ABC of oxygen therapy in acute care: Why? Who? How?

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CASE

Mrs B is a 73 year old lady with a known history of COPD. She is admitted to the respiratory ward with non-infective exacerbation of her COPD. Her vital signs are HR 78 bpm, RR 32 bpm, SpO_2 84% on room air, BP 146/88 mmHg, Temp 37.5 °C. As you are clerking this patient's admission, the nurse asks you, "What shall we do about oxygen?"

INTRODUCTION

Oxygen is likely the most common medication that is used in patients with acute health problems. However, it is hardly thought of as a medication by many medical students. Pre-hospital and emergency practitioners are likely to give supplemental oxygen to virtually all breathless and sick patients. A study from the United Kingdom estimated that 34% of all patients transferred to hospitals receive supplemental oxygen at some stage, which equated to about two million instances of oxygen use per annum.[1] Nevertheless, multiple studies have showed that doctors poorly prescribe oxygen therapy in acute settings. Furthermore and when they do prescribe it, it is often unnecessary. In one study from Auckland's North Shore Hospital, only 8% of all administered oxygen was actually prescribed and of this 75% was deemed unnecessary.[2] Similar findings were reported from countries such as Australia, the United Kingdom and the United States.[3,4]

Junior doctors administer oxygen for three main reasons; to correct existing tissue hypoxia, to prevent potential tissue hypoxia, and to alleviate breathlessness. The only evidence for oxygen use is in the correction of an existing hypoxemia.[5] The concepts of hypoxia and hypoxemia are further explored below.

Studies suggest that administering oxygen to patients in which doctors anticipate a potential hypoxia might actually place the patient at increased risk of poor outcome if hypoxia does actually occur except in situations such as pre-oxygenation prior to anaesthesia induction.[6] Furthermore, a recent Cochrane review concluded that there is no evidence to suggest that oxygen benefits breathless non-hypoxemic patients and oxygen maybe detrimental in such patients.[5] Although oxygen is commonly used for breathlessness there is no convincing evidence for efficacy and evidence for harm. The desire to provide a therapy because "we can, and it should help" should be resisted.

Medical students and house officers will encounter situations in which they will have to think about the administration of oxygen to sick patients. Therefore, it is essential to have a good understanding of the role and use of oxygen therapy in acute care. This review article provides a practical approach to the use of hospital-based oxygen therapy in acute care setting.

PRE-ASSESSMENT

These questions are to assess your level of understanding of oxygen in clinical settings before the clinical review. Answer True or False for each question (adapted from Cooper, N and Cramp, P: Essential Guide to Acute Care, BMJ publishing, 2003).

1) Administering 2 litres / minute oxygen via a simple face mask is safe in COPD

2) Patients with COPD should never be given more than 28% oxygen

3) Nasal cannulae set at 2 litres per minute deliver FiO_2 of 0.28

4) The correct treatment for a raised pCO_2 is to decrease the fraction of inspired oxygen

5) In a patient with acute severe asthma, a Venturi mask providing 28% oxygen is indicated as first line treatment.

Answers: FFFFF

WHO SHOULD GET SUPPLEMENTAL OXYGEN IN ACUTE CARE?

Oxygen therapy should be used in the management of existing hypoxemia. Hypoxemia is a low arterial oxygen tension below the normal expected value of (85-100 mmHg). The British Thoracic Society (BTS) guideline defined hypoxemia as $PaO_2 < 60$ mmHg or $SaO_2 < 90\%$.[7] Thus the diagnosis of hypoxemia is readily made by arterial blood gas (ABG) sampling, which allows direct measurement of pO_2 and SaO_2 (arterial oxygen saturation). The term "hypoxia" by contrast means the lack of oxygen at tissue level. This is not readily measured: evidence for tissue hypoxia is often indirect in clinical medicine, for instance hypoxia can be indirectly estimated by parameters of tissue perfusion such as lactate. It is important to note that SaO_2 can also be estimated using a pulse oximeter and this is usually referred to as SpO_2. It is important to appreciate that the decision to treat

hypoxemia is case-sensitive. The treating physician might treat a patient with oxygen who does not meet the BTS criteria if they have co-morbidities in which a lesser degree of hypoxia can be detrimental.

Hypoxaemic conditions	Hypoxic conditions
COPD	Shock
Acute Asthma	Congestive Heart Failure
Interstitial Lung Disease (ILD)	Sepsis
Pneumonia	Thyrotoxicosis
Pulmonary Oedema	Anemia
Acute Respiratory Distress Syndrome	

Figure 1 *shows examples of hypoxemic and hypoxic conditions. The benefit of oxygen therapy in hypoxemia management is supported by several well-conducted randomized controlled trials.[5] However, the use of oxygen in hypoxic non-hypoxemic conditions such as heart failure is not yet substantiated.[5,8]*

HOW SHOULD YOU GIVE OXYGEN?

A variety of different systems are available for delivering oxygen to patients. Some (such as nasal cannulae) are more appropriate for long term domiciliary use than for use in acute illness. It is important to understand the difference between a percentage (or fraction of inspired oxygen FiO_2) and a flow rate (litres per minute). In clinical scenarios it is common to hear descriptions such as a patient being on "2 litres of oxygen", but this information does little to convey understanding of the FiO_2 and an appreciation of this is vital if oxygen is to be prescribed safely.

HOW IS OXYGEN PROVIDED ON THE WARDS?

In hospital, the fixed supply ("ward") 100% oxygen is piped from a large central liquid oxygen reservoir. Supplies to patients are controlled by individual plug in regulators. The majority of these will supply oxygen at flow rates of 0 - 15 litres per minute, although higher flow (30 L/min) and lower flow regulators (usually carefully titrated up to 2 L/min for paediatric use) are available. Unless another gas is entrained, flow rates from ward regulators cannot exceed the maximum regulator output. Similarly, oxygen cylinders which are used for patients in transit or mobilizing contain pure oxygen and have regulators that allow flows of up to 15 L/min.

WHAT DEVICES ARE AVAILABLE FOR GIVING OXYGEN?

Oxygen delivery devices can be categorized into two forms; variable and fixed performance. Prescribers should be familiar with these in order to provide appropriate oxygen therapy using the appropriate device. Variable performance devices include nasal cannulae (also called nasal specs or nasal prongs) and simple face masks (Hudson masks). Such devices provide variable percentage of oxygen depending on the respiratory rate and tidal volume of the patient. Fixed performance devices provide a constant percentage of inspired oxygen independent from the patient's respiratory effort. This is achieved with a mask design utilizing the Bernoulli Effect. There is an increase in gas velocity and a decrease in pressure as the gas passes through a constriction.[9] So-called venturi masks allow the entrainment of air through precisely engineered vents under the influence of this pressure drop. This results in a fixed concentration of oxygen in a high gas flow that is greater than the peak inspiratory flow rate of the patient.

Figures below depict the oxygen masks widely used in acute care setting in New Zealand (*Adapted from Cooper, N and Cramp, P: Essential Guide to Acute Care, BMJ publishing, 2003*).

Figure 2 *Nasal cannula*

Figure 3 *Non-rebreather mask with reservoir bag.*

Figure 4 *Venturi mask*

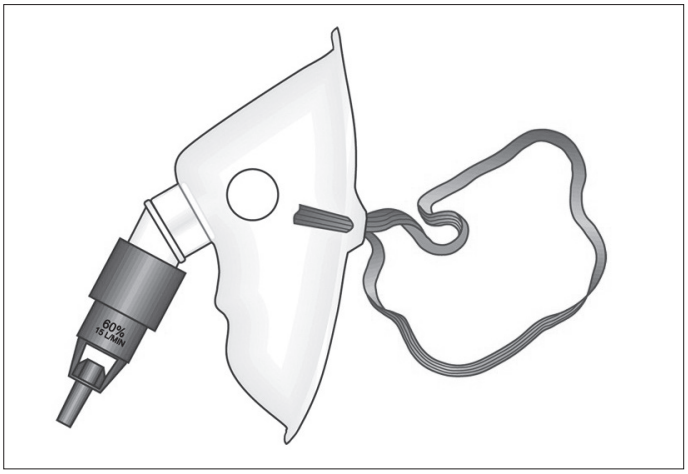

Figure 5 *Venturi mask illustration*

In order to understand the difference between the two types, it is critical to appreciate the concept of Inspiratory Flow Rate (IFR). IFR is the inward flow rate of inspired gas and the maximum is usually quoted to be around 35 L/min. This IFR varies throughout respiration and depends on physical features of the patient such as body size. If the oxygen delivery device is to have fixed performance, the oxygen delivered must match or be greater than the peak inspiratory flow rate. Variable performance devices provide supplemental oxygen below the IFR and their delivery capacity is determined by factors such as patient minute ventilation and body size. The exact percentage of oxygen delivered using variable performance devices is difficult to calculate and varies between breaths and even between phases of same breath. However, the exact percentage of inspired oxygen is known or can be easily calculated when using fixed performance devices. Commonly used Venturi masks come with different coloured jets that provide specific concentration of oxygen. The table below provides a guide to the colours and their corresponding oxygen concentration capacity.

Figure 6 *below provides a guide to the colours and their corresponding oxygen concentration capacity.*

Jet colour	Oxygen flow rate L/min	Oxygen delivered %
Blue	2	24
White	4	28
Yellow	6	35
Red	8	40
Green	12	60

WHAT DO YOU ACHIEVE BY GIVING OXYGEN?

The goal from administering oxygen is to relieve hypoxemia by increasing the alveolar oxygen tension. Therefore it is only effective if alveolar capillary units have functional ventilation. This may also lead to reduced work of breathing (i.e. tachypnea and use of accessory muscles) and reduced work of the heart (i.e. tachycardia and hypertension). Hypoxemia also causes pulmonary vasoconstriction and supplemental oxygen may ameliorate this response. Furthermore, oxygen administration in hypoxemic patients may reduce confusion and increase alertness. However, oxygen is most effective in treating hypoxemia due to hypoventilation, disturbances in diffusion between oxygen and blood, and low inspired pressures of oxygen (such as during altitude exposure). It is less effective in hypoxemia due to V/Q mismatch and ineffective in true shunt. It is therefore critical to manage the underlying condition that created hypoxic state if possible. For example, in hypoxemia due to post-operative atelectasis (effectively a cause of V/Q mismatch), encouraging patients to cough and take deep breaths is important in maximising the benefit of oxygen.

WHEN TO STOP?

Oxygen therapy should be discontinued as soon as the indication for its use ceases. As soon as the patient stabilizes from a physiological perspective, weaning process should be initiated. Clinical and laboratory measures such as vital signs and ABG parameters can help clinicians decide when to start weaning a hypoxemic patient off oxygen therapy. The weaning process can be achieved gradually by reducing the inspired oxygen concentration in increments for a period of time with regular re-evaluation of the patient. If there is no further deterioration of patient condition then oxygen therapy can be withdrawn all together. In patients who are chronically hypoxic the weaning of acute supplemental oxygen may be prolonged. Note also that patients may derive a feeling of 'comfort' by having oxygen available, as patients, family (and often members of the medical team) may believe that breathlessness is a symptom of hypoxaemia, rather than a result of an underlying illness. Oxygen is, however, an expensive intervention and creating psychological dependency on it is unlikely to benefit the independence and well-being of patients. There is some evidence that the amelioration of breathlessness by the flow of oxygen may be mediated by stimulation of branches of the trigeminal nerve: thus, it may be the flow of gas (e.g. air) rather than the composition of that gas (such as a raised FiO_2) that has clinical effect. This may be best achieved with the use of fans at the bedside to promote a feeling of the flow of air.[10]

CAN I CAUSE HARM BY ADMINISTERING OXYGEN TO A NON-HYPOXEMIC PATIENT?

The British Thoracic Society oxygen guideline warns from two groups of risks that can occur from unwarranted use of oxygen supplementation in non-hypoxemic patients.[7] Physiological risks include; worsening of V/Q mismatch, absorption atelectasis, coronary and cerebral vasoconstriction, reduced cardiac output, damage from oxygen free radicals and increased systematic vascular resistance. In addition, clinical risks, which are more relevant to practicing junior doctors, include worsening of a hypercapnic respiratory failure, masking clinical deterioration, specific risks in patients with previous lung damage or acid aspiration, and worse outcomes in non-hypoxemic mild to moderate stroke patients. Such risks are less common than untreated hypoxemia. The use of fixed performance devices and continuous monitoring are essential measures when treating high risk groups such as COPD patients in order to minimize the risk of hypercapnic failure.

WHICH MASK SHOULD I USE FOR WHICH PATIENT?

Figure 7 below describes the type of oxygen delivery masks appropriate to be used in different situations.

Mask type	Examples of conditions
Nasal prongs	long term oxygen therapy at home; to allow oxygen therapy whilst eating, talking etc
Simple face mask, face mask with reservoir bag	Higher oxygen is required but tight control of concentration is not important, eg: severe asthma, acute left ventricular failure, pneumonia, trauma and severe sepsis. Note: masks should always be set at minimum of 10 L/min to avoid rebreathing.
Venturi masks	Controlled treatment with oxygen is required in patients with respiratory failure. E.g. COPD patients with chronic hypercapnia and reliance on hypoxic drive.

HOW DO YOU PRESCRIBE OXYGEN?

Oxygen should be regarded as a drug and therefore similar rigour should be applied to prescribing to reduce the risk of drug errors and harm. The initial oxygen prescription should indicate the dose, mode of delivery, and whether oxygen to be given continuously or on as required basis (PRN). The BTS guideline indicated that the most important aspect of oxygen prescription is to indicate the target range of arterial oxygen saturation.[7] The guideline also advocates for the integration of oxygen prescription section in hospital drug charts.

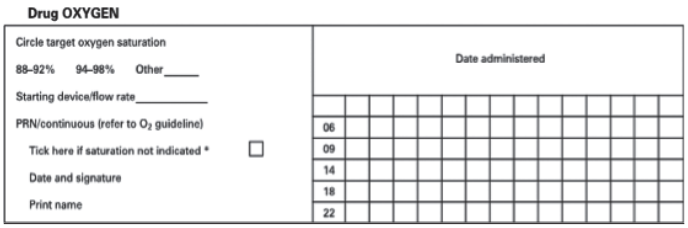

Figure 8 shows an example of the guideline.

BACK TO MRS B:

An appropriate response to the nurse's concern will be to consider oxygen delivery using a fixed performance device such as a Venturi mask. The safest approach would be to titrate the fraction of inspired oxygen upward using the different Venturi masks until the desired level of oxygen saturation is reached. If there are significant concerns about loss of hypoxic respiratory drive, then consideration could be given to serial arterial blood gas measurements to check the arterial PCO_2.

TAKE HOME MESSAGES

1. Oxygen is a drug and should be prescribed appropriately.
2. Main indication for acute oxygen therapy is hypoxemia.
3. Oxygen does not help the feeling of breathlessness in non-hypoxemic patients.
4. Oxygen masks come in two forms; low flow and high flow masks.
5. Prescribers should be familiar of which system to use in what situation.

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