Introduction
Low-flow oxygen therapy devices are often the first choice for the treatment of mild to moderate hypoxaemia (SpO2 90-95%) (Pierce 1995). Ensuring that oxygen is administered in a timely and appropriate way using the right device is an important aspect of patient care. Selecting the right device can be difficult as there are a variety to choose from and a lack of practical information on selection (Eastwood et al 2004). This paper provides an overview of oxygen therapy principles, describing the indications and care requirements of three low-flow oxygen therapy devices and providing an algorithm for managing refractory hypoxaemia.

Principles of low-flow oxygen therapy
Oxygen (O2) is a physiologic requirement for normal cellular function (energy production through aerobic metabolism), and is vital to sustaining human life (Treacher and Leach 1993). The normal partial pressure of arterial oxygen (PaO2) at atmospheric pressure (760 mmHg) is 80 to 100 mmHg. This equates with a normal oxygen saturation of ≥ 95% when measured by arterial blood sampling (SaO2) or by pulse oximetry (SpO2) (Considine 2005a).

Oxygen therapy is the therapeutic administration of oxygen to patients for the treatment or prevention of hypoxaemia (low-below oxygen levels) or hypoxia (inadequate oxygen at the cellular level). A failure to maintain adequate blood oxygen levels can result in the progressive deterioration of the patient, beginning with cell death, and if prolonged, organ failure and ultimately body system failure and death (Considine 2005a).

Early clinical signs and symptoms of hypoxaemia (Considine 2005a) are:
- Shortness of breath (dyspnoea),
- Alteration in respiratory rate (bradypnoea or tachypnoea),
- Anxiety and agitation.

Indications for initiating oxygen therapy (Kallstrom 2002) include:
- Hypoxaemia (SpO2 < 90),
- Respiratory distress,
- Post anaesthesia recovery,
- Cardiac and respiratory arrest,
- Systemic hypotension (systolic BP < 100mmHg),
- Low cardiac output states and metabolic acidosis (HCO3- < 18mmol/l).

Administering oxygen does have some risks (O'Connor and Vender 1995). These comprise, but are not limited to:
- Pulmonary - oxygen toxicity, absorption atelectasis, CO2 retention,
- Equipment - device malfunction or oxygen supply failure,
- Occupational - increased fire hazard.

The incidence and extent of these risks is not clearly reported in the literature. In all cases however, risks associated with oxygen therapy should never prevent oxygen from being given to a hypoxaemic patient.

When caring for a patient receiving oxygen it is important to assess their:
- Conscious state,
- Pulmonary function (breath sounds and chest wall symmetry),
- Adequacy of respiration and normal parameters of respiration (SpO2/SpO2),
- Ventilation (respiratory rate and depth, PaCO2),
- Signs and symptoms of therapy-related complications (e.g. pressure sores on the nares or around the base of nose, excessive drying of mucous membranes of the upper airway),
- Cardiac function (heart rate and blood pressure),
- Co-morbidities or medications that may effect respiratory function, e.g. chronic obstructive airways disease, anaesthetic agents or anaesthetic agents.

Low-flow oxygen therapy devices
Excluding anaesthetic circuits and hyperbaric oxygen chambers, oxygen therapy devices are classified as high-flow or low-flow systems (O'Connor and Vender 1995, Oh and Duncan 1988). High-flow systems deliver a consistent fraction of inspired oxygen concentrations (FiO2) as the oxygen flow rate is sufficient to meet or exceed the patient's inspiratory volume and peak inspiratory flow rate (PIFR).
Low-flow systems also deliver a variable FiO2 because of changes in ventilatory pattern (tidal volume, respiratory rate, and PIFR); the entrainment of room air in order to meet inspiratory volume and; device-related characteristics such as shape and oxygen flow capabilities (Barnes 2000, O'Connor and Vender 1995, Callanno et al 1995).

Low-flow oxygen therapy devices are generally used in patients with minimal respiratory distress, adequate ventilatory patterns but still require supplemental oxygen for therapeutic reasons (Callanno et al 1995, Oh and Duncan 1988). Low-flow oxygen therapy devices are generally easily accessible and often the first choice for the treatment of mild to moderate hypoxaemia (SpO2 90-95%). Low-flow oxygen devices are still capable of providing high FiO2 if a patient was to have a slow, shallow ventilatory pattern (O'Connor and Vender 1995).

Two of the most commonly used low-flow oxygen therapy devices are nasal prongs (NP) and simple face masks (FM). An emerging alternative to these two devices is the use of oxygen catheters to achieve nasopharyngeal oxygen therapy (NPO) in adult patients (Eastwood and Dennis 2006, Eastwood et al 2004). A description and list of care requirements for NPO therapy: NP, and FM is provided below. A comparison of these devices is shown in Table 1 below.

Other low-flow oxygen devices such as partial rebreather masks and non-rebreather masks have been excluded from this paper as they are typically used to treat more severe forms of hypoxaemia and often require specialised nursing knowledge and care during their use. Each device will now be described in detail with its accompanying nursing care.

**Nasopharyngeal oxygen catheters**

Nasopharyngeal oxygen therapy (NPO) is the delivery of supplemental oxygen directly into the nasopharynx via an oxygen catheter (size 10 FG for adults) (Eastwood et al 2004, Frey and Shann 2003). When positioned correctly the tip of the catheter is visible just below the soft palate. The catheter is secured in position by an adhesive dressing or tape placed on the patient's cheek. Oxygen tubing is then connected to the distal end of the catheter. Oxygen flow rates are adjusted to meet target blood oxygen concentrations (SpO2/SaO2) (Eastwood and Dennis 2006).

Care requirements for NPO therapy:
- ensure catheter is placed correctly (tip just visible below the soft palate when mouth open),
- removal of catheter for cleaning with sterile water 12-24 hourly (to reduced the risk of obstruction),
- use oxygen flow rates ≤ 6 L/min,
- observe for catheter related pressure on the nares, drying of the back of the throat, and bleeding from the nose (Eastwood and Dennis 2006).

**Nasal prongs**

Nasal prongs (also known as nasal cannula or nasal spectacles) consist of two short tapered prongs (about 1 cm in length).
Each prong lies approximately 1 cm within each nostril. Tubing of the nasal prongs is looped over the ears and secured under the chin. Oxygen tubing of the nasal prongs is then connected to an oxygen outlet (McConnell 1996). Oxygen flows are adjusted to meet target blood oxygen concentrations (SpO₂/SaO₂). They are relatively cheap, easy to apply, and generally tolerated well by patients. They rarely interfere with a patient’s ability to eat, talk, sleep and cough (Costello et al 1995, Fairfield et al 1991, Stewart and Howard 1990). However they can be easily dislodged, which may result in an unacceptable drop in blood oxygen levels (Hess et al 1984).

Care requirements for nasal prongs:

• ensure nasal prongs are correctly placed (prong in each nostril) and secured,
• be vigilant for prong dislodgement or displacement,
• observe for catheter related pressure on the nares, drying of the back of the throat, and bleeding from the nose (McConnell 1996).

Simple face masks

Simple face masks are half-pear shaped, made of plastic, and worn over the nose and mouth (Barnes 2000). Mask strapping is tightened around the patient’s head to ensure a secure fit. Oxygen tubing is then connected from the mask to the oxygen outlet. Administered oxygen flow rates are faster than that of NPO or NP therapy. Face mask oxygen therapy however can induce claustrophobic sensations in some patients; cause drying of the mouth and nose; hinder the passage of vomitus and; require removal for eating and drinking (Eastwood and Dennis 2006).

Care requirements for FM:

• ensure mask is fitted correctly (covering nose and mouth),
• maintain oxygen flow rates > 6 L/min (to limit carbon dioxide re-breathing),
• be watchful for the frequent removal of the mask by the patient,
• observe for device-related complications such as the development of pressure areas on the bridge of the nose or skin irritation around the ears (Nerlich 1997, McConnell 1997).

Selecting the right device

Selecting the right device can lead to more efficient use of resources (ie oxygen, oxygen therapy equipment and nursing time), treatment tailored to better meet patient needs, health care cost savings, and increased patient satisfaction and compliance with low-flow oxygen therapy. For effective oxygen administration nurses need to select the appropriate device and oxygen flow rates.

Several questions can assist in the process of device selection.

• What low-flow oxygen therapy devices are available?
• Do I have the knowledge and skill to effectively use these devices?
• Will the device selected be able to meet the patient’s oxygen requirements?
• Are there any patient-related factors that would prevent a particular device being used?
• Are there any device-related factors that would prevent its use?
• What alternative devices can I access should the initial device fail to achieve adequate blood oxygen levels?

As a guide, NPO therapy should be considered in patients who require modest increases in FiO₂ but are unable to wear a FM or to overcome some of the disadvantages associated with NP oxygen therapy (ie that the prongs can easily dislodge or cause skin irritation around the ears and nares). Nasal prongs are for patients who require small to modest increases in FiO₂, are still able to eat and talk unhindered, or find the wearing of a FM uncomfortable or distressing. Face masks can be reserved for patients with greater FiO₂ requirements or temporary abnormal lung ventilation patterns (ie the immediate post-operative period).

If a patient finds the experience of oxygen therapy uncomfortable or distressing, informing them of the reason for therapy may provide reassurance and alleviate concern. Additionally, it may be beneficial to trial a different device and discuss its comfort, as this may improve compliance with treatment while still maintaining satisfactory blood oxygen levels.

Treatment of refractory hypoxaemia

Refractory or unresolved hypoxaemia is potentially life-threatening. Nurses play a pivotal role in the management of hypoxaemic states (Considine 2005b). Current published protocols and reviews for oxygen administration however often fail to provide practical information to assist with the selection and use of oxygen devices (Kallstrom 2002, Cunningham 1997, Treacher and Leach 1998, O’Connor and Vender 1995). In response, a five step practical approach to the management of refractory hypoxaemia will now be described and a treatment plan shown in table 2 (next page). As well as its therapeutic benefit managing refractory hypoxaemia in a systematic way minimizes the harmful effects of low-blood oxygen levels.

Step one: identify and treat underlying cause of hypoxaemia if possible.

The major causes of hypoxaemia are hypoventilation, ventilation-perfusion inequalities, lung disease, or low PaO₂ (as experienced at high altitude).

Step two: establish a target SpO₂/SaO₂.

Because different patients have different oxygen therapy requirements it is important to establish a target SpO₂/SaO₂ in consultation with the patient’s treating physician.

It is important to note that within the group of patients with Chronic Obstructive Airways Disease (COAD) who rely on their hypoxic drive to stimulate breathing; incorrect administration of supplemental oxygen can cause respiratory depression. These patients require carefully controlled oxygen therapy with close monitoring of SpO₂ or PaO₂ concentrations (Nerlich 1997, Doyle 1992). Additionally, to prevent tissue hypoxia there are clinical conditions where oxygen is administered in the presence of normal PaO₂/SaO₂. These conditions include myocardial infarction and carbon monoxide poisoning (Considine 2005).

Step three: select an appropriate low-flow oxygen therapy device.

Consider patient-related, nurse-related, and context specific
Factors that may impact on the administration of oxygen.

Step four: fit device and adjust oxygen flow rates to achieve target SpO2/SaO2.

Correct fit and patient education for the reasons of oxygen therapy is essential to optimising effective oxygen therapy. Adjuncts to oxygen therapy include:

- optimum patient positioning,
- analgesia,
- patient education, and
- chest physiotherapy.

Step five: evaluate oxygen therapy effectiveness.

Achieving the target SpO2/SaO2 concentration is the fundamental determinant of therapy effectiveness. Effectiveness may also be measured for the patient in terms of comfort and compliance with therapy; the nurse in terms of time and user-friendliness; and for the hospital in terms of cost and use.

Nurses make decisions every day regarding the selection and management of low-flow oxygen therapy devices. Improvements in the selection process however are warranted. The development and implementation of clinical practice guidelines supported by best available evidence has the potential to improve this aspect of practice. Until appropriate guidelines are developed, when supplemental oxygen is needed, the simplest, most effective form of therapy should be given.

References


Dennis, M. 2003. Oxygen therapy (unpublished lecture manuscript). Deakin University, School of Nursing, Burwood, Victoria, Australia.


