Hypoxemic and Hypercapnic Respiratory Failure

CRC 431
Cardiorespiratory Care
University of South Alabama
Outline

- Pathophysiology
- Etiology
- Signs and Symptoms
- Diagnosis
- Lab Data
- Respiratory Management
Respiratory Failure

- not a disease, rather a dysfunction
- syndrome in which the respiratory system fails in one or both of its gas exchange functions:
  - oxygenation
  - carbon dioxide elimination
- classified as either:
  - Hypoxemic (type I)
  - Hypercapnic (type II)
Respiratory Failure

Respiratory failure is inadequate gas exchange caused by dysfunction of one or more essential components of the respiratory system:

- Chest wall (bony thorax)
- Conducting airways
- Alveoli
- Pulmonary circulation
- Respiratory muscles or neurons
- Brain or spinal cord (central nervous system)
Respiratory Failure

Hypoxemic respiratory failure (type I)
- characterized by PaO₂ lower than 60 mm Hg with a normal or low PaCO₂
- pH less than 7.35
- most common form of respiratory failure
- associated with virtually all acute diseases of the lung involving:
  - Intra-alveolar filling: pneumonia, pulmonary edema
  - collapsed alveoli: atelectasis
- Hypoxemia caused by shunting is refractory to O₂ therapy; PPV + O₂ are needed
Respiratory Failure

Hypercapnic respiratory failure (type II)

- \( \text{PaCO}_2 \) greater than 50 mm Hg
- pH less than 7.35
- \( \text{PaCO}_2 \) rises rapidly and respiratory acidosis develops
- \( \text{PaO}_2 \) decreases slowly

Causes: disorders compromising alveolar ventilation and \( \text{CO}_2 \) removal

- Hypoxemia amenable to supplemental \( \text{O}_2 \)
Respiratory Failure

Respiratory failure may be

- Acute
  - Asthma exacerbation
  - Acute respiratory distress syndrome
- Chronic
  - Stable COPD
  - Moderate or severe kyphoscoliosis
- Acute on chronic
  - COPD exacerbation
Respiratory Failure Epidemiology

- 360K cases in US per year
- 36% experience death in hospital
- Morbidity and mortality rates increase with age of patients and co-morbidities
Hypoxemic Respiratory Failure

Physiological Mechanisms
- Ventilation-perfusion mismatching
- Intrapulmonary shunting
- Diffusion impairment
- Alveolar hypoventilation
Hypoxemic Respiratory Failure

Examples of type I respiratory failure:

- Cardiogenic (high pressure) pulmonary edema
- Non-cardiogenic (permeability) pulmonary edema
- Pulmonary fibrosis
- Pneumonia and pulmonary hemorrhage
- Pulmonary vascular problems
  - Pulmonary embolism
  - Pulmonary hypertension
Hypoxemic Respiratory Failure

Clinical Manifestations:
- Dyspnea
- Tachypnea
- Intercostal muscle retractions
- Accessory muscle use
- Paradoxical breathing (late sign)
- Cyanosis (late sign)
- Agitated, disoriented, delirious, restless, combative, confused
- Coma (late sign)
Hypoxemic Respiratory Failure

Clinical Manifestations (con’t):

– Tachycardia
– Hypertension
– Cold, clammy skin (hypoperfusion)
– Dysrhythmias (late sign)
– Hypotension (late sign)
– Fatigue
– Needs to pause to breathe when speaking; speaks haltingly
Hypercapnic Respiratory Failure

Physiological mechanisms

- Decreased alveolar ventilation and CO$_2$ removal
- Increased dead space ventilation
  - Increased anatomical dead space ventilation
  - Increased alveolar dead space ventilation
Hypercapnic Respiratory Failure

Clinical Manifestations:
- Dyspnea
- Tachypnea
- Intercostal muscle retractions
- Accessory muscle use
- Paradoxical breathing (late sign)
- Cyanosis (late sign)
- Agitated, disoriented, delirious, restless, combative, confused
- Coma (late sign)
Hypercapnic Respiratory Failure

Clinical Manifestations (con’t):

- Tachycardia
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Hypercapnic Respiratory Failure

Etiology of hypercapnic respiratory failure

- Nervous system failure
  - Central hypoventilation
- Respiratory muscle failure
  - Amyotrophic lateral sclerosis
- Neuromuscular transmission failure
  - Myasthenia gravis
  - Guillain-Barré syndrome
- Airway failure
  - Airway obstruction (COPD, bronchiectasis, cystic fibrosis)
Hypercapnic Respiratory Failure

Etiology of hypercapnic respiratory failure
- Chest wall and pleural space problems
  - Kyphoscoliosis
  - Morbid obesity
  - Pneumothorax
  - Fluid in pleural cavity (hemothorax)
Respiratory Failure

Knowing the patient’s primary medical problem helps determine what is causing the respiratory failure.

Knowing the pathophysiological mechanism of the patient’s respiratory failure helps determine if the respiratory failure is:

- Hypoxemic respiratory failure
- Hypercapnic respiratory failure
Respiratory Failure

Examples:

- Non-cardiogenic pulmonary edema is suspected by the presence of risk factors of ARDS:
  - Sepsis
  - Trauma
  - Aspiration
  - Smoke inhalation
  - Near drowning

Hypoxemic respiratory failure caused by intrapulmonary shunting.
Respiratory Failure

Example:

- Accompanying sensory abnormalities or symptoms of general muscle weakness may suggest neuromuscular respiratory failure:
  - Myasthenia gravis
  - Guillain-Barré syndrome

Hypercapnic respiratory failure caused by decreased alveolar ventilation.
Respiratory Failure

Example:
- Cardiogenic pulmonary edema suggested by chest pain, paroxysmal nocturnal dyspnea, and orthopnea.

Hypoxemic respiratory failure caused by fluid filled alveoli.
Respiratory Failure

Example:

- Elevated jugular venous pressure suggests right ventricular dysfunction resulting from accompanying pulmonary hypertension.

Hypoxemic respiratory failure caused by V/Q mismatch, decreased DLCO, low RV cardiac output.
Respiratory Failure

Example:

- COPD exacerbation suggested by history of heavy smoking, cough, sputum production.

Hypercapnic respiratory failure caused by obstructed expiratory airflow.
Respiratory Failure

**Laboratory Date**

- **ABGs:**
  - Quantifies magnitude of gas exchange abnormality
  - Differentiates between acute and chronic forms
  - Determines severity of the respiratory failure and its management
  - Identifies type of respiratory failure
    - Hypoxemic: Low PaO$_2$ and low PaCO$_2$
    - Hypercapnic: Low PaO$_2$ and high PaCO$_2$

- **CBC**
  - Anemia: may contribute to hypoxemia and hypoxia
  - Polycythemia: suggests chronic hypoxemia
  - Leukopenia: suggests possible viral infection
  - Neutrophilia (leukocytosis): suggest bacterial infection
Respiratory Failure

Laboratory Date
- Thyroid panel for TSH
  - serum levels of thyroid stimulating hormone
  - Determine possible hypothyroidism
  - potentially reversible of respiratory failure

- Chest radiography
  - May be helpful differentiating between cardiogenic and non-cardiogenic pulmonary edema
    - Increased heart size, vascular redistribution, peribronchial cuffing, pleural effusions, septal lines, and perihilar bat-wing distribution of infiltrates suggest cardiogenic pulmonary edema
Respiratory Failure

Laboratory Date
- PFTs
  - beneficial for chronic respiratory failure
  - Acute patients are unable to perform PFTs

- Patients with acute respiratory failure generally should be admitted to ICU.
- Most patients with chronic respiratory failure can be treated at home with oxygen supplementation and/or ventilatory assist devices