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GUEST EDITORIAL

Hypoxaemia during induction of general anaesthesia in pregnant women – a surrogate for overall airway difficulty?

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Obstetric general anaesthesia continues to present unique challenges as a result of factors that may include: anatomical and physiological changes of pregnancy; indications for surgery based on the wellbeing of the fetus; clinical urgency; and remote locations of obstetric operating rooms. It is clear that the incidence of failed intubation is greater in obstetric than non-obstetric practice, even if the definition of this outcome is surprisingly variable.[1] Difficult intubation is also defined variably[2] and potentially open to even more subjectivity. Is there an objective marker that can indicate a change in a woman's physical status resulting from a failure to speedily position a tracheal tube and commence lung ventilation? One answer, when we consider the usual sequence of general anaesthetic induction–muscle paralysis–apnoea, is that of hypoxaemia at induction measured by pulse oximetry. The manoeuvres that are taken to avoid this include: maximising oxygen stored in the lungs; rapidly-acting drugs to allow intubation as soon as possible after anaesthetic induction; and, in some cases, facemask ventilation of the lungs (see below). Although brief mild hypoxaemia is not harmful in itself, it is clear that this can progress to organ damage if it is severe and prolonged. Hypoxaemia ($SpO_2 \leq 95\%$) has been found to be associated with difficult intubation defined as multiple attempts at intubation.[3] Predictors of hypoxaemia ($SpO_2 < 90\%$) have been investigated[4] as well as the association of hypoxaemia with hypertensive disorders of pregnancy.[5]

This issue of SAJAA contains another analysis from the Cape Town Obstetric Airway Management Registry (ObAMR)[6] including 1 095 women having obstetric general anaesthesia.[7] The primary aim of the study was to identify pre-induction risk factors for hypoxaemia ($SpO_2 < 90\%$). This moves the focus on from the circular argument whereby markers of difficult intubation[3,5] or post-induction findings (grade of laryngoscopy[4]) are shown to be associated with hypoxaemia; what we need to know is whether we can identify women at risk of problems *before we put them at risk*.

We have to accept some intrinsic limitations to the database. The lowest saturation was recorded by the anaesthetist, rather than an electronic monitoring/recording system. The ObAMR possibly only captures 80% or so of eligible cases. These factors could lead to significant bias. However, the summary findings of the study do make sense in a mechanistic fashion: multivariable analysis shows that the factors associated with hypoxaemia are raised body mass index (BMI), decreased baseline oxygen saturation and airway oedema.

At this point, it should be noted that the findings may not be generalisable from the South African context to high-income countries. Two of the significant factors associated with maternal desaturation indicate maternal pathology. Airway oedema is likely to be rather a 'soft' sign but this, together with decreased baseline oxygen saturation, are likely to be associated with the 31% of women who had preeclampsia/eclampsia. Hypertensive disease of pregnancy has been found to be associated with desaturation at induction,[5] but this was not borne out in the present study in the multivariable analysis. It is impossible to explain desaturation at induction merely as a consequence of raised blood pressure; however, the more specific corollaries of hypertensive disease, airway swelling and $\dot{V}/\dot{Q}$ mismatch, may explain this association.

How about airway assessment – is this a waste of time?[8] One might argue that it is in the population under question, where maternal pathology is the main associate of airway problems; however the study would have to be repeated elsewhere where obstetric anaesthesia is more usually carried out on healthy women in order to give a more definitive verdict. The study did show statistical associations between Mallampati score 3 and 4, thyromental distance of less than 6.5 cm and limited mandibular protrusion with hypoxaemia, supporting the extensive literature showing there is some predictive value from bedside airway assessment. On the other hand, a Cochrane review concluded that bedside screening tests fail to detect a large proportion of difficult airways.[9] Additionally, airway assessment for many cases requiring obstetric general anaesthesia is often hindered by urgency and multiple distractions; in one large observational study this was not done in 40% of cases.[10] There also needs to be an understanding that a difficult airway occurs as a result of a complex situational interplay of patient factors, practitioner, equipment, expertise and circumstances[2] and unfortunately, these are not easy to quantify and document.

Burger et al. conclude by suggesting that further research might indicate whether different management options could

reduce hypoxaemia at induction.[7] They describe a standardised protocol of pre-oxygenation to an end-tidal oxygen fraction of 0.8, rapid sequence induction and tracheal intubation with application of cricoid pressure. The Obstetric Anaesthetists Association and Difficult Airway Society (OAA/DAS) obstetric difficult airway guidelines were published seven years ago,[11] yet various recommended strategies are not routinely applied in clinical practice.[12,13] Manoeuvres that might reduce desaturation include: head-up positioning (increase oxygen stores), nasal oxygenation and gentle mask ventilation (replace oxygen stores), videolaryngoscopy and reducing/releasing cricoid pressure in the event of difficult laryngoscopy (facilitate intubation). It is incumbent on anaesthetists to reduce the risk of hypoxaemia during induction of general anaesthesia and therefore such strategies should now be routine practice in all general anaesthetics or, as a minimum, in women identified to be at risk of potential airway problems.

Peri-intubation oxygenation techniques, in particular apnoeic oxygenation, are now well established.[14,15] Low-flow (LFNO) or high-flow nasal oxygenation (HFNO) techniques have been shown to prolong safe apnoea periods in non-obstetric patients during induction of general anaesthesia.[16-18] Because of ethical concerns, the majority of evidence for HFNO and LFNO in pregnant women comes from computational simulated physiological modelling studies rather than clinical studies.[19-21] One small, randomised, clinical study demonstrated the superiority of peri-intubation HFNO compared with facemask pre-oxygenation in pregnant women during rapid-sequence induction.[22] These studies have established the benefits of both HFNO and LFNO in prolonging safe apnoea period in pregnant women, although the benefits are less consistent as the BMI increases.[20,21] It is not clear why apnoeic oxygenation techniques are less consistent in patients with high BMI, but strategies such as head-up positioning, maintaining a patent airway and keeping the mouth closed may impact on the efficacy of the technique.[23] Mask ventilation while using HFNO is normally avoided because of the risk of barotrauma. However, a recent design modification of the HFNO Optiflow© system allows seamless switching from HFNO to mask ventilation, enabling HFNO to be used interchangeably with rescue mask ventilation without interrupting oxygen delivery.[24] Mouth closure when using HFNO for pre-oxygenation helps to achieve the target end-tidal oxygen levels of 90%, but studies have shown that only 38% of pregnant women are able to keep their mouth closed while using HFNO.[25,26]

A failed intubation rate of 1 in 274 in the current study is in keeping with previously published data.[1] The OAA/DAS guidelines recommend limiting the number of intubation attempts to three or less and early use of a second-generation supraglottic airway device in order to minimise hypoxaemia and airway trauma.[11] In the current study, the incidence of hypoxaemia was 9.7% after the first intubation attempt compared with 46% and 60% after the second and third attempts. It is imperative to remember that prevention of maternal hypoxaemia after failed intubation benefits not only the woman but also reduces adverse effects on the fetus.[27]

Airway-related studies and publications have a tendency to emphasise and focus on airway management during intubation yet often fail to address airway complications at extubation, and this study is no exception. Assessment of the airway should include prediction and planning for a potential difficult extubation in order to reduce adverse events such as hypoxaemia at extubation. The three factors found in this study to be associated with higher risk of hypoxaemia at induction, high BMI, airway oedema and preoperative hypoxaemia, are likely to link with difficult airway management during extubation as well.

Obstetric airway management registries such as the ObAMR have the potential to generate national or international collaboration. Sharing of common pitfalls, and highlighting unique differences, can help to foster targeted teaching and training programmes to guide clinical practice. However, to achieve this, all registries would need to record salient management factors, minimise bias with data collection, and have clear, objective and measurable endpoints. Clinical endpoints, 'a characteristic or variable that reflects how a patient feels, functions or survives', may be the most important for general medical research,[28] but in anaesthesia we aim to leave the patient at the end of the intervention as well as they were at the beginning – therefore without a clinical endpoint following any perioperative difficulties in anaesthetic management. A surrogate endpoint is a 'biomarker intended to substitute for a clinical endpoint', and a biomarker is 'a characteristic that is objectively measured and evaluated as an indication of normal biological processes, pathogenic processes, or pharmacological responses to a therapeutic intervention'.[28] In this case oxygen saturation fulfils the criteria of a 'clear, objective and measureable' biomarker. However for comparability we require standardisation, especially as to the severity of hypoxaemia ($SpO_2 \leq 95\%$ [3] or $SpO_2 < 90\%$ [4,5,7]). Further validation is required before we can adopt hypoxaemia as an equivalent or superior endpoint than airway difficulty.[29]

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