

EDITORIAL

Pre-oxygenation for rapid sequence induction: Is high-flow nasal oxygenation worth the hassle?

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High-flow nasal oxygen therapy (HFNO) is used to deliver humidified and heated mixed air/oxygen at a flow rate of up to $70 \text{ l}\cdot\text{min}^{-1}$, the aim being to deliver a respiratory gas flow volume sufficient to meet or exceed the patient's inspiratory flow rate. The acronym THRIVE (trans-nasal humidified rapid insufflation ventilatory exchange) is also commonly used when HFNO is used in apnoeic patients. The high flow rates associated with this technique are tolerated in awake patients because the oxygen administered is warmed and humidified, making it comfortable to use and particularly beneficial in spontaneously breathing patients who have an increased work of breathing, typically up to $40 \text{ l}\cdot\text{min}^{-1}$. In unconscious patients, even higher flow rates of $70 \text{ l}\cdot\text{min}^{-1}$ may be used. Since the introduction of HFNO, there has been a lot of interest in its application in airway management and there have been calls for it to be incorporated into the Difficult Airway Society (DAS) [1] and Obstetric Anaesthetists Association (OAA) guidelines [2]. DAS have suggested that HFNO may have a role in difficult airway management [2], but does not elaborate, and the OAA guidelines for oxygenation during apnoea and airway instrumentation mention HFNO, but state there is currently no data in pregnant patients [3]. However, since these guidelines were published in 2015, the role of HFNO in these situations may become clearer with the next update. Recent guidelines published for the management of tracheal intubation in critically ill patients recommend using HFNO during and between tracheal intubation attempts [4]. Other reported uses include: apnoeic oxygenation in upper airway surgery [5]; oxygenation for airway procedures such as awake fiberoptic intubation [6]; bronchoscopy; and endobronchial ultrasound [7]. Intensive care applications include the treatment of hypoxaemic acute respiratory failure in patients who do not respond to conventional

oxygen therapy and to prevent post-extubation respiratory failure and tracheal re-intubation [8].

HFNO has been shown to maintain arterial oxygenation for 30 minutes of apnoea during laryngeal surgery [5,9]. In some cases, 60 minutes of apnoea [5] was tolerated, with some carbon dioxide clearance occurring by the interaction between supraglottic flow vortices generated by the high nasal flow and cardio-pneumatic movements [10]. Unlike oxygen delivered via a face mask, it can continue to be given during oral surgery and airway instrumentation, and there is little doubt that there are many situations where HFNO has value.

Rapid sequence induction is a high-risk procedure for the development of hypoxaemia [11] and is usually conducted as an emergency in patients who are already ill, may have impaired oxygenation and tolerate desaturation poorly. It is often performed by junior anaesthetists and in "out-of-hours" or unfamiliar settings. In this edition of the journal a group from Stockholm and Switzerland investigated whether pre-oxygenation with HFNO prior to and during rapid sequence induction is superior to use of a tight facemask (which is the conventional method of denitrogenation) [12]. Although this question has been addressed before, this study differs from those in that it is relatively large, randomised, multi-centre and included activity outside of normal working hours [3,13].

Theoretically, the ability to continue to administer oxygen during airway management has advantages if the airway is clear and there is a conduit for pulmonary oxygen delivery. A study using Optiflow™ (Fisher and Paykel Healthcare, Auckland, New Zealand) for pre-oxygenation in healthy volunteers showed that, although it was effective in increasing end-tidal oxygen ($E_T O_2$), the extent of denitrogenation was too variable for it to be a reliable

alternative to a facemask [14]. Two studies using this device for oxygen and rapid sequence induction have been previously published in this journal. Mir et al. compared a facemask with THRIVE for pre-oxygenation and found no difference in the partial pressure of oxygen (PaO_2), carbon dioxide (PaCO_2), or pH in arterial blood; however, patients managed using THRIVE had longer apnoea and tracheal intubation times [15]. Lodenius et al. compared THRIVE to facemask pre-oxygenation for RSI in a randomised trial. There were no desaturations in patients managed with THRIVE but 12% of patients pre-oxygenated with a facemask desaturated. There were no differences in the apnoea or tracheal intubation times [13].

However, is HFNO a solution for prolonging safe apnoea time during difficult airway management? Sjoblom et al. [12] showed an increase in time to tracheal intubation in the HFNO group. The reasons given include an assumption that knowledge that safe apnoea time might be increased may have led to more care and attention during tracheal intubation. As one of the aims of rapid sequence induction is to promptly secure the airway in order to protect it from regurgitation in an unconscious patient, this does not seem rational. Since the oxygen is given nasally and the apparatus is not cumbersome or likely to interfere with instrumentation, it is probably not a mechanical issue. Another fear is that some of the oxygen may enter the stomach under pressure due to high flows or if the patient swallows during the pre-oxygenation phase. Although this is assuaged to some extent in this study as only one patient out of the 174 had signs of regurgitation, gastric insufflation was not formerly investigated and could still have occurred without regurgitation. A study of healthy volunteers found that HFNO rates of up to $70 \text{ l}\cdot\text{min}^{-1}$ did not result in gastric distension or an increase in gastric contents when viewed with

ultrasound. However, whether these data can be extrapolated to paralysed patients under anaesthesia or those with a potential full stomach, remains uncertain [16].

Another potential weakness of the study is the calculation of the sample size. The authors based this on an assumption of 10% desaturation in the facemask group from a previous similar study showing a 12.5% desaturation rate to $< 93\%$ SpO₂ [13]. This rate appears to be remarkably high, considering obese, pregnant and patients with a low SpO₂ were already excluded. One large study of hypoxaemia after induction of anaesthesia in 2398 patients, quoted a desaturation rate of 6.6% to a SpO₂ $< 95\%$ and 1.4% to $< 90\%$ in the facemask cohort [11].

One group of patients who are at particularly high risk of desaturation and poor outcome during rapid sequence induction are the critically ill [4]. These patients are often already hypoxic with other organ dysfunction. An unblinded, randomised study of patients on intensive care with hypoxic respiratory failure who required tracheal intubation showed no statistical difference between the lowest oxygen saturation and desaturation below 80% between those pre-oxygenated with a facemask or HFNO [17]

Obese patients desaturate faster[18] and have a higher risk of an adverse airway events compared to those with a normal BMI [19]. A study by Wong et al. in patients who were morbidly obese showed that safe apnoea times could be extended by 40% by using HFNO for pre-oxygenation in patients with a BMI > 40 compared to conventional facemask pre-oxygenation [20]. However, this study excluded those with a known difficult airway and those subsequently found to be Cormack and Lehane grade 3 or 4 at laryngoscopy. Patients such as these who are obese and have a potentially difficult airway are surely the ones who are at highest risk of desaturation and who would potentially benefit the most from any

potential increase in apnoea time. Oxygen reserve index, derived from multi-wavelength pulse oximetry, is an interesting technology that may have some utility in rapid sequence induction, particularly in the critically ill, where it can increase the warning time of desaturation by around 48 s [21].

Women who are pregnant are also at increased risk of having a difficult airway [22]. Two studies of pre-oxygenation [23,24] compared the use of standard high-flow facemask and HFNO in healthy parturients; HFNO was less reliable at achieving an $E_T O_2$ concentration of > 90% [23], with the authors of one study suggesting that HFNO was inadequate for pre-oxygenation in term pregnant women and that further studies are needed to justify its use [24]. Unfortunately, both this study and others of HFNO have excluded these patients, so it is still unclear as to whether this group will potentially benefit from HFNO.

Other authors have voiced concerns that HFNO may lead anaesthetists to use this technique and embark on general anaesthesia for high-risk patients with potential difficult airways when another procedure may be more appropriate or safer, for example, awake tracheal intubation [25]. They raise an important point that this technique relies on airway patency which may be difficult to determine and maintain in a critical airway situation. Similar concerns have been raised regarding inappropriate persistence with HFNO for patients in intensive care units, when early tracheal intubation may have been more appropriate [26].

Facemask ventilation is a step in the DAS failed tracheal intubation algorithm. A study of neurosurgical patients compared HFNO with facemask for preoxygenation followed by manual ventilation for the facemask group between intubation attempts [27]. Arterial oxygenation was higher in manual ventilation group. In addition, the presence of CO_2 on the capnogram is reassuring that the airway is patent, whereas it is difficult to determine

patency during apnoeic oxygenation with HFNO. The concern is that this may lead to persisting with HFNO when manual ventilation may be more appropriate.

Several studies have shown that the use of continuous positive airways pressure (CPAP) or positive end-expiratory pressure (PEEP) with 100% oxygen during pre-oxygenation with a conventional facemask can increase non-hypoxaemic apnoea time [28,29]. Since one of the proposed mechanisms of HFNO is provision of low levels of positive airway pressure [30,31], why not just pre-oxygenate with a normal facemask and provide positive airway pressure using the anaesthetic circuit? This technique is familiar to most anaesthetists, can be used to provide manual ventilation if required and is cheaper.

Considering the results of this latest study and others, HFNO can be used as a means of pre-oxygenation prior to rapid sequence induction and seems to be safe, assuming airway patency. It has advantages in that it is well tolerated, non-invasive and not harmful.

However, it is more expensive, time consuming, technically more difficult to prepare and does not appear to have any major benefit in terms of apnoea desaturation time over facemask pre-oxygenation in low risk patients. The question of whether it will prolong safe apnoea times in obese, pregnant and other high risk patients remains unresolved.

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