The Thoracic Society of Australia & New Zealand
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OXYGEN GUIDELINES

FOR ACUTE OXYGEN USE IN ADULTS

Clinical Practice Guideline

"Swimming between the flags"

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GLOSSARY

ABG:	Arterial blood gas
BTS:	British Thoracic Society
COPD:	Chronic obstructive pulmonary disease
CPAP:	Continuous positive airway pressure
FiO2:	Fraction of inspired oxygen
HDU:	High dependency unit
HFNC:	High flow nasal cannulae
ICU:	Intensive care unit
MDI:	Metered dose inhaler
PaCO2:	Arterial partial pressure of carbon dioxide
PaO2:	Arterial partial pressure of oxygen
PCO2:	Partial pressure of carbon dioxide
SaO2:	Arterial oxygen saturation (measured by arterial blood gas)
SIGN:	Scottish Intercollegiate Guidelines Network
SpO2:	Arterial oxygen saturation measured by pulse oximeter
TSANZ:	Thoracic Society of Australia and New Zealand
NIV:	Non-invasive ventilation

INTRODUCTION

Purpose:

The purpose of the TSANZ guidelines is to provide simple, practical evidence-based recommendations for the acute use of oxygen in adults in clinical practice. The intended users are all health professionals responsible for the administration and/or monitoring of oxygen therapy in the management of acute medical patients in the community and hospital settings (excluding peri-operative and intensive care patients), those responsible for the training of such health professionals, and both public and private health organisations which deliver oxygen therapy. The guidelines represent an educational initiative of the TSANZ, which was established to improve the knowledge and understanding of lung disease, to prevent respiratory illness through research and health promotion, and improve health care for people with respiratory disorders (http://www.thoracic.org.au/).

Systematic review:

The 2008 and draft 2015 British Thoracic Society (BTS) Guidelines for Emergency Oxygen Use in Adult Patients1, 2 were reviewed, including all references in these documents which were evaluated in their entirety, together with additional references and texts where relevant. A systematic review was not performed for the purposes of developing this guideline. The BTS commissioned the Centre for Reviews and Dissemination and Centre for Health Economics at the University of York, United Kingdom, to undertake Bespoke literature searches, using defined search strategies (Appendix 14, www.brit-thoracic.org.uk). While the TSANZ Oxygen Guideline recommendations are similar to the BTS 2015 Oxygen Guidelines, there are a number of key differences including the general target oxygen saturation range (92-96% vs 94-98%) and the algorithms for emergency use of oxygen including greater emphasis on titration of oxygen administered via nasal cannulae. In contrast to the BTS 2015 Oxygen Guidelines, an extensive list of references is not provided, but rather reference is made to key reviews, studies and guidelines where appropriate. The readers are referred to the 2015 BTS guidelines for the more comprehensive detail that it provides.

Grading:

Grades of recommendation are presented below and relate to the National Health and Medical Research Council grading system, based on evidence base, consistency of evidence, clinical impact, generalisability, and applicability.3 For a full explanation of the recommendation grades please go to https://www.nhmrc.gov.au/_files_nhmrc/file/guidelines/developers/nhmrc_levels_grades_evidence_120423.pdf

Grade of recommendation	Description
A	Body of evidence can be trusted to guide practice
B	Body of evidence can be trusted to guide practice in most situations
C	Body of evidence provides some support for recommendation(s) but care should be taken in its application
D	Body of evidence is weak and recommendation must be applied with caution

Guideline Development Group:

This group included representatives from a range of professions and disciplines relevant to the scope of the guidelines.

Peer review:

The draft guidelines were peer-reviewed by the Australasian College for Emergency Medicine, the Australian and New Zealand College of Anaethetists, the Australian College of Nursing Ltd, the Cardiac Society of Australia and New Zealand, the Australian and New Zealand Intensive Care Society, the Council of Ambulance Authorities Inc, and the Internal Medicine Society of Australia and New Zealand.

Dissemination plan:

The guidelines will be sent to all medical and nursing directors of all hospitals, primary care organisations and ambulance services, and the deans of all medical, physiotherapy and nursing schools in Australia and New Zealand.

Implementation:

The implementation of these guidelines by organisations will require communication, education and training strategies and an audit system for monitoring compliance within a designated timeframe.

Expiry date: 2019

Conflict of interest statements:

Richard Beasley has received research funding from Fisher & Paykel Healthcare (<$NZ 50,000). He is a member of the 2015 BTS Oxygen Guidelines Group. Jimmy Chien, Claude Farah, Gregory King, Haydn Walters, James Douglas, Rosemary Moore, Janine Pilcher and Sheree Smith have no relevant conflicts of interest to declare.

KEY RECOMMENDATIONS

1. **Pulse oximetry should be available in all clinical situations in which oxygen is used. [GRADE C]**

2. **Arterial blood gas measurements should be considered in the following situations: [GRADE C]**
   - Critically ill patients with cardiorespiratory or metabolic dysfunction
   - In patients with an SpO_2 <92%
   - Deteriorating oxygen saturation requiring increased FiO_2
   - Patients at risk of hypercapnia
   - Breathless patients in whom a reliable oximetry signal cannot be obtained.

3. **Oxygen saturation measured by pulse oximetry should be considered a 'vital sign' and documented with other vital signs in patient assessment and management. [GRADE D]**

4. **An oxygen prescription should be documented in the patient records and drug chart. [GRADE D]**

5. **In COPD [GRADE B] and other conditions [GRADE C] associated with chronic respiratory failure, oxygen should be administered if the SpO_2 is less than 88%, and titrated to a target SpO_2 range of 88% to 92%.**

6. **In other acute medical conditions, oxygen should be administered if the SpO_2 is less than 92%, and titrated to a target SpO_2 range of 92% to 96%. [GRADE C]**

7. **Patients who need an:**
   - FiO_2 >0.40 (such as >6 Litres per minute via a simple face mask) to maintain an adequate SpO_2, should receive senior clinician review. [GRADE D]
   - FiO_2 >0.50 (such as >8 Litres per minute via a simple face mask) to maintain an adequate SpO_2, should be referred for ICU review. [GRADE D]

8. **In COPD and other conditions associated with chronic respiratory failure the preferred method of bronchodilator administration is an air-driven nebuliser or metered dose inhaler +/- a spacer. [GRADE B]**

9. **For most patients standard nasal cannulae are the preferred method of oxygen delivery, with the flow rate varied to achieve the target oxygen saturation. [GRADE D]**

10. **In patients with hypercapnic respiratory failure (arterial pH <7.35 and $PaCO_2$ >45 mmHg), NIV or invasive ventilation should be considered. [GRADE A] COPD patients with a pH <7.26 managed with NIV require intensive monitoring with a low threshold for intubation. [GRADE A]**

11. **It is recommended that patients receiving ventilatory support are located in an area, such as an HDU, ICU, a close observation unit or monitored bed unit, where there are adequate numbers of staff experienced in ventilatory support to provide an appropriate level of monitoring and titration of therapy. [GRADE D]**

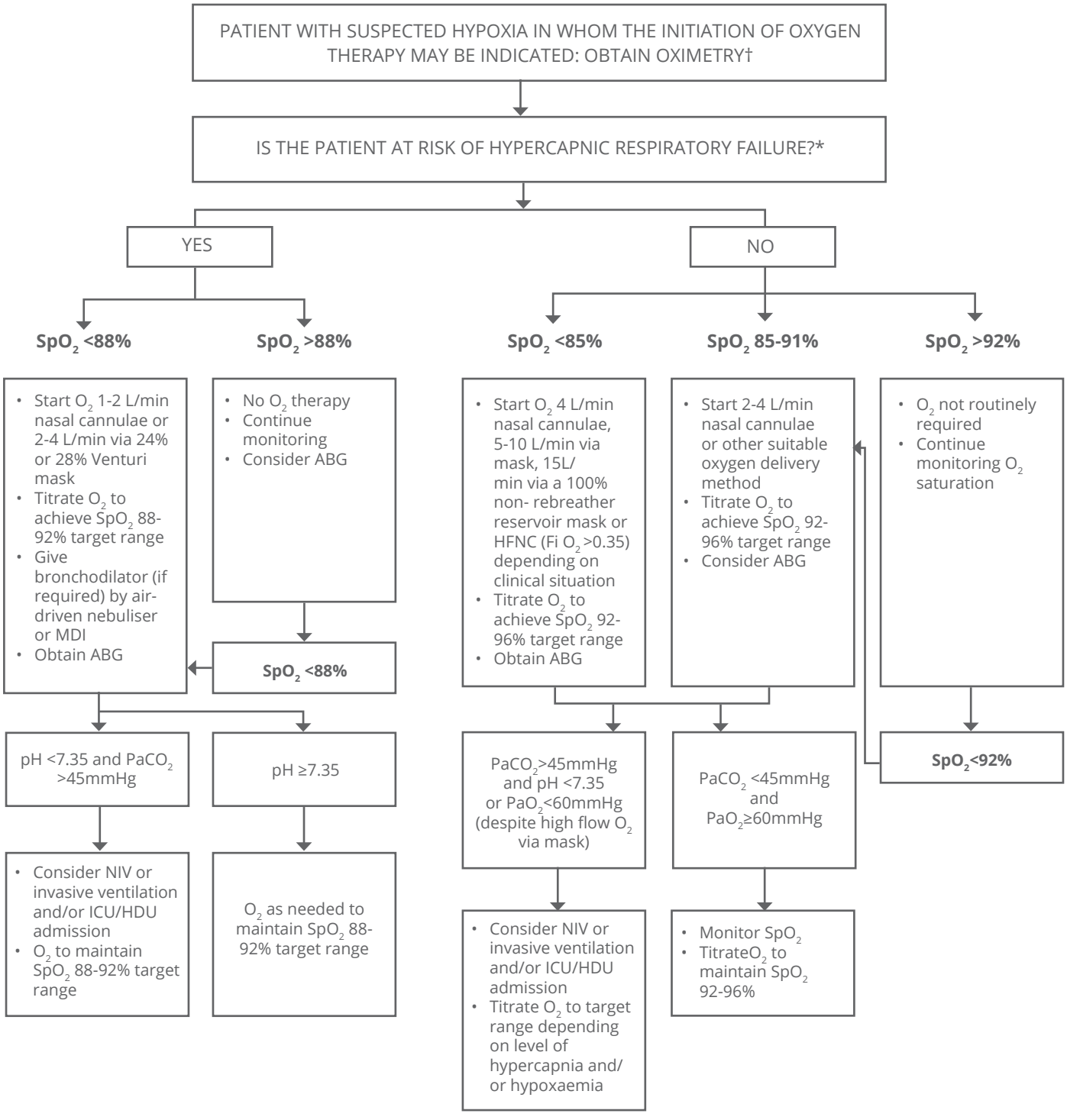

Figure 1: Treatment algorithm for oxygen therapy

This Figure is a summary of the guidelines presented in Section B, please refer to the text for full recommendations, references and evidence grading.

† If oximetry is not available, or reliable oxygen saturations cannot be determined and hypoxaemia is suspected, oxygen can be delivered at:

• 1-2 L/min via nasal cannulae or 2-4 L/min via 24% or 28% Venturi mask in patients with acute exacerbations of COPD or conditions known to be associated with chronic respiratory failure*

• 4 L/min oxygen via nasal cannulae in patients who are not critically ill and life-threatening hypoxaemia is not suspected.

• 5-10 L/min via simple face mask or 15 L/min through a reservoir mask in patients who are critically ill or in whom life-threatening hypoxaemia is suspected (e.g. post-cardiac arrest or resuscitation, shock, sepsis, near drowning, anaphylaxis, major head injury, or in suspected carbon monoxide poisoning). NIV or invasive ventilation and transfer to HDU or ICU should also be considered in this situation.

* Such as obesity hypoventilation syndrome, chest wall deformities, cystic fibrosis, bronchiectasis or neuromuscular disease.

ABG: Arterial blood gas, COPD: Chronic obstructive pulmonary disease, HDU: High Dependency Unit, HFNC: High flow nasal cannulae, ICU: Intensive Care Unit, MDI: Metered dose inhaler, NIV: Non-invasive ventilation, O_2: Oxygen, $PaCO_2$: Arterial partial pressure of carbon dioxide, PaO_2: Arterial partial pressure of oxygen, Sats: oxygen saturations, SpO_2: Oxygen saturation determined by pulse oximetry.

CONCEPTS

1. Oxygen should be considered as a drug that is prescribed and administered for specific indications, with a documented target oxygen saturation range, and with regular monitoring of the patient's response.

2. Oxygen is prescribed for the relief of hypoxaemia, not breathlessness. (Footnote 1)

3. Hypoxaemia is both a marker of risk of a poor outcome due to the severity of the underlying disease(s) that has caused hypoxaemia, and an independent risk factor of poor outcome. (Footnote 2)

4. There are risks associated with both hypoxaemia and hyperoxaemia, which underlie the importance of prescribing oxygen, only if required, to within a target oxygen saturation range. (Footnotes 2 to 4)

5. The 'swimming between the flags' concept of titrating oxygen therapy, to within a specific target oxygen saturation range applies to a wide range of clinical situations, in addition to exacerbations of chronic obstructive pulmonary disease (COPD). (Footnotes 2 to 4)

6. The variable accuracy of pulse oximetry in the estimation of arterial oxygen saturation (SaO_2) represents the major limitation in its use to guide the titration of oxygen therapy. (Footnote 5)

7. The use of high concentration oxygen in a breathless patient in an attempt to protect against hypoxaemia in the event of a subsequent deterioration has the potential to cause delay in recognising clinical deterioration and reduce the time available to initiate additional treatment. (Footnote 6)

8. If a patient who requires a high fraction of inspired oxygen (FiO_2) to maintain adequate oxygen saturations deteriorates, there is limited opportunity to increase FiO2 to avoid life threatening hypoxaemia. For this reason, patients who need high FiO_2's should receive senior clinician review and transfer to an area where there are appropriate numbers of competent staff able to provide more intensive monitoring and therapy. (Footnote 6)

RECOMMENDATIONS

Assessment:

1. Pulse oximetry should be available in all clinical situations in which oxygen is used.[4] **[Grade C]**

Practice point: *There is variable accuracy of pulse oximetry to predict SaO_2 in acutely ill patients, with SpO_2 measurements both over and under estimating SaO_2, with wide limits of agreement.[4-9] The accuracy of SpO_2 may worsen with progressive hypoxaemia.[8, 9] Clinicians need to be aware of the variable accuracy of SpO_2 in the utilisation of pulse oximetry in clinical practice. (Footnote 5) An SpO_2 of >92% is a practical lower threshold to rule out hypoxaemia, defined as an SaO_2 <90%7 or an arterial partial pressure of oxygen (PaO_2) <60mmHg (8 kPa).[5]*

2. Arterial blood gas (ABG) measurement should be considered in the following situations: **[Grade C]**
   - Critically ill patients with cardiorespiratory or metabolic dysfunction
   - In patients with an SpO_2 <92% in whom hypoxaemia may be present
   - Deteriorating oxygen saturation requiring increased FiO_2
   - Patients at risk of hypercapnia (see below)
   - Breathless patients in whom a reliable oximetry signal cannot be obtained.

Peripheral venous blood gas analysis is a less invasive test, however it does not provide an accurate estimate of $PaCO_2$ or PaO_2.[10] It does, however, provide rapid clinically important information to assess acutely unwell patients, including pH, lactate, glucose, haemoglobin, sodium and potassium. In addition it provides a venous partial pressure of carbon dioxide which if less than <40mmHg, effectively rules out hypercapnia.[10] (Footnote 7)

Arterialised capillary earlobe or fingertip blood gas measurements represent an alternative if unable to obtain an ABG measurement, recognising that whilst providing accurate information about $PaCO_2$ and pH, it variably underestimates PaO_2 measurements.[11, 12] As a result, patient assessment can be based on pH and PCO_2 levels measured from earlobe or fingertip blood gases, together with SpO_2 by pulse oximetry.

Practice point: *Hypoxaemia requires investigation and treatment of the underlying cause, and consideration of the contribution of hypoventilation, including measurement of arterial partial pressure of carbon dioxide ($PaCO_2$) and pH.*

Prescription:

1. A specific oxygen prescription should be documented in the patient records and the drug chart.[13] **[Grade D]**

Practice point: *The main requirement for an oxygen prescription is documentation of the target SpO_2 range.*

In its most detailed form, the prescription could include the delivery system and interface, the target oxygen saturation range, the range of flow rates for each delivery system, and instruction as to SpO_2 and FiO_2 at which clinical review should be sought. Considerable space on the prescription form is needed to provide such detail.

Oxygen administration: (see Figure 1)

1. An SpO_2 target of 88% to 92% is recommended in exacerbations of COPD,[14] [Grade B] and other conditions associated with chronic respiratory failure (such as obesity hypoventilation syndrome,[15] bronchiectasis, cystic fibrosis,[16] neuromuscular disease and chest wall deformities such as severe kyphoscoliosis). **[Grade C]**

Practice points: *Where there is diagnostic uncertainty as to whether COPD is the primary cause of the exacerbation, it may be preferable to titrate oxygen therapy to the 88-92% SpO_2 target range.[14, 17, 18,19] (Footnote 8)*

If the patient is breathing room air and has saturations >88% then the initiation of oxygen is not routinely required and may place the patient at risk of oxygen saturations outside the target saturation range.

2. In the presence of hypoxaemia in other acute medical conditions, oxygen should be administered to achieve a target SpO_2 range of 92% to 96%.[20, 21] **[Grade C]** (Footnote 9)

Practice point: *If the patient is breathing room air and has saturations >92% then the initiation of oxygen is not routinely required and may place the patient at risk of oxygen saturations outside the target saturation range.*

3. A target of around 85% is recommended in patients previously exposed to bleomycin or in paraquat poisoning.[22-24] **[Grade C]** (Footnote 10)

4. Patients with carbon monoxide poisoning should receive normobaric hyperoxia or hyperbaric oxygen therapy.[25, 26] **[Grade B]** Note that pulse oximetry is likely to be inaccurate in this setting.[4]

Practice point: *In the immediate assessment of an acutely unwell patient, oxygen saturations should be measured by oximetry, pending the availability of blood gas results if required (See Assessment, Point 2).*

a. In the presence of COPD or conditions associated with chronic respiratory failure:

- *If SpO_2 ≥88%, oxygen therapy is not initially required.*
- *If SpO_2 <88%, oxygen can be administered at 1-2 L/min via nasal cannulae or 2-4 L/min via 24% or 28% Venturi mask, and titrated to achieve target SpO_2.*
- *The avoidance of inappropriate high concentration oxygen therapy may be facilitated by the provision of a COPD oxygen alert card[27]*

b. In the absence of COPD or known chronic respiratory failure:

- *If SpO_2 ≥92%, oxygen therapy is not routinely required.*
- *If SpO_2 85-91%, oxygen can be initially instituted at 2-4 L/min via nasal cannulae or other suitable oxygen delivery method, and titrated to achieve target SpO_2. In many situations this range of oxygen saturations is unlikely to be associated with risk, although oxygen is commonly administered.*
- *If SpO_2 <85%, oxygen can be initiated at 4 L/min via nasal cannulae, through a simple face mask at 5-10 L/min, a 100% non-rebreather reservoir mask at 15 L/min, or humidified high flow nasal cannulae (FiO_2 >0.35). The choice of delivery system will depend on the SpO_2 level (higher FiO_2s with increasingly more severe reductions in SpO_2), and titrated to achieve the target SpO_2 as soon as practically possible.*

Practice point: *If oximetry is not available, or reliable SpO_2 cannot be determined and hypoxaemia is suspected, oxygen can be delivered at:*

- *1-2 L/min via nasal cannulae or 2-4 L/min via 24% or 28% Venturi mask in patients with acute exacerbations of COPD or conditions known to be associated with chronic respiratory failure.*
- *2-4 L/min oxygen via nasal cannulae in patients who are not critically ill and life-threatening hypoxaemia is not suspected.*
- *5-10 L/min via simple face mask, 15 L/min through a 100% non-rebreather reservoir mask or high flow nasal cannulae (FiO_2 >0.35) in patients in whom life-threatening hypoxaemia is suspected (See Figure).*

Monitoring:

1. Monitoring of SpO_2 is a fundamental requirement for a target SpO_2 to be achieved.

2. An important component of monitoring is the documentation of delivery system and flow rate, in addition to the SpO_2.

Practice point: *As hypoxia is a risk factor for poor clinical outcomes,[28] pulse oximetry is a 'vital sign', to be considered together with other signs, including respiratory rate, which is a predictor of potentially serious clinical events.[29]* **[Grade D]**

The New South Wales Standard Adult Observation Chart provides a practical example of the documentation of SpO_2 as one of the vital signs and a designated level for clinical review and rapid response.

(http://nswhealth.moodle.com.au/DOH/DETECT/content/00_worry/when_to_worry_07.htm).

3. Patients who need an estimated FiO_2 of >0.40, such as >6 Litres per minute via a simple face mask, to maintain an adequate SpO_2, should receive senior clinician review and may require transfer to a facility such as HDU, where there are appropriate numbers of competent staff able to provide more intensive monitoring and therapy. **[Grade D]**

4. Patients who need an estimated FiO_2 of >0.50, such as >8 Litres per minute via a simple face mask, to maintain an adequate SpO_2, should receive ICU review and most will require ICU transfer. **[Grade D]**

Practice point: *In patients whose oxygen saturations improve with oxygen therapy to above the target oxygen saturation range, their inspired oxygen therapy can be reduced or stopped. Oxygen saturation monitoring would continue to allow the detection of any subsequent deterioration of the underlying condition and the requirement to increase or resume oxygen therapy.*

A reduction in SpO_2 while the FiO_2 is maintained, or increasing FiO_2 requirements to maintain SpO_2 should lead to a further assessment of the patient.

Delivery system:

1. For most patients standard nasal cannulae are the preferred method of oxygen delivery, with the flow rate varied to achieve the target oxygen saturation. **[Grade D]** (Footnote 11)

2. The FiO_2 levels delivered by the different delivery systems may vary considerably between patients and be influenced by a number of factors, including respiratory rate and whether the patient's mouth is open or closed.30-37 Approximate FiO_2 values delivered by different delivery systems are:

- Standard nasal cannulae can deliver an FiO_2 of 0.24-0.35 at an oxygen flow of 1-4 L/min
- Venturi masks can deliver an FiO_2 of 0.24-0.60
- High flow nasal cannulae can deliver an FiO_2 of 0.21-0.80
- A simple face mask can deliver an FiO_2 of 0.35-0.60 at an oxygen flow of 5-10L/min
- A 100% non-rebreather reservoir mask at 15 L/min can deliver an FiO_2 of >0.60

3. For simple face masks, flow rates <5 L/min should be avoided due to the potential risk of carbon dioxide rebreathing.[38, 39] **[Grade C]**

4. Humidification of oxygen via high flow nasal cannulae may improve comfort and tolerance.[40, 41](Footnote 12)

Bronchodilator administration:

1. In COPD and other conditions associated with chronic respiratory failure, if bronchodilator is required, the preferred methods of administration are via an air-driven nebuliser or via a metered dose inhaler +/- a spacer, with supplementary nasal oxygen continued as required.[14, 42] **[Grade B]**

> ***Practice point:*** *The administration of bronchodilator via an oxygen-driven nebuliser has the potential to cause an increase in $PaCO_2$.[43, 44] It has been recommended that if an oxygen-driven nebuliser is used, then its use is limited to 6 minutes.[1]*

2. In asthma, if bronchodilator is required, methods of delivery include an oxygen or air-driven nebuliser or metered dose inhaler +/- a spacer.[45]

Positioning:

1. Fully conscious hypoxaemic patients should be allowed to position themselves according to their preference and comfort. **[Grade D]** In some, but not all patients, upright posture may result in improved oxygenation.[46-48]

Ventilatory support:

1. In patients with hypercapnic respiratory failure, in whom an ABG measurement shows a pH <7.35 and $PaCO_2$ >45 mmHg, NIV or invasive ventilation should be considered.[49-53] **[Grade A]** COPD patients with a pH <7.26 managed with NIV require more intensive monitoring with a low threshold for intubation.[52] **[Grade A]**

2. In patients in whom oxygen-induced hypercapnia is suspected, oxygen therapy should be titrated to maintain the 88-92% target oxygen saturation range and not be abruptly stopped due to the risk of profound rebound hypoxaemia.[54-56] **[Grade C]**

3. In patients with severe cardiogenic pulmonary oedema continuous positive airway pressure (CPAP) should be considered.[57] **[Grade A]**

4. NIV is not routinely recommended in acute hypoxaemic respiratory failure, as results from clinical trials and observational studies have provided mixed results for various patient groups,[50, 58-61] however there is some evidence of benefit in certain patients with immunosuppression.[50, 59, 61-63]

5. It is recommended that patients receiving ventilatory support are located in a ward area such as an HDU, ICU, a close observation unit or monitored bed unit, where there are adequate numbers of staff experienced in ventilatory support to provide an appropriate level of monitoring and titration of therapy.[49] **[Grade D]**

FOOTNOTES

1. Oxygen therapy does not relieve breathlessness in the absence of hypoxaemia. For example, there is no clinical benefit with short burst oxygen therapy in COPD patients with breathlessness,[64] or with the use of oxygen over room air via nasal cannulae for patients with COPD who do not have severe resting hypoxaemia.[65] Similarly, there is no additional symptomatic benefit in the use of daily oxygen over room air via nasal cannulae for refractory breathlessness in the palliative setting.[66]

   In the absence of hypoxaemia, oxygen therapy is not indicated in the treatment of acute coronary syndrome or stroke, conditions associated with reversible ischaemia. In myocardial infarction, high concentration oxygen therapy is associated with greater infarct size, when compared with room air or titrated oxygen therapy if required to avoid hypoxaemia.[67, 68] In stroke, routine administration of continuous or nocturnal oxygen therapy does not improve outcomes.[69, 70]

2. Hypoxaemia is both a marker of risk of a poor outcome due to the severity of the underlying disease(s) that has caused hypoxaemia, and an independent risk factor of poor outcome.[28, 71] The clinical impact depends on the underlying cause(s), the speed of onset and severity of hypoxaemia, the age of the patient, and associated comorbidities. It has been proposed that a PaO_2 of 50mmHg (6.6 kPa) can be considered as the safe lower limit of hypoxaemia in patients with COPD,[72] and that oxygen therapy which achieves a PaO_2 of at least 50 mmHg would prevent immediate death from hypoxaemia.[73]

3. The potential risks due to hyperoxaemia with high concentration oxygen therapy include respiratory (increased $PaCO_2$, absorption atelectasis and direct pulmonary toxicity), cardiovascular (increased systemic vascular resistance and blood pressure, reduced coronary artery blood flow, reduced cardiac output), cerebrovascular (reduced cerebral blood flow) effects, and increased reperfusion injury due to increased reactive oxygen species.[74-78]

4. The physiological response of an increase in $PaCO_2$ due to high concentration oxygen therapy has been demonstrated not only in stable and acute exacerbations of COPD,[72] but also in severe asthma,[20, 79] community-acquired pneumonia[21] and obesity hypoventilation syndrome.[15] Proposed mechanisms for oxygen induced hypercapnia include increased ventilation perfusion mismatch due to reduced hypoxic pulmonary vasoconstriction, reduced ventilatory drive, atelectasis and the Haldane effect, with the contribution of each likely to depend on the clinical situation.[1]

5. There is variable accuracy of pulse oximetry to predict SaO_2 in acutely ill patients, with SpO_2 measurements both over and under estimating SaO_2, with wide limits of agreement.[4-9] Clinicians need to be aware of the variable accuracy of SpO_2 in the utlisation of pulse oximetry in clinical practice. Factors that might affect the accuracy of pulse oximetry include severe hypoxaemia, carboxyhaemoglobin and methaemoglobin levels, anaemia, dark skin, low perfusion, excessive ambient light and nail polish.[4, 8, 9]

6. The use of high flow oxygen in an attempt to protect against subsequent hypoxaemia in the event of deterioration has the potential to delay the recognition of such a deterioration.[80, 81] This may provide a false reassurance that the patient is stable. There is likely to be no major change in vital signs[82] or a marked decrease in SpO_2 as assessed by pulse oximetry[83] until a potentially life-threatening situation has developed. At this stage there is limited opportunity to further increase the oxygen therapy while medical review and an intervention such as transfer to an HDU or ICU is undertaken.

   Similarly, if a patient who requires a high FiO_2 to maintain adequate SpO_2 deteriorates there is limited capacity to increase FiO_2 to avoid life threatening hypoxaemia. For this reason it is recommended that patients who need an FiO_2 >0.40, such as >6 Litres per minute via a simple face mask, to maintain an adequate SpO_2, should receive senior clinician review and may require transfer to a ward area, such as an HDU. Likewise, patients who need an FiO_2 >0.50, such as >8 Litres per minute via a simple face mask, to maintain an adequate SpO_2, should receive ICU review as most will require ICU transfer.

7. Peripheral venous blood gas analysis is a less invasive test than an ABG, however it does not provide an accurate estimate of $PaCO_2$ or PaO_2. It does, however, provide rapid clinically important information to assess acutely unwell patients, including pH, lactate, glucose, haemoglobin, sodium and potassium. In addition it provides a PCO_2 which, if less than <40mmHg, essentially rules out hypercapnia. A systematic review and meta-analysis has compared venous and ABG measurements.[10] The point estimate for the difference between $PaCO_2$ and venous PCO2 was 4.1mmHg higher for the venous reading, but with wide 95% confidence limits from 10.7 mmHg higher to 2.4 mmHg lower. $PaO_2$was higher than venous PO_2 by 36.9mmHg with a 95% confidence interval of 27.2 to 46.6 mmHg. Arterial pH values were slightly higher than venous pH; 0.03 with a 95% confidence interval of 0.029 to 0.038.

8. A target SpO_2 range of 88-92% is recommended in the treatment of COPD and other conditions associated with chronic respiratory failure due to demonstration of:

    - A greater than two-fold reduction in mortality with pre-hospital oxygen therapy titrated to this target, compared with high concentration oxygen therapy in patients with an acute exacerbation of COPD.[14]
    - An increase in $PaCO_2$ with 100% oxygen therapy in patients with chronic respiratory failure due to obesity hypoventilation syndrome.[15]

9. A general target SpO_2 range of 92-96% in acute medical conditions has been recommended, incorporating a lower range than that recommended in the BTS guidelines (94-98%). This lower target recognises that:

    - An SpO_2 of >92% is a practical lower threshold to rule out hypoxaemia, defined as an SaO_2 <90%7 or a PaO_2 <60mmHg (8 kPa).[5]
    - There is no known risk of hypoxic tissue injury at an SaO_2 of 90%.
    - Older healthy subjects have SaO_2levels to this lower level of 90%.[84, 85]
    - Healthy subjects have a mean nadir SpO_2 of around 90% during sleep.[86]
    - Subjects with sleep disordered breathing commonly tolerate SpO_2 levels between 80 and 90% for prolonged periods.[86]
    - Adults with comorbidities tolerate SpO_2 levels between 80 and 90% during long distance travel.[87]
    - Guidelines for acute coronary syndrome[88] and heart failure[89] recommend administration of oxygen if the SpO_2 is <93% and <90%, respectively.
    - In adults with coronary artery disease, anaerobic metabolism indicative of myocardial ischaemia is observed in some patients with SaO_2 between 70 and 85%, suggesting a 'safe' lower limit of oxygen saturation of 90%.[90]
    - There is an evidence-base for titration of oxygen therapy to a target SpO_2 range of 93 to 95% in acute severe asthma,[20] and community-acquired pneumonia.[21]
    - There is an evidence-base for the safety of oxygen therapy to a target SpO_2 range of 88 to 92% in acute exacerbations of COPD.[14]
    - This recommendation is likely to reduce excessive use of high concentration oxygen therapy.
    - An upper level of 96% avoids the potential risks of hyperoxia and allows for patient improvement to be recognised earlier during monitoring, so that oxygen can be down-titrated.

10. A target SpO_2 range of 85% is recommended in patients with prior exposure to bleomycin or in paraquat poisoning is due to the demonstration of:

    - Potentiation of lung injury by oxygen[22, 23]
    - Lack of harm from hypoxaemia with saturations around 85% in these clinical situations[24]

11. The potential advantages of nasal cannulae as an initial method of delivering oxygen therapy are:

    - Ability to give nebulised bronchodilator at the same time as oxygen is administered.
    - Oxygen can be prescribed by variable flows to achieve a target saturation range rather than a fixed FiO_2, although oxygenation may be maintained better with Venturi mask.[32]
    - Comfort, ease of use and low cost.
    - Less likely to be taken off to eat or speak, and less likely to fall off.
    - No risk of rebreathing of carbon dioxide.

12. Humidified High Flow Nasal Cannulae are an alternative to standard low flow nasal cannulae or high flow masks for oxygen delivery.[34, 40, 41, 91, 92] There are no established evidence-based recommendations to guide appropriate clinical use in adults, however currently some centres recommend HFNC only in the ED, HDU or ICU. The potential benefits, demonstrated mostly from observational studies, of this delivery system include:

    - Greater comfort and tolerance via delivery of warmed and humidifed nasal oxygen, compared with delivery via a face mask
    - Better titration of FiO_2 across a wider range of FiO_2's
    - Preservation of upper airways function, such as speech, swallowing and cough

Potential disadvantages of HFNC include:

- Risk of complacency if a high FiO_2 requirement is not recognised to represent life-threatening illness requiring more than correction of hypoxaemia (see footnote 6)
- Role in severe exacerbations of COPD and asthma has not been investigated

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