LECTURE OBJECTIVES:

1. Understand the anatomy and physiology associated with the respiratory system
2. Differentiate normal versus abnormal findings on a respiratory assessment
3. Interpret arterial blood gases
4. Discuss diagnostic procedures used in the assessment of the patient with pulmonary dysfunction
5. Describe the etiology, pathophysiology, and clinical manifestations of selected pulmonary disorders
6. Discuss the nursing priorities and management of the patient with selected pulmonary disorders
7. Describe the different types and modes of mechanical ventilators
8. Discuss complications related to mechanical ventilation
9. Utilize troubleshooting techniques for mechanical ventilators
10. Identify pharmacologic agents used in conjunction with patients experiencing pulmonary alterations and patients mechanically ventilated
11. Identify priorities in nursing care and management for patients receiving and being weaned on mechanical ventilators

READING ASSIGNMENT:

Baird, Keen & Swearingen, pg 14-23
Black & Hawks, pg 1732 - 1742, Chapter 65
Smith, Duell & Martin, Unit 5 & 6 (Pg 903-920)
Urden, Stacy & Lough, Unit 4

LECTURE OUTLINE:

See next page
I. Anatomy and Physiology Review

A. Upper Airways
   1. Nasal Cavity
   
   2. Pharynx
      - Extends from nose to larynx. Divided into three sections
         - Nasopharynx:
         - Oropharynx:
         - Laryngopharynx:
   
   3. Larynx (voice box)

B. Lower Airways
   1. Trachea (windpipe)
   
   2. Bronchi

C. Lungs and Alveoli
   1. Lungs
   
   2. Lung Volumes
      - Residual volume
      - Tidal volume:
         - Inspiratory reserve volume:
         - Expiratory reserve volume:
   
   3. Alveoli
      - Alveolar walls are extremely thin with extensive interconnecting capillaries

D. Thorax

E. Diaphragm

F. Pleurae

G. Function of Respiratory System
   1. Ventilation: movement of air in and out the lungs
      a. Compliance: the ease at which the lungs expand
      b. Surface tension: restricts alveolar expansion on inspiration and aids alveolar collapse expiration
      c. Muscular effort
   
   2. Respiratory control
   
   3. Gas exchange and transport
      - Gas movement across the alveolar-capillary membrane occurs by the process of diffusion
      - Diffusion: the process by which substances scatter themselves evenly throughout an available space
- Oxyhemoglobin: the combination of oxygen and hemoglobin
- Oxyhemoglobin Dissociation Curve: the relationship between PaO2 (partial pressure of arterial oxygen) and the saturation of hemoglobin
- Changes in the affinity of oxygen for hemoglobin cause the oxyhemoglobin to shift from the normal

4. Regulation of Acid-Base Balance

5. Reaction to Injury

6. Effects of Aging

II. Pulmonary Assessment and Diagnostic Procedures

A. History (why do it?)

B. Clinical Assessment (inspection, palpation, percussion, auscultation)
   1. Inspection Priorities
      a. Observe tongue and sublingual area
      b. Assess chest wall configuration
      c. Evaluate respiratory effort
      d. Other
   2. Palpation Priorities
      a. Tracheal Position
      b. Respiratory Excursion
      c. Tactile Fremitis
   3. Percussion Priorities
      a. Evaluate underlying lung structure
      b. Assess diaphragmatic excursion
   4. Auscultation Priorities
      a. Evaluate normal breath sounds
      b. Identifying abnormal breath sounds
      c. Assess voice sounds (bronchophony, whispering pectoriloquy, egophony)

C. Laboratory Studies
   1. Arterial Blood Gases
      a. PaO2: measures partial pressure (tension) of oxygen dissolved in arterial blood plasma. Normal range is 80 to 100 mm Hg. Determines hypoxia.
      c. PaCO2 indicates if the body can ventilate well enough to rid the body of carbon dioxide. CO2 is a respiratory component. Normal range is 35 - 45 mm Hg
      d. Bicarbonate (HCO3) is a metabolic component. Normal range is 22 - 26 mEq/L
      e. Compensation (pH normal, PaCO2 and HCO3 abnormal); Partial compensation (abnormal pH, PaCO2 and HCO3); Uncompensation (pH abnormal, either HCO3 or PaCO2 abnormal)
**Interpretation of Arterial Blood Gases**

1. **Evaluate pH**
   The normal pH is 7.35 - 7.45, with the midpoint being 7.40. Consider all values higher than 7.40 alkaline and all values lower than 7.40 acidic. Then decide if the ABG is acidic or alkaline.

2. **Evaluate CO2**
   CO2 is a respiratory component. The normal range is 35 - 45 mm Hg. If the CO2 is less than 35, it’s alkaline. If it’s more than 45, it’s acidic.

3. **Evaluate HCO3**
   HCO3 is an metabolic component. The normal range is 22 - 26 mEq/L. If the HCO3 is less than 22, it’s acidic. If it’s greater than 26, it’s alkaline.

4. If both the CO2 and the HCO3 are abnormal, the acid/base status is determined by the component that deviates furthest from its normal range.

5. **Determine compensation**
   If pH is normal, but CO2 and HCO3 are abnormal, it’s compensated. If all values are abnormal, it’s partially compensated.

With abnormal ABG values, the pH will change according to metabolic and respiratory function. To determine if the problem is respiratory, envision a seesaw.

**Respiratory Seesaw (Inverse relationship)**

**Normal**

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**Respiratory Acidosis:** As PCO2 goes up, pH goes down

    PCO2

    pH

**Respiratory Alkalosis:** As PCO2 goes down, pH goes up

    pH

    PCO2

To determine if the problem is metabolic, envision an elevator.

**Metabolic Elevator (Direct relationship)**

**Normal**

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**Metabolic Acidosis:** As HCO₃ goes down, the pH goes down

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**Metabolic Alkalosis:** As the HCO₃ goes up, the pH goes up

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See Arterial Blood Gas Interpretation Practice Sheet

2. **Oxygen saturation:** measures the amount of O₂ bound to hemoglobin (SaO₂)

3. **Sputum Studies:** assist in identifying and treating pulmonary infections. Usually done in morning. May be tested for gram stain and culture and sensitivity

**D. Diagnostic Procedures**
1. Chest radiography
2. Exercise testing
3. Bronchoscopy
4. Lung biopsy
5. MRI
6. Pulmonary angiography
7. Pulmonary function tests
8. Thoracentesis
9. Computed tomography
10. Ultrasonography
11. Ventilation perfusion scan

**III. Pulmonary Disorders**

A. **Acute Respiratory Failure:** condition in which pulmonary system fails to maintain adequate gas exchange

1. **Etiology:** usually secondary to another disorder that has altered the function of the pulmonary system in a such a way as to decrease the ventilatory drive. Causes may be extrapulmonary or intrapulmonary.
   a. **Extrapulmonary-**
   b. **Intrapulmonary -**

2. **Pathophysiology:** Hypoxemia due to various causes
a. Alveolar Hypoventilation -

b. Ventilation/perfusion Mismatching -

c. Intrapulmonary shunting -

d. Complications -

3. Assessment and Diagnosis:

4. Medical Management: treat underlying cause, promote adequate gas exchange, correct acidosis, nutritional support, and prevent complications
   a. Oxygenation -
   b. Ventilation -
   c. Pharmacology -
   d. Acidosis -
   e. Nutrition -
   f. Complications -

5. Nursing Management: nursing care is directed by the specific etiology of the respiratory failure. Common nursing diagnosis include - Impaired gas exchange, Ineffective breathing pattern, Imbalanced nutrition: less than body requirements, Acute confusion, Knowledge deficit. Priorities of care are directed at the following:
   a. Optimizing oxygenation through proper positioning, preventing desaturation, and promoting secretion clearance
   b. Providing patient education

B. Acute Respiratory Distress Syndrome (ARDS): a sudden, progressive form of respiratory failure characterized by severe dyspnea, hypoxemia, diffuse bilateral infiltrates

1. Etiology - categorized as direct (lung epithelium sustains a direct insult) or indirect (insult occurs elsewhere in the body and mediators are transmitted through the bloodstream to the lungs) depending on the primary site of the injury
   a. Direct injuries:
   b. Indirect injuries:

2. Pathophysiology - initiated by a massive inflammatory response by the lungs as a result of an injury. This increases permeability of the alveolar membrane which results in fluid movement into the interstitial and alveolar spaces. This leads to noncardiogenic pulmonary edema which decrease lung compliance and impairs oxygen transport. Progression is described in three phases
   a. Exudative phase -
   b. Proliferative phase -
   c. Fibrotic phase -

3. Assessment and Diagnosis: signs and symptoms vary. Patient may have restlessness, tachypnea, dyspnea, fatigue, accessory muscle use, crackles, low PaO2, and “white out”
on chest radiograph (diffuse, patchy interstitial and alveolar infiltrates)

4. Medical Management: treat underlying cause, promote gas exchange, support tissue oxygenation, and prevent complications
   a. Oxygen therapy -
   b. Positive End Expiratory Pressure (PEEP) -
   c. Ventilation: permissive hypercapnia -
   d. Tissue perfusion-

5. Nursing Management: Nursing diagnosis include impaired gas exchange, decreased cardiac output, imbalanced nutrition, anxiety, compromised family coping
   a. Optimizing oxygenation and ventilation by preventing desaturation, promoting secretion clearance, and proper positioning
   b. Prone positioning-ARDS causes greater damage to dependent areas of the lungs. Turning the patient prone improves perfusion to less damaged parts of the lungs, improves V/Q matching, and decreases intrapulmonary shunting. More effective when initiated early

C. Pneumonia: an acute inflammation of the lung parenchyma that is caused by an infectious agent that can lead to alveolar condensation. May be classified as community acquired pneumonia or hospital acquired pneumonia
   1. Etiology: pathogens vary depending on the type
      a. Severe community acquired pneumonia:
      b. Hospital acquired pneumonia:

   2. Pathophysiology: defense mechanisms of the lungs lose their effectiveness allowing organisms to penetrate the lower respiratory tract, where inflammation develops. Inflamed and fluid-filled alveolar sacs cannot exchange oxygen and carbon dioxide effectively. Conditions predisposing a patient to pneumonia include depressed gag and cough reflex and fluid in the alveoli. Bacteria may invade the respiratory tract by inhalation aerosolized infectious particles, aspiration of organisms colonizing the oropharynx, migration from adjacent sites, direct inoculation of organisms into the lower airway, spread of infection to the lungs from adjacent structures and through the blood; and reactivation of latent infection.

   3. Assessment and Diagnosis:
      a. Clinical manifestations may vary.
      b. Diagnosis:

   4. Medical Management
      a. Antibiotic therapy-
      b. Oxygen therapy-
      c. Fluid management-
      d. Nutritional support
      e. Treat associated medical problems and complications
f. Mucolytics and therapeutic bronchoscopy may be needed for patients having difficulty mobilizing secretions

5. Nursing Management: common nursing diagnosis include ineffective airway clearance, impaired gas exchange, risk for infection, and powerlessness. Nursing priorities include the following:
   a. Optimizing oxygenation (positioning, secretion clearance, preventing desaturation)
   b. Prevent the spread of infection (handwashing, oral care, suctioning)
   c. Provide comfort and emotional support
   d. Monitor for complications

D. Aspiration Lung Disorder: the presence of abnormal substances in the airways and alveoli as a result of aspiration

1. Etiology: Gastric contents and oropharyngeal bacteria are the most common aspirates in critically ill patients. Risk factors listed below.
   a. Altered level of consciousness
   b. Depressed cough, gag, or swallow reflex
   c. Presence of feeding tube
   d. Presence of artificial airway
   e. Ileus or gastric distention
   f. History of GI disorders (dysphagia, achalasia, GERD, esophageal strictures)

2. Pathophysiology:
   a. Acid (pH less than 2.5) liquid aspiration.
   b. Acid food particle
   c. Nonacid liquid gastric content aspiration
   d. Nonacid food particle aspiration

3. Assessment and Diagnosis:
   a. Assessment:
   b. Diagnostic:

4. Medical Management: if aspiration is witnessed, place patient in slight Trendelenburg position (6-8 inches), turn to right lateral decubitus position (aids drainage and avoids involvement of the other lung areas), suction oropharyngeal, bronchoscopy (to remove large particulate aspirate), supplemental O2 or mechanical ventilation, and fluid replacement

5. Nursing Management: Nursing diagnosis include impaired gas exchange, ineffective airway clearance, risk for aspiration, risk for infection, ineffective coping. Nursing priorities include the following:
   a. Optimizing oxygenation (proper positioning, preventing desaturation, and promoting secretion clearance)
   b. Preventing further aspiration (confirm feeding tube placement, check for aspiration of gastric content in the lungs, elevate HOB 30 degrees or more, frequent suctioning, and ensure proper inflation of artificial airway cuffs)
   c. Provide comfort and emotional support
   d. Monitor for complications
E. Pulmonary Embolism: occlusion of a portion of the pulmonary blood vessels by an embolus (blood clot)

1. Etiology and Risk Factors
   a. Thrombi (usually originating in the deep calf, femoral, popliteal, or iliac veins)
   b. Other sources include tumors, fat, air, bone marrow, amniotic fluid, etc
   c. Surgery (hip, knee, abdominal, pelvic)
   d. Venous stasis (A fib, decreased CO, immobility)
   e. Cardiovascular disease (CHF, cardiomyopathy, etc)
   f. Cancer (stomach, trauma, pancreatic, ovarian)
   g. Trauma (lower extremities, pelvis, hip)
   h. Gynecologic status (pregnancy, oral contraceptives)

2. Pathophysiology:

3. Assessment and Diagnosis
   a. Assessment-
   b. Diagnostic-

4. Medical Management
   a. Stabilizing the cardiopulmonary status (O2, IV fluids, inotropic agents)
   b. Anticoagulant therapy (heparin, warfarin, lovenox)
   c. Fibrinolytic therapy
   d. Compression stockings or intermittent pneumatic leg compression
   e. Percutaneous venous filter placement (Greenfield) in IVC
   f. Pulmonary embolectomy

5. Nursing Management: Nursing diagnosis include impaired gas exchanged, acute pain, anxiety, and knowledge deficit
   a. Monitor ABG’s and pulse ox
   b. Check for peripheral edema, distended neck veins
   c. Oxygen
   d. Elevate HOB
   e. Provide emotional support
   f. Pain control for comfort
   g. Monitor for bleeding
   h. Patient education

F. Fractured Ribs: common chest injury particularly in older adults. Usually the 5th through the 9th ribs. They compromise respirations (shallow breathing, infection, and possible lung puncture)
   1. Assessment-
   2. Management-

G. Flail Chest: fractures or two or more adjacent ribs on the same side and possibly, the sternum, with each bone fractured into two or more segments.
   1. Assessment-
   2. Management-

H. Pneumothorax: the presence of air in the pleural space that prohibits complete lung expansion. This causes the lung to collapse. It may be open or closed. It may be spontaneous or traumatic.
   1. Risk Factors-
2. Assessment-

3. Diagnostic- chest x-ray may reveal a slight tracheal shift away from the affected side.

4. Management
   a. Insertion of 18 gauge needle into 2nd or 3rd ICS midclavicular line
   b. Chest tube placement in pleural space (4th or 5th ICS midaxillary or anterior axillary line)
   c. Thoracotomy
   d. VATS (thoracoscopy)
   e. Supplemental oxygen

I. Hemothorax: an accumulation of blood and fluid in the pleural cavity. May be present in patients with chest injuries.
   1. Clinical Manifestations- respiratory distress, shock, mediastinal shift, dullness upon percussion
   2. Diagnostic- chest x-ray
   3. Management
      a. Insert 16 gauge needle into 5th or 6th ICS at midaxillary line (if in severe distress)
      b. Chest tube (to drain intrathoracic accumulations of blood)
      c. Thoracotomy
      d. VATS
      e. Fluid replacement
      f. Supplemental oxygen

J. Thoracic Surgery: surgical procedures that require opening the thoracic cavity (thoracotomy). See table 14-4 on Page 245 of Priorities in Critical Care Nursing
   1. Preoperative Care- Evaluate appropriateness of surgery, patient’s cardiopulmonary function. Uncontrolled dysrhythmias, acute MI, sever CHF, and unstable angina are all contraindications for surgery.
   2. Complications and Medical Management
      a. Acute respiratory failure-
      b. Bronchopleural fistula-
      c. Hemorrhage-
      d. Cardiovascular disturbances-
      e. Mediastinal shift-
   3. Postoperative Nursing Management: Common nursing diagnosis include ineffective breathing pattern, impaired gas exchange, acute pain, disturbed body image, and compromised family coping.
      a. Optimizing oxygenation and ventilation- positioning, preventing desaturation, and promoting secretion clearance
      b. Preventing atelectasis- Proper positioning- dependent upon the type of surgery.

         -Early ambulation-
- Deep breathing and incentive spirometry -

- Pain management -

4. Maintaining Chest Tube System: Placed after all thoracic surgery procedure (except pneumonectomy) to remove air and fluid, help reexpand the remaining lung tissue by establishing negative pressure in the pleural space. This system of drainage has three main parts: the collection chamber, water-seal chamber, and suction-control chamber

   a. The **collection chamber** -
   
   b. **Water-seal chamber** -
   
   c. **Suction-control chamber** -
   
   d. Chest tube removal -

5. Assisting Return to Adequate Activity Level
   a. ROM exercises for shoulder on operative side (a few days after surgery)
   b. Sit up in chair (day after surgery)
   c. Increase activity systematically with attention to patient’s activity tolerance level

IV. Mechanical Ventilation

A. Indications for Mechanical Ventilation:

B. Types of Mechanical Ventilators
   1. Positive pressure:
   
   2. High frequency:

C. Mechanical Ventilator Modes and Terms
   1. Controlled mechanical ventilation (CMV):
   
   2. Assist-control ventilation (ACV):
   
   3. Synchronized intermittent mandatory ventilation (SIMV):
   
   4. Positive end-expiratory pressure (PEEP):
   
   5. Pressure support ventilation (PSV):
   
   6. Continuous positive airway pressure (CPAP):
   
   7. Fraction of inspired oxygen (FiO2):
   
   8. Peak airway inspiratory pressure (PIP):
   
   9. Tidal Volume:

D. Complications Related to Mechanical Ventilation

E. Troubleshooting Mechanical Ventilation Problems

1. **ALWAYS ASSESS YOUR PATIENT FIRST, NOT THE VENTILATOR**
2. High pressure alarm situations:
3. Low pressure alarm situations:

F. Pharmacologic Agents Used With Mechanical Ventilation

G. Weaning the Patient from the Mechanical Ventilator

H. Nursing Care of the Patient on the Mechanical Ventilator
   1. Impaired gas exchange
   2. Ineffective airway clearance
   3. Ineffective breathing pattern
   4. Risk for infection
   5. Anxiety

V. Suctioning and Tracheostomy Care (Smith, Duell & Martin textbook)
   A. Film
   B. Demonstration
   C. Practice time
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<th>Item</th>
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<th>PCO2 Normal 35-45</th>
<th>HCO3 Normal 22-26</th>
<th>Acidic or Alkaline</th>
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