Keywords Blood gases/Hypercapnia/Respiratory failure/Wristband

This article has been double-blind peer reviewed

In this article...

- Dangers of excessive use of oxygen therapy in patients who are acutely ill
- Guidance from the British Thoracic Society and an international expert panel
- Alert cards and wristbands for patients at risk of hypercapnic respiratory failure

Ensuring the safe use of emergency oxygen therapy in acutely ill patients

Nursing Times Self-assessment

Key points

There are still misconceptions and poor practices regarding emergency oxygen therapy

Oxygen is a drug and should be prescribed and administered correctly

Hyperoxaemia (high blood-oxygen levels) can be detrimental to some patients

Careful titration of oxygen to appropriate target ranges enhances patient safety

Alert cards and wristbands can help identify patients at risk of hypercapnic respiratory failure

Authors Ellean Hiley is nursing programme leader, Edge Hill University; Emma Rickards is advanced respiratory practitioner and early supported discharge and oxygen matron, Knowsley Community Respiratory Service, Liverpool Heart and Chest Hospital Foundation Trust; Carol Ann Kelly is reader in respiratory care, Faculty of Health and Social Care, Edge Hill University.

Abstract Health professionals in all areas of care commonly look after patients who receive emergency oxygen therapy. They need to be aware that the excessive use of oxygen can be detrimental to some patients, in particular those with, or at higher risk of, hypercapnia. This article discusses the appropriate use of oxygen therapy in the emergency setting with the aim of improving patient safety and outcomes. It refers to current guidance on the indications for emergency oxygen therapy, its prescription, monitoring, titration and discontinuation.

Citation Hiley E et al (2019) Ensuring the safe use of emergency oxygen therapy in acutely ill patients. *Nursing Times* [online]; 115: 4, 18-21.

Oxygen therapy is commonly given to correct hypoxaemia (low oxygen levels in the blood) or protect against potential hypoxaemia. In such instances, oxygen is a drug and, as such, should be prescribed and administered appropriately, with all necessary precautions taken.

Traditionally, oxygen therapy was given to patients presenting with breathlessness and hypoxia (low oxygen levels in the tissues) in emergency situations due to a common misconception that it could reduce breathlessness (Dhruve et al, 2015). However, in recent years, there has been a debate about the benefits and risks of delivering emergency oxygen therapy to all patients presenting critically, as evidence suggests that hyperoxaemia (high levels of oxygen in the blood) could pose a risk of harm – and even increased mortality – particularly in the pre-hospital setting (Stub et al, 2015; Pountain and Roffe, 2012; Austin et al, 2010). A recent systematic review and meta-analysis highlights that inappropriate use of emergency oxygen is now understood to potentially cause more harm than good, and that the use of conservative oxygen therapy titrated to the patient's needs reduces patient mortality (Chu et al, 2018).

The British Thoracic Society (BTS) first published guidance on oxygen use in adults in emergency settings in 2008; the latest revision, by O'Driscoll et al, was published in 2017. However, audits have shown that poor practice persists in terms of both the prescription and the administration of oxygen (BTS, 2015). This can be, in part, attributed to ingrained misconceptions (Kelly et al, 2018); it is important to challenge these to promote the safe use of oxygen.

When is emergency oxygen therapy necessary?

Emergency oxygen therapy is one of the most common therapeutic interventions used by health professionals. The aim of emergency oxygen therapy – traditionally

administered to stabilise patients who are critically ill – is to improve tissue perfusion and reduce hypoxaemia, with the overall goal of preventing tissue and organ damage. It is important to note, however, that emergency oxygen therapy does not treat the source of the hypoxia (low supply of oxygen to the tissues) (O'Driscoll et al, 2017), and that further assessment and investigation will be needed to identify and treat the underlying cause of the acute presentation.

Criteria for starting patients on emergency oxygen therapy relate to their overall condition. Today this is routinely assessed with pulse oximetry, which measures the percentage of oxygen haemoglobin saturation (Olive, 2016). An improvement in measured oxygen saturation levels to 'normal' or 'near-normal' ranges following the commencement of oxygen will help to assess the continued need for supplemental oxygen, gauge its effectiveness if administered, and protect from the risk of hypercapnia (higher-than-normal levels of carbon dioxide in the blood).

Hypercapnia is a potential side-effect of excessive oxygen and can lead to respiratory acidosis, in which the pH level of the blood is outside the normal range (Box 1). This is called type-II respiratory failure (Higgins and Guest, 2008) and is a significant cause of mortality in patients who are at high risk from the effects of over-oxygenation, including – but not solely – patients with chronic obstructive pulmonary disease (COPD) (O'Driscoll et al, 2017).

The recommended oxygen haemoglobin saturation (SpO_2) range is 94-98% for most patients and 88-92% for those at risk of type-II hypercapnic respiratory failure. This is sufficient to ensure adequate oxygen delivery without causing or exacerbating acidosis.

Prompted by Chu et al's (2018) systematic review, an international panel of experts published a rapid recommendation clinical practice guideline on oxygen therapy for patients who are acutely ill: Siemieniuk et al (2018) recommend oxygen saturation levels are not maintained any higher than 96% in most patients. The rationale is that blood-oxygen levels of >96% could create a small but important risk of death without plausible benefit. The authors further recommend that oxygen therapy is not given to patients presenting with acute stroke or myocardial infarction (MI) who have an SpO_2 of ≥92%, and propose a target oxygen saturation of no more than 90-92% for these patients. The dangers of over-oxygenation and the rationale for shifting from a liberal to a cautious use of oxygen therapy are outlined later in this article.

According to O'Driscoll et al (2017), it is necessary to collect arterial or capillary blood gases:

- If there is a sudden drop in oxygen saturations to <94%;
- If there is a sudden change in several National Early Warning Score 2 (NEWS2) (Royal College of Physicians, 2017) parameters;
- In any previously stable patient who has deteriorated;
- In patients with metabolic disease;
- In patients who are at risk of hypercapnic respiratory failure.

The optimum time to perform this test is before the start of oxygen therapy or, if it has already started, 30-60 minutes after any increase in the amount of oxygen delivered. Measuring the blood-oxygen level can be adequately performed with oximetry between adjustments. When blood gases are taken, several parameters are measured to help the health professional assess respiratory system function and metabolic processes in the body; normal readings for these parameters are outlined in Box 1.

QUICK FACT

88-92%
Recommended oxygen saturation for those at risk of hypercapnic respiratory failure

Prescribing and decision making

Oxygen is a drug and, as such, a drug prescription card or electronic prescription is recommended. The prescription should be written as soon as possible after an emergency and the start of oxygen therapy (Dhruve et al, 2015; Gatter et al, 2015). Once a patient has been stabilised, health professionals need to decide whether to continue therapy, when to titrate it or when to stop it altogether (Gatter et al, 2015). As a precaution in case of future deterioration, a target saturation range should be recorded on the drug prescription chart as a guide (O'Driscoll et al, 2017). Continued monitoring of blood-oxygen levels is important and can be done via regular pulse oximetry. Changes in oxygen saturation levels can identify a stable patient requiring a decrease in the administered oxygen. Any fall in oxygen saturation levels will require an urgent review of treatment.

The BTS guideline:

- Provides health professionals with recommended parameters to adjust the amount of oxygen that is delivered according to oxygen saturation levels;
- Indicates when oxygen should be titrated;
- Indicates when oxygen should be discontinued;
- Offers guidance to help health professionals correctly write out oxygen prescriptions and record oxygen delivery, both in terms of percentage concentration and administration device (O'Driscoll et al, 2017).

Box 1. Normal blood gas values

- pH: 7.35-7.45 (pH <7.35 = acidosis, pH >7.45 = alkalosis)
- Partial pressure of oxygen (PaO_2): 10.6-14.0kPa*
- Partial pressure of carbon dioxide ($PaCO_2$): 4.7-6.6kPa*
- Bicarbonate (HCO_3): 22-26mEq/L
- Oxygen saturation (O_2 sat): 94-96%

*Parameters for PaO_2 and $PaCO_2$ may vary slightly, according to local practice

Table 1. NEWS2 target oxygen saturation levels

Patient group	Oxygen saturation target	Notes
Acutely ill patients with no known previous respiratory failure	≥96%	Readings below this incur a score that is added to the overall score for a set of observations, and actioned accordingly
Patients at risk of hypercapnic respiratory failure (those with COPD or other hypercapnic disorders, such as cystic fibrosis)	88-92%	Readings >93% on oxygen and readings <88% on air incur a score that is added to the overall score for a set of observations, and actioned accordingly

COPD = chronic obstructive pulmonary disease. NEWS = National Early Warning Score.

Source: Adapted from Royal College of Physicians (2017)

Fig 1. **Example of an oxygen alert card**

OXGYGEN ALERT CARD

Name

I have a chronic respiratory condition and I am at risk of having a raised carbon dioxide level in my blood during flare-ups of my condition (exacerbations)

Please use my % **Venturi mask to achieve an oxygen saturation of** % **to** % **during exacerbations of my condition**

Use compressed air to drive nebulisers (with 2L/min nasal oxygen)
If compressed air is not available, limit oxygen-driven nebulisers to 6min

However, compliance with the guidance has been low; in a 2015 audit representing around 50% of acute hospital beds in the UK, 42.5% of patients on oxygen therapy had no valid prescription and audits of prescribed drug charts showed that poor prescribing persists (BTS, 2015).

To improve oxygen prescribing, the NEWS2 (RCP, 2017) has two different target oxygen saturation levels, thereby acknowledging the need for lower target saturations in patients at risk of hypercapnic respiratory failure (Table 1).

Delivery and monitoring

Patients' presentation and any known underlying condition will determine the choice of delivery device; these are divided into three categories:

- High concentration – delivers oxygen at concentrations of 60-90% when used at a flow rate of 15L/min;
- Medium concentration – delivers oxygen concentrations of 40-60%;
- Low concentration – delivers oxygen concentrations of 24-40%.

In an emergency, a high-concentration device should be used. Once the patient is stable, the delivery device used will depend on the percentage of oxygen to be administered and saturation levels required. Box 2 outlines the different types of devices.

When emergency oxygen therapy is administered, the BTS guideline (O'Driscoll et al, 2017) states that:

- Pulse oximetry should be available;
- Air or oxygen should be noted on the observation chart when oxygen saturations are recorded;
- Blood gases should be repeated every 30 minutes when oxygen is titrated;
- Only staff trained in oxygen therapy should titrate oxygen delivery.

Box 2. **Oxygen delivery devices**

- **Non-rebreathing masks** (high-concentration device) deliver a flow rate of 15L/min, providing 60-90% of oxygen (O'Driscoll et al, 2017); it is suitable for initial use in an emergency for most patients
- **Simple masks** (medium-concentration device) deliver a flow rate of 5-10L/min, providing 40-60% of oxygen
- **Venturi masks** rely on valves to provide accurate oxygen delivery, are less dependent on oxygen flow rates and can deliver both medium and low concentrations of oxygen
- **Nasal cannulae** can also be used to deliver medium or low concentrations of oxygen, with a flow rate of 1-4L/min providing 24-40% of oxygen (O'Driscoll et al, 2017)

"Health professionals often do not reduce oxygen therapy quickly enough to prevent hyperoxaemia"

Dangers of excessive oxygen

Emergency oxygen therapy can be extremely beneficial but can also be harmful to patients and it is important to understand that excessive oxygen in the body can be toxic (Kelly and Lynes, 2015). There is now increased awareness that emergency oxygen therapy, including titration and discontinuation, needs to be carefully considered before being started (Kelly and Lynes, 2015) because of the risk of hyperoxaemia (Kane et al, 2013).

When commencing oxygen therapy in an emergency situation, it is important to know that a high dose that is later reduced is more effective at reducing hypoxia than a low dose that is later increased (Lavery and Corris, 2012). However, health professionals often do not reduce oxygen therapy quickly enough to prevent hyperoxaemia, and this liberal use of oxygen can have a negative physiological impact on the patient (Dobbe et al, 2018).

Although training on emergency oxygen therapy has increased over the past decade, there is still a lack of prescription compliance and, therefore, the potential to put patients at risk (Thein et al, 2018). Two main patient groups are at risk when given unnecessary emergency oxygen therapy:

- Patients with cardiovascular conditions such as stroke and MI (Stub et al, 2015; Pountain and Roffe, 2012);
- Patients with chronic respiratory or neuromuscular conditions, who are at risk of type-II respiratory failure (O'Driscoll et al, 2017).

In cardiovascular conditions, the adverse effects of hyperoxaemia are decreased cardiac output and vasodilation, which can further exacerbate ischaemia and lead to the patient's condition deteriorating (Stub et al, 2015; Pountain and Roffe, 2012). As such, patients presenting with stroke or MI should be on a lower target oxygen saturation range (Siemieniuk et al, 2018).

For patients at risk of type-II respiratory failure, the risks relate to the potential retention of carbon dioxide and resultant acidosis. These patients can be identified by oxygen alert cards or wristbands.

Alert cards and wristbands

In the community setting, the BTS recommends that oxygen alert cards (Fig 1) be provided to patients with COPD who have a history of hypercapnic respiratory failure ($PaCo_2$ >6kPa) to mitigate inappropriate oxygen prescription in the emergency setting (Hardinge et al, 2015). The cards alert health professionals delivering oxygen to these patients that they must ensure oxygen is administered and titrated safely to target saturations of 88-92%.

Oxygen alert cards will help protect adult patients with a history of hypercapnia from the dangers of hyperoxaemia and related iatrogenic mortality (death caused by medical treatment). They indicate what percentage Venturi mask should be used to achieve a suitable target saturation range for the individual and is transferrable from the community to the acute hospital setting (Olive, 2018; Kane et al, 2013).

Fig 2. **Example of oxygen alert wristband**

There are drawbacks to alert cards, however, including patients losing them, paramedics failing to locate them, and relatives failing to present them to emergency services. All these scenarios may lead to inappropriate oxygen prescription and could put lives at risk (Rickards et al, 2018).

To overcome these issues, Liverpool Heart and Chest Hospital Foundation Trust has introduced oxygen alert wristbands (Fig 2). OxyBands are given, in addition to alert cards, to patients with a history of hypercapnia; patients are instructed to wear them at all times, and present them to paramedics and health professionals in hospital to alert them to the risks of administering high-flow oxygen (Rickards et al, 2018).

A retrospective audit looked at 20 cases of oxygen prescriptions before, and 20 cases after, the OxyBands were introduced. Without wristbands, inappropriate oxygen was prescribed on nine occasions; after their introduction, inappropriate oxygen had been prescribed on only one occasion, and this had been when the patient had failed to wear the wristband (Rickards et al, 2018). OxyBands are a great patient safety initiative that has improved the administration of emergency oxygen therapy in a high-risk group.

Conclusion

Administering excessive emergency oxygen therapy is dangerous. This article highlights the importance of complying with the guidance and, in particular, that relating to monitoring and titration.

Oxygen should be prescribed appropriately in either a written or electronic format and the prescription should specify the: delivery device, flow rate and individual target saturation range.

Recording accurate observations allows health professionals to titrate oxygen at the earliest possible point and the NEWS2 accommodates for lower oxygen saturation ranges for those at risk of type-II respiratory failure. The use of oxygen alert cards and wristbands can be beneficial in the community to prevent excessive emergency oxygen therapy being administered.

A shift in culture is needed to promote the prudent use of oxygen and the custom of using high-flow oxygen for prolonged periods needs to be challenged to ensure oxygen therapy is administered safely. In brief, the advice is: use the minimum amount of oxygen necessary. **NT**

References

Austin MA et al (2010) Effect of high flow oxygen on mortality in chronic obstructive pulmonary disease patients in prehospital setting: randomised controlled trial. *British Medical Journal;* 341: c5462.
British Thoracic Society (2015) *Emergency Oxygen Audit Report.* Bit.ly/BTSOygenReport2015
Chu DK et al (2018) Mortality and morbidity in acutely ill adults treated with liberal versus conservative oxygen therapy (IOTA): a systematic review and meta-analysis. *Lancet;* 391: 10131, 1693-1705.
Dhruve H et al (2015) Oxygen therapy: emergency use and long term treatment. *Clinical Pharmacist;* 7, 5.
Dobbe ASM et al (2018) Titration of oxygen therapy in critically ill emergency department patients: a feasibility study. *BMC Emergency Medicine;* 18: 17.
Gatter M et al (2015) Changing an ingrained culture: improving the safety of oxygen therapy ay University Hospitals Bristol NHS Foundation Trust. *BMJ Quality Improvement Reports;* 4: 1, pii: u203238.w1474.
Hardinge M et al (2015) British Thoracic Society guidelines for home oxygen in adults. *Thorax;* 70: S1, i1-43.
Higgins D, Guest J (2008) Acute respiratory failure 1: assessing patients. *Nursing Times;* 104: 36, 24-25.
Kelly CA et al (2018) A wolf in sheep's clothing? Patients' and healthcare professionals' perceptions of oxygen therapy: an interpretative phenomenological analysis. *Clinical Respiratory Journal;* 12: 2, 616-632.
Kelly CA, Lynes D (2015) To give or not to give: is that the question? The changing face of emergency oxygen therapy. *International Journal of Critical Care and Emergency Medicine;* 1: 2.
Lavery GG, Corris PA (2012) Should we be giving high concentration oxygen to all patients treated in an ambulance? *Journal of the Royal College of Physicians Edinburgh;* 42: 1, 36-42.
Kane B et al (2013) Emergency oxygen therapy: from guideline to implementation. *Breathe;* 9, 246-253.
O'Driscoll BR et al (2017) BTS guideline for oxygen use in adults in healthcare and emergency settings. *Thorax;* 72: S1, ii1-ii90.
Olive S (2018) *Trust Guideline for the Distribution of Oxygen Alert Cards to Adult Patients with or at Risk of Hypercapnic Respiratory Failure.* Bit.ly/OliveAlertCards
Olive S (2016) Using pulse oximetry to assess oxygen levels. *Nursing Times;* 112: 16, 12-13.
Pountain SJ, Roffe C (2012) Does routine oxygen supplementation in patients with acute stroke improve outcome? *British Medical Journal;* 345: e6976.
Rickards E et al (2018) Oxygen alert cards versus oxygen alert wrist bands (OxyBand) in COPD. *European Respiratory Journal;* 52: PA692.
Royal College of Physicians (2017) *National Early Warning Score (NEWS) 2: Standardising the Assessment of Acute-illness Severity in the NHS.* Bit.ly/NEWS2RCP
Siemieniuk RAC et al (2018) Oxygen therapy for acutely ill medical patients: a clinical practice guideline. *British Medical Journal;* 363: k4169.
Stub D et al (2015) Air versus oxygen in ST-segment-elevation myocardial infarction. *Circulation;* 131: 24, 2143-2150.
Thein OS et al (2018) Oxygen prescription: improving compliance using methods from BMJ Open Quality journal. *BMJ Open Quality;* 7: 2, e000288.

Nursing Times Self-assessment online

Test your knowledge with Nursing Times Self-assessment after reading this article. If you score 80% or more, you will receive a personalised certificate that you can download and store in your **NT Portfolio** as CPD or revalidation evidence.

Visit **nursingtimes.net/NTSAOxygen** to take the test.

For more on this topic online

- Use of excessive oxygen in the acutely ill increases mortality rate **Bit.ly/NTExcessOxygen**