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Respiratory Failure

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Introduction

Respiratory failure is a clinical condition that happens when the respiratory system fails to maintain its main function which is gas exchange, in which PaO2 lower than 60 mmHg and/or PaCO2 higher than 50 mmHg.

Respiratory failure is classified according to blood gases abnormalities into type 1 and type 2.

Type 1(hypoxemic) respiratory failure: in which PaO2 < 60 mmHg with normal or subnormal PaCO2.In this type the gas exchange is impaired at the level of aveolo-capillary membrane. Examples of type I respiratory failure is carcinogenic or non-cardiogenic pulmonary edema and severe pneumonia.

Type 2 (hypercapnic) respiratory failure: in which PaCO2 > 50 mmHg. Hypoxemia is common and it is due to respiratory pump failure.

Also respiratory failure is classified according to its onset, course and duration into acute, chronic and acute on top of chronic respiratory failure.

Etiology

Respiratory failure may be due to pulmonary or extra-pulmonary causes which include:

CNS causes due to depression of the neural drive to breath as in cases of overdose of a narcotic and sedative.

Disorders of peripheral nervous system: Respiratory muscle, and chest wall weakness as in cases of Guillian-Barre syndrome and myasthenia gravis.

Upper and lower airways obstruction: due to various causes as in cases of exacerbation of chronic obstructive pulmonary diseases and acute severe bronchial asthma

Abnormities of the alveoli that result in type 1 (hypoxemic) respiratory failure as in cases of pulmonary edema and severe pneumonia.[1].

Epidemiology

The overall frequency of respiratory failure is not well known as respiratory failure is a syndrome rather than a single disease process.

Pathophysiology

The main path physiologic mechanisms of respiratory failure are:

Hypoventilation: in which PaCO2 and PaO2 and alveolar –arterial PO2 gradient is normal. Depression of CNS from

drugs is an example of this condition.

V/P mismatch: this is the most common cause of hypoxemia. Administration. Of 100% O2 eliminate hypoxemia.

Shunt: in which there is persistent hypoxemia despite 100% O2 inhalation. In cases of shunt the deoxygenated blood (mixed venous blood) bypasses the alveoli without being oxygenated and mixes with oxygenated blood that has flowed through the ventilated alveoli, and this leads to hypoxemia as in cases of pulmonary edema (cardiogenic or noncardiogenic), pneumonia and atelectasis

History and Physical

Symptoms and signs of hypoxemia

- Dyspnea,irritability
- Confusion, somnolence, fits
- Tachycardia, arrhythmia
- Tachypnea
- Cyanosis

Symptoms and signs of hypercapnia

- Headache
- Change of behavior
- Coma
- Asterixis
- Papilloedema
- Warm extremities

Symptoms and signs of the underlying disease

Examples:

Fever, cough, sputum production, chest pain in cases of pneumonia.

History of sepsis, polytrauma, burn, or blood transfusions before the onset of acute respiratory failure may point to acute respiratory distress syndrome[2].

Evaluation

The following investigations are needed:

- Arterial blood gases (ABG) is mandatory to confirm the diagnosis of respiratory failure.
- Chest radiography is needed as it can detect chest wall, pleural and lung parenchymal Lesions.
- Investigations needed for detecting the underlying cause of the respiratory failure these may include:
    - Complete blood count (CBC)
    - Sputum, blood and urine culture

- Blood electrolytes and thyroid function tests
- Pulmonary function tests
- Electrocardiography (ECG)
- Echocardiography
- Bronchoscopy

Treatment / Management

This includes supportive measures and treatment of the underlying cause.

Supportive measures which depend on depending on airways management to maintain adequate ventilation and correction of the blood gases abnormalities

Correction of Hypoxemia

The goal is to maintain adequate tissues oxygenation, generally achieved with an arterial oxygen tension (PaO2) of 60 mm Hg or arterial oxygen saturation (SaO2) about 90%.

Un-controlled oxygen supplementation can result in oxygen toxicity and CO2 (carbon dioxide) narcosis. So the inspired oxygen concentration should be adjusted at the lowest level which is sufficient for tissue oxygenation.

Oxygen can be delivered by several routes depending on the clinical situations in which we may use nasal canula, simple face mask nonrebreathing mask or high flow nasal canula.

Extracorporeal membrane oxygenation may be needed in refractory cases[3].

Correction of hypercapnia and respiratory acidosis

This may be achieved by treating the underlying cause or providing ventilatory support.[4]

Ventilatory support for the patient with respiratory failure

The goals of ventilator support in respiratory failure are:

- Correct hypoxemia
- Correct acute respiratory acidosis
- Resting of ventilatory muscles

Common indications for mechanical ventilation include the following:

- Apnea with respiratory arrest
- Tachypnea with respiratory rate >30 breaths per minute
- Disturbed conscious level or coma
- Respiratory muscle fatigue
- Hemodynamic instability
- Failure of supplemental oxygen to increase PaO2 to 55-60 mm Hg
- Hypercapnea with arterial pH less than 7.25[5].

The choice of invasive or noninvasive ventilatory support depends on the clinical situation whether the condition is

acute or chronic and how severe it is. It also depends on the underlying cause. If there is no absolute indications for invasive mechanical ventilation or intubations and if there is no contraindications for noninvasive ventilation non-invasive ventilation is preferred particularly in cases of COPD exacerbation[6][7], Cardiogenic pulmonary edema[6][8]and Obesity hypoventilation syndrome[9].

Complications

Complications from respiratory failure may be a result of blood gases disturbances or from the therapeutic approach itself

Example of these complications:

Lung complications: for example, pulmonary embolism irreversible scarring of the lungs, pneumothorax and dependence on a ventilator.

Cardiac complications: for example, heart failure arrhythmias and acute myocarial infarction[10].

Neurological complications: a prolonged period of brain hypoxia can lead to irreversible brain damage and brain death.

Renal: acute renal failure may occur due to hypoperfusionand and/or nephrotoxic drugs**.**

Gastro-intestinal: stress ulcer, ileus, and hemorrhage[11]

Nutritional: malnutrition, diarrhea hypoglycemia, electrolyte disturbances[12]

Consultations

During management of respiratory failure consultation for other specialties may be indicated like cardiac and neurological consultation.

Pearls and Other Issues

- Liberal oxygen supplementation beyond the required level for adequate tissue oxygenation may be hazardous and may lead to deterioration of the patient condition as in cases of acute on top of chronic type 2 respiratory failure in patients with chronic obstructive pulmonary disease[13].
- During mechanical ventilation carbon dioxide over-wash should be avoided in patients with acute on top of chronic type 2 respiratory failure by adjusting the ventilatory parameters to maintain carbon dioxide to its basal level.
- Lung protective strategy is mandatory during mechanical ventilation in especially in cases of acute respiratory distress syndrome[2].

Enhancing Healthcare Team Outcomes

The diagnosis of the underlying cause of respiratory failure and its treatment is challenging as respiratory failure may result from numerous pulmonary and extrapulmonary causes, so consultation for other specialties, for example, neurological and cardiac consultation may be mandatory. As complications from respiratory failure may be due to improper patient positioning and poor adherence to infection control policies, so the nurses are vital members of the interprofessional group assuring that appropriate position is rendered. Also, complications can be the result of drug toxicities or drug interactions so a pharmacist should be incorporated in the management team for respiratory failure cases. The job of the nurse carries a far more important role if the patient is on the mechanical ventilator. The nurse has to monitor the patient 24/7 and assess each organ system several times a day. The nurse also is responsible for suctioning, positioning and feeding of the patient. Because the patient with respiratory failure is usually on multiple

medications, the pharmacist is responsible for ensuring the most appropriate drug is administered without causing drug interactions or severe adverse reactions. Finally, patient in respiratory failure is also looked after respiratory therapists for chest therapy or administration of oxygen. [14][15][16](Level V)

Outcomes

The prognosis of respiratory failure varies according to underlying causes and other factors like the age of the patients and the associated co morbidities [17].

Questions

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