Airway problems in pregnancy

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Objectives: **To provide a current review of the literature regarding airway problems in pregnancy and management.**

Background: **Obstetrical anesthesia is considered to be a high-risk practice that exposes the anesthesiologist to increased medicolegal liability. Anesthetic management of a parturient is a challenge because it involves simultaneous care of both mother and baby. Failure to appropriately manage a difficult or failed intubation increases the risk of hypoxemic cardiopulmonary arrest and/or pulmonary aspiration, resulting in a high probability of maternal morbidity and mortality.**

Data: **Anesthesia is the seventh leading cause of maternal mortality in the United States. Anatomic and physiologic changes during pregnancy place the parturient at increased risk for airway management problems. It is essential to perform a thorough preanesthetic evaluation and identify the factors predictive of difficult intubation. Airway devices such as the laryngeal mask airway, ProSeal, intubating laryngeal mask airway, Combitube, and laryngeal tube are described and have been used during failed intubation in pregnant patients.**

Conclusion: **Teamwork between an anesthesiologist and an obstetrician is absolutely essential for the safety of both the mother and baby. Most of us tend to agree that airway emergencies have a way of occurring at the worst possible times. It is essential that all anesthesia care practitioners must have a preconceived and well thought-out algorithm and emergency airway equipment to deal with airway emergencies during difficult or failed intubation of a parturient. (Crit Care Med 2005; 33[Suppl.]:S259–S268)**

Key Words: Pregnancy; difficult intubation; preeclampsia; maternal mortality; difficult airway algorithm; general anesthesia; regional anesthesia; failed intubation; cesarean section; labor

The management of a difficult airway in an obstetrical patient is especially challenging during an acute obstetrical emergency and can be an anesthesiologist's worst nightmare (1). Failure to appropriately manage a difficult or failed intubation increases the risk of hypoxemic cardiopulmonary arrest and/or pulmonary aspiration, resulting in a high probability of maternal morbidity and mortality. A timely preoperative airway evaluation, recognition of factors associated with or predisposing to difficult airway, and appropriate preparation for dealing with both anticipated and unanticipated difficulties of airway management are essential to reduce anesthesia-related maternal and fetal morbidity and mortality (2).

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Several factors tend to evoke apprehension in even the most competent anesthesiologist when dealing with a pregnant woman. The most important factors are pregnancy-related altered anatomy and physiology impacting anesthetic management, the urgent nature of the obstetrical practice, leading to limited time for adequate anesthetic preparation, and the potential risk of impacting both mother and baby (3).

Anesthesia-Related Maternal Mortality

Even though anesthesia-related maternal mortality rates have improved in the United States, anesthesia still remains prominent amongst the leading causes of maternal mortality; it is the seventh leading cause of maternal mortality in the United States. The other six leading causes of maternal mortality are embolism, hypertensive disorders, hemorrhage, infection, cardiomyopathy, and cerebrovascular accident (4). General anesthesia is more likely to be associated with maternal mortality than is regional anesthesia in the obstetrical patient, for the following reasons: airway management tends to be more difficult in pregnant patients; general anesthesia is chosen in emergency surgeries, particularly when there is minimum time allowed for adequate preoperative evaluation; in conversion of regional anesthetic to general anesthesia, secondary to failed regional anesthesia, hemorrhage, or prolonged surgery, the patient is not usually placed in an optimal position for intubation; there is increased usage of regional anesthesia in obstetrics; residents lack experience because of minimal exposure to general anesthesia for cesarean sections, resulting in decreased airway management skills for obstetrical patients.

The Closed Claims Analysis of the American Society of Anesthesiologists (ASA) revealed that respiratory events accounted for the single largest class of injury (5). The case studies included both general anesthesia and regional anesthesia. Three mechanisms accounted for nearly three-quarters of the cases: inadequate ventilation (38%), esophageal intubation (17%), and difficult intubation (18%). Care was judged substandard in 76% of the claims for adverse respiratory events (6). According to the closed claims study by Chadwick and colleagues, difficult tracheal intubation and esophageal intubation comprised 23% of damaging events associated with obstetrical general anesthesia (7). Complications of anesthesia-related deaths due to airway manage-

Table 1. Anatomic and physiological factors affecting the obstetric airway

Upper airway edema	Decreased functional residual capacity
Breast enlargement	Increased oxygen consumption
Excessive weight gain	Increased risk of aspiration
Cephalad displacement of diaphragm	Preeclampsia

ment problems included aspiration of gastric contents, intubation problems, esophageal intubation, inadequate ventilation, and respiratory failure.

Anatomic and Physiologic Changes During Pregnancy

There are a number of anatomic and physiologic changes during pregnancy that result in difficult airway and pose a threat to difficult or failed intubation (Table 1). Capillary engorgement of the mucosa throughout the respiratory tract causes swelling of the nasal and oral pharynx, larynx, and trachea, resulting in difficulty with nasal breathing, epistaxis, and voice changes (8, 9). Elevated estrogen levels and an increase in blood volume associated with pregnancy may contribute to the mucosal edema (10). These changes may be markedly exacerbated by a mild upper respiratory tract infection, fluid overload, or the edema associated with preeclampsia, which can lead to a severely compromised airway (11–13).

Pregnancy is associated with a shift in the position of the stomach caused by the gravid uterus, which also changes the angle of the gastroesophageal junction, resulting in incompetence of the gastroesophageal pinchcock mechanism (14). The progesterone-mediated smooth-muscle relaxant effect on the gastrointestinal mucosa, along with the anatomic changes secondary to the gravid uterus, places the parturient at risk for regurgitation and pulmonary aspiration. Lower esophageal sphincter tone is decreased, allowing gastric reflux and heartburn during pregnancy (15). Studies have shown that gastric emptying is prolonged during labor (16, 17). Therefore, the parturient is prone to silent regurgitation, active vomiting, and aspiration during general anesthesia or impaired consciousness (18). All parturients undergoing an anesthetic for cesarean section are considered at risk for pulmonary aspiration and should receive aspiration prophylaxis preoperatively.

A parturient gains 20 kg or more during pregnancy. The weight gain results from the increasing size of the uterus and fetus, increased volumes of blood and interstitial fluid, and deposition of fat. There is also a significant increase in breast size during pregnancy. Increased weight gain during pregnancy and large breast size can cause difficulty with intubation. Proper positioning, with blankets under the shoulders, and use of a short-handled laryngoscope can minimize the hazards of difficult laryngoscopy.

Airway Assessment

Most airway catastrophes occur when airway difficulty is not recognized before induction of anesthesia. Timely evaluation of the parturient's airway and adequate preparation to deal with the airway in the nonemergent setting are helpful in avoiding airway catastrophes. Eighty-seven percent of emergency or urgent cesarean deliveries can be anticipated by regular evaluation of patients who are admitted to the labor and delivery suite, thus allowing for early placement of a functioning epidural and avoiding instrumentation of the airway when the cesarean section is called or when the patient is committed to having a cesarean section (19).

There are a few simple preoperative bedside determinations that can be performed quickly to evaluate the airway in a pregnant patient. These include but are not limited to mouth opening, Mallampati class, thyromental distance, atlanto-occipital extension, and ability to protrude the mandible.

Mallampati Class

The relationship of the base of the tongue to the oropharyngeal structures—uvula, tonsillar pillars, and faucial pillars—forms the basis of the Mallampati classification. Mallampati hypothesized that when the base of the tongue is disproportionately large in relation to the oropharyngeal cavity, the enlarged base of the tongue can obscure the visibility of the tonsillar pillars and uvula (20) and result in difficulty with laryngoscopy and intubation. Based on the original Mallampati classification and the modification by Samsoon and Young, there are four classes (21): class I, visualization of soft palate, uvula, and tonsillar pillars; class II, visualization of soft palate and base of uvula; class III, visualization of soft palate only; and class IV, visualization of only hard palate. Samsoon and Young demonstrated that there is significant correlation between the ability to visualize pharyngeal structures and ease of laryngoscopy (Fig. 1).

Cormack and Lehane evaluated the laryngoscopic view of the glottis and divided it into four grades (22) (Fig. 2): grade I = most of the glottis visible; grade II = only posterior portion of glottis visible; grade III = only epiglottis visible; grade IV = epiglottis not visible.

A significant correlation has been noted between Mallampati class and laryngoscopic view grade. Patients with class I and II airways are almost always easy to intubate and are associated with laryngoscopic grade I and II views, whereas patients with Mallampati class III and IV airways are associated with laryngoscopic grade III and IV views (21).

Atlanto-Occipital Joint Extension

This extension is important in aligning the oral, pharyngeal, and laryngeal axes during laryngoscopy. Normally the atlanto-occipital joint allows a 35-degree extension of the head over the neck. A reduction in the extension of the joint can cause difficulty with intubation. Complete atlanto-occipital joint immobility can compromise the view of glottis during laryngoscopy. Sniffing position is achieved by moderate flexion of the neck on the chest and extension of the atlanto-occipital joint. With the patient in proper sniffing position, the view of the larynx is less obscured by the tongue.

Thyromental Distance

This is defined as the distance from the chin to the notch of the thyroid cartilage. The thyromental distance gives an estimate of the mandibular space and is easy to measure either by a ruler or by number of finger-breadths. A measurement of >6.5 cm with no other anatomic abnormalities indicates easy intubation. A measurement of 6–6.5 cm indicates that laryngoscopy and intubation may be difficult but most likely possible. If the distance is <6 cm, laryngoscopy and intubation may be difficult or impossible. Mandibular space is an important predic-

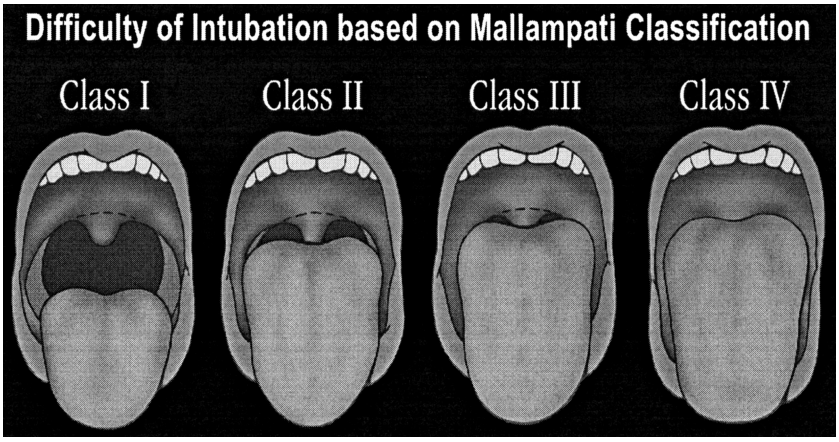

Figure 1. Difficulty of intubation based on Mallampati classification. Adapted from Mallampati SR: A clinical sign to predict difficult tracheal intubation: A prospective study. *Can J Anaesth* 1985; 32:429.

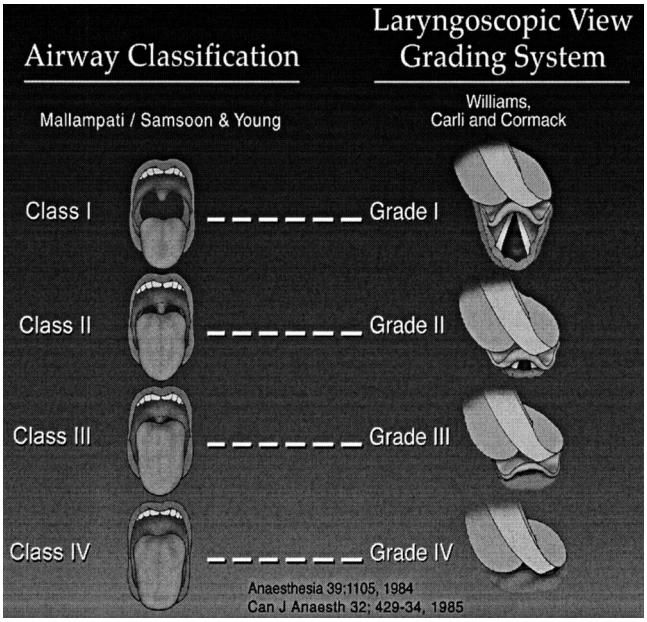

Figure 2. Airway classification in relation to laryngoscopic view grading system. Adapted from *Anesthesia* 1984; 39:1105; *Anaesthesia* 1987; 42:487; and *Can J Anaesth* 1985; 32:429.

tor of difficult intubation because the tongue is displaced into this space during laryngoscopy.

Data suggest that the Mallampati score changes during gestation, with an increase to class IV airway between 12 and 38 wks of gestation. The increase in the Mallampati score is secondary to weight gain during pregnancy (23). The trend toward a worsening Mallampati score is also thought to be due to increased pharyngeal edema and fatty infiltration of pharyngeal tissue. During labor, parturients are susceptible to developing airway tissue edema as a result of excessive intravenous infusion of fluids, resulting in a lowering of the already decreased colloid osmotic pressure (24). The shift in the Starling forces results in an exacerbation of airway edema, thus increasing the Mallampati class. The bearing down efforts and Valsalva maneuver during labor also exacerbate the worsening of the Mallampati score (8), and it is recommended that the airway be reassessed before induction of general anesthesia (25).

It is clear that no single airway assessment can reliably predict a difficult airway. Nevertheless, preoperative predictors of difficult airway are essential to facilitate the management of the airway and to reduce the likelihood of adverse outcomes. Predicting difficult airway enables the anesthesia practitioner to implement proper care and thus avoid airway catastrophes. Every pregnant patient who will undergo an operative delivery should have a preanesthetic evaluation that emphasizes the airway examination as outlined by the ASA practice guidelines (26).

Rocke and colleagues conducted a preoperative airway assessment and recorded the potential risk factors for difficult intubation in 1,500 pregnant females undergoing elective and emergency cesarean sections under general anesthesia (27). The authors found a strong correlation between difficulty in visualizing oropharyngeal structures and subsequent difficulty with tracheal intubation. The associated risk factors included short neck (SN), protruding maxillary incisors (PMI), receding mandible (RM), and Mallampati class III and IV airways. The relative risk of experiencing a difficult intubation in comparison with an uncomplicated class I airway assessment was as follows: class II, 3.23; class III, 7.58; class IV, 11.3; SN, 5.01; RM, 9.71; and PMI, 8.0 (Fig. 3). Using the probability index and/or combination of risk factors showed that with a combination of either class III or IV plus PMI, SN, and RM, the probability of difficult laryngoscopy was >90% (Fig. 4).

Occipito-atlanto-axial disease is associated with poor mandibular protrusion. Calder and colleagues (28) examined 253 patients preoperatively before surgery for cervical spine disease. Mandibular protrusion was assessed by asking the patient to protrude the mandible as far as possible. The degree of protrusion was classified as follows: class A = the lower incisors can be protruded anterior to the upper incisors; class B = the lower incisors can be brought edge to edge with the upper incisors but not anterior to them; class C = the lower incisors cannot be brought edge to edge.

The grade of glottic visibility was determined at direct laryngoscopy with use of the Cormack and Lehane classification. Class C protrusion was the only finding always associated with difficult mask ventilation and intubation. Patients with class A mandibular protrusion rarely posed difficulty (28).(Fig. 5)

Preeclampsia and Airway-Related Changes

Patients with preeclampsia have narrower upper airways than normal preg-

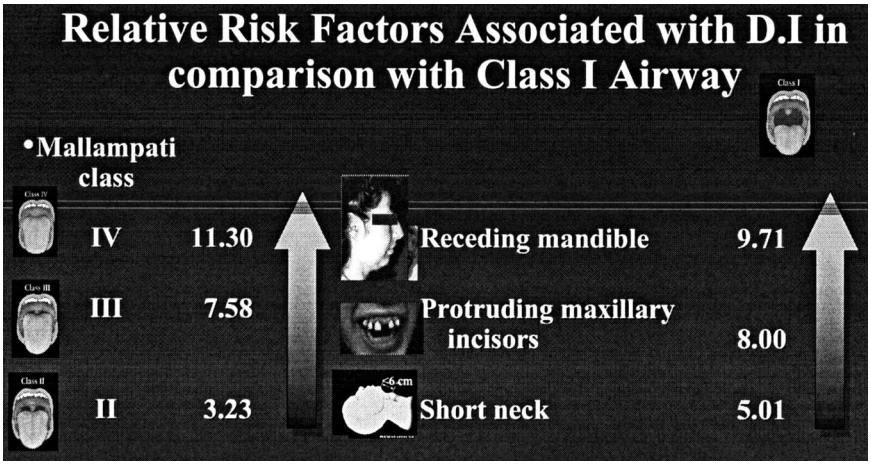

Figure 3. Relative risk factors associated with difficult intubation (*DI*) in comparison with class I airway. Adapted from *Anesthesiology* 1992; 77:67.

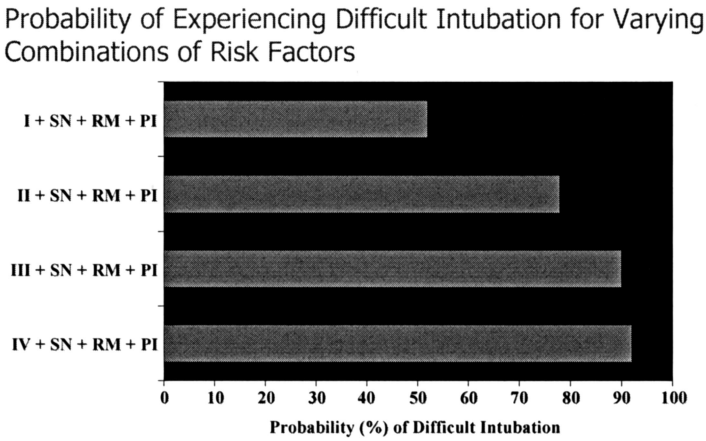

Figure 4. Probability of experiencing difficult intubation with varying combinations of risk factors. Adapted from *Anesthesiology* 1992; 77:67.

nant women, secondary to significant tissue edema along with soft-tissue deposition in the neck. Data show upper airway narrowing in preeclamptic patients during sleep (29). Reduced plasma proteins due to proteinuria and marked fluid retention (especially in the head and neck region) make the tongue larger and less mobile, causing more difficult identification of landmarks in preeclamptic parturients. In severe preeclampsia, edema of the face and neck should alert the anesthesiologist to the possibility of a difficult intubation, whereas edema of the tongue may be an indication for immediate airway compromise (8, 11, 30–32).

Preeclampsia, accompanied by soft-tissue edema and coagulopathy, complicates repeated attempts at direct laryngoscopy, causing laceration and bleeding in the upper airway, thus complicating the management of a difficult airway (33). Upper respiratory infection can further compromise the edematous airway in preeclampsia (11. Marked upper airway edema and swelling of the tongue and soft tissues can be severe enough to cause total airway obstruction (34). Laryngeal edema, facial edema, enlarged tongue, voice change, or stridor can rapidly develop in a preeclamptic patient without any warning signs; therefore, caution should be exercised even during extubation (35). Dysphonia due to uvular edema has also been reported (36).

Morbid Obesity and Difficult Airway

Morbid obesity in pregnancy is associated with increased risk for diabetes, hypertension, preeclampsia, and primary cesarean section (37, 38). There is also a higher incidence of difficult labor in morbidly obese parturients, with increased likelihood of instrumental delivery and postpartum hemorrhage in these patients, conditions all requiring an anesthetic intervention (39, 40).

The incidence of partially obliterated oropharyngeal anatomy among obese parturients is double that among non obese parturients (27, 41). There is not only an increased risk of difficult intubation but also increased difficulty in maintaining adequate mask ventilation. Mask ventilation tends to be difficult because of low chest wall compliance and increased intra-abdominal pressure (30). Hood et al. (37) showed that in morbidly obese parturients (>130 kg), difficult intubation was encountered more frequently.

Morbidly obese parturients are at increased risk for anesthesia-related morbidity and mortality during cesarean section and, in particular, increased risk of failed intubation and gastric aspiration during procedures under general anesthesia (41, 42). A review by investigators in Michigan of anesthesia-related maternal mortality showed that obesity was a major risk factor for maternal mortality (41). The obstetrical closed-claims files indicate that damaging events related to the respiratory system were significantly more common in obese parturients (32%) than in nonobese parturients (7%). Death was also more common among the obese parturients. The problems highlight the increased need to have airway algorithms and equipment readily available when caring for these obese parturients (43).

Obstetricians' Role in Management of Difficult Airway

A collegial and collaborative approach between obstetricians and anesthesiologists when dealing with high-risk parturients facilitates optimum patient care. According to the American College of Obstetricians and Gynecologists (ACOG) Committee Opinion (1992), the obstetrical care team should be alert to the presence of risk factors that place the parturient at increased risk for complications from general anesthesia (44). The anesthesiologist should be alerted when such risk factors are identified. Consideration should be given to early placement of a functioning labor epidural in these patients.

Training of obstetrical residents improves patient safety and educates them regarding risks of failed intubation. As more anesthesiologists become aware of and receive training in advanced airway

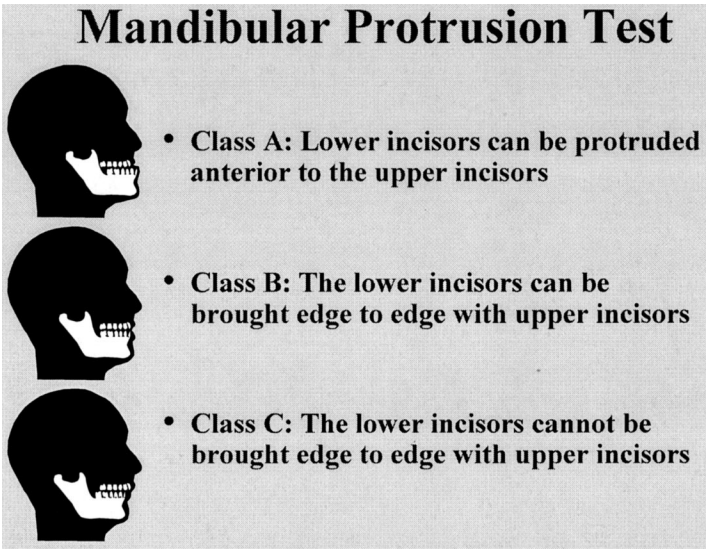

Figure 5. Mandibular protrusion test. Adapted from *Anaesthesia* 1995; 50:756.

management, it will in turn lead to the training of other physicians, thus resulting in a decrease in airway disasters (45). Gaiser and colleagues conducted a study of 160 parturients to evaluate obstetricians' ability to assess the airway before and after instruction in airway examination. The authors concluded that although instruction in airway examination did not affect obstetricians' ability to predict difficult airway, it changed their approach to labor analgesia. The attending obstetricians requested prophylactic placement of early epidural catheters in patients who were thought to have difficult airways (46).

If the anesthesia care team recognizes a difficult airway in a parturient, the obstetrician and anesthesiologist should discuss placement of a continuous epidural or spinal catheter as soon as it is determined to commit the patient to labor and delivery. Early intervention and placement of a functioning regional anesthetic will minimize emergency induction of general anesthesia in parturients with difficult airways. The obstetricians should also recognize that in the event of an urgent/emergent cesarean section, establishing a surgical block is quicker than establishing adequate anesthesia, as compared with an awake intubation or, even worse, securing an airway after failed intubation under suboptimal conditions.

Management of Difficult Airway in Obstetrics

Incidence of Failed Intubation. Failed intubation occurs in the general surgical population at a rate of 1 in 2,330 (21).The incidence of failed intubation is approximately eight times higher in the obstetrical population than among nonobstetrical patients, where the estimated incidence is found to be 1 in 280 (47). Furthermore, the incidence of fatal failed intubation is 13 times higher in the obstetrical population (48).

Labor. After a thorough preanesthetic evaluation is done and difficult airway is suspected, communication with the obstetrical colleagues becomes essential. Early labor analgesia is initiated, and having a functional epidural catheter helps establish surgical anesthesia for a cesarean section if needed. It is essential for an anesthesiologist to get involved earlier rather than later, especially for high-risk parturients, such as obese or preeclamptic parturients with difficult airway. A functioning epidural block avoids the need for general anesthesia and airway instrumentation, thus reducing the potential for airway disasters.

The ACOG bulletin (2002) recommends that "when feasible, obstetrical practitioners should delay the administration of epidural anesthesia in nulliparous women until the cervical dilation reaches at least 4–5 cm and that other forms of analgesia should be used until that time" (49). This recommendation is based on studies that identified an association between the epidural analgesia initiated early in labor and an increased rate of cesarean section (50, 51). However, a recent landmark study published in the *New England Journal of Medicine* (52), involving 750 nulliparous women, demonstrated that the incidence of cesarean section rate was not increased when neuraxial analgesia was initiated early in labor. In contrast, early neuraxial analgesia provided better analgesia and resulted in a shorter duration of labor than did systemic analgesia.

For patients in whom technical difficulties are encountered during epidural placement or in cases of accidental dural puncture, the epidural catheter can be threaded into the epidural space and continuous spinal analgesia can be used as an alternate technique during labor. Caution should be used when dosing a continuous spinal catheter for a cesarean section, particularly in a patient with a difficult airway, in order to avoid a high or total spinal anesthesia (53).

Cesarean Section: Anticipated Difficult Airway. Under controlled circumstances, anesthesiologists should have adequate time to evaluate an airway and administer aspiration prophylaxis. When a difficult airway is suspected and surgery is nonurgent, three options are available: awake intubation, regional anesthesia, and local anesthesia. Regional anesthesia and local anesthesia may not always be a solution because of the chance of conversion to general anesthesia, especially during massive hemorrhage or failed local/regional anesthesia. Emergent induction of general anesthesia under suboptimal conditions can result in significant morbidity and mortality.

Manipulation of the upper airway in a parturient requires special attention. Placement of oral/nasal airways, suctioning, and careless laryngoscopy can result in airway trauma and bleeding. Manipulation of the nasal airway can lead to epistaxis. Smaller endotracheal tubes are recommended for parturients because of the mucosal swelling, which decreases the area of the glottic opening. Breast engorgement can hinder laryngoscopy; thus, proper positioning is necessary along with the availability of a short-handled blade.

The most important criterion for ensuring successful direct laryngoscopy and tracheal intubation, particularly in the obese parturient, is proper patient position. It is essential that the morbidly obese parturient be placed with head, upper body, and shoulders significantly elevated above the chest. In order to accomplish the same, one must create a ramp, using folded towels or blankets under the shoulders and head. The Elevation Pillow

(Mercury Medical, Clearwater, FL) is shaped like a ramp and is designed for optimizing the sniff position.

Awake Fiberoptic Intubation. When an anesthesiologist anticipates difficult airway and predicts difficult mask ventilation and intubation, a very safe option is to secure the airway with a tracheal tube while the patient remains awake—although awake intubation can be time-consuming. There are several compelling reasons to perform an awake intubation at the very outset in a patient with a recognized difficult airway: the natural airway will be better preserved in most patients when they are awake; adequate muscle tone is maintained to keep the relevant upper airway structures (base of tongue, vallecula, epiglottis, larynx, esophagus, and posterior pharyngeal wall) separated from one another and much easier to identify (54).

Full aspiration prophylaxis should be instituted before intubation. An anticholinergic drying agent such as glycopyrrolate allows better application and absorption of local anesthetics to the airway mucosa and thus improves visualization of the oropharyngeal structures.

The route of fiberscopic intubation is important in pregnant patients. The nasal mucosa is engorged in pregnancy, and despite vasoconstriction this can precipitate epistaxis, leading to a compromised airway. The oral route is commonly used and preferred. Topical anesthesia is the primary anesthetic for an awake intubation. It can be achieved with a spray of lidocaine at the base of the tongue and lateral pharyngeal walls, along with application of lidocaine jelly to the base of the tongue via a tongue blade. Sufficient time must be allowed to anesthetize all portions of the airway. This helps to minimize the swallowing and gag reflexes. The larynx and trachea can be topically anesthetized by injection of lidocaine through the cricothyroid membrane or via the suction port of the fiberscope (55). The patient is at risk for aspiration if regurgitation or vomiting takes place after topical anesthesia and before the airway is secured. A shorter interval between application of topical anesthesia and tracheal intubation lessens the potential of aspiration (56).

Once the upper airway is properly anesthetized, there are other, different techniques for intubating the trachea. Either direct or fiberscope-guided laryngoscopy or a combined technique of direct laryngoscopy and fiberscopy can be used. The choice of technique depends on the skill and experience of the anesthesiologist. With adequate psychological and pharmacologic preparation, patients can tolerate either direct laryngoscopy or fiberscopically guided intubation (57).

Regional Anesthesia. Regional anesthesia is the best possible choice in most cases of anticipated difficult airway (9). Either spinal or epidural anesthesia is acceptable, provided no contraindications exist in the absence of fetal compromise. Drugs for aspiration prophylaxis should be given before either anesthetic, along with an intravenous fluid bolus. When a cesarean section is nonemergent, epidural anesthesia can be used. The advantages of epidural anesthesia are slow titration of the block and avoidance of major hemodynamic and respiratory compromise. When time is limited, spinal anesthesia is the choice. With adequate fluid bolus and appropriate dosing of local anesthetic, surgical anesthesia can be established very quickly. After regional anesthesia is in place, supplemental oxygen should be provided to the mother along with left uterine displacement to avoid aortocaval compression.

The advantages of regional anesthesia include the following: the mother is awake and can protect her airway; airway manipulation is not necessary; the incidence of acid aspiration is decreased.

If regional anesthesia is administered to a patient with difficult airway, then close monitoring, an experienced anesthesiologist, and equipment should be immediately available to establish an airway in case a need arises.

Local Anesthesia. In patients with a difficult airway undergoing urgent cesarean section, regional anesthesia is contradicted; one can choose local anesthesia as the primary anesthetic technique. It is used frequently in developing countries but rarely developed ones today. In most teaching institutions, an obstetrics resident may complete training without ever having seen or done a cesarean section under local anesthesia. In our institution, the obstetricians are trying to propose a protocol in which every senior resident should perform at least one cesarean section under local anesthesia before completion of the residency. There have been a few case reports with very good description of the technique for cesarean section (58). The advantages of local anesthesia are as follows: the obstetrician can perform the technique without waiting for an anesthesiologist; airway manipulation is not necessary; hemodynamic stability is maintained if a safe dose of local anesthetic is used; the awake mother has protective airway.

Cesarean Section: Unanticipated Difficult Airway. In a patient requiring an emergency cesarean section for fetal distress, the urgency may limit the anesthesiologist's opportunity to perform a complete assessment of the airway. The head position should be optimized for anticipated tracheal intubation by aligning the oral, pharyngeal, and laryngeal axes. The ideal position (sniffing position) is achieved by elevating the head, flexing the neck, and extending the head at the atlanto-occipital joint. No matter how emergent the need for delivery, time should be taken before induction of general anesthesia to ensure proper positioning (33). After initial attempts at intubation fail, management goals include maternal oxygenation, airway protection, and prompt delivery of the baby. If possible, consider returning to spontaneous ventilation, awakening the mother, and calling for help. In most of the situations other than maternal hemorrhage and fetal distress, the mother can be awakened and fetal status reassessed. If the fetal status is reassuring, either regional anesthetic or an awake intubation is considered.

When the first attempt at intubation fails, a different blade may be used, and a more experienced anesthesia practitioner should attempt intubation. More than three attempts at laryngoscopy can cause edema and trauma of the oropharyngeal tissues, leading to an unmanageable airway. If intubation fails after a maximum of three attempts, a failed-intubation plan, with the aim of maintaining oxygenation and awakening the mother, should be initiated immediately (59).

Failed Initial Attempts at Intubation. The recommendation in the case of a grade III laryngoscopic view is that no more than three attempts at laryngoscopy and intubation should be made. Repeated intubation attempts increase the damage and lead to edema of the larynx and other airway structures. Useful aids in such a situation include an Eschmann gum elastic bougie, smaller endotracheal tube, or a hockey-stick bend on the distal end of a smaller (6.0-mm) endotracheal tube. In a grade IV laryngoscopic view, the Difficult Airway Algorithm should be followed without delay (60).

Nonemergent Pathway: Can Ventilate, Cannot Intubate. If surgery needs to

proceed after initial attempts at failed intubation, mask ventilation with cricoid pressure is attempted. Call for help immediately. If the patient cannot be intubated, gas exchange is totally dependent on mask ventilation. The optimal attempt at conventional mask ventilation should be a two-person effort. Better mask seal and jaw thrust and greater tidal volume are achieved with two people than one person (61). Appropriate-size oral airway should be used for successful mask ventilation. If mask ventilation is easy and steps are taken to minimize aspiration, patient should be awakened in the absence of fetal distress. Mask ventilation is continued with cricoid pressure until the patient is fully able to protect her airway (62). Adequate oxygenation without aspiration is the goal at this juncture.

In 2003, practice guidelines for management of the difficult airway were updated. Under these new guidelines, laryngeal mask airway (LMA) is the tool of choice in a "cannot ventilate, cannot intubate" (CVCI) situation. If the LMA proves to be successful, a nonemergency situation arises and a nonemergency pathway of the Difficult Airway Algorithm can be followed. When placing the LMA, cricoid pressure needs to be released transiently. Data from all studies assessing the efficacy of LMA insertion with or without cricoid pressure show that LMA insertion is more successful without cricoid pressure (94%) than with cricoid pressure (79%) (63–66). If the LMA fails, an emergency pathway with the Combitube, transtracheal jet ventilation (TTJV), and a surgical airway are the reasonable options.

Airway Devices. When recognized before attempts at tracheal intubation, virtually all difficult airways can be secured by the selected use of specialized tracheal intubation techniques. LMA, ProSeal LMA, and Combitube are supraglottic airway devices and can be successfully used if there is no airway obstruction at or below the glottis. Recently the use of a laryngeal tube has also been found to be useful in a difficult airway–failed intubation situation.

Laryngeal Mask Airway. The invention of LMA has revolutionized the management of difficult airway. It has been used extensively all over the world to provide a safe airway in patients who are not at risk for aspiration of gastric contents. LMA is not routinely used in pregnant patients because they are at high risk for aspiration. If intubation and mask ventilation of the patient prove impossible, the use of LMA may be life-saving, however. The unanticipated arm of the Difficult Airway Algorithm has changed so that the LMA is no longer in neither the emergency pathway nor the nonemergency pathway but in fact is among the routine airway techniques. This change is probably due to familiarity with the LMA, its availability, and the high success rate for both experienced and new users. It was introduced into the ASA Difficult Airway Algorithm in the mid 1990s. It can be used as a ventilatory device or an intubating conduit and fits into the Difficult Airway Algorithm in several places as both recognized and unrecognized difficult airway. LMA should be used earlier rather than later following failed endotracheal intubation. Han and colleagues reported the successful use of the LMA as a ventilatory device in 1,060 of 1,067 patients for elective cesarean delivery (67).

The ASA Task Force on the management of a difficult airway states that availability of equipment for the management of a difficult airway is associated with reduced maternal complications and also recommends that labor and delivery units should have equipment readily available to manage airway emergencies (26, 56). In a German survey, LMAs were available in 91% of the obstetrics departments, similar to figures from the United Kingdom (91.4%). According to the same survey, 72% of anesthesiologists favored LMA as the first treatment option for the CVCI situation (68). In a survey in the United Kingdom, 71.8% of obstetrical anesthesiologists advocated use of LMA in a CVCI situation. Eight anesthesiologists stated that LMA proved to be a 'lifesaver' (69). Recently, 18 obstetrics units in Ireland were surveyed for difficult airway equipment. All of the units had LMA as an alternative device for ventilation and intubation. Fifty percent of the units also had an intubating laryngeal mask airway (ILMA) among their airway equipment (70). Ezri and colleagues conducted a survey in Israel to evaluate the practices of Israeli anesthetists regarding familiarity with airway devices. Ninety-six percent of the anesthetists were skilled with LMAs and 73% with fiberoptics. Of the obstetrical rooms surveyed in this study, only 36% were equipped with laryngeal masks, 24% with fiberscopes, and 22% with equipment for tracheal puncture (71).

ProSeal-LMA (PLMA). PLMA was introduced into clinical practice in 2000. This device is a modification of the classic LMA and provides a better seal and better airway protection. It has a second lumen, arising from the tip of the laryngeal mask and terminating outside of the patient airway. This lumen, which is called the gastric drain, has been demonstrated to effectively vent passively or actively regurgitated esophageal contents. An orogastric tube can be placed through this lumen to empty the stomach. The design of the PLMA reliably allows positive pressure ventilation up to 30–40 cm H_2O. Thus, the seal is 10 cm H_2O higher, giving it greater ventilatory capability than the classic LMA.

The PLMA has been successfully used in parturients after failed intubation during rapid-sequence induction (56, 72, 73) and in postoperative respiratory support (56, 72). It has also been used during eight sessions of electroconvulsive therapy in a pregnant woman at 20–22 wks of gestation with a known difficult airway (74). Recently, a study was approved for a cohort-controlled study using PLMA in 100 elective cesarean section patients (75).

Intubating Laryngeal Mask Airway. The major difference between the ILMA and the classic LMA lies in the design and the function of the shaft. In the classic LMA, the primary function of the shaft is to serve as a gas conduit. In the ILMA, the shaft is rigid and serves two additional purposes: it acts as an insertion tool that ensures the alignment of the mask with the glottic opening, and it provides a conduit for a smooth and atraumatic intubation when the mask aperture is in alignment with the glottic opening. ILMA has also been used in parturients after failed intubation (76, 77).

Laryngeal Tube. Laryngeal tube is a new supraglottic airway device. It is a multiple-use silicon tube with an oropharyngeal and esophageal low-pressure cuff and a ventilation outlet between these cuffs. While the head is kept in neutral position, the tube is placed into the oropharynx until resistance is felt. Both the cuffs are then inflated and the ventilation outlet is placed in front of the vocal cords (78). Laryngeal tube-S (LTS) is a newer-generation laryngeal tube that is fitted with a second lumen for suctioning and gastric drainage. LTS has been recently used in a parturient having an urgent cesarean section in a CVCI situation (79).

The LTS may be a good choice for emergency airway management. It provides a higher airway seal than the classic LMA and insertion time is comparable.

An airway pressure of 40 cm H_2O can be achieved without gastric inflation (79). It may have a role in obstetrical emergency airway management.

Combitube. The Esophageal Tracheal Combitube is another airway device that can be used to establish an airway when mask ventilation and intubation have failed. It is a disposable, double-lumen tube with an esophageal and large pharyngeal cuff. It received approval in 1988 from the U.S. Food and Drug Administration. It can be placed blindly or with the help of a laryngoscope. The Combitube provides an option for blind intubation of either the esophagus or trachea. In either position, the patient can be oxygenated and ventilated, and the airway is protected against aspiration of gastric contents. Combitube has been successfully used for management of failed intubation in cesarean delivery (80). It has a good safety record, as inexperienced personnel without any formal training can place it promptly and quickly.

If mask ventilation cannot be achieved and a CVCI situation exists, it is critical to implement immediate life- saving maneuvers, such as TTJV, cricothyroidotomy, or surgical tracheostomy.

Emergent Pathway: CVCI. When mask ventilation is not possible and the patient cannot be intubated, a CVCI exists and gas exchange must be restored as quickly as possible. If airway obstruction occurs, cricothyroidotomy or surgical airway is the technique of choice in the event of a life-threatening situation. TTJV in a patient with airway obstruction can be hazardous if there is no route for air escape.

Transtracheal Jet Ventilation. Percutaneous insertion of a large-gauge intravenous catheter through the cricothyroid membrane is simple, quick, and relatively safe in most patients. Cricothyroidotomy is faster than conventional tracheostomy. It is probably the fastest route to oxygenation in a desaturating patient. When performing jet ventilation, it is essential to allow for adequate exhalation to avoid barotrauma. The recommendation is to use two nasal trumpets and allow enough time for exhalation. To achieve adequate oxygenation and ventilation, the TTJV system must have a sufficient high- pressure oxygen source (50 psi) that can drive oxygen through noncompliant tubing and the small TTJV catheter.

TTJV is not a very popular technique because it is a surgical procedure and can produce complications such as pneumomediastinum, pneumothorax, and subcutaneous emphysema. Oxygenation via TTJV is only a temporary measure, and one person is dedicated solely to holding the catheter in place at the patient's neck (61). All anesthesia care practitioners should be familiar with the technical aspects of TTJV, but experience with this technique in obstetrics is limited and not reported in the literature. Experience gained with LMAs and Combitubes in elective surgeries makes the use of nonsurgical devices preferable to TTJV.

Cricothyroidotomy and Surgical Tracheostomy. Performance of an emergent, hurried cricothyroidotomy or tracheostomy can be dangerous. Percutaneous surgical cricothyrotomy or tracheostomy is probably a better option than open cricothyrotomy or tracheostomy. Percutaneous cricothyrotomy is safe, quick, and as easy to perform as TTJV (9). Surgical assistance should be summoned earlier in the event of a difficult intubation so that help will be available at the appropriate time.

Aspiration of Gastric Contents. Aspiration remains the number one cause of death in obstetrical anesthesia, and it is frequently associated with difficult/failed intubation or esophageal intubation (4). The patient at greatest risk for aspiration is the obese parturient who has eaten after the onset of labor or within 6 to 8 hrs of delivery. After 28 wks of gestation, all appropriate precautions should be taken to prevent aspiration. The technique of rapid-sequence induction with cricoid pressure and endotracheal intubation was introduced in obstetrical anesthesia practice to protect the airway from pulmonary aspiration. Improper application of cricoid pressure can lead to problems with difficulty during intubation.

The obstetrical patient is particularly vulnerable to pulmonary aspiration due to gastrointestinal changes, hormonal changes, parenteral analgesics, and labor-induction agents. Pressure on the abdomen during delivery and the loss of gag reflex during anesthesia may be contributing factors to the aspiration of liquid gastric contents. Loss of consciousness due to local anesthetic toxicity, total spinal anesthesia, and eclampsia can also predispose a parturient to aspiration. Aspiration can also occur during a high spinal or epidural block when the patient cannot cough or clear her airway effectively (4).

CONCLUSION

The inability to maintain a patent airway after attempts at failed intubation remains a major concern with regard to anesthesia-related maternal morbidity and mortality and is also a significant source of malpractice claims in obstetrics (6, 30). Teamwork between an anesthesiologist and an obstetrician is absolutely essential for the safety of both the mother and baby. Most of us tend to agree that airway emergencies have a way of occurring at the worst possible times. It is essential that all anesthesia care practitioners have a preconceived and well thought-out algorithm and equipment available to deal with airway emergencies during difficult or failed intubation in a parturient. Even if intubation is not possible, every effort should be made to maintain adequate ventilation and, more important, oxygenation of mother and fetus.

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