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Acute Respiratory Failure
Guidelines

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Disclaimer

Definition

- Respiratory failure is a life-threatening impairment of oxygenation, carbon dioxide elimination, or both. resulting in hypoxia (defined by PaO2 ≤ 8kPa) and subdivided into 2 types according to PaCO2 levels.

- Acute respiratory failure (ARF) is defined as acute and progressive hypoxemia developing within hours, days, or up to a month caused by various respiratory, cardiovascular, or systemic diseases in previously healthy patients.

Classification

- Type 1 (Hypoxemic)
- PO2 < 50 mmHg on room air. Usually seen in patients with acute pulmonary edema or acute lung injury. These disorders interfere with the lung's ability to oxygenate blood as it flows through the pulmonary vasculature.
- Type 2 (Hypercapnic/ Ventilatory)
- PCO2 > 50 mmHg (if not a chronic CO2 retainer). This is usually seen in patients with an increased work of breathing due to airflow obstruction or decreased respiratory system compliance, with decreased respiratory muscle power due to neuromuscular disease, or with central respiratory failure and decreased respiratory drive.
- Type 3 (Peri-operative).
- This is generally a subset of type 1 failure but is sometimes considered separately because it is so common.
- `Type 4 (Shock)
- secondary to cardiovascular instability.

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Etiologies:

ARF can result from a variety of etiologies. It can result from primary pulmonary pathologies or can be initiated by extra-pulmonary pathology. Causes are often multifactorial. Acute respiratory failure can be caused by abnormalities in:

1. CNS (drugs, metabolic encephalopathy, CNS infections, increased ICP, OSA, Central alveolar hypoventilation)
2. spinal cord (trauma, transverse myelitis)
3. neuromuscular system (polio, tetanus, M.S., M. Gravis, Guillain-Barre, critical care or steroid myopathy)
4. chest wall (Kyphoscoliosis, obesity)
5. upper airways (obstruction from tissue enlargement, infection, mass; vocal cord paralysis, tracheomalacia)
6. lower airways (bronchospasm, CHF, infection)
7. lung parenchyma (infection, interstitial lung disease)
8. cardiovascular system

Clinical Signs and Symptoms of Acute Respiratory Failure

Clinical manifestations of respiratory distress reflect signs and symptoms of hypoxemia, hypercapnia, or the increased work of breathing necessary. These include:

- Altered mental status (agitation, somnolence).
- Peripheral or central cyanosis or decreased oxygen saturation on pulse oximetry.
- Manifestations of a "stress response" including tachycardia, hypertension, and diaphoresis.
- Evidence of increased respiratory work of breathing including accessory muscle use, nasal flaring, intercostal indrawing, suprasternal or supraclavicular retractions, tachypnea.
- Evidence of diaphragmatic fatigue (abdominal paradox).
- Abnormal arterial blood gas results.

Diagnosis

Diagnosis is clinical, supplemented by measurements of arterial or venous blood gases (ABGs or VBGs) and chest x-ray.

- **Blood gas Analysis**

ARF is typically diagnosed according to a PaO2 ≤ 60 mmHg at room air or PaO2/FIO2 ratio ≤ 300.

P/F Ratio Calculations

The P/F (PaO2/FIO2) ratio is a powerful objective tool to identify acute hypoxemic respiratory failure at any time while the patient is receiving supplemental oxygen, a frequent problem faced by documentation specialists where no room air ABG is available, or pulse oximetry readings seem equivocal.
The P/F ratio equals the arterial pO2 (“P”) from the ABG divided by the FIO2 (“F”).
The fraction (percent) of inspired oxygen that the patient is receiving expressed as a decimal (40% oxygen = FIO2 of 0.40).
A P/F Ratio of less than 300 indicates acute respiratory failure. Many physicians are unfamiliar with the P/F ratio, but it has been validated and used in the context of ARDS for many years, where acute respiratory failure is called “acute lung injury.”
A P/F ratio < 300 indicates mild ARDS, < 200 is consistent with moderate ARDS and < 100 is severe ARDS.

The P/F ratio indicates what the pO2 would be on room air:
P/F ratio < 300 is equivalent to a pO2 < 60 mm Hg on room air P/F ratio < 250 is equivalent to a pO2 < 50 mm Hg on room air P/F ratio < 200 is equivalent to a pO2 < 40 mm Hg on room air.

Example: Suppose the pO2 is 90mmHg on 40% oxygen (FIO2 = .40). The P/F ratio = 90 divided by .40 = 225. The pO2 on room air in this case would have been about 45 mmHg (well below the “cut-off” of 60mmHg).
The P/F ratio should not be used to diagnose acute-on-chronic respiratory failure since many patients with chronic respiratory failure already have a P/F ratio.

SpO2 translated to PO2

The arterial pO2 measured by arterial blood gas (ABG) is the definitive method for calculating the P/F ratio.
However, when the pO2 is unknown because an ABG is not available, the SpO2 measured by pulse oximetry can be used to approximate the pO2, as shown in the Table below.

PO2 (percent)	**PO2** (percent)
86	51
87	52
88	54
89	56

90	58
91	60
92	64
93	68
94	73

It is important to note that estimating the pO2 from the SpO2 becomes unreliable when the SpO2 is 98% - 100%.

Chest x-ray

1. Clear CXR with hypoxemia and normocapnia indicate Pulmonary embolus, R to L shunt, or Shock.
2. Diffusely white (opacified) CXR with hypoxemia and normocapnia indicate ARDS, NCPE, CHF, or pulmonary fibrosis.
3. Localized infiltrates indicate pneumonia, atelectasis, infarct.
4. Clear CXR with hypercapnia indicates COPD, asthma, overdose, neuromuscular weakness.

Management of Acute Respiratory Failure

The management of acute respiratory failure can be divided into an urgent resuscitation phase followed by a phase of ongoing care. The goal of the urgent resuscitation phase is to stabilize the patient as much as possible and to prevent any further life-threatening deterioration. Once these goals are accomplished the focus should then shift towards diagnosis of the underlying process, and then the institution of therapy targeted at reversing the primary etiology of the ARF.

- **Urgent resuscitation**
  1. Oxygenation
  2. Airway control
  3. Ventilator management
  4. Stabilization of the circulation
  5. Bronchodilators/ Steroids

- **Ongoing care**
  1. Differential diagnosis and investigations
  2. Therapeutic plan tailored to diagnosis.

Oxygenation

Almost all patients with ARF require supplemental oxygen. All should be placed on a pulse oximeter and oxygen saturation should generally be maintained above 90%. Oxygen diffuses from the alveolus across the alveolar membrane into capillary blood. The rate of diffusion is driven by the oxygen partial-pressure gradient. Therefore, increasing the PAO2 with supplementary oxygen should improve the transfer of oxygen into the pulmonary capillary blood.

There are several different devices that can be used to deliver oxygen. They differ in terms of whether they are open or closed systems, whether they deliver low or high oxygen concentrations, and whether they are low or high flow systems. Their effectiveness depends upon whether they can deliver enough oxygen at a sufficient flow rate to meet the patients' demands. Non-intubated patients spontaneously breathing through an open system will "entrain" some room air from their environment with each breath. Thus, the ultimate oxygen concentration delivered to them will depend upon how much was delivered by the oxygen device and how much was entrained room air. The lower the flow delivered by the oxygen device, and the higher the patient's own inspiratory flow is, the more room that will be entrained resulting in a lower oxygen concentration. For example, a tachypneic patient will likely have a high respiratory drive and high inspiratory flows. He will require a high flow system in order to prevent significant entrainment of room air and thus dilution of the delivered oxygen.

Nasal Cannula: Low-flow, low oxygen concentration, open device. 100 % oxygen is delivered through cannula at 0.5 to 6 L/min. Higher flow rates do not increase the FIO2 significantly and lead to drying of the mucosa and patient discomfort. The resulting FIO2 depends upon the patient's minute ventilation and how much room air is entrained. Thus, it cannot be precisely controlled. The maximal oxygen concentration at the trachea is not likely to exceed 40 to 50 %. Nasal prongs are generally used for relatively stable patients who do not require high FIO2 or precise control of their FIO2.

Venturi masks: These are variable oxygen concentration, low to moderate flow, open devices. These air entrainment masks deliver 100% oxygen through a jet-mixing device that causes a controlled entrainment

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of air and thus allows for deliver of precise oxygen concentrations from 24 to 50 %. These masks are useful in patients with COPD in whom a precise titration of oxygen concentration may be desirable in order to minimize an increase in PCO2.

Reservoir Face Masks: These are high flow, high oxygen, open devices designed to minimize entrainment of air in patients with high inspiratory flow demands. These masks incorporate a reservoir bag that is filled with 100% oxygen. If the patient makes an inspiratory effort generating a flow higher than the wall circuit can deliver, the reservoir of oxygen will be emptied to minimize entrainment of room air. The use of "tusks" on the facemask is a similar principle. The bag should be at least partially distended throughout the respiratory cycle.

Resuscitation Bag-Mask-Valve Unit. High oxygen, high flow device. The oxygen flow should be kept high (15 L/min) when this device is used. When the mask is held firmly over the face with a good facemask seal, entrainment of room air is minimized

Non-Invasive Positive Pressure Ventilation (NPPV): NPPV provides ventilatory assistance, positive pressure, and a controlled oxygen concentration using a tight-fitting facemask as the interface between the patient and the ventilator instead of an endotracheal tube. It can be used in order to avoid or prevent intubation in carefully selected patients.

Introduction to Mechanical Ventilation

Patient may intubated and connected to MV when indicated .

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