Is it time for apnoeic oxygenation during endotracheal intubation in critically ill patients?

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Endotracheal intubation is a potentially hazardous procedure performed in the intensive care unit. A combination of cardiorespiratory compromise and the increased metabolic demands of critical illness can lead to the rapid onset of hypoxia with apnoea. Critical oxygen desaturation (which may be defined as arterial oxygen desaturation to less than 70%) places patients at risk of considerable morbidity.[1] Complications may include haemodynamic collapse, arrhythmias and hypoxic brain injury.[2,3] Existing research indicates that desaturation to < 85% may occur in as little as 23 seconds in critically ill patients. This is 25 times as fast as desaturation described in healthy adults.[4,5] Given that estimates of the incidence of difficult intubation in ICU patients can be as high as 20%, and that 10% of ICU intubations needed at least 10 minutes, any technique that could potentially delay the onset of desaturation would be of considerable benefit.[6,7]

Preoxygenation before intubation has traditionally been used to increase the time from apnoea to desaturation, and a variety of methods have been described.[1] The efficacy of preoxygenation alone in extending safe apnoea time in ICU patients has been questioned.[8] However, its use is still considered the standard of care. Patients typically do not receive any other supplemental oxygen as attempts are made to intubate them in the ICU.

A potential method to extend the time from apnoea to critical desaturation is by "apnoeic oxygenation". This refers to the delivery of 100% oxygen to the airways and lungs without ventilation. The aim is to maintain oxygenation during the apnoeic period while airway manipulation is performed. Apnoeic oxygenation is not a new concept. It was first described in humans by Holmdahl in 1956, and has subsequently been used in several settings, principally in the operating room.[9-12] Intensivists will be familiar with its use to facilitate apnoea testing during the determination of brain death,[10] and its popularity is increasing in the emergency department (ED) for patients undergoing rapid-sequence induction.[1]

Physiologically, apnoeic oxygenation is based on the concept that during the apnoeic period, oxygen continues to be extracted from the functional residual capacity of the lungs into the pulmonary circulation at a rate of 250 mL/minute, to maintain metabolic oxygen requirements. However, because of the greater solubility of carbon dioxide in blood, it is only excreted into the alveoli at a rate of about 10 mL/minute. This results in a net gas flow from air to blood, and a volume loss of 240 mL/minute. Hence, subatmospheric conditions are established in the alveoli, providing a gradient for oxygen to be drawn from the proximal airways to allow continued oxygen uptake.[9]

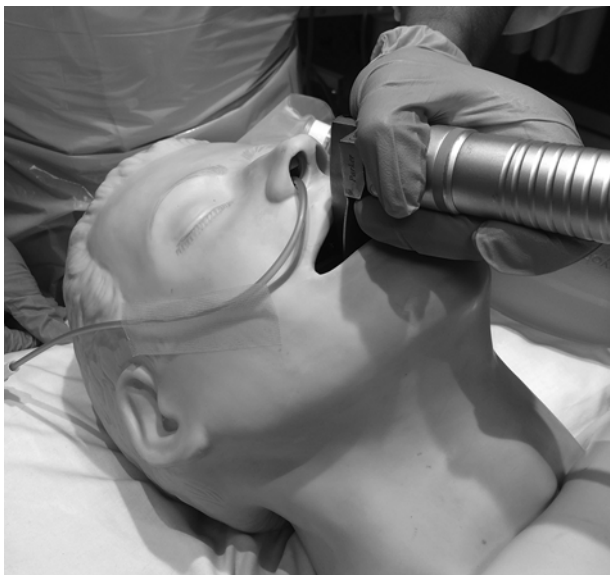
Clinical studies of apnoeic oxygenation, including randomised trials, indicate a potential benefit in elective operating room patients. Experimental studies have shown prolonged periods of maintained oxygenation of up to 55 minutes with the use of this technique.[13] Subsequently, Teller and colleagues found that the use of apnoeic oxygenation via a nasal catheter after conventional preoxygenation increased the time to desaturation from around 7 minutes to 10 minutes.[14] These results have been reproduced in healthy elective surgical patients with significant increases in the time to desaturation.[15,16] Similar results have been reported in studies of paediatric patients.[17,18] Christodoulou and colleagues recently performed a comparative study of different oxygen flow rates of 2 L/minute, 5 L/minute and 10 L/minute via nasal cannulae. The results of this study indicated that higher flow rates were associated with significantly improved oxygenation.[19]

Similarly, patients who are considered at increased risk of rapid desaturation during airway management have benefited from the use of apnoeic oxygenation in trials.[4] Baraka and colleagues studied patients with morbid obesity who were undergoing elective bariatric surgery and found that the use of apnoeic oxygenation extended the period of safe apnoea from 2.5 minutes to over 4 minutes.[20] A subsequent trial by Ramachandran and colleagues in a similar group of patients during a simulated difficult intubation scenario found that the use of apnoeic oxygenation via nasal cannulae led to a longer average time to desaturation from 3.5 to 5.3 minutes, and a significantly higher minimum arterial oxygen saturation from 88% to 94%.[21]

On the basis of these studies, the technique has been suggested as a method to prolong safe intubation times during rapid-sequence induction in the operating room.[13-21] Importantly, however, these studies were performed in patients who would be considered at low risk for desaturation; they were well oxygenated before induction, with normal cardiorespiratory status, adequate haemoglobin concentration and normal resting metabolic requirements.

Figure 1. Nasal insufflation continues during laryngoscopy and intubation

Figure 2. Oxygen insufflation via a nasopharyngeal catheter is an alternative to nasal prongs



This significantly limits the generalisability of these studies to critically ill patients with severe cardiorespiratory disease, in whom these conditions would clearly not be met. Large shunt fractions resulting from critical illness would conceivably limit the effect of any additional oxygen delivered, and the efficacy of the technique in the presence of severe upper airway obstruction is unknown.

To our knowledge, there are currently no completed clinical trials of apnoeic oxygenation in critically ill human patients. Evidence from an animal study performed by Engström and colleagues indicates potential clinical use in patients with hypoxic respiratory failure. The use of apnoeic oxygenation via a pharyngeal catheter prolonged the time to life-threatening hypoxia (defined as < 60%) from around 2 minutes to more than 10 minutes when the estimated shunt fraction was less than 25%. However, with a shunt fraction of more than 40%, the benefit was reduced to only 10 additional seconds. The authors concluded that the technique might be useful when intubating critically ill patients with acute respiratory failure.[22] A subsequent commentary by Rappolo supports this concept and suggests that pharyngeal oxygenation should be considered during emergency intubation in the ICU.[23]

Levitan and Weingart have described a simple technique of apnoeic oxygenation during rapid-sequence induction in the ED, termed the "NO DESAT" method.[1] This involves the placement of nasal prongs before induction. The prongs are not initially connected to the oxygen flow. Preoxygenation is then performed in a conventional manner (ie, use of a bag mask valve, non-invasive ventilation or a non-rebreather mask). On induction, with the onset of apnoea, oxygen is provided via nasal prongs at 15 L/minute and the face mask is then removed. Intubation is subsequently performed while nasal insufflation continues (Figure 1). This method purports to provide close to 100% inspired oxygen to the oropharynx.[10] French nasopharyngeal catheters can be used as an alternative to nasal prongs (Figure 2).

Given the heterogeneity of oxygen delivery routes in clinical studies (with the use of nasal cannulae or nasopharyngeal catheters both being described) and the lack of direct comparison of efficacy, the ideal method of oxygen delivery for apnoeic oxygenation is not known. Difficulties may be encountered with insertion of nasopharyngeal catheters. Insertion may be uncomfortable in patients who are awake and their use may be contraindicated in some situations (eg, fractures of the base of skull). The correct depth of insertion of the nasopharyngeal catheter is also important. This is described as equal to the distance between the nares and the tragus of the ear.[24] An excessive depth of insertion may render the technique ineffective due to oesophageal placement of the catheter. Nasopharyngeal catheters also carry the risk of epistaxis.[24]

The potential risks of apnoeic oxygenation are minor. During apnoeic oxygenation, there will be no significant carbon dioxide clearance. The technique may theoretically also promote absorption atelectasis. Practical concerns are that the use of nasal cannulae may be cumbersome and may interfere with the bag valve mask seal. The high flow

rates via the nasal cannulae may also be uncomfortable for the patient. Finally, during the technique, two separate oxygen supplies are needed.

Apnoeic oxygenation is simple to employ, with minimal risk. It is currently being recommended and used with increasing frequency in patients undergoing intubation in the ED. Despite its physiological plausibility and evidence of efficacy in patients without critical illness, further clinical studies are required before it can be recommended for use in critically ill patients in the ICU.

Competing interests

None declared.

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