Structure and Function of the Pulmonary System

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Structures of the Pulmonary System

- Airways
- Blood vessels
- Chest wall
- Lungs
  - Lobes
  - Segments
  - Lobules
Structures of the Pulmonary System
Structures of the Pulmonary System

- Conducting airways
  - Upper airways
    - Nasopharynx
    - Oropharynx
  - Larynx
    - Connects upper and lower airways
- Lower airways
  - Trachea
  - Bronchi
  - Terminal bronchioles
Structures of the Pulmonary System
# Structures of the Pulmonary System

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(Redrawn from Thompson JM et al: Mosby’s clinical nursing, ed 5, St Louis, 2002, Mosby.)
Structures of the Pulmonary System
Structures of the Pulmonary System
Pulmonary and Bronchial Circulation

- Pulmonary circulation has a lower pressure than the systemic circulation
- One third of pulmonary vessels are filled with blood at any given time
- Pulmonary artery divides and enters the lung at the hilus
- Each bronchus and bronchiole has an accompanying artery or arteriole
Pulmonary and Bronchial Circulation

Diagram showing the pulmonary and bronchial circulation with labels such as pulmonary arteries, pulmonary veins, superior vena cava, aortic arch, lobar branches to right lung, capillary beds, right lung, left lung, right ventricle, left ventricle, right atrium, left atrium, and inferior vena cava.
Chest Wall and Pleura

- Chest wall
  - Skin, ribs, and intercostal muscles
  - Thoracic cavity
- Pleura
  - Serous membrane
  - Parietal and visceral layers
  - Pleural space (cavity)
  - Pleural fluid
Function of the Pulmonary System

- Ventilation
  - Mechanical movement of gas or air into and out of the lungs
- Minute volume
  - Ventilatory rate multiplied by the volume of air per breath
- Alveolar ventilation
Mechanics of Breathing

- Major and accessory muscles
  - Major muscles of inspiration
    - Diaphragm
    - External intercostals
  - Accessory muscles of inspiration
    - Sternocleidomastoid and scalene muscles
  - Accessory muscles of expiration
    - Abdominal and internal intercostal muscles
Muscles of Ventilation
Mechanics of Breathing

Dobuler: Pulmonary
Gas Transport

• Four steps
  • Ventilation of the lungs
  • Diffusion of oxygen from the alveoli into the capillary blood
  • Perfusion of systemic capillaries with oxygenated blood
  • Diffusion of oxygen from systemic capillaries into the cells
• Diffusion of CO$_2$ occurs in reverse order
Tests of Pulmonary Function

- Spirometry
- Diffusion capacity
- Residual volume
- Functional reserve capacity (FRC)
- Total lung capacity
- Arterial blood gas analysis
- Chest radiographs
Signs and Symptoms of Pulmonary Disease

- **Dyspnea**
  - Subjective sensation of uncomfortable breathing
- **Orthopnea**
  - Dyspnea when a person is lying down
- **Paroxysmal nocturnal dyspnea**
- **Abnormal breathing patterns**
  - Kussmaul respirations (hyperpnea)
  - Cheyne-Stokes respirations
Signs and Symptoms of Pulmonary Disease

- Hypoventilation
- Hyperventilation
- Cough
  - Acute cough
  - Chronic cough
- Hemoptysis
Signs and Symptoms of Pulmonary Disease

- Cyanosis
- Pain
- Clubbing
- Abnormal sputum
Conditions Caused by Pulmonary Disease or Injury

• Hypercapnia
• Hypoxemia
  • Hypoxemia versus hypoxia
  • Ventilation-perfusion abnormalities
    • Shunting
• Acute respiratory failure
• Pulmonary edema
  • Excess water in the lungs
Conditions Caused by Pulmonary Disease or Injury

- Aspiration
  - Passage of fluid and solid particles into the lungs
- Atelectasis
  - Compression atelectasis
  - Absorption atelectasis
- Bronchiectasis
  - Persistent abnormal dilation of the bronchi
  - Cylindrical, saccular, and varicose
Conditions Caused by Pulmonary Disease or Injury

- **Bronchiolitis**
  - Inflammatory obstruction of the small airways
  - Most common in children
  - Occurs in adults with chronic bronchitis, in association with a viral infection, or with inhalation of toxic gases

- **Bronchiolitis obliterans**
  - Late-stage fibrotic disease of the airways
  - Can occur with all causes of bronchiolitis
Pleural Abnormalities

- Pneumothorax
  - Open pneumothorax
  - Tension pneumothorax
  - Spontaneous pneumothorax
  - Secondary pneumothorax
Pneumothorax

- Normal lung
- Chest wall
- Pleural space
- Mediastinum
- Diaphragm

Outside air enters because of disruption of chest wall and parietal pleura.
Lung air enters because of disruption of visceral pleura.
Pleural Abnormalities

- Pleural effusion
  - Transudative effusion
  - Exudative effusion
  - Pleurisy
  - Hemothorax
- Empyema
  - Infected pleural effusion
Pulmonary Disorders

- Acute respiratory distress syndrome (ARDS)
  - Fulminant form of respiratory failure characterized by acute lung inflammation and diffuse alveolocapillary injury
  - Injury to the pulmonary capillary endothelium
  - Inflammation and platelet activation
  - Surfactant inactivation
  - Atelectasis
Pulmonary Disorders

- Postoperative respiratory failure
  - Atelectasis
  - Pneumonia
  - Pulmonary edema
  - Pulmonary emboli
- Prevention
  - Frequent turning, deep breathing, early ambulation, air humidification, and incentive spirometry
Obstructive Pulmonary Disease

- Airway obstruction that is worse with expiration
- Common signs and symptoms
  - Dyspnea and wheezing
- Common obstructive disorders
  - Asthma
  - Emphysema
  - Chronic bronchitis
Asthma

Allergen or irritant exposure

- Immune activation (IL-4, IgE production)
- Mast cell degranulation

Vasoactive mediators

- Vasodilation
  - Increased capillary permeability

Chemotactic mediators

- Cellular infiltration (neutrophils, lymphocytes, eosinophils)

- Bronchospasm
- Vascular congestion
- Mucus secretion
- Impaired mucociliary function
- Thickening of airway walls
- Increased contractile response of bronchial smooth muscle

- Bronchial hyperresponsiveness
- Airway obstruction

Autonomic dysregulation

Release of toxic neuropeptides

Epithelial desquamation and fibrosis

Dobuler: Pulmonary
Chronic Obstructive Pulmonary Disease
Chronic Obstructive Pulmonary Disease

- Chronic bronchitis
  - Hypersecretion of mucus and chronic productive cough that lasts for at least 3 months of the year and for at least 2 consecutive years
  - Inspired irritants increase mucus production and the size and number of mucous glands
  - The mucus is thicker than normal
Chronic Obstructive Pulmonary Disease

- Emphysema
  - Abnormal permanent enlargement of the gas-exchange airways accompanied by destruction of alveolar walls without obvious fibrosis
  - Loss of elastic recoil
  - Centriacinar emphysema
  - Panacinar emphysema
Emphysema

(Micrographs from Damjanov I, Linder J, editors: Anderson’s pathology, ed 10, St Louis, 1996, Mosby.)
Respiratory Tract Infections

- Pneumonia
  - Community-acquired pneumonia
    - *Streptococcus pneumoniae*
  - Hospital-acquired (nosocomial) pneumonia
  - Pneumococcal pneumonia
  - Viral pneumonia
Pneumococcal Pneumonia
Respiratory Tract Infections

- Acute bronchitis
  - Acute infection or inflammation of the airways or bronchi
  - Commonly follows a viral illness
  - Acute bronchitis causes similar symptoms to pneumonia but does not demonstrate pulmonary consolidation and chest infiltrates
Pulmonary Vascular Disease

- Pulmonary embolism
  - Occlusion of a portion of the pulmonary vascular bed by a thrombus, embolus, tissue fragment, lipids, or an air bubble
  - Pulmonary emboli commonly arise from the deep veins in the thigh
- Virchow triad
  - Venous stasis, hypercoagulability, and injuries to the endothelial cells that line the vessels
Pulmonary Embolism
Cancer

• Lip cancer
  • Most common form
    • Exophytic
  • Stages

• Laryngeal cancer
  • Forms
    • Carcinoma of the true vocal cords (most common)
    • Supraglottic
    • Subglottic
Lip and Laryngeal Cancer
Lung Cancer

- Bronchogenic carcinomas
- Most common cause is cigarette smoking
  - Heavy smokers have a 20 times greater chance of developing lung cancer than nonsmokers
  - Smoking is related to cancers of the larynx, oral cavity, esophagus, and urinary bladder
- Environmental or occupational risk factors are also associated with lung cancer
Lung Cancer

- Non–small cell lung cancer
  - Squamous cell carcinoma
  - Adenocarcinoma
- Large cell carcinoma (undifferentiated)
- Small cell carcinoma
Lung Cancer
Other Lung Cancers

- Bronchial carcinoid tumors
- Adenocystic tumors (cylindromas)
- Mucoepidermoid carcinomas
- Mesotheliomas
Symptoms of OSA

• Result from disruption of normal sleep architecture
• Frequent arousals and inability to achieve or maintain deeper stages of sleep
  • Excessive daytime sleepiness
  • Poor sleep quality
  • Automobile accidents
  • Personality changes
  • Memory disturbances
  • Erectile dysfunction
  • Depression
Might you have sleep apnea?

- Do you snore?
- Excessively tired during the day?
- Wake during sleep feeling breathless?
- Stop breathing during sleep?
- History of hypertension
- Difficulty falling or staying asleep?
- Restless legs?

“Yes” to 2 or more is indication for PSG