Respiratory System:
Management of Oxygen Transport Problems

Objectives:

1. Describe the structures and functions of the respiratory system.

2. Analyze arterial blood gases.

3. Discuss the clinical manifestations and nursing care for the patient with COPD.

4. Describe the manifestations and treatment of pneumothorax, pleural effusion, pulmonary edema, and pulmonary emboli.

5. Discuss the use of metered dose inhalers and describe the correct procedure for use.

6. Describe contributing factors which may lead to the development of Adult Respiratory Distress Syndrome.

7. Identify significant subjective and objective assessment data related to the respiratory system.

8. Review the current status of TB infections in the U.S.


Readings:


Use the following outline, along with the readings, to fulfill the objectives of the course.

Normal Respiratory System

I. Upper airways (includes nasal cavity, paranasal sinuses, pharynx, and larynx)
   A. Airway conduction
   B. Defense mechanisms
   C. Provides humidity

II. Lower respiratory tract
   A. Conducting airways (include trachea, right and left main stem bronchi, secondary bronchi, and bronchioles)

   B. Acinus (gas exchange units that include the respiratory bronchioles, alveolar ducts and sacs, and alveoli)
      1. Alveoli are small air sacs that form the functional units of the lungs
         a. There are 3 million in the adult, total volume of 2500ml., surface area capable of diffusing gases equal about the size of a tennis court if spread out.
b. The alveoli have intimate contact with the capillary bed where the gas exchange is made  
c. The alveoli naturally have the tendency to collapse  
- surfactant (phospholipid) is secreted which decreases the surface tension of the alveoli and decrease the amount of pressure needed to inflate the alveoli  

-Normally, each person takes a slightly larger "sigh" breath every 5-6 breaths which stretches the alveoli and causes surfactant to be released.  
- Insufficient surfactant causes RDS in infants, ARDS in adults

III. Thorax and lungs

A. Thorax boundaries are sternum, 12 ribs, and 12 thoracic vertebrae

B. Muscles of respiration include diaphragm and intercostals, and accessory muscles include the abdominal, sternocleidomastoid, and the pectoral muscles
   1. Ventilation is accomplished by changing the intrathoracic pressure in relation to the atmospheric pressure - so that air moves in and out.
      a. Inspiration is caused by lowering the intrathoracic pressure by enlarging the thoracic cavity.
         - by contraction of the diaphragm (which lowers it)
         - by contraction of external intercostal muscles (which raises the chest walls)
      b. Expiration is passive.
         - the diaphragm and the intercostal muscles relax and the thoracic cavity becomes smaller by elastic recoil, the intrathoracic pressure raises, and air moves out.

C. The right lung has 3 lobes, the left lung has 2 lobes

D. The lungs are lined by the visceral pleura, the chest wall is lined by the parietal pleura; the negative pressure in the pleural space (between the two membranes) prevents the lungs from separating from the chest wall.
   1. The pleural space (space or sac between the two pleura) is normally filled with a small amount of fluid which provides lubrication and allows the layers to "slide" over each other during respiration. It also increases cohesion between the pleural layers, facilitating expansion of the parietal pleura and attached lung as a single unit.
a. A pleural effusion is a collection of larger amounts of fluid in the space caused by changes in colloid osmotic pressure or blockages in the lymph drainage system.
   b. If the fluid becomes infected, it is called an empyema.

IV. Respiration is defined as the process of gas exchange (uptake of oxygen and the elimination of carbon dioxide) between living cells and the environment.

   A. Most gas exchange occurs in the alveoli, some in the respiratory bronchioles

   B. Control of respiration by the respiratory center, a cluster of cells in the medulla and pons which respond to both chemical and mechanical signals from the body.

   C. Chemoreceptors in the medulla respond to changes in hydrogen ion concentration (pH). An increase in PaCO2 stimulates respiration; a decrease in PaCO2 depresses respiration.

   D. Peripheral chemoreceptors (carotid bodies, aortic bodies) respond to a decrease in PaO2, decrease in pH, and an increase in PaCO2.

      1. In COPD where PaCO2 is chronically elevated the medulla becomes desensitized to the increased PaCO2 and then hypoxemia becomes the most important stimulus for respiration (carbon dioxide narcosis). This is why the nurse needs to be careful when administering high oxygen flow rates to the COPD patient - it may diminish their stimulus to breathe.

   E. Mechanical receptors are located in the lungs, upper airways, chest wall, and diaphragm which prevent overdistension of the lungs.

   F. Respiratory defense mechanisms:
      1. filtration of air by the upper airways
      2. mucociliary clearance system
         -which is decreased by infection, atropine, alcohol, dehydration, smoking, anesthesia, and increased O2 concentration
      3. cough reflex
      4. reflex bronchoconstriction
         -both #3 and #4 clear the airways and prevent entry of irritants
      5. alveolar macrophages which phagocytize foreign particles
         -effectiveness is decreased by smoking, infections, prolonged use of steroids
Respiratory Assessment

I. History

A. General Health

B. Health habits
   1. Smoking history
   2. Exercise

C. Occupation

D. Complaints: cough, sputum, hemoptysis, dyspnea, shortness of breath, chest pain

II. Physical Assessment

A. General

B. Skin color
   1. cyanosis - late sign, oxygen saturation is below 80% before it shows
   2. clubbing of nails - sign of chronic hypoxemia

C. Respiratory rate, rhythm effects of activity, conversation

D. Use of accessory muscles for breathing

E. Chest symmetry, increased anterior-posterior (A-P) diameter or barrel chest seen with COPD

F. Palpation
   1. expansion (decrease with restrictive disease)
   2. tactile fremitus
   3. deviated trachea: deviates to side of least pressure

G. Percussion
   1. Resonance: normal
   2. Dullness: indicates consolidation
   3. Hyperresonance: heard with COPD

H. Auscultation
1. Normal breath sounds (sometimes called vesicular)
2. Abnormal breath sounds
   a. decreased breath sounds
   b. Crackles (used to be called rales), from air bubbling through fluid or sudden opening of closed airways (heard with pneumonia, atelectasis, pulmonary edema, CHF)
      - sounds like rubbing hair between fingers next to ear
   c. Rhonchi: due to narrowed airways, heard during excess mucus production as with COPD
   d. Wheeze: generated by vibrations of narrowed airways (heard with COPD, especially asthma. Sound has a continuous, musical quality
   e. Pleural friction rub: due to roughened pleurae rubbing against each other (heard in pleurisy)
   f. Bronchophony and egophony: due to altered transmission of voice sounds (heard with consolidation and pneumonia)

Oxygen Therapy

A. Purpose:
   1. administration of increased concentrations of oxygen (over 21%)
   2. used to treat both acute and chronic hypoxia

B. Indications
   1. PaO2 less than 80 or saturation less than 90%
      a. oxygen saturation is the amount of oxygen carried by the hemoglobin in comparison to the amount of oxygen the hemoglobin can carry
   2. Signs of hypoxia
      a. Tachypnea (rapid respirations)
      b. Dyspnea (difficult respirations)
      c. Tachycardia
      d. Dysrhythmias (PVCs)
      e. Cyanosis (late sign, oxygen saturation usually is below 80%)
      f. restlessness
      g. disorientation
      h. personality changes
      i. combativeness
      j. coma
k. fatigue
l. decreased urinary output
m. hypertension

3. PaO2 between 60-80 is relative hypoxemia, less than 50 is classified as respiratory failure

C. Types of therapy
   1. Nasal cannula
      a. most commonly used
      b. not accurate for more than 4 liters
   2. Face mask
      a. mask inconvenient
      b. chosen when humidification needed, patient breathes through mouth
      c. never use with less than 5 liters/minute to avoid rebreathing exhaled CO2
      d. more accurate if mask is secure
   3. Partial re-breathing mask
      a. similar to a mask with a reservoir bag added
      b. needs O2 flow of greater than 5 liters to limit re-breathing CO2
      c. more accurate than nasal cannula and face mask and used for acutely ill patients requiring 40-60% oxygen
   4. High-flow systems: non-rebreathing masks and venturi mask
      a. can accurately provide high concentrations of oxygen
      b. Venturi (Venti) mask most accurate
   5. Mechanical ventilation
      a. use of a machine to provide ventilation when a patient cannot adequately oxygenate themselves
      b. negative pressure - iron lung concept
      c. positive pressure - most commonly seen
         -requires intubation
         -forces air into the lungs and the patient passively expires
      d. complications:
         -infection
         -Pneumomediastinum (barotrauma)
         -oxygen toxicity
         -difficulty weaning
         -gastrointestinal bleeding

Chronic Obstructive Pulmonary Disease
A. Definition: a diagnostic category for respiratory conditions that involve a persistent obstruction/limitation of airflow; collectively referring to chronic bronchitis, emphysema, and asthma.

B. Pathophysiology/clinical manifestations: clinically difficult to distinguish among these three disorders, as all cause diffuse limitation in airflow and have common manifestations; often coexisting in same individual; however, pathogenesis of airflow obstruction differs among these three disorders.

1. Chronic bronchitis: as defined by the American Thoracic Society as excessive sputum production with cough for a minimum of 3 months per year and for 2 consecutive years.
   a. Hypertrophy and hyperplasia of submucosal bronchial glands
   b. excessive mucus production
   c. impaired ciliary function
   d. recurring infections of the lower respiratory tract
   e. inflammatory process causes narrowing of airways & mucus plugs
   f. bronchioles become damaged and fibrotic
   g. decreased ventilation/perfusion (V/Q) ratio
   h. Clinical manifestations:
      -chronic productive cough
      -shortness of breath
      -typical "blue bloater" appearance

2. Pulmonary Emphysema: abnormal, permanent enlargement of air spaces distal to the terminal bronchioles, accompanied by destruction of alveolar walls
   a. hyperinflation of alveoli
   b. destruction of alveolar walls
   c. destruction of alveolar capillary walls
   d. narrowed, tortuous small airways
   e. loss of lung elasticity
   f. Clinical manifestations:
      -barrel chested appearance
      -shortness of breath
      -typical "pink puffer" appearance
      -hypoxemia & hypercarbia more common with emphysema due to the tendency for hypoventilation and ventilation/perfusion mismatch

3. Asthma: intermittent, usually reversible, hyperirritability of airways, characterized by periodic exacerbation.
   a. 3 types
      -extrinsic (allergic)
      -intrinsic (idiopathic, non-allergic)
mixed
b. reversible, diffuse airway obstruction, usually gradual onset, more often at night
c. Clinical manifestations:
   - wheezing
   - coughing
   - dyspnea
   - chest tightness
   - expiration usually more difficult than inspiration
d. Status Asthmaticus - severe, life threatening, refractory to usual treatment with bronchodilators and hydration
   - causes include: URI, abrupt discontinuation of medications, abuse of aerosol meds, massive exposure to allergens, ingestion of beta-adrenergic blockers (Inderal)
   - usual treatment: subcutaneous epinephrine, Terbutaline, IV aminophylline, steroids

4. Nursing Care:
   a. Assess character of breathing patterns, breath sounds, percuss for resonance, and observe sputum.
   b. Promote mobilization of secretions through mucolytic agents, increased humidification, fluid intake of one & 1/2 to 2 liters/day, suctioning, chest physiotherapy.
   c. Positioning to allow for maximum breathing
d. Instruct patient on pursed-lip breathing and abdominal breathing
e. Administer low flow O2 because patients with COPD and with high levels of PaCO2, use hypoxia as a stimulus to breathe.
f. Measure O2 saturation (non-invasive with pulse oximetry or ear oximetry) q 4-8 hours and prn
g. Provide adequate rest periods and pace activities
h. Assess for signs of infection
i. Provide adequate nutrition, may need frequent small feedings due to shortness of breath while eating
j. Provide instruction to patient and family concerning disease process, medications, how to restructure activities to minimize dyspnea. Discuss/review use of Peak/Flow meter that can be used by patient at home to monitor lung capacity as it fluctuates with disease and can predict exacerbations of disease. Observe/teach proper use of metered-dose inhalers; an extender or air-chamber device can be helpful with the elderly who use metered-dose inhalers (MDI's)

Pneumonia
A. Definition: acute infection causing inflammation of lung tissue and alveoli filled with exudate

B. Pathophysiology:
   1. Infectious viral, fungal, or bacterial agents may be introduced by inhalation, aspiration, or spread from primary infection through circulation.
   2. Extent of inflammatory process varies and may involve different areas of lung parenchyma and pleura depending on type of pneumonia and host condition.
   3. Some pathological changes include:
      a. hypertrophy and hyper secretion of lung mucous membrane lining
      b. congestion as alveoli become fluid filled
      c. massive dilation of capillaries
      d. infiltration of affected lung area with RBCs, leukocytes, and fibrins with subsequent consolidation
      e. inflammation of pleurae
      f. atelectasis and impaired gas exchange
      g. bacteremia
      h. right-to-left shunting and hypoxemia

C. Etiology:
   1. Gram-positive bacteria:
      a. streptococcus pneumoniae
      b. Staphylococcus aureus
      c. Streptococcus pyogenes
   2. Gram-negative bacteria:
      a. Klebsiella pneumonia
      b. Pseudomonas aeruginosa
      c. Haemophilus influenzae
      d. Legionella pneumophila
   3. Anaerobic bacteria:
      a. anaerobic streptococci
      b. Bacteroides species
   4. Mycoplasma pneumoniae
5. Viruses

6. Fungal:
   a. Histoplasma capsulatum
   b. Cidioides immitis
   c. Aspergillus

7. Pneumocystis carinii (has been considered a protozoan, but is probably closes to a fungus)

D. Incidence:
   a. Leading infectious cause of death: accounts for 10% of hospital admissions

E. Clinical Manifestations:

1. Typical manifestations:
   a. Fever and chills
   b. Productive cough with green or rusty spots
   c. tachypnea, nasal flaring, dyspnea, retraction
   d. pleuritic chest pain
   e. crackles, dullness over consolidation, bronchophony and egophony

2. Atypical manifestations:
   a. malaise/fatigue
   b. headache
   c. sore throat
   d. GI manifestations: diarrhea, abdominal pain, vomiting, nausea

F. Diagnosis
1. chest x-ray
2. sputum
3. CBC
4. arterial blood gases

G. Medical Management:
1. expectorant (guaifenesin) - helps facilitate a productive cough
2. antibiotics
3. bronchodilators - relax bronchial smooth muscles to decrease spasm & pain
4. antitussives: suppress cough - to treat a dry, non-productive cough

H. Nursing Care:
1. Administer medications
2. teach about effective coughing/splinting
3. evaluate treatment effectiveness
4. position patient in high-fowlers position in bed to promote effective breathing
5. administer/monitor need for oxygen
6. monitor respirations, breath sounds, blood gases, pulse-oximetry
7. increase fluid intake to 2-3 liters per day unless contraindicated
8. Assess for signs of dehydration: poor skin turgor, dry mucous membranes, hypotension, tachycardia
9. Assess character of pain and effect on respiration
10. Provide comfort measures; analgesics as ordered, comfortable positioning, cool baths, skin care
11. Educate about disease process

Tuberculosis

A. Definition: bacterial infection caused by Mycobacterium tuberculosis; usually involves lungs, but may also cause extrapulmonary infections in bones, lymph nodes, kidneys, and meninges and may spread throughout bloodstream (miliary tuberculosis)

B. Pathophysiology:
   1. inhaled bacilli implanted in bronchioles and alveoli
   2. inflammation occurs to counteract infection
   3. Granulomatous lesion called tubercle formed and surrounded by lymphocytes
   4. lesion undergoes necrosis characterized by cheesy consistency in center, which may become liquefied and cause cavitation
   5. When lesion heals, tubercle bacilli remain in lung in walled-off, dormant state and may be reactivated if organisms rapidly multiply and body defenses lowered.

C. Etiology:
   1. organisms spread by inhalation of minute tubercle-laden droplets when an infected person speaks, coughs, or sneezes

D. Clinical manifestations:
   1. Systemic, nonspecific manifestations: fatigue, malaise, anorexia, weight loss, low-grade fever, night sweats
   2. Pulmonary manifestations; cough with productive mucopurulent sputum, pleuritic chest pain, dyspnea. hemoptysis (advanced cases)
E. Diagnostic examination:
   1. Tuberculin test: positive reaction indicates evidence of tuberculous exposure; most accurate tuberculin test is Mantoux test or intracutaneous injection of either PPD (purified protein derivative) or OT (old tuberculin prepared from dead tubercle bacilli); positive reaction is measured in mm of induration and the significance varies depending on the history of the patient (see "Keeping TB in Check", Nursing '99)
   2. Chest x-ray: shows evidence of active infection, i.e., pulmonary infiltration, nodules, cavitations
   3. Sputum exam: three or more early morning specimens may be needed to confirm diagnosis; usually acid-fast bacilli identified with sputum smears is the first bacteriological evidence; sometimes the cultures have to be obtained via bronchoscopy if the patient is unable to produce an adequate specimen

F. Medical management:
   1. antitubercular medications
   2. is reportable to the Health Department, medications are free, and the Health Department will follow-up to ensure that the patient is compliant with treatment

G. Nursing Care:
   1. Place the patient in Respiratory/Droplet Precautions if TB is suspected
      a. room with "reverse air-flow"
      b. UV light boxes to "sterilize" the air
      c. Health care personnel should wear properly fitted respirator masks when in contact with the patient
   2. Assist diagnostic testing
   3. Administer medications and monitor for toxic/side effects
   4. Instruct patient on preventing the spread of infection (careful handwashing, covering nose and mouth when coughing and sneezing, proper handling and disposal of sputum)
   5. Instruct patient on the disease process, the importance of receiving the full course of antitubercular medications
   6. Psychosocial support

H. Current significance of disease
   1. Increased incidence with immunologically suppressed population and influx of immigrants from 3rd world nations
   2. Emergence of Multi-drug resistant strains, related to non-compliance of patients in following the full course of recommended treatment
Pulmonary Edema

A. Definition: Abnormal accumulation of extra-vascular fluid in the lungs; edema can be due to left ventricular heart failure (cardiogenic pulmonary edema) or noncardiogenic edema due to pulmonary hypertension and breakdown of alveolar-capillary membrane

B. Pathophysiology:
   1. Cardiogenic pulmonary edema: left ventricular failure; pulmonary vascular congestion; increased capillary hydrostatic pressure; movement of edema to alveoli; alveolar flooding occurs
   2. Non-cardiogenic pulmonary edema: hydrostatic pressures normal, but alveolar-capillary membrane damaged; with resultant flooding of alveoli
   3. Either type: fluid-filled alveoli decrease diffusion; disruption of surfactant predisposes the alveoli to collapse; "foam" created as air and fluid mix; lung compliance decreases; both right-to-left shunting and decreased V/Q ratios can limit oxygenation

C. Incidence
   1. Non-cardiogenic pulmonary edema
      a. occurs as a complication in adult respiratory distress syndrome (ARDS)
      b. about 150,000 cases of ARDS annually in the U.S.
   2. Cardiogenic pulmonary edema
      a. more common
      b. occurs as a complication of left ventricular failure, myocardial infarction, mitral stenosis, or fluid overload

D. Predisposing/precipitating factors:
   1. ARDS (life-threatening condition that leads to respiratory failure with about a 50% mortality rate; is a complication from a variety of disorders, including sepsis, trauma, and pneumonia)
   2. Left ventricular failure
   3. Fluid overload
   4. Myocardial infarction
   5. Mitral stenosis

E. Clinical manifestations: Cardiogenic
   1. Dyspnea
   2. Orthopnea
   3. Paroxysmal nocturnal dyspnea
   4. Pink, frothy sputum
   5. Crackles
   6. S3 or S4 (heart sounds) are present
7. Hypotension
8. Hypoxia

F. Clinical manifestations: Non-cardiogenic
   1. Tachypnea
   2. Hypoxia to the point of cyanosis
   3. Crackles
   4. Acute respiratory distress and rapid deterioration

G. Medical management:
   1. Medications:
      a. Ionotropics to increase the force of heart contractions: dopamine & dobutamine
      b. Diuretics/Dialysis
      c. Sometimes aminophylline to dilate bronchials, Morphine to decrease anxiety

H. Nursing Care:
   1. Monitor fluid status on patients at risk
      a. Intake and output
      b. DAILY WEIGHTS
   2. Monitor blood gases
   3. If on ventilator, suction frequently
   4. Maintain oxygenation as possible with cannula/mask; may need ventilator with positive end-expiratory pressure (PEEP)
   5. Restrict fluids and sodium
   6. Administer drugs as ordered
   7. Prevent pulmonary infection with strict asepsis in suctioning and handwashing
   8. Maintain nutritional support
   9. Psychosocial support to patient and family
   10. Discuss the disease process with patient and family

Pulmonary Embolism

A. Definition: obstruction to blood flow in a pulmonary artery or capillary caused by a thrombus

B. Pathophysiology:
   1. Layers of platelets and fibrin collect (often near a venous valve) to produce a clot; often fibrinolysis occurs to dissolve the clot; however, an embolism occurs when the clot dislodges and travels to the lungs
2. Once thrombus lodges, it decreases the size of the pulmonary vasculature resulting in hypoxia from ventilation/perfusion (V/Q) mismatching.
3. Surfactant is lost in the region of the emboli so that atelectasis occurs, resulting in right-to-left shunting.
4. Loss of surfactant also results in increased permeability of the alveolar-capillary membrane, with resultant pulmonary edema and decreased diffusion.
5. The mechanical stimulus of the embolism causes an intense pulmonary vasoconstriction, promoting pulmonary hypertension and pulmonary edema.

C. Etiology: Blood clot, fat, amniotic fluid, air, tumor fragments, foreign material, such as sutures or bullets, sepsis, parasites.

D. Incidence:
1. At least 500,000 cases of pulmonary embolism in U.S. annually.
2. At least 50,000 deaths are attributed to pulmonary embolism yearly in U.S.

F. Predisposing factors:
1. Venous stasis.
2. Increased blood coagulability.
3. Damage to the vascular wall.
4. Postoperative patients, especially elderly patients with hip surgery or pelvic surgery.
5. Obesity.
7. Immobility.
8. Multiple fractures.
10. COPD.

G. Clinical Manifestations:
1. Dyspnea.
2. Chest pain.
3. Acute anxiety.
5. Hemoptysis.
6. Tachycardia.
7. Decreased PaO2.

H. Diagnostic examinations:
1. Nuclear medicine V/Q scan.
2. Pulmonary angiogram.
3. ECG and arterial blood gases

I. Complications: pulmonary infarction occurs in less than 10% of the cases which causes an area of the lung to be destroyed

J. Medical management:
   1. Treatment with anticoagulant therapy

K. Nursing Care:
   1. Prevention of formation of the clot in those patients at risk through early ambulation, use of thromboembolic stockings, mechanical leg compression devices, and stabilizing injured limbs
   2. Once emboli has developed, treat with anticoagulants, vena caval filters, embolectomy, and sometimes thrombolytic therapy (streptokinase, TPA)
   3. Oxygen or mechanical ventilation as ordered and needed
   4. Administer steroids and diuretics (fat emboli only) as ordered
   5. Psychosocial support
   6. Discuss with patient and family the disease process
   7. Patient education concerning the long-term use of oral anticoagulants and prevention of the formation of clots