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ORIGINAL ARTICLE

Incidence of unanticipated difficult airway in obstetric patients in a teaching institution

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Abstract
Purpose Our aim was to determine the incidence of difficult intubation during pregnancy-related surgery at a high-risk, high-volume teaching institution.
Methods Airway experience was analyzed among patients who had pregnancy-related surgery under general anesthesia from January 2001 through February 2006. A difficult airway was defined as needing three or more direct laryngoscopy (DL) attempts, use of the additional airway equipment after the DL attempts, or conversion to regional anesthesia due to inability to intubate. Airway characteristics were compared between patients with and without a difficult airway. In addition, pre- and postoperative airway evaluations were compared to identify factors closely related to changes from pregnancy.
Results In a total of 30,766 operations, 2,158 (7%) were performed with general anesthesia. Among these, 1,026 (47.5%) were for emergency cesarean delivery (CD), 610 (28.3%) for nonemergency CD, and 522 (24.2%) for non-CD procedures. A total of 12 patients (0.56%) were identified as having a difficult airway. Four patients were intubated with further DL attempts; others required mask ventilation and other airway equipment. Two patients were ventilated through a laryngeal mask airway without further intubation attempts. Ten of the 12 difficult airway cases were encountered by residents during their first year of clinical anesthesia training. There were no maternal or fetal complications except one possible aspiration.
Conclusion Unanticipated difficult airways accounted for 0.56% of all pregnancy-related surgical patients. More than 99.9% of all obstetric patients could be intubated. A difficult airway is more likely to be encountered by anesthesia providers with <1 year of experience. Proper use of airway equipment may help secure the obstetric airway or provide adequate ventilation. Emergency CD did not add an additional level of difficulty over nonemergency CD.

Keywords Airway · Obstetrics · Pregnancy

Introduction

Airway-related complications are the leading cause of anesthesia-related maternal mortality [1]. General anesthesia is frequently considered during emergent situations when a delay in anesthesia is to be avoided. The decision to perform general versus regional anesthesia in pregnant patients is based on the anesthesia provider's knowledge, skills, equipment, and staff support. It is critically important to understand the risk of a difficult or failed intubation among these patients. Whereas it is believed that the obstetric airway is more difficult than the nonobstetric airway, the true incidence of a difficult or failed airway in pregnancy has been brought into question [2–4]. A recent analysis of obstetric claims before and after 1990 showed a significant reduction over time in airway-related incidents, such as esophageal intubation, aspiration, and hypoxia.

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On the other hand, prolonged attempts at regional anesthesia contributed to cases of newborn deaths or brain damage that were attributed to delays in anesthesia [5]. The decrease in airway-related incidents may reflect an overall trend of decreasing use of general anesthesia in parturients. Alternatively, improved airway equipment and management skills among obstetric anesthesia providers in recent years may have contributed to the reduction of airway-related complications. Several studies have found that there were no anesthesia-related deaths secondary to a failed airway during induction [6, 7], supporting the latter hypothesis. During emergency situations, a good understanding of the risk of encountering a difficult airway in an obstetric patient would help anesthesiologists balance the risks and benefits of regional versus general anesthesia.

In 1992, Rocke et al. [8] associated airway exam findings with various levels of difficulty upon intubation in 1,500 pregnant patients. In wanting to document a more recent experience, we performed a retrospective review of obstetric intubations from 2001 to 2006 in our high-volume teaching institution with the aim of identifying factors associated with a difficult airway and the incidence of a difficult airway during pregnancy-related surgery. As difficult or failed intubations remain relatively infrequent, we aimed to separate patients with a difficult airway from those without instead of stratifying graded levels of physical findings and intraoperative encounters. Our simple goal was to attempt to identify possible contributing factors to the difficult airway experience, such as anatomy, types of surgery, whether the surgery was emergent, and the type of operator who performed the initial intubation attempt.

Materials and methods

The study was a retrospective analysis of prospectively collected consecutive data over 5 years. It was approved by the Institutional Review Boards of the University of Texas Southwestern Medical Center at Dallas and the Parkland Memorial Hospital, Dallas, Tx, USA, with a consent waiver for the retrospective study. The obstetric service at the Parkland Memorial Hospital is an inner city tertiary referral center that handles 16,000 deliveries annually. In addition to emergency cesarean deliveries (CDs), general anesthesia was performed due to maternal refusal of regional anesthesia; maternal medical conditions such as cardiopulmonary failure; severe sepsis; difficulty of or contraindications to regional anesthesia such as previous back surgery; and thrombocytopenia or other risks of coagulopathy. Some anesthesiologists elected to perform or convert to general anesthesia if the regional anesthesia procedure was too time consuming or complex in certain patients, such as those undergoing a postpartum hysterectomy, in order to facilitate surgical exposure or provide patient comfort. At our institution, a group of full-time dedicated obstetric anesthesiologists supervised a mixture of certified registered nurse anesthetists (CRNAs) and residents at various training levels. A practice manual containing detailed guidelines, including choice of induction drugs, was distributed to each new resident, CRNA, and faculty. Communications between obstetricians, nurses, and anesthesia providers were carried out through instant radios (walkie-talkies), and the faculty anesthesiologist was always present during induction. As all attending anesthesiologists were full-time obstetric anesthesiologists and the core remained relatively stable, we believe our observation represented a reasonable consistency in practice pattern and airway equipment availability.

All patients arriving in the Labor and Delivery Unit were routinely evaluated preoperatively by a senior resident in the second or third year of clinical anesthesia training (CA-2 or CA-3) or a senior CRNA (typically with $\geq$3years of experience). Residents in their first year of clinical anesthesia training (CA-1) typically focus on gaining hands-on experience with various regional and general anesthesia techniques, including intubations. For all patients undergoing general anesthesia, an encounter form (Fig. 1) was filled out by research personnel with data from the preoperative evaluation and anesthesia records. Occasionally, only a brief airway exam could be performed prior to extremely emergent operations when patients were transported directly from the Emergency Department or the obstetric triage area. In these patients, detailed airway exams were performed in the immediate postoperative period, and data were recorded at that time. All encounter forms were examined in the mornings and evenings, ensuring data collection on every patient was completed within 12 h of surgery.

All patients received 30 ml of sodium citrate orally. Patients underwent a rapid sequence intubation with cricoid pressure. General anesthesia was induced with thiopental or propofol, and succinylcholine 1.5–2.0 mg/kg was administered for neuromuscular blockade. Whereas the initial intubation attempt was typically performed by a CRNA or resident, the faculty anesthesiologist would immediately take over if the initial attempt was not successful. This practice, which allows a junior person to have one attempt, was established to allow for adequate training of residents while maintaining patient safety. Additional intubation attempts by the attending anesthesiologists might have included further direct laryngoscopy (DL) with the same or different blades, repositioning of the patient's head and/or shoulders, the use of additional maneuvers such as mask ventilation, or the use of additional equipment such as a gum-elastic bougie, laryngeal mask airway (LMA) with cricoid pressure, fiberoptic scopes, or via an

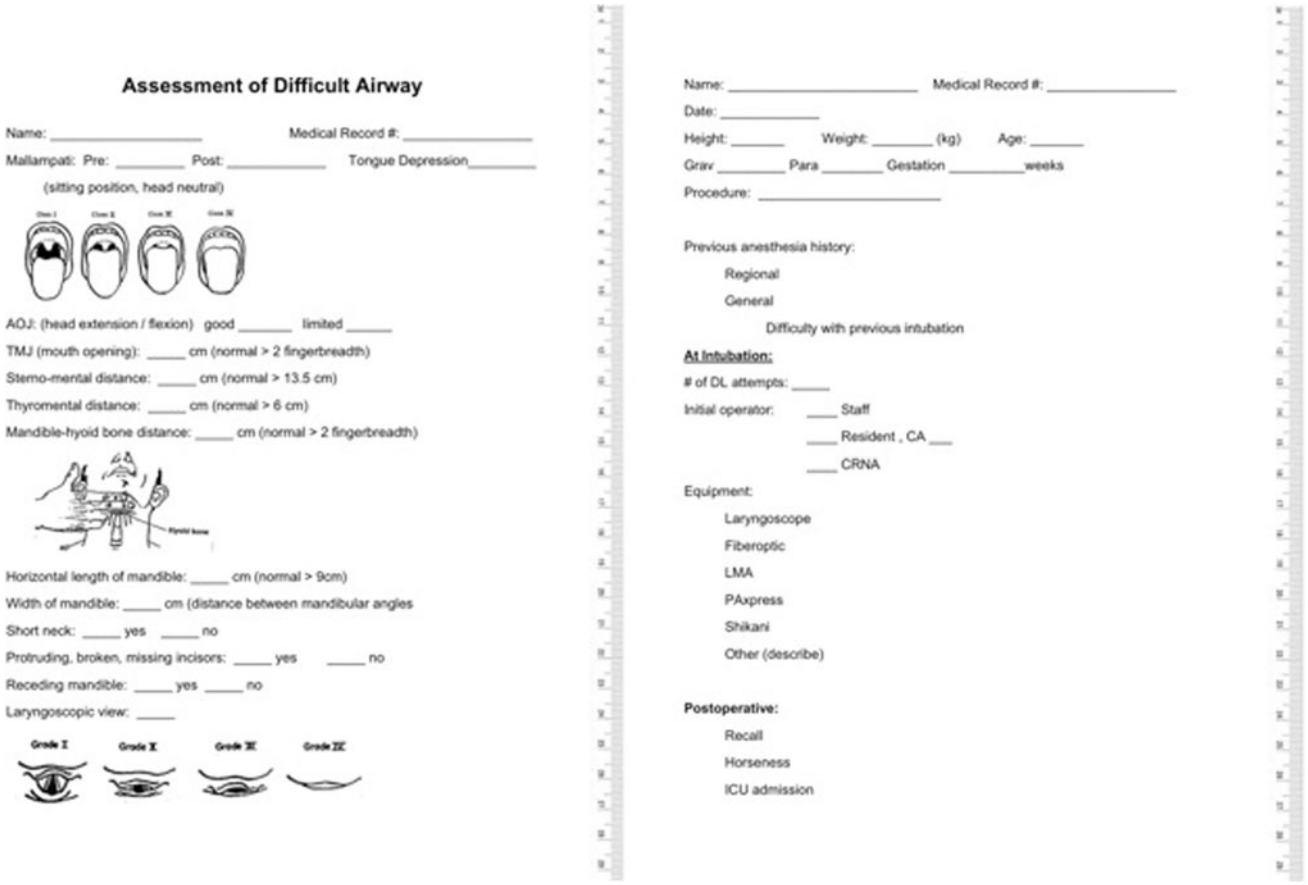

Fig. 1 Encounter form used to document findings of pre- and postoperative airway exam and intraoperative encounter

intubating LMA (iLMA). Videolaryngoscopes were not available to our practice during the study period. The findings by the attending anesthesiologist were considered final and entered in the encounter form. The encounter form contained key demographic and airway assessment variables as well as intraoperative findings (Fig. 1). These variables included: age, weight, Mallampati airway class, head/neck extension, sternomental distance, thyromental distance, mandible–hyoid distance, horizontal mandible length, and abnormalities in neck length or movements. Intraoperatively, the Cormack Lahane laryngoscopic view grade, the number of DL attempts, and the use of mask ventilation or additional airway equipment after the initial DL attempt were also recorded. On the side of the encounter form was a calibrated ruler used to perform necessary airway measurements. The initial operator (attending anesthesiologist, CRNA, or resident with the level of training) was also noted. Other anesthesia-related events such as aspiration and intraoperative awareness were also recorded. A difficult airway was defined as needing three or more DL attempts or the use of any maneuvers or techniques outside the rapid sequence induction routine, including mask ventilation due to oxygen desaturation from the unsuccessful intubation attempt(s), the use of additional airway equipment, or the inability to intubate. Based on these criteria, patients were divided into the difficult airway and the nondifficult airway groups. For continuous variables, the means and standard deviations (SD) were used to summarize the numeric values for each group, and Student's t tests were used to compare the difference between groups. For categorical variables, chi-square tests were used to compare the percentage difference between groups. A p value of <0.05 was regarded as statistically significant.

Results

From June 2001 through February 2006, 82,054 women delivered newborns at our institution. Overall, 20,610 (25%) patients had a CD. Labor epidural analgesia was performed in 24,528 patients (29.9% epidural rate), of whom 18,731 delivered vaginally and 5,797 converted to CD. There were 30,766 anesthetic procedures performed for surgeries related to pregnancy and/or childbirths. Among these, 2,158 patients received general endotracheal

anesthesia. Principle physical characteristics and surgical indications are shown in Table 1. Of the 2,158 patients under general anesthesia, 1,026 (47.5%) were for emergency ("stat") CD, 610 (28.3%) for nonemergency CD, and 522 (24.2%) for non-CD procedures, such as dilatation and curettage, postpartum tubal ligation, and postpartum exploratory laparotomy/hysterectomy. Overall, the general anesthesia rate was 8% for CD and 7% for all obstetric surgical procedures.

A total of 12 patients (0.56%) among those who had general anesthesia were identified as having a difficult airway by the definition stated above, with a 95% CI 0.24–0.87%. There was not enough evidence to suggest that any particular preoperative variable was related to a difficult airway. As could be expected, a poor Mallampati class was more likely to be associated with a difficult airway; however, there were no airway exam variables predicting such a poor view or a subsequent difficult intubation (Table 1). With a low incidence of difficult airway, the post hoc analysis indicated a statistical power too low to detect differences in these variables between groups, despite a near 5-year observation period. Of the 12 patients with a difficult airway, four (33.3%) had an emergency CD, two (16.7%) had a nonemergency CD, and six (50%) had non-CD procedures. The incidence of a difficult airway in these three types of procedures were 0.39%, 0.32%, and 1.2%, respectively, with no statistical differences between emergency or nonemergency CD or

Table 1 Airway characteristics and intraoperative encounters in patients with and without a difficult airway

	Difficult airway ($n = 12$)	Non-difficult airway ($n = 2{,}146$)
Age (years)	30.5 (5.6)	26.7 (6.4)
Height (cm)	165.1 (9.4)	158.0 (7.6)
Weight (kg)	99.3 (30.4)	79.4 (19.3)
Body mass index	33.5 (2.2)	31.6 (0.2)
Gestational age (for CD, weeks)	38–41 (40.5)	19–43 (38)
Emergency CD	4 (33.3%)	1,020 (47.5%)
Non-emergent CD	2 (16.7%)	608 (28.3%)
Non-CD case distribution		
Within 48 h of term delivery	4 (33.3%)	352 (16.4%)
8–12 weeks gestation	2 (16.7%)	164 (7.6%)
Preoperative		
MP class		
I	3 (25.0%)	592 (27.6%)
II	7 (58.3%)	1,363 (63.5%)
III	2 (16.7%)	185 (8.6%)
IV	0 (0.0%)	6 (0.3%)
Sternomental distance (cm)	13.5 ± 1.0	13.9 ± 1.0
Thyromental distance (cm)	6.8 ± 1.2	7.1 ± 1.0
Mandible–hyoid distance (cm)	3.8 ± 0.7	3.8 ± 1.1
Horizontal mandible length (cm)	9.8 ± 1.3	9.9 ± 1.1
Mandible width (cm)	10.5 ± 1.8	9.9 ± 1.5
Abnormalities in		
Head/neck extension	0 (0.0%)	40 (1.9%)
Neck length	1 (8.3%)	119 (5.5%)
Intraoperative		
DL view grade		
I	1 (8.3%)	1,771 (82.5%)*
II	1 (8.3%)	310 (14.5%)
III	3 (25.0%)	60 (2.8%)*
IV	7 (58.3%)	5 (0.2%)*
Initial operator		
Attending anesthesiologists	0 (0.0%)	34 (1.6%)
Residents	10 (83.3%)	879 (41.0%)**
CRNA	2 (16.7%)	1,233 (57.4%)

Demographic data presented as mean (SD) or (%); gestational age presented as range (median)

CD cesarean delivery, *MP* Mallampati, *DL* direct laryngoscopy, *CRNA* certified registered nurse anesthetist

* $p < 0.01$ versus group with a difficult airway, ** $p < 0.01$ comparing difficult versus nondifficult airway

between CD and non-CD procedures. Of the six patients with other procedures, there were two dilatation and curettage procedures, two exploratory laparotomies for postpartum bleeding, and two postpartum tubal ligations. The two dilatation and curettage procedures were performed between 8 and 12 weeks of gestation, and the exploratory laparotomies and postpartum tubal ligations were performed within 48 h of term delivery.

Detailed airway encounters of the 12 patients with a difficult airway are shown in Table 2. Four patients were successfully intubated with additional DL attempts by attending anesthesiologists: one required a gum-elastic bougie, and one required Ambu bag ventilation between DL attempts; two were intubated via an iLMA and two with fiberoptic scope via the iLMA. Two patients completed emergency CD under general anesthesia ventilated through an iLMA with cricoid pressure and no further attempts to intubate. There was one case of possible maternal aspiration suggested by a decrease in oxygen saturation between 90% and 93% and a local infiltrate on chest X-ray in the immediate postoperative period, but the patient's oxygenation spontaneously improved without further treatment. The patient was discharged on the third postoperative day after an uneventful course without a repeat chest X-ray. There were no other maternal or fetal complications related to respiration. During the postoperative evaluation performed within 24 h of surgery, there were no documented reports of intraoperative awareness, hoarseness, or other complications. In ten of the 12 patients with a difficult airway, CA-1 residents were the initial operator attempting the endotracheal intubation. Given the relative rarity of a difficult airway, we did not perform a multivariate analysis or a multiple testing comparison correction.

Discussion

In our practice, regional analgesia was the technique of choice in obstetric patients. Despite the emphasis we placed on regional anesthesia in obstetrics, our general anesthesia rate of 8% for CD (7% for all obstetrical surgical procedures) was higher than a report of 0.5–1% from another teaching institution [9]. We attribute this to the patient population with its cultural and socioeconomic differences. Our hospital is located in the southern region neighboring Mexico, with >70% of the patient population being Hispanic. Our epidural rate was <30%, lower than the national average. Our patients were frequently multiparous, more

Table 2 Detailed intraoperative encounters of patients with a difficult airway

Patient	Procedure	MP	Ini. op.	DL view	DL attempts	Reason for general anesthesia	Encounter
1	D&C	I	Resident[a]	4	3	Patient refused regional block	Intubated on 3rd attempt
2	E. CD	II	CRNA	4	3	Emergency	Intubated on 3rd attempt
3	CD	II	Resident[a]	3	3	Failed epidural dosing up	Intubated on 3rd attempts, required Ambu bag between laryngoscopy attempts
4	Exp. Lap.	II	Resident[a]	3	4	To provide comfort and exposure	Intubated on 4th attempt
5	BTL	I	Resident	4	6	Refused regional block	Intubated on 6th attempt, 6 cm goiter noted upon hyperextension of neck
6	BTL	III	Resident	3	1	Unsuccessful regional block	Intubated with Bougie
7	E. CD	III	Resident[a]	4	5	Emergency	Intubated via iLMA
8	Exp. Lap.	II	CRNA	4	3	Comfort and exposure	Intubated via iLMA
9	D&C	I	Resident	1	3	Patient emotionally unstable and uncooperative	Intubated with fiberoptic scope via iLMA; attending noted "sub-glottic stenosis"; possible aspiration on CXR, recovered uneventfully
10	CD	II	Resident	4	3	Unsuccessful regional block	Intubated with fiberoptic scope via iLMA
11	E. CD	II	Resident[a]	2	3	Emergency	Not intubated. Surgery under iLMA with cricoid pressure "very anterior" cords noted by attending.
12	E. CD	II	Resident	4	5	Emergency	Not intubated. Surgery under iLMA with cricoid pressure

Attending anesthesiologists performed subsequent intubation attempts beyond the initial attempt by residents or certified registered nurse anesthetists (CRNAs)

D&C cervical dilation and curettage, *E. CD* emergency CD, *BTL* open bilateral tubal ligation, *Exp. Lap.* exploratory laparotomy, *MP* Mallampati class, *Ini. Op.* initial operator, *DL* direct laryngoscopy, *GA* general anesthesia, *CXR* chest X-ray

[a] With training experience of ≤3 months

reluctant to have epidural analgesia, and most importantly, lacking proper prenatal care. We were more likely to experience obstetric emergencies, and without an epidural catheter, time-critical maternal or fetal conditions were more likely to be handled with general anesthesia.

Goldszmidt summarized studies from the 1980s through the 1990s and found that the incidence of a difficult intubation ranged from approximately 1% to 6% and that of a failed intubation from 0.1% to 0.6% [2]. In many of the studies cited, a difficult airway was defined as a grade 3 or 4 view and a failed intubation as inability to intubate with a single dose of succinylcholine. We intended to capture every possible patient who might have posed a challenge for the anesthesia provider during the intubation attempt, as repeated attempts would likely cause maternal and fetal harm related to oxygen desaturation. In our experience, two DL attempts are sometimes encountered in patients with a normal airway because of insufficient time for succinylcholine to take effect or poor head positioning during the first DL attempt, particularly in an emergency situation. In a teaching institution, operator inexperience may also cause inability to intubate a normal airway on the first attempt.

Other studies have shown the role of trainee experience in the difficult obstetric airway: less-experienced operators were more likely to encounter airway difficulties [4, 10], Our results further demonstrate the role of relatively inexperienced operators in the difficult airway experience, as ten of the 12 difficult airway patients were initially attempted by residents during their first year of clinical anesthesia training; five of them had only been in training for $\leq$3 months. The second attempt by the attending anesthesiologist should eliminate a falsely difficult airway from insufficient time for succinylcholine or poor technique of the initial operator.

Results of our study show a 0.56% incidence of a difficult airway in patients induced for general anesthesia at our teaching institution. This number may not reflect the true incidence of a difficult airway, as some anesthesiologists may have deliberately avoided general anesthesia in patients with a suspected or known difficult airway. Nonetheless, our findings are comparable with that of Djabatey [3], who also found that, except for one case of aspiration, no other maternal or fetal complications occurred in their series of 3,430 patients. In another study that combined the experiences of Australia and New Zealand, a difficult intubation was defined as needing more than one DL attempt. Of 1,095 women in the study, the incidence of a difficult intubation was 3.3%. As expected, this is higher than our finding because they used a more stringent definition of a difficult airway. However, patients who could not be intubated at all accounted for only 0.4% [11]. Rahman et al. [4] combined patient data in 11 hospitals in the UK. They found the rate of inability to intubate with a single dose of succinylcholine to be 0.4%. In our series, in addition to further attempts by attending anesthesiologists, five patients were intubated with the use of additional airway equipment. In only two patients was intubation not further attempted after three or more DL attempts, making the incidence of a "failed" intubation 0.09%.

An earlier analysis by Hawkins using data from the US Centers for Disease Control and Prevention's Pregnancy-Related Mortality Surveillance System from 1979 through 1990 showed that general anesthesia was associated with a remarkable increase in mortality rates in pregnant women [1]. Davies et al. [5] recently compared closed claims from the database of the American Society of Anesthesiologists (ASA) and found that, compared with the pre-1990 era, respiratory causes of injury claims decreased from 24% to 4%, inadequate oxygenation/ventilation decreased from 5% to 1%, and esophageal intubation decreased from 4% to 0%, despite a similar rate of difficult intubation (from 5% to 3%) before and after 1990. Most notably, there were no deaths from a difficult intubation after 2000 in the database. This trend is also shown in other studies [6] [7]. The lower incidences of airway-related injuries may reflect the overall decline in the use of general anesthesia in parturients [12], but better preparation in airway management with more choices of airway equipment in recent years may have also contributed to the reduction in airway-related morbidities. For example, in four of our 12 patients with a difficult airway, an iLMA was used either as a tool to intubate blindly or fiberoptically, or as the sole means of ventilation. Since the conclusion of our study, we have added videolaryngoscopes to our airway tools. These relatively new technologies allow better visualization of the glottis of patients with otherwise difficult airways.

In the comprehensive analysis of Rocke et al. [8], a variety of anatomical factors were found to be associated with different levels of difficulty upon intubation. Specifically, a poor Mallampati class was closely linked to a poor laryngoscopic view and a subsequent difficult or failed intubation. Due to the rarity of a truly difficult airway, we did not attempt to perform a multivariate data analysis, as such an analysis would require at least 40–50 cases in the difficult airway group to achieve enough power in our study. Recruiting the number of patients to generate this number of cases in the difficult airway group would be impractical within any institution over a period of time with a consistent anesthesia practice. For this reason, we only performed univariate analysis to compare patients with and without a difficult airway. The statistical power was too low to detect differences in preoperative exam variables between groups. Understandably, a poor laryngoscopic view was associated with a difficult intubation, but this certainly offered no practical value. The human factor, on the other hand, was a key component in the

encounters of a difficult airway, as ten of the 12 difficult airways in our study were first attempted by CA-1 residents. Given these results, delaying the obstetric anesthesia rotation by 6–12 months for new residents could help minimize the effect of inexperience in difficult airway and may maximize maternal safety.

In conclusion, the incidence of an unanticipated difficult intubation in pregnant patients at our teaching institution is 0.56%. With constant attending supervision, more than 99.9% of pregnant patients who were induced for general anesthesia were ultimately intubated. This incidence, however, may not reflect patients with a suspected or known difficult airway in whom general anesthesia may have been deliberately avoided. Emergency surgery did not add an additional level of difficulty to the obstetric airway. Proper use of additional airway equipment may help reduce the risk of being unable to intubate pregnant patients. However, these conclusions come from a high-risk, high-volume institution with adequate staff and equipment support. Whether these findings are applicable in other types of practices is not known.

Conflict of interest None.

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