Emergency oxygen treatment is used two million times a year by ambulance services, and almost one in five hospital patients in the UK are being treated with oxygen at any one time.

Oxygen therapy: emergency use and long-term treatment

By Hetal Dhruve, Claire Davey and Jim Pursell

Oxygen treatment is used to save lives. Emergency oxygen is used around two million times a year by ambulance services in the UK, equivalent to around 34% of all ambulance journeys, and around 18% of hospital inpatients in the UK are treated with oxygen at any one time. Some of its main indications are for respiratory failure, in which there is inadequate oxygenation or elimination of carbon dioxide from mixed venous blood, and to treat severe hypoxaemia resulting from ischaemic heart disease, sepsis or trauma.

However, when used incorrectly, oxygen can have detrimental effects to patients’ conditions and be fatal. Underuse of oxygen can expose critically ill patients to risk of hypoxic organ damage. Overuse of oxygen can also be harmful, especially in premature infants and those with carbon dioxide-retaining conditions such as chronic obstructive pulmonary disease (COPD).

This article outlines the use of oxygen in emergency treatment, and in long-term therapy.

Oxygen in blood

Haemoglobin is a large protein made up of four protein chains. At the centre of each chain there is a haem group, containing iron. Oxygen binds to each of the four iron ions of the haemoglobin molecule and circulates the body. Haemoglobin’s ability to bind oxygen is known as an oxygen saturation (SO₂), and can be measured directly from an arterial blood sample (see ‘Reference ranges for oxygen in blood’).

The relationship between oxygen saturation and the partial pressure of oxygen (PO₂) in the blood is called the oxyhaemoglobin dissociation curve (see ‘Oxyhaemoglobin dissociation curve’).

Type 1 respiratory failure occurs when there are low oxygen saturation levels. It can be defined as PO₂ <8kPa or 60mmHg (SO₂ approximately 90%), with low or normal partial pressure of carbon dioxide (PCO₂) levels. Type 2 respiratory failure occurs when there are low oxygen saturation levels and high PCO₂ levels.

IN SHORT

The only evidence-based indication for the use of oxygen in emergencies is to correct hypoxaemia; it is not used to alleviate breathlessness in non-hypoxaemic patients. Oxygen saturation should be checked by pulse oximetry (and supplemented by arterial blood gases tests where necessary) for at least five minutes after starting oxygen therapy and within 30 minutes after initiation. If oxygen saturation falls below the target saturation and the patient is unstable, treatment should be reviewed.

Patients discharged with oxygen should undergo formal assessment for long term oxygen therapy after a period of stability of at least eight weeks to assess if oxygen is still required and that patients are compliant with treatment. All patients using oxygen at home should be referred to a home oxygen service (to prevent indefinite continuation of oxygen therapy if it is not required), issued with an oxygen alert card and counselled on the use of oxygen.
failure, most prevalent in patients with COPD, occurs because of an inability to remove carbon dioxide, which results in hypercapnia; therefore PCO₂ is above the normal range and oxygen levels (PO₂) levels may be normal or low. The excess carbon dioxide can combine with water to form carbonic acid (H₂CO₃) in the blood which, in turn, dissociates to bicarbonate (HCO₃⁻) and hydrogen (H⁺) ions and results in respiratory acidosis³.

Hypoxaemia, where there is a low PO₂, can also occur in patients when the oxygen carrying-capacity of the blood is low; for example, in patients with anaemia. All patients presenting with hypoxaemia should have haematinics tests performed to rule out these conditions¹,².

**Emergency oxygen**

The only evidence-based indication for the use of oxygen in emergencies is to correct hypoxaemia; it is not used to alleviate breathlessness in non-hypoxaemic patients. However, where there is a sudden reduction of more than 3% in SO₂, further assessment may be warranted as this indicates possible acute illness, such as exacerbations of asthma or COPD and myocardial infarction⁴.

Oxygen should be started immediately and prescribed as soon as possible in emergency situations. In all other situations, oxygen should be prescribed in accordance with a legal prescription. All healthcare professionals who administer the oxygen therapy (usually a nurse or physiotherapist) should be fully trained and follow local or national protocols to ensure safe prescribing and administration of oxygen².

Medical oxygen is classified as a medicinal product but according to the legal status in the UK it is a General Sales List (GSL) product and therefore does not require a prescription. However, the use and supply of oxygen is similar to all other GSL medicines when administered in a healthcare setting it should be documented on a prescription chart alongside all other medicines. The prescription chart should be completed when oxygen therapy is initiated. An appropriate delivery system and flow rates should be specified on the patient’s chart, and it should also be indicated whether the patient is having continuous oxygen or oxygen as required².

Oxygen saturation should be checked by pulse oximetry (and supplemented by arterial blood gases tests where necessary) for at least five minutes after starting oxygen therapy and within 30 minutes after initiation. If oxygen saturation falls below the target saturation and the patient is unstable, treatment should be reviewed. If oxygen saturation is above the target range and the patient is stable, the delivery system and oxygen flow rate should be reduced accordingly².

Pulse oximetry is dependent on pulsatile flow: Readings may be compromised if the patient has cold hands, especially those with severe Raynaud’s phenomenon. The accuracy of the readings may also be affected by shock, skin pigmentation and nail varnish².

Patients with hypercapnia and a target saturation of 88–92% should have their blood gases checked within 30–60 minutes to ensure that carbon dioxide levels are not rising while administering oxygen therapy. This is also recommended for patients who are at risk of developing hypercapnic respiratory failure but have a normal PCO₂ on the initial blood gas measurement. Stable patients whose target oxygen saturation is within 94–98% do not require repeated blood gas measurements⁵.

Other vital signs, such as pulse, blood pressure, temperature and respiratory rate, should be checked, as these can affect the oxygen saturation levels⁶,⁷. Once a patient is stable with satisfactory SO₂, oxygen should be reduced and discontinued. Oxygen saturations should be reviewed regularly during a stay in hospital as an inpatient, and by the home oxygen service if a patient is discharged while on oxygen³.

A fraction of patients will de-saturate without oxygen therapy if there has been an interruption in the gaseous exchange, leading to hypoxia. This may be a consequence of major trauma, sepsis or acute illness. Pregnant women who suffer from major trauma, sepsis or acute illness should receive the same oxygen therapy as other acutely ill patients²,⁴,⁶.
Patients aged over 70 years may have oxygen saturations below 94% but do not require oxygen therapy when clinically stable 2.

Home oxygen
Home oxygen is used in patients with chronic hypoxaemia, defined as a PO₂ ≤7.3kPa, or ≤8kPa if there are any symptoms of peripheral oedema, polycythaemia or pulmonary hypertension. Typically, treatment involves using oxygen for a minimum of 15 hours per day. This corrects abnormalities in blood oxygen for longer periods, particularly at night, when hypoxaemia is often greater for patients with COPD. Oxygen treatment should aim to achieve a target SO₂ of 94–98% for most acutely ill patients, or 88–92% for those at risk of hypercapnic respiratory failure 3.

Patients discharged with oxygen should be advised that therapy may not be long term and will be followed up at home within eight weeks of discharge.

All patients should be instructed on duration of use per day (i.e. 15 hours or 24 hours).

Symptoms of potential overdose include morning headache and increased drowsiness; patients should be counselled on identification of this.

Emergency services should be aware of target saturation and treat patients appropriately.

Oxygen alert cards

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Target ranges

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target ranges</th>
</tr>
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<tbody>
<tr>
<td>SO₂ (arterial oxygen saturation)</td>
<td>94–98%</td>
</tr>
<tr>
<td>SO₂ in hypercapnic patients</td>
<td>88–92%</td>
</tr>
<tr>
<td>PO₂ (partial oxygen pressure, oxygen tension)</td>
<td>&gt;10kPa (75mmHg)</td>
</tr>
<tr>
<td>PCO₂ (partial carbon dioxide pressure)</td>
<td>4.6–6.1 kPa (34–46mmHg)</td>
</tr>
<tr>
<td>pH</td>
<td>7.35–7.45</td>
</tr>
<tr>
<td>HCO₃⁻ (bicarbonate)</td>
<td>22–26mmol/L</td>
</tr>
</tbody>
</table>

*In the upright position, values may be lower in the supine position

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OXYGEN ALERT CARD

Name ____________________________

I am at risk of type II respiratory failure with a raised CO₂ level. Please use my _____ % venturi mask to achieve an oxygen saturation of _____ % to _____ % during exacerbations.

Use compressed air to drive nebulisers (with nasal oxygen at 2 L/min). If compressed air not available, limit oxygen-driven nebulisers to six minutes.

Patients who exacerbate frequently and are unable to achieve an eight-week period of stability may require assessment for LTOT sooner. LTOT should not be prescribed during an acute exacerbation and should be limited to patients with a SO₂ of ≤92% who are breathless and unable to manage without the use of oxygen 3.

Patients are assessed for LTOT using pulse oximetry and either arterial blood gas or capillary blood gas tests. During a period of clinical stability, patients should undergo two arterial blood gas measurements at least three weeks apart. Patients eligible for LTOT should be initiated on a flow rate of 1L/min, and titrated up in 1L/min increments after 20 minutes, until SO₂ > 90%. Arterial blood gases are then measured to confirm that a target PO₂ ≤8kPa (60mmHg) at rest has been achieved 3. Oxygen may be discontinued if clinical improvement is made and the patient is stable.

Home oxygen should undergo formal assessment for LTOT after a period of stability of at least eight weeks from their last exacerbation or discharge from hospital. In 2001, 30–58% of patients were discharged from hospital but no longer met the criteria for LTOT 3. This has improved over the years in some areas but many patients are still inappropriately continued on LTOT. Although only a small number of patients are prescribed LTOT, the total annual cost of the home oxygen service in England was almost £87m in 2014–2015. However, a review of treatment has reduced the annual spend by 20%. It is estimated that if every patient received a follow-up eight weeks post-discharge, £10–20m could be saved each year 5.

Patient groups requiring LTOT

Patients with COPD often require LTOT, and the Nocturnal Oxygen Therapy Trial (NOTT) and UK Medicines Research Council (UK MRC) trials, which took place in the 1980s, showed that LTOT treatment in appropriate patients can improve survival rates by around 40%, irrespective of chronic hypercapnia and previous episodes of oedema or pulmonary hypertension 4. NOTT was the first randomised controlled trial of LTOT in patients with COPD and included 203 patients who were randomised to receive either continuous oxygen therapy or 12-hour nocturnal oxygen therapy. Results from this trial suggested that overall mortality in the nocturnal group was 1.94 times that in the continuous oxygen
therapy group over an eight year follow-up. The UK MRC domiciliary oxygen trial studied 87 patients with chronic bronchitis and emphysema who were hypoxaemic, mostly hypercapnic and had a previously documented episode of cor pulmonale. These patients were randomised to receive no oxygen or 15 hours of oxygen a day. Over a five year follow-up, 19 patients (45%) died in the treatment group and 30 patients in the control (no oxygen) group (66.7%). Subsequent studies have confirmed that patients with clinically stable COPD with chronic hypoxaemia have improved pulmonary haemodynamics and life expectancy when treated with LTOT for at least 15 hours per day. LTOT has also been shown to correct nocturnal SO2, decrease sleep latency and improve sleep quality for patients with COPD who develop hypoxaemia.

Patients receiving oxygen for 24 hours a day are at risk of increased CO2 levels; therefore the target SO2 for patients with COPD should be 88–92%. Target oxygen saturations for all other conditions be considered for patients with resting hypoxaemia can use LTOT to improve tissue oxygenation and prevent complications. LTOT should be considered for patients with a resting PO2≤7.3kPa for patients with advanced cardiac failure, and a resting PO2≤8.0kPa for patients with advanced neuromuscular disorder or chest wall disease (e.g. kyphoscoliosis, thoracoplasty) may develop nocturnal hypoventilation, which causes nocturnal hypoaxemia and leads to chronic respiratory failure. LTOT may be indicated in addition to non-invasion ventilation (NIV) in these patients in cases where NIV alone has not corrected the hypoxaemia.

Patients with interstitial lung disease and cystic fibrosis may develop chronic hypoxaemia, leading to poor tissue oxygenation and development of complications such as pulmonary hypertension. However, there are a lack of data to support the use of oxygen in these patients. Therefore, recommendations for use are extrapolated from evidence in COPD patients.

**Oxygen delivery**

Oxygen equipment must suit a patient’s lifestyle and enable them to remain as independent as possible. It can be delivered from concentrators, cylinders or as liquid oxygen. Concentrators are the most common device for LTOT delivery. An oxygen concentrator is an electronic device which takes room air and passes it through a filtering system, removing nitrogen to supply concentrated oxygen through a mask or nasal cannulae. These concentrators are installed and maintained by oxygen provider companies.

Oxygen therapy is delivered by a nasal cannulae or mask. Nasal cannulae are more common due to comfort and tolerance but can have variable oxygen delivery. Venturi masks are designed to deliver accurate concentrations where it is clinically important to correct oxygen levels, often during acute episodes.

**Oxygen and smoking**

Smoking is contraindicated in patients taking oxygen therapy and increases the risk of house fires; smoking and oxygen use accounted for ten reported burns in London between December 2013 and May 2015, four of which resulted in death. Despite this, 14–51% of home oxygen users in Europe continue to smoke.

All patients using home oxygen should be encouraged to stop smoking and all patients willing to make a serious attempt to quit should be offered pharmacological support and should be referred to a local stop smoking clinic. If they continue to smoke, a fire risk assessment must be completed for patients by the fire service, oxygen contractor and health team to consider the risk-benefit of the therapy; this may result in patients being refused oxygen therapy.

Patients should not use e-cigarettes and chargers in close proximity to their oxygen, as these may also cause the oxygen to ignite.

**References:**