Acute Respiratory Failure: What’s Still Current? What’s New?

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Objectives

• differentiate between Type I and Type II acute respiratory failure
• select the primary management strategy for selected causes of acute respiratory failure.
• discuss new concepts in the management of acute respiratory failure

ARF: Definition

• Failure of the respiratory system to provide for the exchange of oxygen and carbon dioxide between the environment and tissues in quantities sufficient to sustain life
  – Hypoxemic normocapnic respiratory failure (Type I): low \( \text{PaO}_2 \) with normal \( \text{PaCO}_2 \)
  – Hypoxemic hypercapnic respiratory failure (Type II): low \( \text{PaO}_2 \) with high \( \text{PaCO}_2 \)

Type I respiratory failure

• Pneumonia
• Pulmonary edema
• Pulmonary fibrosis
• Pleural effusion
• Pneumothorax
• Asthma

Type II respiratory failure

• COPD with acute exacerbation
• Status asthmaticus
• CNS depressant drugs
• Anesthesia
• Neuromuscular blocking drugs
  – Muscle paralytics
  – Aminoglycosides
  – Organophosphate poisoning

Type I respiratory failure

• Atelectasis
• Aspiration pneumonitis
• ARDS (early)
• Smoke inhalation
• Pulmonary embolism
• Kyphoscoliosis
• Fat embolism
Type II respiratory failure

- Head trauma
- Poliomyelitis
- Amyotrophic lateral sclerosis
- Spinal cord injury
- Guillain-Barré syndrome
- Myasthenia gravis
- Multiple sclerosis

Type II respiratory failure

- Muscular dystrophy
- Morbid obesity
- Chest trauma
- Surgery: especially thoracic, abdominal, flank incision
- Sleep apnea
- Tracheal obstruction
- Epiglottis
- Cystic fibrosis
- Near-drowning

ARF: Pathophysiology

- Hypoventilation
- Ventilation-perfusion mismatching
- Shunting
- Diffusion defects

V/Q Ratio: pathologic imbalances

V/Q Ratio: Clinical presentation

- History of precipitating factor
- Clinical indications of respiratory distress
- Clinical indications of hypoxia
- Clinical indications of hypercapnia

Determinants of Diffusion

- Surface area
- Thickness of alveolar-capillary membrane
- Diffusion coefficient of the gas
- Driving pressure of the gas
  - fraction x pressure (e.g., FIO₂ x barometric pressure)
Clinical indications of respiratory distress

- Nasal flaring
- Sternal retractions
- Intercostal retractions
- Pursed lip breathing
- Tripod positioning
- Use of accessory muscles
- Speaking only one or two words between breaths
- Cough

Clinical indications of hypoxia

- Restlessness → confusion → lethargy → coma
- Tachycardia → dysrhythmias
- Tachypnea
- Dyspnea
- Use of accessory muscles
- Mild hypertension (early) → hypotension (late)
- Cyanosis may be present (depending on hemoglobin level)

Clinical indications of hypercapnia

- Irritability, confusion
- Inability to concentration → somnolence → coma
- Bradypnea
- Tachycardia → dysrhythmias
- Hypotension
- Headache
- Facial rubor (plethora)

ARF: Diagnostic

- Arterial blood gas changes
  - PaO$_2$ < 50-60 mm Hg
  - PaCO$_2$ > 50 mm Hg with a pH of < 7.30
- Chest X-ray: may identify cause

Acute Respiratory Failure

- #1: Treatment of Cause

Collaborative management
Airway and ventilation

- Positioning
  - Head of bed to 30°
  - Overbed table for patient to lean on
  - “Good lung down” if unilateral lung condition exists (exception: pneumonectomy)
  - Prone position especially in ARDS

Hydration

- Two to three liters/24 hours unless contraindicated by cardiac or renal disease
  - Oral fluids: noncaffeinated
  - Intravenous fluids: usually D$_5$NS

Upper airway obstruction
Airway secretions
Overdosage of narcotics
Bronchospasm
Pneumothorax
Pneumonia
Postoperative pain
ARDS
Myasthenic crisis
Atelectasis

- antimicrobials
- deep breathing and incentive spirometry
- chest tube
- positioning and airway placement
- cholinergic drugs and mechanical ventilator
- encouragement of coughing, suctioning if cannot effectively cough
- PEEP
- bronchodilators
- naloxone (Narcan)
- analgesics

HOB 30°

Positioning: good lung down

Prone positioning in ARDS

- Increased Pa$_O_2$ by 42-70 mm Hg and remained elevated for several hours; facilitated a decrease in FIO$_2$ and PEEP
Bronchial hygiene and chest physiotherapy

• Inspiratory maneuvers: deep breathing; incentive spirometry
• Analgesics in doses adequate to allow patient to deep breath and cough as indicated

Bronchial hygiene and chest physiotherapy

• Encouragement of the patient to cough if rhonchi are audible; suctioning if the patient is unable to clear airways
  – Suction only if necessary
  – Hyperoxygenate prior to, during, and after suctioning
  – Limit suctioning to 10-15 seconds with 100-120 mm Hg negative pressure
  – Rinse catheter but do not instill saline
    • Saline instillation (i.e., lavage) is ineffective, decreases oxygen levels, and contributes to VAP
    • Adequate humidification and hydration must be ensured

Bronchial hygiene and chest physiotherapy

• Postural drainage, percussion, vibration may be necessary
• Bronchoscopy may be necessary if airway clearance techniques are inadequate

Noninvasive Positive Pressure Ventilation

• Does not require intubation
• Used to try to avert intubation and mechanical ventilation

Noninvasive Positive Pressure Ventilation

• COPD: Standard of care for COPD if no contraindications
• Cardiogenic pulmonary edema: Evidence is strong
• Obesity: Require higher positive pressures and it takes longer to reduce PaCO₂

Noninvasive Positive Pressure Ventilation

• Asthma: Evidence is weak but positive
• Hypoxemic respiratory failure: Evidence is weak but positive
• Post-extubation respiratory failure: Evidence weak but negative
Noninvasive Positive Pressure Ventilation

- **Modes**
  - CPAP increases driving pressure of oxygen
  - Bi-PAP = pressure support + CPAP
    - Decreases work of breathing
    - Increases driving pressure of oxygen

Intubation and Mechanical Ventilation

- Intubation and mechanical ventilation may be necessary if PaCO₂ continues to rise and acidosis develops

The goal of mechanical ventilation is to normalize the pH, not necessary the PaCO₂

- It is not appropriate to normalize the PaCO₂ in patients with COPD and chronic hypercapnia (this causes metabolic alkalosis, eventual excretion of sodium bicarbonate, and weaning difficulties)

Mismanagement of ARF in COPD

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Intubation and Mechanical Ventilation

- Mechanical ventilation is indicated for respiratory muscle fatigue to allow respiratory muscle rest and recovery
- Permissive hypercapnia may be used to prevent VILI especially in patients with ARDS
- Helium-oxygen mixture may be used in airway obstruction such as status asthmaticus or tumor disease
**Drug therapy**

- Bronchodilators may be indicated
  - Long (salmeterol [Serevent]) and/or short-acting beta$_2$ adrenergic agonists (e.g., metaproterenol [Alupent], albuterol [Proventil])
  - Xanthines (e.g., aminophylline, theophylline)
  - Anticholinergic (e.g., ipratropium bromide [Atrovent])
  - Magnesium

- Pulmonary vasodilator may be indicated
  - Xanthines (e.g. aminophylline, theophylline)
  - Nitric oxide
  - Prostanoids
    - Epoprostenol (Flolan)
    - Iloprost (Ventavis)
    - Treprostinil (Remodulin [IV], Tyvaso [inhalation])
  - Endothelin receptor antagonists: bosentan (Tracleer)

- Antibiotics are indicated for bacterial infection
- Steroids are indicated in asthma

- Fibrinolytics are indicated for pulmonary embolism with right ventricular failure and/or refractory hypoxemia; anticoagulants are indicated for pulmonary embolism (primary if fibrinolytics are not indicated or after fibrinolytics if fibrinolytics are indicate)
  - Lepirudin (Refudan), a recombinant hirudin, or argatroban may be used in patients with history of HITT
    - These are direct thrombin inhibitors

- Expectorants (e.g. guaifenesin [Robitussin], potassium iodide [SSKI]) may be used but hydration is most important
- Mucolytics (e.g. acetylcysteine [Mucomyst]) may be used to decrease the tenacity of the mucus
- Sedatives: generally avoided unless patient is very agitated
- Antitussives: avoid use of antitussives

**Optimization of oxygen delivery and minimization of oxygen consumption**
Oxygen as indicated for hypoxemia

- Nasal cannula or mask; masks are contraindicated in hypercapnic patients as the high concentration of oxygen provided by these delivery system would likely eliminate the hypoxic drive.
- Flow rate or oxygen concentration to keep SpO₂ approximately 95% unless contraindicated; in patients with chronic hypercapnia, adjust flow rate or oxygen concentration to keep SpO₂ approximately 88-92%.

PEEP

- Decrease shunt
- Decrease surface tension and work of breathing
- Increase driving pressure to achieve
  - Same PaO₂ on lower FIO₂
  - Better PaO₂ on same FIO₂

Optimization of oxygen delivery and minimization of oxygen consumption

- Rest periods especially after meals or activities
- Quiet, restful environment
- Treatment of fever: antipyretics; cooling blankets

Optimization of oxygen delivery and minimization of oxygen consumption

- Positive end-expiratory pressure (PEEP): may be necessary to maintain adequate SaO₂, PaO₂
- Blood administration: may be necessary to provide adequate tissue delivery of oxygen if hemoglobin is low
- Fluid administration, inotropes, intra-aortic balloon pump, etc.: may be necessary to provide adequate tissue delivery of oxygen if cardiac output/index is low
Treat infection if present
- Antibiotics
- Bronchial hygiene techniques

Nutritional Support
- Malnutrition impairs:
  - respiratory muscle function
  - functioning of the immune system

Nutritional Support
- Enteral nutrition: helps to prevent translocation of bacteria from the GI tract to the lymphatics and blood vessels
- High protein and calorie diet rich in omega 3
- Multivitamin and mineral replacement: vitamins A, C, E, zinc, selenium
- Reduced carbohydrates during weaning

Monitor for complications
- Dysrhythmias
- Pulmonary infections: pneumonia
- Pulmonary edema
- Pulmonary embolism
- Barotrauma or volutrauma
- Pulmonary fibrosis
- Oxygen toxicity

Monitor for complications
- Acid-base imbalance
  - Respiratory acidosis
  - Respiratory alkalosis: when ventilation is excessive
  - Metabolic alkalosis: when $\text{PaCO}_2$ is normalized rather than the pH
- Electrolyte imbalance: frequently iatrogenic
- Renal failure

Monitor for complications
- GI complications: abdominal distention; ileus; ulcer; hemorrhage
  - ? PPI, H$_2$ antagonists, antacids
- Thromboembolism: LMWH
- Disseminated intravascular coagulation
- Sepsis; septic shock
- Psychologic responses: psychosis; depression
Evaluation

• Baseline oxygenation parameters: lower baseline oxygenation is a poor prognostic marker

Patient and Family Education

• Respiratory treatments
• Pharmacology therapies
• Recognition of clinical indications of infection and impending respiratory failure

Case Study

References


References


Which parameter differentiates between type I and type II acute respiratory failure? (more than one may be correct)

a. SaO₂
b. PaO₂
c. pH
d. PaCO₂
In a patient on noninvasive mechanical ventilation, which of the following would be an indication for intubation and mechanical ventilation? (more than one may be correct)

a. Altered level of consciousness
b. Hemodynamic instability
c. Progressive increase in PaCO₂ and worsening respiratory acidosis