Delivering oxygen therapy in acute care: part 1

Oxygen administration is important and common, but can cause harm. Nurses often have to start patients on oxygen therapy so need a good understanding of its use.

In this article...

- The normal physiology of breathing
- Types, common causes and diagnosis of respiratory failure
- An overview of positive pressure ventilation

Author Steven Vates is a staff nurse at the intensive care unit, St James’s University Hospital, Leeds.


Respiratory problems are common presenting complaints that require prompt assessment and management (Carroll, 2007). The implications for the patient if respiratory problems are not managed correctly can be severe.

This two-part series identifies the indications for and use of a variety of oxygen administration methods, and the underlying theory to these interventions.

Part one will discuss the importance of respiratory support in hospitals, the normal physiology of breathing, respiratory failure and positive pressure ventilation. Part two looks at methods of administering oxygen, and their indications and contraindications.

Oxygen administration is a common intervention in hospitals; oxygen therapy is not risk free and has the potential to cause great harm to patients (Howell, 2001). Oxygen is a drug and should always be prescribed and administered as such.

This is backed by the National Patient Safety Agency, which has highlighted continuing problems with prescribing, patient monitoring and confusion regarding equipment and administration (NPSA, 2009).

The responsibility for initiating oxygen therapy often falls inappropriately on nurses, potentially increasing clinical risk and claims of negligence (Howell, 2001). As a result there is a need for greater understanding of oxygen therapy among nurses.

Normal physiology

The respiratory system is divided into upper and lower parts. The upper respiratory system consists of the nose, pharynx (throat) and associated structures, and the lower consists of the larynx, trachea, bronchi and lungs.

The main muscles of inspiration are the diaphragm and external intercostal muscles. Each lung is enclosed and protected by two layers of serous membrane, the visceral and parietal pleura. Due to the space occupied by the heart, the left lung is approximately 10% smaller than the right. The lungs are divided into distinct lobes, two on the left and three on the right (Tortora and Grabowski, 2003).

According to Marieb and Hoehn (2006), breathing is a process dependent on volume changes in the thoracic cavity, leading to pressure change and air flow. There are two phases of breathing – inspiration, where air flows into the lungs, and expiration where gases exit the lungs (Fig 1). The simple rule is that air will always flow from an area of high pressure to an area of low pressure (Tortora and Grabowski, 2003).

Inspiration

Inspiration is initiated by the contraction of the diaphragm and external intercostal muscles, which makes the thoracic cavity larger and the lungs expand. As the thoracic cavity becomes larger, the pressure drops and the pressure between the space inside the lungs and the air surrounding the person becomes unequal. This drop in pressure is equalised by air flowing into the lungs where gas exchange can occur (Marieb and Hoehn, 2006).

When the respiratory system is under stress, accessory respiratory muscles, including the sternocleidomastoid, scalene and internal intercostals are used, resulting in a visible change to respiration. As muscles control inhalation, the process is active (Tortora and Grabowski, 2003).

Expiration

During expiration, the opposite occurs – the respiratory muscles relax and the size of the thoracic cavity decreases. As the size is reduced, the pressure inside the thorax is higher than the surrounding environment and the air flows from high to low

Keywords: Oxygen therapy/Respiratory failure/Positive pressure ventilation

This article has been double-blind peer reviewed

QUICK FACT

10% The left lung is approximately 10% smaller than the right

In this article...

- The normal physiology of breathing
- Types, common causes and diagnosis of respiratory failure
- An overview of positive pressure ventilation

Author Steven Vates is a staff nurse at the intensive care unit, St James’s University Hospital, Leeds.


Respiratory problems are common presenting complaints that require prompt assessment and management (Carroll, 2007). The implications for the patient if respiratory problems are not managed correctly can be severe.

This two-part series identifies the indications for and use of a variety of oxygen administration methods, and the underlying theory to these interventions.

Part one will discuss the importance of respiratory support in hospitals, the normal physiology of breathing, respiratory failure and positive pressure ventilation. Part two looks at methods of administering oxygen, and their indications and contraindications.

Oxygen administration is a common intervention in hospitals; oxygen therapy is not risk free and has the potential to cause great harm to patients (Howell, 2001). Oxygen is a drug and should always be prescribed and administered as such.

This is backed by the National Patient Safety Agency, which has highlighted continuing problems with prescribing, patient monitoring and confusion regarding equipment and administration (NPSA, 2009).

The responsibility for initiating oxygen therapy often falls inappropriately on nurses, potentially increasing clinical risk and claims of negligence (Howell, 2001). As a result there is a need for greater understanding of oxygen therapy among nurses.

Normal physiology

The respiratory system is divided into upper and lower parts. The upper respiratory system consists of the nose, pharynx (throat) and associated structures, and the lower consists of the larynx, trachea, bronchi and lungs.

The main muscles of inspiration are the diaphragm and external intercostal muscles. Each lung is enclosed and protected by two layers of serous membrane, the visceral and parietal pleura. Due to the space occupied by the heart, the left lung is approximately 10% smaller than the right. The lungs are divided into distinct lobes, two on the left and three on the right (Tortora and Grabowski, 2003).

According to Marieb and Hoehn (2006), breathing is a process dependent on volume changes in the thoracic cavity, leading to pressure change and air flow. There are two phases of breathing – inspiration, where air flows into the lungs, and expiration where gases exit the lungs (Fig 1). The simple rule is that air will always flow from an area of high pressure to an area of low pressure (Tortora and Grabowski, 2003).

Inspiration

Inspiration is initiated by the contraction of the diaphragm and external intercostal muscles, which makes the thoracic cavity larger and the lungs expand. As the thoracic cavity becomes larger, the pressure drops and the pressure between the space inside the lungs and the air surrounding the person becomes unequal. This drop in pressure is equalised by air flowing into the lungs where gas exchange can occur (Marieb and Hoehn, 2006).

When the respiratory system is under stress, accessory respiratory muscles, including the sternocleidomastoid, scalene and internal intercostals are used, resulting in a visible change to respiration. As muscles control inhalation, the process is active (Tortora and Grabowski, 2003).

Expiration

During expiration, the opposite occurs – the respiratory muscles relax and the size of the thoracic cavity decreases. As the size is reduced, the pressure inside the thorax is higher than the surrounding environment and the air flows from high to low

Keywords: Oxygen therapy/Respiratory failure/Positive pressure ventilation

This article has been double-blind peer reviewed

QUICK FACT

10% The left lung is approximately 10% smaller than the right
dangerous as elevated levels of carbon dioxide may cause acidosis (Carroll, 2007). Patients with respiratory failure are likely to show signs of respiratory distress such as tachypnoea (rapid breathing), tachycardia (rapid heart rate), cyanosis (blue tinge associated with hypoxia) and unresponsiveness. Patients with COPD have an increased risk of either type of respiratory failure. As many chronically retain carbon dioxide, oxygen must be administered with caution to avoid exacerbating the condition.

5 Patients with COPD have an increased risk of respiratory failure. As many chronically retain carbon dioxide, oxygen must be administered with caution to avoid exacerbating the condition.

Types of respiratory failure
Respiratory failure is classed as type I or type II. Type I is characterised by hypoxia (low oxygen levels) with normal or low levels of carbon dioxide, and type II is characterised by hypoxia with hypercapnia (Box 1). Hypercapnia is particularly dangerous as elevated levels of carbon dioxide may cause acidosis (Carroll, 2007). Patients with respiratory failure are likely to show signs of respiratory distress such as tachypnoea (rapid breathing), tachycardia (rapid heart rate), cyanosis (blue tinge associated with hypoxia) and unresponsiveness.

Patients with COPD have an increased risk of either type of respiratory failure. Many retain carbon dioxide chronically alongside a continuous hypoxic state. As inappropriate administration of oxygen may cause or worsen hypercapnia, it is particularly risky for this patient group. This highlights the need for medical involvement, good prescribing practice and a great deal of care in oxygen administration.

Regardless of lung pathology, in a clinical emergency, oxygen must be administered and the absence of a prescription in these circumstances is acceptable (BTS, 2008). The Resuscitation Council (2010) acknowledge the potential harm of excessive oxygen administration and recommend titrating oxygen to achieve saturations of 94-98%. The oxygen therapy administered should be recorded in patients’ notes (BTS, 2008).
RESPIRATORY FAILURE

**Type I**
- Hypoxia (low oxygen levels) with normal or low levels of carbon dioxide. A PaO₂ <8kPa on blood gas assessment is considered significant.

**Type II**
- Hypoxia accompanied by hypercapnia (high carbon dioxide). A PaO₂ <8kPa and PaCO₂ >6.5kPa are considered significant.

**Common causes**
- Asthma
- Pneumonia
- Pulmonary oedema
- Pneumothorax
- Pulmonary embolism
- COPD

**Common Causes**
- Exhaustion following prolonged type I failure
- Severe asthma
- Neuromuscular disorders
- Respiratory depression due to medication
- Muscular dystrophies
- Encephalitis
- COPD

**Diagnosis**
The standard method of diagnosis in respiratory failure is arterial blood gas assessment. Although there can be problems obtaining and testing arterial blood samples outside hospitals, portable capillary blood gas analysis is becoming increasingly available for patients with chronic respiratory failure in the community.

Pulse oximetry is often the first line of assessment or only available nursing intervention in both primary and acute care. Despite being unreliable in some circumstances, it remains a useful tool (Higgins and Guest, 2008).

**Positive pressure ventilation**
Normal breathing works by creating low pressure in the thorax and allowing air to flow into the space and equalise the pressure. This is known as negative pressure ventilation (Fig 1). Patients who are very ill and no longer able to use this system to breathe adequately may require assistance. This is positive pressure ventilation which can support self-ventilation or replace a patient’s normal breathing.

Adam and Osborne (2005) describe positive pressure ventilation as gas being mechanically driven into the airways under a positive pressure, allowing movement of gas from the mouth and/or nose via a secured airway (for example a tracheostomy or endotracheal tube) to the alveoli. This can reduce or replace the work of muscles used in breathing. Exhalation typically remains passive and dependent on the elastic recoil of the lungs. A small positive pressure is maintained in the airways on exhalation to maintain alveolar expansion, prevent further lung collapse, giving greater time for gas exchange and increasing oxygenation.

There are many systems of positive pressure ventilation. It can be invasive or non-invasive, the patient can trigger their own breaths, or all breaths can be entirely mechanical. However, the principle of air being forced into the lungs and then removed is common to all systems.

Because air moves in and out of the lungs, positive pressure ventilation can seem physiologically normal. However, it is the physiological opposite of the body’s normal means of negative pressure ventilation and is at the more extreme end of the spectrum of oxygen therapy. The side effects are numerous and can be severe. Risks are much higher in those receiving invasive positive pressure ventilation (see part 2).

When using this system of ventilation, both the inspiratory and expiratory pressures can be set and adjusted. This means the pressure of gas in the lungs oscillates between two preset pressure points. In non-invasive ventilation, this is commonly described as the inspiratory positive airway pressure and the expiratory positive airway pressure (Chapman et al, 2009).

**Conclusion**
This article has discussed the importance of respiratory support in hospitals. It has examined the normal physiology of breathing, respiratory failure and introduced positive pressure ventilation.

The second article will discuss in more detail the indications, practicalities and contraindications of a variety of oxygen therapies. It will highlight a spectrum of support for nurses that can act as a learning tool and an aid to respiratory assessment. NT

**References**