Bio217: Pathophysiology Class Notes
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Unit VII: Respiratory System Disorders

Chapter 25: Structure & Function of Pulmonary System
Chapter 26: Alterations of Pulmonary Function

Structure and Function of the Pulmonary System

Chapter 25

Structures of the Pulmonary System

- Conducting Airways
- Pulmonary circulation
- Lungs
  - Lobes (__________________________)
  - Segments
  - Lobules

Structures of the Pulmonary System

- Conducting airways (__________________________)
- Upper airways
  - Nasopharynx
  - Oropharynx
  - Laryngopharynx
- Lower airways
  - Trachea
  - Bronchi
  - Terminal bronchioles
Structures of the Pulmonary System
- Gas-exchange airways
  - Respiratory bronchioles
  - Alveolar ducts
  - Alveoli
- Epithelial cells
  - Type I alveolar cells
    - Alveolar structure
  - Type II alveolar cells
    - Surfactant production

Pulmonary and Bronchial Circulation
- Pulmonary circulation has lower pressure than systemic circulation (~1/5 pressure)
- Pulmonary artery divides and enters lung at hilus
- Each bronchus and bronchiol has an accompanying artery or arteriole
- Alveolarcapillary (__________) membrane
  - Formed by the shared alveolar and capillary walls
  - Gas exchange occurs across this membrane

Alveolarcapillary (respiratory) membrane
O₂ and CO₂ – trading places

Chest Wall and Pleura
- Chest wall
  - ________________
- Thoracic cavity
- Pleura
  - Serous membrane
  - Parietal and visceral layers
  - Pleural space (cavity)
- Pleural fluid

Alveolar gas exchange – how much O₂ and CO₂ trade places in alveoli?

Ventilation to perfusion ratio (V/Q) - depends on amt. of air in alveoli (ventilation) to amt. of air in blood (perfusion)

Normal lung: Alveoli rec. air ~4 L/min
  - Capillaries supply blood ~5 L/min
  = 4:5 = 0.8
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Unit 7

Thoracic Cavity

Function of the Pulmonary System

- Ventilation
  - Mechanical movement of gas or air into and out of lungs
  - Minute volume (L/min) = total volume of air entering lungs/min
    = Ventilatory rate (breaths/min) x TV
  - Alveolar ventilation = vol. of gas/unit time that reaches gas exchange portion of lung
    = (TV - dead space) x ventilatory rate
  - PFTs (Pulmonary function tests) measure lung volumes and rates to diagnose disorders

Ventilation

- Neurochemical control
  - Respiratory center
    - Dorsal respiratory group - rhythm of respiration
    - Ventral respiratory group - becomes active during increased respiration
  - Pneumotaxic center - limits amt. of inspired air
  - Apneustic center - prevents overinflation of lungs
  - Central chemoreceptors respond to pH, pCO₂, pO₂
  - Peripheral chemoreceptors (carotid & aortic bodies)
  - Respond to decr. pO₂

Neurochemical Respiratory Control

Mechanics of Breathing

- Alveolar surface tension and ventilation
- Function of surfactant
- Elastic properties of the lung and chest wall
  - Elastic recoil - lungs return to resting state
  - Compliance - distensibility of lung and chest wall (opposite of elasticity)
- Airway resistance - depends on R and flow
- Work of breathing - effort of muscles for ventilation
Mechanics of Breathing

Gas Transport
- Diffusion of $\text{O}_2$
  - Ventilation of the lungs
  - Diffusion of oxygen from alveoli into capillary blood
  - Perfusion of systemic capillaries with oxygenated blood
  - Diffusion of oxygen from systemic capillaries into cells

- Diffusion of $\text{CO}_2$ occurs in reverse order

Measurement of Gas Pressure

Gas Transport
- Oxygen transport
  - Diffusion across the alveolocapillary membrane
  - Determinants of arterial oxygenation
    - Hemoglobin binding, oxygen saturation
    - Oxyhemoglobin association and dissociation
    - Oxyhemoglobin dissociation curve
    - Bohr effect

- Carbon dioxide transport
  - Dissolved in plasma
  - Bicarbonate
  - Carbamino compounds

- Haldane effect
  - Effect of $\text{O}_2$ on $\text{CO}_2$ transport out of blood
1. The cilia of the bronchial wall:
   - A. Ingest bacteria
   - B. Trigger sneeze reflex
   - C. Trap and remove bacteria
   - D. Propel mucus and trapped bacteria toward oropharynx

2. As the terminal bronchioles are approached:
   - A. Epithelium becomes thicker
   - B. Mucus-producing glands increase
   - C. Epithelium becomes thinner
   - D. Cartilage support increases
   - E. SMC layer thickens

3. The left primary bronchus:
   - A. Is shorter and wider than the right
   - B. Is symmetrical to the right
   - C. Is more vertical than the right bronchus
   - D. Is more angled than the right

4. Alveoli are excellent for gas exchange due to:
   - A. Large surface area
   - B. Thin epithelial layer
   - C. Extensive vascularization
   - D. All of the above

5. When the diaphragm and ext. intercostals contract:
   - A. Intrathoracic V increases
   - B. Intrathoracic P increases
   - C. Intrathoracic V decreases
   - D. None of the above

6. A shift to the right in the O2-Hb dissociation curve:
   - A. Prevents O2 release at cell level
   - B. Cause O2 to bind tighter to Hb
   - C. Improves O2 release at cell level
   - D. Both a and b

7. The DRG of neurons:
   - A. Sets the automatic rhythm of respiration
   - B. Modifies the rhythm of respiration
   - C. Is active when increase ventilation is required
   - D. None of the above

Alterations of Pulmonary Function

Chapter 26

Signs and Symptoms of Pulmonary Disease

- Dyspnea
  - Subjective sensation of uncomfortable breathing
  - Orthopnea
    - Dyspnea when a person is lying down
  - Paroxysmal nocturnal dyspnea (PND)

- Abnormal breathing patterns
  - Kussmaul respirations (hyperpnea) – due to increased exercise or metabolic acidosis
  - Cheyne-Stokes respirations – alternating deep and shallow breathing (due to slowed blood flow to brainstem)

- Hypoventilation

- Hyperventilation

- Cough
  - Acute cough
  - Chronic cough

- Hemoptysis – (not to be confused with hematemesis= vomiting blood)
Pulmonary Edema

- Pulmonary edema = ________________
  - Most common cause is heart disease (LV fails → increased pulm. cap. hydrostatic pressure; inhalation of toxic gas; lymphatic system blockage)

- Atelectasis = _____________
  - Tends to occur after surgery, post-op patients breathe shallowly and develop thick secretions (inc. incentive spirometer to increase collateral ventilation between adjacent alveoli)

Pleural Abnormalities

- Pneumothorax
  - _______ in pleural cavity due to rupture of visceral or parietal pleura

Pleural Abnormalities

- Pleural effusion – fluid in pleural space
  - Transudative (watery) or exudative (high WBCs) effusion
  - Hemothorax - _______ in pleural cavity
  - Empyema – pus in pleural cavity

Conditions Caused by Pulmonary Disease or Injury

- Abscess formation and cavitation
- Abscess
- Consolidation
- Cavitation
- Pulmonary fibrosis
  - Excessive amount of _____________ in the lung

Pulmonary Disorders

Progression of ARDS:
- Assault to pulmonary system
- Respiratory distress
- Decreased lung compliance (distensibility of lung and chest wall)
- Severe respiratory failure
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

Chronic Obstructive Pulmonary Disease

- Airway obstruction that is worse with expiration

Obstructive Pulmonary Disease

- Common signs and symptoms
  - Dyspnea and wheezing
- Common obstructive disorders
  - Asthma
  - Emphysema
  - Chronic bronchitis

Respiratory Tract Infections

- Pneumonia – acute infection of lung (____________) that impairs gas exchange usually
- Classified:
  - Origin - bacterial, viral, fungal
  - Location
    - Bronchopneumonia (distal airways & alveoli);
    - Lobar pneumonia (in part or entire lobe)
- Type
  - Primary (inhale or aspirate pathogen)
  - Secondary (may occur after lung damage following chemical insult or from bacteria in blood)

Pneumococcal Pneumonia
Common causal microbes

- Streptococcus pneumoniae (aka Pneumococcus)
  - high mortality rate in elderly
- Mycoplasma pneumoniae
  - common in young people esp. living in close quarters
- Influenza – most common viral pneumonia
  - Legionella species → Legionnaire’s disease
  - Pseudomonas aeruginosa, S. aureus – most common nosocomial infectious agents

Pathophysiology

- Aspiration of secretions (oro- and laryngopharynx)
- Inhale microbes from infected persons (cough, sneeze…)
- Lines of defense
  - microbes expelled from naso- and oropharynx
  - alveolar macrophages
  - Activation of inflammatory and immune responses
  → alveolar edema

Characteristics

- Bacterial (Streptococcal)
  - sudden onset chill, temp 102 to 104 °F
  - follows upper resp. tract infection
- Viral (Influenza)
  - cough, cyanosis, high fever, substernal pain, headache, myalgia

Pathophysiology

- Avian Influenza (H5N1)
  - highly pathogenic virus caused infection in poultry in Asia and infected humans in 1997
  - At first infected humans who had close contact with birds
  - Several cases mutated virus spread from human to human
  - Fever, cough, sore throat, muscle aches, eye infections
- Swine flu (H1N1)
  - Pandemic flu April 2009 – June 2010
  - Similar symptoms to seasonal flu
  - CDC reported “61 million cases (12,500 deaths)”

Respiratory Tract Infections

- Tuberculosis – infectious disease that affects mostly lungs, can involve other systems
  - Due to exposure to Mycobacterium tuberculosis
  - Airborne transmission – cough or sneeze spreads infected droplets
  - (granulomatous lesion) – macrophages ingest bacilli → tubercles →
  - Caseous necrosis and scar tissue
  - Positive tuberculin skin test (PPD)
  - Once bacilli isolated in tubercles → immunity and dormancy

Pulmonary Embolism

- Venous thrombosis
  - Thrombus formation
  - Development of pulmonary embolism
  - Hypoxia, shock, pulmonary infarction
  - Release of inflammatory and thrombolytic substances
  - Paroxysmal dyspnea
  - Thrombus formation
  - Hypertension
  - Respiratory distress
  - Pulmonary infarction
  - Hemorrhage
  - Shock
  - Death
Pulmonary Embolism

- **Pulmonary embolism** – blockage of pulmonary vessel by _______ (blood clot, tissue, lipid, foreign object or air)
- Risk factors – conditions → blood clotting
  - (venous stasis, hypercoagulability, injury to endothelial lining, genetic)
- Pathophysiology
  - Massive occlusion → blockage of pulmonary artery
  - Embolism w/ infarction – large enough to cause tissue death
  - Embolism w/out infarction – no permanent damage if no infarction clots are dissolved.

Pulmonary Embolism

- Most clots dev. in lower extremities, DVT.
- Clinical:
  - Sudden onset chest pain, dyspnea, tachypnea, tachycardia
  - → severe pulmonary HT and shock
- Treatment:
  - Prevention is best
  - Leg elevation, ambulation, calf compression
  - Anticoagulants (heparin) and antithrombotics
  - Surgery (thrombectomy)

Pulmonary Vascular Disease

- **Pulmonary hypertension**
  - Mean pulmonary artery pressure 5 to 10 mm Hg above normal or above 20 mm Hg
  - Primary pulmonary HT (PPH)
    - Idiopathic, rare
    - Malfunction of endothelium → incr. VC (thromboxane) and decr. VD (prostacyclin)
  - Vessel wall changes (thick & fibrous) → VC → incr. R → incr. P in pulmonary arteries
  - Secondary pulmonary HT
    - Due to respiratory disease (hypoxemia, arterial VC)
    - Pulmonary venous HT – due to CHF

Pulmonary Hypertension

Pulmonary Hypertension

Lung Cancer

- **Bronchogenic carcinomas**
  - Arise from ____________ of resp. tract
  - Epidemic in US (most common cause of cancer death)
  - 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 (slow)
  - Adenocarcinoma (moderate)
  - Large cell carcinoma (undifferentiated, rapid)
  - Small cell carcinoma (very rapid)
Lung Cancer

- **Pathophysiology**
  - Tobacco smoke >30 carcinogens → 80-90% of lung cancers
  - Genetic predisposition
  - Both lead to genetic abnormalities in bronchial cells
    - Loss of tumor suppressing genes
    - Tumor progression due to growth factors
    - Mucosa suffers from chronic exposure to smoke → metaplasia → carcinoma → spreads in lung → metastasis (brain, bone, liver)

- **Evaluation and treatment**
  - TNM classification
    - **Tumor**
    - **Nodal involvement**
    - **Metastasis**
  - Surgery, chemotherapy, and radiation

Matching:

1. Kussmaul resp. → a. Alveolar collapse
2. Hemptysis → b. Cough blood
3. Cyanosis → c. Decr. arterial oxygenation
4. Cheyne-Stokes → d. Apnea, incr. vent., apnea
5. Atelectasis → e. Incr. vent. rate, effortless TV, no exp. pause

6. Pulmonary edema may be caused by abnormal:
   - A. Capillary hydrostatic press.
   - B. Capillary oncotic pressure
   - C. Cap. Permeability
   - D. All of the above

Matching:

7. Pneumonia → a. Originate from thrombi in legs
8. TB → b. Caused by air pollutants
9. Chronic bronchitis → c. Caused by aerobic bacillus
10. Pulmonary emboli → d. May be caused by mycoplasms

11. The metastasis of lung squamous cell carcinoma is:
   - A. Late
   - B. Very early and widespread
   - C. Early
   - D. Never seen