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PURPOSE

This course is required; District of Columbia Board of Nursing. The purpose of this course is to provide health care professionals; LPN, RN, ARNP, Therapists, students, Certified Nursing Assistants (CNA), Home Health Aids (HHA), and other individuals with the opportunity to review Pharmacology; the medication pharmacodynamics, pharmacokinetics; absorption, distribution, metabolism, elimination. Review of the therapeutic value and/or the potential toxicity of chemical agents on biological systems. Describe of medication interactions, side effects /adverse reactions, review of precautions and contraindications, discuss common medical and medication errors and steps to avoid them, identify patients who require special considerations when administering medications, discuss Medication RIGHTS, review of HIGH alert drugs and review the Institute for safe medication practices (ISMP) recommendations. Discuss various categories of medications such as: Analgesics, Allergy medications, Antibiotics, Anticonvulsants, Anticoagulants, Antifungal, Asthma, Antiviral medications. Review of Cardiovascular, corticosteroids, Cholesterol lowering drugs and some medications used for patients with Diabetes.

OBJECTIVES

TRAIN FOR SUCCESS INC.
PHARMACOLOGY 15 Hr

After successful completion of this course the students will be able to:

1. Discuss pharmacokinetics and Pharmacodynamics.
2. Describe absorption, distribution, metabolism and elimination process.
3. Describe of medication interactions, side effects /adverse reactions.
4. Describe various precautions and contraindications.
5. Discuss common medical and medication errors and steps to avoid them.
6. Identify patients who require special considerations when administering medications.
7. Discuss Medication RIGHTS
8. Discuss HIGH alert drugs and review the Institute of safe medication practices Recommendations.
9. Discuss various categories of medications such as Analgesics, Allergy medications, Antibiotics, Anticonvulsants, Anticoagulants, Antifungal, Asthma, Antiviral medications.
10. Discuss various Cardiovascular, corticosteroids, Cholesterol lowering medications,
11. Discuss various medications used for patients with Diabetes

INTRODUCTION

Pharmacology

Pharmacology is the branch of medicine and biology concerned with the study of drug/medication action, where a drug/ medication can be defined as any molecule; natural, manmade or endogenous; from within body that exerts biochemical or physiological effects on an organism, organ, tissue or cell.

Pharmacology, in simple term, is the study of interactions that occur between a living organism and chemicals that affect abnormal or normal biochemical functions. If the substance has medicinal properties, it is considered pharmaceutical.

During earlier years, pharmacologists focused mainly on natural substances, such as plant extracts. Pharmacology developed in the 19th century as a biomedical science that applied the principles of scientific experimentation to therapeutic contexts. Currently pharmacologists utilizes molecular biology, chemistry, genetics and other tools to transform information about molecular mechanism and targets into therapies directed against disease, pathogens, defects and create methods for preventative care and diagnostics.

Pharmacology also includes the study of the therapeutic value and/or the potential toxicity of chemical agents on biological systems.

Pharmacology involves:

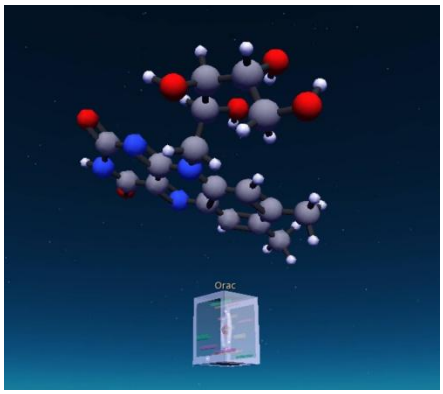
- Drug composition and properties,
- synthesis and drug design,
- molecular and cellular mechanisms,
- organ and systems mechanisms,
- signal transduction and cellular communication,
- molecular diagnostics,
- interactions,
- toxicology,
- chemical biology,

- therapy and medical applications,
- antipathogenic capabilities.

Pharmacological studies range from:

- those that examine the effects of chemical agents on subcellular mechanisms,
- to those that deal with the potential hazards of pesticides and herbicides,
- to those that focus on the treatment and prevention of major diseases with drug therapy.

Pharmacologists also utilize molecular modeling and use computerized design as drug discovery tools to understand cell function.



The two main areas of pharmacology are:

- pharmacodynamics and
- pharmacokinetics.

Pharmacodynamics discusses the chemicals with biological receptors while pharmacokinetics discusses the absorption, distribution, metabolism, and excretion of chemicals from the body/ biological systems.

Pharmacodynamics

Pharmacodynamics involces the study of the molecular, biochemical, and physiological effects of drugs on cellular systems and their mechanisms of action.

Pharmacokinetics

Pharmacokinetics discusses the absorption, distribution, metabolism, and excretion of chemicals from the body/ biological systems.

Pharmacogenetics
Pharmacogenetics - the study of how people respond differently to drugs due to their genetic inheritance (is a growing body of knowledge that will significantly influence prescribing).

DRUG ABSORPTION

For compounds to reach the tissue, it usually must be taken into the bloodstream, sometimes by mucous surfaces such as the Gastrointestinal (GI) tract (intestinal absorption), before being taken up by the cells.

Various factors can reduce the extent to which the medication is absorbed after oral administration, such as:

- Poor compound solubility,
- gastric emptying time,
- intestinal transit time,
- chemical instability in the stomach,
- inability to permeate the intestinal wall.

Absorption critically determines the compound's bioavailability. Drugs that absorb poorly when taken orally may be administered in another way, for example intravenously (IV) or via inhalation. Route of administration is therefore a vital consideration.

Drug absorption is determined by:

- The medication's physicochemical properties (relating to both physical and chemical properties),
- Formulation (the process of preparing a drug in a specific way or form),
- Route of administration.

Medication forms such as capsules, tablets, solutions; dosage along with additional ingredients, are formulated to be administered by different routes, for example: oral, parenteral, inhalational etc.

Medications need to be in solution for it to be absorbed. Therefore solid forms such as tablets, must be able to disintegrate and disaggregate (separate or break up from a mass).

A medication has to cross several semi permeable cell membranes before the medication reaches the systemic circulation, unless it was given intravenously. Cell membranes are barriers (biologic barrier) that inhibit passage of drug/medication molecules. The membranes are made up of or composed primarily of a bimolecular lipid matrix that determines the permeability of the membrane.

Medications may cross the cell membranes by:

- Passive diffusion,
- Facilitated passive diffusion,
- Active transport,
- Pinocytosis -
  (Introduction of fluids into a cell by invagination of the cell membrane,followed by formation of vesicles within the cells).
- At other times various globular proteins that are embedded in the matrix function as receptors and help in transporting molecules across the membranes.

Passive diffusion

Drugs/medications diffuse across a cell membrane from a region of high concentration to region of low concentration. Diffusion across the cell membrane is a type of passive transport (simple diffusion) or transport across the cell membrane that does not require energy. The cell membrane is a phospholipid bilayer (lipid bilayer; a two-layered arrangement of phosphate and lipid molecules that form the cell membrane). Molecules that are hydrophobic, can pass through the cell membrane by simple diffusion (unassisted passage). Very small molecules can also slip through the cell membrane, even if they are hydrophilic.

Passive Transport: Facilitating Diffusion

There are different types of passageways into the cell. Facilitated diffusion is passive transport that utilizes integral membrane proteins to help larger, hydrophilic, charged, polar molecules across a concentration gradient. The integral membrane proteins span the phospholipid bilayer (lipid bilayer), connecting the inside and the outside of the cells.

Two types of integral membrane proteins help transport molecules, such as ions and polar molecules, which cannot diffuse through the hydrophobic layer, without help.

The first are:

- Carrier proteins (proteins that bind a molecule to facilitate transport through the cell membrane).

The second are:

- Channel proteins (proteins that create a passageway to transport molecules and ions through the cell membrane). This channel protein creates a pore through the hydrophobic region which allows polar molecules to just pass through.

ACTIVE TRANSPORT

Active transport is very selective, requiring energy expenditure and transport against a concentration gradient. Active transport seems to be limited to drugs structurally similar to endogenous substances for example sugars, ions, amino acids vitamins. These drugs/medications are usually absorbed from specific sites within the small intestine.

Pinocytosis

Pinocytosis known as fluid endocytosis, cell drinking, bulk-phase pinocytosis; fluid or small particles are engulfed by a cell. The cell membrane forms an invagination, encloses the particles or fluid and forms a vesicle. Energy expenditure is required.

ORAL ADMINISTRATION

For a medication that has been administered by mouth (orally) to be absorbed, it has to be able to survive the interactions with low pH and multiple encounters with gastrointestinal secretions, enzymes and other substances. Peptide medications are susceptible to becoming degraded and therefore they are not given by mouth. Absorption of oral medications involves transport across the membranes of epithelial cells in the gastrointestinal tract.

As mentioned earlier, absorption is affected by:

- Poor compound solubility,
- gastric emptying time,
- intestinal transit time,

- Presence of mucus
- chemical instability in the stomach,
- inability to permeate the intestinal wall
- The nature of the epithelial membranes
- Difference in pH throughout the GI tract
- Blood perfusion
- Presence of bile

The oral mucosa

The oral mucosa is the mucous membrane lining the inside of the mouth (a thin epithelium) that consists of stratified squamous epithelium (oral epithelium) and an underlying connective tissue (lamina propria) and rich vascularity which favor absorption; but contact is usually too short for substantial absorption. The oral mucosa is also layered with mucin (pH of 5.5-7), negatively charged due to sialic acid, and can form tight adhesion.

Buccal or sublingual administration

The two mechanism of absorption through sublingual or buccal administration; tissues are transcellular and paracellular. Through transcellular pathway (the primary route), drugs diffuse from one cell to the other cell. When the medication is placed between the cheek and gums (buccal administration) or under the tongue (sublingual administration) the medication is retained longer, enhancing the absorption.

Some ideal features of drugs for buccal or sublingual delivery are:

- a small molecular weight,
- lipophilic, undegradable by enzymes in the mucosa, and does not require high plasma concentrations.

For Dosage forms; the desirable features are:

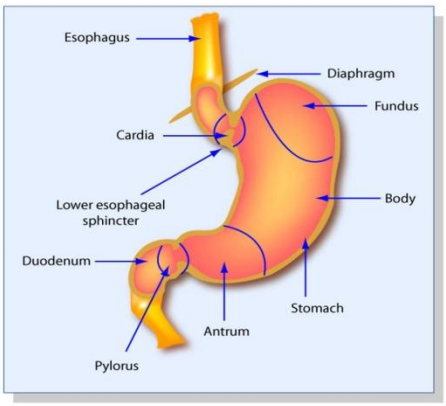
- low irritation or no irritation,
- low variability,
- high bioavailibility,
- low cost.

The dosage forms of buccal delivery system that are available include:

- Tablets,
- Lollipops,
- Sprays,
- Mucoadhesive gels.

The stomach

The stomach has a large epithelial surface; however its thick mucous layer and the short transit time limit absorption. Most drugs are either weak acids or weak bases (part ionized and part unionized). The ionized portion is charged, which attracts water molecules, therefore forming large complexes. The stomach is capable of absorbing most acidic medications and the very weakly basic drugs. When medications are administered by mouth, the medication first reaches the stomach where it disintegrates and dissolves in the gastric lumen. It is then evacuated into the small intestine. Because of the small intestines permeability, large surface area and high blood flow, the small intestine is the primary site for absorption.



Therefore, gastric emptying is an important factor influencing the rate of drug absorption. Foods, especially fat, can slow gastric emptying. Absorption can be limited by the short transit period of the drug through the small intestine (2-4 hours). Colon (large intestines) is usually a very poor site of absorption due to the colon has less permeability and low surface area. However, some medications are absorbed at this site because of the long period of transit (24-48 hours).

In the gastrointestinal tract the medications can be degraded by:

- Gastric acidity,
- Intestinal membrane enzymes,
- Complexion with food constituents and /or bacterial enzymes.

The small intestine

Most absorption occurs within the small intestine. Type of food intake, affects gastric absorption for example foods that are high in fat, slows gastric emptying and also the rate of drug absorption. Therefore taking some medications on an empty stomach will speed up the absorption.

Medications that affect gastric emptying, also affect the absorption rate of other medications. Food may enhance the extent of absorption for poorly soluble medications, reduce it for drugs degraded in the stomach or have little effect or no effect.

The small intestine has the largest surface area for drug absorption in the gastrointestinal tract, and the membranes are more permeable than those within the stomach. Therefore, most medications are absorbed primarily in the small intestine, and the acids (despite their ability as un-ionized medications to readily cross membranes) are absorbed faster in the intestine than in the stomach. In the duodenum, the intraluminal pH is 4 to 5 and becomes more alkaline up to pH 8 in the lower ileum.

Other factors can influence the absorption of drugs;

- Gastrointestinal micro -flora may reduce absorption.
- Reduced blood flow may lower the concentration gradient across the intestinal mucosa and decrease absorption by passive diffusion.
- Intestinal transit time can also influence drug absorption, especially for medications that are absorbed by active transport that dissolve slowly, or that are polar (with low lipid solubility for example some antibiotics).

To promote adherence, clinicians /Healthcare providers should prescribe chewable tablets and oral suspensions for children < 8 yr. In adults and adolescents, most drugs are given by mouth as tablets and/or capsules.

All solid medications have to dissolve before absorption can occur; the dissolution rate determines the availability of the medication for absorption. Manipulating the formulation such as the medication's form as crystal, salt, or hydrate, can change the dissolution rate and therefore control the absorption.

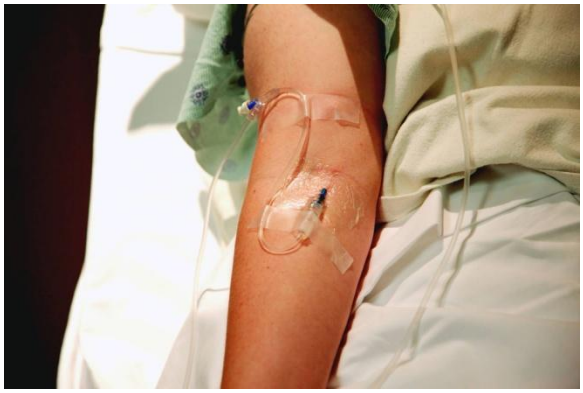
After absorption through the intestinal epithelium, medications can be secreted back into the intestinal lumen through active transporters for example the P-glycoprotein (PGp). Some medications are further metabolized as a consequence of hepatic first-pass effect, which also limits their absorption. The sublingual route and also the rectal route can be used to by pass the first-pass effect. This influences the bioavailability of the drug.

PARENTERAL ADMINISTRATION

Any route that is not enteral, including:

- Subcutaneous; under the skin, for example Insulin injection, hypodermoclysis.
- Intravenous; into a vein, for example total parenteral nutrition (TPN), IV Vancomycin
- Intra-muscular; into the muscle for example immunization; Diphtheria-tetanus-pertussis (DTaP, Tdap)

- Intra-arterial; into an artery for example vasodilator drugs in the treatment of vasospasm, thrombolytic drugs for treatment of embolism
- Intraosseous infusion; into the bone, an indirect intravenous access because the bone marrow drains directly into the venous system. This route is used for fluids and medications in emergency medicine and pediatrics whenever the intravenous (IV) access is very difficult.
- Intracerebral; into the brain parenchyma.
- Intracerebroventricular; into cerebral ventricular system.
- Intrathecal; an injection into the spinal canal.



Medications that are administered intravenously (IV) directly enter the systemic circulation. Medications injected Intramuscularly (IM) or subcutaneously (sc) has to cross one or more biologic membranes to reach the systemic circulation.

If protein drugs with molecular mass > 20,000 g/mol are injected Intramuscularly (IM) or subcutaneously (SC), movement across capillary membranes is so slow that most absorption occurs by way of the lymphatic system. Therefore, drug delivery to systemic circulation is slower and sometimes incomplete because the drug is metabolized before it reaches systemic circulation (first-pass metabolism).

First-pass metabolism is defined as the intestinal and hepatic alteration or degradation of a substance or a drug taken by mouth, after absorption, removing some of the active substances from the blood before it enters into the general circulation.

Perfusion

Perfusion is the process of the body delivering blood to the capillary bed in its biological tissue. Perfusion affects the capillary absorption of small molecules that is injected Intramuscularly (IM) or subcutaneously (sc). Therefore, injection site can affect the absorption rate.

Absorption after Intramuscularly (IM) or subcutaneously (SC) injection may be delayed in patients who have poor peripheral perfusion, for example during hypotension or during shock.

CONTROLLED-RELEASE FORMS OF DRUGS

Some medications benefit from being administered in dosage forms that do not release the drug immediately upon entering the fluid or acids in the stomach. Some medications are better absorbed or exhibit fewer side effects when they are administered in dosage forms that dissolve slowly over time.

Dosage forms can be designed;

- To release medications over time at predetermined rates,
- To release medications after a certain time after ingestion, or
- To release medications under intestinal pH versus under gastric pH.

Controlled-release forms also limit fluctuation in the plasma drug concentration, provide a more uniform therapeutic effect , and also minimize adverse effects. The absorption rate is slowed by coating drug particles with water-insoluble material or wax and other materials, by embedding the drug in a matrix that releases it slowly during the travel time through the gastrointestinal tract or by complexing the medication with ion-exchange resins.

Most absorption of controlled-release forms occurs in the large intestine. Instruct patients **not to crush** these forms of medications because crushing or altering a controlled-release capsule or tablet will interfere with the effectiveness of the medication and can be dangerous to the patient.

Transdermal controlled-release forms

The transdermal patch is a medicated adhesive patch that is applied to the skin to deliver a specific dosage of medication through the skin and into the bloodstream. One of the advantages of a transdermal drug delivery route is that the patch provides a controlled release of the medication into the patients. Transdermal controlled-release forms are designed to release the medication for an extended time, sometimes for many days. However, medications for transdermal delivery need to have suitable skin penetration characteristics, and high potency due to the penetration rate and area of application are limited.

Distribution

The medication needs to be carried to its effector site, most frequently by way of the bloodstream. From the bloodstream the medication may distribute into the body's tissues, muscles and organs. After entry into the systemic circulation, either by intravascular administration or by absorption from any of the various extracellular

sites, the medication is subjected to numerous distribution processes that tend to lower its plasma concentration.

Distribution is defined as the reversible transfer of a medication between one compartment to another.

Some factors affecting medication distribution include:

- Regional blood flow rates,
- Molecular size, polarity, binding to serum proteins, forming a complex.

Distribution can be a serious problem at some natural barriers for example the blood–brain barrier.

Once absorbed, most medications do not spread evenly throughout the body. Medications that are water-soluble drugs (dissolve in water), usually stay within the blood and the interstitial space (fluid that surrounds the cells). Medications that are fat-soluble drugs (dissolve in fat), usually concentrate in fatty tissues. Some medications may concentrate mainly in only one small part of the body, for example iodine; concentrates primarily in the thyroid gland because the tissues in the thyroid gland have a special ability to retain that medication.

DIFFERENT SPEED

Medications penetrate different tissues at different rates, depending on the medication's ability to cross membranes. Fat-soluble medications may cross cell membranes more quickly than water-soluble medications. For some medications, transport mechanisms assist movement into the tissues or out of the tissues. Some medications will leave the bloodstream slowly due to the fact that they bind to proteins circulating in the bloodstream. Other medications will rapidly leave the blood and enter other tissues because they are less tightly bound to proteins in the blood.

Some of the molecules or all the molecules of a drug in the bloodstream may be bound to blood proteins. The protein-bound part is inactive; as the unbound drug is distributed to the tissues and the level in the bloodstream reduces, blood proteins gradually release the drug/medication bound to them.

Some medications accumulate in certain tissues, for example Digoxin accumulates in skeletal and heart muscles. These tissues slowly release the drug into the bloodstream, keeping blood levels of the drug from reducing too quickly and therefore prolonging the effect of the medication. Some medications, for example, those that accumulate in fatty tissues, may leave the tissues so slow and circulate in the blood for days after the patient has stopped taking the medication.

Distribution may vary from person to person

Distribution of a particular medication may also vary from person to person, according to their physiological characteristics. For example, people who are overweight (obese) may store large amounts of fat-soluble medications, and individuals who are very thin may store very little. Also the elderly individual, even when they are thin, may store large amounts of fat-soluble medications because the proportion of body fat increases with age.

Drug Metabolism

Compounds start to break down as soon as they enter the body. The liver is the principal site of drug metabolism. As metabolism occurs, the parent (initial) compound is converted to new compounds called metabolites. Metabolism typically inactivates medications, however some drug metabolites are pharmacologically active (sometimes more so than the parent compound). When metabolites are pharmacologically inactive (inert), metabolism deactivates the administered dose of the parent drug and reduces the effects on the body. Metabolites may also be pharmacologically active; even more so than the parent drug. A weakly active or inactive substance that has an active metabolite is called a prodrug.

Prodrugs can be used to:

- Improve drug delivery or pharmacokinetics,
- To decrease toxicity, or
- To target the drug to specific tissues or cells.

Drugs can be metabolized by:

- Oxidation,
- Reduction,
- Hydrolysis,
- Hydration,
- Conjugation,
- Condensation, or
- Isomerization.

The goal of metabolism is to make the drug easier to excrete. The enzymes that are involved in metabolism are present in many tissues but are more concentrated within the liver.

Drug metabolism rates

Drug metabolism rates definitely vary among patients. Some patients will metabolize a medication very quickly; before the therapeutic blood and/or tissue concentrations are reached; while other patients may metabolize the drug so slow that normal dosage result in toxic effects.

Individual drug metabolism rates are influenced by:

- ✓ Genetic factors,
- ✓ Coexisting disorders especially chronic liver disease or advanced heart failure,

- ✓ Drug interactions such as those involving the inhibition or induction of metabolism.

For many drugs, metabolism occurs in 2 phases:

Phase I reactions

Involve formation of a modified or new functional group (oxidation, reduction, hydrolysis); these reactions are nonsynthetic.

Phase II reactions

Involve conjugation with an endogenous substance for example, sulfate, glycine; these reactions are synthetic. Metabolites formed in synthetic reactions are more polar and therefore more readily excreted by the kidneys in the urine and the liver in the bile; than those formed in nonsynthetic reactions.

Some medications undergo only phase I or phase II reactions.

The metabolism rate

For almost all medications, the metabolism rate in any given pathway has a capacity limitation (an upper limit). However, at therapeutic concentrations of most medications, usually only small portion/fraction of the metabolizing enzyme's sites are occupied, and the metabolism rate increases with medication concentration. In this case, kinetics (first-order elimination), the metabolism rate of the medication is a constant fraction of the drug remaining in the body; the medication has a specific half-life.

When most of the enzyme sites are occupied, metabolism occurs at the maximal rate and does not change in proportion to medication concentration; zero-order kinetics (a fixed amount of medication is metabolized per unit time).

As medication concentration increases, metabolism shifts from the first-order to the zero-order kinetics.

Enzyme system

Cytochrome P450 (CYP450), enzymes are essential for the metabolism of many drugs. CYP450 - a microsomal superfamily of isoenzymes that catalyzes the oxidation of many medications. CYP450 enzymes can be induced or inhibited by many medications and substances resulting in medication interactions in which one medication enhances the toxicity or reduces the therapeutic effect of another medication.

The physician may use cytochrome P450 (CYP450) tests to help determine how the body metabolizes a medication. The body contains P450 enzymes to process medications. Because of genetic/ inherited traits that cause variations in these enzymes, medications may affect each individual differently.

Cytochrome P450 tests

For cytochrome P450 tests, a sample of DNA is taken for laboratory testing. It can be retrieved in one of 3 ways:

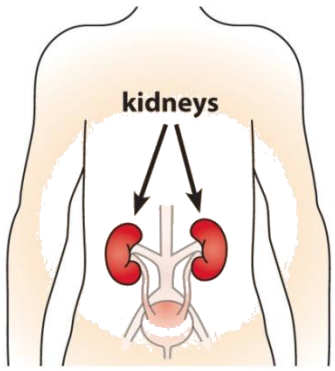
- **Blood test**
  Blood sample is drawn from a vein.
- **Cheek swab**
  A cotton swab is rubbed inside the cheek to get a cell sample.
- **Saliva collection**
  Saliva is collected in a tube.

  Obtaining the DNA sample may take a few minutes. The sample will then be sent to a laboratory where the DNA is analyzed for specific genes.

Excretion of Drugs

Compounds and their metabolites need to be removed from the body by way of excretion, which is usually accomplished through the kidneys in the urine or in the feces. If excretion is not completed, accumulation of foreign/toxic substances can adversely affect normal metabolism. The kidney is an important site where products are excreted through urine; also biliary excretion or fecal excretion is the process that initiates in the liver and passes through to the GI tract until the products are finally excreted along with feces or waste products and excretion occurs through the lungs for example, anesthetic gases.

The kidneys are the primary organs for excreting substances which are water-soluble. The biliary system contributes to excretion to the degree that medication is not reabsorbed from the gastrointestinal tract. The contribution of intestine, sweat, saliva, breast milk, and lungs to excretion is small, except for exhalation of volatile anesthetics. Excretion via breast milk may affect the breastfeeding infant. Hepatic metabolism often increases water solubility and drug polarity; then the metabolites are more readily excreted.



Excretion of medications by the kidney involves three main mechanisms:

- Glomerular filtration of unbound drug.
- Active secretion of (free and protein-bound) drug by transporters.

- Filtrate (100 fold concentrated) in tubules for a favorable concentration gradient so that it may be secreted by passive diffusion; passed out through the urine.

Filtration:
Filtration involves the pores or aqueous channels through which the hydrophilic drugs can pass. Filtration occurs in the jejunum (middle segment of the small intestine; between the duodenum and the ileum) and the proximal tubules of the kidneys.

Renal excretion

Renal filtration accounts for most medication excretion. About 1/5th of the plasma reaching the glomerulus is filtered through pores within the glomerular endothelium; almost all water and most electrolytes are actively and passively reabsorbed from the renal tubules back into the circulation. Polar compounds, which account for most drug metabolites, cannot diffuse back into the circulation and are usually excreted unless a specific transport mechanism is present for their reabsorption. As the individual gets older (elderly), renal drug/medication excretion decrease at age 80, clearance is reduced to ½ of what it was at 30 years old.

The principles of transmembrane passage (passage occurring across a membrane) govern renal handling of medications. Medications bound to plasma proteins remain in the circulation; only unbound medications are contained in the glomerular filtrate. Un-ionized forms of medications and their metabolites reabsorbed readily from tubular fluids.

The pH of urine which varies from 4.5 to 8.0, may also affect drug reabsorption and excretion; the pH of the urine determines the ionization state of a weak acid or base. Acidification of urine increases reabsorption and decreases excretion of weak acids, and decreases reabsorption of weak bases. Alkalinization of urine has the opposite effect.

The extent to which changes in urinary pH alter the rate of drug elimination depends on:

- The contribution of the renal route to total elimination,
- The polarity of the un-ionized form, and
- The molecule's degree of ionization.

Active tubular secretion in the proximal tubule is important in the elimination of many Medications/drugs. This energy dependent process can be blocked by metabolic inhibitors. When medication concentration is high, secretory transport can reach an upper limit (transport maximum); each substance has a characteristic transport maximum.

Cations and Anions are handled by separate transport mechanisms. Normally, the anion secretory system eliminates metabolites conjugated with:

- Glycine,
- sulfate, or
- glucuronic acid.

Anions compete with each other for secretion.

Biliary excretion

Some medications and their metabolites are excreted in bile. Active secretory transport is required because they are transported across the biliary epithelium against a concentration gradient. When the plasma drug concentrations are high, secretory

transport can reach a transport maximum (an upper limit). Substances with similar physicochemical properties may then compete for excretion.

Drugs with a molecular weight of > 300 g/mol and with both polar and lipophilic groups are more likely to be excreted in bile; smaller molecules are generally excreted only in negligible quantity (small). Conjugation (the addition of a molecule to the drug) with glucuronic acid facilitates biliary excretion.

Enterohepatic circulation (cycle) -Circulation of substances such as bile salts that are absorbed from the intestines and transported to the liver, where they are secreted into the bile and again enter the intestine. In the enterohepatic circulation, a medication /drug secreted in bile is reabsorbed into circulation from the intestines.

The pharmacological sciences can be further subdivided:

Neuropharmacology

Neuropharmacology is the study of how drugs interact with components of the central and peripheral nervous system, including the brain, spinal cord, and the nerves that communicate with different parts of the body.

Neuropharmacologists study drug actions; they work to develop new medications to treat neurochemical disorders, are often responsible for evaluating the safety of new psychiatric medications and their level of efficacy, they may study neurological effects of medications such as anesthetics, psycho-stimulants etc. on the human body, including how the medications influence behavior, the senses, memory and mood.

Neuropharmacology study involves specializations in areas such as:

- Neurotransmission,
- Drug neurotoxicity,
- Nervous system disorders,
- Behavioral pharmacology.

Neuropharmacologists may study drugs already in use to determine more precisely the neurobiochemical or neurophysiological functions of the nervous system that are modified by the medication action.

Clinical pharmacology

Clinical pharmacology is the application of pharmacodynamics and pharmacokinetics to patients with illness/ diseases. Clinical pharmacology involves connecting the gap between medical practice and laboratory science. The main goal is to promote the safety of prescription, maximize the drug effects and minimize the side effects.

Clinical pharmacologists

Clinical pharmacologists study how the drugs work, how they interact with other drugs, how their effects can alter disease processes, and how disease can alter/ affect their effects. Clinical pharmacologists usually have scientific and medical training which assists them in evaluating evidence and produce new data/information through well designed studies.

Cardiovascular pharmacology

Cardiovascular pharmacology concerns the effects of medications on the heart, the cardiovascular system, and the sections of the endocrine and nervous systems that participate in regulating cardiac and vascular function.

With Cardiovascular pharmacology contributes to the safety profile of potential new medications and provides pharmacological data that can be used for optimization of further compounds and the ultimate selection of compounds suitable for clinical development. Researchers observe the effects of medications on blood flow in vascular

beds, arterial pressure, release of mediators, and the effects on neural activity that arise from central nervous system structures.

Molecular pharmacology

Molecular pharmacology is involved with the biochemical and the biophysical characteristics of interactions between drug/medication molecules and those of the cell. It is molecular biology applied to pharmacological and toxicological issues/questions. The methods of molecular pharmacology include precise mathematical, physical, chemical and molecular biological techniques to understand how cells respond to pharmacologic agents or hormones, and how chemical structure correlates with biological activities.

Biochemical pharmacology

Biochemical pharmacology involves using the methods of biochemistry, cell physiology and cell biology, to determine how drugs influence and interact with, the chemical makeup of the organism. The biochemical pharmacologist uses drugs as means to discover new data/ information about biosynthetic pathways and the kinetics, and researches, investigates how drugs can correct the biochemical abnormalities that are responsible for illness.

Endocrine pharmacology

Endocrine pharmacology involves the study of actions of drugs that are either hormone derivatives or hormones or drugs that may modify the actions of hormones that are secreted normally; through research /study related to glands and their secretions.

Behavioral pharmacology

Behavioral pharmacology involves studying the effects of drugs on behaviors. Research may include subjects such as the effects of the psychoactive drug on memory, learning, sleep, wakefulness, drug addiction, etc. and the behavioral results/ consequences of experimental interventions in the enzyme activities and brain neurotransmitter levels and the process of metabolism.

Chemotherapy

Chemotherapy is the area of pharmacology that deals with drugs /chemical substances used for the treatment of microbial infections and malignancies such as cancer. Pharmacologists work to develop chemotherapeutic drugs that will inhibit the growth of, or destroy/kill, the infectious agent or cancer cell without seriously harming or impairing the normal functions of the patient.

Veterinary pharmacology

Veterinary pharmacology involves the use of drugs for health problems and diseases that are unique to animals.

Systems and integrated pharmacology

Systems and integrated pharmacology involves the study of complex systems and whole animal model approach to best investigate and predict the efficacy and usefulness of new treatment/ approach modalities in human trials/ experiments. Results obtained at the cellular, molecular or organ system levels are studied for their relevance to human disease.

Past civilizations has contributed to the present knowledge of medications/drugs and drug preparations. As in past civilizations, people tried animal, plant and mineral materials for possible use as foods, they observed both toxic and therapeutic actions of some of these materials.

BIRTH OF EXPERIMENTAL PHARMACOLOGY

Francois Magendie (6 October 1783 – 7 October 1855)

The birth of experimental pharmacology is generally associated with the work of the French physiologist, Francois Magendie, in the early 19th century.

Francois Magendie made significant contributions to the fields of neuroanatomy, physiology, and pharmacology.

Francois Magendie was the first to prove the functional difference of the spinal nerves. His pioneer studies of the effects of drugs on various parts of the body led to the scientific introduction into medical practice of compounds such as strychnine and morphine. His research on strychnine-containing plants clearly established the site of action of these substances as being the spinal cord, and provided evidence for the view that drugs and poisonous contents must be absorbed into the bloodstream and carried to the site of action before producing their effects.

Francois Magendie work on carbon monoxide poisoning and curare induced muscle relaxation helped to establish some of the techniques and principles of the science of pharmacology.

Paul Ehrlich (14 March 1854 – 20 August 1915)

Paul Ehrlich (14 March 1854 – 20 August 1915) was a German physician and a scientist who worked in the fields of immunology, hematology and antimicrobial chemotherapy. Paul Ehrlich invented the precursor technique to Gram staining of bacteria. The methods he developed for staining tissue made it possible to distinguish between different types of blood cells, which led to the capability to diagnose numerous blood diseases.

In the early 20th century, Paul Ehrlich conceived the idea of seeking special chemical agents with which to selectively treat infections and is therefore considered the “Father of Chemotherapy.” Paul Ehrlich worked on the concept of the “magic bullet” treatment of infections which prepared the way for the modern day chemotherapy.

The Institute for Safe Medication Practices (ISMP)

The Institute for Safe Medication Practices (ISMP) is known and respected worldwide as the premier resource for accurate, impartial, and timely medication safety information. They also provide guidelines and various lists of High-alert medications for different health care settings.

HIGH ALERT DRUGS

High-alert medications are medications that have a heightened risk of causing significant harm to patients, when these medications are administered in error. Mistakes may or may not be more commonly seen with these medications; however the consequences of an error are devastating to the patients as well as the nurse or practitioner who made the error.

High-alert medications provided by the Institute for Safe Medication Practices (ISMP) can be used to determine which medications do require special precautions /safeguards to reduce the risk of errors and therefore minimize harm.

According to the Institute for Safe Medication Practices (ISMP) strategies may include:

- Providing mandatory patient education,
- Improving access to information about these drugs,
- Using auxiliary labels
- Using automated alerts,
- Employing automated or independent double checks when necessary,
- Standardizing prescribing, storaging, dispensing, and administration of these products.

See more from ISMP GUIDELINES AT
HTTP://WWW.ISMP.ORG/TOOLS/GUIDELINES/DEFAULT.ASP

MEDICAL ERRORS

Some common causes of medical errors are:

- **Communication problems**: most common problems
- **Patient-related problems:** improper identification of patient, inadequate education of patient and not obtaining informed consent.
- **Human problems**: lack of knowledge, failure to follow standard of care, or failure to follow procedures and poor documentation.
- **Inadequate information flow:** problems which prevent information delivery/ availability in a timely manner for example laboratory results.
- **Staffing pattern -work flow**: such as; not enough staff and / or supervision.
- **Technical failure**: equipment may failure, inadequate instruction for use of equipment.
- **Organizational transfer of knowledge:** inadequacy in education or training for those who are providing care.
- **Inadequate policies and procedures**: failure in processes of care, inadequate procedures or lack of procedures in place.

Adverse medical event

Per the Department of Health and Human Services Office of Inspector General, an estimated 13.5 percent of hospitalized Medicare beneficiaries experienced adverse events during their hospital stays. Of the nearly 1 million Medicare beneficiaries discharged from hospitals in October 2008, about 1 in 7 experienced an adverse event that met at least 1 of our criteria (13.5 percent). An additional 13.5 percent of Medicare beneficiaries experienced events during their hospital stays that resulted in temporary harm. Temporary harm events are those that require intervention but do not cause lasting harm.

As the Federal Government's principal agency for protecting the health of Americans, the Department of Health & Human Services (HHS) is uniquely positioned to lead national efforts to reduce adverse events in hospitals. As part of a national strategy to improve health care quality mandated by the Patient Protection and Affordable Care Act (ACA), HHS is to identify areas that have the potential for improving health care quality. Because many adverse events we identified were preventable, the study confirms the need and opportunity for hospitals to significantly reduce the incidence of events. A

number of agencies within HHS share responsibility for addressing this issue, most prominently the Agency for Healthcare Research and Quality (AHRQ) as a coordinating body for efforts to improve health care quality and CMS as an oversight entity and the Nation's largest health care payer.

Therefore, we recommend the following: AHRQ and CMS should broaden patient safety efforts to include all types of adverse events. This broader definition would apply to a number of activities, including setting priorities for research, establishing guidelines for hospital reporting, developing prevention strategies, measuring health care quality, and determining payment policies. AHRQ and CMS should enhance efforts to identify adverse events. Identifying adverse events assists policymakers and researchers in directing resources to the areas of greatest need, setting clear goals for improvement, assessing the effectiveness of specific strategies, holding hospitals accountable, and gauging progress in reducing incidence.

- AHRQ should sponsor periodic, ongoing measurement of the incidence of adverse events.
- AHRQ should continue to encourage hospital participation with Patient Safety Organizations, entities intended to receive adverse event reports from hospitals, and forward the information to a national AHRQ database.
- CMS should use Present on Admission Indicators in billing data to calculate the frequency of adverse events occurring within hospitals.

Sentinel event

The Joint Commission states that a sentinel event is an unexpected occurrence involving death or serious physical or psychological injury, or the risk thereof. Serious injury specifically includes loss of limb or function. In support of its mission to continuously improve the safety and quality of health care provided to the public, The Joint Commission in its accreditation process reviews hospitals' activities in response to sentinel events. The accreditation process includes all full accreditation surveys and, as appropriate, for-cause surveys, and random validation surveys specific to Evidence of Standards Compliance (ESC) The phrase "or the risk thereof" includes any process variation for which a recurrence would carry a significant chance of a serious adverse outcome. Such events are called "sentinel" because they signal the need for immediate investigation and response. The terms "sentinel event" and "error" are not synonymous; not all sentinel events occur because of an error, and not all errors result in sentinel events.

Goals of the Sentinel Event Policy

The policy has four goals:

1. To have a positive impact in improving patient care, treatment, and services and preventing sentinel events
2. To focus the attention of a hospital that has experienced a sentinel event on understanding the factors that contributed to the event (such as underlying causes, latent conditions and active failures in defense systems, or organizational culture), and on changing the hospital's culture, systems, and processes to reduce the probability of such an event in the future
3. To increase the general knowledge about sentinel events, their contributing factors, and strategies for prevention
4. To maintain the confidence of the public and accredited hospitals in the accreditation process

Root Cause Analysis

Root cause analysis is a process for identifying the factors that underlie variation in performance, including the occurrence or possible occurrence of a sentinel event. A root cause analysis focuses primarily on systems and processes, not on individual performance. The analysis progresses from special causes in clinical processes to common causes in organizational processes and systems and identifies potential improvements in these processes or systems that would tend to decrease the likelihood of such events in the future or determines, after analysis that no such improvement opportunities exist.

Joint commission requires a root cause analysis and a corrective action plan to be performed for each sentinel event. It should be used as a tool for identifying strategies to prevent errors from happening again in the future. This process is in place to improve safety.

The goal of the root cause analysis (RCA) is to discover:
• What has happened?
• Why did it happen?
• What should be done to prevent it from reoccurring?

The following guidelines for a Root Cause Analysis should include:

• Root cause statements to include the cause and the effect
• Do not use Negative descriptions in root cause statements
• Every human error has a preceding cause
• Violation of a procedure is not root cause, but has a preceding cause
• Failure to act is only a root cause when there is a pre-existing duty to act

Failure mode and effects analysis (FMEA) was one of the first systematic techniques for failure analysis. It was developed by reliability engineers in the late 1940s to study problems that might arise from malfunctions of military systems. An FMEA is often the first step of a system reliability study. It involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes, and their causes and effects. For each component, the failure modes and their resulting effects on the rest of the system are recorded in a specific FMEA tool/ worksheet. There are numerous variations of such worksheets. An FMEA is mainly a qualitative analysis.

FMEA includes review of the following:

- Steps in the process
- Failure modes (What could go wrong?)
- Failure causes (Why would the failure happen?)
- Failure effects (What would be the consequences of each failure?)

Organizations use the Failure mode and effects analysis Tool to evaluate processes for possible failures and to prevent them by correcting the processes proactively rather than reacting after failures have occurred. The FMEA Tool is particularly useful in evaluating a new process prior to implementation and in assessing the impact of a proposed change to an existing process.

Patients' Right-to-Know

Chapter 381 section 028 of the Florida Statutes referred to as "Patients' Right-to-Know About Adverse Medical Incidents Act." The Legislature finds that this section of the State Constitution is intended to grant patient access to records of adverse medical incidents, which records were made or received in the course of business by a health care facility or provider, and not to repeal or otherwise modify existing laws governing the use of these records and the information contained therein. The Legislature further finds that all existing laws extending criminal and civil immunity to individuals providing information to quality of care committees or organizations and all existing laws concerning the discoverability or admissibility into evidence of records of an adverse medical incident in any judicial or administrative proceeding remain in full force and effect. (Please check your state legislature for more information).

"Adverse medical incident" means medical negligence, intentional misconduct, and any other act, neglect, or default of a health care facility or health care provider which caused or could have caused injury to or the death of a patient, including, but not limited to, those incidents that are required by state or federal law to be reported to any governmental agency or body, incidents that are reported to any governmental agency or body, and incidents that are reported to or reviewed by any health care facility peer

review, risk management, quality assurance, credentials, or similar committee or any representative of any such committee.(FS 381.028)

PATIENTS' RIGHT OF ACCESS

Patients have a right to have access to any records made or received in the course of business by a health care facility or health care provider relating to any adverse medical incident. In providing access to these records, the health care facility or health care provider may not disclose the identity of patients involved in the incidents and shall maintain any privacy restrictions imposed by federal law.

Medication safety programs

According to the Centers for Disease Control and Prevention (CDC), Medications are generally safe when they are used as prescribed or as their labeling describes. However, there are risks in taking any medication. Each year in the United States, adverse drug events; injury resulting from the use of medication, result in over 700,000 visits to hospital emergency departments. Many adverse drug events are preventable. Patients and caregivers can help reduce the risk of harm from medicines by learning about medication safety.

According to U.S. Food and Drug Administration, within the Center for Drug Evaluation and Research (CDER), the Division of Medication Error Prevention and Analysis (DMEPA) reviews medication error reports on marketed human drugs including prescription drugs, generic drugs, and over-the-counter drugs.

The DMEPA uses the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) definition of a medication error. Specifically, a medication error is "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use."

The DMEPA includes a medication error prevention program staffed with healthcare professionals. Among their many duties, program staff:

- review medication error reports sent to MedWatch,
- evaluate causality, and
- Analyze the data to provide solutions to reduce the risk of medication errors to industry and others at FDA.

Additionally, the DMEPA prospectively reviews

- proprietary names,
- labeling,
- packaging, and
- Product design prior to drug approval to help prevent medication errors.

The DMEPA also works closely with federal partners, patient safety organizations such as Institute for Safe Medication Practices (ISMP), standard setting organizations such as the United States Pharmacopeia (USP), and foreign regulators to address broader product safety issues.

Role of the U.S. Food and Drug Administration (FDA)

Drug Name Review:
To reduce / minimize medication name confusion, the U.S. Food and Drug Administration reviews about 400 drug names a year that companies submit as proposed brand names. The agency rejects about one-third of the names that drug companies propose.

Drug Labels:
FDA regulations require all over-the-counter (OTC) drug products (more than 100,000) to have a standardized "drug facts label." FDA has also improved prescription drug package inserts for health care professionals.

Drug Labeling and Packaging:
FDA works with drug companies to reduce the risk of errors that may result from similar-looking labeling and packaging, or from poor product design.

Bar Code Label Rule:
In accordance with an FDA rule that went into effect in 2004, bar codes are required on product labels for certain drugs and biologics such as blood. When used with bar code scanner and computerized patient information systems, bar code technology can help ensure that the right dose of the right drug is given to the right patient at the right time.
Error Analyses:
FDA reviews about 1,400 reports of medication errors per month and analyzes them to determine the cause and type of error.
Guidances for Industry:
FDA is working on three new guidance; one on complete submission requirements for anaylsis of trade names, one about the pitfalls of drug labeling, and another on best test practices for naming drugs.
Public Education:
FDA spreads the message about medication error prevention through public health advisories, medication guides, and outreach partnerships with other organizations.
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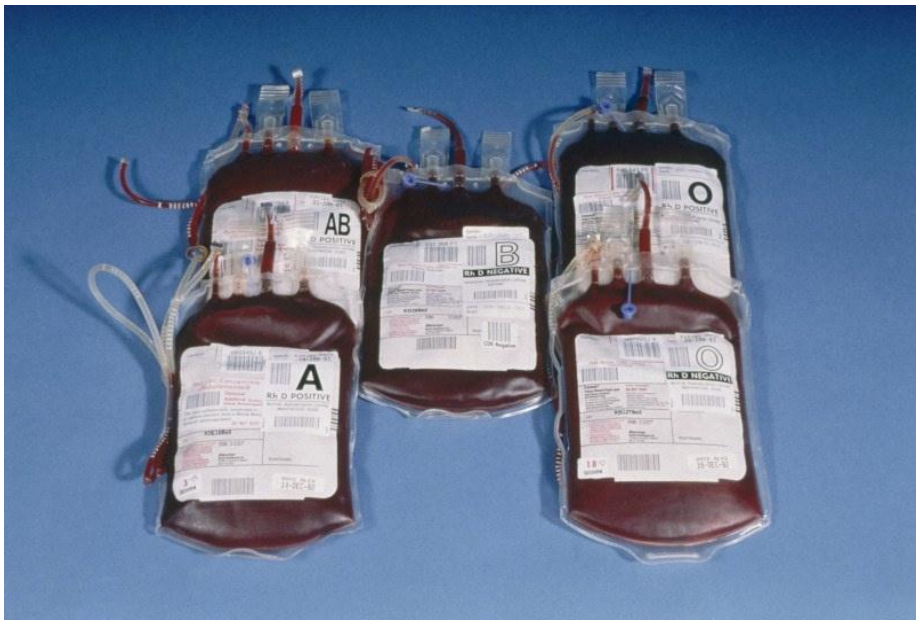


Medication Errors

Medication errors are referred to as preventable adverse drug events.
The three most common errors are:

- Omission errors (did not administer an ordered medication).
- Quantity errors - Improper dose (any medication dosage, quantity or strength that different from what was prescribed).
- Unauthorized drug errors- the medication administered or dispensed was not authorized by the prescriber; this category involves administering or dispensing the wrong medication.

Medication safety is the responsibility of everyone who handles medications. The original five rights of medication administration (Right patient, medication, dosage, time, and route) have increased to the nine rights of medication administration within the ALF, adding the right documentation, right to refuse, right reason, and right response which we will review in this course study. Other resources have also added the Right drug preparation, Right assessment and the Right approach. Follow your facility's policy and procedures.

According to the Elder affairs 2012, medication errors alone, occurring either in or out of the hospital, are estimated to account for 7,000 deaths annually. Adverse drug events cause more than 770,000 injuries and deaths each year and cost up to $5.6 million per hospital.

Rights of medication administration

1. The Right Patient

ALWAYS check to make sure that you have the Right patient.
Patients may be moved to a different room.
Patients may switch beds within the same room.

Identification Procedure

ALWAYS verify the name of the patient by getting:

Two verbal identifiers: Ask the patient to state their full name, and their Date of Birth. Check the ID bracelet very carefully. Check the identity of the patient before you help him/her with their medication or administer the medication.

It is **mandatory** for you to use *at least two (2)* identifiers. If you administer medications to the wrong patient this may cause a fatal error. You ***cannot*** use a bed or room number as identifiers. A patient may accidentally enter a room and even go to bed in the wrong room.

Some identifiers include the patient's:

- First, middle and last name,
- DOB – Date of Birth (month, day and year),
- Photograph,
- a medical record number/ code number given to that patient
- social security number.

2. The Right Medication

The medication may belong to someone else,
so ALWAYS verify the medication label.
Do NOT use any medication that has a label that you cannot read.
Do NOT use any medication unless it has a complete label.
Read and check the label against the medication record at least three times and tell the person the name of the medicine before you administer.
If the person says they do not take that medicine, STOP. Do not administer. Report this to your supervisor. It is an error if a patient takes the wrong medication. This must be reported.

3. The Right Dosage

The patient needs to take the right dosage that is ordered by the Physician or the Health care Practitioner, to achieve the desired effect of the medication. Taking too much of the medication can lead to an overdose. Take steps to reduce overdose errors. Follow the systems in place – for triple checking dosages. Make sure the medication is recorded, so that a second dose is not accidentally given. Giving a half of the ordered dose of medication is also not the correct dosage. Not giving the right amount of the drug is also a medication error and has to be reported.

4. The Right Time

Timing is also very important when assisting with medication. Some medications need to reach a consistent level in the bloodstream to work effectively. This means that the medications need to be taken at the right times to keep that level of medication in the system. Usually, the liver or kidneys will remove the medication from the blood and high levels of the medication can build up in the system which can lead to toxicity if that dose is taken too soon. Also, if the patient miss a dose or wait too long between the doses, there might not be enough of the medication in the body to work effectively.

The standard acceptable time is within one hour before or after the scheduled administration time or it is considered a medication error.

5. The Right Route

Route of medication administration refers to the path by which the medication is taken into the body. Medications are made in various forms and for administration by different routes. Check the medication order to find out the right route. If the medication label states administer by mouth and the medication is placed intravenously (I.V.) It is an error and must also be reported.

6. The Right Documentation

The right documentation involves properly recording /documenting each dose offered on the patient's record. Document only ***AFTER*** the ordered medication is administered. Document the time, route, and any other specific information, including refusal of medication.

7. Right to REFUSE

By Florida's law, a patient has the right to refuse a medication. A patient should not be forced to take a medication. Also, you cannot hide the medication in the patient's food and / or drink.

8. Right Reason

Confirm the rationale for the ordered medication. Is the patient taking the Tylenol for the headache or for fever? If you are not sure of the reason for a medication, ALWAYS ask. Ask the physician. Knowing the reason for the medication will help you to check the patient for the desired effect.

9. Right Response

After administering the medication assess/ observe to find out what happens afterward. Professionals are trained to know how medications move through the body, what the effect of the medication is, and what adverse effects may occur. Adverse effects may include allergic reactions to the drug, overdose of the drug, and drug interactions between multiple drugs.

Make sure that the medication had the desired effect. If a Tylenol was taken for a headache, check the patient and find out if the headache was relieved. If the headache was not resolved the Physician / health care practitioner needs to be notified. Document the patient's report and your observation and that the physician was notified.

Preventable event

A medication error is any preventable event that can cause or lead to inappropriate medication use or harm to the patient while the medication is in the control of the health care professional, pharmacist, patient, or consumer. Errors in prescribing, dispensing and administering medications can lead to serious injuries. Other causes of medication errors include; poor communication between health care providers, between providers and patients, prescribing errors; product labeling, packaging, dispensing, distribution, education, monitoring, medical abbreviations, sound alike medication names, Illegible prescriptions or confusing directions.

Most medication errors can be prevented. Patient needs to be educated regarding their medications and take responsibility for monitoring the effectiveness and side effects. Always ask questions or share concerns with the physician or pharmacist and other health care workers. Also the health care worker should take steps to prevent medication errors.

DO NO HARM!!!!

HOW TO PREVENT MEDICATION ERRORS

Always TRIPLE Check Medications- the three checks.
The DOs and DON'Ts can help you make sure that your patient's medication works safely to improve their well being and overall health.

Medication DOs...

1. DO Administer /assist resident in taking each medication exactly as it has been prescribed.
2. DO make sure that all your patients'/residents' physicians and Health Care Practitioners know about all your patients'/ residents' medications.
3. DO let your patients' physicians know about any other over-the-counter medications, supplements, vitamins and herbs they are taking.
4. DO try to use the same pharmacy to fill all your patients' prescriptions, so that the pharmacist can help you keep track of everything the patients are taking.
5. DO keep medications out of the reach of children.
6. DO use the triple check system when checking medications.
7. DO read the medication labels, follow the instructions.
8. DO make sure all medication orders are written and signed.
9. DO make sure all medication orders are on the right patient/ resident chart.
10. DO identify the patient/ resident every time you assist with the medications.

Medication DON'Ts...

1.DO Not change your patients' medication dose or schedule without talking with their physician or health care provider.
2. DO Not share or use any medications prescribed for any other patient or person.
3. DO Not break or crush pills unless the patient's physician instructs you to do so.
4. DO Not use medications that are expired.
5. DO Not use abbreviations.
6. DO Not assist with any medications already poured by someone else. You cannot be sure what it is.
7. DO Not touch the medications with your hand.
8. DO Not hide the medications in food. Medications cannot be "hidden" in foods or drinks. A resident may knowingly take a medication with food if it is easier.
9. DO Not use contaminated medications or medications dropped on the floor.

Some factors that affect medication errors include:

- Inaccurate Patient identification
- Incorrect calculation
- Poor communication
- Inaccurate abbreviation
- Incorrect order interpretation
- Inaccurate dilutent
- Inaccurate patient label
- Improper labeling
- Inaccurate packaging
- Medication not available
- Sound alike drug
- Equipment problem

Abbreviations

Abbreviation means a shortened form of a word or phrase. Abbreviations can lead to some serious or life threatening errors, therefore there are guidelines in place. The Joint Commission has set guidelines and rules; all healthcare settings has to standardize abbreviations, acronyms and symbols that they are using. They are also required to adhere to a Do Not Use list.

The Do Not Use List includes some of the following:

Do Not Use **u**, or for unit. Mistaken some times for zero. You must write "unit"
Do Not use **iu** for international unit. Mistaken for IV. Write "international unit"
Do Not Use **Q.D., QD, q.d., qd** (Daily). Mistaken for each other. Write "Daily".
Do Not Use **Q.O.D. QOD, q.o.d., qod** (every other day). Write "every other day"
See the complete Do Not Use List (The Joint Commission http://www.jointcommission.org/assets/1/18/Do_Not_Use_List.pdf**)**

Other reasons for medication administration errors include:

- Nurse error,
- actions of the physicians,
- system issues,
- actions of the pharmacists

Some Steps to Implement to Reduce Drug-Name Errors include:

- Have knowledge of the drug and dosage of medication you will administer.
- Implement Physician Order Entry
- Have standardized system in place for processing the medication dosage and dose times.
- Implement unit doses
- Standardize abbreviations
- Limit the different Intravenous /infusion pumps

Errors of Omission and Errors of commission

Error is an act of commission (doing something wrong) or omission (failing to do the right thing) that leads to an undesirable outcome or significant potential for such an outcome. For instance, ordering a medication for a patient with a documented allergy to that medication would be an act of commission. Failing to prescribe a proven medication that has major benefits for an eligible patient.

Errors of omission are more difficult to recognize than errors of commission but likely represent a larger problem. In other words, there are likely many more instances in which the provision of additional diagnostic, therapeutic, or preventive modalities would have improved care than there are instances in which the care provided quite literally should not have been provided. In many ways, this point echoes the generally agreed-upon view in the health care quality literature that underuse far exceeds overuse, even though the latter historically received greater attention.

The Joint Commission National Patient Safety Goals for Hospital (2015) relate to the following goals:

- Correct patient identification - Use at least two ways to identify patient when providing treatment, care, and services for example, Name and Date of Birth; this is done to make sure that the correct patient gets the correct treatment and medication.
- Improve effectiveness of communication among the staff- Get important test results to the right staff person on time.
- Use medications safely- Before a procedure, label medications. Use extra care with patients who are taking blood thinners. Record and pass along correct information about the patient's medication. Find out what medications the patient is taking and compare them to the new medications.
- Use alarms safely- Make improvements to make sure that alarms on the medical devices/ equipment are heard and responded to on time.
- Prevent infection- Use the hand cleaning guidelines from the Centers for Disease Control and Prevention or the World Health Organization. Set goals for improving hand cleaning. Use the goals to improve hand cleaning.
- Identify patient safety risks - Find out which patients are most likely to try to commit suicide
- Prevent mistakes in surgery- Make sure that the correct surgery is done on the correct patient and at the correct place on the patient's body. Mark the correct place on the patient's body where the surgery is to be done. Pause before the surgery to make sure that a mistake is not being made.

The Joint Commission National Patient Safety Goals for Home Care (2015) relate to the following goals:

Identify patients correctly -Use at least two ways to identify patients. For example, use the patient's name and date of birth. This is done to make sure that each patient gets the correct medicine and treatment.

Use medicines safely - Record and pass along correct information about a patient's medicines. Find out what medicines the patient is taking. Compare those medicines to new medicines given to the patient. Make sure the patient knows which medicines to take when they are at home. Tell the patient it is important to bring their up-to-date list of medicines every time they visit a doctor.

Prevent infection - Use the hand cleaning guidelines from the Centers for Disease Control and Prevention or the World Health Organization. Set goals for improving hand cleaning. Use the goals to improve hand cleaning.

Prevent patients from falling - Find out which patients are most likely to fall. For example, is the patient taking any medicines that might make them weak, dizzy or sleepy? Take action to prevent falls for these patients.

Identify patient safety risks - Find out if there are any risks for patients who are getting oxygen. For example, fires in the patient's home.

Root Cause Analysis (RCA)

The Joint Commission requires that a thorough, credible root cause analysis (RCA) be performed for each reported sentinel event. The goal of a Root Cause Analysis is to find out:

- What happened.
- Why did it happen.
- What do you do to prevent it from happening again.

Root Cause Analysis is a tool for the identification of error prevention strategies. It is a process for finding causes of error with goal of preventing any recurrence.

Some factors that influence occurrence of errors by nurses include:

- Tired, fatigue, worked too many days/ shifts
- Increase patient load/volume
- Incomplete orders can lead to misinterpretation
- Distraction while completing tasks
- System issues
- Rushing tasks
- Failure to comply with policy and procedures
- Inadequate knowledge
- Inadequate skill (not knowing how to operate a new equipment)
- Working on a different unit than accustom to
- Inaccurate Labeling of medication
- Handwriting illegible
- Taking short cuts (not following the process)
- Not labeling medications or syringes
- Using trial and error in new situation
- Look-alike and sound alike drug names

There are five stages of the medication process:

1. Prescribing and ordering
2. Transcribing and verifying
3. Dispensing and delivering
4. Administering
5. Monitoring and reporting

1. Prescribing and Ordering

Errors resulting from prescribing and ordering have caused patients to receive the wrong medication or the wrong dosage. Preventable errors occur because systems for safely prescribing and ordering medication are not appropriately used.
• A widely recognized cause of error is illegible handwritten prescriptions.
• Errors may result from insufficient or missing information about co-prescribed medications, past dose-response relationships, laboratory values and allergic sensitivities.
• Errors in prescribing can occur when an incorrect drug or dose is selected, or when a regimen is too complex.
• When prescriptions are transmitted orally, sound-alike names may cause error.
• Similarly, drugs with similar-looking names can be incorrectly dispensed when prescriptions are handwritten.

• Errors may occur because a prescription is never transmitted to a pharmacy, or a prescription is never filled by the patient.
• Physician sampling of medications can contribute to medication errors due to the lack of both adequate documentation and drug utilization review.

2. Transcribing and verifying

Transcription, the transfer of information from an order sheet to nursing documentation forms, is a source of many medication errors. Contributing factors include incomplete or illegible prescriber orders; incomplete or illegible nurse handwriting; use of abbreviations; and lack of familiarity with drug names. In addition to errors associated with transcribing the drug name, there is also opportunity for errors when transcribing the dose, route or frequency. Preparing a medication administration record (MAR) in an environment that is noisy or poorly lit can also contribute to errors. What can you do to minimize the opportunity for an error?
• Clarify the order before the prescriber leaves the unit.
• Contact the prescriber if the order is not legible.
• Do not process incomplete orders. Orders must contain the following information: drug name, dose, route, dosage form and frequency of administration.
• Minimize the use of abbreviations and certainly avoid the use of unapproved abbreviations on the MAR.
• Never use the letter 'U' as an abbreviation for units.
• Use a leading zero before a decimal.
• Do not use a trailing zero after the decimal.
• Include indications whenever possible.
• Check your own handwriting: is it legible? If not, think about printing using block letters.
• Complete the transcription process in a quiet area well lit area, away from distractions. If you are transcribing orders in a busy environment, there is the likelihood that you may make an error.
• Implement a system to check the medication administration record document against active orders whether the MAR is manually or computer generated.
• Implement a second check system for the transcription.

3. Dispensing and Delivery

The term dispensing error refers to medication errors linked to the pharmacy or to whatever health care professional dispenses the medication. These include errors of commission (e.g. dispensing the wrong drug, wrong dose or an incorrect entry into the computer system) and those of omission (e.g. failure to counsel the patient, screen for interactions or ambiguous language on a label). Errors may be potential -- detected and corrected prior to the administration of the medication to the patient. The three most common dispensing errors are: dispensing an incorrect medication, dosage strength or

dosage form; miscalculating a dose; and failing to identify drug interactions or contraindications.

4. Medication Administration

Errors caused by drug administration can be made by the health care provider or by the patient themselves. Much of the problem in drug administration is communication. Patients are often unaware that errors can happen and often do not take an active role in understanding what is being communicated to them. Errors most often occur when communication is unclear regarding: drug name, drug appearance, why the patient is taking the drug, how much and how often to take it, when is the best time to take it, how long to take it, what common side effects could occur, what to do about a missed dose, common interactions with other drugs or foods, and whether this new drug replaces or augments other therapy. Over-the-counter medications can lead to medication errors because labels may not be sufficiently read or understood, and health care providers are often unaware when patients are taking over-the-counter medications.

5. Monitoring and reporting

Reporting Medication Errors
Health care professionals and consumers have the opportunity to report the occurrence of medication errors to a variety of organizations.

Examples include:

- the Institute of Safe Medication Practices (ISMP) and the
- Food and Drug Administration (FDA).

These organizations collectively review error submissions. Case reports are published to educate health care professionals regarding errors and near errors. In some cases, the FDA may work with drug manufacturers and others to inform them about concerns with pharmaceutical labeling, packaging and nomenclature to make appropriate changes to reduce the risk of medication errors. Academy of Managed Care Pharmacy (AMCP) has voiced support for a medication error reporting system that encourages participation and provides confidentiality and protection of the information reported and the person(s) reporting. To be successful a medication error reporting system must have protections for those reporting.

Often, pharmacists view mandatory reporting laws and regulations as punitive, especially if public disclosure is included. Compliance with such programs is likely to be less than optimal since the results of reporting could include lawsuits, regulatory enforcement actions, forfeiture of pharmacy license, and loss of professional reputation

with accompanying loss of business. Regulatory and advocacy activity provides for improving monitoring of medication errors.

The Food and Drug Administration (FDA) MedWatch reporting system provides a comprehensive sentry position for many medication errors to be reported. Although designed primarily for reporting adverse events from medication use, FDA's MedWatch is an appropriate venue to discover medication errors, such as prescribing misadventures and look-alike, sound-alike errors leading to adverse reactions. Many state boards of pharmacy have begun medication error reporting initiatives to detect trends in ambulatory dispensing errors. Most are limited to mandatory internal reporting systems within a setting, for example where errors must be logged and open for board inspection during routine visits and complaint investigation. Many physician boards and associations participate in prescribing error investigations, driven primarily by peer review and consumer complaint resolution.

Keys to Error Prevention

Patient Education

Health care professionals must provide adequate patient education about the appropriate use of their medications as part of any error prevention program. Proper education empowers the patient to participate in their health care and safeguard against errors. Some examples of instructions to patients that can help prevent medication errors are:

1. Know the names and indications of the medications
2. Read the medication information sheet provided by the pharmacists
3. Do not share the medications with others
4. Check the expiration date of the medications and dispose of expired drugs
5. Learn about proper drug storage
6. Always keep medications out of the reach of children
7. Learn about potential drug interactions and warnings

The responsibility for the prevention of medical errors rests not only with health care professionals and health care systems but also with the patients themselves. By being informed not only about the names of their medications but the reasons for their use, the times they should be administered and the correct dose, patients can act as the final check in the system. The practice of carrying a continually updated list of medications can be invaluable in the event of an emergency or if patients cannot speak for themselves. This reduces the chance of miscommunications or misinformation. When patients take an active and informed role in his or her health care, many errors can be prevented.

Prior Authorization

Prior authorization programs are used by managed health care systems as a tool to assist in providing quality, cost-effective prescription drug benefits. Improving the patient safety by promoting appropriate drug use is a very integral function of prior authorization programs.

Electronic Technology

Bar Coding another way in which electronic technology can improve patient safety and reduce medication errors is through the use of standard machine-readable codes such as bar codes. Medication bar coding is a tool that can help ensure that the right medication and the right dose are administered to the right patient. Today's technology imbeds increasing amounts of information within a bar code that can be scanned, on even the smallest packages.

Electronic Prescription Record

An electronic prescription record (EPR) contains all the data legally required to fill, label, dispense and/or submit a payment request for a prescription. Pharmacists use the record as a tool to reduce medication errors by guarding against drug interactions, duplicate therapy and drug contraindications.

E-prescribing

Enter orders on the computer: Utilization of electronic prescribing by entering orders on a computer, which is referred to as Computerized Physician Order Entry (CPOE), is a technology that could help prevent many medication errors. CPOE systems allow physicians to enter prescription orders into a computer or other device directly, thus

eliminating or significantly reducing the need for handwritten orders. E-prescribing and Computerized Physician Order Entry (CPOE), can reduce medication errors by eliminating illegible, unable to read, not clear and poorly handwritten prescriptions, ensuring proper terminology and abbreviations, and preventing ambiguous orders and omitted information.

Electronic drug utilization reviews (DUR)

Due to the technology of the electronic prescription record, pharmacists are able to conduct prospective online drug utilization reviews (DUR). The online drug utilization reviews process allows the pharmacist to conduct a review of the prescription order at the time the patient comes in to fill the prescription and proactively resolve potential drug-patient problems such as drug-drug interactions, over-use, under-use and medication allergies.

Automated Medication Dispensing

Automated medication dispensing systems are widely used as a less labor-intensive method of dispensing medications. Automated pharmacy dispensing systems are more efficient at performing pharmacists' tasks that require tedious, repetitive motions, high concentration and reliable record keeping, which all have potential to lead to medication dispensing errors.

Internal Quality Control Procedures

Most medication dispensing settings have developed quality evaluation procedures. These practices provide workflow evaluation and error reporting analyses, which lead to excellent protection from medication error. These procedures and evaluations have led to several changes in standard practice for ambulatory pharmacy, generally adopted as acceptable professional practice. These changes have provided additional safety checks, such as image displays, as part of the final dispensing review process, and the addition of descriptive text on prescription labels. These practices not only allow for final dispensing checks, but also allow for patient monitoring of consistency between label description and vial contents.

TELEPHONE ORDERS

VERBAL ORDERS

Verbal orders are orders that are spoken (verbal) in person or by the telephone, therefore there is more room for errors to take place than for orders that are sent electronically or written down.

Interpreting speech:

Verbal orders can result in error because there are so many variable/ factors that can affect the intended order such as Interpreting speech.

Interpreting speech may be problematic because of the different pronunciations, various accents and dialects. Often times there are interruptions, background noise, unfamiliar drug names, sound alike drugs and different terminology that can compound the problem.

After the verbal order is received, the order has to be transcribed as a written order, which may also increase the risk or potential for error in the ordering process.

When the nurse receives a verbal order, the physician or prescriber who gave the order assumes that the nurse understood or heard correctly. Then the nurse places a call to the pharmacy and this leads to a potential for/ more room for error. The pharmacist now relies on the accuracy of the nurse's written transcription of the verbal order and the pronunciation when the order is read to the pharmacist. The pharmacist may hear a sound-alike drug name or misheard the number (dosage) which will affect the accuracy of verbal orders.

Communicating multiple medications verbally at the same time is another factor that increases the potential for error.

Safe Practices

Some tips for safe practices include:

- Limit verbal orders of medication or prescription orders to urgent situations in which immediate written electronic communication is not possible. For example, facilities can implement in their policy and procedure to have prescriber complete written orders when present and the patient's chart is available; disallow verbal orders under such circumstances. Verbal orders can be restricted to situations where it is impossible or difficult for hard copy or electronic order transmission, for example during a sterile procedure.
- Those receiving the verbal orders can be required to time, date, sign and note the verbal order according to prescribed procedures.
- For the prescribers, speak clearly when giving verbal orders.

For those who are receiving the order:

- Write down the complete order or enter into computer
- Read it back and receiving confirmation from the prescriber who gave the order.
- the prescriber or the individual receiving the order can spell unfamiliar drug names, using M as in Mary," "B as in Boy," to make sure heard correctly.

- Prescribers can be mandated to verify and sign/date orders within a predetermined time frame.

- For all medication orders, include the indication/ purpose of the drug to make sure that the order makes sense in the context of the patient's diagnosis or condition. Many reported sound-alike name medications have different purpose /indications.

- Disallow medication requests from the nursing units to the pharmacy unless the verbal order has been transcribed onto an order form and simultaneously faxed to pharmacist so that the pharmacist can see the order before the medication is dispensed.

- Limit verbal orders to formulary drugs. The names of medications that are unfamiliar to the nurse are more likely to be misheard and their indication and dosages may not be familiar.

- Raise awareness of problematic drug name pairs at work /facility based on the reports submitted to patient safety authority reporting systems so that the practitioners can be prepared to challenge questionable orders.

- Include the mg/kg dose along with the patient's specific dose for all verbal medication orders for neonatal/pediatric patients.

- Prescribers can ask for important patient information for example drug allergies, diagnosis and lab values and that may affect the prescribed medications.

- Limit the number of personnel who can receive telephone / verbal orders.

- Standardize the unit-change and shift-change method of reporting.

- Express dosage of medications by unit of weight for example g, mg, mMol, mEq. Verbal orders that specify the dosage in terms of the number of tablets, ampuls, or vials, and verbal orders that state a volume but does not include the concentration, have led to medication errors and serious patient injury because many medications are available in several strengths and package sizes.

- Record the verbal order directly onto an order sheet in the patient's chart. Transcription from a scrap paper to the patient's chart is a potential for additional errors.

- Have a Phone or pager number so that you can get in touch with prescriber timely if there are follow-up questions.

- Disallow verbal orders for chemotherapy due to the complexity and potential for tragic / fatal errors.

- Have another individual (second person) listen to a verbal order whenever possible. Inexperienced staff or students may require special supervision when working with verbal orders.

- Annually review a list of look-alike and sound-alike medications used by your facility, and implement steps to prevent medication errors that involves the interchange of those medications.

- Utilize Hands-off communication; before the nurse leaves that assigned patient that nurse needs to communicate with the oncoming nurse or team regarding the patient. The patient is being transferred from one caregiver to another; therefore effective communication is vital to the prevention of errors. hands-off communication also occurs when patients are transferred to other facilities, therefore effective reporting / communication is vital to the continuity of care for that patient. Hands-off communications needs to include interactive questions and answers.

Medication reconciliation

Medication reconciliation refers to the process of avoiding inconsistencies across transitions in care by reviewing all the patient's medication regimen at the time of admission, transfer, and discharge; ensuring that it is compared with the new regimen that is being considered for the new facility of care.

When patients are admitted to the hospital or transferred from one unit to another during their hospital stay, or upon discharge from the hospital, they often have changes made to their existing medications or receive new medicines. During this transition, there is a potential for errors to occur. Errors may occur due to:

- The hospital-based health care provider might not have received the patients' complete pre-admission medication lists,
- The Health care provider may not be aware of recent medication changes,
- the new medication regimen prescribed at the time of discharge may inadvertently omit needed medications,
- the new medication regimen prescribed at the time of discharge may contain unnecessarily duplicate existing therapies,
- the new medication regimen prescribed at the time of discharge may contain incorrect dosages.

These discrepancies put the patient at risk for adverse drug events (ADEs), which have been shown to be one of the most common types of adverse events after a hospital discharge.

As of July 2011, medication reconciliation has been incorporated into National Patient Safety Goal as improving safety of using medications. This National Patient Safety Goal requires that organizations have to maintain and communicate correct medication information and also compare the medications information that the patient brought to the hospital with the new medications ordered for the patient by the hospital so that discrepancies can be identified and resolved.

DRUG INDICATIONS FOR USE

An indication is a valid reason to use a certain medication, test, procedure, or surgery. The opposite of an indication is a contraindication; a reason to withhold a certain medication or medical treatment etc. due to the harm that it would cause the patient.

All medications have an indication for use. Most of the indications for use are related to the desired actions of the medication. If you do not know the indication for use of a medication that your patient is taking, use a reference such as a drug guide or ask your supervisor or a Pharmacist.

Some medications are not allowed to be used or they are contraindicated for some patients. Therefore, the medication should not be given to the patient. Other medications may only be used with some patients when they are used with extreme caution and with frequent monitoring.

A very common contraindication is an allergy or sensitivity to the medicines. Always check the patient’s medical record for allergies and ask the patient before you assist. Sometimes you will observe NKA on the patient's medical record /chart; this indicates that the patient has no known allergies. Sometimes you may observe NKDA- this means no known drug allergies.

ALLERGY

Allergy involves hypersensitivity or an exaggerated response of the immune system, often to common substances such as medication, pollen or foods. A rash or a life threatening reaction such as Anaphylaxis can occur if the patient takes a medication that he/ she is allergic to.

Some types of Allergies include:

- Food allergies e.g. peanuts, peanut butter, shellfish
- Drug allergies
- Latex allergies e.g. latex gloves
- Seasonal allergies
- Animal allergy

Some signs of Allergic reactions include:

- Itching , Hives
- Redness of the skin
- Dyspnea, Shortness of Breath (SOB)
- Problems with breathing
- Throat swelling
- Loss of consciousness
- Irregular heart beat /rhythm
  Decrease in the blood pressure (BP)
  Abdominal discomfort / cramps
- Nausea and / or vomiting
- Death

Anaphylaxis

Anaphylaxis is a severe, whole-body *allergic reaction* to a chemical or substance that has become an allergen. An allergen is a substance that can cause an allergic reaction. Some drugs such as, Penicillin, aspirin, x-ray dye, morphine and others may cause an anaphylactic-like reaction when the patient is first exposed to them. Anaphylaxis is an emergency situation that requires medical attention immediately. Call 911 immediately.

Symptoms will develop very quickly, often within seconds or minutes. They may include:

- Difficulty breathing
- Facial swelling
- Redness of the skin
- Itchy /hives
- Light headed / dizziness
- Loss of consciousness
- Swelling of the face and eyes
- Chest tightness/ discomfort

- Palpitations
- High pitched abnormal breathing sounds
- Wheezing
- Coughing
- Speech becomes slurred
- Difficulty swallowing
- Swelling of the tongue
- Restlessness / anxiety
- Diarrhea
- Abdominal pain
- Nausea or vomiting
- Death

Medication interactions

Some medications may interact with other medications, various herbs, foods, supplements and drink for example; alcohol. Medication interactions can cause the medication that the patient is taking, to be less effective, or cause unexpected side effects, or cause an increase action of a particular medication. Some drugs interaction can be very harmful to the patient. Always read the medication label for every prescription and nonprescription medications.

Take the time to learn about the medication interactions. You will reduce the risk of potentially harmful medication interactions and / or side effects.

Medication interactions fall into three categories:

Drug to drug interactions
Drug to drug interaction occur whenever two or more medications react with each other. This drug-drug interaction may cause the patient to experience an undesired side effect / reaction, for example, patient who takes a blood thinner e.g. Coumadin and then takes aspirin for a headache will increase the risk of bleeding.

Drug to food/beverage interactions
Drug to food / beverage interactions result from medications reacting with the food or drink. For example, having alcohol with some medications may cause the patient to feel sleepy or slow his/ her reaction.

Drug to condition interactions
Drug to condition interactions may occur when the patient has an existing medical condition / disease that makes some medications potentially harmful. For example, patients with high blood pressure may experience an undesired reaction if he/she takes a cough or decongestant medication.

ADVERSE REACTIONS / SIDE EFFECTS

Side effects

A side effect is also known as an adverse effect, adverse event, or undesirable secondary effect when a medication or treatment goes beyond the desired effect and causes or leads to a problem (an undesirable secondary effect). Some side effects are not life threatening but others can be life threatening.

Side effects vary for each patient, and depend on different factors such as;

- the patient's general health,
- age,
- the stage of their disease,
- weight and
- Gender.

Adverse drug reactions

Adverse drug reactions are serious and they can also lead to death. Some medications also have toxic effects. Learn about the possible adverse drug reactions, side effects and the toxic effects of all the medications that your patient is taking so that you can report them.

DOSAGES/ DOSES

All medications have prescribed amount or dosage ranges for the adults and for children. Older patients are at greater risk for adverse drug events because of the metabolic changes and decreased medication clearance that is associated with the aging process. Some adult dosages may be lowered for the older patient because they are more susceptible to adverse medication reactions, side effects, over dose and even toxicity. Adolescents can take the adult dosages. Children are given medications with a dose that is based on their body weight.

Toxicity

Toxicity is the degree to which a substance /a toxin can cause harm to humans or animals.

- Acute toxicity involves the harmful effects in an individual or organism through short-term exposure.

- Subchronic toxicity is the ability of a toxic substance to cause effects for more than one year but less than the lifetime of the exposed organism.

- Chronic toxicity is the ability of a mixture of substances or a substance to cause harmful effects over an extended time period, usually upon continuous or repeated exposure, that can sometimes last for the entire lifetime of the exposed organism/ individual.

Toxicology is the study of adverse and/or toxic effects of drugs/medications and other chemical agents. It involves both drugs used in the treatment of diseases as well as chemicals that may cause environmental, household or industrial hazards.

Medication Routes and Forms

Route of medication administration refers to the path by which the medication is taken into the body. Medications are made in various forms and for administration by different routes. Some routes may be unsafe or ineffective. This can be due to the patient's health conditions, such as unable to swallow, dehydration or other factors. Some medications can be administered by more than one route, for example Tylenol is available in tablet form, suppository and also in liquid etc. The tablet may be taken by mouth in tablet or liquid form; however, a child might not be able to take the tablet and able to take the liquid and/ or a suppository may need to be given by a nurse per rectum if the patient is unable to take the medication by mouth. The medication order has to state the form and the route that the physician wants the patient to take.

Route of administration will vary depending on:

- The property of the medication,
- Its action of the medication,
- The desired effect,
- The patient's physical wellbeing,
- The patient's mental status,
- The patient's age.

Routes of medication administration include:

• oral route (by mouth)
• sublingual route (under tongue)
• buccal route (inside the cheek)
• otic (ear)
• ophthalmic (eye)
• topical (applied on the skin)
• nasal route (nose)
• vaginal route (vagina)
• rectal (by rectum)
• inhalation (by inhaling)
• nasogastric tube (tube in the nose to the stomach)
. gastrostomy tube (tube in the stomach)
• intramuscular (into the muscle)
• subcutaneous (under skin)
• intradermal (in the skin)
• intravenous (into the vein via an I.V)
• transdermal (through the skin e.g. a patch on the skin)

Forms of medications

Medications are made in various forms meaning that they are available in more than one form. Therefore a tablet cannot be given if the order says liquid.

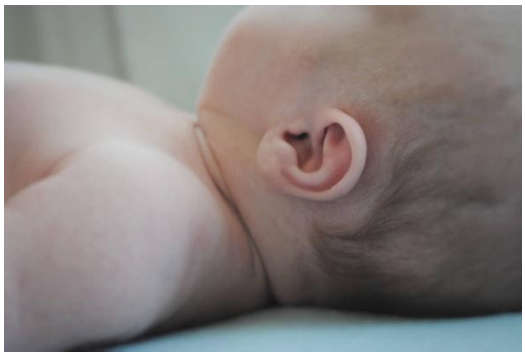
Different forms of medications include:

- capsule (regular and sustained release)
- tablet
- suppositories (rectal and vaginal)
- elixir
- syrup
- cream
- oral suspension
- tincture
- paste
- ointment
- drop (ears and eye)
- Intravenous /IV solutions and suspension
- metered dose inhaler

Some Route and Form considerations

When a patient is very ill or has a problem such as difficulty with swallowing, the following things can be done:

- Crush the pill and put it into applesauce or open the capsule and put it into applesauce. Some medications **cannot be crushed**. Some of these medications include time release capsules, sublingual medications, some coated tablets and other medications that may upset the stomach. Check with the Pharmacist or supervisor to find out if a medication can be crushed or what that medication can be mixed with.
- Use the liquid form of the medication. Using a liquid form can also help patients who have trouble swallowing or using the tablets and/or the capsules. At other times the nurse may have to administer the medication by I.V.



MEDICATION DELIVERY CONSIDERATIONS

Age is one factor that you must consider when giving medications;

- For an infant you may use a dropper, syringe or nipple for liquid oral medication.
- For the toddler you may use a cup or spoon for oral liquid medication.
- For the preschool and School Age children, they may be able to take tablets and capsules.
- For adolescents, they are allowed to take adult dosages, forms and routes of Medications.

ELDERLY POPULATION

The gastrointestinal (GI) tract

The gastrointestinal tract may change as the individual get older and this may affect how some medications are absorbed. The aging process can reduce gastrointestinal motility and gastrointestinal blood flow.

Gastric acid secretion is reduced in older adults and this can result in an elevation in gastric pH. Increased gastric pH and reduced gastric blood flow may cause reduced drug absorption, whereas reduced gastrointestinal motility may result in more of the medications being absorbed.

DISTRIBUTION OF THE DRUG

As the individual gets older, the aging process can have a significant effect on how the medication is distributed in the body. As the body ages, there are several age related changes; muscle mass declines and proportion of body fat increases.

The aging process also is associated with a reduction in total body fluids (water), which can affect the volume of distribution of water-soluble drugs. Older individuals in general produce less albumin, which binds drugs in the bloodstream. Reduction in albumin; protein binding, may result in an increase in free drug concentration.

Healthcare providers / physicians need to take these changes into consideration when prescribing medications to the older adults. If these changes are not taken into consideration, this can result in drug toxicity, among other anomalies.

DRUG METABOLISM

The aging process can also affect drug metabolism. Several physiological changes occurs in the elderly that can influence metabolic capacity such as; hepatic blood flow is decreased / reduced in the elderly adult, this can affect metabolism because the medication is introduced to the liver at a much lower rate. During the aging process, liver mass and the intrinsic metabolic activity (CYP450 enzyme system) is also reduced.

EXCRETION

Aging changes in the kidneys

As mentioned earlier, the kidneys have multiple functions including:

- Filtering the blood and help to remove waste and excess fluid from the body.
- The kidneys also assist in controlling the body's chemical balance.

The urinary system includes:

- The kidneys, ureters, bladder, and the urethra.

Aging Changes and the effects on the Kidneys

- As the individuals get older, the kidneys and the bladder change. This can definitely affect their function.
- Muscular changes and changes in the reproductive system also affect bladder control.

Within a healthy aging individual, kidney function remains normal. However with illness, medications, and other conditions may cause changes in the kidney function.

Changes in the kidneys:

As the individual gets older the amount of kidney tissue also decreases. The nephrons, (filtering units in the kidneys) also decreases. The nephrons are responsible for filtering waste material from the blood; therefore, what will happen when this function is not taking place effectively? Filter function is not doing the work it should be doing. The blood vessels that supply the kidneys can also become hardened. This will affect the rate at which the kidneys will filter blood (slower rate). The reduction in glomerular filtration rate will influence dosing / dosage of medications; knowing which medications are excreted renally and knowing how to adjust the dosage of those medications in patients with renal impairment is vital to ensure safe and effective drug dosing in all patients

Due to the physiological changes in the elderly individuals, they may also be at high risk for certain drug adverse effects. Many older individuals are prone to the effects that certain medications have on the central nervous system; such as confusion, sedation, dizziness and seizures. These effects cause problems for the elderly persons, who may be extremely sensitive to any drug-induced actions on the central nervous system.

PEDIATRIC

The absorption, distribution, excretion and metabolism of medication can vary throughout infancy, early childhood and puberty.

Drug Absorption
Drug absorption in infants and children can be altered from adult values by 2 factors:

- Gastrointestinal (GI) function and
- Blood flow at the site of administration (rectal, intramuscular or percutaneous).

Most medications that are administered orally are absorbed in the small intestine.

Since infants have proportionately larger small intestinal surface areas, this may result in unpredictable absorption compared with adults. Infants have increased intestinal motility, which can alter the absorption of medications with limited water solubility. (PA and NP 2016).

Neonates have reduced lipase secretion, which decreases the ability for the neonate to absorb lipid formulations. Gastric pH is higher in the neonate (pH >5) and infant (pH 2-4). Gastric pH reaches adult levels (pH 2-3) at age 20 months to 30 months.

Young infants (<12 months) have increased percutaneous absorption of topical medications due to well-hydrated, thinner stratum corneum. Systemic toxicity may occur with small amounts of topical application of medications.

Distribution

Within the 1st few months of life, there are changes within body composition that alters the physiologic spaces in which medications are distributed.

Infants and newborns have a higher percentage of body water; 70% - 80% (infants) and in adults; 60%. The percentage of total body water is related to the amount of body fat; at maturity, men have slightly higher total body water than women, mainly due to the differences in body composition.

The % of body water in infants, neonates and during puberty can affect the dosing of some medications drugs.

Infants, who are younger than 6 months old, have less plasma proteins available for drug binding. This will cause increase levels of unbound medications, resulting in drug toxicity, this may occur with normal or low plasma concentration of total drug.

The blood-brain barrier is incomplete and permeable in the newborn, leading to increased central nervous system (CNS) effects of some medications. Phenobarbital levels in the brains of neonates are higher than phenobarbital levels in older children and adults.

Elimination

Renal elimination rates are affected by the lower glomerular filtration rate in newborns, which is only 30% to 40% of adult values. The glomerular filtration rate rises in the first 2 weeks of life in the preterm and term neonate; birthweight >1,500 g.

By age 6 to 12 months, the glomerular filtration rate reaches adult values. Any medication that depends on renal excretion are cleared slowly in neonates.

- Drug dosages and dosing intervals in newborns needs to be adjusted accordingly when prescribing certain medications.

Renal blood flow is also reduced in neonates and reaches adult levels at approximately 9 months old.

Metabolism

As mentioned earlier, most of the research has been conducted in the adult population.

In the very young neonate and infant, the delayed maturity of drug-metabolizing enzymes may account for drug toxicity. The pathways of drug clearance develop variably over the1st year of life and may be influenced by medications that induce drug-metabolizing enzymes.

There has been an increase in knowledge about the role of phase I cytochrome P450 and phase II enzymes in drug metabolism during the past few years, however a lot is still not known.

Pediatric formulations

Pediatric formulations for several medications are lacking. Many medications are effective in adults but not used in children because of the lack of pediatric formulations.

There is also not enough funding available for the development of liquid stable forms of medications.

The Food and Drug Administration Modernization Act (FDAMA) incentive encourages pediatric formulations of new medications, but there is not enough financial incentive for older medications.

One of the obstacles is that data about the stability of medications in liquid form is scarce.

Stability of medications can be affected by several factors, such as:

- Storage temperature,
- Type of container and vehicle; sugar can affect the stability of some medications.

The National Institute of Child Health and Human Development (NICHD) has established pediatric pharmacology research units (PPRUs) to facilitate the study of pediatric pharmacology. The mission of the pediatric pharmacology research unit network is to facilitate and promote pediatric labeling of new medications or drugs that are already on the market.

The pediatric pharmacology research units study the pharmacokinetics and pharmacodynamics of medications in a collaboration which involves pediatric academic researchers, pediatric clinical pharmacologists and industry.

SOME MAJOR CATEGORY OF MEDICATIONS

ALLERGY MEDICATIONS

Epinephrine injection

Epinephrine injection is used along with emergency medical treatment to treat life-threatening allergic reactions caused by medications, foods, insect stings or insect bites, latex, and other causes.

Epinephrine is in the class of medications called Alpha- and Beta-adrenergic agonists (sympathomimetic agents).

Epinephrine works by relaxing the muscles in the airways while it tightens /constricts blood vessels.

Epinephrine is a chemical that narrows blood vessels and opens airways in the lungs. These effects can reverse severe wheezing, hypotension (low blood pressure), severe itching of the skin, hives, and other symptoms of an allergic reaction.

Epinephrine injection is used to treat anaphylaxis (severe allergic reactions) to insect bites or stings, medications, foods and other allergens.

Epinephrine is also used to treat exercise-induced anaphylaxis.

Epinephrine auto-injectors such as EpiPen and EpiPen Jr. are available and should be kept on hand for self-injection by individuals with a history of an severe allergic reaction.

DESCRIPTION

Adrenalin® (epinephrine injection, USP) is a clear, colorless, sterile solution containing 1 mg/mL (1:1000) epinephrine, packaged as 1 mL of solution in a single-use clear glass vial or 30 mL of solution in a multiple-dose amber glass vial.

Epinephrine is a sympathomimetic catecholamine.
The chemical name of epinephrine is: 1,2-Benzenediol, 4-[(1R)-1-hydroxy-2-(methylamino)ethyl]-, or (-)-3,4-Dihydroxy-α-[2(methylamino)ethyl]benzyl alcohol.

Epinephrine solution deteriorates rapidly on exposure to air or light, turning pink from oxidation to adrenochrome and brown from the formation of melanin.

Pharmacokinetic properties
Epinephrine is rapid in onset and of short duration and is rapidly distributed to the heart, spleen, several glandular tissues and adrenergic nerves.

Epinephrine crosses the placenta and is excreted in breast milk.
Epinephrine is approximately 50% bound to plasma proteins. The onset of action is rapid and after i.v. infusion the half-life is approximately 5-10 minutes.

Epinephrine is rapidly metabolized in the liver and tissues.

PATIENT TEACHING

Possible side effects of epinephrine injection

Serious side effect may include:

- Increased breathing difficulty,
- Elevated BP (High blood pressure)
- severe headache,
- blurred vision,
- buzzing in the ears,
- anxiety,
- confusion,
- chest pain,
- shortness of breath,

- uneven heartbeats,
- seizure.

Less serious side effects may include:

- sweating
- nausea / vomiting
- pale skin
- feeling short of breath
- dizziness
- weakness
- tremors
- Headache
- feeling nervous
- anxious.

To report SUSPECTED ADVERSE REACTIONS, contact FDA at 1-800-FDA-1088 or www.fda.gov/medwatch.

Adrenalin® is available as a single-use 1 mL vial and a multiple-use 30 mL vial.

- The 1 mL vial is for use intramuscular, subcutaneous, and intraocular use.
- The 30 mL vial is for intramuscular and subcutaneous use only, and is NOT FOR OPHTHALMIC USE.

Anaphylaxis (Adrenalin® 1 mL Single-Use and 30 mL Multiple-Dose Vials)

Emergency treatment of allergic reactions (Type I), including anaphylaxis, which may result from allergic reactions to insect stings, biting insects, foods, drugs, sera, diagnostic testing substances and other allergens, as well as idiopathic anaphylaxis or exercise-induced anaphylaxis.

The signs and symptoms associated with anaphylaxis include:

- flushing,
- apprehension,
- syncope,
- tachycardia,
- thready or unobtainable pulse associated with hypotension,
- convulsions,
- vomiting,
- diarrhea and abdominal cramps,

- involuntary voiding,
- airway swelling,
- laryngospasm,
- bronchospasm,
- Pruritus
- Urticaria or angioedema
- swelling of the eyelids, lips, and tongue.

Induction and Maintenance of Mydriasis during Intraocular Surgery (Adrenalin® 1 mL single-use vial only)

Induction and maintenance of mydriasis during intraocular surgery.

Overdosage

Overdosage of epinephrine may produce elevated arterial pressure, which may result in cerebrovascular hemorrhage, especially in the elderly patient. Overdosage can also result in pulmonary edema due to peripheral vascular constriction together with cardiac stimulation.

- Treatment consists of a rapidly acting α-adrenergic blocking drug and respiratory support.

Epinephrine is rapidly inactivated in the body and treatment following overdose with epinephrine is primarily supportive. If necessary, pressor effects may be counteracted by rapidly acting vasodilators or α-adrenergic blocking medications.

Overdosage may results in extreme pallor and coldness of the skin, metabolic acidosis due to increased blood lactic acid level, and kidney failure. Appropriate corrective measures must be taken in such situations.

Warn patients with the diagnosis of diabetes that they may develop increased blood glucose levels after epinephrine administration.

Diphenhydramine (Benadryl)

Brand Names: Aler-Tab, Allergy, Allermax, Altaryl, Benadryl Allergy, Benadryl DF, Benadryl Dye Free Allergy, Benadryl Ultratab, Children's Allergy, Diphen Cough, Diphenhist, Dytuss, PediaCare Children's Allergy, Q-Dryl, Q-Dryl A/F, Siladryl, Siladryl Allergy, Silphen Cough, Simply Sleep, Sleep-ettes, Sleep-ettes D, Sominex Maximum Strength Caplet, Theraflu Thin Strips Multi Symptom, Triaminic Thin Strips Cough & Runny Nose, Unisom Sleepgels Maximum Strength, Valu-Dryl

Generic Name: Diphenhydramine
Diphenhydramine is an antihistamine.

Diphenhydramine blocks the effects of the naturally occurring chemical histamine in the body.

Diphenhydramine is used to treat sneezing; runny nose; itching, watery eyes; hives; rashes; itching; and other symptoms of allergies and the common cold.

Diphenhydramine is also used to suppress coughs, to treat motion sickness, to induce sleep, and to treat mild forms of Parkinson's disease and other purposes not listed.

DOSAGE

A typical dose of Benadryl is 25-50 mg every 4-6 hours.

Benadryl adds to the sedating effects of alcohol and other sedating medications.

Benadryl can intensify the drying effects of drugs with anticholinergic properties.

Benadryl has not been adequately evaluated in pregnant women. Benadryl is secreted in breast milk.

Because of the risk of stimulation and seizures in newborns and premature infants, antihistamines should not be used by nursing mothers.

INSTRUCT PATIENTS – CAUTION !!!

Use caution when driving, operating machinery, or performing other hazardous activities. Diphenhydramine may cause dizziness or drowsiness. Instruct patients that If they experience dizziness or drowsiness, avoid these activities.

Alcohol may increase drowsiness and dizziness while taking diphenhydramine.

Instruct patients not to take diphenhydramine if they have taken a monoamine oxidase inhibitor (MAOI). A very dangerous medication interaction could occur and lead to serious side effects.

PATIENT TEACHING (continue)

Before taking Benadryl, tell the physician/ healthcare provider if have

- glaucoma or increased pressure in the eye
- a stomach ulcer
- an enlarged prostate,
- bladder problems
- difficulty urinating
- hyperthyroidism
- hypertension
- any type of heart problems
- asthma.

Diphenhydramine is in the FDA pregnancy category B. This means that it is not expected to be harmful to an unborn baby.

Infants are especially sensitive to the effects of antihistamines, and side effects could occur in a breast feeding baby.

Instruct patients:

Do not take diphenhydramine without first talking to the healthcare provider if they are nursing a baby.

If patients are over 60 years of age, they may be more likely to experience side effects from diphenhydramine. They may require a lower dose of this medication.

Talk to the pharmacist or physician before taking other over-the-counter cold, cough, allergy, or other insomnia drugs. These products may contain medications that are similar to diphenhydramine, which may lead to an antihistamine overdose.

SIDE EFFECTS

Stop taking diphenhydramine and seek emergency medical attention if experience an allergic reaction such as: difficulty breathing; closing of the throat; swelling of the lips, tongue or face or develops hives.

Other, less serious side effects may be more likely to occur such as:

- sleepiness,
- fatigue,
- dizziness
- headache;
- dry mouth; or
- Difficulty urinating
- an enlarged prostate.

Common side effects of Benadryl include:

- Sedation,
- tiredness,
- sleepiness,
- dizziness,
- disturbed coordination,
- constipation,
- dry mouth
- dry nose
- dry throat,
- difficulty urinating,
- upset stomach.

Benadryl may also cause double vision, blurred vision, tremor, nausea loss of appetite, and other side effects may occur.

Side effects may be reported to FDA at 1-800-FDA-1088.

PHARMACOKINETICS

Absorption: Benadryl is well absorbed after PO (oral) or intramuscular (IM) administration and 40–60% of an oral dose reaches systemic circulation due to first-pass metabolism.

Distribution: Widely distributed; crosses the placenta- enters the breast milk.

Metabolism and Excretion: 95% metabolized by the liver.

Half-life: 2.4–7 hr.

Time / Action Profile (antihistaminic effects)

ROUTE	ONSET	PEAK	DURATION
PO	15-60 Min	2-4 hr	4-8 hr
IM	20- 30 min	2-4 hr	4-8 hr
IV	Rapid	unknown	4-8 hr

ANALGESICS (PAIN RELIEVERS)

TYLENOL

Tylenol (acetaminophen) is a pain reliever and a fever reducer.

Tylenol is used to treat many conditions such as headache, muscle aches, arthritis, backache, toothaches, colds, and fevers.

INDICATIONS

USES

Temporary relieves minor aches and pains due to:

minor pain of arthritis
backache
the common cold
muscular aches
premenstural and menstrual cramps
headache
toothache
temporarily reduces fever

PATIENT TEACHING

Side effects of acetaminophen

Get emergency medical help if experience any of these signs of allergic reactions such as:

- Hives,
- difficulty breathing
- swelling of face,
- swelling of lips,
- swelling of tongue,
- swelling of throat.

Instruct patients to STOP taking the medication and call the physician immediately if they have serious side effects such as:

- nausea,
- upper stomach pain,
- itching,
- loss of appetite,
- dark urine,
- clay-colored stools,
- jaundice (yellow color to eyes or skin).

and other side effects may occur.

Overdose Management

In 1985, the United States Food and Drug Administration (FDA) approved acetylcysteine (N-acetyl cysteine (NAC) as an antidote for the treatment of acetaminophen overdose.

N-acetyl cysteine treats acetaminophen (Tylenol) poisoning by binding the poisonous forms of acetaminophen that are formed in the liver.

OVERDOSE

If overdose is suspected, contact a poison control center or emergency room immediately. US residents can call the local poison control center at 1-800-222-1222.

Symptoms of overdose may include:

- nausea,
- vomiting,
- loss of appetite,
- sweating,
- abdominal pain,
- stomach pain,
- extreme tiredness,
- yellowing eyes,
- yellowing of the skin,
- dark urine.

ASPIRIN

Aspirin is a salicylate. It works by reducing substances in the body that cause fever, pain and inflammation.

Aspirin is used to treat pain, and reduce fever or inflammation. It is sometimes used to treat or prevent heart attacks, strokes, and chest pain (angina).

Pharmacokinetics

Absorption:

Well absorbed from the upper small intestine

Absorption from enteric coated drugs may not be reliable

Rectal absorption is slow and variable.

Distribution:

Quickly and widely distributed

Crosses the placenta

Enters breast milk.

Metabolism and Excretion:

Metabolized by the liver – extensively

Inactive metabolites are excreted by the kidneys.

Half-life: 2–3 hr for low doses; up to 15–30 hr with larger doses because of saturation of liver metabolism.

TIME/ACTION PROFILE

ROUTE	ONSET	PEAK	DURATION
PO	5–30 min	1–3 hr	3–6 hr

Contraindications/Precautions

Contraindicated in:

Hypersensitivity to aspirin or other salicylates;
Cross-sensitivity with other Nonsteroidal anti-inflammatory drugs (NSAIDs) may exist.

Bleeding disorders or thrombocytopenia;

Pediatric

May increase the risk of Reye's syndrome in children or adolescents with viral infections.

Use with caution in:

History of GI bleeding

History of ulcer disease

Chronic alcohol use

Alcohol abuse

Severe hepatic

Renal disease

OBSTETRIC:

Salicylates may have adverse effects on the fetus and the woman and should be avoided during pregnancy, especially during the 3rd trimester.

Lactation:

Safety is not established.

Geriatric: Increase risk of adverse reactions such as gastrointestinal bleeding

The elderly patients are more sensitive to toxic levels.

Lab Test

Hepatic function

Monitor hepatic function;

- Before antirheumatic therapy
- If symptoms of hepatotoxicity occur;
- Especially in patients; children with rheumatic fever, juvenile arthritis, systemic lupus erythematosus, or with pre-existing hepatic disorder /disease.

Serum ALT, AST and alkaline phosphatase

May cause increase serum ALT**,** AST and alkaline phosphatase, especially when plasma concentrations exceed 25 mg/100 mL.

Serum salicylate levels

Monitor serum salicylate levels periodically with prolonged high-dose therapy to determine safety, dose, and efficacy.

Prothrombin time; Bleeding time, Hematocrit

May prolong bleeding time for 4–7 days.

In large dosage, may cause prolonged prothrombin time.

Monitor hematocrit to assess for gastrointestinal blood loss, in prolonged high dose therapy.

Toxicity / Overdose

Monitor for the onset of:

- Tinnitus,
- Headache,
- Hyperventilation,
- Agitation,

- Mental confusion,
- lethargy, diarrhea,
- sweating.

If the above symptoms occur, withhold the medication and contact the physician or other health care provider immediately.

SIDE EFFECTS

Aspirin may cause side effects:

- Nausea
- Vomiting
- Stomach pain
- Heartburn

Some side effects can be serious:

Hives

Rash

Swelling of the eyes,

Swelling of the face,

Swelling of the lips,

Swelling of the tongue,

Swelling of the throat

wheezing

Difficulty breathing

Hoarseness

Rapid heartbeat

Rapid breathing

Clammy, cold skin

Ringing in the ears

loss of hearing

blood in vomit

Vomit (coffee grounds)

Blood in stools- bright red

Tarry or black stools

Aspirin may also cause other side effects.

If there is serious side effect it may be reported to the Food and Drug Administration's (FDA) MedWatch Adverse Event Reporting program online (http://www.fda.gov/Safety/MedWatch) or by phone (1-800-332-1088).

In case of overdose, call the poison control center at 1-800-222-1222.

Some symptoms of overdose may include:

Burning pain in the throat

Burning pain in the stomach

Fever

Vomiting

Decreased urination

Restlessness

Irritability

Fear

Nervousness

Dizziness

Double vision

Confusion

Hallucination (hearing voices or seeing things that are not there)

Seizures

Drowsiness

Loss of consciousness for a period of time

Shaking uncontrollable; (a part of the body).

Treatment

Treatment depends on the amount of aspirin, the time it was swallowed and the overall condition of the patient.

Treatment may include:

Activated charcoal

Airway support (oxygen, breathing tube/ ventilator).

Intravenous (IV) fluids

Laxative

Blood tests

Urine tests

Chest x-ray

Electrocardiogram (EKG)

Medications to treat symptoms

Other medications may be administered IV, including potassium and sodium bicarbonate, which will help the body remove aspirin that has already been digested.

If these treatments do not work or the overdose is extremely severe, hemodialysis (kidney machine) may be needed to remove aspirin from the blood.

ANTIBIOTICS

Antibiotics are medications that are used to fight bacterial infections. The first antibiotic was penicillin, discovered accidentally from a mold culture.

Although antibiotics are useful in a wide variety of infections, it is important to realize that antibiotics only treat bacterial infections.

PENICILLIN VK

Penicillin V potassium is an antibiotic used to treat certain infections caused by bacteria such as scarlet fever, pneumonia, and throat, skin, ear infections.

PENICILLIN V POTASSIUM
(penicillin v potassium) Tablet

PENICILLIN V POTASSIUM
(penicillin v potassium) Powder for Solution

Indications

Treatment of a wide variety of infections including:

- Pneumococcal pneumonia,
- Streptococcal pharyngitis,
- Syphilis,
- Gonorrhea strains.

Action

Bind to the bacterial cell wall, leading to cell death.

Pharmacokinetics

Absorption:

Variably absorbed from the gastrointestinal tract.
Resists acid degradation in the gastrointestinal tract.

Distribution:

Widely distributed although central nervous system (CNS) penetration is poor in the presence of normal meninges.
Crosses the placenta
Enters breast milk.
Protein Binding: 60%.

Metabolism and Excretion:

Minimal; metabolized by the liver, excreted mainly by the kidneys (unchanged).

Half-life: 30–60 min.

Time / Action Blood levels

ROUTE	ONSET	PEAK	DURATION
PO	rapid	0.5–1 hr	4–6 hr

Use Cautiously in:

Severe renal insufficiency - dose reduction is recommended.

OBSTETRIC: safety not established.

Lactation: Safety not established

GERIATRIC:

Consider decreased body mass, age related decrease in renal age related decrease in hepatic, age related decrease in cardiac function, concurrent diseases and drug therapy.

SIDE EFFECTS

- Seizures
- Diarrhea,
- Anaphylaxis,
- Epigastric distress,
- nausea,
- vomiting,
- pseudomembranous colitis
- Rash,
- urticaria
- Eosinophilia,
- leukopenia

Laboratory Test Considerations

May cause neutropenia and leucopenia (especially with hepatic impairment or prolonged therapy.

May cause elevated ALT, AST, LDH, and serum alkaline phosphatase concentrations.

May cause positive direct Coombs' test results.

CIPROFLOXACIN

Indications

Ciprofloxacin is an antibiotic in a group of drugs called fluoroquinolones

Ciprofloxacin fights bacteria in the body; is used to treat different types of bacterial infections.

Action

Inhibits bacterial DNA synthesis by inhibiting DNA gyrase enzyme.

Pharmacokinetics

Absorption:

70% absorbed following oral administration

Intravenous administration results in complete bioavailability.

Distribution:

Widely distributed.

High tissue levels are achieved.

High urinary levels are achieved

Crosses the placenta

Enters breast milk.

Metabolism

15% metabolized by the liver,

Excretion: 40–50% excreted by the kidneys (unchanged).

Half-life: 4 hr.

Time / Action profile - blood levels

ROUTE	ONSET	PEAK	DURATION
PO	rapid	1–2 hr	12 hr
PO-ER	rapid	1–4 hr	24 hr
IV	rapid	end of infusion	12 hr

Use Cautiously in:
Patients with known or suspected central nervous system disorder.
Renal impairment; dose reduction if Creatinine Clearance Rate (ccr) ≤50 mL/min.

Lactation: Safety not established (except for treatment of anthrax)

Geriatric: Increase risk of side effects/ adverse reactions.

Side Effects

Some side effects may include but not limited to:

- Severe dizziness,
- fainting,
- fast heartbeat,
- pounding heartbeat,
- Sudden pain,
- bruising,
- swelling,
- stiffness,
- tenderness,
- loss of movement in any of the joints,
- Diarrhea (that is bloody or watery),
- Confusion,
- hallucinations,
- Depression.

Patient needs emergency medical help for signs of an allergic reaction such as:

- Hives
- Difficult breathing
- Swelling of the face,
- Swelling of the lips,
- Swelling of the tongue,
- Swelling of the throat.

INSTRUCT PATIENTS TO:

Stop using ciprofloxacin and call the physician immediately if they experience serious side effects.

ANTICOAGULANTS

WARFARIN

COUMADIN (warfarin sodium) tablets and COUMADIN (warfarin sodium) for injection contain warfarin sodium, an anticoagulant that acts by inhibiting vitamin K-dependent coagulation factors.

Action

Interferes with hepatic synthesis of vitamin K-dependent clotting factors (II, VII, IX, and X).

Therapeutic Effects: Prevention of thromboembolic events.

Pharmacokinetics

Absorption: Well absorbed from the gastrointestinal after oral administration.

Distribution: Cross the placenta BUT does not enter the breast milk.

Protein Binding: 99%.

Metabolism and Excretion: Metabolized by the liver.

Half-life: 42 hrs

Time /Action

ROUTE	ONSET	PEAK	DURATION
PO, IV	36–72 hr	5–7 days	2–5 days

Indications

Prophylaxis and treatment of:

- Venous thrombosis,
- Pulmonary embolism (PE),
- Atrial fibrillation (a-fib) with embolization.

Management of myocardial infarction:

- Reduces risk of death,
- Reduces risk of subsequent Myocardial Infarct (MI),
- Reduces the risk of future thromboembolic occurrences.
- Prevention of thrombus forming and embolization after placement of prosthetic valve.

Contraindicated in:

- Uncontrolled bleed
- Open wound
- Ulcer disease
- Recent eye surgery or injury
- Recent brain surgery or injury
- spinal cord surgery or injury
- Severe liver disease
- Severe kidney disease
- Uncontrolled hypertension
- Obstetric: Crosses placenta; may cause fatal hemorrhage in fetus. May cause congenital anomaly/ malformation.

Use Cautiously in individuals with:

- Malignancy
- Patients with history of ulcer disease
- Patients with history of liver disease
- History of poor or non compliance

Pediatric:

Has been used safely (may require frequent PT/INR monitoring)

Geriatric:

Initiate / maintain at lower dosage.

Side Effects / adverse reactions:

Nausea, loss of appetite, or stomach/abdominal cramps /pain dermal necrosis, bleeding, fever may occur.

Lab Test Considerations:

Monitor PT/ INR and other clotting factors during therapy.

Therapeutic PT ranges 1.3–1.5 times greater than control.

Normal INR (not taking anticoagulants) is 0.8–1.2.

An INR of 2.5–3.5 is recommended for patients at very high risk of passage of an embolus within the bloodstream, for example, patients with mitral valve replacement patients with ventricular hypertrophy.

Lower levels are usually acceptable when the risk is lower.

Assess hepatic function and complete blood count (CBC) before therapy and periodically during therapy.

Assess stool and the urine for occult blood prior therapy and periodically throughout therapy.

Toxicity and Overdose:

Sometimes withholding one or more doses of warfarin is sufficient if the international normalized ratio (INR) is excessively elevated or if there is minor bleeding.

If anticoagulation needs to be immediately reversed or if overdose occurs, the antidote is **vitamin K (phytonadione, AquaMEPHYTON**).

Administration of whole blood or plasma also may be required in severe bleeding because of the delayed onset of the vitamin K.

OVERDOSE

INSTRUCT PATIENTS:

If overdose is suspected, contact the emergency room or poison control center immediately. US - local poison control center at 1-800-222-1222.

Signs and Symptoms may include:

Bleeding for example;

- appearance of blood in urine, hematuria,
- blood in stool,
- excessive menstrual bleeding,
- melena (black stools),
- petechiae,
- excessive bruising
- persistent oozing of blood from superficial injuries,
- unexplained reduction in hemoglobin (manifestation of excess anticoagulation).

High Alert

Medication errors involving anticoagulants have resulted in serious harm and /or death from internal or intracranial bleeding.

HEPARIN

Heparin Sodium
Injection, USP 2000 and 2500 USP Units/mL
Heparin Sodium ADD-Vantage™ Vial

Heparin sodium is indicated for:

- Atrial fibrillation (A-fib) with embolization
- Treatment of acute and chronic consumption coagulopathies (disseminated intravascular coagulation (DIC)
- Prevention of clotting in arterial and heart surgery
- Anticoagulant therapy in prophylaxis and treatment of venous thrombosis and its extension
- In a low-dose regimen- for prevention of postoperative deep venous thrombosis (DVT) and pulmonary embolism when undergoing major abdomino-thoracic surgery or patients who for other reasons are at risk of developing thromboembolic disease.
- Prophylaxis and treatment of pulmonary embolism
- Prophylaxis and treatment of peripheral arterial embolism.

PHARMACOLOGY

Heparin inhibits reactions that lead to clotting of blood and formation of fibrin clots both *in vitro* and in vivo. The drug acts at multiple sites in the normal coagulation system.

Small amounts of heparin in combination with antithrombin III ; heparin cofactor, can inhibit thrombosis by:

- inactivating activated Factor X and
- inhibiting the conversion of prothrombin to thrombin.

Once active thrombosis has developed, larger amounts of heparin can inhibit further coagulation by inactivating thrombin and preventing the conversion of fibrinogen to fibrin.

Heparin also prevents formation of stable fibrin clot in inhibiting the activation of the fibrin stabilizing factor.

Bleeding time is usually not affected by heparin.

Clotting time is prolonged by full therapeutic doses of heparin; most of the time, it is not measurably affected by low doses of heparin.

Peak plasma levels of heparin are achieved 2 to 4 hours after subcutaneous administration, however there are individual variations.

Heparin does not have fibrinolytic activity; therefore, it will not lyse existing clots.

COMPLICATIONS

Hemorrhage

Hemorrhage is a main complication that can result from taking the heparin therapy. A prolong clotting time or minor bleeding during therapy, may be controlled by withdrawing heparin therapy.

Hypersensitivity

Generalized hypersensitivity reactions have been reported with;

- Fever,
- chills,
- fever,
- urticaria
- asthma,
- rhinitis,
- lacrimation,
- headache,
- nausea
- vomiting

Also some anaphylactoid reactions may include:

- Shock (occur more rarely)
- Itching and burning (especially plantar site of feet may occur).

Thrombocytopenia (deficiency of platelets in the blood) has been reported to occur in patients who are receiving heparin.

LAB CONSIDERATIONS

Significant elevations of aminotransferase (SGOT [S-AST] and SGPT [S-ALT]) levels have occurred in a high percentage of patients received heparin.

OVERDOSE

Signs and Symptoms

- Bleeding is the chief sign of heparin overdosage
- Nosebleeds,
- blood in urine
- tarry stools
- Easy bruising
- petechial.

Treatment

Neutralization of heparin effect

When bleeding /clinical circumstances require reversal of heparinization;

- protamine sulfate (1% solution) by slow infusion will neutralize heparin sodium.

Administration of the protamine sulfate may cause severe hypotensive and severe anaphylactoid reactions.

ANTICONVULSANTS

ANTICONVULSANTS (ANTI-SEIZURE)

DILANTIN

Indications

For prevention / treatment of tonic-clonic; grand mal seizure and complex partial seizures, may also be used to treat certain types of irregular heartbeat.

Action

It works by reducing the spread of seizure activity in the brain. Limits seizure by altering ion transport. May also reduce synaptic transmission.

Therapeutic Effects:

Diminished seizure activity.

Pharmacokinetics

Absorption:

Absorbed slowly from the gastrointestinal tract.
Bioavailability may differ among products.

Distribution:

Distributes into the CSF and other body fluids and tissues.

Enters breast milk

Crosses the placenta

Preferentially distribute into the fatty tissue.

Protein Binding:

Adults 90–95%

Decreased protein binding in neonates (up to 20% free fraction available),

Infants (up to 15% free).

Metabolism

Mostly metabolized by the liver.

Excretion:

Minimal amounts excreted in urine.

Half-life: 22 hr (range 7–42 hr).

Time / action (anticonvulsant effect)

ROUTE	ONSET	PEAK	DURATION
PO	2–24 hr (1 wk)	1.5–3 hr	6–12 hr
PO-ER	2–24 hr (1 wk)	4–12 hr	12–36 hr
IV	0.5–1 hr (1 wk)	rapid	12–24 hr

(1 wk) is time required for onset of action without loading dose.

Use Cautiously in:

- Every patient - may increase the risk of suicidal behaviors or thoughts
- Renal or hepatic disease- due to increase risk of adverse reactions (reduce dose recommended for hepatic impairment)
- Patients with severe respiratory disease or cardiac or disease (use of intravenous (IV) phenytoin may result in an increased risk of serious adverse reactions).
- Obstetric: safety not established (may result in hemorrhage in the newborn)
- Lactation: Safety not established

- Pediatric: Suspension which contains sodium benzoate, a metabolite of benzyl alcohol that can cause potentially fatal gasping syndrome in neonates.
- Geriatric: Use of IV phenytoin may result in an increase risk of serious adverse reactions.

Side Effects /adverse Reactions

- Confusion,
- Agitation,
- Suicidal thoughts,
- Ataxia,
- Dizziness,
- drowsiness,
- dysarthria,
- dyskinesia,
- extrapyramidal syndrome,
- headache,
- insomnia,
- weakness
- Diplopia,
- Nystagmus
- hypotension (increase with IV phenytoin),
- tachycardia
- gingival hyperplasia,
- nausea,
- constipation,

- drug-induced hepatitis,
- vomiting,
- Rash,
- Fever
- Pruritus,
- Aplastic anemia,
- leukopenia,
- thrombocytopenia,
- osteoporosis
- And other allergic reactions (such as Stevens-Johnson syndrome).

ANTIFUNGAL MEDICATION

DIFLUCAN

Indications

Diflucan (fluconazole) is an antifungal medication.

PO and Intravenous:

- Fungal infections which is caused by susceptible organisms, including: esophageal or oropharyngeal or candidiasis,
- Serious systemic infections (candida)
- Urinary tract infections (UTI),
- Peritonitis,
- Cryptococcal meningitis.
- Prevention of candidiasis in patients who have bone marrow transplantation.

PO: Single-dose oral treatment of vaginal candidiasis.

Action

Inhibits synthesis of fungal sterols (necessary component of cell membrane).

Therapeutic Effects:

Fungistatic action (interfering with synthesis of the fungal cell membrane) against susceptible organisms.

May be fungicidal in higher concentrations. Spectrum: Cryptococcus neoformans. Candida spp.

Pharmacokinetics

Absorption:

Well absorbed after oral (PO) administration.

Distribution:

Widely distributed; good penetration into saliva, eye, CSF, sputum, skin, vaginal fluid, and peritoneum, (Excreted in breast milk).

Metabolism

<10% metabolized by the liver.

Excretion:

>80% excreted unchanged by the kidneys

Half-life: Premature neonate: 46–74 hr; Children: 19–25 hr (PO) and 15–17 hr (IV); Adults: 30 hr (increase in renal impairment).

Time /action (blood level)

ROUTE	ONSET	PEAK	DURATION
PO	unknown	2–4 hr	24 hr
IV	rapid	end of infusion	24 hr

Use Cautiously in:

Renal impairment (dose reduction required if CCr <50 mL/min)

Underlying liver disease

Obstetric: Safety not established

Lactation: Usually compatible with breastfeeding

Geriatric: Increased risk of adverse reactions such as diarrhea, vomiting, rash, seizures (consider age-related reduction in renal function in determining dose).

Side Effects/ Adverse Reactions

- Headache,
- Dizziness,
- Seizures
- Hepatotoxicity
- Abdominal discomfort,
- Diarrhea,
- Nausea,
- Vomiting,
- Skin disorders such as Stevens-Johnson syndrome,
- Hypokalemia,
- Allergic reactions may also include anaphylaxis.

Incidence of adverse reactions is increased in patients with HIV.

ANTIVIRAL

ACYCLOVIR

Indications

PO administration:

Genital herpes infections (recurrent infections).

Localized cutaneous herpes zoster infections; shingles and chickenpox; varicella.

Intravenous (IV):

Severe initial episodes of genital herpes (in nonimmunosuppressed patient).

Cutaneous or mucosal herpes simplex infections or herpes zoster infections;shingles in immunosuppressed patients.

Herpes simplex encephalitis.

Topical:

Cream; Cold sores; recurrent herpes labialis.

Ointment:

Treat limited non–life-threatening herpes simplex infections in immunocompromised patients (prefer systemic treatment).

Action

Interferes with viral DNA synthesis.

Therapeutic Effects:

Inhibition of viral replication, decreased viral shedding, and reduced time for healing of lesions.

Pharmacokinetics

Absorption:

Despite poor absorption (15–30%), therapeutic blood levels are achieved.

Distribution:

Widely distributed - CSF concentrations are 50% of plasma.

Crosses placenta, enters breast milk.

Protein Binding: <30%.

Metabolism

Metabolized by liver

Excretion: >90% eliminated unchanged by kidneys

Half-life: Neonates: 4 hr; Children 1–12 yr: 2–3 hr; Adults: 2–3.5 hr (↑ in renal failure).

Time /action (antiviral blood level)

ROUTE	ONSET	PEAK	DURATION
PO	unknown	1.5–2.5 hr	4 hr
IV	Rapid	end of infusion	8 hr

Use Cautiously in:

Pre-existing serious hepatic, neurologic, pulmonary, or fluid and electrolyte abnormalities.

Renal impairment (dose alteration recommended if CCr <50 mL/min).

Geriatric: Due to age related reduction in renal function.

Patients who are obese (dose should be based on ideal body weight)

Obstetric /Lactation: Safety not established.

Side Effects and adverse Reaction

- Dizziness,
- Seizure,
- headache,
- hallucinations,
- trembling,
- diarrhea,
- nausea,
- vomiting,
- elevated liver enzymes,
- hyperbilirubinemia,
- abdominal pain,
- anorexia,
- renal pain,
- Renal failure,
- crystalluria,
- hematuria,
- Stevens –Johnson syndrome,
- hives,
- ache,
- skin rashes,

- unusual sweating,
- change in menstrual cycle
- joint pain,
- phlebitis,
- polydipsia
- and others not mentioned.
-

Lab Test Considerations:

Monitor BUN, serum creatinine, and CCr before and during therapy.

increased BUN and serum creatinine levels or decreased CCr may indicate renal failure.

ASTHMA MEDICATIONS

Montelukast Sodium (Singulair)

Montelukast is a leukotriene inhibitor.

Leukotrienes are chemicals the body releases when you breathe in an allergen for example pollens. These chemicals cause swelling in the lungs and tightening of the muscles around the airways, which can result in asthma symptoms.

Montelukast is used;

- to prevent asthma attacks (in adults and children as young as 12 months old),
- to prevent exercise-induced bronchospasm (in adults and children who are at least 6 years old).
- to treat symptoms of year-round allergies (perennial) in adults and children who are at least 6 months old.
- to treat symptoms of seasonal allergies in adults and children (at least 2 years old).
- to prevent exercise-induced bronchoconstriction; narrowing of the air passages in the lungs, in adults / teenagers who are at least 15 years old and are not already taking this medication for other conditions.

Montelukast will not work quick enough to treat an asthma attack that has already begun; (use only a fast-acting inhalation medication to treat an asthma attack). Regularly used to prevent the wheezing and shortness of breath caused by asthma and decrease the number of asthma attacks. As mentioned earlier Montelukast is also used before exercise to prevent breathing problems (bronchospasm) during exercise.

Side effects of montelukast (Singulair)

Side effect may include but not limited to:

- skin rash,
- bruising,

- severe tingling,
- numbness,
- pain,
- muscle weakness
- mood changes
- behavior changes,
- anxiety,
- depression,
- thoughts about suicide
- tremors
- shaking
- easy bruising,
- unusual bleeding from mouth, nose, vagina, rectum,
- severe sinus pain, swelling, or irritation
- worsening asthma symptoms
- severe skin reaction
- fever,
- sore throat,
- swelling of the face or tongue
- headache
- stomach pain,
- heartburn,
- upset stomach,
- nausea,
- diarrhea
- tooth pain
- feeling tired
- fever,
- stuffy nose,
- sore throat,
- cough,
- hoarseness
- mild rash

INSTRUCT PATIENTS TO:

Get emergency medical help if have any signs of an allergic reaction including:

- Hives
- Difficulty breathing
- swelling of the face,
- swelling of the lips,
- swelling of the tongue,
- swelling of the throat.

ALBUTEROL

Indications

Used as a bronchodilator to control and prevent reversible airway obstruction caused by COPD or asthma.

Inhalation:

Used as a quick-relief agent for acute bronchospasm and for prevention of exercise-induced bronchospasm.

PO:

Used as a long-term control agent for patients with chronic persistent bronchospasm.

Action

Binds to beta2-adrenergic receptors in airway smooth muscle, leading to activation of adenyl cyclase and increased levels of cyclic-3′, 5′-adenosine monophosphate (cAMP).

Increases in cAMP activate kinases, which inhibit the phosphorylation of myosin and decrease intracellular calcium.

Decreased intracellular calcium relaxes smooth muscle airways.

Relaxation of airway smooth muscle; bronchodilation.

Selective for beta2; pulmonary receptors.

Therapeutic Effects:

Bronchodilation

Pharmacokinetics

Absorption:

Well absorbed after oral administration but quickly undergoes extensive metabolism.

Distribution:

Small amounts appear in the breast milk.

Metabolism and Excretion: metabolized by the liver and other tissues.

Half-life:

Oral 2.7–5 hr

Inhalation: 3.8 hr.

Time /action (bronchodilation)

ROUTE	ONSET	PEAK	DURATION
PO	15–30 min	2–3 hr	4–6 hr or more
PO–ER	30 min	2–3 hr	12 hr
Inhalation	5–15 min	60–90 min	3–6 hr

Contraindicated in:

Hypersensitivity to adrenergic amines.

Use Cautiously in:

- Cardiac disease
- Hypertension
- Hyperthyroidism
- Diabetes
- Glaucoma
- Seizure disorders

Obstetric ,Lactation and Pediatric:

Safety not established for pregnant women near term, breastfeeding women, and children <2 yr.

Geriatric: increase risk of adverse reactions (may require reduced dose).

Side Effects / Adverse Reactions

- Nervousness,
- restlessness,
- tremor,
- headache,
- insomnia
- Paradoxical bronchospasm (excessive use of inhalers)
- chest pain,
- palpitations,
- angina,
- arrhythmias,
- hypertension,
- nausea,
- vomiting,
- hyperglycemia
- hypokalemia,
- tremor.

Patient and Family Teaching

Instruct patients to take albuterol as prescribed.

Remind patients not to exceed the recommended dose; this may cause adverse effects, paradoxical bronchospasm or loss of effectiveness of medication.

Instruct patient to contact the physician/ health care provider immediately if shortness of breath is not relieved by medication or is accompanied by dizziness, diaphoresis, chest pains or palpitations.

Advise patient to consult physician/ health care provider before taking any over the counter medications, natural /herbal products, or alcohol while taking this medication.

Caution patient also to avoid smoking and other respiratory irritants.

Inform patient that albuterol may cause an unusual taste or bad taste.

Inhalation:

Instruct patient in the proper use of the metered-dose inhaler or nebulizer.

Advise patients to use albuterol first if using other inhalation medications and allow 5 minutes to elapse before using other inhalant medications unless otherwise directed.

Advise patient to use water to rinse mouth after each inhalation dose to minimize dry mouth.

Pediatric:

Caution adolescents and the parents about overuse of inhalers, which can cause heart damage and life-threatening arrhythmias.

CARDIOVASCULAR MEDICATIONS

DIGOXIN

Indications

- Heart failure
- Atrial fibrillation and
- Atrial flutter (slows ventricular rate)
- Paroxysmal atrial tachycardia.

Action

- Increases the force of myocardial contraction.
- Prolongs refractory period of AV node.
- Decrease conduction through SA and AV nodes.

Therapeutic Effects:

Increase cardiac output, positive inotropic effect and slowing of the heart rate (negative chronotropic effect).

Pharmacokinetics

Absorption:

60–80% absorbed after PO administration of tablets

70-85% absorbed following administration of elixir.

Absorption from liquid filled capsule is 90–100%

80% absorbed from IM sites (IM route not recommended due to pain/irritation).

Distribution:

Widely distributed

crosses placenta

Enters breast milk.

Metabolism / Excretion:

Excreted almost entirely unchanged by the kidneys.

Half-life: 36–48 hr (increased in renal impairment).

Time /action (antiarrhythmic or inotropic effects, provided that a loading dose has been administered).

ROUTE	ONSET	PEAK	DURATION
Digoxin PO	30–120 min	2–8 hr	2–4 days
Digoxin IM	30 min	4–6 hr	2–4 days
Digoxin IV	5–30 min	1–4 hr	2–4 days

(with impaired renal function duration will be longer)

Contraindicated in:

Hypersensitivity

Uncontrolled ventricular arrhythmias

AV block (in absence of pacemaker)

Constrictive pericarditis

Use Cautiously in:

- Patients with hypokalemia- will increase the risk of digoxin toxicity,
- Hypomagnesemia - may increase the risk of digoxin toxicity,
- Hypercalcemia – will increase the risk of toxicity; especially with mild hypokalemia,
- Diuretic use - may cause electrolyte imbalance such as hypokalemia and hypomagnesemia,
- Geriatric: sensitive to toxic effects (dose adjustments required for age related decrease in renal function / body weight,
- Myocardial infarction,
- Hypothyroidism,
- Renal impairment - dose reduction required,
- Obesity - dose should be based on ideal body weight,
- Obstetric: safety has not been established (has been used during pregnancy without adverse effects on fetus)
- Lactation - similar concentrations in serum and breast milk (use with caution).

Side Effects / adverse reactions

- Fatigue,
- headache,
- weakness
- blurred vision,
- Green or yellow vision
- Arrhythmias,
- bradycardia,
- ECG changes,

- AV block,
- SA block
- anorexia,
- nausea,
- vomiting,
- diarrhea
- thrombocytopenia
- electrolyte imbalances (with acute digoxin toxicity).

Assessment

Monitor apical pulse for 1 min before administering the medication.

Withhold dose and notify physician if pulse rate is <60 bpm in an adult . Also notify physician/ health care provider promptly of any significant changes in or quality of pulse, rate or rhythm of pulse.

Pediatric:

Heart rates vary in children depending on age, ask physician to specify at what heart rate digoxin should be withheld.

Geriatric:

Assess for falls risk. Digoxin has been associated with increased risk of falls in elderly. Implement prevention measures per facility policy.

Lab Test Considerations:

Evaluate serum electrolyte levels;

Monitor potassium, magnesium, and calcium levels

Monitor renal functions monitor hepatic functions during therapy.

Notify physician /health care provider before giving dose if patient has hypokalemia.

Hypomagnesemia, hypokalemia or hypercalcemia may cause the patient to be more susceptible to digitalis toxicity.

Pediatric:

Neonates may have falsely elevated serum digoxin concentrations.

Geriatric:

Older adults may be toxic even when serum concentrations are within normal range, therefore assess for clinical symptoms of toxicity even when the serum levels are normal.

Toxicity and Overdose:

Therapeutic serum digoxin levels range from 0.5–2 ng/mL. Serum levels may be drawn 6–8 hr after a dose is administered (may be drawn immediately before the next dose).

For the patient with congestive heart failure, the ideal range of levels of digoxin in the blood, (the therapeutic range) may be between 0.5 and 0.8 ng/mL. If the patient is taking digoxin because of an irregular heartbeat, the patient probably should have a blood level between 1.5 and 2.0 ng/mL. Most individuals find that the symptoms improve when the digoxin levels are within these ranges.

Geriatric:

Older adults are at increased risk for toxic effects of digoxin due to age related decreased renal clearance (can exist when serum creatinine levels are normal).

Digoxin requirements in the elderly patient may change (a formerly therapeutic dose can become toxic).

Observe for signs and symptoms of toxicity

In adults and older children, the first signs of toxicity usually include:

- Abdominal pain,
- Anorexia,
- nausea,
- vomiting,
- visual disturbances,

- Bradycardia,
- And other arrhythmias.

In infants and small children;

- the first symptoms of overdose- usually cardiac arrhythmias.

If cardiac arrhythmias appear, withhold the drug and notify pediatrician/ healthcare provider immediately.

Patient /Family Teaching

Instruct patients and family to take medication as directed, at the same time every day. Teach patients to take pulse and to contact healthcare provider before taking medication if pulse rate is <60 or >100 bpm.

Pediatric:

Teach parents that changes in heart rate; cardiac arrhythmias such as bradycardia, are among the 1st signs of digoxin toxicity in infants/ children.

Teach parents in apical heart rate assessment and instruct them to notify the physician/ healthcare provider if heart rate is outside of range set by pediatrician, before giving the next dose.

Review the signs and symptoms of digitalis toxicity with patient /family. Advice patients to notify physician immediately if these symptoms occur or if experience symptoms of congestive heart failure. Instruct patients that these symptoms may be resemble those of flu or cold.

Advise patient not to take any antacids or antidiarrheals within 2 hr of taking digoxin.

Patients who are taking digoxin should ALWAYS carry identification (ID) describing disease process and medication regimen.

Geriatric:

Review fall risk and prevention strategies with the elderly and the families.

Remind them of the importance of follow up examinations to determine the effectiveness of the therapy and to monitor for toxicity.

METOPROLOL

Indication

Hypertension (high blood pressure), angina pectoris, prevention of myocardial infarct (MI) and decreased mortality in patients with recent myocardial infarct. Management of stable, symptomatic; class II or III heart failure due to hypertensive, ischemic or cardiomyopathc origin.

Action

Blocks stimulation of beta1 (myocardial) adrenergic receptors; (does not usually affect beta2 - pulmonary, vascular, uterine) adrenergic receptor sites.

Therapeutic Effects:

- Reduce blood pressure and reduce heart rate.
- Decreased frequency of angina pectoris attacks.
- Reduced rate of cardiovascular mortality and decrease hospitalization in patients with heart failure.

Pharmacokinetics

Absorption:

Well absorbed after PO administration.

Distribution:

Crosses the blood-brain barrier,

Crosses Placenta

Small quantity enter breast milk

Metabolism and Excretion:

Metabolized by the liver.

Half-life: 3–7 hr.

Time / action (cardiovascular effects)

ROUTE	ONSET	PEAK	DURATION
PO	15 min	unknown	6–12 hr
PO–ER	unknown	6–12 hr	24 hr
IV	immediate	20 min	5–8 hr

Maximal effects on blood pressure (chronic therapy) may not occur for 1 wk.
Hypotensive effects may persist for up to four weeks after drug has been discontinued.

Contraindications

Contraindicated in uncompensated congestive heart failure, Cardiogenic shock, Bradycardia Pulmonary edema or heart block.

Use Cautiously in:

Patients with renal impairment, hepatic impairment.

Geriatric:

Increase sensitivity to beta blockers (initial dose reduction recommended), pulmonary disease such as asthma (beta1 selectivity may be lost at higher doses), diabetes mellitus (may mask signs/symptoms of hypoglycemia).

Patients who have history of severe allergic reactions- intensity of reactions may be increased.

Obstetric, lactation, pediatric:

Safety not established, all agents cross placenta and may cause fetal bradycardia, respiratory depression, hypotension or hypoglycemia.

Side Effects / adverse effects

- Fatigue,
- weakness,
- Anxiety,
- Depression,
- Dizziness,
- Drowsiness,
- Insomnia,
- memory loss,
- mental status changes,
- nervousness,
- nightmares,
- blurred vision,
- stuffy nose,
- bronchospasm,
- wheezing,
- Bradycardia,
- congestive heart failure,
- Pulmonary edema,
- hypotension,
- peripheral vasoconstriction,
- constipation,
- diarrhea,
- drug induced hepatitis,

- dry mouth,
- flatulence,
- gastric pain,
- heartburn,
- increased liver enzymes,
- nausea/ vomiting,
- erectile dysfunction,
- decrease libido,
- urinary frequency,
- rashes,
- hyperglycemia,
- hypoglycemia,
- Arthralgia,
- Joint pain,
- Drug-induced lupus syndrome.

Assessment

Monitor blood pressure (BP), pulse and ECG often during dose adjustments and during therapy.

Usually if heart rate <40 bpm, and cardiac output is also decreased, atropine IV is administered.

Monitor intake and output (I&O) and daily weights. Assess for signs and symptoms of congestive heart failure such as rales /crackles, dyspnea, weight gain, jugular venous distention peripheral edema.

Assess for angina during therapy.

Lab Test Considerations:

- May cause increased blood urea nitrogen (BUN),
- increased serum lipoprotein,
- increased potassium,
- increased triglyceride,
- increased uric acid levels,
- Increased antinuclear antibody ANA levels.
- increase in blood glucose levels,
- increased serum alkaline phosphatase,
- increased LDH,
- increased AST, and
- increased ALT levels.

CHOLESTEROL LOWERING MEDICATIONS

SIMVASTATIN

Indication

Simvastatin is used to help lower cholesterol and fats in the blood. It belongs to a group of drugs that is known as statins. Simvastatin works by reducing the amount of cholesterol that is made by the liver. Manages primary hypercholesterolemia and mixed dyslipidemia. Reduces the risk of myocardial infarct (MI), stroke, coronary revascularization and cardiovascular mortality in patients with coronary heart disease.

Action

Inhibit an enzyme, 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase, which is responsible for catalyzing an early step in the synthesis of cholesterol.

Therapeutic Effects:

Lowers the total cholesterol, LDL cholesterol and triglycerides, slightly increase HDL. Slows of the progression of coronary atherosclerosis ; therefore decrease in coronary heart disease related events.

Pharmacokinetics

Absorption:

85% absorbed and quickly metabolized.

Distribution:

Simvastatin; unknown.

Protein Binding:

Simvastatin >98%.

Metabolism and Excretion:

Extensively metabolized by; amount excreted unchanged in urine- simvastatin 13%.

Half-life: simvastatin unknown.

Time /action (cholesterol-lowering effect)

ROUTE	ONSET	PEAK	(DURATION after discontinuation)
PO	several days	2–4 wk	unknown

Contraindications

Contraindicated in:

Hypersensitivity,

Active liver disease or unexplained persistent elevations in ALT or AST,

severe renal impairment (CCr <30 mL/min),

Obstetric: Potential for fetal anomalies

Lactation: can disrupt lipid metabolism in infants.

Assessment

Obtain dietary history (fat consumption).

Lab Test Considerations:

Assess serum cholesterol and triglyceride levels prior to initiating, after 4 to 6 wk of therapy, and after, periodically.

Monitor liver function tests such as AST, before, also at 12 weeks after starting therapy or after dose elevation, and then every 6 months.

If patients develop muscle tenderness while taking the drug therapy, monitor creatine kinase (CK) levels. If CK levels are >10 times the upper limit of normal or myopathy develops, therapy should be discontinued.

CORTICOSTEROIDS

PREDNISONE

Prednisone is used to treat wide a variety of chronic diseases including: Inflammatory, arthritis, severe allergies, blood disorders, skin diseases, breathing problems, cancer, and immune system / autoimmune disorders.

Prednisone belongs to a class of drugs called corticosteroids. It decreases the immune system's response to various diseases to reduce symptoms such as allergic-type reactions, inflammation/ swelling.

Action

It suppresses inflammation and the normal immune response, with multiple intense metabolic effects. Suppress the adrenal function at chronic doses of 5 mg per day.

Therapeutic Effects:

Suppression of inflammation, modification of normal immune response.

Pharmacokinetics

Absorption:

Well absorbed after PO administration.

Distribution:

Widely distributed

Crosses placenta (probably enters breast milk).

Metabolism

Metabolized by the liver.

Excretion:

Urine (as conjugates).

Half-life: 3.4–3.8 hr (plasma),

18–36 hr (tissue)

Adrenal suppression lasts 1.25–1.5 days.

Time /action (anti-inflammatory activity)

ROUTE	ONSET	PEAK	DURATION
PO	hrs	unknown	1.25–1.5 days

Contraindications

Contraindicated in:

Some products contain alcohol and should be avoided in patients with known intolerance

Lactation: Avoid chronic use.

Use Cautiously in:

Chronic treatment may lead to adrenal suppression; use lowest possible dosage for short period of time.

Pediatric: Chronic use will result in reduced growth (use lowest dose for shortest time). Stress such as infections, surgery (supplemental doses may be needed). Potential infections may mask signs; inflammation, fever.

Obstetric: Safety not established.

Side Effects / Adverse Reactions

Side effects and adverse reactions are more common with high dose and /or long-term use of the drug. Side effects / adverse reactions may include:

- Depression,
- Euphoria,
- Headache,

- Increased intracranial pressure in children,
- personality changes,
- Restlessness,
- cataracts,
- Increased intraocular pressure,
- Hypertension,
- Peptic ulcers,
- anorexia,
- nausea/ vomiting,
- Acne,
- Decrease wound healing,
- ecchymoses,
- Hirsutism,
- Petechiae,
- Adrenal suppression,
- Hyperglycemia,
- Fluid retention,
- Hypokalemia,
- Thrombophlebitis,
- weight gain,
- weight loss
- muscle wasting,
- osteoporosis,
- Avascular necrosis of joints,

- muscle pain,
- Cushingoid appearance; buffalo hump, moon face,
- Increase risk of infection.

Assessment

Assess patient for signs of adrenal insufficiency before and during therapy. Signs of adrenal insufficiency such as:

- Hypotension,
- weight loss,
- weakness,
- nausea/ vomiting,
- anorexia,
- lethargy,
- confusion,
- restlessness.

Monitor intake and output (I&O) and daily weight.

Assess patients for peripheral edema, weight gain, crackles/rales, or dyspnea. Notify physician/ healthcare provider if occur.

Pediatric:

Children should have periodic growth evaluations.

Lab Test Considerations:

Monitor serum glucose and electrolytes. May cause elevations in glucose levels (hyperglycemia), especially in patients with diabetes. May also cause decreased potassium (hypokalemia).

Patients who are on prolonged therapy should routinely have;

- Hematologic levels, electrolytes, and urine and serum glucose assessed.

May cause decrease in white blood cell (WBC) counts.

May decrease serum potassium and calcium and increase serum sodium concentrations.

Guaiac-test stools; quickly report the presence of guaiac positive stools.

May increase serum lipid and cholesterol levels.

May suppress reactions to the allergy skin test.

Adrenal function tests; adrenal function tests may be ordered periodically to assess the degree of hypothalamic; pituitary; adrenal axis suppression in systemic/ chronic topical therapy .

Patient and Family Teaching

Teach patients and family the correct technique of medication administration. Instruct them to take the medication as prescribed.

Do not stop medication suddenly; may result in adrenal insufficiency such as: nausea, anorexia, fatigue, weakness, dyspnea, hypoglycemia hypotension. If these signs occur, notify the physician/ healthcare provider immediately (can be life threatening).

Teach patients and family about possible side effects. Instruct patient to inform physician/ healthcare provider immediately if experience severe abdominal pain or tarry stools, unusual weight gain, swelling, bruising, tiredness, visual disturbances, bone pain or behavior changes or nonhealing sores.

Instruct patients to notify healthcare providers of medication regimen before surgery or other treatments.

Instruct patients to always carry identification (ID) describing disease process and medication regimen (if experiences emergency and unable to relate medical history).

Instruct patients to avoid alcohol during therapy.

DIABETIC MEDICATIONS

METFORMIN

Indications

Used for management of type 2 diabetes mellitus (DM). May be used with insulin, diet or oral hypoglycemics.

Action

Decrease amount of glucose the liver produces. Reduces intestinal glucose absorption. Also increases sensitivity to insulin.

Therapeutic Effects:

Maintenance of blood glucose.

Pharmacokinetics

Absorption:

50–60% absorbed after PO administration.

Distribution:

Enters the breast milk in concentrations similar to plasma.

Metabolism

Not metabolized

Excretion:

Eliminated almost unchanged by the kidneys.

Half-life: 17.6 hr.

Time /action (blood level)

ROUTE	ONSET	PEAK	DURATION
PO	unknown	unknown	12 hr

XR	unknown	4–8 hr	24 hr

Contraindicated in:

Hypersensitivity,

Metabolic acidosis

Dehydration,

sepsis,

hypoxemia,

hepatic impairment,

excess alcohol use (acute or chronic)

Renal dysfunction (serum creatinine >1.5 mg/dL in men or >1.4 mg/dL in female);

Radiographic studies that requires IV iodine contrast media (withhold metformin)

Congestive heart failure

Side Effects/ adverse reactions

- Abdominal bloating,
- Diarrhea,
- Nausea/ vomiting,
- unpleasant metallic taste,
- hypoglycemia
- Lactic acidosis,
- Reduced vitamin B12 values.

Assessment

If combined with oral sulfonylureas, monitor for signs /symptoms of hypoglycemic reactions such as:

- Sweating,
- tachycardia,
- abdominal pain,
- weakness,
- hunger,
- dizziness,
- tremor,
- headache,
- anxiety.

Monitor patients who develop illness or have abnormal labs; assess for lactic acidosis or ketoacidosis.

Assess labs:

- serum electrolytes,
- ketones,
- glucose,
- blood pH,
- lactate,
- pyruvate
- metformin levels.

If acidosis is present, metformin should be discontinued immediately and initiate treatment for the acidosis.

Lab Test Considerations:

Monitor serum glucose and glycosylated hemoglobin during therapy to evaluate effectiveness of therapy. May cause false positive results for urine ketones.

Monitor blood glucose routinely by patient and every 3 months by the physician/ healthcare provider to determine the effectiveness of the medication.

Assess renal function before starting and at least yearly during the therapy. Metformin should be discontinued if renal impairment occurs.

Monitor the serum folic acid and vitamin B12 (every 1–2 yr with long term therapy). Metformin may interfere with absorption.

Patient and family teaching

Instruct patient to take metformin as directed.

Encourage patient to follow prescribed diet, medication, and exercise regimen to prevent hyperglycemic or hypoglycemic episodes.

Review signs of hypoglycemia and hyperglycemia with patient and how to treat if occurs.

Teach the patients and families (as applicable) the proper testing of blood glucose and also urine ketones. These tests need to be monitored closely during times of illness or stress.

Teach the patient and family the risk of lactic acidosis and to monitor for symptoms.

Symptoms of lactic acidosis may include:

- chills,
- diarrhea,
- dizziness,
- low blood pressure,

- muscle pain,
- sleepiness,
- slow heartbeat
- slow pulse,
- dyspnea,
- weakness

All should be reported to the physician/ healthcare provider immediately.

Instruct patients to report the occurrence of diarrhea, nausea, vomiting, and stomach pain or fullness to the physician / healthcare provider.

TAKE EXAM

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