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Respiratory and Airway Considerations in Obstetric Patients

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Abstract

Purpose of Review The purpose of this article is to provide the current evidences on respiratory and airway medicine in the obstetric population.

Recent Findings The prevalence of obstructive sleep apnea (OSA) among pregnant women is increasing. Upper body elevation improves respiratory mechanics in parturients and reduces the risk of postpartum OSA. Clinically significant respiratory depression from neuraxial opioid administration, compared to parenteral, is extremely rare.

The incidence of failed tracheal intubation in obstetric patients is higher than that in non-obstetric patients and it has been unchanged recently. The first obstetric-specific guidelines for the management of difficult airway were published in 2015.

The incidence of serious aspiration in obstetric patients is low and has been decreasing. Interventions to reduce aspiration at cesarean delivery recommended by recently published guidelines and clinical studies will be discussed. Supplemental oxygen during uncomplicated delivery, either cesarean or vaginal, has been controversial.

Summary Understanding the changes in airway anatomy and respiratory physiology related to pregnancy, and adherence to evidence-based guidelines are essential in taking care of obstetric patients. Recently published scholarly articles and clinical guidelines relevant to respiratory physiology and airway management in obstetric anesthesia will be presented.

Keywords Airway changes in pregnancy · OSA in pregnancy · Obstetric airway management · Obstetric general anesthesia · Aspiration in pregnancy · Supplemental oxygen for parturients

Introduction

Pregnancy is associated with significant changes in respiratory physiology and airway anatomy. These changes place parturients at increased risk of complications associated with airway problems.

Decades ago, when the majority of cesarean sections were performed under general anesthesia, the predominant causes of anesthesia-related death were related to airway management, such as failed intubation, failed oxygenation, and aspiration of gastric contents [1]. Airway-related deaths have become unusual recently [2], presumably as a result of increased use of regional anesthesia, better education and training protocols, use of failed intubation drills and monitoring such as capnography and oximetry during induction, maintenance, and recovery from anesthesia.

The increased use of regional anesthesia, however, has resulted in the lack of experience and confidence attained by anesthesiologists in providing general anesthesia for cesarean delivery [1]. Understanding the pregnancy-related changes in airway anatomy and respiratory physiology and familiarizing oneself with evidence-based guidelines are the keys to minimizing the risk of respiratory complications when taking care of obstetric patients.

This review will provide an overview of respiratory and airway considerations in this unique patient population, and review recommendations provided by recent clinical studies and guidelines in obstetric airway management.

This article is part of the Topical Collection on *Obstetric Anesthesia*

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Airway Changes in Pregnancy

Airway Changes During Pregnancy

Upper airway anatomy changes during pregnancy. While the Mallampati score has been found to increase during pregnancy

[3], changes in upper airway caliber had been poorly studied in this population, until Leboulanger et al. found a decrease in pharyngeal cross-sectional area, without any significant change in the laryngeal and tracheal areas [4]. Using acoustic reflection, they suggested that potential intubation difficulties in pregnant patients are not related to a narrowing of the larynx or trachea, but to a more difficult laryngeal view due to an increase in local fatty tissue volume, (i.e., pharyngeal edema), and to other factors such as generalized weight gain and increased breast size.

Airway Changes During Labor

As parturients undergo labor and delivery, further airway changes occur. Kodali et al. evaluated the airway changes of 61 women during labor and found that the Mallampati airway class increased from pre-labor to post labor in 38% of the women; the airway increased one grade higher in 33% and two grades higher in 5% after labor [5]. The authors emphasize the importance of a careful airway evaluation just before administering anesthesia during labor rather than obtaining this information from the pre-labor evaluations.

Respiratory Changes in Pregnancy

Obstructive Sleep Apnea

Obstructive sleep apnea (OSA) during pregnancy has been reported to affect between 5% and 26% of women [6–8], and its prevalence is increasing in the USA [9]. The variation in prevalence reported in literature seems partly due to the elusiveness in diagnosing OSA in pregnancy; screening tools that are validated in the nonpregnant population have been shown to be poorly predictive of OSA in pregnancy, and pregnancy-specific screening measures are lacking [8].

Using polysomnography as the standard diagnostic test, Pien et al. conducted a prospective cohort study and found that 10.5% and 26.7% of women in the first and third trimester, respectively, had OSA defined as the apnea-hypopnea index (AHI, apnea+hypopnea/hour of sleep) of five and above [6]. Their multivariable analyses demonstrated that first trimester body mass index and maternal age were significantly and independently associated with third trimester OSA.

In a retrospective analysis using the Nationwide Inpatient Sample (NIS) database, Louis et al. found that OSA is associated with increased odds of pregnancy-related morbidities including preeclampsia, eclampsia, cardiomyopathy, pulmonary embolism, and in-hospital mortality, after controlling for obesity and other potential confounders [9]. Upper airway obstruction and hypoventilation during the early postpartum period can lead to maternal cardiopulmonary arrest [10].

As the prevalence of obesity among parturients and advanced maternal age is both increasing in the USA in recent years [11, 12], the rates of OSA are likely to rise further. Therefore, future research of perinatal OSA should focus on interventions that improve the obstetrical outcomes of this particular patient population.

Upper Body Elevation in Obstructive Sleep Apnea

An intervention that clinicians can make to prevent adverse outcomes of pregnancy- related OSA is upper body elevation during sleep. We performed polysomnography in non-elevated and 45° elevated upper body position among women during the first 48 h after delivery and demonstrated that elevation of the upper body significantly reduced AHI from 7.7 ± 2.2/h in non-elevated to 4.5 ± 1.4/h in 45° elevated upper body position during sleep [7]. The incidence of moderate to severe postpartum sleep apnea defined as AHI > 15 decreased from 20% in the non-elevated position to 10% in the 45° elevated body position. We also measured upper airway cross-sectional area (CSA) by acoustic pharyngometry and found that change from the non-elevated to sitting position increased inspiratory upper airway CSA during wakefulness and this increase was correlated with position-dependent decrease in AHI during sleep [7].

The elevation of the upper body has been previously found to increase functional residual capacity (FRC) of healthy term parturients without significant changes in vital signs [13]. This intervention is consistent with the ASA guideline on perioperative management of patients with OSA, which recommends: “patients at increased perioperative risk from OSA should be placed in non-supine positions throughout the recovery process” [14•] and should be considered in high-risk obstetric patients both pre- and postdelivery.

Respiratory Depression from Neuraxial Opioid

Intrathecal or epidural morphine is widely used for patients undergoing cesarean delivery [15]. Neuraxial opioids have been previously shown to depress the respiratory centers in the brainstem via direct and/or indirect mechanisms [16], and respiratory depression is a potential risk among postpartum patients receiving neuraxial morphine [16].

From the Anesthesia Closed Claims Project database of 9799 claims, Lee et al. detected 17 cases of respiratory depression associated with neuraxial morphine administration [17]. While estimating the incidence is difficult as definitions of “respiratory depression” vary in the literature [18], the prevalence of clinically significant respiratory depression (CSRD) seems to be extremely rare in this population. In a retrospective study that included 5036 women who underwent cesarean delivery and received neuraxial morphine, there were no instances of naloxone administration for the reversal of respiratory depression, with the upper 95% confidence limit for respiratory depression of 0.07% (1 event per 1429 cases) [19].

In a recently published systematic review, Sharawi et al. calculated the prevalence range of CSRD with the use of neuraxial morphine as between 1.08 (95% CI, 0.24–7.22) to 1.63 (95% CI, 0.62–8.77) per 10,000 [20•].

Respiratory Monitoring after Neuraxial Opioid

This extremely low incidence of CSRD may be partially owing to clinicians' vigilance to respiratory monitoring after cesarean delivery. According to the survey of members of the Society of Obstetric Anesthesia and Perinatology (SOAP), the majority of respondents (93%) reported that their institution had a protocol for monitoring patients after administration of neuraxial opioids [15].

The American Society of Anesthesiology (ASA) recommends that respiratory monitoring should be performed at least once per hour for the first 12 h after single-injection neuraxial morphine (not including sustained- or extended-release epidural morphine), followed by monitoring at least once every 2 h for the next 12 h (i.e., from 12 to 24 h) [21•]. If sustained- or extended-release epidural morphine is given, monitoring should be continued at least once every 4 h after 24 h for a minimum of 48 h. The ASA guideline also recommends increased monitoring (e.g., intensity, duration, or additional methods of monitoring) for patients at increased risk of respiratory depression such as those with obesity and OSA. There is an upcoming SOAP consensus statement providing specific guidance on the monitoring of obstetric patients that received neuraxial morphine post-cesarean delivery.

Airway Management

Failed Intubation and Difficult Airway—Incidence, Risk Factors

A recent review of the literature on obstetric failed tracheal intubation worldwide from 1970 to 2014 demonstrated that the incidence remained unchanged at 2.6 per 1000 anesthetics (1 in 390) for obstetric general anesthesia and 2.3 per 1000 general anesthetics (1 in 443) for cesarean delivery [22]. This is significantly higher than the reported incidence in non-obstetric surgical patients undergoing general anesthesia (1 in 2230) [23]. Maternal mortality due to failed intubation in this series was 2.3 per 100,000 general anesthetics for cesarean delivery (one death per 90 failed intubations). There were three cases where a front-of-neck airway access procedure (surgical airway) was attempted, giving an incidence of 3.4 per 100,000 general anesthetics for cesarean delivery (one procedure per 60 failed intubations) [22].

A retrospective survey in the United Kingdom showed that parturients whose tracheal intubation failed were significantly older, heavier, with higher BMI, and with Mallampati score > 1 [24••]. The multivariate analyses showed that age, BMI, and a recorded Mallampati score were significant independent predictors of failed tracheal intubation.

Preoxygenation Before General Anesthesia for Cesarean Delivery

Given the increased risk of difficult intubation, optimal preoxygenation is a key to avoiding maternal hypoxemia and fetal complications during induction of general anesthesia. It has been reported in pregnant women [25] as well as in the obese population [26] that preoxygenation with eight deep breaths over 1 min is more effective than four deep breaths over 30 s and is equally effective as the traditional technique of 3-min tidal volume breathing. When inducing general anesthesia for an emergent cesarean delivery, preoxygenating with eight deep breaths is an efficient and effective technique.

Failed Intubation and Difficult Airway—Guidelines

In 2015, the Obstetric Anesthetists' Association and Difficult Airway Society published the first obstetric-specific guidelines for the management of difficult and failed tracheal intubation [27••]. They developed four algorithms; three specific algorithms and the Master algorithm (Fig. 1) that gives a composite overview of the three. Algorithm 1 (safe obstetric general anesthesia) emphasizes the importance of planning and preparation and describes best practice for rapid sequence induction and laryngoscopy. Gentle bag/face mask ventilation (maximal inflation pressure < 20 cmH2O) with correctly applied cricoid pressure is recommended during rapid sequence induction to reduce oxygen desaturation. Given the increased risk of airway bleeding and swelling in parturients, it is recommended to limit the number of intubation attempts to two to three (with the third attempt only by an experienced anesthesiologist), instead of a maximum of three plus one attempts recommended in the non-obstetric population [28]. Videolaryngoscopes improve glottic visualization and their use is advocated in the algorithm, although no studies have compared different types of videolaryngoscopes for the obstetric population [29].

Algorithm 2 discusses the management of failed tracheal intubation. When inserting a supraglottic airway device (SAD), a second-generation SAD with a gastric drain tube is recommended, and the number of its insertion attempts should be limited to two. Algorithm 3 reviews the management of "can't intubate, can't oxygenate" situation. The flowchart is similar to that for non-obstetric population [28], except that parturients need maternal-specific advanced life support and perimortem cesarean delivery if the front-of-neck procedure has failed.

Special attention should be paid to calling for skilled help, calling for the difficult airway cart, limiting the number of attempts at intubation, considering the use of a SAD, and reconsidering a surgical airway, as these areas are often

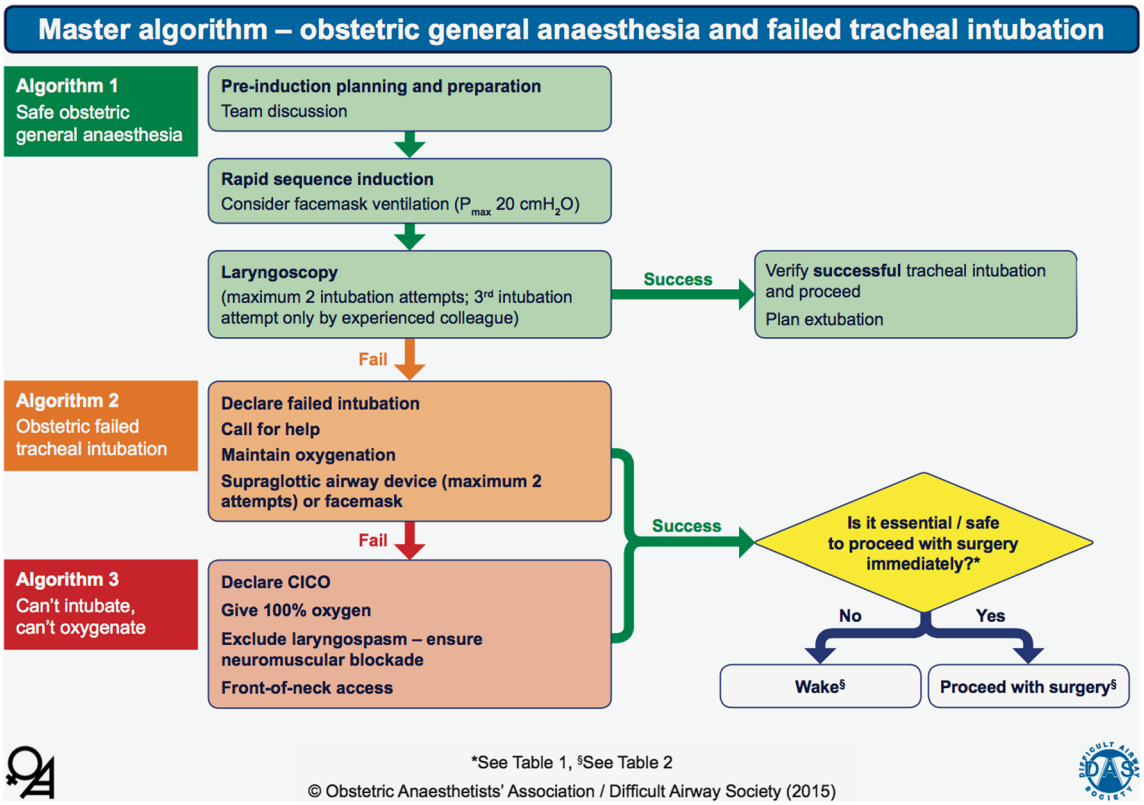

Fig. 1 OAA DAS Obstetric Airway Guidelines 2015—Master Algorithm. Reproduced from Mushambi MC , Kinsella SM, Popat M, Swales H, Ramaswamy KK, Winton AL, Quinn AC. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management of difficult and failed tracheal intubation in obstetrics. Anaesthesia 2015; 70: 1286 – 1306, with permission from Obstetric Anaesthetists' Association / Difficult Airway Society.

forgotten in simulation sessions to train residents for unanticipated difficult airway in obstetric patients [30].

Supraglottic Airway Device During Cesarean Delivery

While the use of SADs is usually considered as a backup plan in the settings of difficult airway, the LMA Supreme™, one of the second-generation SADs, has been recommended as the first-line device for airway management in scheduled and emergent cesarean deliveries by some [31, 32]. In these studies, the LMA Supreme™ was used for non-obese parturients after fasting >4 h and without potentially difficult airway or GERD, and no aspiration, regurgitation or respiratory complications were observed. The authors concluded that this device could be a useful alternative to tracheal intubation for cesarean delivery in a carefully selected group of parturients.

Aspiration

Incidence

The Serious Complication Repository Project of the Society for Obstetric Anesthesia and Perinatology (SOAP) found no event of serious aspiration in more than 5000 obstetric general anesthetics [33•]. Clinically significant aspiration of gastric contents, historically one of the most feared complications in obstetric anesthesia, is not as common as previously noted or suspected [33•]. However, in cases of failed tracheal intubation, the incidence of aspiration is reported to be as high as 8% [22, 24••].

Fasting During Labor

Oral intake is restricted in many facilities during labor and delivery to decrease the maternal risk of aspiration. Because aspiration is a rare event, it is easier to discuss the potential harm of restricted oral intake (i.e., decreased maternal energy or satisfaction) than it is to demonstrate the harm of eating in labor [34]. The updated Cochrane review of regurgitation during general anesthesia or Mendelson's syndrome was unable to undertake a systematic review as no women included in the review suffered from these complications [35•].

The accumulation of these published data led to the update in the practice guidelines published by the ASA and the SOAP in 2016. For aspiration prevention, it is recommended that oral intake of moderate amounts of clear liquids may be allowed for uncomplicated laboring patients, while solid foods should generally be avoided in laboring patients [36••]. Laboring patients

with additional aspiration risk factors, including morbid obesity, diabetes mellitus, or difficult airway, or patients at increased risk for operative delivery may be further restricted in their oral intake, to be determined on a case-by-case basis [36••].

For the uncomplicated parturients undergoing elective surgery including scheduled cesarean delivery, the same preoperative fasting guidelines apply as for non-obstetric patients [37].

Gastric Volume

When assessing the aspiration risk of each parturient, either in labor or before cesarean delivery, point-of-care gastric ultrasonography has been described as a useful and reliable tool. In nonpregnant patients, Bouvet et al. performed bedside ultrasonography in the supine position and found a significant positive relationship between the antral cross-sectional area (CSA) before induction of anesthesia, and gastric fluid volume aspirated through a gastric tube after tracheal intubation [38]. The authors recommended the cutoff value of antral CSA of 340 mm^2 for the diagnosis of "risk stomach" (defined by the presence of solid particles and/or gastric fluid volume 0.8 ml/kg).

These cutoff values, however, may alter during pregnancy with the enlarging uterus compressing and displacing the stomach. For term parturients after fasting overnight before elective cesarean delivery, an antral CSA of 10.3 cm^2 in the right decubitus position is suggested as the upper limit of normal findings [39]. In laboring patients, on the other hand, the cutoff values of 608 mm^2 in the supine position is suggested to identify an ingested volume > 1.5 ml kg^{-1} [40] and may correspond to a full stomach and an increased risk of pulmonary aspiration [41].

Aspiration Prophylaxis

In a prospective observational study of 1095 women receiving general anesthesia for cesarean delivery, McDonnell et al. reported that antacid prophylaxis (most commonly sodium citrate, ranitidine or both) was used in 94% of elective cases and 64% of emergencies [42]. A recent Cochrane review examined studies that compared different types of aspiration prophylaxis and suggested that, although the evidence was of poor quality, the combination of antacids plus H2 antagonists was more effective than no intervention, and superior to antacids alone in preventing low gastric pH [43•]. The practice guidelines by the ASA and the SOAP [36••] recommend the timely administration of nonparticulate antacids, H2-receptor antagonists, and/or metoclopramide for aspiration prophylaxis before surgical procedures (e.g., cesarean delivery or postpartum tubal ligation).

Supplemental Oxygen

Cesarean Delivery

Oxygen was historically given to pregnant women during a cesarean delivery under regional anesthesia to prevent maternal desaturation and improve fetal oxygenation. In a recently updated Cochrane review that compared mothers who received supplemental oxygen and those who did not, none of the 11 trials reported maternal desaturation [44•]. Their meta-analysis showed no significant differences in average Apgar scores at 1 min and 5 min, although the evidence was of low quality. A randomized controlled trial (RCT) conducted by Khaw et al. once reported that breathing high FiO2 during elective cesarean delivery can cause an increase in oxygen free radical activity in both mother and fetus [45]. The authors of the Cochrane review, however, concluded that these results should be interpreted with caution due to the low-grade quality of the evidence [44•]. In current practice, many practitioners now do not employ supplemental oxygen during elective cesarean delivery under regional anesthesia unless otherwise indicated.

For patients undergoing *emergency* cesarean delivery under regional anesthesia, on the other hand, there is no available meta-analysis data. Another RCT published by Khaw et al. reported that breathing 60% oxygen during emergency cesarean delivery increased fetal oxygenation without increase in lipid peroxidation in the mother or fetus [46]. This effect was of greater magnitude in patients with suspected fetal compromise compared with those without. Since there was no evidence of harm in contrast to their previous work with elective cesarean delivery, it would be reasonable to provide supplemental oxygen especially in the presence of suspected fetal compromise.

The increase in free radical activity in the mother and baby during general anesthesia has been demonstrated to be independent of the inspired oxygen [47]. Therefore, it seems feasible to administer 100% oxygen for mothers undergoing general anesthesia without inducing an increase in lipid peroxidation [47].

Vaginal

Oxygen is administered quite often to women in labor, especially to those with concerning fetal heart rate patterns. It was previously demonstrated that oxygen administration to laboring patients with nonreassuring fetal heart rate patterns increases fetal oxygen saturation substantially and significantly, and that fetuses with the lowest initial oxygen saturations appear to increase the most [48].

Based on a recent review of the literature, Hamel et al. challenged this practice and concluded that maternal oxygen administration for intrauterine resuscitation is of unproven benefit and is potentially harmful [49•]. Garite et al. disagrees with the conclusion of Hamel et al. and argues that there is no

substantial evidence that, except in theory, maternal oxygen administration causes any harm to the fetus [50].

There have been no published studies addressing maternal oxygen therapy for fetal distress, and therefore, a Cochrane review was unable to evaluate its effectiveness [51]. Based on the best available evidence, it appears reasonable to administer oxygen in labor complicated by concerning fetal heart rate patterns indicative of fetal hypoxia.

Conclusions

Much effort and progress have been made over the past decade to reduce the risk of airway-related and respiratory complications among obstetric patients. Airway anatomy and respiratory physiology continue to change throughout pregnancy, making anesthetic management for parturients more challenging.

Clinicians taking care of obstetric patients need to be familiar with these changes and continue to update oneself with relevant guidelines and recommendations in key-related areas such as p.o. intake in labor, maternal oxygenation during labor and cesarean delivery, and maternal difficult airway management.

Compliance with Ethical Standards

Conflict of Interest Ayumi Maeda, Nobuko Fujita, and Yasuko Nagasaka declare they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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