NMNEC Concept: **Gas Exchange**

Mega-Concept: Health and Illness

Category: Oxygenation and Hemostasis

Concept Name: Gas Exchange

Concept Definition:
Mechanisms that facilitate and impair oxygen transport to the cells and the removal of carbon dioxide from the cells of the body.

Scope and Categories:

- **Scope:** Gas exchange is the process by which oxygenated air enters the respiratory tract, flows into the lungs, and is transported to the cells. Carbon dioxide is transported from the cells to the lungs and expelled via the respiratory tract.
  Adequate → varying degrees of inadequate gas exchange on a continuum
- **Categories:**
  - Ventilation is the inhalation of oxygenated air and exhalation of carbon dioxide. It may be impaired by insufficient oxygen or physical or physiologic barriers that alter or affect the upper and/or lower respiratory tract.
  - Alveolar respiration is the movement of oxygen and carbon dioxide at the alveolar levels.
  - Cellular respiration is the movement of oxygen and carbon dioxide at the cellular levels.

Risk Factors:
Ineffective gas exchange may affect individuals of all ages, gender, race, or socioeconomic status.

Populations at Risk:

- Premature infants are at risk for altered gas exchange due to immaturity of the lungs.
- Young children are at risk due to decreased alveolar surface and an increased exposure to respiratory pathogens.

- Older adults are at risk because of the structural and physiologic changes that occur with aging.

Individual Risk Factors:

- Tobacco: results in structural changes in the smaller airways and alveoli. It is the most significant risk factor and the single most preventable cause of death/disease in the United States (Wilson, 2017).
- Air-pollution**:** may be associated with disorders of ventilation (asthma) and gas exchange (chronic obstructive pulmonary disease [COPD]).
- Allergies: an immunologic response to an allergen that results in bronchoconstriction or obstruction.
- Aspiration: may result in the partial or complete occlusion of the airway or destruction of the alveolar integrity by the acidic pH of the aspirate.
- Immobility: often results in hypoventilation, atelectasis, and pneumonia.
- Immunosuppression: increases the risk of respiratory infection
- Poverty: affects living conditions, nutrition, sanitation, and immunity, and increases exposure to pathogens through close living quarters.

Physiological Processes and Consequences:

- Gas exchange is dependent on
    - Intact triggers
    - Patent, intact airways
    - Patent, functional alveoli
    - Sufficient cardiac output

Pathophysiological Processes and Consequences:

- Impaired ventilation: examples of causes include neuromuscular defects, obstruction, bronchoconstriction, COPD, respiratory suppressants (opioids)
- Alveolar and cellular respiration:
    - Low partial pressure of oxygen present at high altitude
    - Alveolar membrane thickness
- Increased alveolar secretions cause increased distance between air and red blood cells (RBCs) for gas movement
- Decreased tissue permeability causes increased distance between air and RBCs for gas movement

    - Surface area of gas exchange: emphysema changes the structure of the alveoli and decreases surface area
- Ventilation-perfusion ratio: pulmonary emboli affect the blood flow to the alveoli, which results in a ventilation-perfusion mismatch

Assessment/Attributes:

Subjective:

- Baseline history (include work & home environment), including data on any breathing problems (current or past, including frequency of upper respiratory tract infections [URIs], allergies, exposure to air pollutants, or smoking), immunizations, or symptoms of respiratory difficulties (cough, wheezing, dyspnea on exertion, sputum production)

Objective:

- Assessment findings, including but not limited to:
- General: oxygen saturation, anxiety, and confusion
- Inspection:
    - Respiratory rate
    - Work of breath: respiratory rate, accessory muscle use, respiratory depth
    - Skin and mucous membrane color
    - Body structure changes
- Auscultate:
    - Breath sounds
- Palpate:
    - Thoracic muscles, trachea, and thoracic wall

Diagnostic Tests:

- Laboratory: arterial blood gas (ABG), complete blood count (CBC), sputum examination, and skin tests
- Radiology: chest x-ray, computed tomography, ventilation-perfusion scans, positron emission tomography
- Pulmonary function studies (vital capacity, tidal volume, peak flow, forced expiratory vital capacity [FEVC] and FEVC1)
- Endoscopy examination: bronchoscopy (biopsy)
- Disease-specific exams: pilocarpine iontophoresis (cystic fibrosis)

Clinical Management – Interdisciplinary:

Primary Prevention: Health Promotion

- Infection control: minimize transmission and spread of respiratory pathogens (hand washing, respiratory precautions)
- Smoking prevention
- Prevention of secondhand smoke exposure
- Immunizations: yearly flu vaccine, pneumococcal and bacilli Calmette-Guerin (BCG) vaccines for high-risk groups
- Prevent postoperative complications: prevent postoperative atelectasis and pneumonia
- Incentive spirometry
- Turn, cough, and deep breathe
- Early mobilization
- Pain control to maximize the above

Secondary Prevention: Screening

- Smoking cessation: prevent lung cancer and structural damage to the lungs
- Screening (i.e., Mantoux skin test)

Tertiary Prevention: Prevention of Disease Progression

- Positioning: promotes ventilation when patient placed in a Fowler's position
- Teach breathing techniques
    - Diaphragmatic/abdominal breathing
    - Pursed lip breathing for COPD, hyperventilation
- Collaborative intervention for altered or ineffective gas exchange:
- Smoking cessation
- Pharmacotherapy
    - Drugs affecting upper airways: decongestants, antihistamines, leukotriene modifiers
    - Drugs affecting lower airways: bronchodilators
    - Mucolytics
    - Antitussives (cough suppressants): expectorants
    - Antibiotics to treat pulmonary infections
- Oxygen therapy
    - Airway management: positioning, suctioning, artificial airways

    - Mechanical ventilation to increase ventilation and prevent and treat atelectasis beyond what is possible by noninvasive techniques
- Chest physiotherapy & postural drainage to mobilize secretions so they can be expectorated
- Invasive procedures
    - Chest tubes: a tube placed in the pleural space to remove fluid and air
    - Thoracentesis: removal of the fluid from the pleural cavity for therapeutic or diagnostic study
    - Bronchoscopy: visual examination of the airways to check for pathology and biopsy
- Nutritional therapy
    - Small, frequent meals during dyspnea
    - High calorie, high protein
    - High lipids, low carbohydrates for COPD
- Hydration: to maintain a low viscosity of secretions
- Weight loss: to promote easier ventilation for morbidly obese

Interrelated Concepts:

- Anxiety: may result in hyperventilation and respiratory alkalosis
- Perfusion: necessary for gas transport
- Acid-base balance: gas exchange or ventilatory imbalances can result in respiratory acidosis (hypoventilation causes carbonic acid excess) or respiratory alkalosis (hyperventilation causes carbonic acid deficit). Increased or decreased ventilation also serves as an acid base compensatory mechanism for metabolic problems
- Mobility: immobility can result in a decrease in ventilation that can cause atelectasis or pneumonia
- Nutrition: nutritional support is necessary for the work of breathing

Exemplars:

New Mexico Nursing Education Consortium (NMNEC) Required Exemplars:

- Atelectasis: a common structural change that occurs from the blockage of bronchi/alveoli from mucus or other foreign objects. It is a common complication in clients during the postoperative period or prolonged hospitalization. There may be no indication of a problem if only a small number of alveoli are implicated to severe

hypoxemia with large areas of the lung affected (National Heart, Lung, and Blood Institute, 2012).

- COPD: a group of progressive and debilitating diseases that was the third leading cause of death in 2014. Cigarette smoking is the primary cause, along with air pollutants, genetic factors, and respiratory infections (Centers for Disease Control and Prevention [CDC], 2017c).

- Asthma: chronic disorder of the airways that compromises ventilation and oxygenation when the airways become inflamed. Asthma can be a primary or secondary disorder (COPD, heart failure). It occurs at all age levels. Currently, 1 in 11 children and 1 in 12 adults have an asthma diagnosis (CDC, 2016).

- Pneumonia: infection that causes lungs to fill with fluid. It is the world's leading cause of death for children under 5 years of age (American Thoracic Society, 2017). For adults in the United States, it is the second most common reason for hospital admission, only superseding birth (American Thoracic Society, 2017).

Optional Exemplars:

- Sudden infant death syndrome (SIDS)
- Pneumothorax
- Cystic fibrosis
- Acute respiratory distress syndrome (ARDS)

References:

Centers for Disease Control and Prevention. (2016, September). *Asthma*. Retrieved from https://www.cdc.gov/asthma/asthmadata.htm

Centers for Disease Control and Prevention. (2017a, August). *Chronic obstructive pulmonary disease (COPD)*. Retrieved from https://www.cdc.gov/copd/index.html

Centers for Disease Control and Prevention. (2017b, October). *Immunizations.* Retrieved from https://www.cdc.gov/vaccines/index.html

Centers for Disease Control and Prevention (2017c, September). *Smoking and tobacco use*. Retrieved from https://www.cdc.gov/tobacco/data_statistics/index.htm

National Heart, Lung, and Blood Institute: Atelectasis: https://www.nhlbi.nih.gov/health/health-topics/topics/atl

Wilson, S. F. (2017). Gas exchange. In J. F. Giddens (Ed.), *Concepts for nursing practice* (2nd ed., pp. 178-188). St. Louis, MO: Elsevier.

Resources:

American Lung Association: http://www.lung.org/

American Thoracic Society. (2017, June). *Pneumonia*. Retrieved from https://www.thoracic.org/professionals/career-development/residents-medical-students/ats-reading-list/pneumonia.php

Center for Disease Control: Asthma: https://www.cdc.gov/asthma/default.htm

Center for Disease Control: COPD: https://www.cdc.gov/copd/index.html

Center for Disease Control: Pneumonia: https://www.cdc.gov/pneumonia/index.html

Centers for Disease Control and Prevention (2017c, September). *Smoking and tobacco use*. Retrieved from https://www.cdc.gov/tobacco/data_statistics/index.htm

HealthyPeople.gov. (2018). *Tobacco use.* Retrieved from https://www.healthypeople.gov/2020/topics-objectives/topic/tobacco-use

National Heart, Lung, and Blood Institute: Asthma: https://www.nhlbi.nih.gov/health/health-topics/topics/asthma

National Heart, Lung, and Blood Institute; COPD: https://www.nhlbi.nih.gov/health/health-topics/topics/copd/

Healthy People 2020: Tobacco: https://www.healthypeople.gov/2020/leading-health-indicators/2020-lhi-topics/Tobacco

Nemours, Kid's Health: Asthma: http://kidshealth.org/en/kids/asthma.html

World Health Organization: Chronic Respiratory disorders: http://www.who.int/respiratory/en/