Delivering oxygen therapy to acutely breathless adults


Summary
Oxygen is a chemical element making up approximately 21% of the atmosphere. It is essential in enabling the body to carry out the metabolic processes required to sustain life. Clinically, it should be considered as a medication that should be used with the same caution extended to all pharmaceutical interventions. The aim of this article is to highlight the role of oxygen in correcting acute respiratory failure in adults and to discuss safe and effective delivery.

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Keywords
Nursing: care; Oxygen therapy; Respiratory system
These keywords are based on the subject headings from the British Nursing Index. This article has been subject to double-blind review. For author and research article guidelines visit the Nursing Standard home page at www.nursing-standard.co.uk. For related articles visit our online archive and search using the keywords.

RESPIRATORY FAILURE is defined as failure to maintain adequate gas exchange and is characterised by abnormalities shown on arterial blood gas (ABG) analysis (British Thoracic Society (BTS) 2002). Respiratory failure can be acute, acute on chronic, or chronic. Although not always clear cut, this distinction is important when deciding the most appropriate treatment strategy.

Acute respiratory failure is a life-threatening complication when alveolar ventilation becomes inadequate for the body’s needs. Even at rest, it is the key symptom of most cardiac and respiratory diseases, such as cardiogenic pulmonary oedema, and of exacerbation of chronic respiratory disease, including chronic obstructive pulmonary disease (COPD), all of which are associated with a high morbidity and mortality (Ray et al 2006).

Respiratory failure is present if hypoxia, a partial pressure of oxygen in arterial blood (PaO₂) of less than 8kPa or 60mmHg, is demonstrated following ABG analysis. Acute respiratory failure can be broadly sub-divided into two distinct types of respiratory failure, based on the level of partial pressure of carbon dioxide in arterial blood (PaCO₂). Normal values of PaO₂ range between 80 and 100mmHg (11-14kPa) and between 35 and 45mmHg (4.7-6.0kPa) for PaCO₂.

Type 1 respiratory failure is: PaCO₂ less than 6.0kPa and PaO₂ less than 8.0kPa. Type 2 respiratory failure is: PaCO₂ greater than 6.0kPa and PaO₂ less than 8.0kPa. The clinical features of acute respiratory failure will vary between patients, but as well as the clinical features of the underlying cause of the respiratory failure, patients commonly exhibit some of the following:

- If hypoxia (a low PaO₂) is present restlessness, confusion and, ultimately, coma.
- If hypercapnia (a raised PaCO₂) is present drowsiness, flapping tremor, warm peripheries, headaches and a bounding pulse may be evident.

Appropriate oxygen therapy is a fundamental component of the management of both types of respiratory failure. The principle aim of the immediate management of any respiratory failure is to reverse hypoxia while reducing, or preventing a further increase in, hypercapnia. The delivery of appropriate oxygen therapy is essential.

Initiation of oxygen therapy
Oxygen delivery relies on the patient having and maintaining a patent airway. The concentration of oxygen given in an acute situation is critical, and inadequate oxygen delivery accounts for more deaths and permanent disability than can be justified, considering the relatively low risks of high oxygen concentration prescription (Bateman and Leach 1998).

A face mask is the preferable method of delivering oxygen to an acutely breathless patient. Different masks are available and should be selected based on the needs of the specific patient. A simple oxygen face mask is a plastic device that fits over a patient’s nose and mouth. It delivers oxygen as the patient breathes through either the nose or the mouth. A simple mask has open side
ports that allow room air to enter the mask and dilute the oxygen, as well as allowing exhaled carbon dioxide to leave the containment space. It is used to deliver moderate to high concentrations of oxygen. It can deliver from 40% to 60% oxygen at a flow rate of 10-12 litres/min.

A partial rebreather oxygen mask is similar to a simple face mask. However, the side ports are covered with one-way discs to prevent room air from entering the mask. These masks have soft plastic reservoir bags connected to them that conserve the first third of the patient’s exhaled air while the rest escapes through the side ports. This is designed to make use of the carbon dioxide as a respiratory stimulant. A partial rebreather mask is used to deliver high concentrations of oxygen. It can deliver 70% to 90% oxygen at a flow of 6-15 litres/min (Martelli 2002).

A non-rebreather oxygen mask is similar to a simple face mask but has multiple one-way valves in the side ports. These valves prevent room air from entering the mask but allow exhaled air to leave the mask. It has a reservoir bag like a partial rebreather mask but the reservoir bag has a one-way valve that prevents exhaled air from entering the reservoir. This allows larger concentrations of oxygen to collect in the reservoir bag for the patient to inhale. A non-rebreather mask is used to deliver high flow oxygen. It can deliver 90% to 100% oxygen at a flow of 15 litres/min (Martelli 2002).

A Venturi oxygen mask is similar to a simple face mask but incorporates an interchangeable Venturi valve that ensures specific proportions of oxygen and room air are mixed to deliver a fraction of inspired oxygen (FiO2). Table 1 shows the number of litres of oxygen and the corresponding oxygen concentration delivered to the patient.

### Management of type 1 respiratory failure

Uncorrected hypoxia is a risk to patients with type 1 respiratory failure. With no compromise to the PaCO2, correcting hypoxia is the priority.

Usual practice to correct hypoxia is to deliver 60-100% oxygen via a face mask, and titrate upwards or downwards (using a Venturi and mask system to ensure accuracy of the percentage of oxygen being delivered) until the lowest percentage of oxygen required to correct the hypoxia (that is, PaO2 > 8.0 kPa) or the oxygen saturation is maintained at or above 92% (National Institute for Clinical Excellence 2004) (Figure 1). Concurrent treatment of the underlying medical condition should also be commenced.

### Management of type 2 respiratory failure

Type 2 respiratory failure can be either acute or acute on chronic. In acute type 2 respiratory failure, it is appropriate to start delivering oxygen therapy at 28%, then carefully titrate upwards to reverse the hypoxia and maintain saturations at above 90%. ABGs are essential in ensuring that hypercapnia does not worsen.

For patients with known type 2 respiratory failure, the use of oxygen therapy carries some added risk. A small percentage will rely on a continued state of hypoxia to drive their respiratory system (a hypoxic drive). High-dose oxygen given to these patients, who commonly have a diagnosis of COPD, can reduce the hypoxic drive to breathe (Bateman and Leach 1998). This causes carbon dioxide retention that may be lethal. In patients known to have chronic type 2 respiratory failure, initial treatment with low oxygen concentrations (starting at 24-28%) should be commenced, with cautious titration upwards to correct hypoxia (Bateman and Leach 1998) (Figure 2).

In the clinical setting it can be difficult to identify those patients who have either a pre-existing or pre-disposition towards a hypoxic drive, for example patients with COPD. Because of this, many practitioners are cautious about giving oxygen at levels above 28% for fear of reducing the drive to breathe. However, patients are more at risk from hypoxia than from hypercapnia.

### TABLE 1

<table>
<thead>
<tr>
<th>Venturi valve (colour)</th>
<th>Flow rate (litres/min)</th>
<th>FiO2 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>White</td>
<td>4</td>
<td>28</td>
</tr>
<tr>
<td>Yellow</td>
<td>6</td>
<td>35</td>
</tr>
<tr>
<td>Red</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Green</td>
<td>12</td>
<td>60</td>
</tr>
</tbody>
</table>

### FIGURE 1

**Oxygen therapy in type 1 respiratory failure**

Acute illness – type 1 respiratory failure

Immediate fraction of inspired oxygen (FiO2) 60% continuously

Specific treatment to correct underlying condition

Titrate FiO2 to lowest level required to correct hypoxia (PaO2 80-106 kPa or SaO2 92%)

Monitor response to therapy

PaO2 = partial pressure of oxygen in arterial blood; SaO2 = oxygen saturation

NURSING STANDARD
Monitoring response to treatment

The key to successful oxygen therapy is careful monitoring, as well as an appropriate and timely response to ensure that hypoxia is corrected as soon as possible. Pulse oximetry is usually adequate to assess response to treatment, but if there is suspicion of hypercapnia then ABGs should be performed. The important steps to consider are (Bateman and Leach 1998):

- ABG analysis or pulse oximetry should be performed before oxygen therapy, if possible.
- ABGs should be measured or oximetry done within two hours of starting oxygen therapy and oxygen adjusted accordingly (an adequate response is defined as \( \text{PaO}_2 > 7.8 \text{kPa} \) or \( \text{SaO}_2 > 92\% \)).
- Hypoxic patients at risk of arrhythmias or respiratory failure should be monitored continuously by oximetry.
- In patients at risk of type 2 respiratory failure, ABGs should be measured more frequently to assess \( \text{PaO}_2 \), \( \text{SaO}_2 \) should be monitored continuously by oximetry.
- In the acute stage, response should be assessed daily by ABG analysis or oximetry and oxygen adjusted accordingly.

All patients on oxygen therapy should be monitored for signs of increasing hypercapnia (tremor, agitation, confusion and headaches) and for signs of a blunting of their hypoxic drive (hypoventilation, drowsiness, flushing and coma). If retention of \( \text{CO}_2 \) is suspected, ABG analysis should be repeated immediately and oxygen titrated downwards as appropriate.

- If possible ABG analysis or pulse oximetry should be carried out before oxygen therapy is commenced.
- ABG analysis or pulse oximetry should be measured within two hours of starting oxygen therapy and alterations made to treatment to ensure an adequate response (defined as \( \text{PaO}_2 > 7.8 \text{kPa} \) or \( \text{SaO}_2 > 92\% \)).
- Patients at risk of arrhythmia or respiratory failure should be monitored continuously.

Oxygen therapy should be stopped when the patient is able to maintain adequate oxygenation while breathing room air.

Conclusion

Oxygen should be considered a prescribed drug and the guidelines used for all pharmaceutical interventions should be followed. In an acute situation the dose of oxygen administered is crucial to the success or failure of treatment. Inadequate oxygen accounts for more deaths and permanent disability than can be justified by the relatively small risks associated with high dose oxygen.

Although 10-15\% of patients with COPD are at risk of respiratory depression from receiving oxygen at levels above 28\%, the risk of hypercapnia in this patient group is often overstressed. The result of this is the undertreatment of serious hypoxia which can result in unnecessary death.

Caution is necessary, and where there is a history of type 2 respiratory failure, consideration to this should be given in the management plan. For the majority of acutely breathless adults, the risks associated with hypoxia far outweigh the risks of reducing hypoxic drive.

References


