Respiratory Failure

Respiratory failure occurs when disease of the heart or lungs leads to failure to maintain adequate blood oxygen levels (hypoxia) or increased blood carbon dioxide levels (hypercapnia).[1]

- Hypoxaemic respiratory failure is characterised by an arterial oxygen tension (PaO$_2$) of <8 kPa (60 mm Hg) with normal or low arterial carbon dioxide tension (PaCO$_2$).
- Hypercapnic respiratory failure is the presence of a PaCO$_2$ >6 kPa (45 mm Hg) and PaO$_2$ <8 kPa.

Respiratory failure can be acute (develops within minutes or hours in patients with no or minor evidence of pre-existing respiratory disease), acute on chronic (an acute deterioration in an individual with pre-existing respiratory failure) or chronic (develops over several days or longer in patients with existing respiratory disease).[1]

Aetiology

**Common causes of type I respiratory failure**
- Chronic obstructive pulmonary disease (COPD).
- Pneumonia.
- Pulmonary oedema.
- Pulmonary fibrosis.
- Asthma.
- Pneumothorax.
- Pulmonary embolism.
- Pulmonary hypertension.
- Cyanotic congenital heart disease.
- Bronchiectasis.
- Acute respiratory distress syndrome.
- Respiratory illness associated with HIV infection.[2]
- Kyphoscoliosis.
- Obesity.[3]

**Common causes of type II respiratory failure**
- COPD.
- Severe asthma.
- Drug overdose, poisoning.
- Myasthenia gravis.
- Polyneuropathy.
- Poliomyelitis.
- Muscle disorders.
- Head injuries and neck injuries.
- Obesity.
- Pulmonary oedema.
- Adult respiratory distress syndrome.
- Hypothyroidism.

Presentation

The cause of respiratory failure is often clear from a thorough history and physical examination. See also the separate Respiratory System History and Examination article.
Symptoms

- The history may indicate the underlying cause - eg, paroxysmal nocturnal dyspnoea, and orthopnoea in pulmonary oedema.
- Both confusion and reduced consciousness may occur.

Signs

- Localised pulmonary findings are determined by the underlying cause.
- Neurological features may include restlessness, anxiety, confusion, seizures or coma.
- Tachycardia and cardiac arrhythmias may result from hypoxaemia and acidosis.
- Cyanosis.
- Polycythaemia is a complication of long-standing hypoxaemia.
- Cor pulmonale: pulmonary hypertension is frequently present and may induce right ventricular failure, leading to hepatomegaly and peripheral oedema.

Investigations

Investigations will depend on the individual cause and severity of respiratory failure and comorbidity. Investigations may include:

- Arterial blood gas analysis: confirmation of the diagnosis.
- CXR: often identifies the cause of respiratory failure.
- FBC: anaemia can contribute to tissue hypoxia; polycythaemia may indicate chronic hypoxaemic respiratory failure.
- Renal function tests and liver function tests: may provide clues to the aetiology or identify complications associated with respiratory failure. Abnormalities in electrolytes such as potassium, magnesium and phosphate may aggravate respiratory failure and other organ dysfunction.
- Serum creatine kinase and troponin I: to help exclude recent myocardial infarction. Elevated creatine kinase may also indicate myositis.
- TFTs (hypothyroidism may cause chronic hypercapnic respiratory failure).
- Spirometry: useful in the evaluation of chronic respiratory failure.
- Echocardiography: if a cardiac cause of acute respiratory failure is suspected.
- Pulmonary function tests are useful in the evaluation of chronic respiratory failure.
- ECG: to evaluate a cardiovascular cause; it may also detect dysrhythmias resulting from severe hypoxaemia or acidosis.
- Right heart catheterisation: should be considered if there is uncertainty about cardiac function, adequacy of volume replacement and systemic oxygen delivery.
- Pulmonary capillary wedge pressure may be helpful in distinguishing cardiogenic from non-cardiogenic oedema.

Management

A patient with acute respiratory failure generally needs prompt hospital admission in an intensive care unit. Many patients with chronic respiratory failure can be treated at home, depending on the severity of respiratory failure, underlying cause, comorbidities and social circumstances.

- Immediate resuscitation may be required.
- Appropriate management of the underlying cause.

The management will depend on the individual patient and treatment may be within the context of palliative care.

Hypoxaemia

- Ensure adequate oxygen delivery to tissues, generally achieved with a PaO$_2$ of 60 mm Hg or an arterial oxygen saturation (SaO$_2$) of greater than 90%.
- Beware the prolonged use of high-concentration oxygen in chronic sufferers who have become reliant on their hypoxic drive to maintain an adequate ventilation rate. Elevating the PaO$_2$ too much may reduce the respiratory rate so that the PaCO$_2$ may rise to dangerously high levels.
- Assisted ventilation:
  - Mechanical ventilation:
    - The goal of mechanical ventilation in acute hypoxaemic respiratory failure is to support adequate gas exchange without harming the lungs.\(^4\)
    - It is used to increase \(\text{PaO}_2\) and to lower \(\text{PaCO}_2\).
    - It also rests the respiratory muscles and is an appropriate therapy for respiratory muscle fatigue.
    - Weaning patients with chronic respiratory failure off of mechanical ventilation may be very difficult.\(^5\)
  - Non-invasive ventilation (NIV):
    - Has been increasingly used as an alternative to invasive ventilation.\(^6, 7\)
    - Improves survival and reduces complications for selected patients with acute respiratory failure.\(^6\)
    - The main indications are exacerbation of COPD, cardiogenic pulmonary oedema, pulmonary infiltrates in immunocompromised patients.\(^9\)
    - When used for weaning patients off mechanical ventilation, reduces rates of death and pneumonia without increasing the risk of weaning failure or re-intubation.\(^5\)
  - Extracorporeal membrane oxygenation (ECMO):
    - Is a mainstay of therapy in neonatal and paediatric patients with life-threatening respiratory and/or cardiac failure. It has also been used for adults with severe respiratory failure.\(^10\)
    - The National Institute for Health and Care Excellence (NICE) recommends that the evidence on the safety of ECMO for severe acute respiratory failure in adults is adequate but shows that there is a risk of serious side-effects.\(^11\)

Strategies to support oxygenation can cause substantial harm through lung stretch injury, oxygen toxicity, transfusion risks and cardiac over-stimulation.\(^12\)

**Hypercapnia and respiratory acidosis**
Correct the underlying cause and/or provide assisted ventilation.

**Complications**

- Pulmonary: for example, pulmonary embolism, pulmonary fibrosis and complications secondary to the use of mechanical ventilation.
- Cardiovascular: for example, cor pulmonale, hypotension, reduced cardiac output, arrhythmias, pericarditis and acute myocardial infarction.
- Gastrointestinal: for example, haemorrhage, gastric distention, ileus, diarrhoea and pneumoperitoneum. Duodenal ulceration caused by stress is common in patients with acute respiratory failure.
- Polycythaemia.
- Hospital-acquired infection: for example, pneumonia, urinary tract infections and catheter-related sepsis are frequent complications of acute respiratory failure.
- Renal: acute kidney injury and abnormalities of electrolytes and acid-base balance are common in critically ill patients with respiratory failure.
- Nutritional: including malnutrition and complications related to administration of enteral or parenteral nutrition. Complications associated with nasogastric tubes - eg, abdominal distention and diarrhoea.

**Prognosis**
The mortality rate associated with respiratory failure depends on the underlying cause as well as the speed of diagnosis and efficacy of management.

**Further reading & references**

- BTS/ICS Guidelines for the Ventilatory Management of Acute Hypercapnic Respiratory Failure in Adults; British Thoracic Society (2016)

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