Difficult Airway in Obstetric Anesthesia: A Review

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Failed intubation and ventilation are important causes of anesthetic-related maternal mortality. The purpose of this article is to review the complex issues in managing the difficult airway in obstetric patients. The importance of prompt and competent decision making in managing difficult airways, as well as a need for appropriate equipment is emphasized. Four case reports reinforce the importance of a systematic approach to management. The overall preference for regional rather than general anesthesia is strongly encouraged. The review also emphasizes the need for professional and experienced team cooperation between the obstetrician and the anesthesiologist for the successful management of these challenging cases.

Target Audience: Obstetricians & Gynecologists, Family Physicians

Learning Objectives: After completion of this article, the reader will be able to break down the complex issues in managing the difficult airway in the obstetric patient, outline the reasons for difficult intubations in pregnancy, and describe the evaluation used to predict a difficult intubation.

The inability to maintain a patent airway after failed or difficult intubation and ventilation remains a major concern of anesthesia-related maternal morbidity or mortality and a significant source of malpractice claims in obstetrics (1, 2). The purpose of this review is to define the difficult airway, highlight the main reasons for difficult or failed intubation, and propose a practical approach to management. It is intended that this review will enrich the practitioner’s knowledge of the complex issues of airway management and enhance his involvement in anesthetic decision making. As noted throughout the review, an important component is the necessity for teamwork between anesthesiologist and obstetrician. The practical points of this review are exemplified by presentation of reports of problematic airway cases.

DEFINITION OF DIFFICULT AIRWAY

The difficult airway is defined according to the stage of airway management in which it is encountered; i.e., laryngoscopy, intubation, or ventilation (3). Difficult laryngoscopy is defined as the inability to visualize any portion of the vocal cords. Endotracheal intubation is considered difficult if it requires more than three attempts or takes longer than 10 minutes. This definition has been recently challenged by Benumof (4), who considers that a reasonably experienced anesthesiologist would be able to recognize a difficult intubation (laryngoscopy) from the first attempt. Difficult mask ventilation means an inability to maintain oxygen saturation (SaO₂) over 90% with an inspired oxygen concentration of 100%...
(O₂) and positive-pressure ventilation. These definitions are intended to establish clear-cut criteria and an exact quantification of the time and number of attempts at intubation and may help the anesthesiologist in deciding whether to call for assistance or to choose another approach for securing the airway. However, it should be understood that it is the failure in oxygenation and ventilation that causes a fatal outcome and not the inability to intubate per se. Thus, the ability to ventilate the patient effectively is of paramount importance.

INCIDENCE OF DIFFICULT INTUBATION AND VENTILATION

In obstetric anesthesia, difficult intubation is frequently unexpected. Although the incidences of airway difficulties encountered were low (7.9%) (5), they were still greater than those in the nonobstetric population (2.5%) (6). The reasons for the higher incidence of difficult airway in obstetric patients are not always evident. Interestingly, the incidence of very difficult intubation is very similar in both obstetric and nonobstetric populations, 2% versus 1.8%, respectively (6, 7). However according to Hawthorne et al. (8), the incidence of failed intubation in the obstetric population is 0.4%—approximately 10 times more frequent than in the general surgical patient population. The number of failed intubations has not decreased over the last 10 years. Mask ventilation was found to be laborious or impossible in 0.02% of patients (9), an incidence common to obstetric and other surgical patients. It is evident that not only pregnancy itself, but also other factors (i.e., distorted anatomy of the airway) are causes for intubation difficulties in pregnancy, although airway edema in pregnancy may certainly worsen the problem.

REASONS FOR DIFFICULT INTUBATION IN PREGNANCY

The reasons for difficult intubation in pregnancy may be divided into two groups: problems related to changes in airway anatomy and problems with the intubation technique.

Airway Anatomy

The anatomy of the airway may be impacted by four mechanisms: preexisting anatomical deformities, airway edema, coexisting diseases involving the airway, and obesity.

Preexisting airway deformities. Airway abnormalities may interfere with intubation mainly by one or more of the following mechanisms: decreased mobility of the neck, limited mouth opening, and reduced submandibular space. Table 1 depicts some changes in airway anatomy (not specific for pregnant patients) that interfere with the normal visualization of the cords. Of these, the most frequently encountered are “bull neck,” “buck teeth” and micrognathia. In any of these cases, the anesthesiologist should expect difficult intubation. Pilkington et al. (10) demonstrated in 242 pregnant women that the incidence of Class III airway (Mallampati classification) increased by 34% as pregnancy progressed. Mallampati classification is based on the view of the back of the mouth with the tongue protruded. The higher the grade (grade IV), the less visible is the junction between the soft and hard palate. The lower the grade (grade I), the more visible is the whole soft palate (uvula).

Airway edema. Airway edema results from hormonally induced fluid retention during pregnancy. This process is augmented by pregnancy-induced hypertension, if present, and by other conditions, such as excess weight gain, fluid overload, head-down position, oxytocin infusion (fluid retention due to the antidiuretic effect), and prolonged Valsalva efforts (11). Repeated intubation attempts may result in mucosal congestion that may lead to airway edema and bleeding. Edema of the face and neck should alert the anesthesiologist to the possibility of difficult intubation, whereas edema of the tongue may herald imminent airway compromise.

Diseases involving the airway. Table 2 presents some of the more frequently encountered diseases involving the airway. As a typical example, rheumatoid arthritis may render standard intubation impossible, necessitating the use of alternative airway management techniques (see “Airway Management for Cesarean Delivery”).

Obesity. Obesity is frequently encountered during pregnancy. Difficult intubation in the obese patient

<table>
<thead>
<tr>
<th>Abnormal airway anatomy (individual variations)</th>
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may be due to a short neck or large tongue and breasts, which make laryngoscopy and intubation laborious (12). In the morbidly obese parturient (greater than 300 lb), the cesarean delivery rate exceeds 50% (13). One third of the tracheal intubations were difficult, with a failure rate of 6% (13). Mask ventilation is often difficult in obese patients because of low chest compliance and increased intra-abdominal pressure. Finally, hypoxemia may ensue very rapidly in cases of failed intubation due to the decreased functional residual capacity and increased \( \text{O}_2 \) consumption.

Problems With the Intubation Technique

The goal of laryngoscopy is to visualize the vocal cords, whereas the goal of intubation is to introduce the endotracheal tube between them. Full visualization of the vocal cords is feasible in only 75% of patients (14). A grading of the laryngoscopic view (15) may aid in understanding the role of airway maneuvers (such as external cricoid pressure) and use of devices, such as the gum elastic bougie (16) in improving the laryngoscopic view or enabling intubation without full visualization of the cords. Failure to visualize the cords may be related to incorrect position for intubation, inadequate technique of laryngoscopy, inadequate muscle relaxation, or failure to apply laryngeal backpressure to facilitate the visualization of the cords. External pressure on the larynx should be applied backward, upward, and to the right (BURP maneuver) (17). The head and the neck of the patient should be placed in the so-called “sniffing” position. This position consists of 30-degree flexion of the neck on the chest and 15-degree extension of the head at the atlanto-occipital joint necessary to bring into one line the pharyngeal, oral, and laryngeal axes for a better laryngoscopic view. The application of cricoid pressure (used to prevent regurgitation of gastric contents) distorts the airway and makes the alignment of the head and neck into the “sniffing” position difficult. Other technical reasons for failure to intubate are related to the clinical expertise of the anesthesiologist dealing with the case. In pregnant patients, the problems encountered with intubation and ventilation are complicated by an impaired balance between oxygen delivery and consumption (18).

Oxygen delivery and arterial oxygenation are decreased as a result of elevation of the diaphragm, obesity, and a decreased inspiratory reserve volume (a component of functional residual capacity), which all give rise to ventilation/perfusion mismatches. These lead to early airway closure in the supine position, which is worsened by general anesthesia itself. Oxygen consumption is increased throughout pregnancy and even more so during active labor. The net result is a rapid fall in arterial and tissue oxygenation. Failure to control the airway and ventilate the patient would worsen hypoxemia and endanger both the mother and fetus. The practical implication of the tendency to develop hypoxemia very rapidly, is the need for preoxygenation (or denitrogenation) consisting of administration of 100% oxygen (for 3–5 minutes) before induction of anesthesia.

**PREOPERATIVE ASSESSMENT: PREDICTING A DIFFICULT INTUBATION**

An excellent interobserver reliability is necessary for any test to be predictive for difficult intubation (19). Table 3 lists some of the examinations and tests used to predict a difficult airway. None of these has a highly predictive value as a single tool. Nonethe-
less, Rocke et al. (5), by evaluating prospectively 1500 cases of elective and emergency intubations, has found that two or more abnormal airway findings are needed for prediction of difficult intubation. He also found that a highly predictive sign was a neutral to extension sterno mental distance of less than 5 cm. Rocke has built a scale of predictive factors showing clearly that the greater the number of abnormal findings, the higher the prediction accuracy for a difficult intubation. Regional anesthesia should be considered if two or more risk factors are found. In addition, anesthesiologists should be familiar with the American Society of Anesthesiologists (ASA) Practice Guidelines for management of the difficult airway (20). Some practitioners may have more experience with fiberoptic airway management than with establishing a well-functioning epidural. Regardless of how skillfully a regional anesthetic is installed, it still may not be satisfactory—block level is too high, duration too short, or toxicity of local anesthetics—so that practitioners prefer to use a general anesthesia.

**ASPIRATION OF GASTRIC CONTENTS: A POSSIBLE RESULT OF DIFFICULT INTUBATION**

Regurgitation of stomach contents into the oropharynx is more likely to occur when there is an increase in abdominal contents, slowing of gastric emptying, or dysfunction of the gastroesophageal sphincter, all present during pregnancy. One of the purposes of intubation is to seal off the entrance to the larynx with a cuffed endotracheal tube. Therefore, aspiration of gastric contents may result from failure to intubate. Once intubation fails, the chances of not being able to ventilate increase markedly. With mask ventilation, there is also a risk of distention of the stomach, and the inherent danger of aspiration of stomach contents. It is for this reason that mask ventilation is avoided during induction of anesthesia in the obstetric patient. There are many well-recognized risk factors, which may lead to a higher propensity for regurgitation in pregnancy, including hormonal changes, physical factors, and parenteral analgesics or induction agents (21). Among the hormonal factors, increased gastrin secretin and progesterone and decreased secretion of motilin are responsible for the delay in gastric emptying. Physical factors include a decreased lower esophageal sphincter tone and increased intragastric pressures, which are both worsened by the lithotomy position and the stress and pain of labor. Use of narcotics during labor and delivery may also delay gastric emptying. Anesthetic agents (e.g., thiopental) relax the upper esophageal sphincter (the last barrier against regurgitation of gastric content) shortly before the patient loses consciousness (22). These changes emphasize the need for the application of cricoid pressure before the patient loses consciousness (23). Cricoid pressure is applied directly over the cricoid cartilage, the only solid structure in the larynx, with the intent of applying backpressure on the esophagus and preventing regurgitation into the oropharynx. However, the effectiveness of cricoid pressure has been questioned (24), inasmuch as patients have died despite its application (25). Gastric distention produced by poor mask ventilation and escape of anesthetic gases into the stomach further increase the intragastric pressure and hamper ventilation. A critical scenario is created due to failure to oxygenate the patient as a result of failed intubation, inadequate mask ventilation, and aspiration of gastric contents. The incidence of aspiration in obstetrics ranges from 1/10,000 to 15/10,000 (26) and it seems to be significantly higher in cesarean deliveries than with other obstetric procedures performed under anesthesia. In a retrospective study, Ezri et al. (27) have found a low incidence of aspiration in parturients.

**TABLE 3**  
**Preoperative tests useful in predicting difficult intubation**

<table>
<thead>
<tr>
<th>No.</th>
<th>Test</th>
<th>Meaning</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Atlanto-occipital movement</td>
<td>Ability to extend head on the neck. 15 degrees is needed for “sniffing” position.</td>
</tr>
<tr>
<td>2</td>
<td>Back of the mouth view (Mallampati classification)</td>
<td>Class I: (the whole uvula is visible)—easy intubation</td>
</tr>
<tr>
<td>3</td>
<td>Jaw movement</td>
<td>Class IV (only the hard palate is visible)—intubation may be difficult</td>
</tr>
<tr>
<td>4</td>
<td>Mouth opening</td>
<td>The ability to protrude the lower teeth over the upper teeth. With prominent (buck’s) upper teeth, insertion of the laryngoscope may be difficult.</td>
</tr>
<tr>
<td>5</td>
<td>Thyromandibular distance</td>
<td>Should be at least 4 cm. Reflects the movement of the TMJ* joint</td>
</tr>
<tr>
<td>6</td>
<td>Thyrosternal distance</td>
<td>&lt;6 cm, a difficult laryngoscopy is predicted.</td>
</tr>
</tbody>
</table>

* TMJ = temporomandibular joint.
requiring short peripartum procedures under general anesthesia without endotracheal intubation.

MATERNAL MORTALITY DUE TO DIFFICULT INTUBATION

The net result of failure to intubate/ventilate is hypoxemia, which may eventually lead to brain damage or death. Failure to intubate/ventilate is responsible for 30% of the overall anesthetic brain damage and death in the general surgical population (28). Information on maternal mortality in the medical literature is scarce, possibly related to fear of litigation.

Nevertheless, data available from the “Confidential Inquires into Maternal Death in England and Wales,” are comprehensive and reliable and provide continuous information since 1952. In the United Kingdom, between 1970 and 1987 (29), maternal death related to anesthesia decreased by 80% from 12.8 to 1.9 per one million live births. Death was associated only with general anesthesia and was caused by aspiration of gastric contents and failed intubation. In the United States, the anesthesia-related maternal death rate has fallen from 4.3 per one million live births in 1979 to 1981 to 1.7 per one million in 1988 to 1990, mainly owing to the increasing use of regional anesthesia for cesarean delivery (30). Most deaths were attributed to airway management difficulties. Surprisingly, despite the widespread use of pulse oximetry (early detection of hypoxemia) and capnography (detection of esophageal intubation) mortality related to general anesthesia did not decrease, and anesthesia-related death is still the sixth leading cause of maternal mortality in the U.S. (5, 30–32). The current overall maternal mortality rate is approximately 9.2 per 100,000 live births (33, 34). Today, failed intubation is the most common cause of anesthesia-related maternal mortality (31) occurring during cesarean deliveries. One of the important factors contributing to maternal death was the failure of communication between the anesthesiologist and the obstetrician. Risk factors for increased anesthetic-related mortality in obstetrics include age over 30 years, obesity, pregnancy-induced hypertension, nonwhite race, and emergency cesarean delivery (35). These findings may point to two important recommendations: 1) increase the use of regional anesthesia for cesarean delivery and 2) improve the safety of general anesthesia (36). This review will emphasize the second recommendation of improving safety for the patients requiring general anesthesia and intubation. The American College of Obstetricians and Gynecologists (ACOG) Committee on Obstetrics (1992) recommends early consultation with an anesthesiologist in patients at high risk for general anesthesia to encourage early decision making and improve the cooperation between the obstetricians and anesthesiologists (37).

DECISION MAKING

When difficult intubation is suspected in airway management, an experienced anesthesiologist and the obstetrician should decide which anesthetic technique is most appropriate. If feasible under these circumstances, the procedure should be performed under regional anesthesia. Appropriate airway management equipment should always be available. Ta-

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**TABLE 4**

<table>
<thead>
<tr>
<th>No.</th>
<th>Device</th>
<th>Comment*</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Airways</td>
<td>Oropharyngeal, nasopharyngeal—3 sizes of each</td>
</tr>
<tr>
<td>2</td>
<td>Bougie</td>
<td>Eschmann, gum-elastic (a long introducer inserted blindly underneath the epiglot-tis, then the ET tube is “railroaded” over it)</td>
</tr>
<tr>
<td>3</td>
<td>ET tubes</td>
<td>At least 3 different sizes</td>
</tr>
<tr>
<td>4</td>
<td>Laryngoscopes</td>
<td>Two sizes of curved (Macintosh) and straight (Miller) blades</td>
</tr>
<tr>
<td>5</td>
<td>LMA and combitube</td>
<td>Size 3 and 4 LMA</td>
</tr>
<tr>
<td>6</td>
<td>Suction device</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Fiberoptic bronchoscope</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Jet injector</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Percutaneous cricothyrotomy kit</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Drugs for topical anesthesia</td>
<td>Lidocaine, ephedrine</td>
</tr>
<tr>
<td>11</td>
<td>Drugs for general anesthesia</td>
<td>Thiopental, succinylcholine, opiates, etc</td>
</tr>
<tr>
<td>12</td>
<td>Drugs for CPR</td>
<td>Atropine, epinephrine, etc</td>
</tr>
<tr>
<td>13</td>
<td>Monitoring equipment</td>
<td>ECG, pulse oximeter, noninvasive blood pressure, capnography (detection of expiratory CO₂ indicates the correct placement of the ET tube), disconnection alarm</td>
</tr>
</tbody>
</table>

* ET = endotracheal; LMA = laryngeal mask airway; CPR = cardiopulmonary resuscitation.
ble 4 lists the basic equipment necessary for the management of a difficult airway.

**AIRWAY MANAGEMENT FOR CESAREAN DELIVERY**

Management depends on whether surgery is elective or urgent and whether a difficult airway is predicted. Furthermore, the condition of the fetus (distressed or not) may influence the anesthetic approach. It is generally accepted that if in an extreme emergency a choice has to be made between survival of the fetus or of the mother, the mother should be protected in preference to the fetus, and this would be an extraordinarily rare occurrence. Nonetheless, it is prudent to emphasize that, in almost all emergency situations, support and resuscitation of the mother will benefit the fetus. One major exception to this is when CPR must be administered to the mother in the third trimester of pregnancy. In this situation, immediate delivery of the fetus will likely benefit both the mother and the fetus/infant because CPR attempts can be ineffective because of the pressure of the pregnant uterus on the great vessels.

**Induction of Anesthesia for Cesarean Delivery With an Apparently Normal Airway**

Table 5 depicts the steps of a standard general anesthesia for cesarean deliveries. When an unexpected difficult intubation is encountered during induction of anesthesia, the patient should be awakened (if there is no indication for an emergency operation) and surgery performed under regional anesthesia (38). Spinal anesthesia is preferred over epidural anesthesia because of its faster onset, higher success rate and lower risk of total spinal anesthesia and local anesthetic toxic reaction, owing to administration of a smaller dose of drug. Although the use of spinal anesthesia for urgent cesarean remains controversial, especially concerning the final level of the block, its duration of action, and the consequences of hypotension, it has gained more acceptance during the last decade (39). According to the ACOG committee opinion (37), cesarean deliveries that are performed for nonreassuring fetal heart rate pattern do not necessarily preclude the use of regional anesthesia. A combination spinal-epidural anesthesia (CSE), a relatively new technique, has gained popularity. It provides the combined advantage of rapid onset of spinal anesthesia together with flexibility of extending or prolonging the duration of the block (40). When the fetus is in acute distress, surgery could proceed even if intubation failed provided oxygenation and ventilation are adequate. If the airway (oxygenation and ventilation) cannot be maintained by a facemask or other airway devices [LMA (laryngeal mask airway), Combitube], an artificial airway should be created (i.e., transtracheal needle jet ventilation, cricothyroidotomy, or tracheostomy) before proceeding with surgery (41).

**Patients With Known or Suspected Airway Problems Before Cesarean Delivery**

Regional anesthesia is indicated if surgery is not urgent (no signs of severe maternal bleeding, severe fetal distress, etc.) and the coagulation tests are acceptable (platelet count >50,000/ml, bleeding time

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<tr>
<th>No.</th>
<th>Steps</th>
<th>Comments</th>
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<tbody>
<tr>
<td>1</td>
<td>Equipment ready</td>
<td>See Table 4</td>
</tr>
<tr>
<td>2</td>
<td>Patient’s position</td>
<td>Left lateral tilt (15 degrees) to avoid supine hypotension airway—“sniffing” position</td>
</tr>
<tr>
<td>3</td>
<td>Monitoring attached</td>
<td>ECG, blood pressure, pulse oximetry, capnography, temperature</td>
</tr>
<tr>
<td>4</td>
<td>Preoxygenation (denitrogenation)</td>
<td>3-5 min of 100% O₂ with normal breathing, or 4 deep breaths of 100% O₂ if there is no time for the first option</td>
</tr>
<tr>
<td>5</td>
<td>Another anesthesiologist available for help</td>
<td>For cricoid pressure</td>
</tr>
<tr>
<td>6</td>
<td>Induction of anesthesia</td>
<td>For unexpected difficult intubation</td>
</tr>
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- Apply cricoid pressure before the patient loses consciousness |
- Inject succinylcholine |
- Wait for 30–40 sec and intubate the trachea |
- Inflate the tube’s cuff |
- Confirm the tube’s correct position by capnography |
- Release cricoid pressure |
- Continue with general anesthesia |
<10 minutes; no significant drop in the platelet count in a short time or evidence of clinical bleeding) (42). In the case of patient refusal or if regional anesthesia is contraindicated, awake fiberoptic intubation may be an option (38, 41). In the case of failure of regional anesthesia, a more experienced anesthesiologist may succeed in performing spinal anesthesia. Equipment for managing the difficult airway should be ready for use in the operating room suite and treatment possibilities discussed with the obstetrician. Risks and benefits should be thoroughly explained to the patient, and she should be strongly encouraged to accept regional anesthesia. If general anesthesia is chosen in the case of failure of regional anesthesia, a comprehensive plan of action should be ready.

Emergency Cesarean Delivery: Urgent Delivery Versus Airway Management

An emergency cesarean delivery is performed for maternal or fetal indications. Severe maternal bleeding and/or fetal distress is among the most common indications for an emergent cesarean.

Even if problems are recognized preoperatively, some surgery cannot be delayed by performing regional anesthesia or fiberoptic intubation. Harmev, Latto, and Vaughan (38) had proposed an urgency delivery scoring system to help answer the dilemma of whether to delay surgery if a difficult intubation is anticipated or occurs with induction of general anesthesia. A simplified form of this scoring is the following:

- **Group 1**: Surgery should be started even if difficult intubation is anticipated. This group includes severe maternal bleeding and severe fetal distress. In these cases, surgery must be performed even if intubation was unsuccessful, provided ventilation and oxygenation of the mother is possible. By no means should surgery begin if oxygenation and ventilation are unsatisfactory.
- **Group 2**: Regional anesthesia is permitted and indicated, and there is no urgency to perform surgery.
- **Group 3**: An intermediate group that includes patients with relative contraindications to regional anesthesia, such as cardiac disease or bleeding, but stable hemodynamics; nevertheless, there is a strong indication for regional anesthesia due to airway pathology. In these cases, clinical common sense, experience, and anesthesiologist-obstetrician team consultation should decide which approach is safest.

ACOG defines fetal distress as acute continuous bradycardia of less than 60 to 80 beats per minute or severe decelerations. Because the term fetal distress is imprecise, the recommendation is to use the term non-reassuring fetal stress. Their recent committee opinion does not give a definition of acute fetal distress. They also state that non-reassuring fetal status is absolutely not contradicted to the use of regional anesthesia (43).

SPECIAL AIRWAY DEVICES AND TECHNIQUES

Two devices have revolutionized the management of difficult airway: the fiberoptic bronchoscope and the laryngeal mask airway (LMA). A detailed discussion on fiberoptic intubation (FI) is beyond the scope of this review, but it should be noted that expertise is needed to perform FI quickly and safely (44, 45). FI may not succeed if the view is impaired by blood and/or secretions (“red out” or “white out”) as may be the case after a failed intubation. Also, FI may be time consuming and, therefore, does not provide an emergency means of securing the airway. Awake intubation may be an alternative to control the airway if regional anesthesia fails in a patient with known or suspected airway problems (46). LMA may sometimes be the only option when mask ventilation is not possible, even with mandibular traction and insertion of oral and nasal airways. Successful ventilation provided by the LMA after failed intubation has been reported in patients undergoing cesarean delivery (47–49). An endotracheal tube can also be inserted through an LMA, either blindly or with the aid of a fiberscope. The main drawback of the LMA is the lack of protection against aspiration. Despite that, in a critical scenario of impossible intubation and ventilation, the crucial role of LMA in providing ventilation outweighs its drawbacks. LMA is inserted blindly without the help of a laryngoscope and, thus, is less traumatic. LMA is composed of a soft mask connected to a tube. Its distal inflated cuff provides a seal around the entrance to the larynx (glottis), and the three apertures on the anterior aspect of the cuff enable ventilation and monitoring of respiration. There are three sizes available for adults: 3, 4, and 5. The new intubating LMA (LMA, Fastrach, WM Bamford, New Zealand) is designed to increase the success rate of intubation through an LMA. The esophageal-tracheal Combi-
tube is a relatively new device designed for management of difficult airway especially after failure of intubation and impossible ventilation. It has two lumens and two cuffs (they help in fixation of the Combitube and sealing of the airway). The “esophageal” lumen provides ventilation through the eight side holes facing the glottic aperture, while the “tracheal” lumen enables suction of the stomach and ventilation of the lungs in the rare cases where the tube enters the trachea accidentally. There are two sizes available: one for standard size patients and one for patients with short stature (<150-cm height). At the moment, the Combitube, like the LMA, is indicated in cases when ventilation through a facemask is impossible. It has the advantage over the LMA of protecting against aspiration of gastric contents. Like the LMA, it is inserted blindly, but is somewhat more traumatic than the LMA. The Combitube has been used successfully for management of failed intubation in cesarean delivery (50). A transtracheal jet ventilation (TTJV) device consists of a simple I.V. plastic cannula (14 or 16 gauge) inserted through the cricothyroid membrane. A jet injector provides ventilation with oxygen pressurized to 50 pounds per square inch (psi). Jet ventilation is used when other modalities of ventilation, including LMA and Combitube, fail or are not available (51). The major risk of TTJV is barotrauma, which may occur if the inflation pressure was not controlled by a pressure-regulator, and emptying of the lungs is not fully allowed by maintenance of an inspiration to expiration ratio of at least 1:3.

**FAILED INTUBATION ALGORITHM**

A universal failed intubation/ventilation algorithm was proposed by Benumof (20) and is currently recommended by the American Society of Anesthesiologists. A practical difficult and failed intubation and ventilation drill, as shown in Figure 1, is proposed by the authors of this review to cover almost every possible clinical situation encountered during anesthesia for cesarean delivery. The main management principle in this algorithm is the overall preference of regional over general anesthesia.

**CASE REPORTS AND DISCUSSION**

**Case 1: Use of LMA for Failure to Intubate/Ventilate**

A 31-year-old, otherwise healthy full-term pregnant woman was scheduled for cesarean delivery because of breech presentation. Her medical history revealed no diseases and no previous surgery. Her airway looked normal. She refused spinal anesthesia. General anesthesia was induced with thiopental and succinylcholine in a rapid sequence manner, while...
cricoid pressure was applied. No part of the glottic structures could be visualized on three successive attempts at laryngoscopy, and the SaO₂ dropped gradually to 90% at the end of the third attempt. Mask ventilation with mandibular thrust and oral and nasal airways was ineffective, and the SaO₂ further dropped to 80%. At this point, a number 3 LMA was placed successfully, and ventilation resumed effectively. Surgery started immediately, and the baby was delivered with Apgar scores of 8 and 9 at 1 and 5 minutes, respectively. The patient was allowed to breathe spontaneously through the LMA while anesthesia was maintained with isoflurane. Cricoid pressure was applied until the end of surgery. This case and the others emphasize the crucial role of LMA in maintaining oxygenation and ventilation with failed intubation and failed mask ventilation.

Case 2: Failure to Intubate/Ventilate—Use of Transtracheal Jet Ventilation

A 30-year-old primipara was scheduled for emergency CD due to fetal distress (fetal bradycardia <80 bpm). On inspection, the airway appeared problematic (short neck, protruding teeth), but the obstetrician determined that there was no time for performing regional anesthesia. After three failed attempts at intubation and failed mask ventilation, the SaO₂ dropped to 70%. Attempts to ventilate through an LMA and then a Combitube were futile. A 14-gauge I.V. cannula was inserted through the cricothyroid membrane. The plastic catheter was connected to a jet injector, and the patient was ventilated effectively over the next 10 minutes. The baby was delivered with Apgar scores of 6 and 9 at 1 and 5 minutes, respectively. After 10 minutes of transtracheal jet ventilation, the trachea was intubated with a fiberscope. When intubation, mask ventilation, and the insertion of an LMA or Combitube all fail, the fastest option to oxygenate the patient is a cannula inserted through the cricothyroid membrane and connected to a patient ventilator.

Case 3: Failed Regional Anesthesia—Fiberoptic Intubation

A 25-year-old morbidly obese patient was scheduled for an elective CD because of severe preeclampsia. She had a short neck and limited mouth opening (<3 cm). Her blood pressure was 190/110 despite of treatment with magnesium sulfate, nifedipine, and hydralazine. Many attempts at performing epidural or spinal anesthesia were unsuccessful. A small sedative bolus of midazolam and an antisialagogue dose of atropine were administered intravenously. A nasal fiberoptic intubation was planned. The nose was anesthetized topically with lidocaine, and ephedrine was used as nasal vasoconstrictor. Once the cords were visualized, lidocaine was sprayed over them through the working channel of the fiberoptic bronchoscope and the trachea was intubated easily. Throughout the procedure, boluses of labetalol were administered for controlling the hypertension. The rest of the management was uneventful. With expected difficult intubation and failed regional anesthesia, awake fiberoptic intubation may be a safer alternative airway management.

Case 4: Failed Intubation—Use of LMA as a Conduit for Fiberoptic Intubation

A 34-year-old primipara with a ruptured uterus and severe fetal bradycardia (<50 bpm) was rushed to the operating room for emergent CD. The patient was pale, tachycardic (135 bpm), with blood pressure 60/40, and barely responsive to verbal stimuli. She was connected to standard monitoring, and four vital capacity breath preoxygenation and rapid sequence induction (ketamine, succinylcholine) with cricoid pressure were performed immediately. The laryngoscopy proved to be difficult, but some glottic structures were identified and the endotracheal tube inserted. Surgery started immediately. On auscultation, although breath sounds were noticed over the lungs, the capnograph trace remained flat, and the patient desaturated rapidly. The tube was removed, and mask ventilation was performed effectively. The baby was delivered with Apgar scores of 1 and 5 at 1 and 5 minutes, respectively. The patient was bleeding actively and intensive resuscitation with blood, blood products, and crystalloids was necessary. At this stage, uterine suture was performed and cesarean hysterectomy was planned. Because of the extent of surgery, the airway had to be secured. An oral fiberoptic intubation failed due to copious bloody secretions. A number 4 intubating LMA was easily inserted, and the patient ventilated through it for a few minutes. A second attempt at fiberoptic intubation with a number 6 endotracheal tube through the LMA was successful. The LMA and the endotracheal tube were left in place until the end of the procedure. During the next hour, seven packed cell blood units were administered, and a hysterectomy was performed. With extensive surgery, the airway should be secured with an endotracheal tube (ETT). This may be more feasible than using a fiberscope inserted through an LMA.
CONCLUSION

The challenge of anesthetizing a pregnant patient is complicated further by difficulties in airway management. As recommended by the American College of Obstetricians and Gynecologists, early consultation between the obstetrician and an experienced anesthesiologist is one of the governing principles of management (37). Another element, for successful and safe management of patients at risk for difficult intubation/ventilation, is the overall provision for regional rather than general anesthesia.

REFERENCES


