

Airway management in patients undergoing emergency Cesarean section

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Abstract Special care is required for airway management of patients undergoing emergency Cesarean section. Although the incidence of difficult intubation and difficult ventilation is similar between pregnant and non-pregnant women, the severity of complications in pregnant patients would be much greater than in non-pregnant patients, if tracheal intubation is found to be difficult: increased risk of pulmonary aspiration, hypoxia, airway obstruction due to laryngeal edema, and a “sleeping baby” being taken out. Rapid-sequence induction of anesthesia is generally indicated to a patient undergoing emergency Cesarean section under general anesthesia. The technique has been evolving, without losing the key premise of minimizing the period of the airway being not protected from pulmonary aspiration, and of permitting rapid wake up if tracheal intubation fails. In this review, I describe the appropriate airway management, based on the current state of knowledge, in a patient undergoing emergency Cesarean section under general anesthesia.

Keywords Airway management · Difficult intubation · Obstetric anesthesia

Introduction

Cesarean section may frequently be performed as an emergency operation and may frequently require general

anesthesia. Special care is required for airway management of patients undergoing emergency Cesarean section because they are at increased risk for respiratory complications. It is not exaggerating to say that appropriate airway management during anesthesia has been developed mainly in the field of obstetric anesthesia: recognition of the risk of pulmonary aspiration [1], national surveys of serious airway complications during anesthesia (e.g., Confidential Enquiries into Maternal Death in the United Kingdom) [2], establishment of an optimal way of laryngoscopy for tracheal intubation (by Cormack and Lehane) [3], and the first algorithm for difficult airway management [4].

For a pregnant woman who requires emergency Cesarean section under general anesthesia, it is necessary to intubate the trachea immediately after induction of anesthesia to prevent pulmonary aspiration, to minimize delivery of anesthetic drugs to a fetus, and to enable obstetricians to start surgery. It is also desirable that the effects of drugs injected are short so that it would be possible to wake the patient up when tracheal intubation has failed. Rapid-sequence induction of anesthesia is generally indicated to meet these requirements.

The traditional method developed in 1950–1960s [5] consisted of preoxygenation, application of cricoid pressure, induction of general anesthesia with thiamylal (or thiopentone), followed immediately by succinylcholine (succinylcholine). Manual ventilation via a facemask was avoided until the airway was protected by a cuffed tracheal tube. The technique remained essentially unchanged for more than half a century, but it has been evolving (particularly since the mid 1980s), without losing the key premise of minimizing the period of the airway not being protected from pulmonary aspiration, and of permitting rapid wake up if tracheal intubation fails.

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I describe the appropriate airway management, based on the current state of knowledge, in a patient undergoing emergency Cesarean section under general anesthesia.

Pulmonary aspiration

Risk

Obstetric patients, in particular those undergoing emergency Cesarean section, are considered to be at increased risk of pulmonary aspiration. For a long time, Mendelson was regarded to be the first to point out (in 1946) [6] the risk of pulmonary aspiration, and his name has been dubbed to the syndrome. It is now clear that he was not the first one [1]. There were already reports in the mid-19th century of death caused by pulmonary aspiration during anesthesia [7]. In the late 1930s, several committees on maternal death pointed out the danger of aspiration during obstetric anesthesia [8–12].

It had also been claimed that Mendelson [6] was the first to show pathological changes caused by pulmonary aspiration, but this is also not true. Winternitz and colleagues reported in 1920 the effect of hydrochloric acid infused into the bronchi of rabbits [13], although they were not thinking of aspiration of gastric acid but of war gases liberating free chlorine. Apfelbach and Christianson (in 1937) [14] were probably the first to report pathological changes caused by aspiration of gastric acid through animal research.

It is not clear whether gastric emptying is delayed in pregnant women, but gastric emptying is frequently delayed in women at labor [15, 16]. In addition, gastric emptying may also be delayed when the patient has pain, stress, and anxiety [17, 18]. Therefore, all the patients who undergo emergency Cesarean section should be regarded as at increased risk of pulmonary aspiration, even when they have not eaten for several hours [15]. Pulmonary aspiration is not confined to the induction of general anesthesia, but it also occurs after tracheal extubation [19]. It should be noted that mortality from aspiration in women undergoing Caesarean section is more frequent after tracheal extubation than during induction of anesthesia [2].

Prevention

Emptying the stomach

In the past, efforts were made to empty the stomach before induction of anesthesia [20, 21]. One method was the injection of apomorphine, which has a strong emetic effect. When it is given intravenously, the patient starts to vomit 15–20 s later, and lasts for 1–2 min. Another method is to insert a gastric tube to remove gastric

contents. Both methods may be effective, but nonetheless stressful to the patient. One report indicates that pregnant women generally claimed that receiving a gastric tube was much more stressful than receiving apomorphine [21]. Because pulmonary aspiration is generally prevented by the current method of rapid-sequence induction of anesthesia, these stressful procedures may usually be unnecessary [22].

Because pulmonary aspiration may frequently occur after tracheal extubation, the stomach contents should be reduced before extubation. To achieve this, a histamine H₂ receptor antagonist, such as cimetidine and ranitidine, may be given either preoperatively or intraoperatively to inhibit secretion of gastric acid [22]. Antacids (such as sodium bicarbonate and magnesium hydroxide) may be given orally before induction of anesthesia to neutralize acidity. Erythromycin, which encourages gastric emptying, may also be given [23, 24]. A large-bore gastric tube should be inserted before emergence from anesthesia to remove gastric contents. Every patient should still be regarded as at increased risk of aspiration after operation because there is no guarantee that the stomach has been emptied with these treatments.

Cricoid pressure

Cricoid pressure was originally described by Sellick in 1961 [25] and since then it has become a routine part of rapid-sequence induction of anesthesia in patients at risk of pulmonary aspiration. Nevertheless, it is necessary to master the correct method of cricoid pressure, because inappropriately applied pressure may cause serious complications, such as difficult tracheal intubation, airway obstruction, pulmonary aspiration, and rarely rupture of the esophagus [26].

Required force Most problems with cricoid pressure occur when too much force is applied [26]. Sellick described that cricoid pressure should be applied lightly initially and then with ‘firm pressure’ as soon as consciousness is lost [25]. Traditional teaching of the required force had been 44 N [27], and cricoid pressure with this force would prevent regurgitation with a theoretical maximum gastric pressure of 59 mmHg in 50 % of patients [28]. However, cricoid pressure with 44 N frequently obstructs the airway [26, 29] and makes tracheal intubation more difficult [30]. Later studies have shown that 20 N of cricoid pressure is probably enough and 30 N is more than enough to prevent regurgitation into the pharynx [26].

In an awake patient, cricoid pressure at 20 N may induce retching [31], which can lead to pulmonary aspiration [32] or esophageal rupture [33, 34]. It is currently

recommended that 10 N (1 kg) should be applied before induction of anesthesia, increasing to 30 N (3 kg) at loss of consciousness [26]. Each anesthesiologist or each assistant who would apply cricoid pressure should master the correct force beforehand by practicing on weighing scales [35].

Effect of cricoid pressure on airway management Cricoid pressure may interfere with all airway management methods. It may cause difficulty with tracheal intubation by distorting the larynx, particularly if the pressure is applied too far from the midline with excessive force or incorrectly to the thyroid cartilage. Cricoid pressure may also prevent ventilation [29, 30]. In a report of 23 failed intubations over a 17-year period in one maternity unit, all mothers survived; cricoid pressure was maintained [36]. In nine patients, it was difficult to ventilate in seven patients (30 %) and impossible in two (9 %). Although other factors, such as upper airway obstruction or laryngeal edema could have been the cause, cricoid pressure might have been the cause of difficult ventilation in these patients.

If both tracheal intubation and ventilation via a facemask have failed, there are two choices of airway that could help: insertion of a supraglottic airway (such as the laryngeal mask airway) or percutaneous cricothyrotomy [37]. Nevertheless, cricoid pressure may make both choices difficult [38, 39]. A recent study has shown that cricoid pressure does not frequently prevent insertion of the i-gel [40], and thus the i-gel may become the first choice in the ‘cannot intubate, cannot ventilate’ scenario.

Applying methods of cricoid pressure The hand applying the cricoid pressure may hamper insertion of a laryngoscope (Fig. 1a). This can be avoided by placing a palm on the patient’s chest (Fig. 1b). For this technique, it may be easier to apply pressure with the index and middle fingers rather than the thumb and index finger (Fig. 1b). The assistant applying the cricoid pressure with the index and middle fingers should practice with a weighing scale to produce appropriate force (10 and 30 N), before induction of anesthesia.

Cricoid pressure, when applied with excessive force, may flex the patient’s head on the neck, making it more difficult to see the glottis at laryngoscopy [41, 42] (Fig. 2a). This can be avoided by supporting the neck by another hand (bimanual cricoid pressure) (Fig. 2b).

Mask ventilation

Mask ventilation is traditionally avoided to minimize gastric insufflation and the associated increased risk of regurgitation; however, effective cricoid pressure should prevent

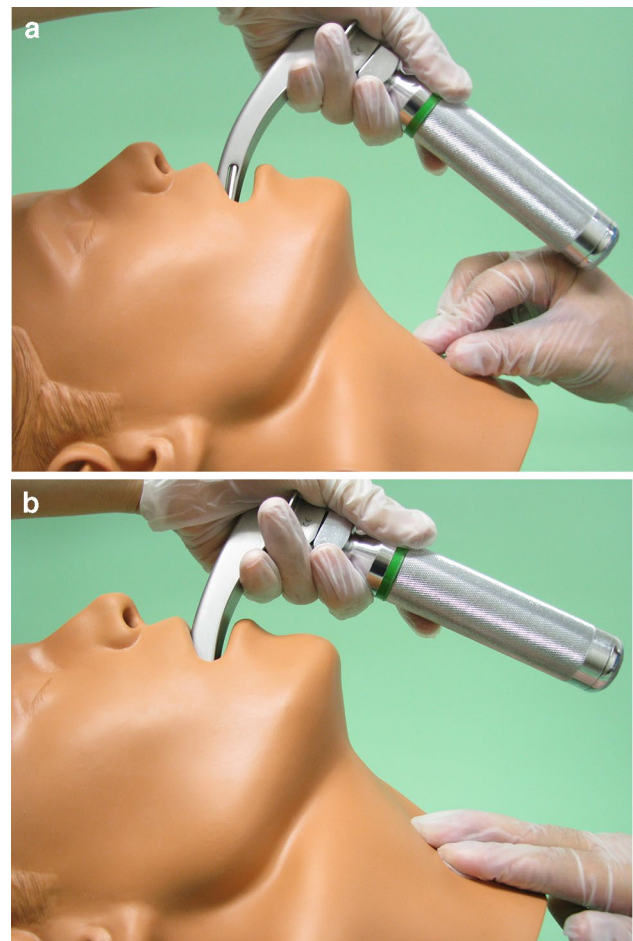


Fig. 1 **a** Conventional cricoid pressure hampering insertion of a laryngoscope. **b** A modified cricoid pressure for insertion of a laryngoscope

gas from passing into the stomach, and thus some clinicians gently inflate the lungs with low inflation pressures to help maintain oxygenation during the apneic period. In early descriptions of the technique, little attention was paid to airway management in the time between loss of consciousness and laryngoscopy, it is now recommended that the airway should be kept patent and the mask seal maintained during this period to allow transfer of oxygen from the breathing system to lungs.

Other complications

Risk

It has long been thought that tracheal intubation is more difficult in pregnant women than in non-pregnant women, because pregnant women are likely to become obese and are likely to have edema of the oropharynx [43]. However,

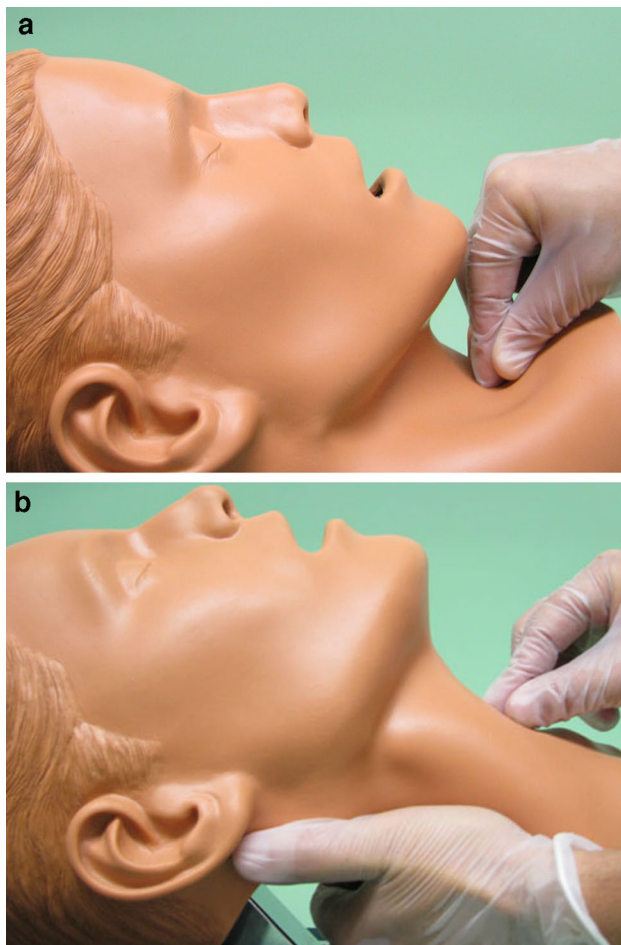


Fig. 2 **a** Cricoid pressure flexing the patient's head on the neck. **b** Supporting the neck by a hand preventing flexion of the head on the neck (bimanual method)

reports indicate that this may not be so. A historical report by Cormack and Lehane—whose categorization of the view of the glottis at laryngoscopy is well known—indicated that an estimated incidence of difficult laryngoscopy (class 3) would be 1 in 2000 [3]. A recent study [44] has also shown that the incidence of difficult tracheal intubation in pregnant women was 0.6 %, which is not greater than the incidence in the general population. In addition, the incidence of difficult facemask ventilation in pregnant patients may be similar to, or no much higher than, the incidence in the general population [45, 46].

If the incidence of difficult intubation and difficult ventilation is similar between pregnant and non-pregnant women, is there no worry? The answer is yes, there is. The severity of complications in pregnant patients would be much greater than in non-pregnant patients, if tracheal intubation is found to be difficult. If tracheal intubation has failed in a patient who needs emergency Cesarean section, the patient will become at risk of life-threatening

pulmonary aspiration. Obstetricians have difficulty in starting emergency surgery, and a “sleeping baby” may be taken out [47]. In addition, pregnant patients have reduced oxygen store [48], and thus they are more likely to be hypoxic after failed intubation. Furthermore, they tend to have laryngeal edema, and thus repeated attempts at tracheal intubation are more likely to cause airway obstruction.

Prevention

Preoxygenation

When a non-pregnant person experiences apnea, it takes 1–2 min to become hypoxic (arterial hemoglobin oxygen saturation (SpO_2) <90 %) [48]. When oxygen is given beforehand, the time to become hypoxic can extend to 7–10 min. In such a circumstance, there is, in theory, little clinical problem even if tracheal intubation has failed. In contrast, in a pregnant woman, hypoxia occurs within 1 min without oxygenation, and 4–6 min with oxygenation [48]. Therefore, it is crucial to preoxygenate a pregnant woman, to minimize hypoxia after the induction of anesthesia.

Classic teaching was that preoxygenation should be carried out with a good facemask seal for 3 min. Oxygenation for 1 min is enough to increase the SpO_2 to 100 %, but it has been reported that oxygenation longer than 1 min can extend the time to become hypoxic during apnea. This difference in the time to hypoxia is partly explained by the difference in the “tissue stores” [49]. A simulation analysis has shown that oxygen will be stored maximally in the arterial blood within 1 min, whereas it would take 3 min for oxygen to be stored maximally in some tissue (in particular, the skeletal muscles) [49]. It is now recommended to ensure optimum denitrogenation of the lungs by confirming that the end-tidal oxygen concentration increases to 85–90 %. This may also take more or less than 3 min [50, 51].

Anesthesia drugs

It is necessary to carry out tracheal intubation as rapidly as possible after induction of general anesthesia. To achieve this, it is necessary to give drugs with a rapid onset. In addition, it is necessary to give drugs with a short duration of effects to wake the patient up when both tracheal intubation and mask ventilation have failed.

Traditionally, thiopental (thiamylal, thiopental) has been used to induce anesthesia and suxamethonium to produce neuromuscular blockade. Currently, propofol is often substituted for thiopental as the induction agent because of familiarity and because of its less frequent airway complications. Opioids, such as fentanyl, are frequently

administered before induction of anesthesia to minimize the cardiovascular responses to laryngoscopy and tracheal intubation.

Until recently, among the neuromuscular blocking agents, suxamethonium had the most rapid onset (about 1 min) and had the shortest duration of effect. Nevertheless, the use of suxamethonium can be associated with serious complications, such as an increase in intragastric pressure, rhabdomyolysis, cardiac arrest due to increased plasma potassium level, as well as postoperative myalgia. In addition, the effect of suxamethonium may not be short enough to wear off before the patient becomes hypoxic during apnea: one study has shown that apnea can last as long as 7 min after the administration of suxamethonium [52], and this effect cannot be reversed. Furthermore, the effect of suxamethonium is prolonged in patients with decreased plasma cholinesterase activity, such as in pregnant women [53].

High-dose rocuronium has been used increasingly in place of suxamethonium because of fewer side effects. The onset time of the “usual” dose of rocuronium (0.6 mg/kg) is about 2 min, whereas the onset time of high-dose rocuronium (1.0–1.2 mg/kg) is about 1 min, which is similar to the onset of suxamethonium [54, 55].

One major problem with the use of high-dose rocuronium was that reversal of its effects was difficult when ventilation turns out to be impossible and when it becomes necessary to recover spontaneous breathing. This problem has been solved by the introduction of sugammadex to clinical practice, because sugammadex injected immediately after injection of high-dose rocuronium can reliably reverse neuromuscular blockade within 2 min [56]. Therefore, sugammadex (given immediately after high-dose rocuronium) would restore neuromuscular function more quickly than suxamethonium wears off. One practical problem with the use of sugammadex is that there may be a delay in administering the required dose (16 mg/kg) of sugammadex [57].

Recommended airway management

Skill development

It has been shown that inexperience is one major reason for failed airway management [44, 58]. For example, tracheal intubation may frequently be difficult, because inexperienced anesthesia providers fail to wait sufficient time for suxamethonium to take effect, or to place the head and neck to the optimal position [44]. Nevertheless, even now, education in airway skills does not occupy a central place in anesthesia training and the training system for the management of the difficult airway is less than ideal worldwide [59].

In such a limited time during rapid-sequence induction of anesthesia, we need to choose appropriate methods and then carry them out rapidly and safely, to prevent these major complications [47]. Therefore, training of appropriate airway management (including cognitive, psychomotor, and behavioral areas) needs to be organized. In addition, each anesthesia department should indicate, based on guidelines, clear airway-management plans in case of difficult tracheal intubation and difficult ventilation, during rapid-sequence induction of anesthesia. For example, as videolaryngoscopes have been shown to be useful in patients with difficult airways [60–62], plans should be made that either a videolaryngoscope is used at the first attempt at tracheal intubation or after failed intubation using a Macintosh laryngoscope. Each anesthesiologist should also plan which supraglottic airway be used as a “rescue”, and should acclimate with the use of the videolaryngoscope and the supraglottic airway during routine anesthesia. In addition, anesthesiologists as well as other staff who would apply cricoid pressure should routinely practice the correct method with appropriate force of cricoid pressure using a weighing scale.

Rapid-sequence induction of anesthesia

In theory, when the patient is at risk of pulmonary aspiration, and difficult tracheal intubation is predicted, general anesthesia should be avoided until the trachea is intubated. In reality, however, when Cesarean section is truly emergent, there may be no time to give spinal anesthesia, and thus either awake intubation or tracheal intubation after rapid-sequence induction of anesthesia needs to be selected. Each institution should establish clear-cut criteria, based on the guidelines about difficult airway management, as to when awake intubation should be selected in patients undergoing emergency Cesarean section.

When rapid-sequence induction of anesthesia is selected, before induction of anesthesia, a facemask is tightly applied to the patient’s face and oxygen is given at least 3 min, so that the SpO₂ is 100 % and the end-tidal oxygen concentration increases to 85–90 %. While the patient is still awake, cricoid pressure is applied lightly (10 N or 1 kg) by a trained assistant who has recently practiced the correct forces. The anesthesiologist should confirm that the assistant’s fingers are correctly placed on the cricoid cartilage and that it is tolerable to the patient.

Rapid-sequence induction of anesthesia is started so that deep anesthesia and full neuromuscular blockade is achieved immediately after the loss of consciousness of the patient to avoid coughing, straining, or retching. Once the patients have lost consciousness, the force on the cricoid cartilage increases to 30 N (3 kg).

Tracheal intubation is attempted about 1 min later, the cuff of a tracheal tube is inflated, and the correct positioning of the tube is confirmed using capnography. The tube may sometimes be inserted wrongly into the esophagus, but the anesthesiologist may have no courage to take the tube out even when esophageal intubation is suspected, particularly when Cesarean section is truly emergent and obstetricians have started operation. Personnel in the operating room should alarm the anesthesiologist to the possibility of incorrect esophageal intubation and advise to take the tube out and to move on to the next step if no capnography waveforms appear [63]. Cricoid pressure is loosened after confirmation of capnography indicates the correct tracheal intubation has been achieved, and if regurgitation occurs, the force is increased again, and regurgitated material should be removed by suction.

If tracheal intubation is found to be difficult, cricoid pressure should not be released at once; changing the direction of cricoid pressure, upward and backward, may improve the view at laryngoscopy. If tracheal intubation is still difficult, manual ventilation is attempted without delay using 100 % oxygen via a facemask and oral airway; the patient is left supine and cricoid pressure is continued. If it is difficult to ventilate via a facemask, the amount of cricoid pressure should be reduced; if difficulty persists, it should be completely released. This should be done in the supine position with a laryngoscope inserted and suction in hand. Ventilation may then be possible, but if not, either insertion of a supraglottic airway (in particular of the i-gel [40]) or of a cricothyrotomy cannula should be attempted without delay [37]. If cricoid pressure prevents insertion of a supraglottic airway, cricoid pressure is temporarily loosened during insertion, and once the device is inserted, the pressure should be reapplied. Cricoid pressure is effective if reapplied after insertion of the laryngeal mask [64], although it may cause a partial airway obstruction [65].

Conclusions

The risk of pulmonary aspiration and other complications has long been recognized in obstetric anesthesia, and several major efforts have been made. A rapid-sequence induction of anesthesia with cricoid pressure was developed and has been evolved, guidelines about difficult airway management have been formulated, new reliable airway devices have been developed, and oximetry and a capnography have become widely available. Because of these efforts, the incidence of maternal death related to serious complications during induction of anesthesia has certainly reduced. Nevertheless, pulmonary aspiration is still one major cause of life-threatening complication in obstetric anesthesia, and in a limited number of patients, tracheal intubation is

unexpectedly difficult, and we face a difficult situation of acting very quickly to secure a clear airway without causing complications. Therefore, we need to make further efforts to elucidate the contributing factors to difficult airways, improve technique and devices, and establish education and training systems in order to attain complication-free airway management in obstetric anesthesia.

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