Guest Editorial

Optimising oxygenation prior to and during tracheal intubation in critically ill patients

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Tracheal intubation (TI) is a common procedure frequently performed in critically ill patients and is an integral part of emergency airway management (EAM). However, it carries inherent risks and can significantly impact patient outcomes. An international observational study evaluating TI practices in critically ill adults reported adverse peri-intubation events in 45% of the patients, with severe hypoxia reported in about 10% of the patients.[1] Similarly, a prospective observational study of TI in critically ill adults in Spanish intensive care units (ICUs) reported a peri-intubation complication rate of 40%, and severe hypoxaemia was observed in 20% of the patients.[2] Critically ill adults requiring EAM often have a physiologically difficult airway (PDA), wherein their physiologic perturbations predispose them to complications during TI and/or the initiation of positive pressure ventilation.[3] These patients are at high risk for rapid desaturation because of reduced functional residual capacity (FRC), ventilation-perfusion (V/Q) mismatch, and shunt—all of which can acutely worsen on induction. Acute hypoxaemic respiratory failure is one of the clinical conditions associated with a PDA and is a common reason for TI in critically ill patients.[4] Patients with acute hypoxaemic respiratory failure have both reduced physiologic reserve and diminished sensitivity to increases in the fraction of inspired oxygen (FiO_2), typically owing to significant V/Q mismatch and/or marked intrapulmonary shunt (e.g. acute respiratory distress syndrome).

Optimising oxygenation before TI is important to prevent severe hypoxaemia peri-intubation and safely extend the interval before the onset of arterial haemoglobin desaturation during apnoea (i.e. the apnoeic interval). A retrospective study from 64 different ICUs demonstrated that lack of pre-oxygenation was independently associated with peri-intubation cardiac arrest.[5] Figure 1 depicts the various time frames within the TI process where there may be an opportunity to enhance oxygenation. The period between the identified need for TI and administration of medications for TI can be used to provide pre-oxygenation, while the time between administration of medications and TI can be utilised to provide apnoeic oxygenation.

Pre-oxygenation, or denitrogenation of the FRC, increases the safe apnoeic interval and helps reduce the risk of hypoxaemia and intubation-related complications.[6] Several methods for pre-oxygenation are utilised in clinical practice. So-called conventional oxygen therapy (COT) entails delivering up to 100% FiO_2 through a non-rebreather mask, self-inflating resuscitator bag, and facemask. COT is less effective in critically ill adults with acute hypoxaemic respiratory failure owing to V/Q mismatch and/or

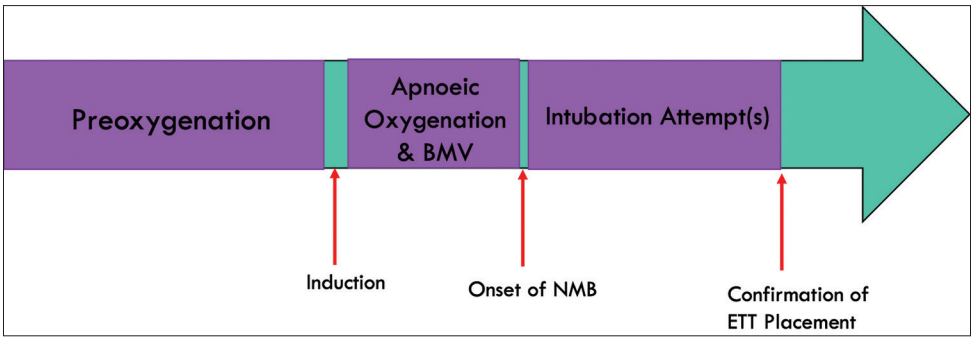

Figure 1: Opportunities to provide supplementary oxygen during the process of tracheal intubation. BMV = bag-mask ventilation; NMB = neuromuscular blockade; ETT = endotracheal tube

shunt physiology. In addition, in patients with high minute ventilation, COT may not be able to meet the flow requirements, thus increasing the entrainment of room air and impairing the impact of pre-oxygenation.

Non-invasive ventilation (NIV) and high-flow nasal oxygenation (HFNO) have been increasingly used in critically ill patients as pre-oxygenation techniques. These modalities can provide more precise control over FiO_2 and positive pressure, which can help combat shunt. A network meta-analysis comparing the various methods of pre-oxygenation in patients with acute hypoxaemic respiratory failure found that both NIV [odds ratio (OR): 0.43, 95% confidence interval (CI): 0.21, 0.87] and HFNO (OR: 0.49, 95% CI: 0.28, 0.88) resulted in a lower risk of intubation-related complications than COT.[7] Prior studies comparing pre-oxygenation using NIV versus COT have also found less oxygen desaturation with NIV.[8,9] While these trials suggest that pre-oxygenation with NIV or HFNO may be superior to COT in critically ill patients with hypoxaemic respiratory failure, these benefits may be less pronounced in patients without acute pulmonary pathology. In the PROTRACH study, pre-oxygenation with HFNO in the ICU compared to COT did not improve the lowest SpO_2 during TI in patients without severe hypoxaemia (ratio of arterial partial pressure in oxygen to fraction of inspired oxygen (PaO_2/FiO_2) above 200 within 4 h before inclusion).[10]

Both NIV and HFNO provide high gas flow to meet metabolic demands and some level of positive pressure. While NIV with a conventional facemask interface must be removed to facilitate TI, HFNO can be maintained during the procedure. The FLORALI 2 study[11] compared NIV or HFNO for pre-oxygenation in hypoxaemic, critical adults undergoing TI and observed no difference in the incidence of severe hypoxaemia during TI. However, the sub-group analysis suggested a potential benefit for NIV among patients with an arterial partial pressure of oxygen (PaO_2) to FiO_2 ratio (P/F ratio) of <200. In many circumstances, there may not be enough time to achieve optimal pre-oxygenation, and some patients may not respond appropriately to pre-oxygenation.[12] Nonetheless, it is important to initiate appropriate oxygen therapy as soon as possible while preparations for TI are underway to maximise pre-oxygenation duration.

To prevent peri-intubation hypoxaemia, two methods of delivering oxygen between administration of drugs for TI and laryngoscopy have been proposed: bag-mask ventilation (BMV) and supplemental oxygen delivered by nasal cannula without ventilation (apnoeic oxygenation). Oxygen delivery via the nasal route offers a unique advantage in preserving access to the airway during TI. Apnoeic oxygenation via nasal cannula can be provided using unwarmed, dry oxygen (standard nasal cannula) or via heated and humidified HFNO. Both BMV and apnoeic oxygenation effectively reduce the risk of peri-intubation hypoxaemia. In a recent meta-analysis, it was observed that apnoeic oxygenation reduced the relative risk of hypoxaemia by 30% (95% CI: 0.59, 0.82), and there was a trend towards lower mortality in patients who received apnoeic oxygenation (relative risk of death: 0.77; 95% CI: 0.59, 1.02).[13] Similarly, in a multi-centre, randomised controlled trial (RCT) conducted, critically ill adults undergoing TI that received BMV had higher oxygen saturations (96% vs. 93%, $P = 0.01$) and a lower incidence of severe hypoxaemia than those receiving no ventilation (relative risk: 0.48; 95% CI: 0.30, 0.77).[14] Operator-reported aspiration events and the incidence of new opacity on chest radiography 48 hours after TI did not differ between the two groups. The study, however, was not powered to detect such differences. When comparing both these techniques, a secondary

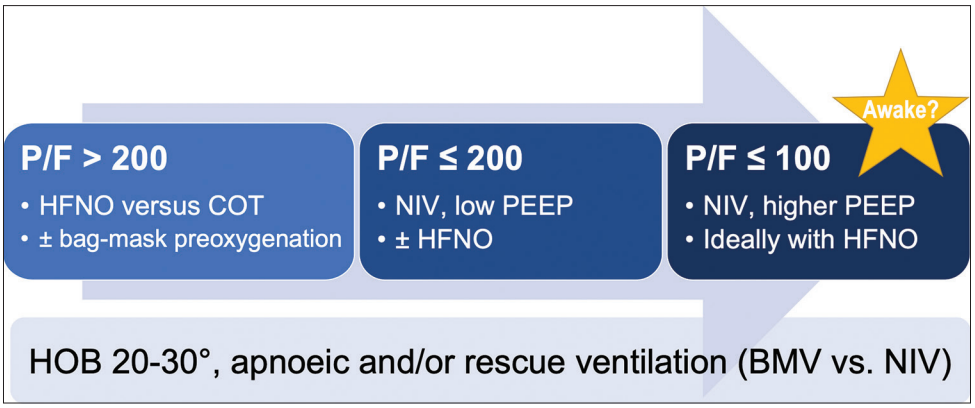

Figure 2: Adaptive pre-oxygenation approach for critically ill adults with acute hypoxaemic respiratory failure requiring tracheal intubation. P/F = arterial partial pressure of oxygen to fraction of inspired oxygen ratio; HFNO = high-flow nasal oxygen; COT = conventional oxygen therapy; NIV = non-invasive ventilation; PEEP = positive end-expiratory pressure; HOB = head of bed; BMV = bag-mask ventilation. Adapted from[16,17]

analysis of data from 138 patients enroled in two consecutive RCTs of airway management in critically ill patients suggested that BMV may be associated with higher oxygen saturation during intubation compared to apnoeic oxygenation (mean difference: 4.2%; 95% CI: 0.7%, 7.8%; $P = 0.02$). Although further studies are needed before recommending one technique over the other, the choice is often based on available resources and patient characteristics. In patients with a low risk of aspiration, BMV might be a better alternative than apnoeic oxygenation with HFNO.

A combination of NIV and HFNO has also been suggested to prevent peri-intubation oxygen desaturation, and the OPTINIV trial, a proof-of-concept study, showed that adding HFNO for apnoeic oxygenation to NIV for pre-oxygenation was more effective in reducing the severity of desaturation compared to NIV alone during TI in critically ill adults.[15] As previously suggested, we advocate for an adaptive approach to pre-oxygenation[16,17] stratified by the severity of respiratory failure, as outlined in Figure 2. In cases of vomiting and in patients with a high risk of aspiration, the risks of positive pressure ventilation may outweigh the benefits, and the decision to use NIV or mask ventilation should be evaluated on a case-by-case basis. Delayed sequence intubation (DSI) using a dissociative dose of ketamine to facilitate pre-oxygenation may be used in patients who are difficult to pre-oxygenate due to compromised mental status. A recent RCT observed that DSI significantly decreases peri-intubation hypoxia compared to standard RSI.[18] There might be situations where peri-intubation hypoxaemia may be refractory to the HFNO and PEEP application. Accepting a lower oxygen saturation while expeditiously performing TI may be the only option in these situations.

Optimising oxygenation before and during TI in critically ill patients is vital to prevent severe complications such as hypoxaemia and cardiovascular collapse. Current evidence suggests that while COT, NIV, and HFNO all offer options for pre-oxygenation, HFNO and NIV should be considered in patients with acute hypoxaemic respiratory failure. In patients with moderate to severe hypoxaemia, NIV may be superior to HFNO. Apnoeic oxygenation with HFNO should be continued during attempts at TI, and gentle BMV may be considered during the apnoeic period to prevent or treat hypoxaemia in patients where the benefits of BMV outweigh the risks.

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