the modes of administration of drugs are different. The mode of administration is designed on the basis of absorption, distribution, metabolism and excretion (ADME) of drugs. Drugs usually follow two processes for their pharmacokinetic behaviour in the body. These are **first order** and **zero order processes**.

First order kinetic: This is the most common process for many drugs. The rate at which absorption, distribution, metabolism and excretion occur are proportional to the concentration of drugs i.e. constant fraction of this drug in the body disappears in each equal interval of time.

Zero order kinetic: It is independent of the amount of drug present at the particular sites of drug absorption or elimination. Few drugs follow this process e.g. ethanol, phenytoin. Here constant amount of the drug is eliminated in each equal interval of time. On repeated administration of drug after certain stage it goes on accumulating in the body and leads to toxic reactions.

Steady state plasma concentration: When a drug dose is given repeatedly over a given period, a steady state is eventually reached, at which point the amount of drug absorbed is in equilibrium with that eliminated from the body. Steady state is achieved after 4 to 5 half –lives for most of the drugs which follow first order kinetics. For example, a drug with half-life of 6 hours will be expected to be at steady state after more than 24 hours of administration. The pattern of drug accumulation during repeated administration of drug at intervals equal to its elimination half-life.

For some drugs, the effects are difficult to measure, toxicity and lack of efficacy are both potential dangers, and/or the therapeutic window is narrow. In these circumstances, doses must be adjusted carefully to a desired steady-state concentration by giving loading and maintenance doses

Loading dose: The loading dose is one or a series of doses that may be given at the onset of therapy with the aim of achieving the target concentration rapidly.

Maintenance dose: To maintain the chosen steady-state or target concentration, the rate of drug administration is adjusted such that the rate of input equals to rate of loss.

Self- assessment 2.9

Define the following terms

1. Steady state plasma concentration
2. Zero order kinetic
3. First order kinetic

2.10 Introduction to pharmacodynamics

Learning activity 2.10

You receive a patient who consults the health post where you are placed as an associate-nurse student. The patient consults for the difficulty swallowing and fever. On the examination, you realize he has tonsillitis and you wish to prescribe the drug. Before proceeding, you bear in your mind that the selective toxicity of a drug must be considered always when the drug is being used.

1. What do you understand by the term “selective toxicity” as it is applied to pharmacodynamics?
2. How do we call the specific areas on cell membranes where many drugs are thought to act?

CONTENT SUMMARY

Pharmacodynamics is the study of the interactions between the chemical components of living systems and the foreign chemicals, including drugs that enter those systems. All living organisms function by a series of complicated, continual chemical reactions. When a new chemical enters the system, multiple changes in and interferences with cell functioning may occur. To avoid such problems, drug development works to provide the most effective and least toxic chemicals for therapeutic use.

Drugs usually work in one of four ways:

1. To replace or act as substitutes for missing chemicals
2. To increase or stimulate certain cellular activities
3. To depress or slow cellular activities
4. To interfere with the functioning of foreign cells, such as invading microorganisms or neoplasms (drugs that act in this way are called chemotherapeutic agents). Drugs can act in several different ways to achieve these results.

Receptor Sites

Many drugs are thought to act at specific areas on cell membranes called receptor sites. The receptor sites react with certain chemicals to cause an effect within the cell. In many situations, nearby enzymes break down the reacting chemicals and open the receptor site for further stimulation. To better understand this process, think of how a key works in a lock. The specific chemical (the key) approaches a cell membrane and finds a perfect f it (the lock) at a receptor site. The interaction between the chemical and the receptor site affects enzyme systems within the cell. The activated enzyme systems then produce certain effects, such as increased or decreased cellular activity, changes in cell membrane permeability, or alterations in cellular metabolism. Some drugs interact directly with receptor sites to cause the same activity that natural chemicals would cause at that site. These drugs are called **agonists**. For example, insulin reacts with specific insulin-receptor sites to change cell membrane permeability, thus promoting the movement of glucose into the cell

Other drugs act to prevent the breakdown of naturaal chemicals that are stimulating the receptor site. Some drugs react with receptor sites to block normal stimulation, producing no effect.

Drug-Enzyme Interactions

Drugs also can cause their effects by interfering with the enzyme systems that act as catalysts for various chemical reactions. Enzyme systems work in a cascade fashion, with one enzyme activating another, and then that enzyme activating another, until

a cellular reaction eventually occurs. If a single step in one of the many enzyme systems is blocked, normal cell function is disrupted. Acetazolamide (Diamox) is a diuretic that blocks the enzyme carbonic anhydrase, which subsequently causes alterations in the hydrogen ion and water exchange system in the kidney, as well as in the eye.

Selective Toxicity

Ideally, all chemotherapeutic agents would act only on enzyme systems that are essential for the life of a pathogen or neoplastic cell and would not affect healthy cells. The ability of a drug to attack only those systems found in foreign cells is known as selective toxicity. Penicillin, an antibiotic used to treat bacterial infections, has selective toxicity. It affects an enzyme system unique to bacteria, causing bacterial cell death without disrupting normal human cell functioning.

Unfortunately, most other chemotherapeutic agents also destroy normal human cells, causing many of the adverse effects associated with antipathogen and antineoplastic chemotherapy. Cells that reproduce or are replaced rapidly (e.g., bone marrow cells, gastrointestinal [GI] cells, hair follicles) are more easily affected by these agents. Consequently, the goal of many chemotherapeutic regimens is to deliver a dose that will be toxic to the invading cells yet cause the least amount of toxicity to the host.

Self- assessment 2.10

1. There are four ways through which drugs usually work. Mention these 4 ways.
2. The drugs administered to humans only affect the target cells, and never harm the human cells because they were made in a specific way. True or False

2.11 Agonist drugs

Learning activity 2.11

Consult the library and read agonist drug, in pharmacology and to be able to respond to the question of the scenario below.

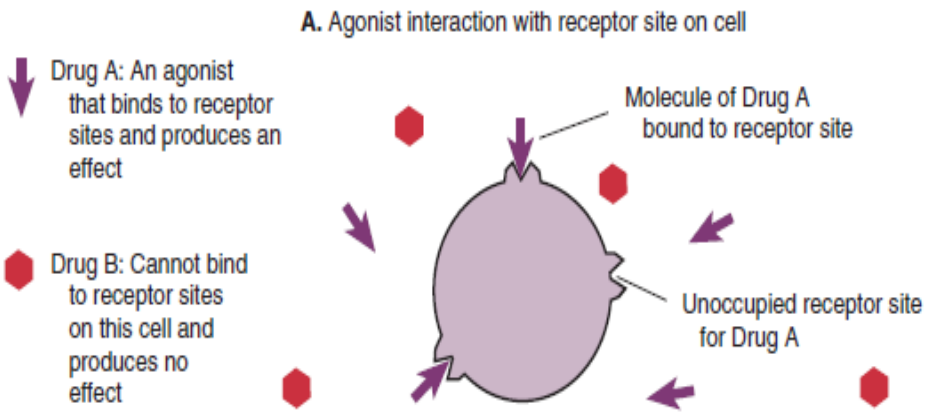
An associate nurse is caring an old woman with diabetes at home. After receiving insulin injection, she asks associate nurse how the insulin will work to allow the glucose to enter the cell.

1. If you were the associate nurse in the scenario. What would you explain to the woman?

CONTENT SUMMARY

Drugs that interact directly with receptor sites to cause the same activity that natural chemicals would cause at that site are **agonists drugs**.

An agonist **medication mimics the action of the signal by binding to and activating a receptor.**



An agonist drug binds to receptor sites and produces an effect.

The insulin is an example of agonist drug as it reacts with specific insulin-receptor sites to change cell membrane permeability, thus promoting the movement of glucose into the cell. This is the same action as natural insulin would do in normal human body.

Full agonists are drugs when administered at concentrations sufficient to saturate the receptor pool, can activate their receptor-effector systems to the maximum extent of which the system is capable and this causes a shift of almost all of the receptor pool. **On the other hand, partial agonists**. The term partial agonist or agonist-antagonist drug describes a medication that produces a weaker, or less efficacious, response than an agonist. It binds to the same receptors and activate them in the same way but do not evoke as great a response, no matter how high the concentration.

Example of full agonist effect in clinical application is administration of bethanechol (Urecholine). It binds to acetylcholine receptors in the autonomic nervous system and produces the same actions as acetylcholine.

Self- assessment 2.11

1. Define agonist drug
2. Differentiate full agonist from partial agonist drug

2.12 Drug Antagonists

Learning activity 2.12

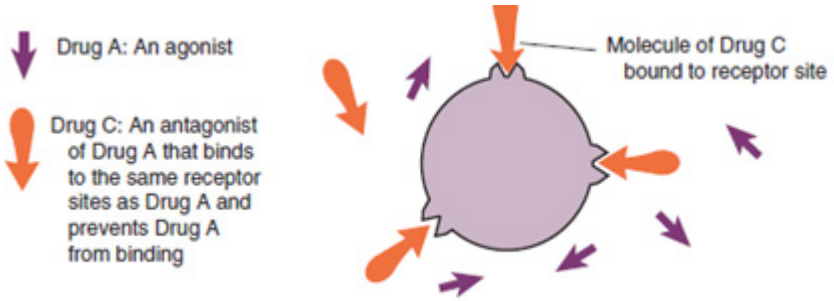
During your clinical placement in the hospital, you observe a nurse giving a drug named atropine to the patient with very slow heart rate. Your colleague asks the nurse how the atropine will increase the heart rate. The nurse explains in short word that the atropine is antagonist of acetylcholine a neurotransmitter of the parasympathetic nervous system that can slow the heart rate.

1. Visit the library and read the content of antagonist drug and briefly describe what the antagonist drug is.

CONTENT SUMMARY

Antagonism is an interaction between two or more drugs that have opposite effects on the body. Antagonist may block or reduce the effectiveness of one or more of the drugs. An antagonist is a medication that typically binds to a receptor without activating them, but instead, decreases the receptors ability to be activated by other agonist. That drug will occupy a receptor and prevent the endogenous chemical from acting. Antagonists often compete with agonists for the receptor binding sites

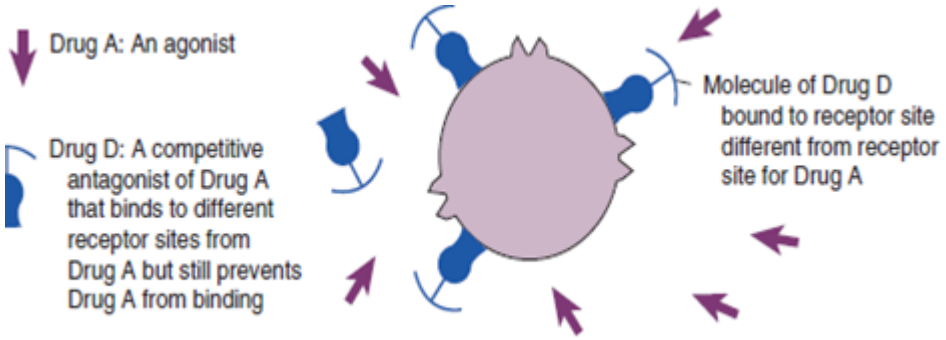
A competitive antagonist is a drug that binds to the same receptor sites as another drug and prevents it from binding.



A noncompetitive antagonist is a drug that binds to different receptor sites from another drug but still prevents that drug from binding.

Not all antagonism is associated with receptors. Functional antagonists inhibit the effects of an agonist not by competing for a receptor but by changing pharmacokinetic factors. For example, antagonists may slow the absorption of a drug. By speeding up metabolism or excretion, an antagonist may enhance the removal of a drug from the body. An other example of antagonism include antidote effect on drugs

The relationships that occur between agonists and antagonists explain many of the drug–drug and drug–food interactions that occur in the body.



An example of antagonist effect in clinical application is the use of the drug atropine which competes with acetylcholine for specific receptors associated with the autonomic nervous system. If the dose is high enough, atropine will inhibit the effects of acetylcholine, because acetylcholine cannot bind to its receptors.

Self- assessment 2.12

1. Define a drug antagonist
2. Differentiate competitive from non- competitive antagonist drug

2.13 Pharmacokinetics in special population

Learning activity 2.13

While you were in clinical practice in consultation room, you saw a senior nurse played attention while prescribing the drugs to the children and old people than other group of people between 20 to 50 years old.

1. Visit the library, read the books of pharmacology on pharmacokinetics special considerations and come up with a summary of why Children often require different doses of drugs than adults.

CONTENT SUMMARY

Pharmacokinetics are typically dependent on a variety of physiological variables (e.g., age, ethnicity, or pregnancy) or pathological conditions (e.g., renal and hepatic insufficiency, cardiac dysfunction, obesity, etc.).

To providing safe and effective medications, pediatric drug therapy represent a great challenge to the health professionals. Children often require different doses of drugs than adults because children's bodies often handle drugs very differently from adults' bodies. In some cases, a pediatric dose is suggested, but in many cases it will need to be calculated based on the weight and the age of the child.

Medications can affect the fetus either by interfering with some important function in the mother which indirectly damages the fetus or by pass across the placenta or acting directly on the fetus.

Most drugs cross the placenta,30% of pregnant women take drugs and 10% take drugs in the first trimester when the fetus is more vulnerable. It is important to discover which drugs can produce fetal damage and which are safe to use but it is difficult because in the period of implantation (5-15 days): Drug toxicity can result in abortion, in Embryonic stage (15 to 55 days): Embryo is changing from a group of cells into a recognizable human being.

The embryo is particularly susceptible to drug toxicity at this time and leads to fetal malformation or **teratogenesis (a process by which congenital malformations are produced in an embryo or fetus)**. Fetogenic stage (55 to birth): Drug damage is less likely but still possible, at Delivery: Drugs may interfere with labour and modify the behaviour of neonates immediately after birth, Food drug administration indicate the potential or actual teratogenic effects of a drug.

The New-borns are unable to break down drugs as effectively older children or adults do. Example the accumulation of chloramphenicol can cause **grey syndrome** due to collapse of circulation.

The period from birth to adolescent is characterised by dramatic changes in physical growth, psychosocial development and sensitivity to drugs. Old persons are among the most consumers of drugs. Yet their metabolism changes with age.

Elder people have fewer albumins in the blood, with certain drug, less protein bound and more are free in the blood and tissue fluids and can therefore produce a greater pharmacological effect.

With advanced age, liver enzyme decreases blood supply especially to liver consequently the absorption decreases, as result some drugs may therefore be more slowly broken down and their blood concentration may rise to toxic levels.

Drugs are also excreted via the kidney. Old age, sometimes associated with kidney diseases, leads to a decline in renal function, so that by the age of 80 years, renal function is only half than at age 40. This again may cause drug accumulation in the Body and evidence that certain systems become more sensitive to drug action with advancing years.

Self- assessment 2.13

1. What are the special considerations in case of pharmacokinetics during drug administration?
2. Why drug toxicity can rise in the people over 80 years old?

2.14 Pharmacodynamics in Special population

Learning activity 2.14

1. Visit the library and read the book of pharmacology on pharmacodynamics special population and summarize how the medication can affect the fetus.

CONTENT SUMARY

All living organisms function by a series of complicated, continual chemical reactions. When a new chemical enters the system, multiple changes in and interferences with cell functioning may occur. To avoid such problems, drug development works to provide the most effective and least toxic chemicals for therapeutic use.

The reactions changes depending on many factors including receptors site age and personal health status. Pregnant women, children and older persons are special population for whom attention must be taken when administering them the medication.

The use of drugs in pregnancy is complicated by the potential for harmful effects on the growing fetus, altered maternal physiology. Because experience with many drugs in pregnancy is severely limited, it should be assumed that all drugs are potentially harmful until sufficient data exist to indicate otherwise.

Some drugs' effect may be serious to the pregnant woman and may even be fatal for the unborn baby. Again when administered during delivery drugs may change neonates behaviors even lead to immediate complications. Medications can affect the fetus either by interfering with some important function in the mother which indirectly damages the fetus or by pass across the placenta or acting directly on the fetus.

There are drugs that have toxicity that when given during implantation period they cause abortion. Other may cause fetal malformation or teratogenesis when administered during the embryonic period of pregnancy. Drugs may interfere with labor and modify the behavior of neonates immediately after birth.

For every pregnant woman, it is imperative to avoid giving drugs as possible in the first 3 months of pregnancy, give drugs at the lowest effective dose for as a short time as possible, avoid recently introduced drugs if possible, **be sure that every female you attempt to give medication is pregnant or not, read drug risk category before administration of any drug to a pregnant female.**

Most drugs pass into breast milk, but at a very low and innocuous concentration. Generally, drugs should be avoided by nursing mothers, but if the drug is essential the baby should feed before the mother take drugs, then when blood levels will be low. Certain drugs should not be used by nursing mothers and, if unavoidable, will require transfer to bottle feeding.

The liver of children is immature and depending on age some are inactive this mark the difference in drug metabolism in the body that finally may cause accumulation and increase drug toxicity.

Children have immature renal system and it is difficult to excrete drugs. This increase risk for toxicity.

Factors affecting pharmacodynamics of a drug in children are summarized as below:

- Reduced gastric acidity some medication that require acid environment to be broken are not well metabolized.
- Small muscle mass: Drugs administered in intramuscular should be at lower dose to allow absorption.
- Thin stratum corneum: Topical application of medication can be easily absorbed and when large amount is applied toxicity be present. Again special attention when administered subcutaneous medication is taken as it is very easy to reach the muscle.
- High proportion of water in body: Water soluble drugs are highly absorbed and lipid soluble drugs are poorly absorbed.
- Reduced protein-binding capability this limit some drug absorption and distribution to the whole body.
- Unpredictable hepatic enzymes production
- Immature renal system

Self- assessment 2.14

1. What are the considerations a nurse might take to avoid harmful drug effects on a pregnant woman?

2.15 Dose-Response Relationships

Learning activity 2.14

An associate nurse was assigned to care for an old man on palliative care. The man is receiving morphine as analgesic drug 5 mg subcutaneous route (SC). Today associated nurse visited the client and the client tells him that the dose he received did not help him. Associated nurse called the physician, and the physician order to increase the dose as 8 mg. The client after receiving 8mg dose, report the relief of pain.

1. In your view, why 5 mg was not reducing pain and 8 mg reduce the pain?

CONTENT SUMMARY

How does a patient respond to varying doses of a drug? Common sense would suggest that a larger dose would produce more drug effect.

An antihypertensive drug would cause a greater reduction in blood pressure if the dose was increased from 50 to 100 mg. These simple examples describe the dose–response relationship, one of the most fundamental concepts in pharmacology.

Examining and comparing dose–response curves can yield a large amount of information about a drug. A dose–response curve plots the drug dose administered to the patient versus the intensity or degree of response obtained.

There are three distinct phases of a dose–response curve that indicate essential pharmacodynamics principles.

Phase 1 occurs at the lowest doses.

The flatness of this portion of the curve indicates that few target cells have been affected by the drug; doses that are too small will not produce a therapeutic effect.

Phase 2 is the rising, straight line portion of the curve. In this portion, there is a linear relationship between the amount of drug administered and the degree of response obtained from the patient. For example, if the dose is doubled, twice as much response may be obtained

This is the most desirable range of doses for pharmacotherapeutics, because giving more drug results in proportionately more effect; a lower drug dose gives less effect.

In phase 3 increasing the drug dose produces no additional therapeutic response a plateau has been reached. This may occur for a number of reasons. One possible explanation is that all the target receptors for the drug are occupied. It could also mean that the drug has brought 100% relief, such as when a migraine headache has been terminated; giving higher doses produces no additional relief.

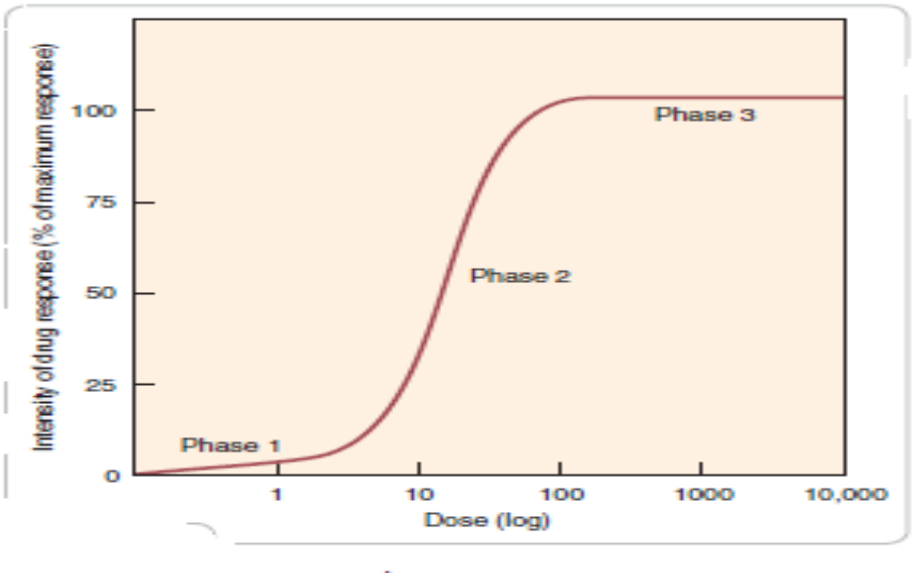


Figure: Dose-response relationships

Self- assessment 2.15

1. After reading the content of the lesson, what do you understand by dose response relationship?

2.16 Potency of drug

Learning activity 2.16

1. Use the textbook of Pharmacology from the library or search on the internet about the term Potency of the drug and make short note on term Potency of drug.

CONTENT SUMMARY

The concept of potency is first fundamental ways to compare medications within therapeutic and pharmacologic classes. Pharmacologic potency can largely determine the administered dose of the chosen drug. For therapeutic purposes, the potency of a drug should be stated in dosage units, usually in terms of a particular therapeutic end point may be used in comparing one drug with another.

Potency is an index of how much drug must be administered to elicit a desired response. A drug that is more potent will produce its therapeutic effect at a lower dose, compared to another drug in the same class.

Thus, potency is a way to compare the doses of two independently administered drugs in terms of how much is needed to produce a particular response.

If a drug were of extremely low potency, we might need to administer that drug in huge doses multiple times a day to achieve beneficial effects. In this case, an alternative drug with higher potency would be desirable. Fortunately, it is rare for a drug to be so lacking in potency that doses of inconvenient magnitude need be given. The only consequence of having greater potency is that a drug with greater potency can be given in smaller doses.

Which is more important to the outcomes of pharmacotherapy: potency or efficacy? Perhaps the best way to understand these important concepts is to use the specific example of headache pain. Two common analgesic therapies are ibuprofen 200mg, and aspirin 650 mg. The fact that ibuprofen relieves pain at **a lower dose indicates that it is more potent than aspirin**.

In clinical practice the term potency is often misused to indicate a more effective drug. The nurse should remember the correct definitions of the words potency and efficacy and try to incorporate them into clinical practice.

In everyday, people tend to use the word potent to express the pharmacologic concept of effectiveness. That is, when most people say, “This drug is very potent,” what they mean is, “This drug produces powerful effects.” They do not mean, “This drug produces its effects at low doses.” In pharmacology, we use the words potent and potency with the specific and appropriate terminology.

Self- assessment 2.16

1. What does “Drug Potency” mean?

   A. A measure of how tightly a drug bind to plasma proteins

   B. A measure of how tightly a drug bind to a receptor

   C. A measure of inhibiting potency of a drug

   D. An index of how much drug must be administered to elicit a desired response.

2.17 Efficacy of drug

Learning activity 2.17

1. Using library Pharmacology textbook/internet search the term efficacy of the drug and make short note on term efficacy of drug.

CONTENT SUMMARY

The concept of efficacy is a second fundamental ways to compare medications within therapeutic and pharmacologic classes, which is defined as the greatest maximal response that can be produced from a particular drug or defined as the largest effect that a drug can produce. Maximal efficacy is indicated by the height of the dose-response curve. The maximal efficacy of a drug is obviously crucial for making clinical decisions when a large response is needed. It may be determined by the drug’s mode of interactions with receptors (as with partial agonists, described above) or by characteristics of the receptor-effector system involved. Thus, therapeutic efficacy may be affected by the characteristics of a particular drug-receptor interaction, but it also depends on a host of other factors.

The best way to understand this important concept is to use the specific example of headache pain. Two common analgesic therapies are ibuprofen 200mg, and aspirin 650mg. The fact that ibuprofen relieves pain at a lower dose indicates that it is more potent than aspirin. At the given doses, however, both are equally effective at relieving headaches; thus they have the same sufficient efficacy to bring relief. Morphine has a greater efficacy than aspirin or ibuprofen and could effectively treat this type of pain. From a pharmacotherapeutic perspective, **efficacy is almost always more important than potency.** In the preceding example, the average dose is unimportant to the patient, but headache relief is essential.

As another comparison, the patient with cancer is much more concerned with how many cancer cells have been killed (efficacy) than with the dose the nurse administered (potency).

Within a pharmacologic class, not all drugs are equally effective at treating a disorder. For example, some antineoplastic drugs kill more cancer cells than others; some antihypertensive agents lower blood pressure to a greater extent than others; and some analgesics are more effective at relieving severe pain than others in the same class. Furthermore, drugs in the same class are effective at different doses: one antibiotic may be effective at a dose of 1mg/kg, whereas another is most effective at 100 mg/kg.

A drug with very high maximal efficacy is not always more desirable than a drug with lower efficacy. Recall that we want to match the intensity of the response to the patient's needs. It is important to note that the potency of a drug implies nothing about its maximal efficacy! Potency and efficacy are completely independent qualities.

Drug A can be more effective than drug B even though drug B may be more potent. Also, drugs A and B can be equally effective even though one may be more potent. The only consequence of having greater potency is that a drug with greater potency can be given in smaller doses.

In deciding which of two drugs to administer to a patient, the prescriber must usually consider their relative effectiveness rather than their relative potency. It is important to distinguish between a drug's potency and its efficacy for clinical use. To choose among drugs and to determine appropriate doses of a drug, the prescriber must know the relative pharmacologic potency and maximal efficacy of the drugs in relation to the desired therapeutic effect. The clinical effectiveness of a drug depends not on its potency (EC50), but on its maximal efficacy and its ability to reach the relevant receptors. This ability can depend on its route of administration, absorption, distribution through the body, and clearance from the blood or site of action.

Self- assessment 2.17

1. The term "drug efficacy" means:

   A. Two drugs combine with one another to form an inactive compound

   B. Two drugs combine with one another to form a more active compound

   C. The greatest maximal response that can be produced from a particular drug or defined as the largest effect that a drug can produce

   D. Two drugs combine with one another to form a more water-soluble compound.

2.18 Therapeutic index

Learning activity 2.18

1. Read the book of pharmacology, discuss on therapeutic index (using library books) and make short notes.

CONTENT SUMMARY

The **therapeutic index (TI**; also referred to as **therapeutic ratio**) is a quantitative measurement of the relative safety of a drug. It is a comparison of the amount of a therapeutic agent that causes the therapeutic effect to the amount that causes toxicity. The related terms **therapeutic window or safety window** refer to a range of doses which optimize between efficacy and toxicity, achieving the greatest therapeutic benefit without resulting in unacceptable side-effects or toxicity.

The larger the therapeutic index (TI), the safer the drug is. If the TI is small (the difference between the two concentrations is very small), the drug must be dosed carefully and the person receiving the drug should be monitored closely for any signs of drug toxicity.

In the early days of pharmaceutical toxicology, TI was frequently determined in animals as lethal dose of a drug for 50% of the population (LD50) divided by the minimum effective dose for 50% of the population (ED50).

Self- assessment 2.18

1. What do you understand by therapeutic index?
2. What the nurse have to do before and after administrating the drug which have small therapeutic index?
3. The term therapeutic window or safety window refer to a range of doses which optimize between:

   A. Efficacy and toxicity

   B. Efficacy and Lethal

   C. Loading and maintenance

   D. Potency and toxicity

2.19 Inter patient Variability

Learning activity 2.19

1. Read the book of pharmacology (using library books), discuss on therapeutic index Inter patient variability and make note.

CONTENT SUMMARY

Once drugs are administered, certain patients fail to react to treatment even when systemic exposure to the drug is within the range associated with therapeutic response. The main reasons are many but most of the time misdiagnosis of the disease or individual lacking the therapeutic target or inability to express a satisfactory response.

The reasons behind patient difference in responsiveness to a given dose of a drug are many. They include genetics, disease, age, gender, body weight, drugs given concomitantly, and various behavioral and environmental factors. Age, body weight, disease, and concomitantly administered drugs are important because they are measurable sources of variability that can be taken into account. Gender-linked differences in hormonal balance, body composition, and activity of certain enzymes manifest themselves in differences in both pharmacokinetics and responsiveness, but overall, the effect of gender is small. Although inheritance accounts for a substantial part of the differences in response among individuals for many drugs, much of this variability is still largely unpredictable, particularly in regard to pharmacodynamics.

The examples of variability in drug response so far have been of the therapeutic effect of the drug, but the situation equally applies to adverse effects. For some relatively minor adverse effects, variability may be as great as, or even greater than, that for the therapeutic effect, particularly when they are associated with the inherent pharmacologic property of the drug (side effects), such as dryness of mouth experienced with some sympathomimetic nasal decongestants. Frequent side effects are also invariably experienced by patients undergoing chemotherapy during cancer treatment. However, in many other therapeutic settings, moderate to severe side effects are much less frequently experienced. Occasionally, the frequency of an adverse effect is so low that it is only detected with any significance when tens of thousands, if not millions, of patients have been treated with the drug. Even so, there is still some relationship between the likelihood and severity of an adverse effect and the exposure to the drug, although establishing it with any confidence may be difficult. The degree and relative contribution of pharmacokinetics and pharmacodynamics to variability in response within a patient population vary with the drug

Self- assessment 2.19

1. What are the reasons behind patient difference in responsiveness to a given dose of a drug?
2. Explain how the gender can affect drug response?

End Unit assessment 2

1. Which of the following statements is True with regard to the meaning of selective toxicity of an antibiotic?

   A. The ability of the anti-infectious agent to affect both microbial and host cells at the same time

   B. The ability of anti-infectious agent to affect the host cell with few effects to the microbial cell

   C. The ability of an anti-infectious agent to affect the bacterial cell wall since the human cell does also have the cell wall

   D. The ability of the anti-infectious agent to affect the infectious agent's cell without affecting the host (human) cell

2. Which of the following pharmacological terms deals with absorption, distribution, metabolism and elimination (excretion) of drugs?

   A. Pharmacodynamics

   B. Pharmacognosy

   C. Pharmacokinetics

   D. Pharmacopoeia

3. Which of the following assertions describes a teratogenic drug?

   A. The drug that can produce severe adverse reactions

   B. The drug that can impact negatively the elderly

   C. The drug that can cause congenital malformation

   D. That drug that have a broad spectrum of activity

4. In pharmacology, “drug tolerance” means:

   A. A potential maximum therapeutic response which a drug can produce if used at right dose

   B. A decreased response to a drug, requiring an increase in dosage to achieve the desired effect

   C. An increased response to a drug, requiring an increase in dosage to achieve the desired effect

   D. A margin between the therapeutic dose and lethal dose of any given antibiotic medication

5. All of the following statements about efficacy and potency are True Except:

   A. Efficacy is usually a more important clinical consideration than potency

   B. Efficacy is the maximum effect of a drug

   C. Potency is a comparative measure, refers to the different doses of two drugs that are needed to produce the same effect

   D. The ED50 is a measure of drug’s efficacy

6. What does “pharmacokinetics” include?

   A. Complications of drug therapy

   B. Drug biotransformation in the organism

   C. Influence of drugs on metabolism processes

   D. Influence of drugs on genes

7. Pharmacodynamics involves the study of the following?

   A. Mechanisms of drug action

   B. Biotransformation of drugs in the organism

   C. Distribution of drugs in the organism

   D. Excretion of drug from the organism

8. If an agonist can produce submaximal effects and has moderate efficacy it’s called:

   A. Partial agonist

   B. Antagonist

   C. Agonist-antagonist

   D. Full agonist

9. Match the description in column 1 to the appropriate term in column 2

Column 1	Column 2
1. Drug binding to receptors and prevents other drugs from binding	A. Partial agonist
2. A drug that when bound to the receptors causes an action as a natural substance	B. Competitive antagonist
3. It produces a weaker effect than an agonist	C. Agonist
4. A drug that binds to different receptor sites from another drug but still prevents that drug from binding.	D. Antagonist
May slow the absorption of a drug	E. Non-competitive antagonist

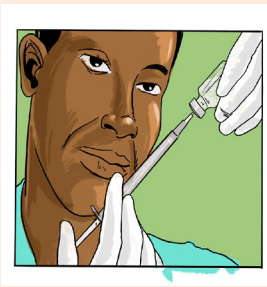
UNIT 3

PRINCIPLES OF DRUG ADMINISTRATION

Key Unit Competence

Administer safely medications to the patients

3.0 Introductory activity

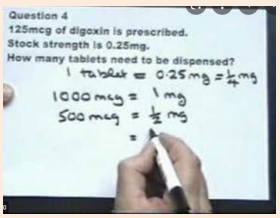
A. 

B 

C. 

D. 

E. 

F. 

Observe the images above and respond to the following question:

1. What do you think people on the images above (A, B, C, D, E, F) are doing?

3.1 The rights of drug administration

Learning activity 3.1

You are carrying out a clinical attachment in the health centre. The patient is prescribed the injectable medication for pain that will be injected intramuscularly. Your colleague carrying out the clinical attachment in the same health centre says there are key elements an associate nurse needs to consider before administering the medication.

1. List the main 10 rights of drug administration that need to be considered before medication administration.
2. In which category of rights of drug administration would checking the expiry date belong?

CONTENT SUMMARY

It is a standard during nursing education to receive instructions on a guide to clinical medication administration and upholding patient safety known as the 'Ten rights' or 'Ten R's' of medication administration (Right Patient, Right Reason or Indication, Right drug, Right dose, Right Route and form, Right Time, Right Documentation, Right Response, Right to Refuse, and Right evaluation). These 'rights' came into being during an era in medicine in which the precedent was that an error committed by a provider was that provider's sole responsibility and patients did not have as much involvement in their own care.

Right Patient: When administering a drug, it is important to use two methods (visual as well as verbal methods) to identify the patient before administering the medication. Nurse must be certain that the patient receiving the drug is the patient for whom the drug has been ordered by reading properly the physician's order. Call the patient by name and ask him to repeat his name aloud. Be very careful if the patient is deaf or otherwise does not understand the language.

A visual identifier may include checking the patient's name on his or her wristband, on the patient's card and on the medicine card for matching name and ID number as on a chart. It is advisable not to address patients by first name or surname alone, in the event, there are two or more patients with identical or similar names in a unit. Depending on the unit that a patient may be in, some patients, such as psychiatric patients, may not wear wristbands or may have altered mentation to the point where they are unable to identify themselves correctly. In these instances, nurses are advised to confirm a patient's identity through alternative means with appropriate due diligence.

If there is no written identification verifying the patient's name, nurse should obtain a wristband or other form of identification before administering the drug. Nurse may also ask the patient to identify him- or herself and request another unique identifier such as date of birth. However, do not ask, "Are you Mr or Mrs A?" Some patients, particularly those who are confused or have difficulty hearing, may respond by answering "yes" even though that is not their name. Some long-term care or rehabilitation care facilities have pictures of the patient available, which allow 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.

Take the medicine and prescription to the patient and check the patient's identity. Check their wristband according to local policy and ensure they state their name and date of birth, rather than simply confirming any details they are given

***Image**: Checking patient's identity*

Right Reason or Indication addresses the **appropriateness** in use of the medication to the patient. Confirm the rationale for use through researching the patient's history while also asking the patient the reason he or she is taking the drug. Always revisit the rationale for long-term medication use. Knowledge of the drug's indication allows the nurse, prescriber, members of the health care team, patient and/or family members to understand what is being treated. Understanding the indication helps pharmacists and nurses to catch potential errors, provide thorough explanations to the patient/family, and decrease challenges to medication reconciliation.

The nurse has the responsibility to verify the reason that the patient is receiving the medication. It is important to understand the indication, which is related to the medical diagnosis. If in doubt about the reason for the order, the nurse must verify the medication order with the prescriber before administration.

Right medication or drug: Some brand names or generic names may have very similar spelling or sound very similar due to prefix, suffix, or starting with the same first letter. Poor handwriting and abbreviations account for many medical errors due to misreading letters or numerals that appear differently to different individuals. Right drug names can be confused, especially when the names sound similar, or the spellings are similar.

Quickly preparing a drug for administration or failing to look up questionable drugs can put you at increased risk for administering the wrong drug. An error in drug name or amount can be found when nurse compares the medication administration record: with the container label, as the item is removed from the card, and before the actual administration of the drug.

The nurse must be careful of drugs whose names sound alike. When administering medications, the nurse compares the label of the medication container with the medication form three times: before removing the container from the drawer or shelf, as the amount of medication ordered is removed from the container and before returning the container to storage.

The nurse must look for colour, odour, and consistency of the drug. Unusual characteristics of the drugs should be questioned. The nurse must also administer medicine only from clearly labelled container and remember to check other critical information on packaging such as the expiration date. The nursing providers should also develop a routine habit of explicitly asking patients about known allergies or history of an allergic. The conversation or anything that distracts the mind not recommended during drug administration. The nurse must be familiar with the trade names.

If there is doubt consult the physician or at least seniors or other reliable sources. Avoid accepting the verbal orders, only in emergencies are accepted. Always identify the patient before giving medication. The nurse must make sure that the drug has not been discontinued by the prescriber.

The nurses administer only the medications they prepare. If an error occurs, the nurse who administers the medication is responsible for the error. Clients who self-administer medications should keep them in their original labelled containers, separate from other medications, to avoid confusion.

Right Route and form: A nurse must know the particulars about each medication before administering it to ensure that the right drug, dose, route, and dosage form are being used. A complete medication order includes the route of administration. Confirm the appropriateness of the prescribed route while also making sure the patient can take/receive the medication by the prescribed route. If a medication order does not include the route, be sure to ask the prescriber to clarify it. Never assume the route of administration.

In addition, it is critical to patient safety to be aware of the right form of medication. For example, there are various dosage forms of a commonly used medication, acetaminophen.

It is available in oral suspension, tablet, capsule, gel cap, and paediatric drops, as well as rectal suppository dosage forms. Nurses need to give the right drug via the right route with use of the correct dosage form.

Medications can be given to patients in different many ways, all of which vary in the time it takes to absorb the chemical, time it takes for the drug to act, and potential side-effects based on the mode of administrations, include oral, intramuscular, intravenous, topical, or subcutaneous injection and others. It is crucial that

nurses remain educated and up to date on newer medications or less commonly administered medications to learn how they are safely delivered to patients before being asked to do so in clinical practice.

If a prescriber's order does not designate a route of administration, the nurse consults the prescriber. The nurse should alert the prescriber immediately if the specified route is not the recommended route and he/she must report immediately if an error occurs in the medication. The nurse must know and must be familiar with the abbreviations used to designate the route of administration.

Right time: Medications can be given to patients in different many ways, all of which vary in the time it takes to absorb the chemical, time it takes for the drug to act, and potential side-effects. Certain drugs have specific intervals or window-periods during which another dose should be given to maintain a therapeutic effect or level.

Often, a guiding principle of this 'right' is that medications should be prescribed as closely to the time as possible, and nurses should not deviate from this time by more than half an hour to avoid consequences such as altering bioavailability or other chemical mechanisms. Similarly, it is crucial that medications that are given by an infusion, such as intravenous medications, are administered at the correct rate.

Failure to deliver a drug at the correct rate may lead to devastating consequences for a patient. For example, vancomycin requires administration by slow intravenous infusion to avoid a complication known as "red man syndrome," a hypersensitivity reaction that is managed by further slowing the infusion rate of vancomycin or discontinuing the agent altogether.

The administering medications at a time that was intended by the prescriber. The nurse must Read the physician's orders, know the hospital routines for the interval, know the abbreviations for the time, give the medicine near the time ordered, give the medicine as ordered in relation to the food intake and give the medicines according to the actions expected. E.g., sleeping pills are given at bedtime.

Right dose: Incorrect dosage, conversion of units, and incorrect substance concentration are a prevalent modality of medication administration error. This error type stems from nurses giving a patient an incorrect dose of medications, even if it is the correct medication and the patient's identity is verified, without first checking to ensure it is the correct strength for the patient. This error type may be due to misplaced decimals, errors in arithmetic, or incorrect conversion between two units.

The nurse must have adapted observing positive behaviors to reduce medical errors include consulting with pharmacy personnel, read physician orders to know the correct dose, consider the age and weight of the patient, know the minimum

and maximum dose of the medicine administered, using calculators to assist in arithmetic, or in some cases, cross-consulting with patients or their families about usual doses they administer at home. Use ounce glasses instead of teaspoons to measure ounces accurately, have written order before you prepare the drug, avoid conversation or anything that distracts the mind.

Right Documentation: Medication error can result from inaccurate documentation. Nurse should ensure appropriate documentations clearly reflect the client's name, the name of the ordered medications, the time the medication was administered, the medication's dosage, route, the date or the method of administration, frequency, the signature of the physician, and Standing orders or routine medication orders. If any of this information is missing the nurse should verify the order with the prescriber.

After the administration of any drug, record the process immediately. Immediate documentation is particularly important when drugs are given on an as-needed (PRN) basis. 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 understand that the administered drug was for pain, or may not know that pain relief is not immediate, and may ask another nurse for the drug again. If the administration of the analgesic was not recorded, the patient might receive a second dose of the analgesic shortly after the first dose. This type of situation can be extremely serious, especially when opioids or other central nervous system depressants are administered. Immediate documentation prevents accidental administration of a drug by another individual and it is essential to the process of administering drugs correctly.

Right Response refers to the drug and its desired response in the patient. Continually assess and evaluate the achievement of the desired response, as well as any undesired response. Examples of data gathering include, but are not limited to, monitoring vital signs, weight, oedema, intake and output, nutritional intake, laboratory values, results of diagnostic testing, and auscultating heart and lung sounds. Document any assessment, intervention, and monitoring as deemed appropriate.

Right to Refuse: The ninth right is that of the right of the patient to refuse. Patients refuse medications for a variety of reasons. If **refusal of a medication occurs, always** respect the patient's right (to refuse), determine the reason, and take appropriate action, including notifying the prescriber. Do not force! Document the refusal and a concise description of the reason for refusal. Document any further actions you take at this time, such as vital signs and/or system assessment. If a consequence to the patient's condition and/or as hospital policy dictates, the prescriber is to be contacted immediately. Never return unwrapped medication to a

container, and discard medication dose according to agency policy. If the wrapper remains intact, return the medication to the automated medication-dispensing system. Revise the nursing care plan as needed.

Right evaluation: The health professional after administrating the medications to the client must ensure the medication is working the way it should, ensure that the medications are reviewed regularly and the ongoing observations if required to detect early any sides' effect or adverse effect associated with the taken medication.

Self- assessment 3.1

1. What are the two methods a nurse can use to identify the right patient before the drug administration?
2. What does the nurse have to do if the patient refuses to take the prescribed medications?
3. Which of the following options addresses the appropriateness in use of the medication to the patient?

   A. Right indication

   B. Right evaluation

   C. Right documentation

   D. Right to refuse
4. You have been instructed to administer an oral medication (Ranitidine 150 mg) to a patient. What is the minimum of times the nurse should check the medication label before administering this drug?

   A. One

   B. Two

   C. Three

   D. Four

3.2 Compliance/adherence to drug regimen

Learning activity 3.2

You are at the healthcare facility where you are carrying out a clinical attachment as a requirement to complete your associate nursing program. A 41-year-old female patient comes 10 days after interrupting his antiretroviral treatment. While discussing with the patient, she reveals that she delayed to come to get antiretroviral medications because the time of appointment coincided with the time she had no money, and as she lives far, she could not travel to the health facility. In your understanding, you realize that the patient was limited by the financial constraints.

1. How can you define the word “drug adherence?”
2. What are the 5 factors (dimensions) that can lead to poor drug adherence and compliance as stated by the World Health Organization?

CONTENT SUMMARY

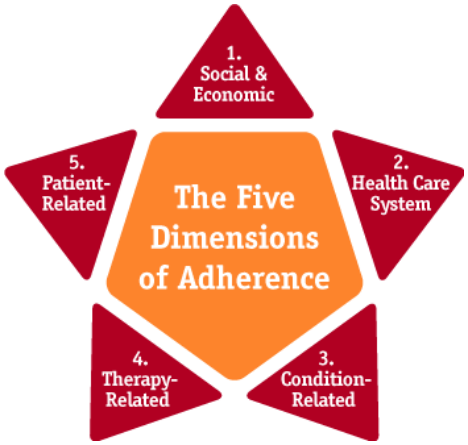
Adherence describes how a patient follows a medical regime recommended by a healthcare provider. Poor treatment adherence represents a complex and challenging problem of international healthcare systems, as it has a substantial impact on clinical outcomes and patient safety and constitutes an important financial burden. Since it is one of the most common causes of treatment failure, it is extremely important for physicians to reliably distinguish between non-adherence and non-response.

Three different terms are used in the literature to describe to which extent a patient’s behaviour corresponds with the advice given by a healthcare provider: **Compliance**, **adherence** and **concordance**. These three terms are often used interchangeably, but they reflect different philosophies of the physician-patient relationship. It can be difficult to accurately compare studies on this topic, since the terminology used differs amongst authors. Until around 2003, the term **compliance** was most widely used in the literature. Compliance implies an authoritarian, asymmetric physician-patient relationship, in which the doctor has the **exclusive decisional** power. Physicians give instructions and patients are passive recipients and should follow the prescribed regime without deviation.

The word compliance may have **negative connotations** as it requests a submissive and obedient patient. The concept of an appropriate physician-patient relationship has substantially changed in the last years, since patients have gained more autonomy. This paradigmatic shift is reflected by the new term **adherence**, which is nowadays preferably used. The concept of adherence is based on a partnership between physician and patient, where both parties are actively involved in finding

a mutual treatment agreement. The word **concordance**, which originated in British literature, goes even further and places the patient in the centre of the **decision-making process**. It focuses less on compliance and more on overall success of treatment as a shared goal.

Factors/dimensions reported to affect adherence



Adherence is a multidimensional phenomenon determined by the interplay of five sets of factors, termed “dimensions” by the World Health Organization:

1. **Social/economic factors**
2. **Provider-patient/health care system factors**
3. **Condition-related factors**
4. **Therapy-related factors**
5. **Patient-related factors**

1. SOCIAL AND ECONOMIC DIMENSIONS
Limited language proficiency
Low health literacy
Lack of family or social support network
Unstable living conditions; homelessness
Burdensome schedule
Limited access to health care facilities
Lack of health care insurance
Inability or difficulty accessing pharmacy
Medication cost

Cultural and lay beliefs about illness and treatment
Elder abuse
2. HEALTH CARE SYSTEM DIMENSIONS
Provider-patient relationship
Provider communication skills (contributing to lack of patient knowledge or understanding of the treatment regimen)
Disparity between the health beliefs of the health care provider and those of the patient
Lack of positive reinforcement from the health care provider
Weak capacity of the system to educate patients and provide follow-up
Lack of knowledge on adherence and of effective interventions for improving it
Patient information materials written at too high literacy level
Restricted formularies; changing medications covered on formularies
High drug costs, copayments, or both
Poor access or missed appointments
Long wait times
Lack of continuity of care
3. CONDITION-RELATED DIMENSIONS
Chronic conditions
Lack of symptoms
Chronic conditions
Lack of symptoms
Severity of symptoms
Depression
Psychotic disorders
Mental retardation/developmental disability

4. THERAPY-RELATED DIMENSIONS
Complexity of medication regimen (number of daily doses; number of concurrent medications)
Treatment requires mastery of certain techniques (injections, inhalers)
Duration of therapy
Frequent changes in medication regimen
Lack of immediate benefit of therapy
Medications with social stigma attached to use
Actual or perceived unpleasant side effects
Treatment interferes with lifestyle or requires significant behavioral changes
5. PATIENT-RELATED DIMENSIONS
Physical Factors
Visual impairment
Hearing impairment
Cognitive impairment
Impaired mobility or dexterity
Swallowing problems
Psychological/Behavioral Factors
Knowledge about disease
Perceived risk/susceptibility to disease
Understanding reason medication is needed
Expectations or attitudes toward treatment
Perceived benefit of treatment
Confidence in ability to follow treatment regimen
Motivation
Fear of possible adverse effects
Fear of dependence
Feeling stigmatized by the disease
Frustration with health care providers
Psychosocial stress, anxiety, anger
Alcohol or substance abuse

Self- assessment 3.2

1. Enumerate patient-related factors affecting adherence to medications.
2. The term “Adherence to drug regimen” has negative connotations as it requests a submissive and obedient patient. It is nowadays less preferable, and was replace by the term “Compliance.” True or False
3. In patient adherence to drug regimen, concordance implies an authoritarian, asymmetric physician-patient relationship, in which the doctor has the exclusive decisional power. True or False

3.3 Drug storage

Learning activity 3.3

Observe the images above and respond to the following questions:

1. What do you think the nurses in image A and B are doing?
2. Which drugs can be stored in the refrigerator?

CONTENT SUMMARY

Drugs and biologicals are to be stored in a secure and orderly manner under proper temperatures and are to be accessible only to licensed nursing and pharmacy personnel. All medications are to be stored in the containers in which they are received, internals separately from externals and both separately from poisons.

Medications received from the Pharmacy should be stored in a secure location that is out of reach from children. Medications that are dispensed in vials, such as tablets and capsules, should not be placed in bathroom or kitchen cabinets where it may be subjected to high humidity. Most medications can only be stored at room temperature, but some medications may require refrigeration or other storage requirements. Please consult with your pharmacist if you are unsure.

The drugs which are supplied to ward are stored in drug cupboards to provide a uniform supply of drugs to the patients. The drugs are stocked in containers, such as boxes and on flexible racks and shelves etc. It must be ensured that drugs which are stored remain preserved during their storage. There should not be any damage due to high temperature or exposure to sunlight. The drugs are to be stored as per the prescribed conditions of their storage. The drugs stored in a drug store should be arranged in such a way that they are easily traceable when required.

Drugs can be stored:

1. According to pharmacological action or

2. Alphabetically

Factors that govern storage of drugs

Proper drug storage

Storage environment

Arrangement of drugs on shelves

The storeroom

The dispensary

A. Proper drug storage

Drugs are stored in a specially designed secure area or space of a building in order to:

- Avoid contamination or deterioration,
- Avoid disfiguration of labels,
- Maintain integrity of packaging and so guarantee quality and potency of drugs during shelf life,
- Prevent or reduce pilferage (stealing things of small value), theft or losses
- Prevent infestation of pests and vermin.

The storage should not hinder the cleaning and should have sufficient space for movement of stocks and handling. Products are to be stored in a manner that prevents damage due to excessive vertical stacking heights and not to exceed **eight stacks**.

Store the products as per product storage condition (As per label) to prevent deterioration of finished product on storage. Monitor and record the temperature of storage area on daily basis.

B. The storage environment

The storage environment should possess the following:

- Adequate temperature,
- Sufficient lighting,
- Clean conditions,
- Humidity control,
- Cold storage facilities, and
- Adequate shelving to ensure integrity of the stored drugs.

Drugs to be stored under condition that prevents contamination & as far as possible, deterioration. They must be “Well closed container” precautions to be taken in relation to the effects of the atmosphere, moisture, heat & light. “Protected from moisture” means that the product is to be “stored in air tight container”. “Protected from light” the product is to be stored either in a container made of material that absorbs actinic light sufficiently to protect the contents from change induced by such light. Temperature: In a deep freeze (-15°C), in a refrigerator 2°C-8°C, Cold or cool 8°C-15°C and Room temperature15°C-25°C.

Drugs stored in the **medicines refrigerator** include: vaccines; insulin; chemotherapy drugs; topical preparations, such as some types of eye drops; and other treatments such as glucagon, which is used to manage severe hypoglycaemia.

Storage premises: The Storage area must be free from unsanitary conditions (Example: rodents, insects, birds). The floor of the warehouse should be made of hard floor (Concrete/kota/epoxy) and must be in a good state of repair and appearance at all times. The floors are kept clean and free of trash, dirt, spillage water, drain water etc. The area must be kept clean. The area used for storage of IV fluids should have adequate space and to prevent exposure to direct sunlight. Secured area availability for damaged, rejected and expired goods. Ensure adequate pest control program in place and shall be carried out at a minimum frequency of a year. The pest control shall cover treatment for termite and rodents.

C. Arrangement of drugs on shelves

Shelves should be made of steel or treated wood. Shelves should be strong. Drugs are arranged in alphabetical order of generic names. Each dosage form of drug is arranged in separate and distinct areas. Most recently received drugs are placed behind old stock on the shelf Except where new drugs have shorter expiration dates. Always put lids properly on tins always and at the close of the day. Put drugs in a dry place protected from light and heat. Store liquids on a pallet on the floor or on the lowest shelf. The store must be cleaned daily and mopped at least once a week.

D. The store room

A well-arranged store enables easy identification of drugs and saves time when picking a drug from the shelves. This helps remove drugs quickly and makes for easy inventory control. The rule of **FIRST IN FIRST OUT (FIFO)** should be applied always. So, drugs that were received first should be used first, because the old stock has shorter expiration dates than the new stock.

In this regard, the principle of **FIRST TO EXPIRE FIRST OUT (FEFO)** should apply. To have access to drugs with shorter expiration dates, put these in front of the shelves. Those with longer expiration dates should be placed behind those with shorter dates.

E. The dispensaries

Clean after each use tablet counters and place within easy reach on the table. Avoid dispensing wrong drugs by arranging drugs on the table in alphabetical order so that the drug being dispensed is not confused with another. Always close drug containers from which drugs are not being dispensed to prevent spillage or dispensing the wrong drug. Medications must not be administered, and products and equipment must not be used beyond their expiry dates. All medical equipment, dressings and solutions used during invasive procedures must be sterile. Single-use devices are meant for single use only and must not be re-used.

Storage, maintenance and security: All drugs, including samples, should be maintained separate from non-medications in a locked cabinet which is sufficiently secure to deny access to unauthorized persons. Key should be available only to authorized personnel who are assigned medication-related responsibilities. Store medications that are “for external use only” separate from medications intended for internal use. Store look-alike and sound-alike drugs (LASA) separately. Maintain temperature between 59 degrees and 86 degrees Fahrenheit for non-refrigerated medications. Where refrigeration is necessary use a “Medications Only” refrigerator and maintain temperature between 36 degrees and 46 degrees Fahrenheit.

On daily basis check, verify and document the proper temperature. All multiple-dose injectable medications should be initialled and have the date of first entry recorded on the label. Rotate medication stock monthly employing a “**FIFO” (first in/first out) process.**

Controlled drug regulation.

- Double locked container, and 2 licensed personnel count (or verify any discrepancies) every shift (8 hours)
- Witness to all discards
- Record on Control Substance Sheet all administrations and wastes.

All details must be completed in the doctors own handwriting, like: Name of drug, Dose of drug, Number of doses or length of course, Signature of prescribing doctor and date.

Storage of controlled drugs

They must be kept in a locked cabinet or cupboard. The keys to the cabinet must be in the possession of an authorised person. Authorised person refers to ward manager or deputy who must be a trained nurse or midwife. Students should not be responsible for the controlled drug cupboard keys.

Recording of controlled drug use: Records in the form of CONTROLLED DRUG REGISTERS must be kept. Each drug must have its own specified page which is headed with the drugs name and strength. The number of ampoules of a drug must be entered and updated with every use.

Must record: The date, time and dose of every drug administration. The name of the patient received the drug. The number of ampoules at the beginning and end of drug administration. The entry must be signed by 2 people who are registered in the respective regulatory body.

Self- assessment 3.3

1. What are the 5 factors that govern the storage of drugs?
2. In order to prevent damage of stored drugs, what is the number of stacks that should not be exceeded in case of vertical stacking?

   A. Two stacks

   B. Twenty stacks

   C. Eight stacks

   D. Fifteen stacks
3. How should the nurse arrange medications in the store room to ensure the **first to expire first out (FEFO)** principle?
4. What are the characteristics of drug storage environment?

3.4 Enteral routes of drug administration

Learning activity 3.4

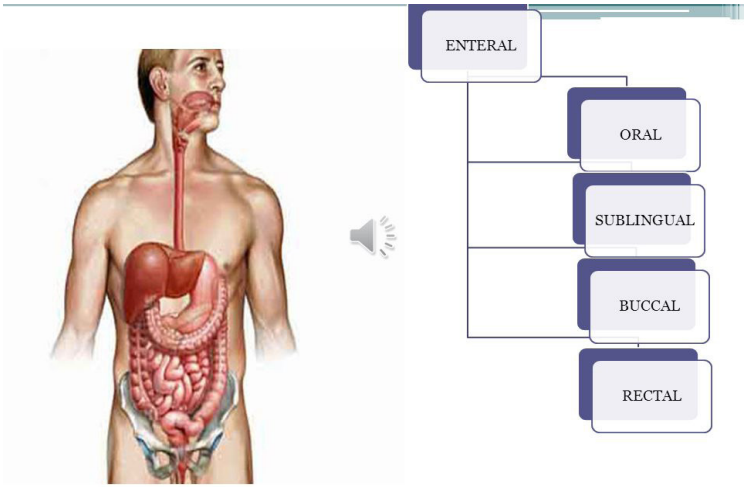
A 50-yaer-old female patient consults the health facility where you are carrying out the clinical placement, for the follow up of her chronic disease. She used to be taking insulin for type 2 diabetes mellitus, and her glycemia has become stable so that she can shift to non-injectable forms. Your colleague in associate nursing program carrying out the clinical placement at the same health facilty wants to shift from injectable from to enteral routes, but she does not remember what an enteral route is.

A. How can you define an enteral route of drug administration to your colleague?

B. What are different types of enteral routes of drug administration would you tell your colleague?

C. Which enteral route poses a greater risk of first-pass effect (first metabolism)?

CONTENT SUMMARY



Routes of drug administration are the medium through which the drug is introduced into the body to show its pharmacological action or for diagnosis. They are generally classified by the location at which the substance is applied or based on the target of action is. Route of administration and dosage form are the main aspects of drug delivery. **Enteral administration** is the involvement of the gastrointestinal tract and is further classified as follows: **Oral Administration, Buccal or Sublingual Administration, and Rectal route.**

i) Oral Administration

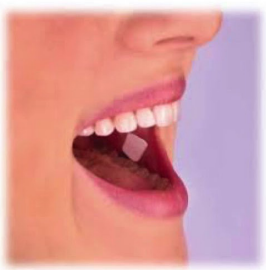
It is the first choice for the administration of drugs. It is designated as Per Os (PO), which means to administer by mouth. The absorption of drugs administered by this route is determined by the physiological state of the GI tract. Types of dosage forms administered through this route include pills, tablets, capsules, solutions, suspensions, emulsions, syrups, elixir, etc.

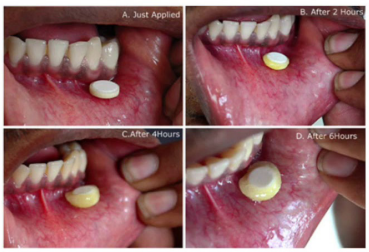
Advantages: Most Convenient and cost-effective. Safest and painless. Self-administered. No sterilisation required.

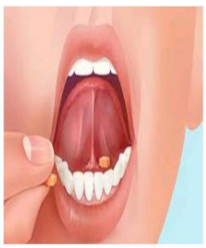
Disadvantages: Not suitable for an emergency as the onset of action is slow. Not suitable for unconscious patients, uncooperative and unreliable patients. For drugs with extensive first-pass metabolism, this route is not used. Unpalatable and highly irritant drugs are not suitable.

ii) Buccal or Sublingual Administration

Sublingual administration involves placing the drug under the tongue. Buccal administration involves placing the pill between the gums and cheek wherein both the cases, the drug is absorbed into the blood. The types of dosage forms for this route include tablets, troches and lozenges. Examples- Nitroglycerin.







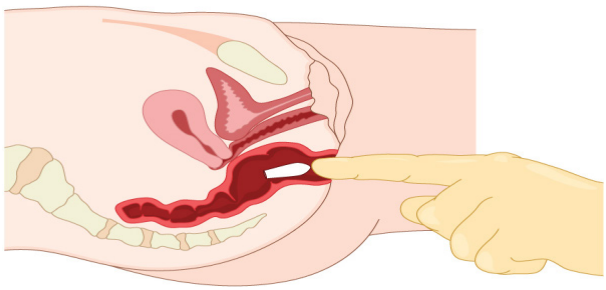
Advantages: Economic & Quick drug absorption. Bypassing the first-pass metabolism. Quick termination-spit off. Self-administered. Increased bioavailability.

Disadvantages:

Not suitable for bitter and irritating drugs. High doses can't be taken. Less patient compliance. Highly ionic drugs cannot be administered.

iii) Rectal route

Rectal medicines are administered through the anus, into the rectum. The types of dosage forms for this route include suppositories and enemas Ex: prednisolone enema, indomethacin, diazepam.



Advantages: It avoids the first-pass metabolism. Suitable for children and old age. It is used for unconscious and vomiting patients. Irritating drugs are contraindicated.

Disadvantages: Absorption is slow and erratic. Not well accepted by patients. Inconvenient.

Self- assessment 3.4

1. Which of the following is an advantage of the oral route of drug administration?

   A. It is easily self-administered method;

   B. Toxicity may be overcome with antidotes;

   C. Drugs avoid first-pass metabolism;

   D. Drugs go directly into the systemic circulation.

3. All of the following are advantages of the rectal route of drug administration, Except:

   A. Suitable for patients with nausea or vomiting

   B. Suitable for the young population (children)

   C. Suitable for patients with unconscious state

   D. Drugs are subject to first-pass metabolism.

3. Pick out the appropriate alimentary route of administration when passage of drugs through liver is minimized:

   A. Rectal

   B. Sublingual

   C. Oral

   D. Intraduodenal

4. The oral route of drug administration is suitable for an emergency situation as the onset of action is rapid. True or False

3.5 Parenteral routes of drug administration

Learning activity 3.5

A 20-year-old male patient is admitted in the healthcare facility for an infectious bacterial disease. The assessment reveals that the patient must be given the tablets to swallow twice a day with plenty of water. After 2 days of the treatment, the nurse realizes that the patient vomits all the drugs he takes, and the nurse needs to shift to another route that would help to ensure that all the drug is taken into the patient's body. The nurse then asks you a question regarding the alternative routes she should use to ensure that the drug is not vomited.

1. Which routes would you advise to the nurse to use?
2. Which angles of the needle would you respect while administering drugs via the 4 main routes?

CONTENT SUMMARY

During patient care, some medications can be administered by parenteral routes. The word parenteral is derived from Greek word "para" which means outside and "enter one" which means the intestine. These are the injection or infusion through a needle or catheter into the body. This route helps bypass the alimentary canal.

The injection is the act of putting a liquid, especially a drug, into a person's body using a needle and a syringe. Injections are classified as follows:

a. Subcutaneous route/injection

The drug is deposited just beneath the skin in the loose subcutaneous tissue. As it is less vascular, absorption is slow, so prolonged action is produced. Only small volumes can be injected. The needle is injected into the pinched skin at 90-degree angle and do this quickly without force. If you have very little fat, then inject at a 45-degree angle. In addition to injection, it is also possible to slowly infuse fluids subcutaneously in the form of hypodermoclysis. A subcutaneous route is used for protein drugs because such drugs would be destroyed in the digestive tract if they were taken orally. Certain drugs (progestins for hormonal birth control) may be given by inserting capsules under the skin.

Advantages: Onset of action is faster than oral route.

Disadvantages: Sterile technique is needed. More expensive. Some drugs can irritate tissue and cause pain. Only small volumes must be administered.

Various forms of subcutaneous (SC) route are: Dermojet, Pellet and Sialistic (non-biodegradable and biodegradable implants).

Dermojet: It is a needleless injection system with a high-pressure jet injector. A high velocity of drug solution is projected from a fine micro orifice using a gun like an implant; the solution passes through the superficial layers and gets deposited in the subcutaneous tissue. It is nearly painless and suitable for mass inoculations. E.g. Insulin.

Pellet: Drug in the form of solid pellet is introduced with Trochar and Cannula which provides sustained release of drug for weeks and months without repeated administration.

E.g. DOCA, Testosterone.

Sialistic (non-biodegradable or biodegradable): Crystalline drug is packed in tubes or capsules and implanted under the skin. Slow and uniform release of drug for months with constant blood levels (non-biodegradable drug have to be removed later). E.g. hormones and contraceptives like “Norplant”.

b. Intravenous route/injection

Method of administering medications directly into the vein using a needle. It is the best way to deliver a precise dose quickly and in a well-controlled manner throughout the body. Drugs are delivered immediately into the bloodstream and tend to take effect more quickly than any other route. Hence it is of great value in an emergency. A 25-gauge needle 2 cm long with 25-degree angle is inserted into the skin. It is also used for irritable solutions which cause pain and damage to tissues if given by subcutaneous or intramuscular injection. A solution containing a drug may be given in a single dose, or continuous infusion from a collapsible plastic bag or infusion pump through thin, flexible tubing inserted to the vein, usually a forearm. Vital organs like heart, brain etc. get exposed to high concentrations of the drug.

Advantages: Rapid onset of action. It bypasses the GI and first-pass metabolism. Useful for drugs which are irritant to intramuscular route.

Disadvantages: Administered by trained person. Accidental overdose can have serious consequences. Limited to highly soluble drugs. Break of skin barrier.

c. Intramuscular route/injection

The drug is injected into one of a large skeletal muscle such as triceps and rectus femoris among others. It is a preferred route when larger volumes of a drug product are needed. It is more vascular; hence absorption is faster and less painful. The angle for IM is 90 degrees. DEPOT preparations (oily solutions and aqueous suspensions) can be injected by this route. Muscle permits the tissue to receive a larger volume of medication (deltoid and biceps maximum of 3ml).

NOTE: IM injections should be avoided in anticoagulant treatment patients as it can produce Local haematoma.

Advantages: Can administer larger volumes. Technically easier than IV. GI and first-pass metabolism are involved.

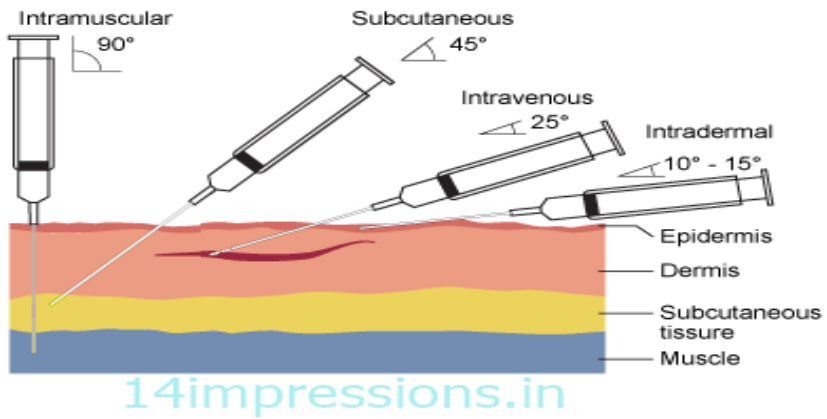
Disadvantages: Break the skin barrier, produce anxiety and painful.

d. Intradermal route/injection

The drug is delivered in the upper layer of the skin to the dermis, where the absorption is low. The angle for ID is 5 to 15 degrees with a needle placed almost flat to the skin. It is the common method used for allergy testing. Injections are made with fine short needles (26 gauge) and a small barrel syringe.

Advantages: Absorption is low, advantage for allergy testing.

Disadvantages: Amount of drug administered must be small.



Needle Insertion Angles

The above are the 4 main routes. The following are other parenteral routes, less commonly used.

e. Intra Arterial route/injection

Intra Arterial injection or infusion is a method of delivering a drug directly into arteries to localise its effect to a particular organ/region while minimising the exposure of the body to potentially toxic effects of the agent.

Advantages: Used in chemotherapy to target drug organs.

Disadvantages: Drugs may be distributed to other tissues or organs.

f. Intra Articular route/injection

It is the injection which is directly delivered into the joints to relieve pain and swelling. Most of the anti-inflammatory drugs for arthritis treatment are given by this route.

Advantages: High concentration is obtained in localized areas. Rapid onset of action.

Disadvantages: Sepsis and joint damage may occur on repeated drug administration.

g. Intrathecal route/injection

Intrathecal administration is a route for drugs via an injection into the spinal canal, or into the subarachnoid space so that it reaches the cerebrospinal fluid (CSF) and is useful in spinal anaesthesia, chemotherapy & pain management applications.

Advantages: Drugs act directly on meninges and CNS. Bypass BBB & Blood-CSF barrier.

Disadvantages: Painful procedure. Expertise needed.

Self- assessment 3.5

1. Parenteral routes of drug administration are:

   A. Intravenous, intramuscular, subcutaneous

   B. Intravenous, intramuscular, intranasal

   C. Intravenous, sublingual, transdermal

   D. Transdermal, subcutaneous, by inhalation

2. All of the following are the disadvantages of intravenous drug administration, Except:

   A. A trained staff is required to administer the drug

   B. Its use is limited to highly soluble drugs.

   C. Accidental overdose can have serious consequences

   D. Drugs undergo first-pass metabolism in the liver

3. Which of the following is the correct angle to use while administering the drugs intramuscularly?

   A. 75%

   B. 50%

   C. 90%

   D. 45%

4. Which of the following statements best defines the intradermal injection?

A. The drug is delivered in the upper layer of the skin to the dermis, where the absorption is low

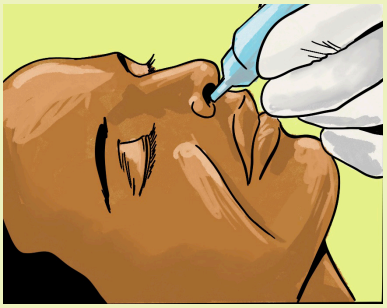
B. The drug is injected into one of a large skeletal muscle such as triceps and rectus femoris

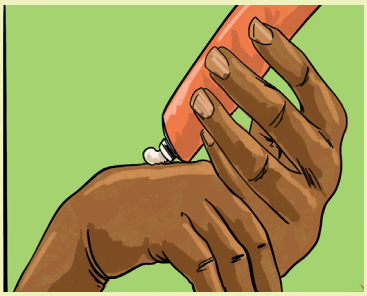
C. Intrathecal administration is a route for drugs via an injection into the spinal canal, or into the subarachnoid space

D. Method of administering medications directly into the vein using a needle and a syringe

3.6 Topical routes of drug administration

Learning activity 3.6





Observe the images above (A, B, C, D), and answer the questions below pertaining to them:

1. What do you observe on these images (ABCD)?
2. What are the benefits of using the route of drug administration in the images above?

CONTENT SUMMARY

The topical route includes: skin, eyes, or other specific membranes, the intranasal, inhalation, intra-vaginal. The medication is applied directly to the body surfaces, including the skin and mucous membranes of eyes, ears, nose, vagina and rectum. Ex: Antibiotics, hormones, narcotics and chemotherapeutics.

The definition of the topical route of administration sometimes states that both the application location and the pharmacodynamic effect thereof is local.

In other cases, **topical** is defined as applied to a localized area of the body or to the surface of a body part regardless of the location of the effect. By this definition, topical administration also includes **transdermal application**, where the substance is administered onto the skin but is **absorbed** into the body to attain **systemic** distribution.

BENEFITS OF THE TOPICAL ROUTE OF DRUG ADMINISTRATION

Medications delivered via the topical route offer a whole host of benefits. Here are five benefits of using a topical drug delivery system.

1. **Alternative to oral administration**

Many patients struggle with oral drug administration. Some risk vomiting, while others find swallowing pills a near-impossible task. Consequently, if an orally administered drug is rejected, this reduces a drug's effectiveness, prolonging the ailment. This problem is most common in infants or young children who are not used to swallowing tablets. Parents often find it difficult to get their children to take medication. Commonly, this results in wasted doses and slower recovery times. By using a topical medication, parents may be able to avoid these problems and help their children feel better more quickly.

2. **Fewer risks of gastrointestinal difficulties**

Different individuals absorb medication at different rates. Oral medications can cause a variety of **digestive side effects**. Patients who experience these often painful side effects may opt to terminate their medication. A topical drug delivery system overcomes this limitation, improving the patient's recovery process.

3. **Fewer risks of abuse**

Medication administered through tablets or injections can easily be abused. Drug abuse by patients is far too common, especially with pain medications. Such abuse can lead to **addiction**. On the other hand, administering medication through ointments or creams greatly lowers the risk of abuse. Topical medications not only help doctors and patients manage ailments, but also help to prevent the problem of drug abuse.

4. Easy to administer

Almost everyone has a fear of something. Some people are afraid of injections or of swallowing tablets, but few are fearful of rubbing an ointment on their skin. For this reason, doctors find it easier to encourage their patients to take their medication when using a topical drug delivery system. The patient can **easily manage the medication** at home.

5. Reduced hospital congestion

Previously, hospitals administered many medications by injection, filling their beds to capacity. Today, if the patient condition isn't serious, the patient can walk into a hospital and walk out again a short time later with topical medication. This leaves hospital beds free to cater to more serious cases and reduces both hospital and patient medical costs.

Innovating with topical drug delivery

The increased adoption of topical medication in recent years has been impressive. This is largely due to the fact that the medication has proven to have more advantages than drawbacks. After all, the skin is ideal for drug administration, as it produces both systematic and local effects.

Call it a life-changing medical innovation. **Topical drug delivery systems** have surely changed the way we look at medication. More and more medical institutions and health practitioners are adopting this form of medication in an attempt to improve their services to patients. This medical breakthrough offers a future of health care that is definitely more effective and agreeable for patients.

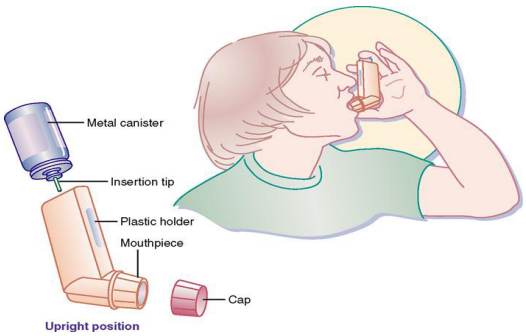
Some types of topical routes of drug administration

Inhalational route

Inhaled medications can be absorbed rapidly and act both systemically and locally. A proper technique with inhaler devices is necessary to achieve the correct dose. Total size absorbed is variable. Nasal Inhalations, Inhalation by smoking a substance is likely the most rapid way to deliver drugs to the brain, as the substance travels directly to the brain without being diluted in the systemic circulation. The severity of dependence on psychoactive may increase with more rapid drug delivery.

Advantages: May be used for local or systemic effects.

Disadvantages: Particle size of drugs determines anatomic placement in the respiratory tract. May stimulate cough reflex. Some drugs may be swallowed



Transdermal route

Transdermal administration is a route wherein active ingredients are delivered across the skin for systemic distribution of the drug. E.g. Transdermal patches. The drug is administered in the form of a patch or an ointment that delivers the drug into the circulation for systemic effect. The absorption rate may vary. It is slow. Increased absorption with occlusive dressings. Formulations and devices for transdermally administered substances include: Transdermal pathways are those by which drugs can cross the skin and reach the systemic circulation. Ex: Transcellular pathway, Intercellular pathway, Microneedles. The more direct route used is known as the transcellular pathway.

Advantages: The transdermal delivery system (patch) is easy to use and withdraw. Continuous release of the drug is observed for a specified period of time. It is used for lipid-soluble drugs with a low dose and low molecular weight. Low pre-systemic metabolism.

Disadvantages: Some irritation by patch or drug. Permeability of skin is variable with the condition, anatomic site, age and gender. Type of cream or ointment base effects the drug release and absorption.

Self- assessment 3.6

1. What are the advantages of administering the drugs by the inhalational route?
2. What are the disadvantages of administering the drugs by the inhalational route?
3. Transdermal administration is a route wherein active ingredients are delivered to the body through an injection in the upper layer of the skin. True or False
4. What are the advantages of administering the drugs by the transdermal route?

3.7 Introduction to medications errors and classification of medication errors

Learning activity 3.7

A 33-year-old male patient is admitted to the hospital where he is being treated with injectable antibiotics. In addition, the patient is receiving two tablets of pain medication every 6 houurs. The nurse on the night shift realizes that the patient received 2 tablets at the latest as indicated. The nurse on the night shift finally realizes that it is the dose that was prescribed for the patient as it appears in the treatment sheet, but after keen search, he realizes that the patient should be taking only 1 tablet for pain medication every 12 hours, instead of 2 tablets every 6 hours. The nurse then withholds the dose, documents it and gets the view from the working team.

1. What type of medication error was committed for this patient?
2. What are other types of medication errors according to their categories or classification?
3. What is the definition of a medication error?

CONTENT SUMMARY

Medicine errors cause considerable patient morbidity, mortality and increased healthcare cost. The most common used definition is that given by the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) in the USA, which defines medication errors as: “Any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer.” The published studies estimated that about 5—10% of hospital admissions were due to the medication errors. It is suspected that approximately 3% of deaths in the Swedish population are because of the medication errors. In Canada, up to 50% of the patient safety incidents in primary care are related to medication errors. Reporting the medication error is one most effective strategy to improve patient safety. While, these reports help to understand the medication errors contributing factors.

Causes of Medication Errors

1. ***Expired Product***: Usually occurs due to improper storage of preparations resulting in deterioration or use of expired products.
2. ***Incorrect Duration***: Duration errors occur when medication is received for a longer or shorter period of time than prescribed.
3. ***Incorrect Preparation***: This error usually occurs with compounding or some other type of preparation before the final administration. An example is choosing the incorrect diluent to reconstitute.

4. ***Incorrect Strength***: It may potentially occur at many points in the medication process. It usually occurs due to human error when similar bottles or syringes with the incorrect strength is selected.

5. ***Incorrect Rate***: Most often occurs with medications that are given as IV push or infusions. This is particularly dangerous with many drugs and may result in significant adverse drug reactions. Examples include tachycardia due to rapid IV epinephrine or red man syndrome due to the rapid administration of vancomycin.

6. ***Incorrect Timing***: In both home and institutional settings, it is challenging to be completely accurate with scheduled doses. The concern is that some medications absorption is significantly altered if taken with or without food. As such, it is important to adhere to scheduled times as commonly; this may lead to under or overdosing.

7. ***Incorrect Dose***: This error includes overdose, underdose, and an extra dose. An incorrect dose occurs when an inappropriate or different medication dose is given other than what was ordered, errors of omission when a scheduled dose of medication is not given, and when a drug is given via an incorrect route. Errors due to incorrect routes usually occur due to unclear labelling or tubing that is adaptive to multiple connectors/lines of access. Incorrect routes often result in result in significant morbidity and mortality.

8. ***Incorrect Dosage Form***: This occurs when a patient receives a dosage form different than prescribed, such as immediate-release instead of extended-release.

9. ***Incorrect Patient Action***: This occurs when a patient takes a medication inappropriately. Patient education is the only way to prevent this type of error.

10. ***Known Allergen***: Dispensing a drug that the patient has an allergy often due to failure to communicate with the patient, inappropriate chart review, inaccurate charting, or lack of technologic interface.

11. ***Known Contraindication***: This occurs when medications are not vigilantly reviewed for drug-drug, drug-disease, or drug-nutrient interactions.

Medication Errors Classification

Errors can be classified according to contextual categories; such as stage of occurrence. So, in accordance with the medication use process, medication errors can be classified as prescribing errors, transcription errors, dispensing errors, administration errors or monitoring errors.

Type of error	Definition
Prescribing errors	Incorrect drugs product selection(based on indications, contraindications, known allergies, existing drug therapy, and other factors), dose, dosage form, quantity, route of administration, concentration, rate of administration, or instruction for use of drug product ordered or authorized by physician(or other legitimate prescriber); illegible prescriptions or medication orders that lead to errors.
Transcription errors	”Any deviation in transcribing medication order from the previous step (order on the order sheet, administrating nursing note and/or documentation of the order in the pharmacy database)”
Dispensing errors	“Any unintended deviation from an interpretable written prescription or medication order end aiding content an labelling errors, any unintended deviation from professional or regulatory references, or guidelines affecting dispensing procedures, is also considered as dispensing error”
Administration errors	“Any deviation from the prescriber’s medication order as written on the patient’s errors chart, manufacturers’ preparation/ administration instructions, or relevant institution policies.
Monitoring errors	Failure to review a prescribed regimen for appropriateness and detection of the problems, or failure to use appropriateness and detection of problems, or failure to use appropriate clinical or laboratory data for adequate assessment of patient response to prescribed therapy.

Self- assessment 3.7

1. What are the causes of medication errors?
2. In which of the following types of medication errors would a medication error which involves incorrect drug product selection based on indications be classified?

   A. Prescribing errors

   B. Transcription errors

   C. Dispensing errors

   D. Monitoring errors

3. In which of the following types of medication errors would a medication error which involves a failure to review a prescribed regimen for appropriateness and detection of problems be classified?

A. Prescribing errors
B. Transcription errors
C. Dispensing errors
D. Monitoring errors

3.8 Actions to take in case of medication errors, and use of high alert medications

Learning activity 3.8

A nurse is preparing to administer an injectable dug to patient. His colleague who is an associate nurse says it is a high alert medication, and advises to check well the prescription in order to avoid any risk of committing a medication error.

1. As a nurse student, how can you define a high alert medication?
2. What are the strategies to reduce errors involving High Alert Medications on the aspect of their storage?

CONTENT SUMMARY

Medication errors are a common finding in healthcare settings. The healthcare providers need to take necessary measures in order to avoid or minimize the medication errors. They do however often occur due to different circumstances. When they do occur, the nurses as well as other healthcare providers must take quick actions, and make sure they report that incident.

Steps of Reporting Medication Errors

1. Any staff member who discovers a medication error whether it's a physician, pharmacist, or a nurse must be immediately complete the **Medication Error Report**. The details include; patient name, hospital number, prescription details, details of errors and any incorrect medicine or dose administered to the patient
2. When these details of errors are recorded on the form, the manager or deputy need to identify those staff involved and explain the error to get them and them write about the error causes any comments about the error. The manager or deputy need to mention the immediate the action taken.
3. Send the completed form to **Pharmacy department** in the hospital within 24 hours

4. The **Medication Safety Officer** needs to complete the medication error from such as assesses the incident severity, conduct Root Cause Analysis if need (for all significant or potentially significant medication errors) and suggest recommendation to reduce reoccurrence the error.
5. The Medication Safety Officer needs to inform **the Medication Safety**
6. Medication Safety officer in the hospital needs to review all the medication errors and to take the required action to avoid occurring similar errors in the future.
7. Forwarded to Total Quality Management (TQM) Department in the hospital.

GUIDELINES ON SAFE USE OF HIGH ALERT MEDICATIONS

High-Alert Medications are medicines that have high potential risk to the patient when they are utilized in error. Although mistakes may or may not be common with these medicines, the significances of an error are dearly more devastating to patients.

Examples: Adrenergic agonists. IV (E.g: Epinephrine, Norepinephrine, Phenylephrine); Anaesthetic agents, general, inhaled and IV (e.g., Propofol, Ketamine)

- Hospitals and healthcare providers aim to provide high quality and safe medical care to their patients, including the safe and effective use of medications.
- These medications, however, can be compared to a two-edged sword: while useful, they can also be harmful as a result of errors associated with their use as well as from adverse events/effects especially with these medications that have a very narrow margin of safety and can cause severe harm to the patient.
- These medications are recognized as High Alert Medications.
- The Institute for Safe Medication Practices has gathered a list of “high-alert” medications. These medications require extra precaution because they have highly potentially rich to the patient when used in error.

Managing High Alert Medications

The pharmacy department in the hospital needs to provide general guidelines for the proper handling of High Alert Medications including the medication list.

Concentrated electrolytes (Potassium & Sodium Phosphate, Potassium Chloride, and Sodium Chloride) are High-Alert Medications, so should not be stocked in the patient care areas Except as part of the crash cart medications. Limited quantities of these concentrated electrolytes can be stocked in specific area such as ICU (Intensive Care Unit) and ER (Emergency Room) and need to be kept in a separate locker and away from the regular ward stock medications and should by monitored frequently by nursing and pharmacy staff.

Label all containers and shelves used for storing High Alert Medications as **"HIGH ALERT MEDICATION**S"

High Alert Medications must be double checked before they are prepared, dispensed and administered to the patients

The Medication Safety officer in the hospital must be check if the staff commitment to do the double check before they are prepared, dispensed and administered to the patients.

Strategies to reduce errors involving High Alert Medication

* **Procurement**
  - Limit the drug strengths available in the hospital.
  - Avoid frequent changes of brand or color and notify the other healthcare staff if there are changes.
  - Inform all relevant personnel regarding in the hospital about the new High Alert Medications listed.
* **Storage**
  - Minimize High Alert Medications from clinical areas, where possible.
  - High Alert Medication should be stored individually in separate labelled plastic container.
  - Label the shelves or containers used for storing Alert Medications as "High Alert Medications."
* **Prescribing**
  - Avoid using abbreviations when prescribing High Alert Medications.
  - Avoid ordering High Alert Medications verbally accept in case of emergency orders.
  - Prescribe oral liquid medications with the dose specified in milligrams.
  - Avoid using trailing zero when prescribing (e.g. 5.0 mg can be mistaken as 50 mg)
  - Reduce the total dose of High Alert Medications in continuous IV drip bags (e.g., 12,500 Units of Heparin in 250 ml vs. 25,000 Units in 500 ml) to reduce risk
- **Dispensing / Supply**

All High Alert Medication containers, product packages, vials or ampoules issued towards units need to have caution label "**High Alert Medications**" Except for parenteral nutrition preparations.

Accuracy check performance must be applied for the High Alert Medications before dispensing the medicines.

GUIDE ON HANDLING LOOK-ALIKE & SOUND-ALIKE MEDICATIONS

The patient safety incidents are widely spread because the health services system become more complex, due to new technologies, medicines and treatments strategies.

Currently, thousands of medications are available in the markets and in the hospitals.

Some of these medicines have similarity in the names or packaging. The evidences show that Look-alike/sound-alike medicines names and packaging are one of the most common contributed factors associated with medication errors.

Look Alike Sound Alike (LASA) medications involve medicines that are visually similar in physical appearance or packaging and names of medications that have spelling similarities and/or similar phonetics.

Contributing Factors

Several Contributing factors may lead to confusion with LASA medications, these include:

- Illegible handwriting.
- Incomplete knowledge of drug names.
- Newly available products.
- Importantly, it has similar packaging or labelling.
- Similar strengths, dosage forms, frequency of administration.
- Finally, similar clinical use

Strategies to avoid errors with LASA Medications

* **Procurement**

Minimize the availability of multiple medicines strengths

Whenever possible, avoid purchase of medicines with similar packaging and appearance. As new products or packages are introduced, compare them with existing packaging.

* **Storage**

Use Tall Man lettering to emphasize differences in medications with sound-alike names.

Tall Man lettering (or Tallman lettering) is the practice of writing part of a medicines name in upper case letters to help distinguish sound-alike/look-alike medications from one another to avoid medication errors.

Examples of Tall Man lettering are metformin and metoprolol

Using caution **red tag notes on shelves**, in order to alert the dispenser that a medicine has look-alike and sound-alike medicines.

Using techniques such as **boldface and differences** to reduce the confusion associated with the use of LASA names on labels in the medicine's storage containers and shelves.

* **Prescribing**

Place LASA medications in locations separate from each other or in non- alphabetical order**.**

Write legibly, using both the brand and generic names for prescribing LASA medications.

Prescription should clearly specify name of medication, dosage form, dose and complete direction for use.

Write the diagnosis or medication's indication for use. This information helps to differentiate possible choices in illegible orders.

In electronic prescribing system, using techniques such as Tall-man lettering, boldface and color differences to reduce the confusion associated with the use of LASA names on the computer screens and medication administration records.

Communicate clearly. Take your time in pronouncing the drug name whenever an oral order made.

Ask that the recipient of the oral communication repeat the medication name and dose.

Minimize the use of Verbal and Telephone orders.

* **Dispensing/Supply**

Identify medicines based on its name and strength and not by its appearance or location.

Check the purpose of the medication and the dose for the medicines dispensed.

Read medication prescription and label carefully at all dispensing stages

Commitment to a final accuracy check by a qualified person, before handing over the medicine to the patient or the patient's representative

Double check should be conducted at any stage during the dispensing and supply process.

Highlight changes in medication appearances to patients upon dispensing.

* **Administration**

Read carefully the medication labels each time during the administration process

Perform the double check to check actual medicine and compare it with the prescription and label.

Check the purpose of the medication and the dose prior to administration.

Self- assessment 3.8

1. How can you define Look Alike Sound Alike (LASA) medications?
2. How can you explain "Tall Man lettering" as a strategy to reduce the errors associated with the use of LASA medications?
3. What are the strategies to avoid errors with LASA medications during their supply/dispensing?
4. What are the strategies to avoid errors with High Alert Medications during their prescription?

3.9 Systems of measurement used in pharmacology

Learning activity 3.9

You are carrying the clinical practice at a health centre. A mother brings her 24-month-old female child who has a lower respiratory infection. An oral liquid antibiotic is prescribed, and the mother is instructed to give 5 mL TDS. The mother does not have a tool to accurately measure 5 mL, and she admits to have different materials meant for household measurement.

1. Which household measurement material equivalent to 5 mL would you tell the mother to use?
2. How many teaspoons are usually in one tablespoon?

CONTENT SUMMARY

Introduction to measuring systems

One of the most essential functions of a health care professional is the ability to perform accurate pharmaceutical measurements, calculations and conversions. Without this ability, a health care professional is not able to apply their knowledge of pharmacology in a practical manner during their everyday work functions. This is important as one incorrect calculation, conversion or measurements will affect a dosage, and can potentially harm a patient. Possessing a working knowledge of the pharmaceutical systems of measurement will only benefit a pharmaceutical professional.

At least four different systems are currently used in drug preparation and delivery: **the metric system, the apothecary system, the household system, and the avoirdupois system**. With the growing number of drugs available and increasing awareness of medication errors that occur in daily practice, efforts have been made to decrease the dependence on so many different systems. In 1995, the U.S. Pharmacopeia Convention established standards requiring that all prescriptions, regardless of the system that was used in the drug dosing, include the metric measure for the quantity and strength of drug. It was also established that drugs may be dispensed only in the metric form. Prescribers are not totally converted to this new standard, however, so the nurse must be able to convert the dose ordered into the available dose form to ensure patient safety. It is important to be able to perform **conversions** (finding the equivalent values between two types of measure, within each system of measure, and between systems of measure).

METRIC SYSTEM

The **metric system** is the most widely used system of measure. It is based on the decimal system, so all units are determined as multiples of 10. This system is used worldwide and makes the sharing of knowledge and research information easier. The metric system uses the gram as the basic unit of solid measure and the liter as the basic unit of liquid measure. When using the metric system to convert from smaller to larger, a person would simply move the decimal to the appropriate number of places to the left. When converting from larger to smaller, a person would move the decimal the necessary number of places to the right.

APOTHECARY SYSTEM

The **apothecary system** is a very old system of measurement that was specifically developed for use by apothecaries or pharmacists. **The apothecary system uses the minim as the basic unit of liquid measure and the grain as the basic unit of solid measure**. It uses weight and volume as divisions of measurement, they include measurements of ounces, gallons, pints and quarts. This system is much harder to use than the metric system and is rarely seen in most clinical settings. Occasionally, a prescriber will write an order in this system, and the dose will have to be converted to an available form. An interesting feature of this system is that it uses Roman numerals placed after the unit of measure to denote amount. For example, 15 grains would be written “gr xv.”

HOUSEHOLD SYSTEM

The household system is the measuring system that is found in recipe books. **This system uses the teaspoon as the basic unit of fluid measure and the pound as the basic unit of solid measure**. Although efforts have been made in recent years to standardize these measuring devices, wide variations have been noted in the capacity of some of them. Patients need to be advised that flatware teaspoons

and drinking cups vary tremendously in the volume that they contain. A flatware teaspoon could hold up to two measuring teaspoons of quantity. When a patient is using a liquid medication at home, it is important to clarify that the measures indicated in the instructions refer to a standardized measuring device.

AVOIRDUPOIS SYSTEM

The avoirdupois system is another older system that was very popular when pharmacists routinely had to compound medications. **This system uses ounces and grains**, but they measure differently than those of the apothecary and household systems. The avoirdupois system is seldom used by prescribers but may be used for bulk medications that come directly from the manufacturer. **The avoirdupois system exclusively measures weight based on 16-ounces equaling 1 lb**. This system of measurement is the everyday weight-measuring system most people recognize. In pharmaceutical measurements, the avoirdupois system is useful for measuring bulk quantities when buying or selling, including over-the-counter pharmaceuticals and chemicals.

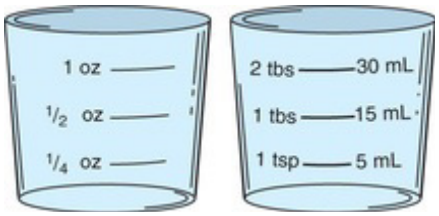
OTHER SYSTEMS

Some drugs are measured in units other than those already discussed. These measures may reflect chemical activity or biological equivalence. One of these measures is the unit. A unit usually reflects the biological activity of the drug in 1 mL of solution. The unit is unique for the drug it measures; a unit of heparin is not comparable to a unit of insulin. Milliequivalents (mEq) are used to measure electrolytes (e.g., potassium, sodium, calcium, fluoride). The milliequivalent refers to the ionic activity of the drug in question; the order is usually written for a number of milliequivalents instead of a volume of drug. International units are sometimes used to measure certain vitamins or enzymes. These are also unique to each drug and cannot be converted to another measuring form.

Material used for measuring liquid for metric and household

A **medicine cup** is a plastic container with scales (metric, household) for measuring liquid medications. Examine the medicine cup carefully before pouring any medication to ensure that the proper scale is being used for measurement. The medicine cup should be placed on a hard surface when measuring liquid medication and then read at eye level. The medicine cup is inaccurate for measuring doses of less than 1 teaspoon, although it is reasonably accurate for larger volumes. A syringe comparable to the volume to be measured should be used for smaller volumes. For volumes of less than 1 mL, a tuberculin syringe should be used.

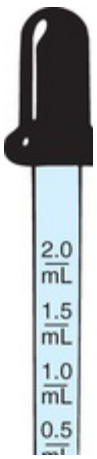
Measuring scales on a medicine cup.



HOUSEHOLD MEASUREMENT	METRIC MEASUREMENT
2 Tbsp	30 mL
1 Tbsp	15 mL
2 tsp	10 mL
1 tsp	5 mL

3 tsp = 1 Tbsp; 2 Tbsp = 30 mL = 1 oz.

mL: Milliliter; oz: unce; Tbsp: Tablespoon; tsp: teaspoon.



Medicine Dropper

The **medicine dropper** may be used to administer eyedrops, eardrops, and, occasionally, pediatric medications. There is great variation with regard to the size of the drop formed, so it is important to use only the dropper supplied by the manufacturer for a specific liquid medication. Before drawing medication into a dropper, it is necessary to become familiar with the calibrations on the barrel. After the medication is drawn into the barrel, the dropper should not be tipped upside down because the medication will run into the bulb, thereby causing some loss of the medication. Medications should not be drawn into the dropper and then transferred to another container for administration because part of the medication will adhere to the second container, thus diminishing the dose delivered.

Teaspoon

Doses of most liquid medications are prescribed in terms using the teaspoon as the unit of measure. However, there is great variation between the volumes measured by various spoons in the home. **In the hospital, 1 teaspoon is converted to 5 mL**, and this is read on the metric scale of the medicine cup. For home use, an oral syringe is recommended. If this is not available, a teaspoon that is used specifically for baking may be used as an accurate measuring device.

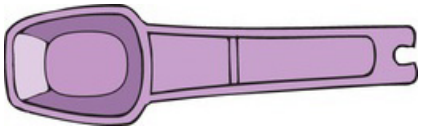


Table: Equivalent units of measurement

Units	Equivalent Units of Measurement		
Weight	1 kilogram (kg, Kg)	=	1000 g = 2.2 lb
	1 gram (g, gm, G, Gm)	=	1000 mg
	1 milligram (mg)	=	1000 mcg
	1 microgram (mcg)	=	1000 ng (nanograms)
Volume	1 liter (L)	=	1000 mL (milliliters)
Length	1 kilometer (km)	=	1000 m
	1 meter (m, M)	=	100 cm
	1 centimeter (cm)	=	10 mm
	2.54 cm	=	1 inch
	25.4 millimeters (mm)	=	1 inch

Self- assessment 3.9

1. What are the 4 main measuring systems used in pharmacology?
2. What is the equivalent metric measurement (in mL) for 2 tablespoons of household measurement?
3. What is the basic unit of liquid measure in household system?
4. What is the equivalent metric measure of 2 teaspoons?

3.10 Characteristics of a well written medical prescription

Learning activity 3.10

You are carrying out clinical practice in a health center. You colleague finds a prescription of paracetamol 500 mg PRN for a patient who is being managed for an intermittent fever. The colleague then gets confused with the meaning of PRN.

1. How can you explain a PRN order to your colleague?
2. What are other types of medication orders?
3. In Rwanda, who have the broadest prescriptive authority of medications?

CONTENT SUMMARY

Introduction

A prescription (℞) is a health-care program implemented by a physician or other medical practitioner in the form of instructions that govern the plan of care for an individual patient.

Prescriptions may include orders to be performed by a patient, caretaker, nurse, pharmacist or other therapist.

Commonly, the term prescription is used to mean an **order to take certain medications**.

Prescriptions have legal implications, as they may indicate that the prescriber takes responsibility for the clinical care of the patient and in particular for monitoring efficacy and safety.

However, as medications have increasingly become pre–packaged manufactured products and medical practice has become more complex, the scope of meaning of the term “prescription” has broadened to also include clinical assessments, laboratory tests, and imaging studies relevant to optimizing the safety or efficacy.

Both pharmacists and prescribers are **regulated professionals** in most jurisdictions.

A prescription as a communications mechanism between them is also regulated and is a legal document.

Regulations may define what constitutes a prescription, the contents and format of the prescription (including the size of the piece of paper and how prescriptions are handled and stored by the pharmacist).

Many jurisdictions will now allow faxed or phone prescriptions containing the same information.

Many **brand** name drugs have **less expensive generic** drug substitutes that are therapeutically and biochemically equivalent.

Prescriptions will also contain instructions on whether the prescriber will allow the pharmacist to **substitute** a generic version of the drug. This instruction is communicated in a number of ways.

In some jurisdictions, the preprinted prescription contains two signature lines: one line has “dispense as written” printed underneath the other line has “substitution permitted” underneath.

Some have a preprinted box “dispense as written” for the prescriber to check off (but this is easily checked off by anyone with access to the prescription).

Other jurisdictions the protocol is for the prescriber to handwrite one of the following phrases: “dispense as written”, “DAW”, “brand necessary”, “do not substitute”, “no substitution”, “medically necessary”, “do not interchange”.

In other jurisdictions may they use completely different languages, never mind a different formula of words.

In some jurisdictions, it may be a legal requirement to include the age of child on the prescription.

For pediatric prescriptions, some advise the inclusion of the age of the child if the patient is less than twelve and the age and months if less than five. In general, including the age on the prescription is helpful. Adding the weight of the child is also helpful.

Prescriptions often have a “label” box. When checked, the pharmacist is instructed to label the medication. When not checked, the patient only receives instructions for taking the medication and no information about the prescription itself.

Some prescribers further inform the patient and pharmacist by providing the indicator for the medication i.e. what is being treated.

This assists the pharmacist in checking for errors as many common medications can be used for multiple medical conditions.

Some prescriptions will specify whether and how many “**repeats**” or “**refills**” are allowed, that is whether the patient may obtain more of the same medication without getting a new prescription from the medical practitioner.

Regulations may restrict some types of drugs from being refilled.

In group practices, the preprinted portion of the prescription may contain multiple prescribers’ names.

Prescribers typically circle themselves to indicate who is prescribing or there may be a checkbox next to their name.

Types of Medication Orders

The health care practitioner prescribes medications in different ways, depending on their purpose. Medications can be prescribed as stat, single-dose, standing, and as needed (prn) orders.

STAT ORDERS

A stat order is an order for a single dose of medication to be given immediately. Stat drugs are often prescribed in emergency situations to modify a serious physiological response; a stat dose of nitroglycerin may be ordered for a client experiencing chest pain.

The nurse should assess and document the client's response to all stat medications.

SINGLE-DOSE ORDERS

Single-dose orders are one-time medications or may require the administration of drops or tablets over a short period of time.

The nurse should administer single-dose orders only once, either at a time specified by the health care practitioner or at the earliest convenient time.

These drugs are often prescribed in preparation for a diagnostic or therapeutic procedure for example, radiopaque tablets may be administered in preparation for a gallbladder test, or a one-time order may be given for a preoperative medication.

STANDING ORDERS

Standing orders are also referred to as scheduled orders because they are administered routinely as specified until the order is canceled by another order.

The standing orders stay in effect until the health care practitioner discontinues or modifies the dosage or frequency with another order or until a prescribed number of days has elapsed as determined by agency policy.

The purpose of a standing medication order is to maintain the desired blood level of the medication.

PRN ORDERS

A drug may be ordered on a prn (as needed) basis as circumstances indicate.

The drug is administered when, in the nurse's judgment, the client's condition requires it.

Before administering a prn medication, the nurse must thoroughly assess the client, using both objective and subjective data in determining the appropriateness of administering the medication.

This type of order is commonly written **for analgesics, antiemetic, and laxatives**.

The order written by the health care practitioner indicates how frequently a prn medication can be given.

A nurse cannot administer a prn medication more frequently than the order indicates without consulting with the health care practitioner for a change in that order.

Examples of prn orders are meperidine (a narcotic analgesic) 75 mg IM q3–4 hours prn incisional pain and Tylenol 650 mg q4 hours prn headache.

When the prn medication has been administered, the nurse documents the assessment and the time of administration.

In addition, the nurse is responsible for monitoring the effectiveness of the medication and documenting the effect in the client's medical record.

The nurse administers the pain medication on the basis of the assessment of the client's pain and as specified in the order.

Who can write prescriptions (that may legally be filled with prescription-only items)?

Any jurisdiction that allows freedom of written communication generally must therefore allow anybody to write a prescription to anybody, in as much as the prescription itself is just written advice.

Therefore "who can write prescriptions" will be explained below as shorthand for "whose prescriptions may legally be filled with items restricted to dispensing via the order of certain persons".

National or legislation governs who can write a prescription.

In Rwanda, physicians have the broadest prescriptive authority.

Many other healthcare professions also have some form of prescriptive authority related to their area of practice. Veterinarians, dentists, and podiatrists have prescribing power.

All the country allows registered certified Nurse practitioners prescription power with some limitations to controlled substances.

Both pharmacists and prescribers are regulated professionals in most jurisdictions. A prescription as a communications mechanism between them is also regulated and is a legal document.

Regulations may define what constitutes a prescription, the contents and format of the prescription including the size of the piece of paper and how prescriptions are handled and stored by the pharmacist.

Many jurisdictions will now allow faxed or phone prescriptions containing the same information.

Parts of the drug order

All orders should be written clearly and legibly, and the drug order should contain seven main parts:

1. Identification of the client (name, age, sex, etc)
2. The date and time when the order is written
3. The name of the drug to be administered
4. The dosage

5. The route by which it is to be administered and special directives about its administration
6. The time of administration and frequency
7. The signature of the person writing the order, such as the physician or advanced practice registered nurse

Conventions for avoiding ambiguity

Not only the drug order and medical prescription should have the above mentioned parts, should they also have the full information in order to give all required details about the order or prescription.

Prescribers have developed many conventions for prescription-writing, with the goal of avoiding ambiguities or misinterpretation.

These include:

- Date medication dispensed
- Sequential number
- Client full identity
- Prescriber's direction for usage including the frequency and route of administration
- Prescriber's name
- Name and address of the agency dispensing
- Name and strength of the drug dispensed

MEDICAL PRESCRIPTION (EXAMPLE 1)

LE BON SAMARITAIN MEDICAL CLINIC **DATE…….**

KIGALI

NAME:

SURNAME:

AGE:

GENDER:

WEIGHT:

MEDICAL PRESCRIPTION

R/……

R/……..

STAMP & SIGNATURE OF PRESCRIBER

Self- assessment 3.10

1. Which of the following statements best describes a STAT order?

   A. The drug is administered when, in the nurse's judgment, the client's condition requires it such as in case of pain management.

   B. These are one-time medications or orders that require the administration of drops or even tablets over a specified short period of time.

   C. An order for a single dose of medication to be given immediately, often in emergency situations to modify a serious physiological response

   D. These are the orders for drugs that are administered routinely as specified until the order is canceled by another order.

2. What are the 7 main parts of a drug order?
3. Some prescriptions will specify whether and how many "repeats" or "refills" are allowed for prescribed drugs. What do you understand by

3.11 Drug dosage calculation

Learning activity 3.11

1. The nurse is preparing to give an oral dose of acetaminophen (Tylenol) to a child who weighs 12 kg. The dose is 15 mg/kg. How many milligrams will the nurse administer for this dose?
2. The patient is to receive 60 mg of gentamicin BID intramuscularly. The available ampules are 80 mg dissolved in 2 mL each. How many milliliters will the associate nurse draw from the ampule at each drug administration (dose)?
3. A 20-year-old male patient is to be given tablets of erythromycin for his respiratory infection. He has been prescribed 500 mg TDS for 7 days. The available erythromycin tablets strength is tablets of 250 mg. How many tablets will the patient receive per day?

CONTENT SUMMARY

Drug Dosage Calculations

Drug dosage calculations are required when the amount of medication ordered (or desired) is different from what is available on hand for the nurse to administer.

Formula:

Amount DESIRED (D) X QUANTITY (Q) = Y (Tablets Required) **Amount on HAND(H)**

Note: When medication is given in tablets, the QUANTITY = 1 since the amount of medication available is specified per (one) tablet.

Example 1: Toprol XL, 50 mg PO, is ordered. Toprol XL is available as 100 mg per tablet. How many tablets would the nurse administer?

Step 1: Determine your givens.	**Amount desired (D) = 50 mg** **Amount on hand (H) = 100 mg** **Quantity = 1**
Step 2: Plug in what you know into the formula and simplify.	**50 mg X 1 = 0.5 tablets** **100 mg**

Therefore, the nurse would administer 0.5 of a tablet.

Example 2: 1200 mg of Klor-Con is ordered. This medication is only available as 600 mg per tablet. How many tablets should the nurse give?

Step 1: Determine your givens.	**Amount desired (D) = 1200 mg** **Amount on hand (H) = 600 mg** **Quantity = 1**
Step 2: Plug in what you know into the formula and simplify.	**1200 mg X 1 = 2 tablets** **600 mg**

Therefore, the nurse should give 2 tablets.

The same formula can be used for dosage calculations where the medication is available as amount per certain volume. In these types of calculations, the volume available on hand is the **quantity**.

Example 3: Dilantin-125 is available as 125 mg/5 mL. Dilantin-125, 0.3 g PO, is ordered. How much should the nurse administer to the patient?

Step 1: Determine your givens.	**Amount desired (D) = 0.3 g** **Amount on hand (H) = 125 mg** **Quantity = 5 mL**
Step 2: Convert 0.3 g to mg (since the ordered dose is in grams but the drug is available on hand in milligrams)	**0.3 g x 1,000 mg/g = 300 mg**
Step 3: Plug in what you know into the formula and simplify.	**300 mg x 5 mL = 12 mL** **125 mg**

Therefore, the nurse would administer 12 mL.

Example 4: Furosemide is available as 40 mg in 1 mL. 10 mg is ordered to be administered through an IV. What amount of furosemide should the nurse administer?

Step 1: Determine your givens.	**Amount desired (D) = 10 mg** **Amount on hand (H) = 40 mg** **Quantity = 1 mL**
Step 2: Plug in what you know into the formula and simplify.	**10 mg x 1 mL = 0.4 mL** **40 mg**

Therefore, the nurse should administer 0.4 mL of furosemide.

Dosage calculations based on body weight

Dosage calculations based on body weight are required when the dosage ordered and administered is dependent on the weight of the patient. For example, many pediatric drugs are ordered and given per weight (usually in kg). Dosage calculations based on body weight are calculated in two main stages.

Stage 1: Using the formula below, calculate the total required dosage based on given the body weight.

Weight (kg) x Dosage Ordered (per kg) = Y (Required Dosage)

Stage 2: Apply the **D/H x Q** formula to calculate the actual amount of medication to be administered.

Example 1: Medrol 4 mg/kg is ordered for a child weighing 64.8 lb. Medrol is available as 500 mg/4mL. How many milliliters of medication must the nurse administer?

Step 1: Determine your givens.	**Weight: 64.8 lb** **Dosage ordered: 4mg/kg** **Available on hand: 500 mg/4mL**
Step 2: Convert 64.5 lb to kg since the infant's weight is given in pounds (lb) but the dosage ordered is in mg per kilogram	**64.8 lb ÷ 2.2 lb/kg = 29.45 kg** **Therefore, the infant's weight is 29.45 kg.**
Step 3: Calculate the required dosage (mg) of medication based on the child's weight.	**Weight (kg) x Dosage Ordered (per kg) = Y (Required dosage)** **29.45X4 mg/kg = 117.8 mg** **Therefore, the required dosage of medication is 58.64 mg.**
Step 4: Calculate the volume of medication (mL) to be administered based on what's available on hand.	**Amount Desired x Quantity = Y** **Amount on Hand** **117.8 mg x 4 ml = 0.942 ml** **500 mg** **Therefore, the nurse must administer 0.942** mL **of medication.**

DROP RATE CALCULATION

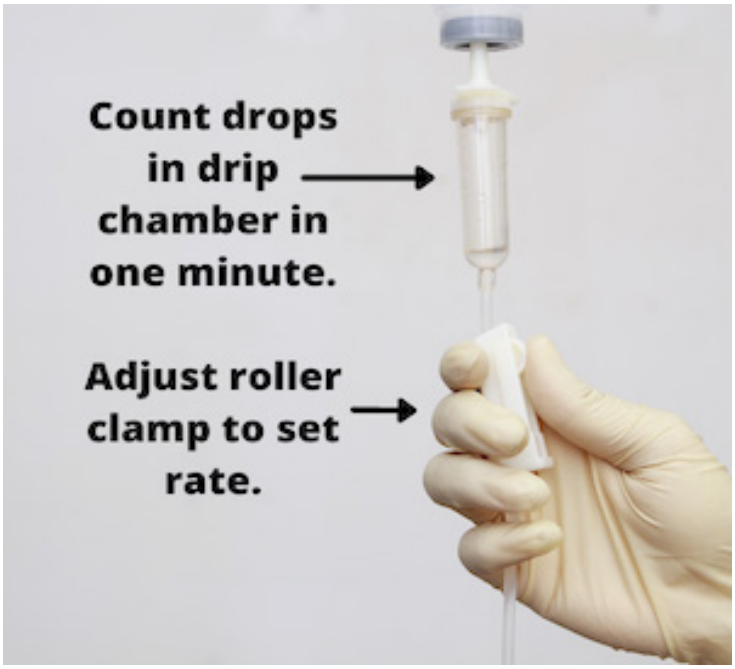
In all health facilities across health care system, many different types of medications are delivered as continuous IV infusions in acute, ambulatory, long-term and critical care settings. With poor attention before during even after IV drug medications, Medication error arise. These errors, which may be having serious negative consequences, can be eliminated or kept to a minimum by knowing the standard to medication errors. The drop rate calculation is very important for all continuous or intermittent IV infusion Continuous IV infusions are often used when the medication needs to be greatly diluted, the drug level in the blood must be tightly controlled, or large volumes of fluids need to be infused.The drop rate calculation requires to have the following information.

The drop rate calculation requires to have the following information

1. Amount of infusion/medication to be given(volume)
2. Ordered dose

3. Time or length of administration in minutes
4. Drop factor: the number of the drops in the iv chamber that is equivalent to 1ml

Having all this information the drop rate or flow rate is calculated as follow:



$$\frac{\text{Volume (ml)}}{\text{Minutes}} \times \frac{\text{Drop Factor}}{\text{(gtt/ml)}} = \text{Flow Rate (gtt/min.)}$$

For IV infusion, tubing varies in size. The macrodrip tubing delivers 10 to 20 gtts/mL and is used to infuse large volumes or to infuse fluids quickly. Microdrip tubing delivers 60 gtts/mL and is used for small or very precise amounts of fluid, as with neonates or pediatric patients. In general, the drop factor is considered as 20 but may change depending on the manufacturer of the infusion set. Before administering IV fluid a nurse must verify it on the available set.

If you simply need to figure out the mL per hour to infuse, take the total volume in mL, divided by the total time in hours, to equal the mL per hour. An IV drip rate is a way of describing the rate of an intravenous infusion based on the number of drops (gtt) that are administered to the patient per minute. This is influenced by the type of the tubing (microdrip or macrodrip), the total volume that is required to be infused, and the time over which the infusion is ordered to run. An IV drop factor reflects the specific size of the drops of IV fluid that the tubing set creates. This is a predetermined number based on the tubing required and available to administer the medication.

Self- assessment 3.11

1. 1000 mg of potassium chloride is ordered. This medication is only available as 500 mg per tablet. How many tablets should the nurse give?
2. Diclofenac injection is available as an ampule of 75mg/3 ml. This means that the concentration is 25 mg/ml or 75 mg/ 3 ml. Question: How much volume of liquid will the client receive when the prescription is to give only 50 mg?
3. A syrup is available as 25mg/5ml and the patient must be given 50mg. What volume in milliliters will be given?

End Unit assessment 3

1. During drug administration, the nurse needs to ensure that all the rights of medication administration are respected. Therefore, while applying the right time, medications should be prescribed as closely to the time as possible, and nurses should not deviate from this time by:

   A. More than two hours to avoid consequences

   B. More than three hours to avoid consequences

   C. More than half an hour to avoid consequences

   D. More than one hour to avoid consequences

2. Which of the following rights of medication administration seeks to ensure the medication is working the way it should after its administration?

   A. Right evaluation

   B. Right documentation

   C. Right route and form

   D. Right patient

3. Which of the following instructions are applied to controlled drug regulation?

   A. The controlled drugs should be in double locked container, and 1 licensed personnel counts (or verifies any discrepancies) every two days.

   B. The controlled drugs should be in double locked container, and 2 licensed personnel count (or verify any discrepancies) every shift.

   C. The controlled drugs should be in double locked container, and 2 licensed personnel counts (or verifies any discrepancies) every two days.

   D. The controlled drugs should be in double locked container, and 1 licensed personnel counts (or verifies any discrepancies) four times a day.

4. Which of the following statements best defines the subcutaneous injection?

   A. The medication is deposited just beneath the skin in the loose subcutaneous tissue.

B. The drug is injected into one of a large skeletal muscle such as triceps and rectus femoris

C. Intrathecal administration is a route for drugs via an injection into the spinal canal, or into the subarachnoid space

D. Method of administering medications directly into the vein using a needle and a syringe

5. In which of the following types of medication errors would a medication error which involves any deviation from the prescriber's medication order as written on the patient's errors chart, manufacturers' preparation, or relevant institution policies be classified?

A. Prescribing errors

B. Administration errors

C. Dispensing errors

D. Monitoring errors

6. How many millilitres are in one teaspoon used in the measurement of drugs?

A. 7 millilitres

B. 10 millilitres

C. 15 millilitres

D. 5 millilitres

7. Which of the following statements best describes a STANDING order?

A. The drug is administered when, in the nurse's judgment, the client's condition requires it such as in case of pain management.

B. These are one-time medications or orders that require the administration of drops or even tablets over a short period of time.

C. An order for a single dose of medication to be given immediately, often in emergency situations to modify a serious physiological response

D. These are the orders for drugs that are administered routinely as specified until the order is canceled by another order.

8. Enumerate social and economic dimensions affecting adherence to medications.

9. Enumerate the advantages of rectal route of drug administration.

10. What are the disadvantages of administering the drugs by the transdermal route?

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