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Better preparation for intubation

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To the Editor—We read with interest the article by Cheng et al[1] who reported a child with peritonsillar abscess and impending airway obstruction who underwent two failed attempts at intubation with consequent rapid desaturation down to an oxygen saturation (SpO_2) level of 50% to 60%, requiring insertion of a laryngeal mask to maintain ventilation before successful intubation. In the same issue, a standard protocol for intubation was suggested by Leung et al.[2] They describe the rescue plan for intubation, alluding to the need for pre-oxygenation for 3 to 5 minutes prior to rapid sequence induction. These articles highlight the need to increase the arterial oxygen reserve to avoid rapid desaturation with all its dire consequences.

We would like to remind readers about a recent technological development that enables measurement and monitoring of the oxygen reserve index (ORI), the increase in arterial oxygen pressure (PaO_2) in real time. As shown by the oxygen dissociation curve, desaturation would be delayed if PaO_2 could be increased from 100 mmHg to say 200 mmHg.[3] Oxygen reserve index is a proprietary technology available using the Masimo pulse oximeter with a range from 0 to 1. When SpO_2 reaches 100%, any further increase is reflected in the ORI that will rise above 0. We suggest that attending doctors pre-oxygenate to an ORI well above 0 to achieve a greater oxygen reserve and prevent the rapid desaturation reported by Cheng et al.[1] We also suggest provision of pre-oxygenation via heated humidified high-flow (HHHF) oxygen with fraction of inspired oxygen (FiO_2) up to 1. Nonetheless, the other end of the spectrum to hypoxaemia is hyperoxia, less obviously harmful but still to be avoided with excessive oxygenation leading to atelectasis.[4,5] To prevent severe hyperoxia, ORI should be maintained at around 0.5. Monitoring the ORI and titrating FiO_2 such that the ORI is maintained above 0 may help prevent both a hypoxic state during intubation and hyperoxia. During intubation, ORI should also be continuously monitored along with SpO_2 since it can predict a decline in SpO_2.

Pre-oxygenation by HHHF followed by continuous HHHF during intubation is also beneficial, even in the presence of paralysis that occurs during rapid sequence induction. Continuous removal of oxygen by red blood cells flowing through the capillaries abutting the alveoli leads to a negative pressure that draws in air from the atmosphere only if the whole airway is patent. This phenomenon is called apnoea oxygenation.[6] Nonetheless classic apnoeic oxygenation in the absence of high flow provides little clearance of carbon dioxide and may lead to progressive respiratory acidosis. The impact of adding high flow on CO_2 clearance is controversial, with CO_2 rising at a much lower rate of 0.15 kPa/min in adults[6] compared with only classic apnoeic oxygenation and a reported rate of 0.45 kPa/min.[7] Nonetheless CO_2 clearance is reported to be lower in children at 0.32 kPa/min.[8] In a single case report, the end-tidal CO_2 was reported to be only 9.1 kPa at the end of apnoea of 46 minutes, much lower than the expected rise to >10 kPa in the absence of ventilation.[9] Fortunately, $PaCO_2$ up to 13.3 kPa is not reported to be associated with adverse outcome.[10] Continuing HHHF during intubation not only facilitates oxygenation, but it also potentially improves CO_2 clearance by flushing of the dead space, hence lowering the risk of CO_2 toxicity.[6] Since HHHF can be administered during intubation without obstructing the procedure, its use should be continued during the intubation process.

Leung et al[2] also mentioned cricoid pressure as an essential step in rapid sequence induction although recent evidence has cast doubt on its effectiveness in preventing aspiration and the potential distortion of anatomy making intubation more difficult.[11] We suggest that cricoid pressure be applied only if deemed essential by the attending team. It should not be performed routinely during rapid sequence induction.

In conclusion, administration of HHHF with enriched oxygen should be incorporated into the standard protocol for pre-oxygenation and used continuously during intubation. Oxygen reserve index should be continuously monitored to achieve mild hyperoxia to prevent rapid desaturation by a timely increase of FiO_2 or flow or chin lift/jaw thrust to establish upper airway patency. This index is also useful to avoid severe hyperoxia and consequent atelectasis.

Author contributions

All authors contributed to the drafting of the letter and critical revision for important intellectual content. All authors approved the final version for publication and take responsibility for its accuracy and integrity.

Conflicts of interest

The authors have no conflicts of interest to disclose.

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Authors' reply

We thank the authors for pointing out the importance of increasing arterial oxygen reserve to avoid rapid desaturation with all its dire consequences.[1] In this regard, we would like to address aspects related to intubation, oxygenation, ventilation and perfusion.

This is even more important in conditions such as status asthmaticus, raised intracranial pressure, and pulmonary hypertension. In these scenarios, rapid sequence intubation might be a misnomer. The patient should be allowed an adequate period of 3 to 5 minutes of pre-oxygenation to prevent desaturation during the intubation process.[2,3]

The oxygen reserve index is a great suggestion if oximeter with this function is available. In an emergency, ensuring oxygen saturation remains well above 90% may be the most we can achieve before attempting intubation with an endotracheal tube or laryngeal mask airway. During an emergency, most of us will probably rely on hearing the beeping and seeing the screen of the oxygen saturation monitor instead of carefully oxygenating until oxygen reserve index is above 0.5.

Understanding the oxygen saturation curve, the pressure-volume curve, and the pathophysiology of hypoxaemia and ventilation/perfusion mismatch is another fundamental mental process that care providers must continuously go through even during the critical moment of resuscitation, with atelectatic shunting and dead-space ventilation being problems at the two extremes of the pressure-volume curve. The concept of ventilation/perfusion mismatch leading to hypoxaemia is fundamental, with overdistention leading to dead-space ventilation as in critical asthma syndrome and collapse or atelectasis leading to shunting in collapse of a large segment of the lung (Fig).[4]

Issues with hypercapnia and hypocapnia are also important in cardiac and cerebral pathologies, and we agree with the authors' comments about CO_2 clearance. Continuous monitoring of arterial CO_2 partial pressure and end-tidal CO_2 prior to securing an airway in an emergency remains challenging and may be impossible.

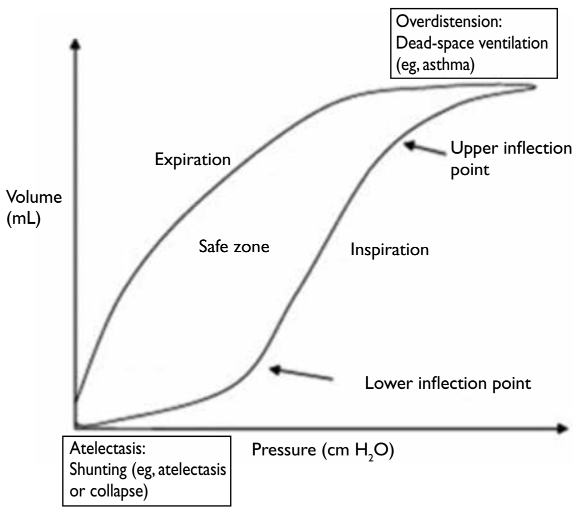

FIG. Concept of ventilation-perfusion mismatch resulting in hypoxaemia

Last, in emergency situations, the use of a laryngeal mask airway and the use of video laryngoscopes to improve glottic visualisation are all important routine methods to avoid hypoxaemia and ensure good oxygenation during emergency resuscitation.

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Acquisition of data: KL Hon, KKY Leung.
Analysis or interpretation of data: KL Hon, KKY Leung.
Drafting of the reply: KL Hon, KKY Leung.
Critical revision of the reply for important intellectual content: All authors.

All authors had full access to the data, contributed to the reply, approved the final version for publication, and take responsibility for its accuracy and integrity.

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