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III & IV Semesters

Textbook of

Pharmacology

for BSc Nursing Students

As per the Revised INC Syllabus (2021–22) for BSc Nursing

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2nd Edition

Joginder Singh Pathania
Rupendra Kumar Bharti
Vikas Sood

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Nursing Knowledge Tree

Second Edition

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Preface to the First Edition

Pharmacology is one of the basics as well as an applied medical sciences. It deals with the study of various drugs, their mode of action, pharmacological effects, side effects and drug-drug interactions. This subject is the backbone of all the drug treatments whatsoever are being used in medical practice as each and every medical specialty has to use drugs for the treatment of its patients. As, no treatment is complete without the use of drugs, appropriate knowledge of drugs is mandatory for all medical personnel involved in the use of drugs.

As we have been teaching Pharmacology to the students of Allied Health Sciences, like nurses, or physiotherapists and students from other fields of Allied Health Sciences since long, we have seen the dilemma in the minds of these students about the appropriate book to follow. In a class, teacher sows the seeds of knowledge in the minds of students, but it is the book that provides water and manure to these seeds for sprouting and blooming into the flowers of knowledge. Hence, the idea of writing a pharmacology book erupted in our minds. This edition of the book is meant for the students of Allied Health Sciences as well as for other health professionals who are already working in the healthcare industry. As this book has been written and organized strictly according to the syllabus, it will be of immense help to the students all over India.

This book provides the basic concepts of Pharmacology in simple language with clinical correlations and adequate knowledge of the subject. The unnecessary theoretical details have been ignored. This book includes the recent drugs and latest concepts, which have been specially highlighted.

This book has been designed to provide a comprehensive, authoritative, simplified and precise knowledge of the subject. Most of the illustrations have been presented in the easily understandable tabular forms, figures and are properly highlighted for the ease of the students.

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Special Features of the Book

Learning Objectives

This chapter is designed to enable the learner to understand:

- Principles of antiseptics, disinfectants, and their role in daily healthcare practice
- Advantages and disadvantages of insecticides
- Nursing responsibilities while handling these chemicals

These enlist what the students will learn after studying the chapters

Each and every topic have been started with clinical case scenario with explanation from theoretical and clinical integration point of view.

1 CASE SCENARIO

Kapil K.K. presented in OPD with complain of generalized weakness, loss of appetite, and paraesthesia. On examination, he was detected with pale, sluggish deep tendon reflex. The peripheral smear shown Hb 5.7 g%. En which of the fa

1 Case Scenario Explanation

The patient with anemia, hypersegmented ne macrocyte in peripheral smear, diminished deep with atrophic gastritis are suggestive of perni This is treated with vitamin B_{12}. Depending upo of the patient the vitamin B_{12} can be given eit or IM route. In pernicious anemia *hydroxocoba* in a dose of 1 mg IM/SC daily for 2 weeks or t symptoms subside, followed by 1 mg injected e for maintenance.

Important information that needs attention has been highlighted in these pointer boxes

Must Know

- **Desferrioxamine** is given by IM/IV route, which acts as an antidote and reduces serum iron levels by helping early excretion of iron.
- Other iron chelating agents are ***deferiprone*** and ***deferasirox***. These are given by oral route in chronic iron overload cases.
- General supportive measures should be instituted simultaneously.

Drug-to-drug interactions have been given separately to help the nurses during their practice

DRUG INTERACTIONS

- Iron is better absorbed in the presence of reducing substances such as ascorbic acid (vitamin C). These substances convert the ferric form of iron to ferrous form and make it more absorbable. Hence, concurrent administration of vitamin C should be done for better absorption of inorganic iron.
- The absorption of iron is decreased in the presence of alkalis, phosphates, phytates, food and drugs such as tetracyclines. Hence, concurrent consumption of these items should be avoided.

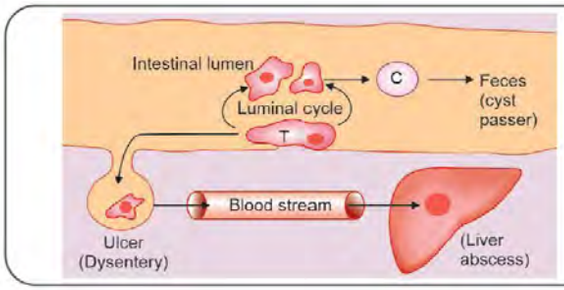

Fig. 8.4: Presentation of amoebiasis

Numerous Figures are used to make learning easy for students

Numerous Tables are used to help students grasp the concepts quickly

Table 8.5: Classification of cephalosporins

Generation	Oral	Parenteral
First generation	Cephalexin Cefadroxil	Cefazolin
Second generation	Cefaclor Cefprozil Cefuroxime axetil	Cefuroxime Cefoxitin
Third generation	Cefixime Cefpodoxime proxetil Cefdinir Ceftibuten Ceftamet pivoxil	Cefotaxime Ceftizoxime Ceftriaxone Ceftazidime Cefoperazone

Nursing implications enlist the various measures required by nurses while administering the drugs of every class

Nursing Implications

Assessment

Baseline Assessment

- Obtain complete medical and personal history related to the diseases prior to admission. That includes history of cerebrovascular, cardiovascular, respiratory, metabolic disease, drug history, drug/food allergy, OTC/herbal drugs, and present prescription.
- Assess for contraindications or cautions: known allergies to these drugs to avoid hypersensitivity reactions.
- Assess any infectious sign and symptoms, fever, swelling, abscess, pain.
- Assess patient related laboratory investigations such as CBC with PS, bacterial culture and microscopy, LFT and RFT.
- Obtain appropriate baseline of vital signs, urinary output, cardiac output, bowel sound, height and weight.
- Assess any sign of bleeding, and patient or caregiver ability to understand instruction.

Important questions of the chapter are enlisted to help students assess and MCQs their learning

ASSESS YOURSELF

Long Answer Questions

1. What are bronchodilators?
2. Classify the drugs used for the treatment of bronchial asthma.
3. Explain pharmacological management of status asthmaticus.
4. Describe the drugs used in dry cough.
5. Describe cetirizine.
6. What do you understand by the nasal decongestants? Describe their uses and side effects.

Short Answer Questions

1. Write short notes on:
   a. Methylxanthines
   b. Montelukast
   c. Sodium cromoglycate
   d. Salbutamol
   e. Codeine

Multiple Choice Questions

1. **A highway truck driver has profuse rhinorrhea and sneezing. Which of the following drugs would you prescribe him?**
   a. Pheniramine
   b. Promethazine
   c. Dimenhydrinate
   d. Cetirizine
2. **Second generation antihistaminics used in allergic rhinitis are:**
   a. Azelastine
   b. Fexofenadine
   c. Chlorpheniramine maleate
   d. Desloratadine
   e. Promethazine
4. **Which of the following drugs has been found to be useful in acute severe asthma?**
   a. Magnesium sulfate
   b. Antileukotriene
   c. Cromolyn sodium
   d. Cyclosporine
5. **Which of the following is *Not* an adverse effect of salbutamol?**
   a. Tachycardia
   b. Tolerance

Syllabus

Pharmacology–I

Placement: III Semester **Theory:** 1 Credit (20 Hours)

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
I	3 (T)	Describe pharmacodynamics, pharmacokinetics, classification, principles of administration of drugs	**Introduction to Pharmacology** • Definitions and branches • Nature and sources of drugs • Dosage forms and routes of drug administration • Terminology used • Classification, abbreviations, prescription, drug calculation, weights and measures • *Pharmacodynamics:* Actions, drug antagonism, synergism, tolerance, receptors, therapeutic, adverse, toxic effects, pharmacovigilance • *Pharmacokinetics:* Absorption, bioavailability, distribution, metabolism, interaction, excretion • Review: Principles of drug administration and treatment individualization ▪ Factors affecting dose, route etc. • Indian pharmacopoeia: Legal issues, drug laws, schedule drugs • Rational use of drugs • Principles of therapeutics	• Lecture cum discussion • Guided reading and written assignment on schedule K drugs	• Short answer • Objective type • Assessment of assignments
II	1 (T)	Describe antiseptics, and disinfectant and nurse's responsibilities	**Pharmacology of Commonly used Antiseptics and Disinfectants** • Antiseptics and disinfectants • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects, toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type
III	2 (T)	Describe drugs acting on gastrointestinal system and nurse's responsibilities	**Drugs Acting on GI System** • Pharmacology of commonly used drugs ▪ Emetics and antiemetics ▪ Laxatives and purgatives ▪ Antacids and antipeptic ulcer drugs ▪ Antidiarrhoeals—fluid and electrolyte therapy, furazolidone, dicyclomine • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects, toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type
IV	2 (T)	Describe drugs acting on respiratory system and nurse's responsibilities	**Drugs Acting on Respiratory System** • Pharmacology of commonly used ▪ Antiasthmatics—Bronchodilators (Salbutamol inhalers)	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type

Contd...

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
			▪ Decongestants ▪ Expectorants, antitussives and mucolytics ▪ Broncho-constrictors and antihistamines • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects toxicity and role of nurse		
v	4 (T)	Describe drugs used on cardiovascular system and nurse's responsibilities	**Drugs used in Treatment of Cardiovascular System and Blood Disorders** • Haematinics, and treatment of anemia and antiadrenergics • Cholinergic and anticholinergic • Adrenergic drugs for CHF and vasodilators • Antianginals • Antiarrhythmics • Antihypertensives • Coagulants and anticoagulants • Antiplatelets and thrombolytics • Hypolipidemics • Plasma expanders and treatment of shock • Drugs used to treat blood disorders • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects, toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type
VI	2 (T)	Describe the drugs used in treatment of endocrine system disorders	**Drugs used in Treatment of Endocrine System Disorders** • Insulin and oral hypoglycemics • Thyroid and anti-thyroid drugs • Steroids ▪ Corticosteroids ▪ Anabolic steroids • Calcitonin, parathormone, vitamin D3, calcium metabolism ▪ Calcium salts	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type
VII	1 (T)	Describe drugs used in skin diseases and nurse's responsibilities	**Drugs used in Treatment of Integumentary System** • Antihistaminics and antipruritics • Topical applications for skin—benzylbenzoate, gamma BHC, clotrimazole, miconazole, silver sulphadiazine (burns) • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type

Contd...

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
VIII	5 (T)	Explain drug therapy/ chemotherapy of specific infections and infestations and nurse's responsibilities	**Drugs used in Treatment of Communicable Diseases (Common Infections, Infestations)** • General principles for use of antimicrobials • Pharmacology of commonly used drugs: ▪ Penicillin, cephalosporin's, aminoglycosides, macrolide and broad spectrum antibiotics, sulfonamides, quinolones, misc. antimicrobials • Anaerobic infections • Antitubercular drugs • Antileprosy drugs • Antimalarials • Antiretroviral drugs • Antiviral agents • Antihelminthics, antiscabies agents • Antifungal agents • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects, toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type

Pharmacology–II
Including Fundamentals of Prescribing Module

Placement: IV Semester **Theory:** 3 Credit (60 Hours)

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
I	4 (T)	Describe drugs used in disorders of ear, nose, throat and eye and nurse's responsibilities	**Drugs used in Disorders of Ear, Nose, Throat and Eye** • Antihistamines • Topical applications for eye (chloramphenicol, gentamycin eye drops), ear (soda glycerin, boric spirit ear drops), nose and buccal cavity-chlorhexidine mouthwash • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects, toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type
II	4 (T)	Describe drugs acting on urinary system and nurse's responsibilities	**Drugs used on Urinary System** • Pharmacology of commonly used drugs ▪ Renin angiotensin system ▪ Diuretics and antidiuretics ▪ Drugs toxic to kidney ▪ Urinary antiseptics ▪ Treatment of UTI – acidifiers and alkalinizers • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type

Contd...

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
III	10 (T)	Describe drugs used on nervous system and nurse's responsibilities	**Drugs Acting on Nervous System** • Basis and applied pharmacology of commonly used drugs • Analgesics and anaesthetics ▪ Analgesics: Nonsteroidal anti-inflammatory (NSAID) drugs ▪ Antipyretics ▪ Opioids and other central analgesics ◆ General (techniques of GA, pre-anesthetic medication) and local anesthetics ◆ Gases: Oxygen, nitrous, oxide, carbondioxide and others • Hypnotics and sedatives • Skeletal muscle relaxants • Antipsychotics ▪ Mood stabilizers • Antidepressants • Antianxiety drugs • Anticonvulsants • Drugs for neurodegenerative disorders and miscellaneous drugs • Stimulants, ethyl alcohol and treatment of methyl alcohol poisoning • Composition, action, dosage, route, indications, contraindications, drug interactions, side effects, adverse effects toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type
IV	5 (T)	Describe drugs used for hormonal disorder and supplementation, contraception and medical termination of pregnancy and nurse's responsibilities	**Drugs used for Hormonal, Disorders and Supplementation, Contraception and Medical Termination of Pregnancy** • Estrogens and progesterones ▪ Oral contraceptives and hormone replacement therapy • Vaginal contraceptives • Drugs for infertility and medical termination of pregnancy ▪ Uterine stimulants and relaxants • Composition, actions dosage route indications contraindications, drugs interactions, side effects, adverse effects, toxicity and role of nurse	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type
V	3 (T)	Develop understanding about important drugs used for women before, during and after labor	**Drugs used for Pregnant Women during Antenatal, Labor and Postnatal Period** • Tetanus prophylaxis • Iron and Vit K1 supplementation • Oxytocin, misoprostol • Ergometrine • Methyl prostaglandin F2-alpha • Magnesium sulphate • Calcium gluconate	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type

Contd...

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
VI	10 (T)	Describe drugs used in deaddiction, emergency, poisoning, vitamins and minerals supplementation, drugs used for immunization and immune-suppression and nurse's responsibilities	**Miscellaneous** • Drugs used for deaddiction • Drugs used in CPR and emergency- adrenaline, chlorpheniramine, hydrocortisone, dexamethasone • IV fluids and electrolytes replacement • Common poisons, drugs used for treatment of poisoning ▪ Activated charcoal ▪ Ipecac ▪ Antidotes ▪ Anti-snake venom (ASV) • Vitamins and minerals supplementation • Vaccines and sera (Universal immunization program schedules) • Anticancer drugs: Chemotherapeutic drugs commonly used • Immunosuppressants and immunostimulants	• Lecture cum discussion • Drug study/ presentation	• Short answer • Objective type
VII	4 (T)	Demonstrate awareness of common drugs used in alternative system of medicine	**Introduction to Drugs used in Alternative Systems of Medicine** • Ayurveda, Homeopathy, Unani and Siddha etc. • Drugs used for common ailments	• Lecture cum discussion • Observational visit	• Short answer • Objective type
VIII	20 (T)	Demonstrate understanding about fundamental principles of prescribing	**Fundamental Principles of Prescribing** • Prescriptive role of nurse practitioners: Introduction • Legal and ethical issues related to prescribing • Principles of prescribing • Steps of prescribing • Prescribing competencies	• Completion of module on fundamental principles of prescribing	• Short answer • Assignments evaluation

Contents

4

DRUGS ACTING ON RESPIRATORY SYSTEM

Learning Objectives

This chapter is designed to enable the learner to understand:

- Principles of bronchodilators and their implications
- Status asthmaticus
- Role and handling of nebulizer, rotahalers
- Corticosteroids in asthma
- Role of partial pressure of CO_2 and bicarbonate in metabolic diseases

Chapter Outline

- Antiasthmatics
  - Simplified View of Allergic Inflammation in the Airways
  - Bronchodilators
  - Leukotriene (LTs) Antagonists (Montelukast and Zafirlukast)
  - Mast Cell Stabilizers
  - Corticosteroids
  - Anti-IgE Antibody
  - Management of Asthma
  - Status Asthmaticus/Refractory Asthma
- Mucolytics
  - Bromhexine
  - Ambroxol
  - Acetylcysteine
  - Carbocysteine
  - Dornase Alfa
  - Contraindications and Cautions
- Decongestants
  - Indications
  - Pharmacokinetics
- Expectorants
  - Mechanism of Action of Expectorants
- Antitussives
  - Classification of Antitussives
- Bronchoconstrictor
- Antihistaminics
  - Histamine
  - Histamine Receptors
  - Antihistaminics (H_1 Antagonists)
  - Classification of Antihistaminics
  - Uses of Antihistaminics
- Acid-Base Balance

ANTIASTHMATICS

1 CASE SCENARIO

A 55-year-old anxious female recently diagnosed with stage 2 hypertension. She was prescribed telmisartan 40 mg twice daily, and 25 mg propranolol for prophylaxis of anxiety. Two days later, she was brought into the casualty with severe breathing difficulty. She was hyperventilating and on examination, bilateral wheezing of lungs was observed. The provisional diagnosis of acute asthmatic attack was made. Which of the following drugs would you prescribe to attenuate this asthmatic attack?

The drugs used to treat the bronchial asthma are called **antiasthmatics**.

Asthma is a chronic inflammatory disease of the airways. It occurs due to hyper responsiveness of tracheobronchial tree to various allergic stimuli. It is characterized by:

- Dyspnea
- Wheeze
- Dry cough

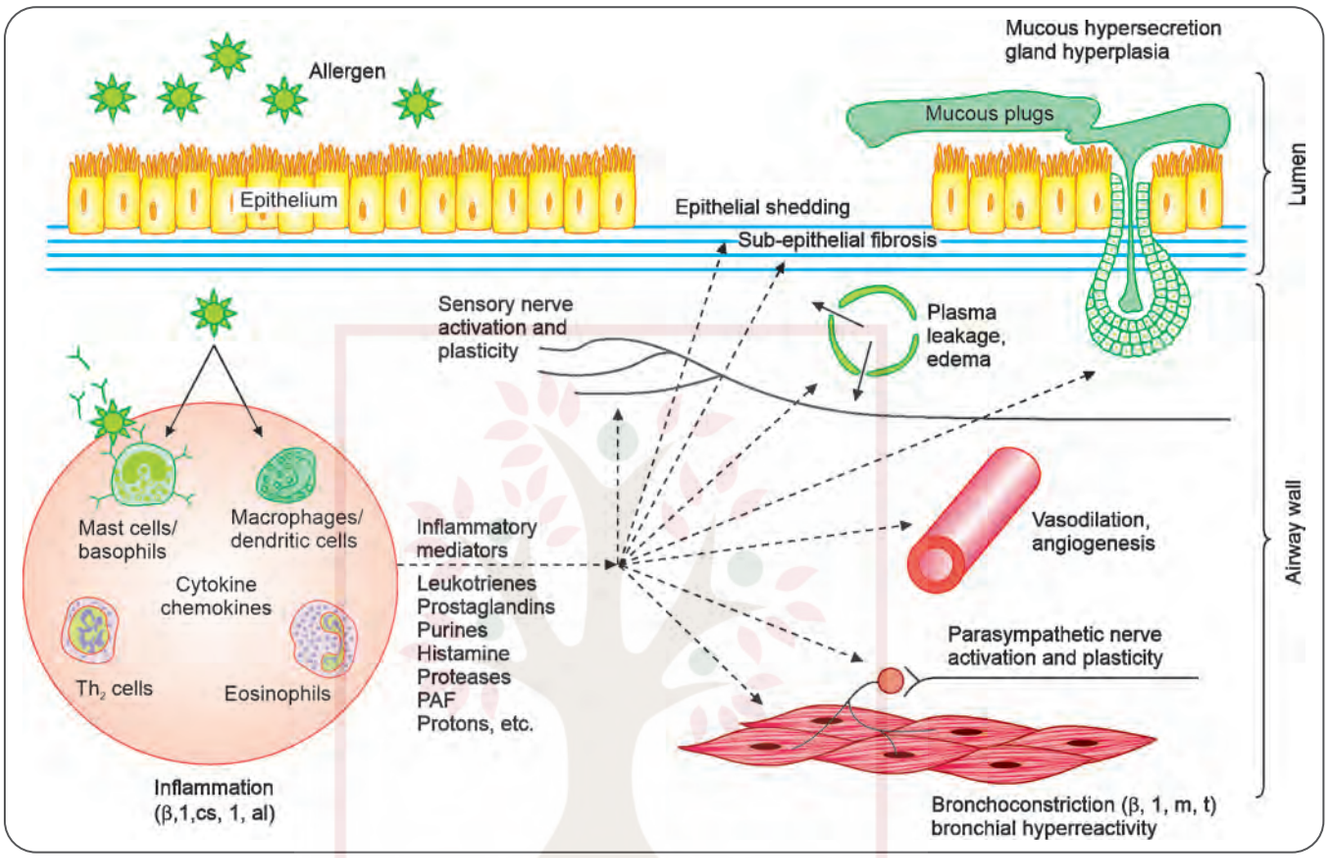

Fig. 4.1: Sites of action of various classes of drugs used in the treatment of asthma

These symptoms occur due to bronchospasm, increased bronchial secretions and edema of the bronchial mucosa.

SIMPLIFIED VIEW OF ALLERGIC INFLAMMATION IN THE AIRWAYS

Asthma is an episodic narrowing of the bronchi thought to be caused by an underlying chronic inflammatory disorder. In allergic asthma, inhaled allergen initiates the inflammatory response by interacting with IgE bound to basophils and mast cells. This leads to a cascade of events involving other immune cells and release of various inflammatory mediators into the interstitial space, where they influence the growth and function of cell types within the airway wall. The drugs available for the treatment of asthma are targeted at inhibiting the inflammatory responses and/or relaxing the bronchial smooth muscle (Fig. 4.1). The various classes of drugs used in treating asthma are β_2 adrenergic agonists; corticosteroids; leukotriene modifiers; muscarinic receptor antagonists; cromolyn; theophylline; anti-IgE therapy.

Asthma is divided into two categories: Extrinsic and Intrinsic asthma.

Table 4.1 lists the differences between extrinsic and intrinsic asthma.

Trigger factors include:

- Upper respiratory tract infection (Intrinsic asthma).
- Allergens, e.g., pollen grains, house dust or smoke, etc.
- Drugs such as Aspirin, nonselective beta-blocker (propranolol), opioids.
- Cold or dry air.
- Exercise induced (sign/symptoms develop when person takes rest after exercise).

Table 4.1: Differences between extrinsic and intrinsic asthma

	Extrinsic asthma	Intrinsic asthma
Time of onset	Childhood	Late/adulthood
Allergy	Personal history or strong family history	No H/O allergy
Level of IgE and eosinophils	Increased	Normal
External stimulus	Required	May or may not be required
Status asthmatics	Less frequent	More frequent

Drugs used in the treatment of bronchial asthma are:

- **Bronchodilators**
  - **Sympathomimetics:** Salbutamol, Terbutaline, Salmeterol, Formoterol, Bambuterol and Ephedrine.
  - **Methylxanthines:** Theophylline, Aminophylline, Doxophylline, Acebrophylline
  - **Anticholinergics:** Tiotropium bromide and Ipratropium bromide
- **Leukotriene antagonists:** Zafirlukast and Montelukast.
- **Mast cell stabilizers:** Ketotifen and Sodium cromoglycate.
- **Corticosteroids**
  - **Systemic:** Prednisolone, Hydrocortisone and Deflazacort, etc.
  - **Inhalational:** Budesonide, Fluticasone, Beclomethasone and Ciclesonide.
- **Anti-IgE antibody:** Omalizumab

BRONCHODILATORS

These are the drugs having ability to dilate the bronchi, which are in a state of bronchospasm. The bronchospasm is due to the contraction/constriction of bronchial smooth muscles which leads to decreased air entry into the tracheobronchial tree resulting in dyspnea and difficult respiration.

There are various classes of drugs which act as bronchodilators such as:

- **Sympathomimetics:** Salbutamol, Salmeterol, Terbutaline, Formoterol, Bambuterol, Ephedrine.
- **Methylxanthines:** Theophylline, Aminophylline, Doxophylline, Acebrophylline
- **Anticholinergics:** Ipratropium bromide, Tiotropium bromide.

Sympathomimetics (Mimicking Sympathetic System)

- These are the drugs which are having actions similar to sympathetic stimulation.
- These drugs are potent bronchodilators.

Mechanism of Bronchodilatation

- **β-receptor is present in the bronchi.**
- The stimulation of these β_2 receptors leads to bronchodilatory effect.
- The bronchodilatory effect is good in constricted bronchi.
- The main mechanism operating at cellular level is as follows:

Must Know

Adrenergic drugs and β_2 receptor agonists → stimulation of β_2 receptor → increased cAMP formation in bronchial muscle cell → bronchodilatory effect.

- In addition, the inflammatory mediator release is also decreased.
- These drugs are the drug of choice due to their effectiveness and rapid bronchodilatory effect in reversible airway obstruction. Preferably, these drugs are given in inhalational form for prompt relief. Details of the sympathomimetic drugs are given in Table 4.2.

Must Know

Adrenaline, Ephedrine and isoprenaline: Although these drugs are bronchodilators, but these are not preferred due to low efficacy, risk of adverse effects and availability of better drugs.

Doses of Nebulizers

- 2–12 years: 0.63–1.25 mg every 4–6 hours.
- Less than 4 years:
  - For quick action: 0.63–2.5 mg every 4–6 hours.
  - Asthma exacerbation: 0.15 mg/kg 3 dose for every 20 minutes followed by 0.15–0.3 mg/kg for every 1–4 hours. In continuous nebulizer 0.5mg/kg/hr.

Table 4.2: Sympathomimetics

Comparison	Salbutamol	Terbutaline	Salmeterol	Formoterol
Dosage and route of administration	• **Adult and >12 years** 2–4 mg TDS OR BD orally. 100–200-mcg by inhalation • **Pediatric:** 2–6 years 0.1 mg/kg TDS orally 6–12 years 2 mg TDS OR QID orally. (Inhaled 15 min before exercise)	• **Adult and pediatric** (>15 years): 5 mg QID orally. 250 mcg by inhalation • **Paediatric** (12–15 years): 2.5 mg TDS orally	• **Adult and pediatric** (≥12 years): 25 mcg pMDI two puff 12 hourly • **Pediatric** (4–12 years) one inhalation BD	• **Adult and pediatric** (>5 years) 12 mcg capsule 12 hourly, *(Capsule inhaled using the Aerolizer inhaler, at least 15 minutes before exercising)*

Contd...

Comparison	Salbutamol	Terbutaline	Salmeterol	Formoterol
Indications	• Long-acting treatment • Prophylaxis of bronchospasm	• Treatment and prophylaxis of bronchospasm in patients >12 years of age	• Prevention of asthma due to exercise • As a maintenance therapy and nocturnal asthma • Chronic obstructive pulmonary disease (COPD)	• Prevention of asthma due to exercise • As a maintenance therapy and nocturnal asthma • COPD
Special points	• Inhaled salbutamol delivered mostly from pressurized metered dose inhaler (pMDI) produces bronchodilatation within 5 minutes and the action lasts for 2–4 hours • Levo-Salbutamol has equal action at half dose	• Use of inhalers should be restricted to symptomatic relief of wheezing	• Long-acting selective beta 2 agonist • Onset of action is slow • Mostly used in combination inhaled steroids	• Long-acting selective beta 2 agonist • It has faster onset of action than Salmeterol • Specially used for round the clock bronchodilatation

- 5–11 years:
  - For quick action: 1.25–5 mg every 4–8 hours.
  - Asthma exacerbation: 0.15mg/kg 3 dose for every 20 minutes followed by 0.15–0.3 mg/kg for every 1–4 hours.
- >12 years:
  - For quick action: 1.25–5 mg every 4–8 hours.
  - Asthma exacerbation: 2.5–5 mg 3 dose for every 20 minutes followed by 2.5–10 mg for every 1–4 hours.

Side Effects of Sympathomimetic Drugs

The side effects are commonly seen with the short acting β_2 receptor agonists such as salbutamol and terbutaline and less commonly with the long acting β_2 receptor agonists such as salmeterol and formoterol. Some commonly seen side effects are muscle tremors, palpitation, restlessness, nervousness, throat irritation, ankle edema and hypokalemia.

Methylxanthines

- The xanthines are in use for the treatment of bronchospasm and asthma since ancient times.
- Theophylline and caffeine are methylxanthines obtained from natural sources. However, because they have a relatively narrow margin of safety and interact with many other drugs, they are no longer considered the first-choice bronchodilators.
- Xanthines, used to treat respiratory diseases include theophylline, aminophylline, and doxophylline.

Mechanism of Action

- **Inhibition of phosphodiesterase (PDE):** PDE enzyme degrades cyclic AMP and methylxanthines inhibits this enzyme, thereby increasing cAMP levels. This increase in cAMP causes bronchodilation.
- **Blockade of adenosine receptors:** Adenosine contracts smooth muscles by acting as a local mediator. Methylxanthines produce opposite effects.
- The calcium (in skeletal and cardiac muscle) from sarcoplasmic reticulum is released. This action is seen in higher dose only.

At normal therapeutic doses, bronchodilation occurs due to mechanism 1 and 2. Action number 3 is observed only at toxic doses.

Theophylline

Pharmacokinetics

- Theophylline is well absorbed orally.
- It is widely distributed in all compartments of body.
- It also crosses the placental barrier and is secreted in milk.
- The metabolism occurs in liver and excretion occurs through kidneys.
- In higher doses, the kinetics of theophylline change from first-order kinetics to zero-order kinetics due to saturation of metabolizing enzyme of liver. Hence, accumulation of drugs occurs which can lead to severe toxicity.

Table 4.3: Side effects of theophylline according to serum levels of theophylline

Serum level (μg/mL)	Side effects
≤20	Uncommon
>20–25	Nausea, vomiting, diarrhea, insomnia, headache, irritability
>30–35	Tachycardia, arrhythmias, hypotension, hyperglycemia, seizures, brain damage, death

Dose

100–300 mg orally, thrice daily.

Side Effects

Theophylline has a narrow margin of safety. Side effect profile is different at different serum levels (Table 4.3).

Aminophylline

- It is a water-soluble drug.
- It is given by slow intravenous route in acute attack of asthma not responding to β_2 agonist.
- It should be given slow intravenously in a dose of 250 mg over 15–20 minutes.
- Rapid IV injection may cause hypotension, arrhythmias which may lead to convulsions, collapse and death.
- It is not given by IM/SC route due to its highly irritating nature.
- In children, the recommended dose is 7.5 mg/kg intravenously.

Hydroxyethyl Theophylline (Etophylline, 80% Theophylline)

- It is administered by intravenous, intramuscular and oral route in a dose of 250 mg.
- It has low irritating nature.

Doxophylline

- It is a methylxanthine with long duration of action and given by oral route.
- It neither interferes with sleep nor stimulates gastric secretion.

Dose

- **Adult:** 400 mg once or twice daily.
- **Children:** 12 mg/kg daily.

Anticholinergics

- These are the drugs which block the action of acetylcholine on muscarinic receptors.
- M_3 cholinergic receptors are present in larger airways and their stimulation causes bronchoconstriction.
- Anticholinergic drugs block M_3 receptors and cause bronchodilation.
- These drugs relax bronchial smooth muscles but response is slower than sympathomimetics.
- These drugs are given by inhalational route.
- These are the bronchodilators of choice in COPD.
- The anticholinergics show a good effect in patients of COPD, asthmatic bronchitis and psychogenic asthma.
- The synergistic effects are obtained by combining the ipratropium bromide with a β_2 agonist in the form of prolonged and potentiated bronchodilatation.
- *Ipratropium bromide* is a short acting (duration 4–6 hours), while *Tiotropium bromide* is long acting (duration 24 hours).
- Available in inhalers, rotacaps and solution forms.

LEUKOTRIENE (LTS) ANTAGONISTS (MONTELUKAST AND ZAFIRLUKAST)

- The pharmacological actions and uses of both these drugs are same.
- Both these agents exhibit competitive antagonism. They antagonise LTs receptor mediated bronchoconstriction, airway mucous secretion, increased vascular permeability and recruitment of eosinophils.

Pharmacokinetics

- These drugs have good oral absorption with high plasma protein binding.
- The metabolism occurs in liver.
- The plasma t½ of montelukast is 3–6 hours and zafirlukast is 8–12 hours.

Indications

- Mild-to-moderate asthma as alternatives to inhaled glucocorticoids.
- Severe asthma (additive effect with inhaled steroids).
- Effective in aspirin-induced asthma and exercise-induced asthma.
- No value in chronic obstructive pulmonary disease.

Table 4.4: Dose of leukotriene antagonists

Drugs	Dose
Montelukast	Adults: 10 mg once daily Children: (age group 2–5 year): 4 mg once daily, (Age group 6–14 year): 5 mg once daily *To be given in the evening.*
Zafirlukast	Adults: 20 mg twice daily, Children (age group 5–11 year): 10 mg twice daily

Side Effects

Headache, rashes and eosinophilia.
Dose (Table 4.4)

MAST CELL STABILIZERS

Cromoglycate Sodium

- It inhibits degranulation of mast cells and reduces the bronchial hyperreactivity.
- Bronchospasm induced by allergens, irritants, cold air and exercise is decreased.
- It does not have a therapeutic effect during an asthmatic attack.
- It is not a bronchodilator, like salbutamol.

Pharmacokinetics

It is not absorbed orally. Hence, given by metered dose inhaler for direct effect on bronchi.

Uses

- **Bronchial asthma:** It is used for the prophylaxis of exercise-induced asthma and mild-to-moderate asthma.
- **Allergic rhinitis:** Some symptomatic improvement is seen after 4–6 weeks.
- Cromoglycate sodium eye drops are given for the prophylaxis of **chronic allergic conjunctivitis**.

Dose

- Metered dose inhaler 1 mg and 5 mg/puff, 2 puffs 4 times daily.
- 2% nasal spray, two spray in both nostrils QID.
- 2% and 4% eye drops: 1 drop in each eye QID.

Adverse Effects

- Systemic toxicity is minimal.
- Other side effects are dizziness, headache, nasal congestion, rashes, arthralgia, etc.

Ketotifen

- It is an antihistaminic (H_1) and not a bronchodilator.
- It is given orally.
- It has some mast cell stabilizing effect also.

Indications

Bronchial asthma, urticaria, food allergy, conjunctivitis, perennial rhinitis and atopic dermatitis.

Adverse Effects

- Generally, well tolerated.
- The other side effects are dry mouth, nausea, sedation, dizziness, increase in weight.

Dose

In adults 1–2 mg twice daily and in children 0.5 mg twice daily.

CORTICOSTEROIDS

- **Systemic:** Prednisolone, Deflazacort, Hydrocortisone, etc.
- **Inhalational:** Budesonide, Fluticasone, Beclomethasone, etc.

Mechanism of Action

- Glucocorticoids do not have bronchodilatory effects.
- These agents decrease the bronchial tree hyper-reactivity and mucosal edema by their potent anti-inflammatory actions.

Systemic Steroids

- The various indications of systemic steroidal therapy in asthma are as follows:
  - **Severe chronic asthma:** Prednisolone is started in a dose of 20–60 mg (or equivalent) daily. (*If, the severe/*

recurrent episodic attacks of asthma are not controlled by steroidal inhaler and bronchodilator).

- **Status asthmaticus/acute asthma exacerbation.**
- **Chronic obstructive pulmonary disease (COPD):** Short-term (1–3 weeks) therapy of oral glucocorticoids can be beneficial during exacerbation of COPD.

Inhalational Steroids

The following inhalational steroids are used frequently in the patients of asthma:

- Beclomethasone dipropionate (available as):
  - INHALER 50 µg, 100 µg, 200 µg per metered dose.
  - ROTACAPS (with rotahalers) 100, 200, 400 µg powder per cap.
- Budesonide: 200–400 µg BD–QID by inhalation in asthma; 200–400 µg/day by intranasal spray for allergic rhinitis.
- Fluticasone propionate: 100–250 µg BD inhalation in asthma.
- Flunisolide: 25 µg per actuation nasal spray.
- Ciclesonide: 80–160 µg by inhalation OD.

These inhalational steroidal agents are used an aerosol form as they have good topical activity on tracheobronchial tree. Their systemic action is poor because of high first pass metabolism.

Adverse Effects

The common side effects are dysphonia, hoarseness of voice, oropharyngeal candidiasis, sore throat and oral thrush.
(These above-mentioned side effects can be controlled by the use of a spacer device and normal saline gargling after every dose)

ANTI-IGE ANTIBODY

Omalizumab

- Omalizumab acts against IgE by binding and neutralizing the free IgE in blood circulation.
- It is a humanized monoclonal antibody and given by subcutaneous route with 62% of bioavailability.
- It does not activate mast cells and other inflammatory mediating cells.
- It is metabolized in liver and excreted through bile.
- The elimination t ½ is 26 days.
- Omalizumab reduces the exacerbations and the requirement of steroidal therapy in severe allergic asthma; therefore, it is indicated in corticosteroid non-responsive asthma, and persistent allergic asthma.
- Side effects are injection site reaction, alopecia, headache, malaise, pruritus, dermatitis, arthralgia, sinusitis, cough, thrombocytopenia, bronchospasm.
- It is very costly. Therefore, reserved for resistant cases only.
- It should be given only after sensitivity test.

Must Know

Drugs Used by Inhalational Route for Asthma Treatment

The following types of antiasthmatic drugs are available in inhalational forms.
Glucocorticoids *(Beclomethasone, Fluticasone, Budesonide, Ciclesonide)*
β_2 ***agonists*** *(Salbutamol, Terbutaline, Salmetrol, etc.)*
Anticholinergics *(Ipratropium bromide, Tiotropium bromide)*
Cromoglycate sodium

- Currently, inhalational agents are the preferred drugs for both short and long-term management of asthma.
- Drugs given by inhalational route have the following advantages over that given by oral route:
- The drug is delivered directly at the site of action.
- Prompt action is achieved.
- Minimal systemic side effects than oral anti-asthamatics.
- Inhalational doses are lower than oral doses of the same drug.

MANAGEMENT OF ASTHMA (TABLE 4.5)

The immediate treatment of asthma is guided by the severity of the signs and symptoms of patient. The main aim of the treatment is to relieve the bronchospasm and prevent the further damage to the respiratory tract. After the asthma is under control for 3–6 months, the medications are reduced in a stepwise manner.

Aerosols

These are the drug preparations which can be converted into vapor form for their maximum effect in the tracheobronchial tree.

Aerosols are of two types:

1. Drug in solution form
2. Drug as dry powder form

- **Drug in solution:** Pressurized metered dose inhaler (pMDI), nebulizers.
  - **Metered dose inhalers:** They are the small handy devices, which can be carried in pockets and used on *as and when required basis*.

Table 4.5: Management of various types of asthma

Type of asthma	Management
Seasonal asthma (Symptoms seen in particular seasons only due to allergens/ cold climatic conditions)	• Inhaled short-acting β_2 receptor agonist • Inhaled steroid in low-dose • Cromoglycate sodium (should be given 3–4 weeks before the onset of seasonal attacks and continued till 3–4 weeks after the season is over)
Mild episodic asthma (Symptoms <1 per day, asymptomatic in between attacks)	• Inhaled short-acting β_2 receptor agonist at the onset of each episode
Mild chronic (persistent) (Acute exacerbation)	• Regular low-dose inhaled steroid • Inhaled cromoglycate sodium • Oral theophylline • Episode treatment with inhaled short acting β_2 receptor agonist
Moderate asthma (Attacks occur >1 per day or mild baseline symptoms)	• Slightly higher dose of inhaled steroid + inhaled long-acting β_2 receptor agonist • Sustained release theophylline may be used in addition • Leukotriene receptor antagonist may be used in addition
Severe asthma (Continuous symptoms; activity limitation; frequent exacerbations/ hospitalization)	• High dose of inhaled steroid administered regularly by a large volume spacer device + inhaled long-acting β_2 receptor agonist (salmeterol) twice daily • Leukotriene antagonist/sustained release oral theophylline/oral β_2 receptor agonist/inhaled ipratropium bromide • Rescue treatment with short-acting inhaled β_2 receptor agonist • Humidified oxygen inhalation

  - **Nebulizers:** It is an electrical drug delivery device, which converts the nebulizing solution into aerosol forms for inhalation with the help of mask. It provides immediate local action on the tracheobronchial tree. It is used at bedside in patients of all age groups.
- **Drug as dry powder:** Spinhaler, rotahalers.
  - **Dry powder inhalers:** They are also a portable handy drug delivery device in which the drug-containing capsule is fitted in a pit. The rotation of the device breaks the capsule, which releases the aerosolized drug. The patient has to take deep inspiration through this device, which carries the aerosolized drug directly to the site of action.

STATUS ASTHMATICUS/ REFRACTORY ASTHMA

It is also known as acute severe asthma. It is a life-threatening condition and mostly occurs due to precipitation of chronic asthma by acute respiratory infection.

Patient presents with following signs/symptoms:

- Unable to speak a sentence due to severe dyspnea.
- Severe cyanosis.
- Pulsus paradoxus (inspiratory fall in systolic blood pressure ≥10 mm Hg).
- Silent chest (No pathological sign during auscultation).
- Encephalopathy, seizure, coma and death if not treated appropriately within the golden period.

Management of Status Asthmaticus

- Hydrocortisone 100 mg intravenously given stat, then 100–200 mg 4–8 hourly infusion (or equivalent dose of another glucocorticoid). The onset of action of hydrocortisone takes about 6 hours.
- 2.5–5 mg of nebulized salbutamol + 0.5 mg of ipratropium bromide.
- Administration of humidified oxygen in high flow.
- Salbutamol/terbutaline 0.4 mg intramuscularly or subcutaneously can be given for its better therapeutic effect.
- In severe respiratory distress, intubation and mechanical ventilation is advocated.
- Broad spectrum antibiotic therapy is required to control the chest infection.
- Correction of electrolyte imbalance.
- Correction of acidosis with Sod. Bicarbonate/lactate infusion.
- If hypokalemia is detected, correct with potassium chloride infusion.
- Recording and maintenance of vitals.

1 Case Scenario Explanation

- For the management of acute attack of bronchial asthma inhaled β_2 agonists such as salbutamol are the main line of drugs, since the patient on propranolol, which is non-selective β-blocker, the effect of β_2 agonists will be ineffective.
- In this situation bronchodilators other than β_2 agonists such as theophylline (methylxanthines) or ipratropium bromide (anticholinergic) are given.

Drug Interactions

- The metabolism of theophylline is enhanced by smoking, phenytoin and rifampicin by microsomal enzyme induction; hence, either dose of theophylline should be increased or the combination should be avoided.
- The metabolism of theophylline is decreased by allopurinol, ciprofloxacin erythromycin and oral contraceptives; hence, either dose of theophylline should be decreased or the combination should be avoided.
- The effects of oral anticoagulants, digitalis, furosemide and oral hypoglycemic are enhanced by theophylline.
- Injection of aminophylline interacts with phenytoin, insulin, erythromycin, tetracyclines, etc. Hence, mixing in the same infusion bottle should be avoided.
- Sodium cromoglycate potentiates the effect of sedatives, hypnotics, antihistaminics and alcohol.

Nursing Implications *Patients Receiving Antiasthmatics*

Assessment

Baseline Assessment

- Obtain complete medical and personal history related to the diseases prior to admission. That includes history of cerebrovascular, cardiovascular, respiratory, metabolic disease, drug history, drug/food allergy, OTC/herbal drugs, and symptoms that associated with any food, seasons or environmental changes.
- Also take proper history of allergens (pollen dust, soap, detergent, carpet, cosmetics, pets, cloths, seasons, etc.) in patient with asthma.
- Assess for contraindications or cautions: known allergies to these drugs to avoid hypersensitivity reactions.
- Assess patients-related laboratory investigations, such as CBC, oxygen saturation, PFT, electrolytes, LFT and RFT.
- Obtain appropriated baseline of vital signs, urinary output, cardiac output, bowel sound, height and weight.
- Assess any sign of sleeping and eating alterations, and patient or caregiver ability to understand instruction.

Assessment during Drug Administration

- During drug administration nurses should monitor patient's hemodynamic status.
- Monitor the therapeutic effect of drugs such as improvement in breathlessness, PFT, nocturnal sleep with better peripheral oxygen perfusion and feeling of wellbeing.
- Frequently monitor vital signs, oxygen saturation, respiratory rate, any additional breath sounds, increase mucous production. Arterial blood gas analysis should be done to diagnose any metabolic/respiratory acidosis.
- It is utmost important to observe any side effect such as cough, fever, palpitation, dry mouth, blurred vision, fatigue, dizziness, drowsiness, tachycardia, tachycardia, increased pulmonary congestion and dyspnea during drug administration and should be reported promptly.

Nursing diagnosis

- Hypoventilation
- Anxiety
- Impaired Tissue Perfusion
- Alteration in sleep pattern
- Tolerance
- Poor knowledge about medicines
- Drug related side effects

Patient-related goals and outcomes

- The patients:
  - Will observe the therapeutic outcome of given drugs like improvement in breathlessness, PFT, nocturnal sleep with better peripheral oxygen perfusion and feeling of wellbeing.
  - Can have negligible drug induce side effects.
  - Can express the indications, side effects and precaution of given drugs.
  - Can self-administer drug in prescribed dose and timing.

Contd...

Nursing interventions	Patient-centered care
To Ensure Drug Therapeutic Effect ➥ It is mandatory to observe patient frequently for any drug-induced effect. Patient's hemodynamic status should be maintained in a normal level as set by the physician. ➥ Continue monitor the therapeutic aim as the drug is given for, such as improvement in breathlessness, PFT, nocturnal sleep with better peripheral oxygen perfusion, reduction in additional breath sounds, and feeling of wellbeing. ➥ Frequently monitor vital signs, oxygen saturation, respiratory rate by pulse oximeter, and arterial blood gas analysis should be done to diagnose any metabolic/respiratory acidosis. ➥ Always keep inhaler bronchodilator (short acting) in case of acute asthmatic attack. Nurse should be aware of the proper route of drug delivery and onset of action of various bronchodilator. ➥ Assure that route of administration is appropriate for each patient to ensure therapeutic effects and decrease adverse effects. ➥ Supportive measures should be provided by nursing staff, that improves the patient's compliance and better outcome. ➥ Follow and teach appropriate technique of routes of administration. **Minimize Side Effects** ➥ Monitoring patients' rate and depth of respiration, adventitious breath sound, if any, abnormal pulmonary secretion with cough; these symptoms are responsible for poor tissue perfusion can cause hypoxia, anxiety, syncope, confusion; it could be sign of ineffective drug therapy. ➥ During aminophylline infusion, keep a check on heart rate as HR >120/min is a sign of toxicity. ➥ Keep a close look on vitals of the patient when administering intravenous medications. ➥ Monitor any sign of nocturnal breathing difficulties, provide highly nutritious diet; In COPD/Asthma, patients unable to performed normal daily life activity (proper eating, sleeping) due to hypoxia. ➥ Follow drug dosing and frequency of bronchodilators, corticosteroids, mast cell stabilizer and anticholinergics as advised by treating physician to avoid acute exacerbation of asthmatic attack. ➥ Do perform postural drainage (with tapping) wherever recommended by the physician. ➥ Nurse should know the appropriate technique to deliver inhaler/MDIs/Rotahalers (especially while administrating inhalational corticosteroids), and after administrating these agents; to avoid the drug must not back to the pharynx. Always wash mouth after delivery inhalational agent to prevent opportunistic infection such as candida or oral thrust and ulcers. ➥ Frequently monitor vital signs, oxygen saturation, respiratory rate, any additional breath sounds, increase mucous production. Arterial blood gas analysis should be done to diagnose any metabolic/respiratory acidosis. ➥ Monitor any drugs induced ADRs, i.e., cough, fever, palpitation, dry mouth, blurred vision, fatigue, dizziness, drowsiness, tachycardia, tachycardia, increased pulmonary congestion and dyspnea during drug administration and should be reported promptly.	➥ Teach the use of inhalers to patients. Advise the patient to brush the teeth after using inhalers to prevent infections in mouth (steroid inhaler cause fungal infection in mouth). ➥ Advise patient not to crush the tablet in mouth except chewable tablets. ➥ Be well conversant with proper use of inhalers, rotahalers and nebulizers. ➥ Provide thorough patient teaching, including drug name, prescribed dose, measures for avoidance of adverse effects, and warning signs that may indicate possible problems. ➥ Advise and instruct patient their caregiver to avoid contact with any noxious food/product which stimulate asthmatic attacks. ➥ Review patient's medications, food and any infectious condition, which may trigger asthma. ➥ Advise patient and their caregivers to maintain a very healthy nutritive diet as: ➥ Increase intake of fluids and try to mobilize mucus in the mouth. ➥ Take meals with high in calorie and nutrition in small amount but frequently to maintain body nutrition and avoid fatigue. ➥ Get ample amount of sleep/rest in between eating and body activity. ➥ The room temperature should be comfortable (not too much cold/hot) to avoid any breathing difficulties. ➥ Minimize exposure of allergens. ➥ Report immediately, if any sign of dyspnea, poor nutrition/food intake, altered sleep patterns or unable to sleep. ➥ Educate patient and their caregiver to report any unwanted side effect such as cough, fever, palpitation, dry mouth, blurred vision, fatigue, dizziness, drowsiness, tachycardia, tachycardia, increased pulmonary congestion and dyspnea. ➥ Educate and instruct patient to follow appropriate drug guidelines: ➥ It is utmost important to know the proper administrating guideline of inhalational agent (inhaler or MDIs or rotahalers); as the drug should reach the bronchi for proper therapeutic effect. ➥ Advise patient to shake/load the inhaler with tablet/powder as instructed. ➥ When corticosteroid and bronchodilator inhalational agents are prescribed; patient should inhale bronchodilator first, and after 10–15 minutes take corticosteroid. ➥ Instruct patient to wash mouth every time after use of inhalers. ➥ Also wash the inhaler and spacer with water daily basis and dry in air.

MUCOLYTICS

(*muco*- mucous; *lytic*- to break)

- These are the drugs, which liquefy the sputum by breaking down the disulfide bonds in mucopolysaccharide strands. The thick tenacious sputum/secretions are very difficult to expel out in cough. These drugs help in easy expulsion of thick, tenacious secretions by decreasing the viscosity of sputum.
- The following drugs act as Mucolytics:
- Bromhexine, Ambroxol, Acetylcysteine, Carbocysteine, Dornase alfa

BROMHEXINE

- It is a potent mucolytic and mucokinetic, capable of inducing thin copious bronchial secretion.
- It is given orally.
- It breaks down the network of fibers in tenacious sputum by depolymerizing mucopolysaccharides and also by liberating lysosomal enzymes.

Dose

- Adults: 8 mg thrice daily.
- Children (1–5 years): 4 mg twice daily and for 5–10 years 4 mg thrice daily.

Side Effects

- Rhinorrhea
- Lacrimation
- Nausea and gastric irritation
- Hypersensitivity.

AMBROXOL

- It is a metabolite of bromhexine.
- It is given orally.
- Its mucolytic action, uses and side effects are similar to bromhexine.

Dose

15–30 mg thrice daily.

ACETYLCYSTEINE

- Acetylcysteine/N-acetylcysteine (NAC) is a mucolytic and antioxidant drug that may also influence several inflammatory pathways.
- Acetylcysteine's sulfhydryl groups, hydrolyze disulfide bonds within mucin, breaking down the oligomers, and making the mucin less viscid.
- These sulfhydryl groups also act as a precursor of reduced glutathione and as a direct reactive oxygen species (ROS) scavenger; hence, it regulates the redox status in the cells for their antioxidant effect.
- It is a good mucolytic, available in solution and tablet form.
- It is administered directly into the respiratory tract by injectable solution, which is given by nebulization or by instilling through tracheostomy tube.
- It opens disulfide bonds in mucoproteins present in sputum and makes it less viscid.
- It is also used as antidote in paracetamol poisoning.

Dose

- By nebulization, 2–20 mL of 10% solution 2–6 hourly.
- By direct instillation in lungs, 1–2 mL of 10–20% solution 1–4 hourly.
- Tablet: 600 mg thrice daily.

CARBOCYSTEINE

- It liquefies viscid sputum in the same way as acetylcysteine.
- It is administered orally.
- Specially given in patients of chronic bronchitis.
- Most effective in *smoker's cough*.

Dose

250–750 mg thrice daily.

Side Effects

- Rashes
- Gastric discomfort hence, contraindicated in peptic ulcer.

Other Uses

Bronchitis, bronchiectasis, sinusitis, etc.

DORNASE ALFA

- It is a mucolytic prepared by recombinant DNA technique.
- It selectively breaks down respiratory tract mucus by separating extracellular DNA from proteins.
- Dornase alfa has a long duration of action.

- It is used in:
  - Cystic fibrosis, which is characterized by thick, tenacious mucous production.
  - Postoperative patients such as patients with tracheostomy to facilitate airway clearance and suction.
  - Clearing of secretions for diagnostic tests (e.g., diagnostic bronchoscopy).

Dose

About 2.5 mg once daily inhaled through nebulizer, may increase to 2.5 mg twice daily, if needed.

CONTRAINDICATIONS AND CAUTIONS

- In patients of acute bronchospasm, the increased secretions can aggravate the problem. Hence, contraindicated.
- Cautious use in patients suffering from peptic ulcer and esophageal varices, because these drugs can break the gastric mucosal barrier.

DECONGESTANTS

- These are the drugs, which decrease the overproduction of secretions by causing local vasoconstriction in the nasal mucosa.
- These drugs provide relief from the discomfort of blocked nose by promoting drainage of secretions and thereby improving airflow.
- Topical decongestants are sympathomimetics, meaning that they imitate the effects of the sympathetic nervous system to cause vasoconstriction.
- They are available as nasal drops and nasal sprays.
- These are used to relieve the discomfort of nasal congestion that accompanies the common cold, sinusitis, and allergic rhinitis.

The commonly used nasal decongestants are:

- **Topical nasal decongestants:** Ephedrine, Xylometazoline, Phenylephrine, Oxymetazoline, etc. (Table 4.6).
- **Oral decongestants:** Pseudoephedrine (Table 4.7).
- **Topical steroid nasal decongestants:** Beclomethasone, Flunisolide Dexamethasone, Budesonide, Triamcinolone, etc. (Table 4.8).

INDICATIONS

- Nasal congestion related to the common cold, sinusitis, and allergic rhinitis.
- To relieve the pain and congestion of otitis media.

Table 4.6: Topical nasal decongestants

Drugs	Dosage
Ephedrine	• Instill solution in each nostril 4 hourly • Do not use for children <6 years unless advised by physician
Xylometazoline	• Adult: Two to three sprays or two to three drops in each nostril 8 hourly (0.17% solution) • Pediatric (2–12 years): Two to three drops of 0.05% solution 8–12 hourly
Phenylephrine	• Adult and pediatric (>6 years): One to two sprays in each nostril 3–4 hourly • Pediatric (2–6 years): Two to three drops of 0.125% solution in each nostril 4 hourly
Oxymetazoline	• Adult and pediatric (>6 years): Two to three sprays or drops in each nostril 12 hourly • Pediatric (2–5 years): Two to three drops of 0.05% solution in each nostril 12 hourly

Table 4.7: Oral decongestants

Drug	Dosage
Pseudoephedrine	• Adult: 60 mg 4–6 hourly • Pediatric: 6–12 years 30 mg 4–6 hourly • 2–5 years 15 mg 4–6 hourly • 1–2 years 0.02 mL/kg 4–6 hourly • 3–12 months: three drops/kg 4–6 hourly

Table 4.8: Topical steroid nasal decongestants

Drug	Dosage
Beclomethasone	• Adult: One to two inhalations in each nostril 12 hourly • Pediatric (6–11 years): One inhalation in each nostril 12 hourly
Flunisolide	• Adult: Two sprays in each nostril 12 hourly • Pediatric (6–14 years): One spray in each nostril 8 hourly to two sprays in each nostril 12 hourly
Dexamethasone	• Adult: Two sprays in each nostril BD to TDS • Pediatric: One to two sprays in each nostril 12 hourly
Budesonide	• Adult and pediatric (>6 years): Two sprays in each nostril morning and evening or four sprays in each nostril in the morning
Triamcinolone	• Adult: Two sprays in each nostril every day

PHARMACOKINETICS

- **Topical nasal decongestants:** The onset of action is almost immediate. These are not generally absorbed systemically. The metabolism occurs in the liver and excretion through kidneys, if the drug is absorbed.
- **Oral decongestants**: Pseudoephedrine is well absorbed and attains peak levels quickly in 20–45 minutes. The metabolism occurs in the liver and excretion through kidneys.
- **Topical steroid nasal decongestants:** The onset of action is not immediate. These drugs may require up to 1 week to produce their effect. The drug should be discontinued, if no effects are seen after 3 weeks. These drugs are not generally absorbed systemically. The absorbed drug (if any) is metabolized in the same way as other steroids.

The contraindications, and adverse effects of various decongestants are given in Tables 4.9 and 4.10, respectively.

Table 4.9: Contraindications and cautions of decongestants

Drug class	Contraindications and cautions
Topical nasal decongestants	• Erosion in the mucous membranes. • Glaucoma, diabetes, coronary disease, hypertension thyroid disease, or prostate hypertrophy
Oral decongestants	• Glaucoma, diabetes, coronary disease, hypertension thyroid disease, or prostate hypertrophy
Topical steroid nasal decongestants	• Active infection such as tuberculosis • Chicken pox or Measles

Table 4.10: Adverse effects of decongestants

Drugs class	Adverse effects
Topical nasal decongestants	• Local stinging and burning • Rebound congestion • Sympathomimetic effects (e.g., increased pulse rate and BP; urinary retention) seen in some patients only
Oral decongestants	• Rebound congestion • Sympathomimetic effects such as anxiety, restlessness, tremors, hypertension, arrhythmias, sweating, and pallor
Topical steroid nasal decongestants	• Local irritation, headache and dryness of the mucosa • Delayed healing in nasal surgery or trauma

EXPECTORANTS

(Mucokinetics, muco-mucous, kinetics-movement)

- Expectorants are also called *Mucokinetics*.
- Expectorants are the drugs which increase the bronchial secretions.
- These drugs also reduce the viscosity of these secretions thereby helping in easy expulsion of the sputum.
- These are included in expectorant formulations in combination with antitussives and antihistaminics.

Examples are:

- **Bronchial secretion enhancers:** Guaiphenesin, Sodium or Potassium citrate, Potassium iodide, Ammonium chloride, Vasaka.
- **Mucolytics:** Acetyl cysteine, Ambroxol, Bromhexine, Carbocisteine.

MECHANISM OF ACTION OF EXPECTORANTS (TABLE 4.11)

Indications

In the treatment of productive cough accompanied with excessive, thick and difficult to remove secretion/sputum.

Adverse Effects

- GI symptoms such as nausea, vomiting, and anorexia (most common).
- Headache, dizziness or both.

Table 4.11: Expectorants

Drug	Dosage	Mechanism of action
Sodium and Potassium citrate	1–2 g	Increase bronchial secretion by salt action
Ammonium chloride	300 mg	Reflexly increase respiratory secretions
Potassium iodide	200–300 mg	Irritate the airway mucosa as it is secreted by bronchial glands
Guaiphenesin (most commonly used)	**Adult and pediatric** (>12 years): 200–400 mg PO 4 hourly **Pediatric**: 6–12 years 100–200 mg 4 hourly 2–6 years 50–100 mg 4 hourly	Enhance mucociliary excretory function as these are secreted by tracheobronchial glands

Precautions

- The most important consideration in the use of these drugs is identifying the exact cause of the underlying cough.
- Prolonged use of the OTC (cough syrup) preparations could result in the masking of important symptoms of a serious underlying disorder.
- These drugs should not be used for more than 1 week; if the cough persists, encourage the patient to seek health care.

The various drugs classes and their sites of action on respiratory tract are given in Figure 4.2.

ANTITUSSIVES

The drugs used to control the dry cough are known as antitussives.

- These drugs act directly on the cough center in the medulla of the brain to depress the cough reflex and raise the threshold of cough center, or
- Act peripherally in the respiratory tract to reduce cough impulses, or both these actions.

The aim of giving antitussives is to control rather than eliminate cough.

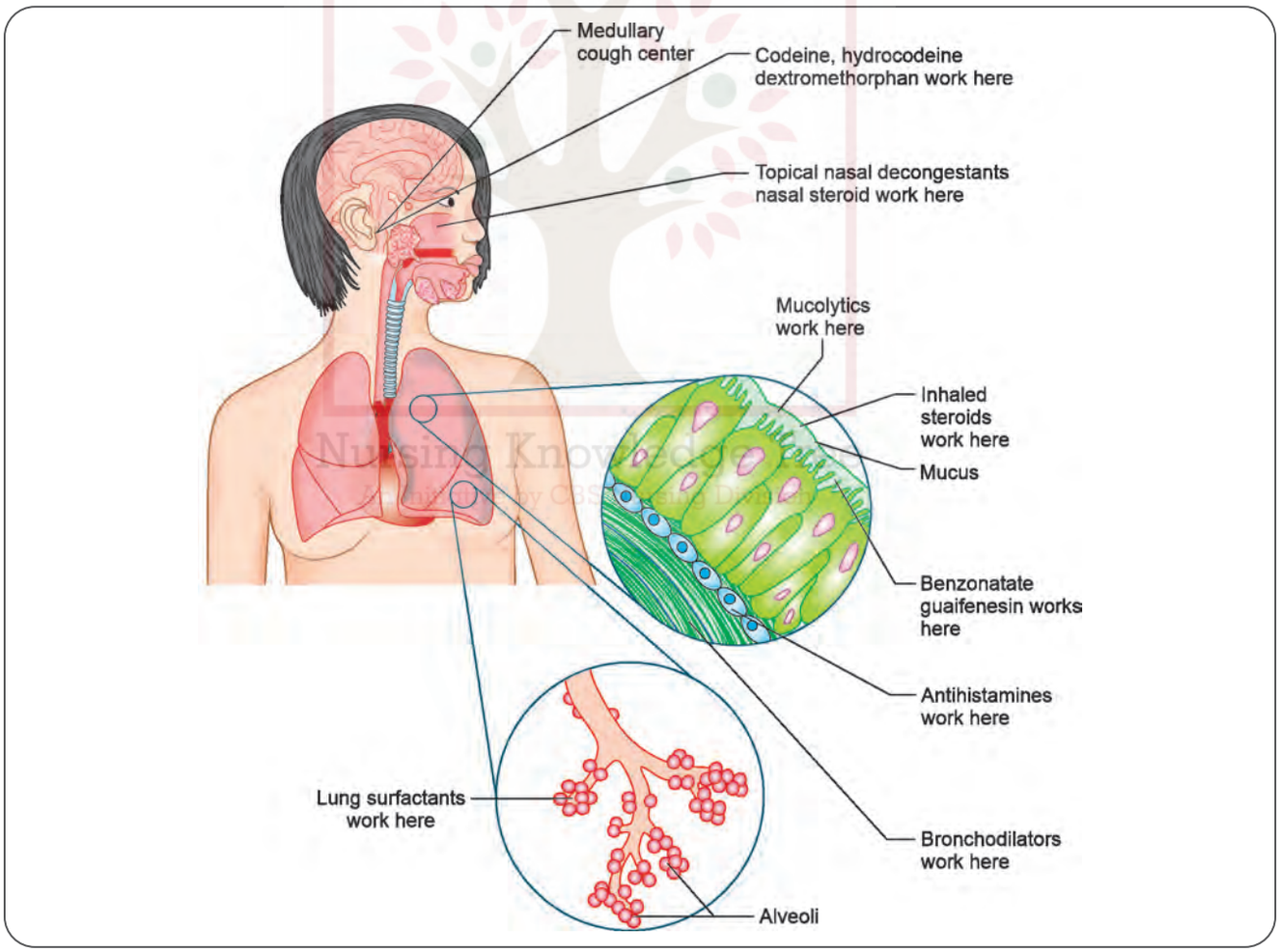

Fig. 4.2: Site of action of various drugs on respiratory tract

CLASSIFICATION OF ANTITUSSIVES

Antitussives can be classified into:

- **Opioids:** Codeine, Pholcodeine, Ethyl morphine
- **Nonopioids:** Noscapine, Dextromethorphan, Chlophedianol

Opioids

Codeine (Methyl Morphine)

- An opium alkaloid, similar to but less potent than morphine
- More selective for cough center.
- Codeine is regarded as the standard antitussive.
- Suppresses cough for about 6 hours.
- Abuse liability is low, but present.

Side Effects and Precautions

- Constipation.
- Respiratory depression (at higher dosage).
- It causes drowsiness. Hence, cautionary advised for drivers.
- It is contraindicated in asthmatics.
- It should be avoided in children.
- Not to be used in head injury patients.

Dose

- Adult: 10–20 mg orally 4–6 hourly.
- Pediatric (6–12 years): 5–10 mg orally 4–6 hourly.
- Pediatric (2–6 years): 2.5–5 mg orally 4–6 hourly.

Pholcodeine

- It is similar to codeine in efficacy as antitussive.
- It is longer acting and acts for 12 hours.
- It has no analgesic or addicting property.

Dose

10–15 mg 12 hourly.

Ethyl Morphine

It is similar to codeine in all actions except constipation, which is less with it.

Dose

10–30 mg 8 hourly.

Nonopioids

Noscapine (Narcotine)

- It is nearly equipotent antitussive as codeine.
- It depresses the cough center.
- It has no narcotic, analgesic or dependence inducing properties.
- Useful in spasmodic cough.

Side Effects

- Headache and nausea
- Bronchoconstriction in asthmatics

Dose

- Adults: Given in a dose of 15–30 mg 3–4 times daily.
- Children (2–6 years): Given in a dose of 7.5 mg 3–4 times daily.
- Children (6–12 years): Given in a dose of 15 mg 3–4 times daily.

Dextromethorphan

- The antitussive action of dextromethorphan is similar to codeine.
- It is a synthetic and centrally acting NMDA (N-methyl D-aspartate) receptor antagonist.
- Constipation not seen.
- Non-addicting.

Side Effects

- Dizziness
- Nausea
- Drowsiness
- Ataxia and hallucinations (at high doses)

Dose

- Adult: 10–30 mg 4–8 hourly; 60 mg 8 hourly for sustained action
- Pediatric (6–12 years): 5–10 mg 4 hourly; 30 mg 8 hourly for sustained action
- Pediatric (2–6 years): 2.5–7.5 mg 4–8 hourly; 15 mg 8 hourly for sustained action

Chlophedianol

- It is an antitussive having central action.
- It has slow onset of action with longer duration.

Side Effects

The common side effects are vertigo, irritability, sedation and dryness of mouth.

Dose

20–40 mg 2–3 times daily.

Pharmacokinetics

- All antitussives are rapidly absorbed orally.
- The metabolism occurs in liver, and excretion through kidneys.
- It crosses the placenta barrier and secreted in breast milk.

Contraindications and Cautions

- Patients with asthma and emphysema because cough suppression in these patients could lead to an accumulation of secretions.
- Patients who are hypersensitive to or have a history of addiction to narcotics.
- During driving, as these drugs can cause sedation and drowsiness.
- Pregnancy and lactation. These drugs are having potential for adverse effects on the fetus or baby, including sedation and CNS depression.

BRONCHOCONSTRICTORS

- The drugs which cause constriction of bronchi (bronchospasm) are called *bronchoconstrictors*.
- Bronchoconstriction is never induced as a part of any treatment, except in experimental animals to check the effectiveness of bronchodilators.
- In experimental animals' *histamine* is commonly used as bronchoconstriction inducing agent.
- Some other bronchoconstrictors are 5HT, LTC_4, LTD_4, PGF_2, PGD_2, PAF and TXA_2.
- Bronchoconstriction due to histamine causes symptoms of dyspnea, which are antagonized with antihistaminics and adrenaline, which act as physiological antagonist.

ANTIHISTAMINICS

The drugs which competitively antagonize the actions of histamine on histaminic receptors are called *antihistaminic drugs.*

HISTAMINE

- A major amount of histamine is present in the mast cells.
- The tissues containing maximum histamine are skin, gastric mucosa, intestinal mucosa, liver, placenta and lungs.
- Brain, gastric mucosa, epidermis and growing regions contain non-mast cell histamine.
- Some other sites where histamine is found are body secretions, blood, pathological fluids and venoms of snake and scorpions.
- *Histamine* acts through various receptors known as histaminic receptors.

HISTAMINE RECEPTORS

The histamine receptors are of four types: *H_1, H_2, H_3 and H_4* (Table 4.12).

- The antihistaminic term is conventionally used for H_1 antagonists only.
- The drugs which antagonise H_2 receptors are called H_2 receptor blockers. H_2 receptor blockers are specifically used for acid suppression in gastric mucosa and are *studied in detail with GIT system.*
- H_3 and H_4 antagonists have not been ascribed any specific clinical utility yet.

ANTIHISTAMINICS (H_1 ANTAGONISTS)

- The H_1 antagonistic drugs act at H_1 receptors and antagonise the actions of histamine competitively.

Table 4.12: Histamine receptors

Receptor	Distribution in body	Actions
H_1 receptor	Airway, intestinal and uterine smooth muscle	Contractions
	Blood vessels	Vasodilatation due to release of nitrous oxide
	Larger blood vessels (smooth muscles)	Vasoconstriction
H_2 receptor	Gastric glands	Increase acid secretion
	Blood vessels	Vasodilatory effect
	Brain	Increase synapse transmission
H_3 receptor	Brain	Sedation
	Lung, spleen, skin and gastric mucosa	Reduction of histamine release
H_4 receptor	Eosinophil, mast cells and basophils	Chemotaxis effect

- The H_1 antihistaminics have many common properties except they differ in their sedative actions mainly.

CLASSIFICATION OF ANTIHISTAMINICS

- First generation: Mild, moderate and highly sedative
- Second generation or nonsedative

First Generation Antihistaminics (Table 4.13)

The first compound of this group was introduced in the late 1930s. These were very frequently used before introduction of less sedating/nonsedating. 2nd generation antihistaminics. Some of these drugs are still used for a variety of purposes.

Table 4.13: First generation of antihistaminics

Drugs	Dose and route of administration
Mild sedatives	
Chlorpheniramine	2–4 mg orally and intramuscularly
Dexchlorpheniramine	2 mg, by oral route
Triprolidine	2.5–5 mg, by oral route
Clemastine	1–2 mg, by oral route
Moderate sedative	
Pheniramine	20–50 mg orally and intramuscularly
Cinnarizine	25–50 mg, by oral route
Cyproheptadine	4 mg, by oral route
Highly sedative	
Diphenhydramine	25–50 mg, by oral route
Promethazine	25–50 mg orally and intramuscularly
Hydroxyzine	25–50 mg, by oral route

Pharmacological Actions

- **Histaminic antagonizing effects:** The bronchoconstriction and the triple response due to histamine are antagonised. The triple response consists of wheal, flare and itch.
- **Antiallergic effects:** The manifestations of immediate hypersensitivity (type I reactions) are suppressed. They are having a good role in the treatment of urticaria, itching and angioedema.
- **Anticholinergic effects:** The acetylcholine produces muscarinic effects through H_1 receptor, which are antagonized by these drugs.
- **CNS effects:** The older antihistaminics show sedative effects, whereas these effects are rarely or not at all seen with the newer second-generation antihistaminics drugs.
- **CVS effects:** No CVS effects are seen on oral administration. Fast IV administration of these drugs can produce sudden hypotension.

Pharmacokinetics

- By both oral and parenteral routes, the absorption of these drugs is optimal.
- The metabolism occurs in liver and excretion occurs through urine.
- These agents show wide distribution in the body tissues and also penetrates the blood brain barrier.
- The 2nd generation agents have poor or absent penetration of blood brain barrier. Hence, have minimal or no sedative effect.

Side Effects

Side effects of first generation H_1 antihistaminics are frequent, but generally mild.

- Some tolerance to side effects develops on repeated use.
- The common side effects are sedation, reduced alertness and ability to concentrate, tendency to fall asleep, headache, listlessness.
- Regular use of conventional antihistamines may interfere with learning due to CNS depressant property hence, not advisable in children.
- Some other side effects due to anticholinergic activity are xerostomia, visual disturbance, GI disturbances and urinary hesitation.

Second Generation Antihistaminics (Table 4.14)

The H_1 receptor blockers, which were marketed after 1980, are called second generation antihistaminics (SGAs).

These have one or more of the following properties:

- No sleepiness due to absence of CNS depression.
- No anticholinergic side effects due to highly H_1 selectivity.

Table 4.14: Second generation antihistaminics

Drug	Dosage	Specific points
Fexofenadine	120–180 mg orally, once daily	Safe in cardiac patients, doesn't cross blood brain barrier
Loratadine	10 mg orally, once daily	Fast acting, with longer t½ of 17 hours
Desloratadine	5 mg orally, once daily	Effective at half the dose of loratadine

Contd...

Drug	Dosage	Specific points
Cetirizine	10 mg orally, once daily	Metabolite of hydroxyzine Mild sedation in some recipients Attains high concentration in skin
Levocetirizine	5–10 mg orally, once daily	It is the active enantiomer of cetirizine Effective at half the dose of cetirizine Less sedative
Azelastine	4 mg orally, once daily; 0.28 mg intranasally	Good topical activity antagonises LT and PAF Provide quick symptomatic relief when given by intranasal route
Rupatadine	10 mg orally, once daily	Additional PAF antagonistic property

- Additional antiallergic mechanisms such as antagonising leukotrienes and PAF.
- Poor antipruritic, antiemetic and antitussive actions.

Major Indications

- **Nose:** Allergic rhinitis, pollinosis, (to control sneezing, runny but not blocked nose).
- **Eye:** Conjunctivitis, red, watering and itchy eyes.
- **Skin:** Atopic eczema, urticaria, dermographism, hay fever,
- **General:** Drug and food allergy.

USES OF ANTIHISTAMINICS

- **Allergic disorders** of eye (*allergic conjunctivitis, angioedema of eyelids, etc.*), nose (*rhinitis, sneezing, etc.*) and skin (*angioedema of lips, itching urticaria, hay fever, etc.*) and other general allergic disorders.
- **Pruritis:** Antihistaminics, like chlorpheniramine, diphenhydramine and cyproheptadine are very commonly used in idiopathic pruritic cases.
- **Common cold:** Second generation antihistamines are less effective in this respect. First generation antihistaminics provide only symptomatic relief by anticholinergic (reduce rhinorrhea) effect, but do not alter the course of the illness.
- **Motion sickness:** Promethazine, diphenhydramine and dimenhydrinate. These drugs should be taken at least one hour before starting journey to get the best effects.
- **Vertigo:** Cinnarizine is commonly used in Meniere's disease and other types of vertigo.

Nursing Implications *Patients Receiving Pharmacotherapy for Symptomatic Cold Relief*

Assessment	Nursing diagnosis
Baseline Assessment ➥ Obtain complete medical and personal history related to the diseases prior to admission. That includes history of cerebrovascular, cardiovascular, respiratory, metabolic disease, drug history, drug/food allergy, OTC/herbal drugs, and symptoms associated with any food, seasons or environmental changes. ➥ Assess for contraindications or cautions: known allergies to these drugs to avoid hypersensitivity reactions. ➥ Assess patients related laboratory investigations such as CBC, oxygen saturation, PFT, electrolytes, LFT and RFT. ➥ Obtain appropriated baseline of vital signs, urinary output, cardiac output, bowel sound, height and weight. ➥ Assess any sign of sleeping alterations, and patient or caregiver ability to understand instruction.	➥ Hypoventilation ➥ Impaired breathing ➥ Anxiety ➥ Alteration in sleep pattern ➥ Poor knowledge about medicines ➥ Drug related side effects

Contd...

Assessment	Nursing diagnosis

Assessment during Drug Administration

- During drug administration nurses should monitor patient's hemodynamic status.
- Monitor the therapeutic effect of drugs such as improvement in breathing, nasal congestion, cough, and reduction in mucous production and other respiratory symptoms.
- Provide steam inhalations with care whenever advised.
- It is utmost important to observe any side effect such as headache, blurred vision, fatigue, dizziness, drowsiness, fever, tachycardia, increased pulmonary congestion, palpitations, syncope, epistaxis, dyspnea and confusion during drug administration and should be reported promptly.

Patient related goals and outcomes

- The patients:
  - Will observe the therapeutic outcome of given drugs, like improvement in breathing, nasal congestion, cough, and reduction in mucous production and other respiratory symptoms.
  - Can have negligible drug induce side effects.
  - Can express the indications, side effects and precaution of given drugs.
  - Can self-administered drug in prescribed dose and timing.

Nursing interventions	Patient-centered care

To Ensure Drug Therapeutic Effect

- It is mandatory to observe patient frequently for any drug induce effect. Patient's hemodynamic status should be maintained in a normal level as set by the physician.
- Continue monitor the therapeutic aim as the drug is given for such as improvement in breathing, nasal congestion, cough, and reduction in mucous production and other respiratory symptoms.
- Provide other measures to help relieve cough (e.g., humidity, cool temperatures, fluids, use of topical lozenges) as appropriate.
- Assure that route of administration is appropriate for each patient to ensure therapeutic effects and decrease adverse effects.
- Supportive measures should be provided by nursing staff, that improves the patient's compliance and better outcome.
- Follow and teach appropriate technique of routes of administration.

Minimize Side Effects

- Do not use decongestants in hypertensive patients.
- As some antihistaminics cause sedation, advise patient to take these drugs at bedtime only.
- Avoid combining the mucolytic agents with other drugs in the nebulizer to avoid the formation of precipitates and potential loss of effectiveness of either drug.
- Monitoring patient's rate and depth of respiration, adventitious breath sound if any, abnormal pulmonary secretion with cough; these symptoms are responsible for poor tissue perfusion can cause hypoxia, anxiety, syncope, confusion; it could be sign of ineffective drug therapy.
- Special care is advised while handling elder patients; as many drugs can cause dizziness; hence there is increased risk of fall.
- Frequently monitor patient vitals; Sympathomimetic decongestant may produce tachycardia and arrhythmias.
- Monitors any severity of respiratory symptoms, such as increase cough, hemoptysis, dyspnea and pulmonary congestion; these could be sign of severity and ineffective drug therapy.

- After administering liquid preparation for cough, advise patient not to take any liquids for 20–30 minutes.
- Educate patient to practice non-pharmacological measure such as steam inhalation, increase fluid intake to liquify and mobilize mucus.
- Educate patient and their caregivers to assist him/her duration ambulation (especially elder patients).
- Provide thorough patient teaching, including drug name, prescribed dose, measures for avoidance of adverse effects, and warning signs that may indicate possible problems.
- Teach the patient appropriate method to cleat nasal blockage and use of nasal decongestant.
- Educate patient and their caregiver to report any unwanted side effects, such as GI upset, cough, fever, palpitation, skin rash, bronchospasm, dry mouth, blurred vision, loss of peripheral vision, visual acuity, colour halos, fatigue, CNS toxicity (restlessness, dizziness, drowsiness, insomnia, weakness), impaired sleep patterns/sleeplessness, tachycardia, tachycardia, increased pulmonary congestion and dyspnea.
- Educate and instruct patient to follow appropriate drug guidelines:
  - Cough suppressants: Syrup should be taken with/without water; coated on the throat and take fluids only after 30-60 minutes.
  - Antihistamines: Tablet/syrup can be taken with water to alleviate allergic symptoms.
  - Nasal decongestants: Apply on the nose; clears nasal passage by blowing followed by the nasal spray.
  - Expectorants: Syrups can be taken with water and increase water intake through tout the day for reduce thickening of mucus production.

Contd...

Nursing interventions	Patient-centered care
➥ Monitor any drugs induce ADRs, i.e., GI upset, cough, fever, palpitation, skin rash, bronchospasm, dry mouth, blurred vision, loss of peripheral vision, visual acuity, colour halos, fatigue, CNS toxicity (restlessness, dizziness, drowsiness, insomnia, weakness), impaired sleep patterns/sleeplessness, tachycardia, tachycardia, increased pulmonary congestion and dyspnea during drug administration and should be reported promptly.	

ACID–BASE BALANCE

- In human being, the normal pH is ranged between 7.35 and 7.45, which depends upon multiple metabolic factors such as level of bicarbonates, deoxygenated haemoglobin and kidney.
- In acid base disorders, whenever pH <7.35 indicates acidosis, and >7.45 indicates alkalosis.
- The normal range of bicarbonate (HCO_3^-) is 22–26 mEq/L and partial pressure of carbon dioxide ($PaCO_2$) is 35–45 mm Hg.
- Any changes in bicarbonate level are related to metabolic; similarly, any changes in $PaCO_2$ are related to respiratory.

Table 4.15 and Figure 4.3 show The difference of metabolic and respiratory disorders and Acid-based disturbances respectively.

Table 4.15: The difference of metabolic and respiratory disorders

Variables	Metabolic acidosis	Metabolic alkalosis	Respiratory acidosis	Respiratory alkalosis
pH	Less than 7.35	More than 7.45	Less than 7.35	More than 7.45
HCO_3^-	Less than 22mEq/L.	Higher than 26 mEq/L	Normal or high or low	Normal or high or low
$PaCO_2$	Normal or high or low	Normal or high or low	Higher than 45 mm Hg	Less than 35 mm Hg
Causes	• Diabetic ketoacidosis. • Severe diarrhea. (Loss of HCO_3). • Hypoaldosteronism. • Acute renal failure (fail to excrete H^+). • Accumulation of acids.	• Severe dehydration. • Severe vomiting (loss of stomach acid or heavy ingestion of antacids). • Hyperaldosteronism (endocrine disorders). • Excess antacids and alkaline drugs.	• CNS depression (anesthesia). • Respiratory muscle paralysis/diaphragm paralysis, rib fractures, etc. • Obstructive lung diseases, e.g., emphysema. • Pulmonary edema.	• Hyperventilation • High altitude (Oxygen deficiency. • Early salicylate intoxication. • Hysterical. • Anorexia nervosa.
Compensatory mechanism	• Increased ventilation. • Renal excretion of hydrogen ions if possible. • K^+ exchanges with excess H^+ in ECF (H^+ into cells, K^+ out of cells).	• Kidney excretes alkaline urine and retain H^+. • Respiratory compensation difficult – hypoventilation limited by hypoxia	• Kidneys eliminate hydrogen ion and retain bicarbonate ion. • Kidney also generates new bicarbonate.	• Kidneys conserve hydrogen ion. • Excrete bicarbonate ion.

Consequences	• Depression of the CNS by reducing of synaptic transmission
	• Generalized weakness
	• Deranged CNS function the greatest threat.
	• Severe acidosis causes:
	  ▪ Disorientation.
	  ▪ Coma.
	  ▪ Death.
			• Hyperexcitability of the central and peripheral nervous systems
			• Nervousness
			• Numbness
			• Headache
			• Muscle spasms or tetany
			• Convulsions
			• Loss of consciousness
			• Death	

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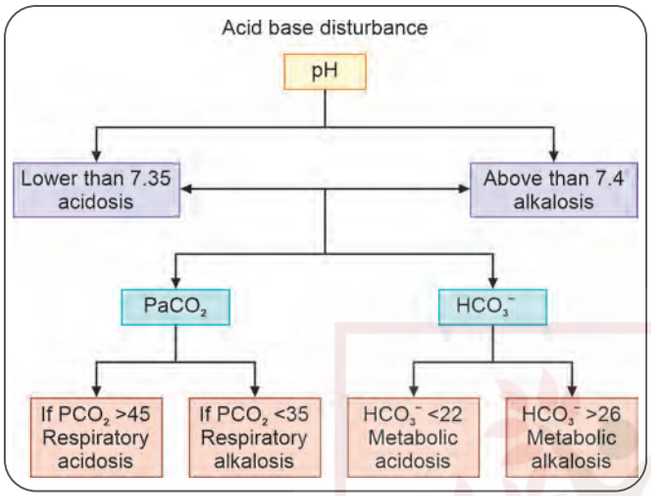

Fig. 4.3: Acid-based disturbances

Imbalance between acid and base can be divided into four types as shown above:

1. Metabolic acidosis
2. Respiratory acidosis
3. Metabolic alkalosis
4. Respiratory alkalosis

ASSESS YOURSELF

Long Answer Questions

1. What are bronchodilators?
2. Classify the drugs used for the treatment of bronchial asthma.
3. Explain pharmacological management of status asthmaticus.
4. Describe the drugs used in dry cough.
5. Describe cetirizine.
6. What do you understand by the nasal decongestants? Describe their uses and side effects.

Short Answer Questions

1. Write short notes on:
   a. Methylxanthines b. Montelukast c. Sodium cromoglycate
   d. Salbutamol e. Codeine
2. What are the differences between inhalers and nebulizers?
3. What are antiallergics?

Multiple Choice Questions

1. **A highway truck driver has profuse rhinorrhea and sneezing. Which of the following drugs would you prescribe him?**
   a. Pheniramine b. Promethazine
   c. Dimenhydrinate d. Cetirizine
2. **Second generation antihistaminics used in allergic rhinitis are:**
   a. Azelastine b. Fexofenadine
   c. Chlorpheniramine maleate
   d. Desloratadine e. Promethazine
3. **Mechanism of action of theophylline in bronchial asthma is:**
   a. Phosphodiesterase 4 inhibition
   b. β_2 agonism
   c. Anticholinergic action
   d. Inhibition of mucociliary clearance
4. **Which of the following drugs has been found to be useful in acute severe asthma?**
   a. Magnesium sulfate
   b. Antileukotriene
   c. Cromolyn sodium
   d. Cyclosporine
5. **Which of the following is *Not* an adverse effect of salbutamol?**
   a. Tachycardia
   b. Tolerance
   c. Hypokalemia
   d. Hypoglycemia

6. True about zafirlukast is:
a. It inhibits the lipoxygenase pathway
b. It decreases the frequency of asthma attacks as compared to glucocorticoids
c. It blocks LT receptor
d. It is effective in acute bronchial asthma
e. It can be administered orally

7. Which of the following anti-asthma drugs is not a bronchodilator?
a. Ipratropium bromide b. Theophylline
c. Formoterol d. Sodium cromoglycate

8. Which of the following β_2 agonists is given by inhalation and is suitable for both terminating acute asthma attacks as well as for twice daily prophylaxis?
a. Terbutaline b. Bambuterol
c. Salmeterol d. Formoterol

9. In comparison to inhaled adrenergic agonists, the inhaled anticholinergics:
a. Are more effective in bronchial asthma
b. Are better suited for controlling an acute attack of asthma
c. Produce slower response in bronchial asthma
d. Produce little benefit in chronic obstructive lung disease

10. All of the following drugs can precipitate an acute attack of asthma; Except:
a. Phenylbutazone b. Naproxen
c. Glucocorticoids d. Aspirin

11. Complications of aerosol steroids use include:
a. Oral candidiasis b. Cushing's syndrome
c. Decreased ACTH d. Systemic complications

12. In a patient of chronic asthma on treatment with theophylline, which of the following should not be used to treat his upper respiratory tract infection?
a. Ampicillin b. Cephalexin
c. Erythromycin d. All of these

13. Advantage of salmeterol over salbutamol is its:
a. Shorter duration of action
b. More potency
c. Longer duration of action
d. Lesser cardiac effects

14. The drug contraindicated in bronchial asthma is:
a. Propranolol b. Ipratropium bromide
c. Theophylline d. Ketotifen

15. Efficacy of salmeterol is increased if it is given along with:
a. Theophylline
b. Corticosteroid
c. Ipratropium
d. Sodium cromoglycate

16. Leukotrienes inhibitors are very effective in which one of the following conditions?
a. Exercise-induced asthma b. Antigen-induced asthma
c. Aspirin-induced asthma d. Occupational asthma

17. The most common dose-related side effect of salbutamol is:
a. Nervousness b. Palpitations
c. Restlessness d. Tremors

18. Which is a "soft steroid" used in bronchial asthma?
a. Budesonide b. Dexamethasone
c. Ciclesonide d. Flunisolide

19. Dextromethorphan is an:
a. Antihistaminic b. Antitussive
c. Expectorant d. Antiallergic

20. Relatively higher dose of theophylline is required to attain therapeutic plasma concentration in:
a. Smokers
b. Congestive heart failure patients
c. Those receiving erythromycin
d. Those receiving cimetidine

21. Which of the following is not a mucolytic?
a. Ambroxol b. Codeine
c. Carbocisteine d. Bromhexine

22. Which drug is not used for acute bronchial asthma?
a. Salmeterol b. Formeterol
c. Salbutamol d. Corticosteroids

23. Mechanism of action of theophylline in bronchial asthma is:
a. Inhibition of phosphodiesterase-IV
b. Beta 2 antagonism
c. Anticholinergic action
d. Inhibition of mucocillary clearance

24. Complications of aerosol steroids used include:
a. Oral candidiasis b. Cushing's syndrome
c. Decreased ACTH d. Systemic complications

25. Which of the following is not a bronchodilator?
a. Ipratropium bromide b. Methylxanthines
c. Steroids d. Anticholinergic

26. Drug inhibits histamine release:
a. d-penicillamine b. Tubocurarine
c. Atracurium d. Nedocromil sodium

27. Leukotriene receptor antagonist used in the management of bronchial asthma:
a. Sodium cormoglycate b. Zafirlukast
c. Zileuton d. Ketotifen

28. Leukotriene receptor antagonist:
a. Zafirlukast b. Nedocromil
c. Latanoprost d. Zileuton

Answer Key

1. d.	2. a, b, d.	3. a.	4. a.	5. d.	6. a, c, e.	7. d.
8. d.	9. c.	10. c.	11. a.	12. c.	13. c.	14. a.
15. b.	16. c.	17. d.	18. c.	19. b.	20. a.	21. b.
22. a.	23. a.	24. a.	25. c.	26. b.	27. b.	28. a

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