Chapter 11
Basic Principles of Pharmacology

Learning Objectives
- Describe pharmacological historic trends
- Differentiate chemical, generic, trade names of drug
- List main sources of drug products
- Describe how drugs are classified

Learning Objectives (Cont'd)
- List authoritative sources for drug information
- List legislative acts controlling drug use, abuse in U.S.
- Differentiate Schedule I, II, III, IV, V substances, list examples
- Discuss standardization of drugs
Learning Objectives (Cont'd)

- Discuss investigational drugs, including Food & Drug Administration approval process and classifications for newly approved drugs.
- Discuss paramedic's responsibilities and scope of management pertinent to administration of medications.

Learning Objectives (Cont'd)

- Review specific anatomy, physiology pertinent to pharmacology with attention to autonomic pharmacology.
- List and describe general drug properties.
- List and describe liquid, solid drug forms.

Learning Objectives (Cont'd)

- List and differentiate drug administration routes, including enteral and parenteral routes.
- Describe mechanisms of drug action.
- List and differentiate phases of drug activity, including pharmaceutical, pharmacokinetic, and pharmacodynamic phases.
Learning Objectives (Cont'd)

- Describe pharmacokinetics and pharmacodynamics, including theories of drug action, drug response relation, factors altering drug responses, predictable drug responses, iatrogenic drug responses, and unpredictable adverse drug responses
- Discuss special considerations in drug treatment regarding pregnant, pediatric, and geriatric patients

Learning Objectives (Cont’d)

- Differentiate drug interactions
- Discuss considerations for storing and securing medications
- List components of drug profile by classification

Introduction

- **Drug**
  - Substance intended to diagnose, cure, relieve, treat, prevent disease
  - Affects structure/function of body
- **Pharmacology**
  - Study of drugs
Historic Trends in Pharmacology

- Ancient health care
  - Potions, religious rituals, crude surgeries
  - Greco-Romans
    - Hippocrates
    - Claudius Galen

Historic Trends in Pharmacology (Cont’d)

- The Renaissance
  - After Roman Empire fall, many reverted to folklore, tradition
  - Muslims, Greeks, Romans, Jews combined knowledge of math, science, created formularies
  - Monasteries
    - Learning sites, pharmacy, medicine

Historic Trends in Pharmacology (Cont’d)

- Modern health care
  - Pharmaceutical laws enacted late 19th, early 20th century protecting public
  - Drugs developed improved chronic illness treatment
  - 1950-current, more changes in pharmacology than any other time
Historic Trends in Pharmacology (Cont'd)

- Present period of change
  - Pharmacology - constant research, development
  - Keep abreast of new medications, technology
    - May be asked questions about patient medications
    - Recognize side effects, adverse reactions
  - Orphan drugs

Drug Names

- Chemical name
  - Description of drug's chemical composition, molecular structure
- Official name
  - Listed in U.S. Pharmacopoeia
- Generic (non-proprietary) name
  - First proposed by manufacturer when submitted to FDA for approval
- Trade (brand/proprietary) name
  - Patented name

Sources of Drugs

- Plants
- Animals, humans
- Minerals/mineral products
- Synthetic chemical substances
- Recombinant DNA technology
Sources of Drugs (Cont’d)

- Plants
  - Alkaloids
  - Glycosides
  - Gums
  - Oils

Sources of Drugs (Cont’d)

- Animals, humans
  - Hormones, vaccines, blood, plasma components
- Minerals/mineral products
  - Chemical elements/compounds found in earth, soil

Sources of Drugs (Cont’d)

- Chemical substances
  - Developed by scientifically duplicating specific compounds
  - Called synthetic drugs when developed in laboratory
- Recombinant DNA technology
  - Genetic engineering
Drug Classification

- Anatomical Therapeutic Chemical Classification System
  - Body System
    - Drug's physiologic classification
  - Mechanism of action
    - Drug's therapeutic classification
  - Class of agent
    - Drug's chemical classification

Sources of Drug Information

- United States Pharmacopeia/Dispensing Information
  - U.S. Pharmacopeia-National Formulary (USP-NF), official source for U.S manufactured drugs
- Physician’s Desk Reference
  - Compilation of 4000+ drugs

Sources of Drug Information (Cont’d)

- American Hospital Formulary Service
  - Information about every U.S. drug available
  - Uses for drugs included in labeling approved by FDA, off-label uses
- Package inserts
  - Drug’s safety, effectiveness
- Other sources
  - Nurses, physicians, pharmacists, poison control
U.S. Drug Legislation

- Laws govern purchase, distribution, dispensation, administration of drugs
  - Must know laws
- Purpose of legislation
  - Protect public from adulterated, mislabeled drugs
- History of legislation
  - Pure Food and Drug Act
    - Standardized name, strength, quality, purity of drugs
  - Federal Food, Drug & Cosmetic Act, 1938
  - Harrison Narcotics Act, 1914
  - Durham-Humphrey Amendments, 1928, required prescriptions for certain drugs
  - All new drugs tested for toxicity

U.S. Drug Legislation (Cont’d)

- History of legislation
  - Pure Food & Drug Act, early 20th century
  - Federal Food, Drug & Cosmetic Act, 1938
  - Harrison Narcotics Act, 1914
  - Durham-Humphrey Amendments, 1928, required prescriptions for certain drugs
  - All new drugs tested for toxicity

U.S. Drug Legislation (Cont’d)

- History of legislation
  - Durham-Humphrey Amendment, 1951
  - Kefauver-Harris Amendment, 1962, required proof of effectiveness, safety of new prescription, over-the-counter drugs before FDA approval
- Schedule of controlled substances
  - Classifications of substances based on their accepted medical use in the U.S., abuse potential, potential for addiction
**U.S. Drug Legislation (Cont’d)**

- Food & Drug Administration
  - Governing body, oversees general safety standards in production of drugs, food, cosmetics
  - U.S. Department of Health & Human Services
  - Regulates medical devices, radiation-emitting products

- Drug Enforcement Administration
  - U.S. Department of Justice
  - Enforces controlled substance laws, monitors need for changing abused drug schedules

- Federal Trade Commission
  - Bureau of Consumer Protection
  - Protects consumers, truth-in-advertising laws

**Standardization of Drugs**

- **Assay**
  - Substance test, finds components
    - Amount, purity

- **Bioassay**
  - Effects on organism, compares results with agreed standard

- United States Pharmacopeia
  - Official standards-setting authority
Investigational Drugs

- Prospective drugs & evaluation
  - Conceptual evidence drug has physiologic benefit
    - Toxicity, drug absorption, metabolism
- Food & Drug Administration approval process
  - Phases of investigation
    - Require specific information, effects on humans
    - 3 phases conducted before New Drug Application (NDA) submitted by manufacturer
    - 4th phase follows NDA approval, not closely monitored by FDA

Investigational Drugs (Cont’d)

- Food & Drug Administration approval process
  - New drug application
    - Sponsor goal, product safe for initial use, compound shows pharmacologic activity justifies commercial development
    - Abbreviated NDA used for generic drugs
      - Preclinical, clinical data not required
      - Must demonstrate performance as original patented drug

Scope of Management

- Responsibilities
  - Safe & effective administration
    - Assess scene, patient
    - Obtain history
    - Know, understand medication patient takes
    - Assess for indications, contraindications
    - Patient pill bottles, copy information exactly
    - Ask patient how administered, may not be correct
    - Check with partner
    - Use drug references
    - Recalculate calculations, dosages
    - Contact medical direction online if necessary
Scope of Management (Cont’d)

- Responsibilities
  - Legal, moral, ethical obligations
  - Give substance according to intended use, indication, written protocols
  - Maintain patient confidentiality
  - Use professionalism

Autonomic Pharmacology

- Nervous system organization & function
  - Central nervous system
    - Brain, spinal cord
    - Electrical impulses sent, received, coordinated
    - Motor, temperature, vibration, sensation transmission
  - Peripheral nervous system
    - All nerves outside of CNS
    - Somatic nervous system
      - Cranial, spinal nerves carry messages to skeletal muscles
      - Controlled voluntarily, consciously

Autonomic Pharmacology (Cont’d)

- Nervous system organization & function
  - Peripheral nervous system
    - Autonomic nervous system
      - Involuntary control
      - ANS nerves message to heart, secretory glands, GI tract smooth muscles, blood vessels, bronchi, genitourinary system
Autonomic Pharmacology (Cont’d)

- Nervous system organization & function
  - Peripheral nervous system
  - Somatic nervous system
  - Autonomic nervous system
    - Sympathetic
    - Parasympathetic

Autonomic Pharmacology (Cont’d)

Parasympathetic & Sympathetic Nervous Systems

Autonomic Pharmacology (Cont’d)

Sympathetic Division of Autonomic Nervous System
Autonomic Pharmacology (Cont’d)

Nervous system organization & function
- Peripheral nervous system
  - Sympathetic division
    - “Fight or Flight” syndrome
  - Parasympathetic division
    - “Feed and breed”
    - “Resting and digesting”

Neurochemical transmission
- Synaptic transmission
  - Preganglionic neuron
  - Postganglionic neuron
  - Ganglion
  - Synaptic junction
  - Neurotransmitter
  - Receptor
- Neurotransmitters
  - Cholinergic
  - Adrenergic
Receptors

Cholinergic receptors
- Acetylcholine
  - Interacts with receptors, physiologic response
Autonomic Pharmacology (Cont’d)

- Receptors
  - Sympathetic receptors
    - Adrenergic receptors
      - When sympathetic division stimulated, adrenal medulla stimulated, releases epinephrine into circulatory system
      - Sympathomimetic
      - Sympatholytics

- Other neurotransmitters & receptors
  - Serotonin
  - Endorphins
  - Neuropeptides

Autonomic Pharmacology (Cont’d)

- Effector cell response
  - Receptor structure
    - Agonist gated ion channel receptors
      - Selected pathway when membrane allows transfer of specific channels across its concentration gradient
Autonomic Pharmacology (Cont’d)

- Effector cell response
  - G protein-coupled receptors
    - Adrenergic, cholinergic receptors
    - Protein chains wind back, forth through cell membrane 7 times
    - Receptor site
    - G protein
    - Effector
  - Second messengers
    - Biochemical messenger
    - Molecule relays signals from receptor on cell surface to target molecules in cell’s nucleus, internal fluid

Autonomic Pharmacology (Cont’d)

- Receptor regulation
  - Downregulation
  - Upregulation
- Altering neurotransmission with drugs
  - Produce biologic effects necessary to minimize disease/injury effects

General Properties of Drugs

- Generally do not give body new function
  - Use existing body function, change for particular advantage
- Exert multiple actions rather than single effect
  - Must consider all actions when choosing
- Physiochemical interaction between drug, body molecule
Drug Forms

- Liquid drug forms
  - Elixir
  - Emulsion
  - Extract
  - Solution
  - Spirit
  - Suspension
  - Syrup
  - Tincture

Drug Forms (Cont’d)

- Solid drug forms
  - Caplet
  - Capsule
  - Enteric-coated tablets
  - Gel cap
  - Pill
  - Powder
  - Suppository
  - Tablet

Drug Forms (Cont’d)

- Gas drug forms
  - Inhaled, absorbed through respiratory tract
  - Commonly used for anesthesia
  - Not common for EMS
Routes of Medication Administration

- Local vs. systemic effects
  - Local effect
    - Affects specific body part
  - Systemic effect
    - Affects entire body

- Enteral routes
  - Passes through any portion of digestive tract

Routes of Medication Administration (Cont’d)

- Enteral routes (Cont’d)
  - Oral
    - First-pass effect
      - Drug breakdown in liver, intestine walls before reaching systemic circulation

Routes of Medication Administration (Cont’d)

- Enteral
  - Sublingual
    - Under tongue
    - Absorbed through mucus membrane, into blood vessels
    - Advantages
      - Accessibility
      - Rapid oral
    - Patient must be adequately hydrated for drug absorption
Routes of Medication Administration (Cont’d)

- **Enteral**
  - **Buccal**
    - Mouth, between gum, cheek mucous membrane, absorbed into blood stream
  - **Rectal**
    - Suppository
    - Eliminates some of “first pass” effect
  - **Gastric**
    - Nasogastric
    - Orogastric
    - Gastrostomy
Routes of Medication Administration (Cont’d)

- Parenteral routes
  - Medication does not pass through digestive tract
  - Avoid first-pass effect
  - Rapid, complete absorption

Routes of Medication Administration (Cont’d)

- Parenteral routes
  - Intravenous
    - Directly into venous circulation
    - Instantaneous

Routes of Medication Administration (Cont’d)

- Parenteral routes
  - Intravenous
    - Needle passed through bone cortex, infused into capillary network
Routes of Medication Administration (Cont’d)

• Parenteral routes
  • Intracardiac
    • Injection directly into heart ventricle during cardiac arrest
    • Coronary artery laceration
    • Heart muscle injection, instead of heart chamber, pneumothorax, cardiac tamponade
    • Not paramedic skill

Routes of Medication Administration (Cont’d)

• Parenteral routes
  • Endotracheal
    • Tracheal tube
    • Unpredictable

Routes of Medication Administration (Cont’d)

• Parenteral routes
  • Inhalation
    • Humidified, nebulized
    • Directly to respiratory tract
• Parenteral routes
  ➢ Intralingual
   • Direct injection into underside of tongue
   • Naloxone, narcotic overdose

• Parenteral routes
  ➢ Intranasal
   • Nasal passages, sinuses

• Parenteral routes
  ➢ Intramuscular
   • Injection directly into skeletal muscle
Routes of Medication Administration (Cont’d)

- Parenteral routes
  - Subcutaneous
    - Liquid form injection placed underneath skin into subcutaneous tissue
    - Slower
  - Transdermal
    - Absorption through skin barrier
    - Slow absorption
    - Look for patches when assessing patient
      - Nitroglycerin - upper chest
      - Nicotine - upper arms, buttocks
      - Nausea - vomiting, dizziness, behind ear
      - Estrogen - buttocks, thighs
      - Pain relief - anywhere
  - Intrathecal
    - Into spinal canal
      - Childbirth, chronic back pain
    - Not paramedic skill
  - Umbilical
    - Used in newborns
    - Requires special training, approval from medical direction

- Intravenous
  - Liquid form injected directly into blood vessels

- Intramuscular
  - Liquid form injected into muscle tissue

- Oral
  - Taken orally in tablet, capsule, liquid form

- Rectal
  - Liquid form instilled into rectum

- Nasal
  - Liquid form insufflated into nasal cavity

- Oral route
  - Liquid form ingested orally

- Transdermal
  - Liquid or semi-solid form absorbed through skin
  - Look for patches when assessing patient
    - Nitroglycerin - upper chest
    - Nicotine - upper arms, buttocks
    - Nausea - vomiting, dizziness, behind ear
    - Estrogen - buttocks, thighs
    - Pain relief - anywhere
Routes of Medication Administration (Cont’d)

- Parenteral routes
  - Intradermal
    - Between dermal skin layers

Mechanisms of Drug Action

- Pharmaceutical phase
  - Broken down into solution in body for absorption
- Pharmacokinetics
  - Modes of transport
    - Passive transport
    - Diffusion
    - Osmosis
    - Facilitated transport
    - Active transport

Mechanisms of Drug Action (Cont’d)

- Pharmacokinetics
  - Stages of drug function
    - Absorption
Mechanisms of Drug Action (Cont'd)

- Pharmacokinetics
  - Stages of drug function
    - Enteric absorption
    - Parenteral absorption
  - Distribution
    - Blood-brain barrier
    - Placental barrier
  - Metabolism
    - Chemical reactions
      - Change active drug into inactive
      - Change less-active/inactive into more active
    - Excretion/elimination
Mechanisms of Drug Action (Cont'd)

- Pharmacodynamics
  - Theories of drug action
    - Drug-receptor interaction

Mechanisms of Drug Action (Cont'd)

- Pharmacodynamics
  - Theories of drug action
    - Affinity
    - Efficacy
    - Agonist
    - Partial agonist
    - Antagonist
    - Acetylation

Mechanisms of Drug Action (Cont'd)

- Pharmacodynamics
  - Drug response relation
    - Plasma level profile
    - Half-life
    - Therapeutic threshold
    - Therapeutic index
Mechanisms of Drug Action (Cont'd)

- Pharmacodynamics
  - Factors that influence drug action
    - Age
    - Gender
    - Body weight
    - Environment
    - General health
    - Genetics
    - Culture
    - Emotional, psychological state
    - Time of administration
    - Administration route
    - Medication history
    - Diet

Mechanisms of Drug Action (Cont'd)

- Pharmacodynamics
  - Predictable, iatrogenic, & unpredictable drug responses

Special Considerations

- Pregnant patients
  - Physiologic changes affect metabolism
  - Teratogen
  - Drug/agent harmful to embryo/fetus development
  - FDA pregnancy risk categories
Special Considerations (Cont’d)

- Pediatric patients
  - Changes from birth to adolescence
  - Doses based on weight, body surface area
  - Broselow tape used

- Geriatric patients
  - Bone mass loss, lean muscle mass, body water changes
  - Body fat decreases
  - Organ degeneration
  - Polypharmacy
  - Self-medication errors

Drug Interactions

- Factors influencing drug action
  - Intestinal absorption
  - Drug metabolism/biotransformation
  - Action at receptor site
  - Renal excretion
  - Alteration of electrolyte balance
  - Drug-drug interactions
  - Competition for plasma protein binding
  - Other drug interactions
  - Drug incompatibilities
Drug Interactions (Cont'd)

- Drug-drug interactions
- Drug-food interactions

Drug Storage

- Some volatile/possible abuse
- Follow protocols
- Check contents before/after shift
  - Expiration dates
  - Quantity
  - Locking mechanisms

Components of a Drug Profile

- Components
  - Generic, trade name
  - Classification
  - How supplied
  - Mechanism of action
  - Pharmacokinetics
  - Indications
  - Dosage
  - Contraindications
Components of a Drug Profile (Cont’d)

- Components
  - Precautions
  - Side effects/adverse effects
  - Route(s) of administration
  - Drug interactions
  - Pregnancy risk category
  - Antidotes
  - Special considerations
    - Pediatric, geriatric, pregnant

Summary

- Drug trade name is brand name, generic is chemical name, chemical name is structure of compound
- Orphan drugs treat rare diseases, conditions
- Sources of drugs include plants, animal/human products, minerals, synthetic chemicals, recombinant DNA technology

Summary (Cont’d)

- Three drug class systems include body system, class of agent, mechanism of action
- Sources of information include Physician’s Desk Reference, hospital formularies, people, pocket references, package inserts
- 1970 Comprehensive Drug Abuse Prevention & Control Act established schedule of controlled substances
Summary (Cont’d)

● U.S. Pharmacopoeia, official public standards-setting authority for prescription, OTC, dietary supplements sold in U.S.
● FDA approval process for investigational drugs has 4 phases
● Safe, effective drug administration responsibility of paramedic

Summary (Cont’d)

● Nervous system contains central, peripheral nervous system
  ➢ CNS - brain, spinal cord
  ➢ Peripheral - all nerves outside of CNS
  ➢ Somatic nervous system, voluntary nerves
  ➢ Autonomic nervous system
    + Sympathetic, parasympathetic
● Sympathetic/adrenergic division, “fight-or-flight”

Summary (Cont’d)

● Parasympathetic/cholinergic division, “resting & digesting”
● Synaptic transmission at synaptic junction
  ➢ Pre/postganglionic nerves connect at ganglion
● Drugs come in liquid, solid, gas forms
Summary (Cont’d)

- Drug route administration affects type of effect, onset of action
  - Enteral drugs enter systemic circulation by GI tract
  - Parenteral drugs enter systemic circulation by bypassing digestive tract
- Medications alter normal body response

Summary (Cont’d)

- Pharmacokinetics - process of how drugs process in body
  - Absorbed, distributed, metabolized, excreted
- Agonist stimulated receptor, causes physiologic response
  - Partial agonist/antagonist may cause physiologic response
  - Antagonist binds with receptor, does not elicit response

Summary (Cont’d)

- Biologic half-life, time required to eliminate 50% from bloodstream
- FDA regulates drugs for safety in pregnancy, pediatric & geriatric patients may have different responses
- Side effects may/may not be harmful
Summary (Cont’d)

- Iatrogenic drug response, unintentional disease/effect produced by physician’s prescribed therapy
- Drug action factors include intestinal absorption, drug metabolism, excretion, electrolytes, drug-drug interactions, incompatibilities

Summary (Cont’d)

- Drug storage important
- Drug profile, complete description of drug, its characteristics

Questions?