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Principles and Practices of Obstetric Airway Management

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Management of the pregnant airway requires constant vigilance among anesthesiologists. This partially may result from the fact that airway deaths continue to be a significant cause of anesthesia-related maternal mortality. It also is widely accepted that the maternal airway is more difficult to manage, largely as a result of the physiologic changes of pregnancy.

The aim of this article is to appraise key concepts relating to the principles and the practice of obstetric airway management. The literature underlying the assumptions about maternal mortality and the increased difficulties in managing maternal airways are reviewed critically. The physiologic and nonphysiologic factors that may contribute to maternal airway difficulties are discussed as are effects of labor on the airway. Management strategies and useful airway adjuncts also are presented.

Principles

Epidemiology and maternal mortality data

Large population studies of maternal mortality reveal the relative importance of problems related to maternal airway management. These can be compared with observations made in similar studies of general populations.

Although the total number of maternal deaths had been decreasing steadily in the United Kingdom between 1968 and 1984, anesthetic deaths consistently accounted for approximately 10% of the total direct maternal deaths [1]. During the triennium, 1982 to 1984, anesthesia was the third

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leading cause of death resulting in 19 of 243 deaths, 15 of which resulted from airway difficulties [2]. During the enquiry spanning 1994 to 1996, anesthesia was responsible for only one of the 268 deaths [3]. Most recently, during the triennium 2000 to 2002, there were six direct deaths resulting from anesthesia (of a total of 261 direct and indirect deaths) of which three were airway deaths [4]. The details are disturbing. All were associated with trainee-grade anesthesiologists who had inadequate senior backup. Two of the cases involved unrecognized esophageal intubations where capnometry was not used. The third case was an aspiration death related to difficulty intubating the esophagus of a morbidly obese parturient.

United States data reveal a similar trend. Hawkins and colleagues [5] looked at all anesthesia-related deaths in obstetrics in the United States from 1979 to 1990 using the Centers for Disease Control and Prevention Pregnancy-Related Mortality Surveillance System. They found that 49% of all anesthesia-related deaths were secondary to airway or respiratory causes. This increased to 73% when only deaths resulting from general anesthesia were considered. The number of deaths per million general anesthetics increased from 20 (1979–1984) to 32.3 (1985–1990). This was associated with a concomitant decrease in the death rate from regional anesthesia. The relative risk (RR) of mortality from general versus regional anesthesia was 16.7. This study was updated to cover the period 1991 to 1996 [6]. During this subsequent time period, the RR fell to 6.7. This decrease may be related to increased usage of pulse oximetry and capnometry and to a more structured approach to difficult intubation. Berg and coworkers [7] used the same database to examine pregnancy-related deaths from 1987 to 1990. Anesthesia accounted for 2.5% of all maternal deaths. Of these, 58% were classified as airway related; the remainder were unspecified.

Panchal and colleagues [8] used data collected by the state of Maryland between 1984 and 1997. Their team examined all hospital admissions to short-stay nonfederal institutions. All maternal deaths were collected for study. There were 135 deaths of which anesthesia-related complications accounted for 7 (5.2%). A Dutch national confidential enquiry [9] studied 113 cases of direct maternal death in the Netherlands between 1983 and 1992. Anesthesia-related complications accounted for only four of these (3%). A smaller study [10] using death certificates in the state of Tennessee between 1989 and 1992 identified 129 women who died within 1 year of delivery. Of these deaths, none was attributable to anesthetic complications. In North Carolina, from 1981 to 1985, May and Greiss [11] showed that 10% of all maternal deaths were secondary to general anesthesia. Endler and colleagues [12] looked at anesthesia-related maternal mortality in Michigan from 1972 to 1984. They found that anesthesia accounted for 6.9% of all maternal deaths and that airway problems were responsible for 40% of those deaths. When this study was updated for the period from 1985 to 2003 [13], some interesting observations were made. During this time, there

were eight (2.3%) anesthesia-related deaths. Half of these were related to general anesthesia or deep sedation but none was the result of difficulty intubating. All were postoperative deaths related to airway obstruction or hypoventilation during emergence or recovery.

These results are in contrast with population studies looking at anesthetic mortality in general populations.

In Western Australia, from 1990 to 1995 [14], there were only 26 deaths directly related to anesthesia; none of these related to airway. In a study of 325,585 anesthetics in Finland in 1986 [15], only five deaths were caused by anesthesia and 15 deaths implicated anesthesia as a minor factor. Of those, 20 deaths only 5 (25%) were related to airway issues (aspiration) and all were judged to have been a minor factor. Finally, in New South Wales, Australia, from 1984 to 1990 [16], only 2.3% of anesthetic-related deaths were the result of airway problems.

There are no studies that explicitly compare the incidence of airway morbidity and mortality for obstetric and nonobstetric patients. From the available data, it can be concluded that anesthetic-related deaths are rare and the incidence in the obstetric and nonobstetric populations seems to be declining over time. In the obstetric population, however, airway problems seem to remain the predominant cause of anesthesia-related death. This is not surprising given the usually young, healthy nature of the obstetric population compared with the surgical population as a whole. The introduction of pulse oximetry and end-tidal carbon dioxide monitoring came into common use over the span of some of these studies as did practice guidelines related to difficult intubation. These may have contributed to some of the declining rates. Also, the increasing use of regional anesthesia for obstetrics exposes fewer and fewer women to airway management in general. This same change in practice, however, also might imply that the patients receiving general anesthesia for caesarean section represent a sicker and more urgent group in more recent studies compared with older cohorts.

Physiologic factors relating to obstetric airway management

Multiple physiologic changes of pregnancy may interact to add anatomic and situational difficulties to the management of the maternal airway, particularly with respect to intubation by direct laryngoscopy. There is much interpersonal variation with respect to how each of these interacts with individual underlying anatomy.

The principal changes contributing to anatomic difficulties relate to the upper airway. Pregnancy is a state of fluid retention. Within the upper airway, this may manifest as edema. This edema may be exacerbated by iatrogenic fluid administration and by pathologies, such as preeclampsia. Maternal weight gain also may result in increased fat deposition within the upper airways. These factors may contribute to increasing tongue size and decreased soft tissue mobility. The oral mucosa also may be more

friable than usual resulting in bleeding from minimal trauma that may obscure attempts at laryngoscopy.

Changes in pulmonary physiology [17] result in rapid desaturation post induction. These changes include increased oxygen consumption and decreased functional residual capacity. These do not add anatomic difficulties but rather shorten the allowable time from induction to intubation while limiting how long intubation may be attempted.

A major physiologic factor that adds complexity to the situation is gastrointestinal changes [17], which increase the risk for reflux of gastric contents and aspiration. Anatomic changes related to relaxation of the lower esophageal sphincter and displacement of the stomach increase risk for reflux as early as the first trimester. Gastric emptying, however, is unaffected until labor or opioid analgesics supervene. During this time, delayed gastric emptying may be observed, further increasing the risks for aspiration.

Finally, during pregnancy, as the breasts engorge, they may interfere with placement of the laryngoscope, necessitating use of a short handle.

Nonphysiologic factors relating to obstetric airway management

In addition to the physiologic factors, several situational issues arise during airway management of pregnant patients that also contribute to difficulties.

Firstly, given current practice patterns, the majority of intubations are for emergent cases. This creates haste and anxiety for operators. This is a set-up for lapses in judgment that may contribute to making a situation more difficult than it would be otherwise. Many of these cases occur outside of usual hours when minimal backup is available.

Intubations usually are accomplished by rapid sequence intubation with application of cricoid pressure. The rapid sequence aspect, although completely appropriate, adds further haste to the situation, possibly contributing to difficulties. The cricoid pressure, if applied improperly, may obscure airway anatomy. Although the usefulness of this maneuver is questioned [18], it still is considered by most practitioners to be the standard of care. Furthermore, in an attempt to minimize fetal exposure to induction and maintenance agents, induction is held until the last possible moment with a patient draped and surgical team ready to make an incision. This is suboptimal from an airway management point of view and subjects anesthesiologists to further pressure.

Finally, depending on local circumstances, the assistance received at induction may be substandard. This may be because of the diminishing incidence of general anesthetics on the labor floor. As a result, assistants are less familiar with airway management. Although most anesthesiologists continue to manage airways routinely in other aspects of their practice, the labor floor assistants usually do not.

Is the pregnant airway truly more difficult to intubate?

To answer this question ideally, a prospective study would be required, comparing intubation of pregnant and nonpregnant patients under standardized conditions using predetermined criteria while controlling for other predictors of difficult intubation, including experience of the operators and anatomic characteristics. If the incidence of difficult intubation in pregnancy were 2%, the study would require more than 4600 patients to demonstrate a 50% difference compared with the nonpregnant state. In the absence of this type of evidence, the existing airway literature can be a guide. This has been addressed recently in a systematic review of the topic [19].

The existing literature covers many different types of studies. Few of these include pregnant and nonpregnant patients. Some of these studies were designed to assess various methods of airway evaluation whereas others were retrospective audits from quality assurance data or other databases. Definitions for difficult and failed intubations and operators and conditions tend to vary from study to study, making comparison difficult.

Four studies compare obstetric and nonobstetric airways. Wong and Hung [20] prospectively studied 151 pregnant and 260 nonpregnant Chinese patients, looking for predictors of difficult intubation in that population. They defined difficult intubation as a Cormack and Lehane [21] grade 3 or 4 view at laryngoscopy. In this small study, there was no difference between the groups, with incidences of 1.99% and 1.54%, respectively. Yeo and colleagues [22] similarly compared 283 gynecologic patients with 277 obstetric patients. They found the incidence of difficult intubation to be 2.2% and 1.8%, respectively. Dhaliwal and coworkers [23] compared 15,150 main operating room (OR) anesthetics to 466 obstetric suite anesthetics using prospectively collected quality assurance data. The incidences of difficult intubation (1.16% versus 0.86%) and failed intubation (0.28% versus 0%) were similar. They did report that 1.5% of the maternity cases required ventilation by facemask during the rapid sequence induction compared with 0.1% of the OR cases; however, the denominator for the OR rapid sequence cases is unknown. Samsoon and Young [24] retrospectively recalled known failed intubations patients from an obstetric registry. The aim of their study was to assess their modification of the Mallampati score [25] (the addition of the fourth class). The study was extended to nonobstetric patients to increase the number of cases. They identified 7 of 1980 obstetric patients (0.35%) and 6 of 13,380 OR patients (0.04%). There is no way to be sure all cases were identified. Furthermore, failures and circumstances were unknown. All of these patients, when recalled at later dates, demonstrated class 4 oropharyngeal views even when no longer pregnant (except for one previous obstetric patient who had tracheal stenosis). This begs the question whether or not they would be difficult in the nonpregnant state or if pregnancy exacerbated the situation.

Six cohort studies of obstetric airways have been published. Barnardo and Jenkins [26] published the results of a prospective audit of obstetric anesthesia activities in the South Thames region of the United Kingdom during the years 1993 to 1998. They defined failed intubation as an intubation not accomplished with a single dose of succinylcholine. They documented an incidence of 36 of 8970 (0.4%). They were able to review 26 of these cases. Twenty-three of these were cesarean sections, of which only four were elective. Sixteen of these cases occurred after hours. Only five of these were cases with a grade 4 view and only one of the operators was a consultant. More than half of the charts failed to demonstrate evidence of an airway assessment. Fortunately, there were no adverse maternal outcomes. Al Rhamadhani and colleagues [27] prospectively studied sternomental distance as a predictor of difficult laryngoscopy in 523 cesarean section patients. The incidence of difficult intubation as defined by a grade 3 or 4 view was 18 of 523 (3.5%). Of these, only one was grade 4. Intubation failed in three of these patients (0.57%). Tsen and coworkers [28] retrospectively reviewed the charts of 536 parturients who had general anesthesia for cesarean sections. The incidence of difficult intubation was 5.8% and failure was 0.19%. During the course of the study (1990–1995), it was observed that the incidence of general anesthesia decreased; however, those receiving it suffered from more systemic disease. Hawthorne and colleagues [29] prospectively audited the incidence of failure to intubate (defined as intubation not accomplished with a single dose of succinylcholine) over a 17-year period (1978–1994). He included data published previously [30]. All patients were visited postoperatively and had an airway assessment. The overall incidence of failure was 23 of 5802 (0.4%). A majority of the cases were emergencies that took place after hours and involved house officers. On postoperative examination, all patients had at least one airway abnormality and more than half had multiple abnormalities. Two of these patients had known previous difficult intubations; two others subsequently were shown to have Klippel-Feil syndrome; one had masseter muscle spasm; and one was intubated easily after being turned to the lateral position. Thus, at least six of the 23 patients could be argued to have had intubation difficulties unrelated to pregnancy. Six patients were reported as having pharyngeal edema; two were preeclamptic; and two generally were edematous—all changes that could be related to pregnancy. Fourteen of these cases were previously or subsequently intubated easily under other circumstances while the patients were no longer pregnant. Rocke and coworkers [31] prospectively assessed the airways of 1500 patients undergoing general anesthesia for cesarean section to correlate the airway examination with subsequent intubation results. There were only two failed intubations, one of which was intubated easily by the consultant resulting in an incidence of 1 of 1500 (0.07%). The incidence of difficulty was 2%. The multivariate analysis showed that only Mallampati score, short neck, retrognathia, and overbite correlated with difficult intubation. Facial and tongue edema, the only

factor they assessed that could be attributable to pregnancy itself, did not correlate.

Glassenberg and coworkers [32] reviewed the intubation results of 2266 parturients who had general anesthetics during two time periods (1980–1984 and 1985–1989). The change in practice that occurred during the second time period was that 127 patients who had anticipated difficult airways were intubated awake. During these two time periods, the incidence of difficulty as defined by requiring multiple attempts increased from 2.2% to 2.6%. The failure rate dropped from 0.37% to 0.2%. Neither of these differences was statistically significant. The investigators also report that half of the failed intubations occurred in patients whose airway examinations appeared normal. The question they ask is whether or not there is an irreducible minimum incidence of failure to intubate, which is inherent in the inability to predict accurately all patients who should be intubated awake. This concept is reinforced by a study of 5379 general surgical patients [33] that looked for predictors of difficult intubation. This study found that 40% of the difficult or failed intubations had not been predicted preoperatively by experienced practitioners who filled out questionnaires after encountering the problem. This issue seems to apply equally outside the labor and delivery suite.

Despite all their limitations, the obstetric airway series suggest that the incidence of difficult intubation ranges from approximately 1% to 6% and the incidence of failed intubation from 0.1% to 0.6%. How does this compare with nonpregnant or general surgical patients? A contemporary review by the Canadian Airway Focus Group [34] suggests that the incidence of difficult intubation in the general population is in the range of 1.5% to 8.5%, whereas the incidence of failed intubation ranges from 0.13% to 0.3%. These are similar to the results found in pregnant patients. The intubation results from large cohorts [35–37] (6184–18,500 patients) of nonpregnant patients also fall within this range.

Airway changes during pregnancy

Airway changes during pregnancy, labor, and delivery are described. Many case reports describe patients who have developed airway edema during labor and delivery [38,39], secondary to preeclampsia [39–41] and post massive fluid and blood transfusion for postpartum hemorrhage [42]. Changes in Mallampati score and actual difficulties in intubation resulted.

These observations are supported by some evidence. One study [43] found that the inability to fully visualize the uvula during a Mallampati test at 36 weeks' gestation was more common in women who had preeclampsia. Another group [44] did a photographic study to look at the changes in Mallampati score during labor in 70 women. They were assessed in early labor, after delivery, and at 48 hours. Thirty-three percent changed their airway one grade higher whereas 5% went up two grades. Eighty-two

percent reverted to their admission grade by 48 hours. This same group did an airway study [45] using acoustic reflectometry, which measures pharyngeal volume and area, which may be surrogate markers for ease of intubation. They looked at only five patients and found that their mean pharyngeal volumes were significantly lower after delivery.

Pilkington and colleagues [46] studied the effect of pregnancy itself on the airway. He submitted 242 pregnant women to photographic Mallampati tests that were performed in a standardized manner at 12 and 38 weeks' gestation. Two photographs were taken each time and all were graded by three blinded assessors. At 12 weeks, 36% were grade 3 and 42% grade 4, but by 38 weeks, 29% were grade 3 and 56% were grade 4. The increased Mallampati scores correlated with gains in body weight, implying that oropharyngeal edema was responsible for the observed changes. The significance of these findings with respect to airway management is unknown. The most striking issue is that the original study by Mallampati documented only 7% of patients in these categories. The investigators attributed this lower incidence to the lack of standardization in how the test was done in the original study. If the high baseline rates of class 3 and 4 airways in this study are accurate, the usefulness of this test is questionable.

Practices

Prevention

Planning for and preventing airway problems in obstetric anesthesia is the cornerstone of practice. Although not all difficult situations are predictable, having safe practices and strategies in place before these events may help lessen the consequences and provide for better outcomes.

The first principal in the prevention of airway misadventure is an attempt to predict which patients may be at risk. Although the ability to predict difficult intubation is poor, no obstetric patient should have an induction of general anesthesia without an airway assessment. In their audit, Barnardo and Jenkins [26] noted that on reviewing the charts, evidence of an airway assessment could be found in less than half of them. In a separate audit [29], Hawthorne and colleagues did retrospective airway assessments on all difficult and failed intubations. They noted that one third were predicted to be difficult and that two out of 23 cases had medical records documenting prior difficulties with intubation. Although no single test has good predictive value, Rocke and coworkers' [31] multivariate analysis of risk factors for difficult intubation in obstetrics demonstrates that risk increases dramatically as the number of abnormal airway findings increases. This is confirmed in a recent meta-analysis of general patients [47].

One strategy to avoid being caught with a potentially difficult airway requiring an urgent general anesthetic is to attempt to avoid the situation completely. Routine assessment of all patients in the labor and delivery

area, or at least all high-risk patients, might allow for proper patient counseling and insertion of "prophylactic" epidurals, which could be used in the unlikely event that patients identified as being at risk for difficulties with airway management present for emergent cesarean section. This includes morbidly obese parturients who may represent a particularly at-risk group [48]. In busy units where assessment of all patients is not realistic, education of the nursing and obstetric staff as to warning signs might be possible, thus allowing them to function as first-line screeners.

Active obstetric management also may be of benefit by reducing the need for urgent cesarean sections. Dysfunctional labors, typically associated with emergent operations, might be identified earlier, thus avoiding this endpoint.

Given that not all difficulties are completely avoidable, it is advisable to have experienced operators immediately available when general anesthesia is administered for cesarean section. This message is reinforced by the Confidential Enquiries into Maternal Deaths in the United Kingdom, where trainees were found to be involved in several direct deaths [4]. This also was the case as described by Barnardo and Jenkins [26] and Hawthorne and colleagues [29] in their audits. Whether or not the presence of consultants would affect the incidence of difficult or failed intubation remains unknown; however, it is reasonable to expect that the management of these cases might be more optimal, resulting in less morbidity.

The final concept regarding prevention relates not to preventing a difficult intubation but to preventing one of its potential consequences, that is aspiration. The ultimate prophylactic regimen is the avoidance of general in favor of regional anesthesia. Where this is not possible, a variety of strategies are widely advocated as prophylaxis. Nonparticulate antacids, H_2 receptor antagonists, or proton-pump inhibitors and prokinetics (eg, metoclopramide) are used widely (described elsewhere) [49,50]. Oral intake of solids usually is restricted [51] and when general anesthesia is induced, a rapid-sequence induction with cricoid pressure is used. Although intuitive, none of these strategies ever has been demonstrated to reduce maternal morbidity [49,52]. Also, the risk for aspiration applies equally to parturients emerging from anesthesia and adequate care also must be taken at this time.

Management

A simple algorithm for management of the difficult maternal airway is shown in Fig. 1.

As discussed previously, all candidates for general anesthesia must have an airway assessment. In cases where airway difficulties are anticipated, general anesthesia should not be induced. Options in this situation include awake intubation or regional or local anesthesia. Although most practitioners likely could institute regional anesthesia more rapidly than they could secure an awake airway, this may not be the best solution for all situations. It is in this setting that a "prophylactic" epidural would be useful if

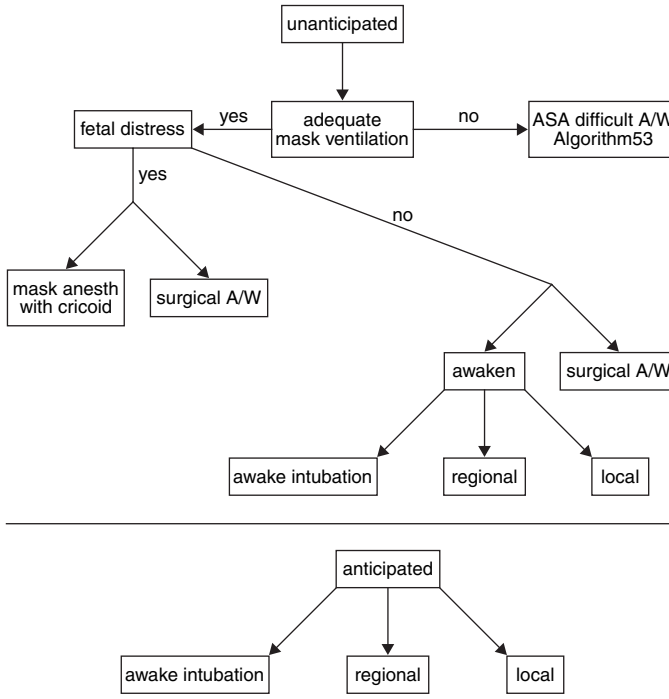

Fig. 1. Algorithm for management of the difficult maternal airway (A/W).

a patient had been laboring. In settings where regional is contraindicated or has failed, skilled help is essential for rapidly securing an awake airway in an emergent situation. Techniques for awake intubation are well described [53]. The most efficient strategy is to begin topicalization of the maternal airway while preparations simultaneously are made for the intubation. There are many options and none is superior to the other but individual practitioners should do what they can do best and most efficiently. The simplest strategy is known as an ''awake look'' [53,54]. Here, direct laryngoscopy is attempted after topicalization of the airway. During this maneuver, a practitioner may intubate directly or assess the true difficulty of intubation and reconsider the diagnosis. Not all practitioners are comfortable with this strategy. Other techniques for securing the airway of an awake patient include fiberoptic intubation or the intubating laryngeal mask both of which can be performed on a topicalized airway [53,55].

In the setting of the unanticipated difficult airway (which may represent up to 50% of all difficult intubations), practitioners must assure themselves that the intubation attempt has been optimal (most qualified operator, good positioning, and optimal laryngoscope blade). Pregnant patients tend to desaturate quickly; thus, there may not be much time for multiple attempts. The important variables include whether or not there is adequate mask

ventilation and the presence of ongoing fetal distress. In situations where there is inadequate mask ventilation, the American Society of Anesthesiologists difficult airway algorithm applies [56]. In situations with adequate mask ventilation, which may include any type of laryngeal mask, it may be reasonable to proceed, particularly in the presence of ongoing fetal distress. In doing so, consideration must be given to whether or not to allow spontaneous mask ventilation or to institute neuromuscular blockade and manually or mechanically ventilate the patient. It also is recommended that cricoid pressure be maintained in situations where it does not interfere with ventilation. The obstetric team should be warned that fundal pressure and head-down positioning should be avoided so as not to potentiate any possible regurgitation of gastric contents. This may necessitate a forceps- or vacuum-assisted delivery. A surgical airway still is an option but the risks for and delay in doing this must be balanced against the risk for proceeding with a mask airway. In the absence of fetal distress, the most prudent course of action is to awaken the patient and proceed per the anticipated difficult airway algorithm. Again, although it is an option, a surgical airway in this setting is unnecessary.

Rescue devices and alternative airways in obstetrics

The most popular rescue device for failed intubation situations is the laryngeal mask airway (LMA). This device can be used as a ventilatory device or a conduit for intubation. In a study of 1097 healthy, selected women having elective cesarean sections under general anesthesia [57], the LMA was 99% effective on the first attempt and 1% effective on the second or third attempt as a ventilatory device. In a survey of 209 obstetric units in the United Kingdom [58], 21 of 24 anesthesiologists who had personal experience with LMAs in failed intubations were successful in using it for ventilation. Eight of these claimed that it was a ''lifesaver.'' The remaining three were successful using a facemask. Bailey and Kitching [59] reported on an informal survey that described the successful use of the LMA as a rescue ventilatory device in nine cases in four departments in the United Kingdom. Brimacombe [60] suggests that the use of the LMA in the difficult obstetric airway is supported by a few studies and many case reports with an expected failure rate of approximately 12%.

The ProSeal LMA [61] is a new LMA that forms a seal and conduit with the respiratory tract and the gastrointestinal tract. The conduit to the gastrointestinal tract allows for gastric drainage and escape of regurgitated fluids whereas the newly designed airway cuff seals at higher pressures than a classic LMA allowing for higher ventilatory pressures, a finding constant across a wide range of body mass index scores. Compared to a classic LMA, these features may be advantageous in the pregnant population. Several case reports have demonstrated good success and no morbidities rescuing failed intubations [62–65] and failed intubation/failed ventilation

[64,66] scenarios with the ProSeal LMA. In several of these cases, the ProSeal was successful in women who had edematous upper airways [62,63,66]. Although these cases likely could have been salvaged just as easily with a classic LMA, the ProSeal allowed insertion of a gastric drainage tube. The value of gastric drainage in this situation and the value of a ProSeal (compared with a classic LMA) on maternal morbidity remain unknown.

The intubating LMA (ILMA) [67] is a rigid LMA designed to serve as a conduit for blind endotracheal intubation while allowing ventilation to take place between intubation attempts. The ILMA can be used for awake intubation after airway topicalization [55] (an alternative to awake fiberoptic intubation) or as a rescue device. Variations include using it as a conduit for a fiberscope or with the use of a lighted stylet. Although there is minimal published experience in the pregnant population, awake use and rescue are described [68,69].

Although the LMA is the best known of the alternative airway devices, another device that may be useful in obstetrics is the GlideScope. The GlideScope is a video laryngoscope with a camera embedded at the tip of the blade that precludes the requirement to obtain a direct view of the glottis. Three series evaluating the devices in almost 1000 unselected patients have shown that it consistently yields an equivalent or superior view to direct laryngoscopy [70–72]. In pregnant patients, Cormack and Lehane grade 3 views at laryngoscopy are a common problem among difficult intubations, and in the nonpregnant population, the GlideScope consistently provides improved glottic views in patients with poor views at direct laryngoscopy [72]. Although there are no publications documenting its use in obstetric patients this device has potential as a rescue device or as a primary tool in cases where difficult intubation is anticipated [73]. In the author's institution, it is used frequently in the main OR and has been used for several anticipated difficult intubations on the labor and delivery floor.

Alternative devices used successfully in pregnant patients include the Esophageal Tracheal Combitube [74] and the Laryngeal Tube S [75].

No single device can be recommended, as much of the data are based on case reports and series that are dependent on local availability and individual skills. Rather, individual practitioners should have a personal armamentarium of alternative airway management techniques (available to them) that they are proficient with and can use reliably in difficult situations.

Summary

Despite the concerns related to the physiologic changes of pregnancy, the best available evidence, from cohort studies, is not convincing regarding the premise that the pregnant population, as a whole, is more difficult to intubate. Studies seem to suggest that a subset of women may develop some oropharyngeal edema during pregnancy and during labor and delivery.

Superimposed preeclampsia and parenteral fluid administration also may contribute to this phenomenon. In certain cases, excessive edema may be present that might contribute to increasing difficulties at intubation. These may or may not be isolated cases. What probably is most important is the airway anatomy on which these changes are superimposed. Some women likely have more "airway reserve" for the accumulation of edema than others with respect to ease of intubation. Whether or not those patients at risk for difficult intubation by preoperative airway assessment can be detected is unknown. It is likely that this ability is limited and that there is an irreducible minimum incidence of difficult and failed intubation despite the best efforts at assessment and prediction.

What seems surer, however, is that induction of general anesthesia for cesarean section is a more complex situation than average, which may lend itself to an increased incidence of difficulty and complications. Given the prevalence of regional anesthesia for cesarean section, most teams have a declining experience at providing general anesthesia for cesarean section. This may contribute to increased problems. Pregnant women are at increased risk for aspiration and may be fasted inadequately. Consequently, all intubations require a rapid-sequence approach. They desaturate quickly allowing for less time to manage difficulties. Many women receiving general anesthesia have significant comorbidities and their operations often are more emergent and occur frequently outside of normal hours. Anesthesiologists may have substandard assistance and are under considerable pressure to proceed quickly. Assessment and judgment may be compromised. For all these reasons, even though the pregnant airway may not be more difficult anatomically, the circumstances are more challenging and must be respected.

Planning and prevention are fundamental to the management of the maternal airway. Patients must receive careful airway assessments, particularly when general anesthesia is contemplated. Prophylactic epidurals may help avoid difficult situations and gastrointestinal prophylaxis may decrease morbidity from aspiration. Experienced help always should be readily available. Anticipated difficult airways should be managed with regional techniques or awake intubation. Unanticipated cases are managed according to difficult airway algorithms. In cases where adequate mask ventilation is possible and fetal distress is ongoing, it may be reasonable to proceed carefully with the delivery. The laryngeal mask and its variations (ProSeal and ILMA) seem to be the most useful adjuncts to airway management in difficult situations. The much newer GlideScope holds some promise in this area based on preliminary studies in nonpregnant patients.

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