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Predictive risk factors of failed laryngeal mask airway insertion at first attempt

Jia Wang, Xiaoping Shi, Tao Xu and Geng Wang

Abstract

Objectives: A failed first attempt at laryngeal mask airway (LMA) insertion could increase the risk of laryngospasm, hypoxemia, and postoperative sore throat. This study was performed to investigate the risk factors for failed first-attempt LMA placement.

Methods: In total, 461 patients who underwent general anesthesia with a Supreme LMA (Teleflex Medical, Shanghai, China) and who had an American Society of Anesthesiologists (ASA) physical status of I to III were prospectively enrolled. The LMA was inserted after anesthetic induction. We recorded the insertion conditions and each patient's age, ASA status, body weight, body mass index (BMI), duration of anesthesia, size of LMA, and cuff pressure; the years of work experience of the anesthesiologists; and the use or nonuse of lidocaine gel as a lubricant.

Results: Successful first-attempt placement of the Supreme LMA was achieved in 438 (95.10%) patients, while first-attempt placement failed in 23 (4.99%). Significant risk factors for failure of first-attempt LMA insertion included high age, high body weight, BMI of <20 kg/m^2, and insertion without using lidocaine gel.

Conclusions: A patient age of >61 years, high body weight, BMI of <20 kg/m^2, and insertion without lidocaine gel could significantly increase the risk of failed first-attempt Supreme LMA insertion.

Keywords

First insertion failure, general anesthesia, high body weight, laryngeal mask airway, lidocaine gel, body mass index

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Introduction

The use of supraglottic airway devices has become increasingly popular and has substituted for endotracheal tubes in many

Department of Anesthesiology, Beijing Jishuitan Hospital, Beijing, P.R. China

Corresponding author:
Geng Wang, Department of Anesthesiology, Beijing Jishuitan Hospital, No. 31 Xinjiekou East Street, Xicheng District, Beijing 100035, P.R. China.
Email: w_geng@163.com

procedures.[1] The laryngeal mask airway (LMA) is a device that provides a supraglottic airway and consists of an inflatable mask and silicone connecting tube. It has been widely used during general anesthesia in the operating room with well-documented success. Since the invention of the LMA in the 1980s,[2] it has gained widespread popularity as an effective, reliable substitute for the endotracheal tube.[3] Use of an LMA has many advantages over endotracheal intubation, such as higher hemodynamic stability, quicker and easier placement, lower requirement for neuromuscular blockade, and lower incidence of postoperative morbidity.[4–6] In addition, the LMA is associated with a lower incidence of perioperative complications such as bucking, laryngospasm, coughing, laryngeal edema, soft tissue trauma, and sore throat.[7,8] Previous studies have demonstrated high success rates of the first attempt at LMA placement during airway management in both endoscopic and open airway procedures.[9,10] These studies showed no significant difference in the proportion of successful LMA insertions between doctors that had trained in simple airway management and experienced anesthesiologists.

The use of an LMA may also be associated with complications and risks because its airway protection is not as tight as that provided by a cuffed endotracheal tube. Previous studies have shown that almost 80% of LMA failures occurred during anesthesia induction or gag placement[11] and that 61% of LMA failures in perioperative airway management occurred during the process of LMA insertion.[12] Failure to insert the LMA at the first attempt could increase the risk of perioperative airway complications and cardiovascular complications and thus increase the hospital stay and medical costs. Therefore, identification of the risk factors for initial failure of LMA insertion can help the anesthesiologist to evaluate patients' conditions during airway management and improve the modality of the operation. However, no prospective studies with a large sample have comprehensively evaluated the risk factors for failure of LMA insertion at the first attempt from two aspects: the patient and the physician. This study was performed to further characterize the perioperative risk factors of failed first-attempt LMA placement by evaluating the process of LMA insertion and the characteristics of 461 patients undergoing general anesthesia with an LMA.

Materials and methods

Patients

Patients with an American Society of Anesthesiologists (ASA) physical status of I to III who underwent general anesthesia with a Supreme LMA (Teleflex Medical, Shanghai, China) for different surgical procedures in our hospital from December 2014 to May 2015 were included in this prospective study. Approval was obtained from the Institutional Research Ethics Board of our hospital. Written informed consent was obtained from all patients, allowing us to store their data in our hospital database and use it for clinical research. The exclusion criteria were an ASA physical status of $\geq$IV, impaired consciousness, communication disorders, features or syndromes suggestive of a difficult airway, severe maxillofacial deformity, emergent surgery, surgery requiring the placement of a tracheal tube, or other contraindications for anesthesia with LMA insertion.

Anesthesia with LMA insertion

A standard anesthesia protocol was followed. All procedures were performed by the senior authors in conjunction with a single nurse anesthetist. The procedures were performed under elective general

anesthesia using an LMA placed by the anesthesiologists according to their routine work habits and experience. Selection of the most appropriately sized LMA was guided by the manufacturer's recommendations based on weight.[13] A size 2 LMA was used for patients weighing <20 kg, a size 2.5 LMA was used for patients weighing 20 to 30 kg, a size 3 LMA was used for patients weighing 30 to 50 kg, a size 4 LMA was used for patients weighing 50 to 70 kg, and a size 5 LMA was used for patients weighing >70 kg. The anesthesiologist further determined the size of the LMA according to the patient's body composition (lanky or stout).

All patients were fasted for 6 h for solid food and 2 h for clear fluids. The patients then underwent venous transfusion of Ringer's solution and monitoring of their blood pressure, heart rate, electrocardiogram, and blood oxygen saturation. The amount of Ringer's solution administered was dependent upon the time at which the patients entered the operating room. The anesthesiologist was positioned on the side of the patient and gave careful attention to the patient's vital signs and controlled the airway. The nurse administered the anesthetic drugs to the patient as requested by the anesthesiologist. A total of 1 to 2 ml of lidocaine gel (0.6 g per 10 ml; Jichuan Pharmaceutical Group Co. Ltd., Taizhou, China) was applied evenly to the surface of the laryngeal mask capsule before induction. All patients were premedicated with an oral solution of 1 to 2 mg midazolam, administered 30 minutes prior to surgery. Induction was achieved with intravenous sufentanil (0.2–0.3 μg/kg), fentanyl (2–3 μg/kg), or propofol (1–2 mg/kg). Additionally, 50 mg of rocuronium or 10 mg of atracurium was administered as a neuromuscular blocking agent for 90 to 180 s. Atropine was not routinely used during general anesthesia; however, when the vagal reflex occurred or the heart rate decreased to <40 beats per minute, a single dose of 0.5 mg of atropine was administered to decrease the vagal activity and repeated as required. After placing the LMA, the doctor immediately confirmed the cuff pressure by reading the airbag pressure gauge after the position of the larynx was suitable. The patient underwent manual ventilation with 100% oxygen. After the anesthesiologist determined that adequate muscle relaxation had occurred (by administration of 0.6–0.9 mg/kg vecuronium bromide for 60–90 s or 0.15 mg/kg of cisatracurium besylate for 120 to 180 s) according to their clinical experience, the LMA was inserted until it met resistance from the bottom of the pharynx. Postoperatively, all patients were sent to the post-anesthesia care unit after establishment of spontaneous breathing. The LMA was removed when the patients were intolerant of the laryngeal mask or could cough, swallow, or open their eyes. Failed LMA insertion was defined as high airway pressure (peak pressure of >25 cmH_2O) or severe air leakage (>20% Vt).

Every attending anesthesiologist who inserted the LMA was given a separate sheet on which they recorded the patient's age (years), ASA status, body mass index (BMI, kg/m^2), duration of anesthesia (minutes), size of LMA, cuff pressure (Pa), work experience (years) of each anesthesiologist, and the use of lidocaine gel as a lubricant (yes or no) (Table 1).

Statistical analysis

Our data analysis was carried out with IBM SPSS Statistics, version 19.0 (IBM Corp., Armonk, NY, USA). Quantitative data are expressed as mean ± standard deviation, and qualitative data are expressed in terms of number and percentage. Univariate analysis was conducted for each variable, with *P* values calculated using Pearson's chi-square test or Fisher's exact test for categorical variables and Student's t test for continuous

Table 1. Patient and anesthetic characteristics

Parameter	Successful first-attempt LMA insertion (n = 438)	Failed first-attempt LMA insertion (n = 23)	*P*-value
Sex (Male/Female)	228 (52.1)/210 (47.9)	17 (73.9)/6 (26.1)	0.053
Age			
Mean age (years)	44.4 ± 19.0	50.3 ± 20.1	0.153
<18	56 (12.8)	1 (4.3)	0.051
19–40	123 (28.1)	8 (34.8)	
41–60	160 (36.5)	4 (17.4)	
>61	99 (22.6)	10 (43.5)	
Body weight (kg)	66.69 ± 14.53	75.21 ± 14.00	0.007*
BMI (kg/m^2)			
<20	58 (13.2)	1 (4.3)	0.027*
20–24	148 (33.8)	3 (13.0)	
24–28	156 (35.6)	15 (65.2)	
>28	76 (17.4)	4 (17.4)	
ASA status			0.460
I	235 (53.7)	14 (60.9)	
II	191 (43.6)	8 (34.8)	
III	12 (2.7)	1 (4.3)	
Lidocaine gel (yes/no)	400 (91.3)/38 (8.7)	17 (73.9)/6 (26.1)	0.016*
Duration of anesthesia (minutes)	138.09 ± 57.78	123.32 ± 44.19	0.238
Size of LMA			0.346
2	7 (1.6)	0 (0.0)	
2.5	3 (0.7)	0 (0.0)	
3	216 (49.3)	7 (30.4)	
4	210 (47.9)	16 (69.6)	
5	2 (0.5)	0 (0.0)	
Cuff pressure (Pa)			0.374
<40	42 (9.6)	2 (13.0)	
40–80	102 (23.3)	2 (8.7)	
80–120	103 (23.5)	6 (26.1)	
>120	191 (43.6)	12 (52.2)	
Doctors' work experience (years)			0.224
1–2	121 (27.6)	9 (39.1)	
3–5	70 (16.0)	5 (21.7)	
>5	247 (56.4)	9 (39.1)	

Data are presented as n (%) or mean ± standard deviation. LMA, laryngeal mask airway; BMI, body mass index; ASA, American Society of Anesthesiologists. *Statistically significant.

variables. A P value of <0.05 was considered significant. Parameters with a P value of <0.1 in the single-factor analysis were included in the multiple logistic regression analysis, and the odds ratio (OR) with 95% confidence interval (95% CI) was recorded.

Results

Patients' baseline information

In total, 461 patients were included in this prospective study. The patients comprised 218 men and 243 women with a mean

weight of 67.18 ± 14.38 kg, mean age of 47.71 ± 19.11 years, and mean BMI 24.58 ± 5.27 kg/m^2. All patients underwent general surgery, including procedures involving the distal upper extremity (elbow and distal end) in 62 patients (including 2 who underwent abdominal flap surgery involving the abdominal wall), proximal upper extremity (femur and shoulder) in 74 patients, lower extremity (knee and distal end) in 210 patients, and proximal lower limb (femur and hip) in 115 patients. Successful placement of the Supreme LMA at the first attempt was achieved in 438 (95.01%) patients (successful first-attempt LMA group), while failed placement at the first attempt occurred in 23 (4.99%) patients (failed first-attempt LMA group). Among these 23 patients, due to high airway pressure or partial airway obstruction, 21 patients pulled out the LMA and required a second attempt without a change in the insertion technique, and the remaining 2 patients required a second attempt at LMA insertion because of an air leak through the drain tube (the LMA was successfully replaced in 1 patient; in the other, it was successfully inserted again after changing the laryngeal mask type). None of the patients required conversion to an alternative airway or tracheal intubation. The patients' demographic information and procedure details are presented in Table 1. The surgeons had almost no objections to the airway management of the patients.

Univariate and multivariate analyses

The univariate analysis (Table 1) showed that patients who did not use lidocaine gel accounted for a higher proportion in the failed first-attempt LMA group than in the successful first-attempt LMA group (26.1% vs. 8.7%, respectively; $P = 0.014$). There were statistically significant differences between the groups in terms of the BMI ($P = 0.027$), mean body weight ($P = 0.007$), and use of lidocaine gel ($P = 0.016$). However, there was no significant difference between the two groups in terms of sex, mean age, ASA status, duration of anesthesia, size of LMA, cuff pressure, or work experience of the anesthesiologists (Table 1). In the multivariate analysis, five predictors of first-attempt LMA insertion failure were identified in the logistic regression analysis (Table 2). In the failed first-attempt LMA group and successful first-attempt LMA group, we found that the age group of >61 years was the strongest independent risk factor for the failure of LMA insertion when compared with the other age groups ($P < 0.001$). We also found statistically significant differences between the groups regarding age (OR, 1.814; 95% CI, 1.054–3.121), BMI of <20 kg/m^2 (OR, 1.765; 95% CI, 1.063–2.932), high body weight (OR, 1.043; 95% CI, 1.011–1.075), and use/nonuse of lidocaine gel (OR, 3.736; 95% CI, 1.350–10.337) (all $P < 0.05$). Thus, the four independent risk factors for the failure of LMA insertion were an age of >61 years, high body weight, BMI of <20 kg/m^2, and nonuse of lidocaine gel.

Complications during LMA insertion

Sore throat associated with LMA insertion occurred in both groups: 334 of 438 (76.3%) patients in the successful first-attempt LMA group and 16 of 23 (69.6%) patients in the failed first-attempt LMA group. There was no significant difference between the two groups.

Discussion

An LMA is a substitute for the routine use of an endotracheal tube for airway management. The risk of life-threatening adverse respiratory incidents during its use is apparently low,[7] but data are lacking regarding the risk-adjusted prediction of LMA

Table 2. Multivariate analysis of first-attempt LMA insertion

Parameter	Successful first-attempt LMA insertion (n = 438)	Failed first-attempt LMA insertion (n = 23)	Odds ratio (95% CI)	*P*-value
Sex			0.386 (0.146–1.017)	0.054
Male	228 (52.1)	17 (73.9)		
Female	210 (47.9)	6 (26.1)		
Age (years)			1.814 (1.054–3.121)	0.031*
<18	56 (12.8)	1 (4.3)		
19–40	123 (28.1)	8 (34.8)		
41–60	160 (36.5)	4 (17.4)		
>61	99 (22.6)	10 (43.5)		
Body weight (kg)	66.69 ± 14.53	75.21 ± 14.00	1.043 (1.011–1.075)	0.007
BMI (kg/m^2)				
<20	58 (13.2)	1 (4.3)	1.765 (1.063–2.932)	0.028*
20–24	148 (33.8)	3 (13.0)		
24–28	156 (35.6)	15 (65.2)		
>28	76 (17.4)	4 (17.4)		
Lidocaine gel			3.736 (1.350–10.337)	0.011*
Yes	400 (91.3)	17 (73.9)		
No	38 (8.7)	6 (26.1)		

Data are presented as n (%) or mean ± standard deviation. LMA, laryngeal mask airway; BMI, body mass index; CI, confidence interval. *Statistically significant.

insertion failure requiring rescue tracheal intubation and its impact on patient outcomes. In total, 461 patients admitted to our hospital from December 2014 to May 2015 for different surgical procedures were enrolled in the current study. This study was designed to investigate the potential risk factors for first-attempt LMA insertion failure and to explore the correlation between the success rate of LMA insertion and the operator's experience by observing the daily routine of the anesthesiologists. The results showed that the incidence of successful LMA insertion at the first attempt was 95.23%, which is consistent with the results of previous large-scale clinical studies[11,14] and further demonstrates that the use of an LMA for airway management during general anesthesia is a simple, safe, and reliable method.[15,16] Additionally, we found no significant correlation between the working life of the anesthesiologists and the success rate of first-attempt LMA insertion, confirming that use of an LMA as an airway tool is easy to learn and can be readily popularized compared with endotracheal intubation.

Some reports have described the risk factors for LMA insertion failure.[17–19] Ramachandran et al.[17] performed a prospective study of 15,795 adult patients in whom an LMA was used for general anesthesia. They studied the whole process of anesthesia with the LMA, including the insertion and maintenance of ventilation, to explore the risk factors for LMA insertion failure. The authors found four independent risk factors for LMA insertion failure: a change in the intraoperative position, high BMI, male sex, and depth of anesthesia.[17] Lalwani et al.[11] conducted a retrospective review of 1199 medical records of children who underwent adenotonsillectomy, and the patients were divided into an LMA group (n = 451), endotracheal tube group (n = 715), and second attempt

group (n = 33). The authors suggested that appropriate patient selection, careful insertion, and avoidance of controlled ventilation might decrease the incidence of LMA failure. Asida and Ahmed[7] performed an observational cohort study of 500 patients with LMA insertion and suggested that the predictors of a failed first attempt of LMA insertion include an abnormal airway anatomy, age of <5 years, use of a size 1.0 and 1.5 LMA, body weight of <16 kg, and use of the intraoperative lateral position. The current study only focused on the process of LMA insertion and aimed to identify independent risk factors leading to first-attempt LMA insertion failure. We found that a BMI of <20 kg/m^2 was an independent risk factor for first-attempt LMA insertion failure.

The current study also showed that the nonuse of lidocaine gel was an independent risk factor for first-attempt LMA insertion failure; this has not been reported in previous studies. One previous study suggested that an LMA might be more suitable than a tracheal tube for airway management in obese patients[4] because a higher rate of successful insertion and lower risk of perioperative airway complications can be achieved. More attention must be given to the risk factors for first-attempt LMA insertion failure. Lidocaine gel, as a common lubricant and surface anesthetic, is often used to lubricate the LMA and thus prevent and reduce the risk of pharyngeal complications after laryngeal mask anesthesia.[20] However, relevant studies do not support our conclusion and instead considered that the existing lubricants, including lidocaine gel, saline, and other medical lubricants, cannot effectively reduce the risk of pharyngeal complications.[21,22] In the current study, however, we confirmed that the use of lidocaine gel may significantly reduce the risk of first-attempt LMA insertion failure, which may help to reduce the risk of complications associated with delayed airway setting. With further study in this field, we believe that lidocaine gel may be recommended as a lubricant to increase the probability of rapid insertion of the LMA, although it was not effective in preventing the risk of perioperative pharyngeal complications in this study.

The current study has limitations due to its prospective nature. First, the number of patients was relatively small. Further studies with larger numbers of patients are needed to confirm our results. Second, this study did not include intraoperative and postoperative observation indexes, such as postoperative sore throat, difficult weaning, or postoperative pulmonary infection; thus, we were unable to explore the effects of first-attempt LMA insertion failure on the above indexes. Third, because data from this study were drawn from a single center, attention should be paid when applying the results to patients nationally or internationally because anesthesia care delivery processes are variable among geographic regions. Finally, the prediction model has modest discrimination, and additional work may be needed to enhance the model's accuracy in the future.

Conclusion

In conclusion, despite some limitations, our data shed light on a largely unstudied clinical issue commonly encountered by anesthesia providers. A patient age of >61 years, high body weight, BMI of <20 kg/m^2, and nonuse of lidocaine gel as a lubricant could increase the risk of first-attempt LMA insertion failure.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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