Editorial

Preoxygenation in pregnant women—is it time to update the 2015 OAA/DAS guidance in light of the expanding evidence base for high flow nasal oxygen?

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Introduction

Pregnant women often require surgery within minutes of the decision to operate due to life threatening fetal and maternal conditions. However, following induction of general anaesthesia pregnant women have a high rate of desaturation (1 in 50 SpO_2 <85%), difficult intubation (1 in 30) and pulmonary aspiration (1 in 1,000) (1-3). Rapid effective preoxygenation is needed to minimise these complications.

In 2015, the Obstetric Anaesthetists' Association (OAA) and Difficult Airway Society produced helpful guidance on managing the obstetric airway (4). Since this time multiple studies have investigated the use of high flow nasal oxygen in pregnant women, alongside an expanding evidence base for non-invasive ventilation (NIV) preoxygenation in non-pregnant patients. This article summarises the evidence for different methods of preoxygenating pregnant women and suggests the time may be nigh to update the 2015 guidance.

Facemask anaesthesia

Three minutes of tidal volume breathing 100% oxygen through a tightfitting facemask using a circle system at [6 litres per minute (L/min)], is the standard method for preoxygenation. However with the advent of real time end tidal oxygen (ETO_2) monitoring, we should target an ETO_2 ≥90% and not use 3 minutes as an endpoint (5). Interestingly recent studies have found that fewer pregnant women than expected may reach ETO_2 ≥90% with facemask preoxygenation—Au *et al.* found only 71% parturients reached ETO_2 ≥90% after 3 minutes (6).

In pregnant women, preoxygenating in a ramped or 30 degree head up position, will increase the functional residual capacity (FRC) and may delay time to desaturation (7). Preoxygenating using 10 L/min via facemask is superior to 5 L/min in pregnant patients, producing a mean ETO_2 of 92% (8). The quickest method of achieving preoxygenation in pregnant women, utilises 8 vital capacity breaths. This should take around 1 minute, and has recently been shown to be equivalent to 3 minutes preoxygenation via facemask (9). Using 100% oxygen for preoxygenation may result in absorption atelectasis after induction of anaesthesia. Therefore, Jung *et al.* investigated using a lower fraction of inspired oxygen (FiO_2) of 80%, finding no difference in patient desaturation rates *vs.* FiO_2 100% in a low risk population (10). This would not be appropriate in pregnant women due to their high risk of desaturation, instead other measures to prevent and reverse absorption atelectasis such

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as should be used instead such as positive end expiratory pressure (PEEP), recruitment manoeuvres and avoiding an FiO_2 of 100% when extubating (5).

High flow nasal oxygen

High flow nasal oxygen aims to delay the onset of desaturation after induction of anaesthesia by providing preoxygenation then apnoeic oxygenation. It has proven very effective at delaying hypoxaemia in non-obstetric populations, including in obese patients who have a different physiology to pregnant women, but who share a similar reduced FRC and high desaturation rate (11). However it is worth noting that the evidence in intensive care patients is mixed, with one study suggesting benefit in mildly hypoxaemic patients, but another showing no benefit over facemask preoxygenation in severely hypoxaemic patients (12,13).

Consideration of using a facemask and then apnoeic oxygenation via nasal cannula at a rate of 5 L/min was suggested in the OAA 2015 guidelines because of evidence in obese populations, but no research had been conducted at this time into high flow nasal oxygen (HFNO) in pregnant women (4).

Five studies have investigated preoxygenating pregnant women with HFNO without then inducing general anaesthesia (Tan 2019, Shippam 2019, Au 2020, Preston 2020, Al-Sulttan 2021) (6,9,14-16). All of these studies have been small, using a maximum of 80 participants. Flow rates used were between 45 to 70 L/minute, with all studies encouraging women to breathe with their mouth closed where possible. Initial studies used 3 minutes of preoxygenation and the latter three used a variable preoxygenation length to assess if this would increase ETO_2.

Overall these studies have found that when using HFNO preoxygenation pregnant women do not reliably achieve an ETO_2 ≥90% despite up to 8 minutes preoxygenation. In the three randomised controlled trials (RCTs), facemask preoxygenation achieved a higher ETO_2 than HFNO (6,9,16). After three minutes of HFNO preoxygenation Tan & Shippam *et al.* found that 60% and 47% patients respectively reached an ETO_2 ≥90%, with a median ETO_2 of 89% and range 70–95% (9,14). There may be benefit in extending the HFNO preoxygenation duration to 4 minutes, alongside applying a simple facemask to minimise air entrainment which allowed 80% of pregnant women to reach ETO_2 ≥90% (6). Whilst not significant, Al-Sulttan *et al.* found a trend towards HFNO being more effective when used with mouth closed rather than open (16).

Two RCTs have assessed HFNO apnoeic oxygenation in pregnant women undergoing elective caesarean section. Zhou *et al.* recently conducted an RCT with 34 pregnant women (17). When using HFNO preoxygenation and apnoeic oxygenation, the ETO_2 after intubation was significantly higher than facemask preoxygenation. No patient randomised to either intervention desaturated. In some ways this is reassuring, but it may reflect the fact that women with body mass index (BMI) >35 were excluded alongside patients with risks for difficult airways. Preoxygenation may also have been carried out more thoroughly than in emergency situations.

A larger study of 101 pregnant women led by Osman, found that HFNO extends the safe apnoea time in pregnant women (SpO_2 <90%) in comparison to facemask preoxygenation with 6 L/min nasal cannula *in situ*, from four to seven minutes (18). Of note this study included obese pregnant women, having an average BMI of 38 (range, 26–43). Unexpectedly the arterial partial pressure of oxygen (PaO_2) was higher using HFNO than facemask immediately after preoxygenation. This is surprising considering previous studies showing HFNO inferiority to facemask preoxygenation (6). A final modelling study has suggested that HFNO provides a longer safe apnoea time than facemask preoxygenation, even if HFNO preoxygenation only achieves an ETO_2 of 60% (19). However, the extension of apnoea time was reduced with increased BMI and there was minimal benefit in patients with a BMI >50. This study does rely on some assumptions which may affect the validity of the results—that a patent airway would be maintained during HFNO which cannot be guaranteed leading to a possible overestimate of safe apnoea time. Additionally, they modelled that after facemask preoxygenation, air would be administered to the glottis, which would only be the case during intubation. This could falsely shorten the predicted apnoea time for facemask preoxygenation.

The two RCTs of elective caesarean section under general anaesthesia suggest that HFNO provides safe hands free preoxygenation and apnoeic oxygenation that may be more effective than facemask at preventing hypoxaemia in pregnant women. Whilst HFNO may provide benefit, there are also potential difficulties in its use. It requires time to set up in an emergency so could delay anaesthesia, unless clear protocols are in place. In addition, if patients desaturate with HFNO, facemask ventilation will be delayed by the need to remove to HFNO to create a seal and avoid barotrauma.

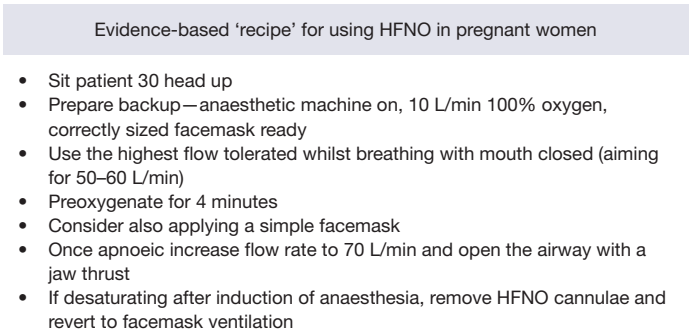

Figure 1 An evidence-based 'recipe' on using HFNO in pregnant women. HFNO, high flow nasal oxygen.

NIV

The use of NIV to preoxygenate pregnant women has not yet been studied, but extrapolation from obese and ICU patients may provide useful insights. NIV is superior to facemask preoxygenation in both obese and hypoxic intensive care patients, but increases the risk of gastric distension and patient discomfort (20,21). However a small study in non-obstetric patients found no gastric insufflation using NIV with peak inspiratory pressures (PIP) of <20 cmH_2O (22). The risk of gastric insufflation may be higher in a pregnant population, due to reduced barrier pressure (23).

Comparing HFNO to NIV, Preoptipop in obese patients found that NIV (PIP 15 cmH_2O, CPAP 5 cm) was superior to HFNO and reduced the rate of desaturation, but was less comfortable for patients (24). The florali-2 trial compared NIV to HFNO during induction of hypoxaemic intensive care patients, finding NIV was superior if the patient was severely hypoxic, but otherwise showed no difference (13).

Conclusions

Based on the published evidence in pregnant women and extrapolating from ICU and obese patients, it seems safe to use HFNO for preoxygenation and apnoeic oxygenation in pregnant women. Whilst the two published RCTs of HFNO in pregnant women are small, both have either suggested benefit, or non-inferiority over facemask anaesthesia. The authors feel that this evidence of a prolonged safe apnoea duration when using HFNO to preoxygenate pregnant women warrants an update to the 2015 OAA guidance. To support this, we have provided an evidence-based 'recipe' on using HFNO in pregnant women (*Figure 1*).

Further research is needed to greater assess the efficacy of HFNO in pregnant women, particularly during obstetric emergencies. Conducting RCTs for pregnant women undergoing emergency surgery is likely to be challenging, therefore the use of observational studies to understand the rate of desaturation and difficult intubation when using HFNO could be very valuable.

In pregnant women with obesity, especially with BMIs over 40, there is less certain evidence for using HFNO preoxygenation. In this population, great care should be used regardless of preoxygenation technique and they may benefit most from studies into NIV preoxygenation.

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Footnote

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References

1. McDonnell NJ, Paech MJ, Clavisi OM, et al. Difficult and failed intubation in obstetric anaesthesia: an observational study of airway management and complications associated with general anaesthesia for caesarean section. Int J Obstet Anesth 2008;17:292-7.
2. Asanathong N, Jiamjira-anon N, Thonsontia JE. Incidence of Adverse Perioperative Airway Complications in Obese Non-Pregnant and Pregnant Patients Undergoing General Anesthesia. Siriraj Med J 2022;74:178-84.
3. Cook T, Woodall N, Frerk C. Major Complications of Airway management in the United Kingdom. Report and Findings. Vol. 106, Fourth National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society, 2011:617-31.
4. Mushambi MC, Kinsella SM, Popat M, et al. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management of difficult and failed tracheal intubation in obstetrics. Anaesthesia 2015;70:1286-306.
5. Nimmagadda U, Salem MR, Crystal GJ. Preoxygenation: Physiologic Basis, Benefits, and Potential Risks. Anesth Analg 2017;124:507-17.
6. Au K, Shippam W, Taylor J, et al. Determining the effective pre-oxygenation interval in obstetric patients using high-flow nasal oxygen and standard flow rate facemask: a biased-coin up-down sequential allocation trial. Anaesthesia 2020;75:609-16.
7. Hignett R, Fernando R, McGlennan A, et al. A randomized crossover study to determine the effect of a 30° head-up versus a supine position on the functional residual capacity of term parturients. Anesth Analg 2011;113:1098-102.
8. Russell EC, Wrench I, Feast M, et al. Pre-oxygenation in pregnancy: the effect of fresh gas flow rates within a circle breathing system. Anaesthesia 2008;63:833-6.
9. Shippam W, Preston R, Douglas J, et al. High-flow nasal oxygen vs. standard flow-rate facemask pre-oxygenation in pregnant patients: a randomised physiological study. Anaesthesia 2019;74:450-6.
10. Jung J, Park S, Lee M, et al. Efficacy of preoxygenation with end-tidal oxygen when using different oxygen concentrations in patients undergoing general surgery: a single-center retrospective observational study. Ann Palliat Med 2022;11:3636-47.
11. Schutzer-Weissmann J, Wojcikiewicz T, Karmali A, et al. Apnoeic oxygenation in morbid obesity: a randomised controlled trial comparing facemask and high-flow nasal oxygen delivery. Br J Anaesth 2023;130:103-10.
12. Miguel-Montanes R, Hajage D, Messika J, et al. Use of high-flow nasal cannula oxygen therapy to prevent desaturation during tracheal intubation of intensive care patients with mild-to-moderate hypoxemia. Crit Care Med 2015;43:574-83.
13. Frat JP, Ricard JD, Quenot JP, et al. Non-invasive ventilation versus high-flow nasal cannula oxygen therapy with apnoeic oxygenation for preoxygenation before intubation of patients with acute hypoxaemic respiratory failure: a randomised, multicentre, open-label trial. Lancet Respir Med 2019;7:303-12.
14. Tan PCF, Millay OJ, Leeton L, et al. High-flow humidified nasal preoxygenation in pregnant women: a prospective observational study. Br J Anaesth 2019;122:86-91.
15. Preston KL, Butler P, Mudannayake R. Determining time to preoxygenation using high-flow nasal oxygen in pregnant women. J Clin Anesth 2020;62:109722.
16. Al-Sulttan S, Bampoe S, Howle R, et al. A prospective, up-down sequential allocation study investigating the effectiveness of vital capacity breaths using high-flow nasal oxygenation versus a tight-fitting face mask to pre-oxygenate term pregnant women. Int J Obstet Anesth 2021;45:28-33.
17. Zhou S, Zhou Y, Cao X, et al. The efficacy of high flow nasal oxygenation for maintaining maternal oxygenation during rapid sequence induction in pregnancy: A prospective randomised clinical trial. Eur J Anaesthesiol 2021;38:1052-8.
18. Osman YM, Abd El-Raof R. High flow nasal cannula oxygen preventing deoxygenation during induction of general anaesthesia in caesarean section: A randomized controlled trial. Trends Anaesth Crit Care 2021;40:23-7.
19. Stolady D, Laviola M, Pillai A, et al. Effect of variable pre-oxygenation endpoints on safe apnoea time using high flow nasal oxygen for women in labour: a modelling investigation. Br J Anaesth 2021;126:889-95.
20. Baillard C, Fosse JP, Sebbane M, et al. Noninvasive

ventilation improves preoxygenation before intubation of hypoxic patients. Am J Respir Crit Care Med 2006;174:171-7.
21. Chiang TL, Tam KW, Chen JT, et al. Non-invasive ventilation for preoxygenation before general anesthesia: a systematic review and meta-analysis of randomized controlled trials. BMC Anesthesiol 2022;22:306.
22. Cajander P, Edmark L, Ahlstrand R, et al. Effect of positive end-expiratory pressure on gastric insufflation during induction of anaesthesia when using pressure-controlled ventilation via a face mask: A randomised controlled trial. Eur J Anaesthesiol 2019;36:625-32.
23. Jolliffe D. Practical gastric physiology. Contin Educ Anaesthesia Crit Care Pain 2009;9:173-7.
24. Vourc'h M, Baud G, Feuillet F, et al. High-flow Nasal Cannulae Versus Non-invasive Ventilation for Preoxygenation of Obese Patients: The PREOPTIPOP Randomized Trial. EClinicalMedicine 2019;13:112-9.

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