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Original Research

Airway Management and Outcomes in Obstetric Patients Undergoing Cesarean Section Under General Anesthesia: A Retrospective Single-Center Descriptive Study

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Abstract

Background: Difficult airway management in obstetric patients remains a significant concern, as pregnancy-related physiological changes increase the risk of failed intubation and associated complications. This study examined the airway management strategies during cesarean sections under general anesthesia and evaluated their relationship with maternal outcomes, such as intubation attempts and oxygenation. **Methods**: This retrospective, descriptive cross-sectional study included 1986 pregnant patients (≥18 years, American Society of Anesthesiologists [ASA] II–III) who underwent tracheal intubation for cesarean section between January 1, 2016, and December 31, 2023. Demographic data, preoperative airway assessments, induction and airway techniques, and intraoperative physiological variables were extracted from electronic medical records. Statistical analyses were performed using SPSS version 22.0. Normality was tested using the Shapiro–Wilk test. Between-group comparisons employed the Student's *t*-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed variables, while categorical variables were compared with χ^2 tests. Logistic regression was performed for categorical predictors, and reference category comparisons were reported using regression *p*-values. **Results**: The median patient age was 31 years, and the median gestational age was 38 weeks. Most patients were classified as ASA II (85.2%) and had no comorbidities (84.4%). Video laryngoscopy (VL) was used in only 39 cases (2%), whereas direct laryngoscopy was used in 1947 cases; stylets or bougies were used in 153 cases. Use of VL was significantly associated with patient category, with higher utilization in cases of category three ($p < 0.001$). Thiopental use was associated with a higher number of intubation attempts compared to propofol ($p = 0.031$). Spearman's correlation analysis revealed that the number of intubation attempts was negatively correlated with lowest oxygen saturation during intubation (r = –0.068, $p = 0.003$) and extubation (r = –0.069, $p = 0.002$), and positively correlated with peak airway pressure after intubation (r = 0.078, $p = 0.001$). **Conclusion**: VL remains underutilized in obstetric general anesthesia despite its potential benefits. These findings highlight the need for improved airway management strategies to enhance safety during cesarean deliveries.

Keywords: obstetrics; cesarean; anesthesia; airway management; video laryngoscopy

1. Introduction

According to the World Health Organization, global cesarean section rates have significantly increased from approximately 7% in 1990 to 21%, with further increases expected throughout this decade [1]. Difficult airway management in obstetric patients remains a major concern, as pregnancy-related physiological changes increase the risk of failed intubation and associated complications. In this population, general anesthesia carries specific risks including airway loss, severe hypoxia, and aspiration of gastric contents [2]. A recent literature review reported the incidence of failed tracheal intubation in obstetric patients undergoing general anesthesia as 1 in 390, with a corresponding maternal mortality rate of 1 death per 90 failed intubations [3].

Consequently, regional anesthesia is preferred whenever possible. However, general anesthesia may still be necessary for pregnant patients undergoing non-obstetric or non-delivery obstetric procedures, as well as certain delivery-related interventions. Despite advancements in airway management techniques and the widespread adoption of video laryngoscopy (VL), the risk of failed intubation remains higher in obstetric patients than in the general surgical population [4]. Difficult intubation, although variably defined, has been reported in 1 out of every 21 obstetric intubations, compared to 1 in 50 among non-obstetric intubations [5].

A combination of maternal, fetal, and situational factors contributes to the challenging airway management in this patient population [6]. Physiological changes during pregnancy, such as airway edema, weight gain, reduced functional residual capacity, and increased oxygen consumption, can lead to rapid desaturation, making timely and successful intubation critical [7]. Additionally, emergency cesarean deliveries often involve time-sensitive decision-making, limiting opportunities for thorough preoperative airway assessment and preparation [8,9].

Given these risks, it is critical to evaluate current airway management practices in obstetric patients receiving general anesthesia and identify areas for improvement. This descriptive cross-sectional study analyzes the largest national dataset of obstetric general anesthesia cases in Qatar, with the aim of describing current practices, patient characteristics, and related outcomes. The primary objective was to describe the airway management strategies used during cesarean section (C-section) under general anesthesia. Secondary objectives included assessing the relationship between airway techniques and maternal outcomes, such as intubation attempts and oxygenation.

2. Materials and Methods

2.1 Study Design and Population

This descriptive cross-sectional retrospective study conducted from August 2024 to May 2025, used data from the medical records of 1986 eligible pregnant patients who required tracheal intubation during elective or emergency cesarean section at Women's Wellness and Research Center Hamad Medical Corporation between January 1, 2016 and December 31, 2023.

2.2 Eligibility Criteria

Inclusion criteria were all pregnant patients aged $\geq$18 years, with American Society of Anesthesiologists (ASA) class II or III, undergoing tracheal intubation for cesarean section in our operating rooms. Patients were excluded if they were under 18 years of age, had an ASA class of IV or higher, or were intubated prior to entering the operating room.

2.3 Data Variables

Data were collected from the electronic medical records after approval from the institutional review board. Key variables included: (1) Demographic information including age, gestational age (GA), gravidity, parity, body mass index (BMI), comorbidities (anemia [10], hypertension and pre-eclampsia [11], thyroid issues [12], multiple sclerosis [13], anti-phospholipid syndrome [14], asthma [15], chronic obstructive pulmonary disease [COPD] [16], and diabetes mellitus [DM] [17]), categories of C-section, and indications for C-section including abruption, fetal distress, no progress, and previous C-section; (2) Preoperative assessment parameters such as ASA score, Mallampati score, Cormack Lehane score, and thyromental distance; and (3) Airway management data including training degree of the anesthetist. The training level of the intubator was categorized as trainee (resident/registrar) in anesthesiology undergoing supervised clinical training or senior (consultant/attending) anesthesiologist with independent practice. The number of intubation attempts, use of video laryngoscope or direct laryngoscope, laryngoscope blade number, use of stylet/bougie, drugs for general anesthesia, and intra-operative data including peripheral oxygen saturation (SpO_2), baseline, 5 and 15 minutes post endotracheal intubation heart rate (HR), 5 and 15 minute post endotracheal intubation mean arterial pressure (MAP) and endtidal carbon dioxide ($EtCO_2$), peak airway pressure (PAP) after intubation, high-dependency unit, and intensive care unit (ICU) durations were also recorded.

The ASA Physical Status Classification System is a standardized tool used to assess and communicate a patient's pre-anesthesia medical comorbidities. It categorizes patients as follows: ASA I—a normal healthy patient; ASA II—a patient with mild systemic disease or a normal pregnancy; ASA III—a patient with severe systemic disease; ASA IV—a patient with systemic disease that is a constant threat to life; ASA V—a moribund patient not expected to survive without the operation; and ASA VI—a declared brain-dead patient whose organs are being removed for donor purposes [18]. The Mallampati classification and Cormack–Lehane grading system are both used to assess airway difficulty. The Mallampati score is a preoperative bedside assessment based on the visibility of oropharyngeal structures, helping predict ease of endotracheal intubation. Class I—full visibility of the soft palate, uvula, and tonsillar pillars; Class II—soft palate and part of the uvula; Class III—base of the uvula; and Class IV—only hard palate [19]. The Cormack–Lehane grading system, used during direct laryngoscopy, classifies the laryngeal view. Grade I—full view of the glottis; Grade II—partial view of the glottis; Grade III—only the epiglottis visible; and Grade IV—neither glottis nor epiglottis visible [20]. Clinically, higher Mallampati classes and Cormack–Lehane grades indicate increasing difficulty in intubation and airway management.

The categories of C-section were defined according to hospital guidelines. Category 1 was defined as C-section is required as there is an immediate threat to maternal or fetal life. Category 2 was defined as C-section is required as there is a maternal or fetal compromise but not immediately life threatening. Category 3 was defined as C-section is required as there is a need for early birth, but no maternal or fetal compromise. Category 4 was defined as C-section is required at a time suitable for woman and the C-section team [21].

Table 1. Baseline characteristics of participants.

Variable	Level	Value
N		1986
Age (years), median (IQR)		31 (18.0–48.0)
Gestational age (weeks), median (IQR)		38 (20.0–43.0)
Gravidity, median (IQR)		3 (1.0–16.0)
Parity, median (IQR)		1 (0.0–13.0)
Body mass index (kg/m^2), median (IQR)		31 (15.0–49.0)
Comorbidities, n (%)	None	1676 (84.4)
	Anemia	91 (4.6)
	Anemia & HTN	1 (0.1)
	Anemia & Thyroid	2 (0.1)
	HTN	37 (1.9)
	HTN & PET	5 (0.3)
	HTN & Thyroid	1 (0.1)
	PET	34 (1.7)
	Multiple sclerosis	2 (0.1)
	Anti-phospholipid syndrome	1 (0.1)
	Thyroid	136 (6.8)
Asthma, n (%)	No	1925 (96.9)
	Yes	61 (3.1)
COPD, n (%)	No	1981 (99.7)
	Yes	5 (0.3)
DM, n (%)	No	1453 (73.2)
	GDM	517 (26.0)
	Previous GDM	16 (0.8)

Abbreviations: HTN, hypertension; PET, preeclampsia; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; GDM, gestational diabetes mellitus; Previous GDM, previous gestational diabetes mellitus; IQR, Interquartile range.

2.4 Data Collection

A standardized Case Report Form (CRF) was provided to the data collection team, who extracted information from the Hospital Cerner System. Under the direct supervision of the Principal Investigator (PI), the team recorded clinical data in the CRFs. All CRFs were anonymized using a coded system that excluded patient identifiers. The coded data sheet was stored exclusively on a secure, non-networked computer located in the PI's locked office. The data were entered into a Microsoft Excel sheet on this secure, non-networked computer, specifically allocated for the study. Patient names were not recorded at any stage; instead, a unique alphanumeric code was assigned to each case.

Operating rooms in the Women's Wellness and Research Center were categorized into Level 2 and Level 3, each assigned a specific letter code for anonymization:

Level 2:

• Women's Wellness Level 2 C-section 01 → Code A.

• Women's Wellness Level 2 C-section 02 → Code B.

Level 3:

• Women's Wellness Level 3 C-section 01 → Code C.

• Women's Wellness Level 3 C-section 02 → Code D.

• Women's Wellness Level 3 gynecology (Gyne) 01 → Code E.

• Women's Wellness Level 3 Gyne 02 → Code F.

• Women's Wellness Level 3 Gyne 03 → Code G.

In the coding system, a unique nine-digit alphanumeric code was generated by combining six digits representing the day, month, and year of the procedure, followed by the operating room designation and the patient's numerical sequence for that 24-hour period (00:00 to 23:59 hours). For example, the code 010718A06 represents the sixth patient in Room WW Level 2 C-Section 01 on July 1, 2018.

2.5 Statistical Analyses

All statistical analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation (SD) for normally distributed data or as median with interquartile range [IQR] for non-normally distributed data, while categorical variables were summarized as frequencies and percentages. For inter-group comparisons, the *t*-test was applied to normally distributed continuous variables, and the Mann–Whitney U test was used for non-normally distributed continuous variables. Chi-square tests were em-

Table 2. Preoperative assessment and intubation data of participants.

Variable	Level	Value
Thyromental distance (cm), median (IQR)		6 (2.0–8.0)
Mallampati score, n (%)	1	138 (6.9)
	2	1500 (75.5)
	3	295 (14.9)
	4	53 (2.7)
Mallampati category, n (%)	1–2	1638 (82.5)
	3–4	348 (17.5)
Cormack-Lehane score, n (%)	1	450 (22.7)
	2	1397 (70.3)
	3	126 (6.3)
	4	13 (0.7)
Cormack-Lehane category, n (%)	1–2	1847 (93.0)
	3–4	139 (7.0)
ASA, n (%)	2	1692 (85.2)
	3	294 (14.8)
Categories of C-section, n (%)	1	1015 (51.1)
	2	461 (23.2)
	3	114 (5.7)
	4	396 (19.9)
Indications for C-section, n (%)	Abruption	155 (7.8)
	Fetal distress	363 (18.3)
	No progress	159 (8.0)
	Previous C-section	474 (23.9)
	Others	835 (42.0)
Intubation by, n (%)	Trainee	277 (13.9)
	Senior	1709 (86.1)
Number of intubation attempts, median (IQR)		1 (1.0–4.0)
Video laryngoscope, n (%)	No	1947 (98.0)
	Yes	39 (2.0)
Laryngoscope blade number, n (%)	2	9 (0.5)
	3	1873 (94.3)
	4	104 (5.2)
Stylet/bougie, n (%)	No	1833 (92.3)
	Yes	153 (7.7)
Drugs for GA, n (%)	None	29 (1.5)
	Propofol	1015 (51.1)
	Thiopental	903 (45.5)
	Others	39 (2.0)

Abbreviations: ASA, American Society of Anesthesiologists; GA, general anesthesia; None, not documented.

ployed to compare categorical variables. Logistic regression was used for categorical predictors, and reference category comparisons were reported using regression p-values. Correlation analyses were conducted using Spearman's correlation method. All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant.

3. Results

3.1 Baseline Characteristics of Participants

Table 1 summarizes the baseline characteristics of the 1986 eligible pregnant patients included in this study. The median age was 31 years, and the median BMI was 31 kg/m^2. The median gestational age was 38 weeks, whereas the median gravidity and parity were 3 and 1, respectively. Although the majority of patients (84.4%) reported no co-

Table 3. Comparison of video laryngoscope and stylet/bougie use in relation to patient and clinical characteristics.

		Video laryngoscope			Stylet/Bougie		
		No (n = 1947)	Yes (n = 39)		No (n = 1833)	Yes (n = 153)	
Variable	Level	Value	Value	*p*-value	Value	Value	*p*-value
Gestational age (weeks), mean ± SD		36.45 ± 3.81	33.56 ± 5.64	0.003	36.49 ± 3.79	35.28 ± 4.6	0.002
DM, n (%)				0.010			0.954
	No	1426 (98.1)	27 (1.9)		1342 (92.4)	111 (7.6)	
	GDM	507 (98.1)	10 (1.9)		476 (92.1)	41 (7.9)	
	Previous GDM	14 (87.5)	2 (12.5)		15 (93.8)	1 (6.3)	
Categories of C-section, n (%)				<0.001			0.011
	1	1003 (98.8)	12 (1.2)	Ref	936 (92.2)	79 (7.8)	Ref
	2	452 (98)	9 (2)	0.252	435 (94.4)	26 (5.6)	0.139
	3	105 (92.1)	9 (7.9)	<0.001	97 (85.1)	17 (14.9)	0.011
	4	387 (97.7)	9 (2.3)	0.135	365 (92.2)	31 (7.8)	0.977
Drugs for GA, n (%)				<0.001			<0.001
	None	29 (100)	0 (0)	0.998	28 (96.6)	1 (3.4)	0.996
	Propofol	980 (96.6)	35 (3.4)	<0.001	898 (88.5)	117 (11.5)	<0.001
	Thiopental	900 (99.7)	3 (0.3)	Ref	872 (96.6)	31 (3.4)	Ref
	Others	38 (97.4)	1 (2.6)	0.077	35 (89.7)	4 (10.3)	0.037
Intubation by, n (%)				0.794			<0.001
	Trainee	271 (97.8)	6 (2.2)		241 (87)	36 (13)	
	Senior	1676 (98.1)	33 (1.9)		1592 (93.2)	117 (6.8)	
HR 15 min post intubation, beats/min, mean ± SD		95.3 ± 17.07	98.21 ± 14.65	0.228	95.34 ± 17.08	95.52 ± 16.46	0.898
Baseline MAP, mmHg, mean ± SD		94.44 ± 15.49	94.83 ± 14.94	0.884	94.37 ± 15.59	95.41 ± 14.14	0.442
MAP 5 min post intubation, mmHg, mean ± SD		86.41 ± 17.55	87.24 ± 17.2	0.773	86.29 ± 17.23	88.06 ± 20.81	0.312
MAP 15 min post intubation, mmHg, mean ± SD		73.36 ± 13.57	74.16 ± 12.75	0.718	73.4 ± 13.52	73.03 ± 14	0.744
$ETCO_2$ 5 min post intubation, mean ± SD		33.42 ± 4.03	34.67 ± 4.49	0.057	33.42 ± 4	33.72 ± 4.53	0.436
$ETCO_2$ 15 min post intubation, mean ± SD		34.43 ± 3.94	34.49 ± 4.38	0.923	34.39 ± 3.99	34.9 ± 3.5	0.122
Lowest SpO_2 during intubation, %, mean ± SD		98.82 ± 2.59	97.72 ± 3.73	0.074	98.85 ± 2.54	98.22 ± 3.4	0.028
Lowest SpO_2 during extubation, %, mean ± SD		98.81 ± 1.86	97.92 ± 5.17	0.293	98.82 ± 1.86	98.39 ± 3.01	0.079
PAP after intubation, cmH_2O, mean ± SD		20.09 ± 4.52	22.1 ± 4.25	0.006	20.07 ± 4.47	20.92 ± 5.11	0.026

Abbreviations: DM, diabetes mellitus; HR, heart rate; MAP, mean arterial pressure; $ETCO_2$, end-tidal carbon dioxide; SpO_2, peripheral oxygen saturation; PAP, peak airway pressure.

morbidities, the most commonly reported condition was thyroid-related issues (6.8%), followed by anemia (4.6%) and hypertension (1.9%). Most patients had no history of asthma or COPD. Regarding DM, 73.2% had no history of the disease, while 26% had gestational DM (GDM).

3.2 Preoperative Assessment and Intubation Data of Participants

Table 2 summarizes the preoperative assessment and intubation data of the study participants. The median thyromental distance was 6 cm (IQR 2–8 cm). Most patients were Mallampati class II (75.5%), followed by class III (14.9%), class I (6.9%), and class IV (2.7%); when grouped, 82.5% were Mallampati class I–II. Similarly, most patients were Cormack–Lehane grade II (70.3%) or grade I (22.7%), with only 7.0% classified as grade III–IV.

The majority of patients were ASA II (85.2%), whereas 14.8% were ASA III. Regarding urgency, more than half of C-section deliveries were Category 1 (51.1%), followed by Category 2 (23.2%), Category 4 (19.9%), and Category 3 (5.7%). The most common indications for C-section were previous C-section delivery (23.9%) and fetal distress (18.3%).

Most intubations were performed by senior anesthesiologists (86.1%). The median number of intubation attempts was 1 (IQR 1–4). A video laryngoscope was used in only 39 patients (2.0%), whereas direct laryngoscopy was used in the remaining 98.0%. Among laryngoscope blades, size 3 was most frequently employed (94.3%), followed by size 4 (5.2%) and size 2 (0.5%). Stylets or bougies were used in 7.7% of cases.

3.3 Airway Techniques and Maternal Outcomes

As shown in Table 3, among the 1986 patients, only 39 were intubated using a video laryngoscope. The mean gestational age was lower in patients who underwent video laryngoscope intubation. Following intubation, the mean peak airway pressure was slightly higher in this group compared to those intubated with a direct laryngoscope. Its use also varied based on the induction agent, with higher usage observed in patients receiving propofol. Furthermore, the percentage of Category 3 cases in whom video laryngoscope was used was higher than that of Category 1 cases.

A stylet or bougie was used in 153 patients, who had a lower mean gestational age. Its use was associated with higher post-intubation peak airway pressure as well as lower lowest SpO_2 during intubation. Stylet or bougie usage differed significantly by patient category, with higher usage in Category 3. Usage was also significantly greater among trainees compared to senior practitioners. Additionally, significant variation was observed based on medication type, with increased use among patients receiving propofol or other medications.

3.4 Airway Device Use According to C-Section Urgency

Among the study cohort, emergent cases (Categories 1–2) included 1015 patients in Category 1 (51.1%) and 461 in Category 2 (23.2%), totaling 1476 patients (74.3%), while non-emergent cases (Categories 3–4) comprised 114 patients in Category 3 (5.7%) and 396 in Category 4 (19.9%), totaling 510 patients (25.7%). Emergent cases accounted for approximately 74% of the cohort and demonstrated similar number of difficult intubations as non-emergent cases. Overall, VL and adjunct use remained rare in both groups, with slightly higher usage rates in non-emergent cases and higher post-intubation airway pressures (Table 4).

3.5 Number of Intubation Attempts

The number of intubation attempts was negatively correlated with the lowest SpO_2 during both intubation and extubation (Table 5). By contrast, PAP after intubation showed a significant positive correlation. Additionally, a significant difference in the number of attempts was found based on the induction agent used with patients receiving thiopental requiring a higher number of intubation attempts compared to those receiving propofol ($p = 0.031$).

4. Discussion

This study offers a comprehensive analysis of challenges associated with general anesthesia and the resulting outcomes in obstetric patients undergoing both elective and emergency cesarean sections. The findings underscore the complexities of airway management in this population, particularly in high-risk scenarios such as emergency cesarean sections.

One of the most striking findings was the infrequent use of VL. Considering that this study analyzed the largest national dataset of obstetric general anesthesia cases in Qatar, the low adoption rate of VL (only 1.2% of Category 1 cases), particularly in emergency settings, suggests a concerning potential gap in the implementation of advanced airway management techniques. A similar trend was reported in a multicenter observational study from England, which found a VL usage rate of 1.9%, despite a reported difficult tracheal intubation rate of 1 in 19 obstetric surgeries [22].

This underutilization issue is concerning, especially given evidence of widespread VL availability following the Coronavirus-2019 (COVID-19) pandemic [23]. Numerous studies have demonstrated that VL improves glottic visualization and reduces intubation difficulty [24], which is critical in obstetric patients who are already at increased risk of difficult intubation compared to the general surgical population. Furthermore, a recent systematic review and meta-analysis confirmed that VL is highly effective as both a primary intubation device in patients with anticipated difficult airways and as a rescue tool after failed direct laryngoscopy [25]. The authors of that review recommended

Table 4. Clinical outcomes stratified by emergent versus non-emergent cesarean deliveries.

Variable	Emergent (category 1–2)	Non-emergent (category 3–4)	
N	1476	510	*p*-value
	Value	Value	
Use of video laryngoscope, n (%)	21 (1.4)	18 (3.5)	
Use of stylet/ bougie, n (%)	105 (7.1)	48 (9.4)	
Number of intubation attempts, median (IQR)	1 (1–4)	1 (1–3)	0.42
Lowest SpO_2 during intubation, %, mean $\pm$ SD	98.6 $\pm$ 2.8	98.3 $\pm$ 3.5	0.08
PAP after intubation, cmH_2O, mean $\pm$ SD	20.2 $\pm$ 4.5	21.0 $\pm$ 4.7	0.003

Table 5. Correlation and comparison of the number of intubation attempts with intraoperative parameters.

Variable	Level	Value	*p*-value
Drugs for GA, mean $\pm$ SD, n (%)			< 0.001
	Propofol	1.07 $\pm$ 0.32, 1015 (51.1)	
	Thiopental	1.11 $\pm$ 0.33, 903 (45.5)	
	Others	1.13 $\pm$ 0.41, 39 (2.0)	
Baseline HR, beats/min, correlation coefficient (r)		–0.015	0.506
HR 5 min post intubation, beats/min, correlation coefficient (r)		0.002	0.914
HR 15 min post intubation, beats/min, correlation coefficient (r)		–0.007	0.748
Baseline MAP, mmHg, Correlation Coefficient (r)		–0.028	0.243
MAP 5 min post intubation, mmHg, correlation coefficient (r)		–0.004	0.850
MAP 15 min post intubation, mmHg, correlation coefficient (r)		–0.037	0.105
$ETCO_2$ 5 min post intubation, mmHg, correlation coefficient (r)		0.021	0.358
$ETCO_2$ 15 min post intubation, mmHg, correlation coefficient (r)		0.020	0.367
Lowest SpO_2 during intubation, %, correlation coefficient (r)		–0.068	0.003
Lowest SpO_2 during extubation, %, correlation coefficient (r)		–0.069	0.002
PAP after intubation, cmH_2O, correlation coefficient (r)		0.078	0.001

routine VL use in both emergency departments and ICUs. Studies including both multicenter and single-center trials have consistently reported that VL is an excellent rescue option, reporting superior first-attempt success rate in difficult airway scenarios [26,27]. Taken together, our findings indicate that VL is more often selected in preterm or lower GA pregnancies, women with metabolic comorbidities such as diabetes, elective but complex C-section categories, and when propofol was the induction agent. Several factors may explain the limited uptake of VL. Many anesthetists remain more comfortable with direct laryngoscopy, reflecting long-standing habits and the influence of training that predated the widespread availability of VL [28]. Gaps in formal education and inconsistent hands-on experience with these devices can further hinder confidence and slow the development of expertise. In addition, the likelihood of encountering a difficult airway during C-section delivery is sometimes underestimated, particularly when no obvious anatomical predictors are present. Overcoming these challenges will require a comprehensive strategy that combines institutional policies, standardized training initiatives, and deliberate efforts to integrate VL into routine management of high-risk obstetric patients.

Potential strategies to improve VL adoption include routine incorporation into training curricula for anesthesiology trainees, simulation-based practice to enhance familiarity, and updates to institutional and national airway management protocols to recommend VL as a first-line or rescue device in obstetric anesthesia. Ensuring that VL equipment is readily available in all obstetric operating rooms could further encourage its use. These measures, together with systematic training, may enhance intubation success and reduce complications in this high-risk population.

Current obstetrics airway management guidelines recommend that, if the initial intubation attempt is unsuccessful, subsequent attempts should aim to improve the view by utilizing adjuncts such as bougie or stylet [29]. However, our data showed relatively low usage of adjunct airway devices (7.7%) overall. While their use was higher in Category 1 cases, likely due to greater complexity of these scenarios, this pattern suggests that such devices are reserved for more challenging scenarios rather than being routinely employed. This highlights the need for broader adoption of these tools, particularly in high-risk obstetric cases, to improve first-pass success rates and reduce complications.

Another noteworthy finding was the association between thiopental use and a higher number of intubation attempts compared to propofol. This suggests that the choice of induction agent may influence intubation outcomes, emphasizing the need for careful selection in obstetric anes-

thesia. A study by Montandrau *et al*. [30] compared propofol and thiopental in women undergoing emergency cesarean section and found no significant differences in Apgar scores. Also, the incidence of neonatal ICU admissions was similar between the groups. These findings, along with our own, highlight that induction agents may have variable effects across populations and clinical contexts.

Limitations

While this study provides valuable insights, it had several limitations. First, the descriptive cross-sectional study design precludes any conclusions regarding causality. Second, the single-institution setting may limit generalizability of the findings to other settings or populations. Third, reliance on electronic medical records for data collection may result in missing or incomplete data, potentially affecting the accuracy of the results. Fourth, the study, by nature, did not account for possible confounding factors, such as variations in surgical technique or the presence of other comorbidities, which could influence the outcomes. The relatively small sample size for certain subgroups, such as those with a history of DM or those using specific medications, may limit the statistical power of the analyses. Further prospective, multicenter studies are needed to validate these findings and explore additional factors that may influence neonatal and maternal outcomes.

As this was a single-center retrospective study, the generalizability of our findings is limited. Variations in institutional resources, operator expertise, and patient populations across different centers may influence airway management practices and outcomes. Future multicenter, prospective studies with larger sample sizes are warranted to validate these findings. In addition, adjustment for potential confounding factors such as maternal comorbidities, GA, indication for cesarean section, anesthetist experience, and time of procedure would strengthen causal inferences. Incorporating multivariate analyses in future research could help clarify the independent contribution of each of these factors.

5. Conclusion

In conclusion, this study highlights the challenges associated with general anesthesia and the related outcomes in obstetric patients undergoing both elective and emergency cesarean sections. The findings emphasize the critical need for improved airway management strategies, including the broader adoption of VL and routine adjunct devices such as stylets and bougies. These enhancements could significantly contribute to improving maternal safety and neonatal outcomes in this high-risk population.

Availability of Data and Materials

The data used in this work are available upon reasonable request from the corresponding author.

Author Contributions

AS, SSV, KCY, MA, VBT, ASM, AK, LR, RF, KTS: conceptualization, writing- original draft, writing- reviewing and editing. AS: supervision. KCY: data analysis. MA: methodology, visualization, project administration. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study received Institutional Review Board approval (MRC-01-24-359) from the Medical Research Center at Hamad Medical Corporation, on 30 July 2024. A waiver of informed consent was granted due to the anonymized nature of the data. The investigators confirm that the study was conducted in full accordance with the Declaration of Helsinki, Good Clinical Practice guidelines, and all relevant national laws and regulations.

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Conflict of Interest

The authors declare no conflict of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work the authors used ChatGpt-3.5 in order to check spell and grammar. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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