

## Anatomy and Primary Functions

The respiratory system is composed of six main organs: the nose, pharynx, larynx, trachea, bronchial tubes, and lungs

- The Lungs: Humans have two lungs; the right lung has three lobes, while the left lung has two. They are a collection of bronchi, bronchioles, and alveoli, appearing spongy because they contain air. They are protected externally by the ribs and internally by a double membrane called the pleura, which contains serous fluid to reduce friction during ventilation.
- Gas Exchange: This occurs exclusively in the alveoli.
- There are two types of alveolar cells:
  - Type I: Provides the surface area for gas exchange.
  - Type II: Secretes surfactants to decrease surface tension and helps destroy entering pathogens.
- Blood Supply: The lungs have a dual supply. The pulmonary circulation facilitates gas exchange, while the bronchial circulation supplies blood to the conducting airways and supporting structures.

## Mechanics and Control of Breathing

- Autonomic Innervation:
  - Parasympathetic: Uses muscarinic receptors to produce airway constriction and increase secretions.
  - Sympathetic: Uses B2 receptors to produce bronchodilation and decrease secretions.
- Breathing Mechanics: Breathing requires open airways and pressure changes created by respiratory muscles. Airway resistance-the impediment to airflow-is greatest in medium-sized bronchi and lowest in smaller bronchioles. Resistance decreases during inspiration as lungs expand and increases during expiration.

## Lung Volumes and Capacities:

- Tidal Volume (TV): Air moving in/out during quiet breathing (~500 mL).
- Residual Volume (RV): Air remaining after maximal expiration; cannot be measured by spirometry.
- Functional Residual Capacity (FRC): RV + Expiratory Reserve Volume (ERV).
- Regulation: Control is both automatic and voluntary. > Chemoreceptors monitor CO<sub>2</sub>, O<sub>2</sub>, and pH levels, while lung receptors monitor airway resistance and expansion. Central chemoreceptors respond mainly to CO<sub>2</sub> and H<sup>+</sup>, while peripheral chemoreceptors respond strongly to low O<sub>2</sub>.

## Clinical Terminology

- Cough Reflex: The primary defense mechanism protecting lungs from secretions and irritants.
- Dyspnea: A subjective sensation of difficulty breathing, which can present as "air hunger".
- Hypoxia: A decrease in blood oxygen levels resulting in decreased tissue oxygenation.
- Acute hypoxemia manifests as increased heart/respiratory rates, cyanosis, and impaired neurological function.

Chronic compensation includes increased ventilation, pulmonary vasoconstriction, and increased RBC production.

## \* Respiratory Diseases

### 1. Hay Fever (Seasonal Allergic Rhinitis)

Sensitivity to airborne allergens like pollen causes the respiratory mucosa to secrete excessive mucus (runny nose) and eyes to become red and itchy. It is treated with antihistamines.

### 2. Bronchial Asthma

Asthma is a common chronic childhood disease characterized by reversible airway obstruction, hypersensitivity, and bronchoconstriction.

- Triggers: Allergens (dust, pollen), anxiety, stress, overexertion, and irritants like smoke.
- Pathophysiology: Features include bronchospasm, mucosal edema, and mucus hypersecretion.

Expiration is affected more than inspiration. → Because of Bronchoconstriction.

- Phases: The Early-Phase (30-60 mins) is dominated by bronchospasm; the Late-Phase is dominated by inflammation and can lead to irreversible damage.
- Special Types: Drug-induced asthma (strikingly caused by aspirin) and occupational asthma.
- Treatment: Bronchodilators (B2 agonists like albuterol), corticosteroids, and epinephrine.
- Status asthmaticus is the most severe form, failing to respond to usual treatment and potentially requiring a tracheotomy.

Triggers → Bronchospasm + Edema + Mucus → Airway obstruction → Expiration difficulty.

### 3. COPD (Chronic Obstructive Pulmonary Disease) = Bronchitis + Emphysema

COPD involves chronic airflow limitation and progressive worsening. It is often a combination of two conditions: Chronic Bronchitis (mucus production) and Emphysema (structural changes).

- Causes: Smoking (99% of cases), environmental exposure, and **alpha-1 antitrypsin deficiency**. *due to Elastase enzyme.*
- Pathophysiology: Air becomes trapped in alveoli due to collapsed airways, leading to poor oxygenation, hypercapnia (CO<sub>2</sub> accumulation), and respiratory acidosis.  $CO_2 \uparrow \rightarrow H^+ \uparrow \rightarrow pH \downarrow \rightarrow \text{Acidosis}$
- Complications: Can lead to Cor Pulmonale (right-sided heart failure)  $\rightarrow$  peripheral lower limbs edema + jugular vein hypertension.
- Treatment: Oxygen, bronchodilators, corticosteroids (to reduce exacerbations), and pulmonary rehabilitation.

*Smoking  $\rightarrow$  COPD  $\rightarrow$  Emphysema  $\rightarrow$  Air trapping  $\rightarrow$  CO<sub>2</sub> retention  $\rightarrow$  Cor pulmonale.*

### 4. Emphysema

A debilitating disease where alveolar walls break down and lungs lose elasticity.

- Mechanism: Irritants activate macrophages and neutrophils to release elastase, an enzyme that breaks down elastin. Elastin is crucial for lung recoil and keeping airways open.
- Alpha-1 Antitrypsin: An anti-protease that normally inhibits elastase; its deficiency leads to unchecked lung destruction.
- Types: Centriacinar (upper lung), Panacinar (lower lung), and Distal acinar (near pleura, can lead to pneumothorax).
- Signs: "Barrel chest," rales (abnormal sounds), and an increased breathing rate to clear CO<sub>2</sub>.

*Tachypnea*

### 5. Pulmonary Tuberculosis (TB)

A chronic infection caused by Mycobacterium tuberculosis

- Pathophysiology: Bacteria are phagocytized by macrophages but inhibit their lysosomal activity. This leads to the formation of a granuloma. A visible granuloma is a **Gohn focus**; when it spreads to lymph nodes, it is a **Gohn complex**. *Granuloma + lymph nodes*
- Fates: 90% of cases stay as latent TB. Active infection can manifest as tuberculosis pneumonia or miliary TB (disseminated tiny spots in other organs). *diff. Granuloma*
- Treatment: A multi-drug regimen (Isoniazid, rifampin, ethambutol, pyrazinamide) lasting several months. *active TB*

*two phases with 6 months at least.  $\rightarrow$  RIPE: Rifampin / Isoniazid / pyrazinamide / Ethambutol } phase 1 1st 4 mths. phase 2 2nd 2 mths*

### 6. Lung Cancer

The leading cause of cancer death, with 80% of cases related to smoking

- Types:
- Squamous cell carcinoma: Common in male smokers; central cavitation is frequent. *squamous = smoker + cavity.*
- Adenocarcinoma: Most common in women and non-smokers. *Adeno = women + Non-smoker.*
- Small cell lung carcinoma (SCLC): Highly malignant, strongest association with smoking, often secretes hormones (causing SIADH) and metastasizes to the brain.
- Symptoms: Persistent cough, hemoptysis (blood in sputum), and paraneoplastic syndromes like hypercalcemia.
- Diagnosis: Chest X-rays, CT/MRI, and sputum cytology. Surgery, chemotherapy, and radiation are used for treatment.