Chapter

Airway Management during Pregnancy and Labor

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Abstract

Pregnant women undergo non-obstetric surgeries as well as cesarean operations. Airway management can be complicated due to physiological changes which occur in the respiratory system of labors. The most common causes of pregnancy-specific hypoxic respiratory failure are eclampsia, preeclampsia, and pulmonary edema that develops secondary to tocolytics. Approximately 10–15% of pregnant women undergo emergency cesarean section. Regional anesthesia is a preferred technique worldwide most commonly, and general anesthesia is applied with rapid sequence induction for the rest of the patients. Difficult Airway Society Master Algorithm for Obstetric Patients is a useful method to manage the airway in labors.

Keywords: airway management, respiratory failure, tracheal intubation, pregnancy, labor

1. Introduction

1.1 Pregnancy and physiological changes in the airway

Several physiological changes develop in the systems during pregnancy. Airway management can be complicated due to these changes that occur in the respiratory system (**Table 1**). Capillary dilatation that occurs during pregnancy due to the gestational hormones including progesterone and estrogen. This causes congestion in the nasopharynx, larynx, trachea, and bronchi. On the other hand, as the uterus expands, the diaphragm elevates approximately 4 centimeters. The decrease in the abdominal muscles' tonus and activity allows the diaphragm to take on more respiratory function. The rise of the diaphragm decreases total lung capacity and functional residual capacity. Relaxation in the airway muscles increases the dead-space capacity. Expiratory reserve and residual volume are reduced. Increased alveolar ventilation and decreased functional residual capacity (FRC) increase the maternal uptake and elimination of inhalation anesthetics. However, decreased FRC and increased metabolic rate predispose to apnea or hypoxemia during hypoventilation periods which can precipitated by airway obstruction and prolonged tracheal intubation attempts.

The changing position of the stomach during pregnancy shifts the intra-abdominal segment of the esophagus towards the thorax in many pregnant women. This leads to a decrease in the tone of the lower esophageal high pressure area, which normally prevents reflux of stomach contents. Hence, pulmonary aspiration risk occurs. The risk is higher during anesthesia induction and tracheal intubation. Therefore, rapid sequence induction is recommended.

Volume	
Tidal Volume	**Increases by 45%**
Inspiratory Reserve Volume	Increases by 5%
Expiratory Reserve Volume	Decreases by 25%
Residual Volume	Decreases by 15%
Capacity	
Total Lung Capacity	Decreases by 5%
Vital Capacity	Does not change
Inspiratory Capacity	Increases by 15%
Functional Capacity	Decreases by 20%

Table 1.
Changes in lung volume and capacity during pregnancy.

2. Anatomic changes in pregnant women

The main changes occur by the consequences of growing uterus. The diaphragm is placed upwards. Hence, a shortening of the ribcage and an increase in the anteroposterior and right–left planes take place. Expansion from the ligamentous attachment areas of the ribs facilitates adaptation to these anatomical changes. With the effect of the increasing weight in the pregnant, the obscurity of the anatomical signs on the face and the enlargement of the breasts are among the reasons that cause the difficulty of tracheal intubation. As the uterus continues growing during pregnancy, the intraabdominal part of the stomach and esophagus are displaced to the left of the diaphragm. With this physiological change, progesterone and estrogen cause a decrease in esophageal lower sphincter pressure.

3. Aspiration prophylaxis and fasting in obstetric patients

Four main drugs are used for aspiration prophylaxis:

1. Sodium citrate: is a non-particulate antacid and increases gastric pH
2. H2-antagonists: Famotidine, cimetidine. They block histamine on the gastric parietal cells.
3. Proton pump inhibitors: Pantoprazole, omeprazole. They block H^+K^+ATPase enzyme system in the parietal cells of stomach.
4. Metoclopramide: stimulates upper gastrointestinal motility, and the lower esophageal sphincter tone rises.

Clear liquids are recommended up to two hours before general anesthesia induction. The fasting period for solids is six to eight hours.

4. Pregnancy and respiratory failure

The most common causes of pregnancy-specific hypoxic respiratory failure are eclampsia, preeclampsia, and pulmonary edema that develops secondary to

tocolytics. Cardiogenic pulmonary edema due to peripartum cardiomyopathy is another cause. Also, placental abruption, chorioamnionitis, obstetric hemorrhage, or endometritis are among emergencies that cause Adult Respiratory Distress Syndrome (ARDS) [1]. On the other hand, non-pregnancy specific causes include aspiration pneumonia, pulmonary embolism, venous air embolism, pneumothorax, atelectasis, pulmonary contusion, trauma, burns, and sepsis.

In pregnancy the chest wall compliance is reduced. The functional residual capacity decreases. This lead to rapid oxygen desaturation during airway management. Upper airway edema becomes another problem. Besides, pulmonary aspiration, viral pneumonitis or thromboembolism risk increases in pregnant patients. Pregnancy carries a risk of increased susceptibility of some pulmonary. Pneumonia is a significant risk factor for maternal morbidity.

5. Preoperative preparation

Approximately 10–15% of pregnant women undergo emergency cesarean section [2]. Regional anesthesia is preferred worldwide most commonly, and general anesthesia is applied with rapid sequence induction (RSI) for the rest of the patients. Some tests and examinations are required to evaluate the airway before anesthesia applications. The ideal test should be simple, fast, and cost-effective in the preoperative evaluation. Most bedside testa are affected with anatomical and physiological changes of pregnancy [3]. It should also have high sensitivity, high specificity, and positive predictive value. According to the American Society of Anesthesiologists (ASA) difficult intubation guidelines, the difficult airway definition can be described as an experienced anesthesiologist experiencing difficulties in ventilation, tracheal intubation, or both [4]. Difficult laryngoscopy is defined as an experienced anesthesiologist's inability to perform intubation in more than three attempts with a conventional laryngoscope. Difficult mask ventilation is defined as the anesthesiologist's inability to maintain oxygenation without assistance, the inability to increase the peripheral oxygen saturation above 90% despite using 100% oxygen, or the inability to correct improper ventilation findings. Gas leakage from the face mask, decreased chest movements and auscultation findings, dilatation of the stomach with air, hypoxemia, cyanosis, or hypercarbia indicate improper ventilation. One of the most commonly used preoperative evaluation tests is the Modified Mallampati score. Mallampati score of 3 and 4, BMI of >26 kg. m^2, mandibular protrusion defect, snoring history, abnormal facial anatomy, and high thyromental distance are among the markers of difficult mask ventilation in pregnant women. Obstructive sleep apnea is another marker of difficult mask ventilation. In the preoperative period, difficult laryngeal mask placement can also be evaluated. Components of the shortening of RODS are listed in **Table 2**.

Protruding maxillary incisors, receding mandible, short interincisor distance, and increased neck circumference are among other difficult airway markers in pregnant women. Other potential risk factors include obesity, short neck, receding

Restricted mouth opening
Obstruction or obesity
Distorted anatomy
Stiffness

Table 2.
Difficult laryngeal mask ventilation markers: RODS.

Difficult intubation story
Interincisor distance < 4 cm
Tiromental distance < 6 cm
Sternomental distance < 12 cm
Head and neck extension < 30°
Mallampati 3–4
Mandibular protrusion (defect or prognathism)
Neck circumference > 40 cm
Submental compliance defect

Table 3.
Preoperative examination findings for direct laryngoscopy and intubation difficulty.

mandible, swollen tongue, and facial edema. The distances that should be measured in the preoperative examination and examination findings that are predictive for direct laryngoscopy and intubation difficulty are given in **Table 3**. In pregnant patients the physiological and the anatomical changes constitute the difficulty for airway management. The susceptibility to hypoxaemia, friability and mucosal engorgement are main causes of failed airway management [2].

6. Preoxygenation and apneic oxygenation in obstetric patients

As obstetric patients are prone to have airway management difficulties, preoxygenation is essential to increase the oxygen reserve before anesthesia induction. The ideal way to determine the sufficiency of preoxygenation is to monitor end tidal oxygen (FeO_2) concentration. FeO_2 < 90% shows inadequate preoxygenation. We have a critical level the oxygen consumption about 250 mL/min. This rate increases during pregnancy. As oxygen is removed from lungs the alveolar partial oxygen pressure decreases during airway interventions. Therefore apneic oxygenation is recommended. Oxygen delivery systems include nasal canula, simple face mask, Ventury mask, non-rebreather mask, insufflation by transtracheal or endobronchial catheters, dual bladed laryngoscopes. High flow nasal cannula is also commonly used for this purpose today. During apneic oxygenation, carbon dioxide levels continue to rise, which can lead to a decrease in pH and respiratory acidosis. However, the use of higher flow more than 15 L/min oxygen during apnea provides better gas washout.

7. Awake intubation

When it is thought that oxygenation and manual ventilation cannot be guaranteed after anesthesia induction in a pregnant woman with difficult intubation, awake intubation is recommended. Expecting a high rate of leakage between the face mask and the face, upper airway collapse as a result of general anesthesia are among the conditions that require awake intubation. Awake intubation can be performed using a video-laryngoscope or flexible bronchoscope [5, 6]. During the procedure, low or, if possible, high flow oxygen applications are recommended to extend the apneic window. If the patient will be intubated under general anesthesia or if it is understood that there is a difficult airway following induction,

the use of a video-laryngoscope is often recommended [7]. Different types of video-laryngoscopes have been presented in studies and case reports. Kariya et al. [8] reported that awake tracheal intubation with Airway Scope is safe in pregnant women with hemodynamic instability.

Topicalization can be performed in different ways. N. Glossopharyngeus nerve block can be performed in palatoglossal arc. It provides the blockade of gag reflex. N. Laryngealis recurrens and superior can be blocked in cervical level. Another technique is to apply local anesthetic infiltration at the oropharyngeal area. Mucosal atomization devices, inhalational lidocaine or lidocaine lolipops are aother alternatives. EMLA contains 2.5% lidocaine and 2.5% prilocaine and is another option for topicalization. The disadvantages include uncooperated patients, oversedation risk and failure due to inexperienced operator.

8. Surgical cricothyroidotomy

The frequency of obesity is increasing in pregnant women. Although regional anesthesia is recommended, surgical intervention may be required under general anesthesia. It is important to identify neck landmarks while performing surgical cricothyroidotomy. Cricothyroidotomy complications vary from 6.1% to 54.5% [9, 10]. Ultrasonography can provide advantages over traditional digital palpation in obese pregnant women by improving the image and increasing the accuracy of cricothyroid membrane identification [11].

9. Difficult airway guide in obstetrics

The incidence of failed tracheal intubation in obstetric patients is 1/390 [12]. In 2015, the Obstetric Anesthetists' Association and Difficult Airway Society in the UK came together and published the Guideline for difficult intubation in obstetrics [13] (**Figure 1**). Three algorithms are defined according to this guide. These consist of safe obstetric general anesthesia, obstetric failed tracheal intubation, and cannot intubate cannot oxygenate (CICO) steps. The first step is the Pre-induction planning and preparation and planning should be done with a team discussion. RSI is the recommended technique. However, mask ventilation can be performed so that the intraabdominal pressure does not exceed 20 cmH20. The practitioner can attempt at most two times in the presence of difficult tracheal intubation. The third attempt should only be performed by an experienced anesthesiologist. If there is a failure, a failed intubation declaration is made, and help is sought. Continuity of oxygenation is essential. 2 ventilation attempts can be made with a laryngeal mask. Ventilation should be continued with a face mask in case of failure. The 3rd algorithm is initiated if oxygenation fails with the mask. CICO is declared. 100% oxygen is continued to be given. Laryngospasm and insufficient muscle relaxation are excluded. If necessary, neuromuscular blockade is repeated. If oxygenation still fails, the front-of-neck access procedure is applied. If oxygenation of the patient can be achieved before starting the surgical airway, the team should decide according to the clinical condition of the pregnant woman. The patient can be awakened or a decision to continue can be given by evaluating the clinical situation of the pregnant woman and the experience of the operator. Maternal and fetal condition, obesity, surgical factors, aspiration risk, and airway require hazards consideration. Obstetric airway may provide a stressful environment because of failure risk of tracheal intubation and difficult mask ventilation. This may cause a risk of

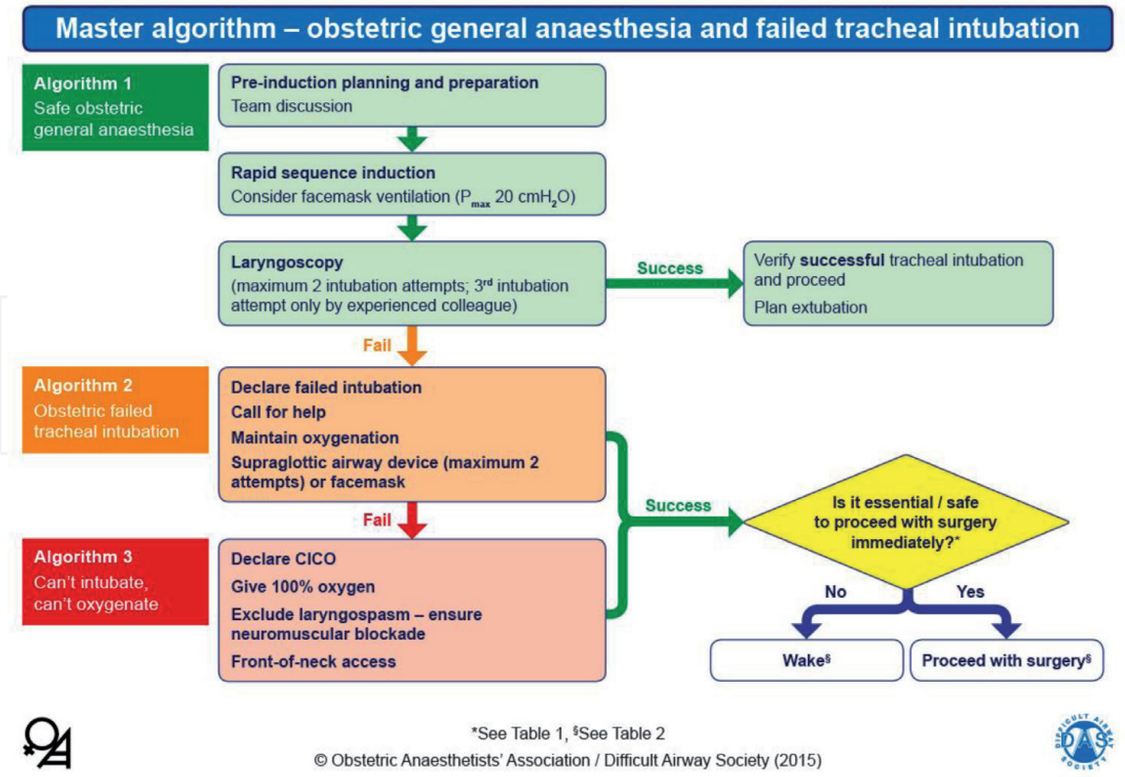

Figure 1.
Difficult airway society master algorithm for obstetric patients.

hypoxaemia, and trauma. Besides, team working should be managed carefully and the team leader should overcome possible errors related with decision-making or time management.

10. Video-laryngoscopes

It is widely available in obstetric units and is often used as a routine tracheal intubation device. It has been reported that it is available in 90% of obstetric units in the UK [2]. Aziz et al. [14] analyzed the data of 180 obstetric patients over 3 years. The first attempt success rate was found to be 100% with video-laryngoscopes. In case of failure in direct laryngoscopy, VL is also used as the rescue device.

Video-laryngoscopes can be classified as unchanneled, channeled, disposible, reusable, standart, angulated, and with tube channels. The selection criteria contains information about experience and competency, training purposes, shape, portability and cost. Necessity of stylet, angle of view, trauma incidence and blade types are among other reasons. For training purposes Macintosh shaped blade with monitor is recommended. In bloody or soiled airway, both Macintosh shaped blade and an extra-curved blade are useful.

11. Supraglottic airway devices

Supraglottic airway can be defined as medical devices that provide ventilation, oxygenation and delivery of anesthetic gases without tracheal intubation. Supraglottic airway devices are less invasive than tracheal tubes. They provide a better airway than a face mask. In DAS Difficult Airway Algorithm, these devices are recommended as resque techniques after failed tracheal intubation. The main

Elective surgeries should be postponed until after birth.
Non-emergency non-obstetric surgical procedures should be postponed as much as possible to the 2nd trimester with the lowest risk of preterm contractions and spontaneous abortion.
An obstetric care provider should be ready in the operating room ready during surgery.
Surgery should be planned in units with neonatal and pediatric services.
It should be decided to remove the fetus or maternal positioning by applying fetal heart rate monitoring.

Table 4.
Tips for anesthesia for non-obstetric surgery in pregnancy.

advantages are providing hemodynamic stability, the protection of mucociliary clearance, easy and fast insertion, less laryngeal trauma, and being easy to learn.

Supraglottic airway devices are also used for flexible bronchoscopic intubation. The success rate ranges from 76% to 100%. Aintree catheter is often used as an indirect method.

12. Training

Studies have reported inexperience as an important cause of failed airway management [15]. Creating checklists and teaching assistants this way is an important educational tool. Simsek et al. [16] reported that the checklist with video-based feedback can be placed in clinical practice permanently. Simulation-based training is among the most frequently used training techniques. However, knowledge and skills acquired through simulation should be able to be transferred to the clinical environment [17].

13. Non-obstetric anesthesia during pregnancy

Approximately 2% of pregnant women require non-obstetric surgery in any trimester [18]. Negative results occur after non-obstetric surgery during pregnancy. Maternal death was reported in 1/12.542 cases (0.006%), and the risk of miscarriage or fetal loss was reported to be 10.5% in the first trimester before the 20th week [19]. This rate was found to be 5.8% when all trimesters were evaluated. The practices to be followed by the ACOG Committee regarding non-obstetric surgeries are summarized in **Table 4** [20].

Airway management can be challenging because of breast engorgement, and weight gain. Edema and bleeding may occur during tracheal intubation or supraglottic airway device insertion. Reduced functional residual capacity and high oxygen consumption should be balanced with apneic oxygenation and preoxygenation. Preparations should be made according to difficult airway management guidelines.

14. Airway management in obstetric patient during COVID-19 pandemic

On admission, COVID-19 test should be performed for the obstetric patients. The testing is vital to protect the hospital staff and to prevent the vertical transfer to the neonate [21]. A checklist should be used for pre-anesthesia evaluation. Patients with COVID-19 may be presented with respiratory symptoms including pneumonia, Acute Respiratory Distress Syndrome (ARDS), lung effusion, and hypoxemia. As a physiological arrangement, functional residual capacity (FRC)

reduces in pregnancy. However these pulmonary conditions increase oxygen consumption, deplete the oxygen stores and cause a deeper decrease in FRC. Besides FRC may be lower than closing capacity when the patient lies in supine position for sugery. Therefore effective preoxygenation with left uterus dislocation is required. The operator should take cautions against fluid overload as the patients are sensitive. The delivery or the cesarean section should be performed in an isolation delivery room or negative pressure operating room [22]. Multi-disciplinary based team work isessential with detailed plans. Rapid sequence induction is recommended. A clamp is also recommended during the preparation period. Following tracheal intubation, lung-protective strategies should be followed including low tidal volume and PEEP titration. The risk of droplet and aerosol transmission of COVID-19 is a potential problem during mask ventilation and tracheal intubation. Personal protective equipment is recommended [23]. The use of barrier-enclosure devices were used in small case series or small-sample simulation studies. The ability to perform airway manuplations is a major concern for these devices. Therefore there is lack of evidence in this regard [24].

15. Extubation of obstetric patients

Stimulation of laryngeal reflexes, oxygen depletion, suppression, airway edema, loss of protective reflexes, an increase in sympathetic adrenergic tonus are main problems related with obstetric patients during extubation. Difficult Airway Society recommends awake extubation in patients with associated risk factors [25]. Bailey maneuver, remifentanil technique, staged extubation set, and tube exchange catheters are among advanced techniques [26]. Bailey maneuver is a technique for laryngeal mask exchange. Behind the tracheal tube a supraglottic airway device is inserted. By this way the operator can both ventilate the patient and extubate through the guidance of fiberoptic visualization. Thus, laryngospasm, bleeding, or edema can be treated early. In remifentanil technique, the patient receives low dose remifentanil infusion in order to prevent cough and postoperative pain. Airway exchange catheters are frequently used during extubation. Awake patients can tolerate these aduncts and oxygenation is possible. If reintubation is indicated the operator can advance the tracheal tube.

16. Postoperative monitoring

Awake extubation should be preferred. Muscle relaxant agents should be reversed. Sugammadex is recommended in cases with rocuronium. The patient can deteriorate and the airway may become obstructed. Therefore monitoring and supervision by experienced personnel are essential. A backup plan should be created and the team should be ready for reintubation. Ventilation, oxygen and carbon dioxide levels should be monitored. Severe preeclampsia, volume overload or existing co-morbidities may complicate the postoperative period.

17. Conclusion

Pregnant women come to the operating room for non-obstetric surgeries as well as cesarean operations. Pregnancy is characterized by significant physiologic changes in the respiratory system and airway. Reduced functional residual capacity, airway edema, and increased oxygen consumption are main factors. These changes

cause airway management to be complicated and difficult. Therefore effective preoxygenation is essential. Besides, apneic oxygenation is recommended in obstetric patients by using low and high flow oxygen delivery systems.

Regional anesthesia is preferred over general anesthesia because of its high risk of complications. Guidelines specific to pregnant women have been published and difficult airway management steps should be followed in patients undergoing general anesthesia. Patients with Covid 19 disease may present with Acute Respiratory Distress Syndrome (ARDS), lung effusion, and hypoxemia. Postoperative care should be planned. Extubation of pregnant patients should be considered awake and advanced techniques should be ready.

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