Preoxygenation in Critically Ill Patients Requiring Intubation: Difficult Questions, No Easy Answers

Airway management in critically ill patients remains a fundamental but challenging procedure, characterized by a high rate of complications. Studies have shown that as many as 40% of intubations in critical care settings are accompanied by severe adverse events,^{1,2} the most frequent complication being hypoxemia. A prospective study from critical care units in Scotland reported that severe hypoxemia ($S_{pO_2} < 80\%$) during endotracheal intubation occurred in 22% of subjects, despite the procedure being carried out by highly skilled teams.³ Patient factors, expertise of the intubating clinician, choice and dose of induction and neuromuscular blocking drugs, and pre-induction management all contribute to safety and outcome.³ In the operating room, one crucial step to minimize desaturation during intubation is preoxygenation by administering high oxygen concentration via face mask. Unfortunately, preoxygenation of critically ill patients is less effective.^{4,5}

Different techniques for preoxygenation have been investigated in the intensive care setting. Tightly fitting bag-valve-mask proved to be only marginally effective.^{4,6} Noninvasive ventilation delivered via face mask for a 3-min period pre-intubation appears to aid in reducing arterial oxyhemoglobin desaturation during the procedure,⁷ although no large randomized trials have confirmed these findings. A limitation of this technique is that its use must be interrupted during laryngoscopy, reducing the benefits, and this may account for its frequent failure to prevent desaturation. In recent years, high-flow nasal cannula (HFNC) has gained attention in critical care due to its capacity to generate positive airway pressure, using a small interface and heated and humidified air flow, providing greater comfort than traditional oxygen therapy.⁸ These features make it an attractive candidate for improving preoxygenation as well as maintaining apneic oxygenation

during intubation attempts in the critically ill. Miguel-Montanes et al⁹ compared non-rebreathing bag reservoir face mask with HFNC for preoxygenation before endotracheal intubation of intensive care subjects with mild to

SEE THE ORIGINAL STUDY ON PAGE 1160

moderate hypoxemia. Their single-center, before-after study showed that the HFNC group maintained higher S_{pO_2} during intubation and experienced a significantly lower prevalence of desaturation events ($< 80\%$) compared with the face mask group.⁹ Their findings were not confirmed by a multi-center randomized controlled trial, where Vourc'h et al¹⁰ compared HFNC with high-flow facial bag-valve-mask for preoxygenation (and apneic oxygenation) in severe hypoxemic subjects and found no difference in the median lowest saturation throughout the intubation procedure.

In the current issue of *RESPIRATORY CARE*, Simon et al¹¹ studied 40 average-sized adult subjects (mean body mass index 25 and 27) with relatively mild hypoxemic respiratory failure, lacking features predictive of a difficult intubation, randomized to receive preoxygenation by HFNC at 50 L/min or by bag-valve-mask. Following a rapid sequence protocol, intubation was quickly accomplished in all subjects by direct laryngoscopy, performed by critical care specialists, 1 min after administering rocuronium. During apnea, oxygenation was by HFNC or application of a face mask without positive pressure. They assessed oxygenation before and 1 min after rocuronium as well as immediately before and at intervals following the institution of positive pressure ventilation. After 1 min of apnea, but before intubation, there was a significant decrease in the S_{pO_2} in the bag-valve-mask but not in the HFNC group. Five subjects in each group experienced oxygen desaturation $< 80\%$, resulting in abandonment of apnea and conversion to emergency intubation in 2 subjects in each group. However, there was no significant difference between the 2 groups in the primary outcome: the lowest oxygen saturation between induction and recovery following positive pressure ventilation. Not reported, but important, laryngoscopy was initiated at 1 min following rocuronium administration, and intubation was successful on the first

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attempt in every subject (personal communication, 2016, Marcel Simon MD, University Medical Center Hamburg-Eppendorf, Hamburg, Germany).

Their findings are consistent with those from Vourc'h et al.¹⁰ As the authors point out, one of the potential reasons for the difference between these 2 trials and the before-after study by Miguel-Montanes et al⁹ could reside in part in the fact that subjects previously receiving noninvasive ventilation or HFNC were not included in the latter, whereas 28% of subjects in the Simon et al study¹¹ and 27% of those in the Vourc'h et al study¹⁰ had been receiving noninvasive ventilation. Differences in severity of hypoxemia as well as indication for intubation might have also played a role.

Another trial evaluated the effect of supplemental oxygenation by HFNC during laryngoscopy (vs no oxygenation) in 150 critically ill subjects and reported no difference in the median lowest arterial oxygen saturation, incidence of oxygen desaturation <90 or <80%, or decrease in oxygen saturation >3% from baseline. Of note, in this study by Semler et al,¹² the oxygen flow via HFNC was limited to 15 L/min, much lower than what was used in the trial from Simon et al,¹¹ who set the HFNC at 50 L/min.

There are several details that may account for the apparently limited benefit from HFNC preoxygenation. Simon et al¹¹ excluded patients likely to be difficult to intubate, and thus the apneic period was brief. In the practice of critical care, we lack such a luxury. Frequently, intubation efforts are prolonged or repeated, placing hypoxemic patients at greater risk.¹³ If confirmed in such scenarios, the observation of a significant decrease in the S_{pO_2} during the apnea phase before intubation in the bag-valve-mask but not in the HFNC group could indeed be of great relevance. Simon et al¹¹ make no mention of whether a jaw thrust, mouth closure, or head-of-bed elevation positioning were employed, all of which may enhance the value of HFNC.¹⁴

Despite its attractive features, the role of HFNC in this setting has yet to be clearly established. To the extent that apnea may be prolonged and associated with a greater risk of hypoxemia, a preoxygenation (or continuous oxygenation) strategy associated with low risk and improved outcomes is clearly desirable. It remains to be determined whether patients at such risk can be reliably predicted and whether HFNC or noninvasive ventilation can provide protection against oxygen desaturation. Further data with high-risk representative patients optimizing the use of the techniques are warranted.

In the meantime, clinicians will continue to vigilantly approach intubation of the critically ill to minimize hypoxemia-related complications, ensuring adequate expertise and/or expert supervision, using optimal techniques (eg, videolaryngoscopy as a primary plan),¹⁵ emphasizing

first-attempt success,¹⁶ and carefully considering the specific merits of sedation and muscle relaxation versus topical anesthesia and maintenance of spontaneous breathing.¹⁷ The journey toward making this high-risk procedure safer continues.

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