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Developing the skill of laryngeal mask insertion

Prospective single center study

Introduction

Securing the airway includes the skill of laryngeal mask insertion (LMI) and this plays a decisive role in perioperative medicine as well as in difficult airway situations [1]. As reported for endotracheal intubation (ETI, [2]) and other manual techniques and skills [3, 4] LMI is also subject to a learning curve [5]. Since introduction of the laryngeal mask by Brain [6] in 1981 the laryngeal mask airway is a frequently used device in perioperative medicine, resuscitation and special airway situations [1, 7, 8]. This raises the question how many LMI procedures constitute sufficient experience and define the probability that this airway device will be successful.

The aim of the present study was to determine the amount of time that first year anesthesiology residents require to perform 40 LMI procedures, to analyze the rates of success and difficulties associated with this procedure and to draw conclusions for duration of training and successful learning.

Material and methods

Subjects

As a quality assurance measure all first year resident physicians at the department of anesthesiology of the University of Heidelberg, Germany, were consecutively evaluated with regard to skill development in LMI in this prospective single center study. Anesthesiologists at the department of anesthesiology perform more than 5,000 LMIs in the operating theatre annually. All LMIs were performed using LMA ProSeal™ (LMA Deutschland, Bonn, Germany), which was the standard supraglottic airway device (SAD) in the operating theatre during the study period for first year resident physicians. On the first day of working in the hospital the residents were informed about the study. Afterwards, they received an evaluation sheet which was independently completed for the LMI procedures performed during medical school training. A board-certified anesthesiologist was present to supervise the residents each time they performed induction (including verbal direction, observation, post-procedure feedback and debriefing). The evaluation of the study data ended once a resident had performed 40 LMI procedures. The sample size of 40 LMIs was defined with respect to the national recommendations suggesting that for learning the technique for SADs, rescue providers should perform and document at least ten uses of SADs under controlled circumstances and supervision in order to become proficient [9]. The capacity of SADs was extended by a factor of 4. The authors carefully examined the resident's documentation after each LMI in order to ensure an adequate evaluation. The schedule of the study was submitted to the ethics committee of the University Hospital of Heidelberg, Germany, which decided that ethical approval was not necessary and no further restrictions were imposed. Further results of this prospective single center study concerning ETI were published elsewhere [2].

Patient characteristics

For each anesthesia induction procedure the following patient characteristics were recorded: age (years) and American Society of Anesthesiologists (ASA) classification. During the preoperative assessment the Mallampati score [10] was documented for each patient and the laryngeal mask was chosen as the SAD according to the patient's condition and the established departmental guidelines. The study participants and the authors did not influence the decision for securing the airway with the laryngeal mask airway.

Successful laryngeal mask insertion

The residents documented the number of attempts until successful LMI for each patient. An attempt to secure the airway was

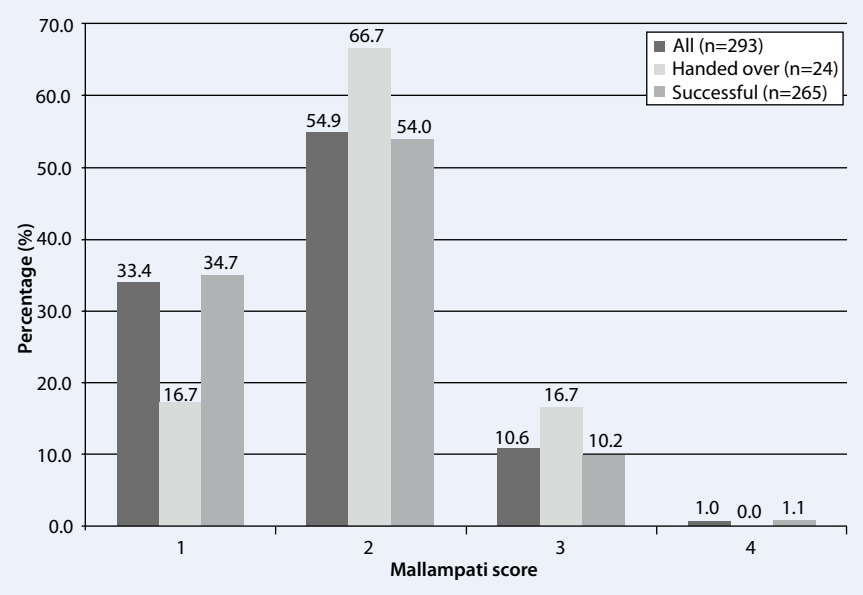

Fig. 1 ▲ Distribution of the Mallampati scores (n=293) of the patients

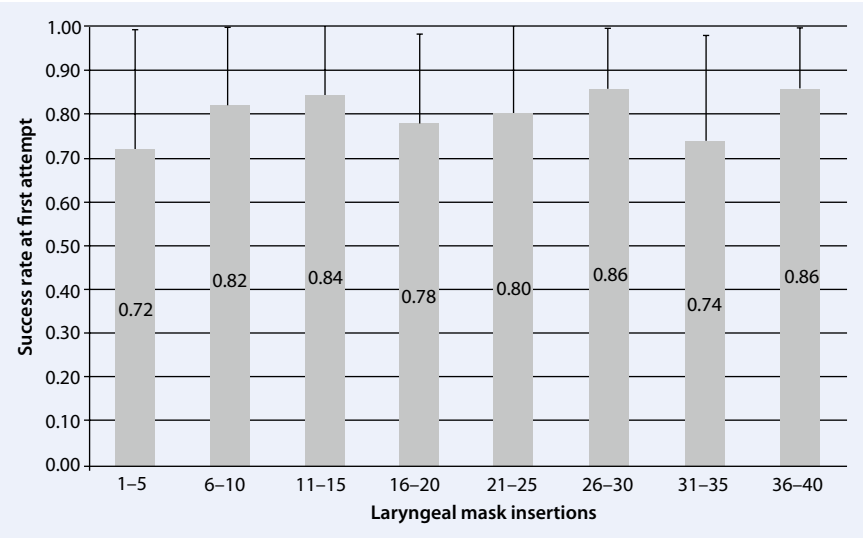

Fig. 2 ▲ Success rate of first laryngeal mask insertion (LMI) attempt in 394 patients with respect to the number of previously performed LMIs (blocks of 5 LMIs mean value ± standard deviation)

defined as inserting the laryngeal mask into the mouth. A LMI was classified as successful if ventilation with the laryngeal mask was effective (e.g. auscultation and capnography) with acceptable air leakage. If the residents interrupted the LMI maneuver an attending physician took over. This decision was based on patient safety, the individual patient characteristics and dynamic factors during the induction. The number of subsequent attempts performed by the physician to successfully secure the airway was also documented. The results are reported in consecutive blocks of five LMI procedures.

Difficulties

For each LMI the residents indicated whether the following obstacles were present: large tongue, blocked jaw, blood/mucus in the mouth, head/neck immobilization, small oral aperture, evasive patient movements, retrognathy, desolate dental chart, short/thick neck or insufficient depth of anesthesia.

Statistical analysis

After a given number of performed interventions the data of the residents' paper sheets were anonymized and entered into an electronic database (Microsoft® Excel 2008, Redmond, WA). All data were analyzed using SPSS® (Version 14.0, SPSS, Chicago, IL). Data are presented in absolute numbers, mean ± standard deviation (SD) or as percentage and in median, minimum (min), maximum (max) and interquartile ranges (IQR) if necessary. After determining the mean and SD the features were analyzed using Student's t-test and the percentages by the χ^2-test. An error probability of $p<0.05$ was considered to be statistically significant.

Results

Subjects

In the period from 2007 to 2010 the first 40 LMIs performed by 10 first year residents were consecutively documented. Before beginning the clinical work in the department the residents had performed a median of 5 (IQR 2–10) laryngeal mask placements. Of the residents two had gained previous experience with LMI in a clinical elective and the eight other residents during anesthesiology sub-internships in the final year of medical school education.

Patient characteristics

A total of 394 laryngeal masks were placed in patients and a completed evaluation sheet was obtained (98.5% of all investigated patients). The patients had a mean age of 57.9±18.8 years (range 4–93 years). The ASA classification was ASA 1 in 17.1%, ASA 2 in 59.9%, ASA 3 in 23.0% and ASA 4 in 0%. The Mallampati score was documented for 293 patients (74.4%) and the scores obtained are shown in **Fig. 1**. No statistical differences in the patient characteristics were found between consecutive blocks of five LMI procedures.

Time intervals

For each consecutive block of 5 LMI procedures the residents required on average 2.41±1.33 (min-max 1–4 and median 2) working days on which they performed at least one LMI procedure. Ultimately, 40 LMIs were achieved in a mean of 18.3±4.14 (min–max 14–26, median 18) days after beginning work in the operating room.

Success rate on the first attempt and on all attempts

The first LMI attempt was successful in 80% of the 394 patients and the mean success rate of LMI on the first attempt in blocks of 5 procedures is shown in **Fig. 2**. The mean LMI success rate within one attempt after the first block of 5 procedures LMIs in comparison to the mean results after 40 LMIs only showed a trend (72 versus 86%, p=0.09). The LMI was successful in 90% of the 394 patients, independent of the number of LMI attempts. The success rate of the residents to successfully perform LMI for all attempts is shown in blocks of 5 LMI procedures in **Fig. 3**. The success rate within all attempts after the first 5 LMIs per resident in comparison to the results after 40 LMIs showed a significant improvement (74 versus 96%, p=0.001). The number of attempts required to successfully perform LMI decreased from 1.45±0.82 after the first 5 attempts to 1.16±0.37 after 40 LMIs (p=0.03). Out of all LMI attempts, in 9 cases more than 3 attempts were needed to secure the airway. Finally, the airway in the 9 cases was secured with LMI or endotracheal tube in 5 versus 4 cases, respectively and 7 out of the 9 cases were handed over to an attending physician.

Unsuccessful laryngeal mask insertion attempts

The residents had to hand over the LMI procedure to an attending physician in 9.4% (n=37) of cases after 1.38±0.59 attempts (min-max 1–3 and median 1). After handing over the laryngeal mask the attending physicians were able to secure the airway in 1.38±0.7 attempts (min–max 1–3 and median 1) and were able to suc-

Abstract · Zusammenfassung

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Developing the skill of laryngeal mask insertion. Prospective single center study

Abstract

Background. Laryngeal mask insertion (LMI) represents a fundamental skill for anesthesiologists in routine management as well as in difficult airway situations. This study aimed to evaluate the time needed by first year anesthesiology residents to perform 40 LMIs and assessed the associated success rates and the number of attempts needed for successful LMI.

Methods. This prospective single center study evaluated the number of work days, the success rate and the attempts needed for successful LMI (LMA ProSeal™) in consecutive blocks of five LMI procedures and the related difficulties and complications.

Results. From 2007 to 2010 a total of 10 anesthesiology resident physicians were evaluated consecutively. These residents needed a mean of 18.3±4.1 (mean ± standard deviation) working days to successfully perform 40 LMIs. The LMI success rate after the first 5 LMIs increased steadily up to the results after 40 LMIs per resident (LMI success rate within 1 attempt 72 versus 86%, p=0.09, LMI success rate within all LMI attempts 74 versus 96%, p=0.001). The mean number of attempts required until successful LMI decreased from 1.45±0.82 after the first 5 LMIs to 1.16±0.37 after 40 LMIs (p=0.03). The most common difficulties associated with unsuccessful LMI by residents that led to handing over to an experienced colleague were small oral aperture (9.8%), short thick neck, large tongue, blood/mucus in the mouth or throat (each 7.3%) and retrognathy (4.9%).

Conclusions. The increasing LMI success rate and the decreasing rate of LMI attempts for successful airway management correlated to a learning curve and development of LMI dexterity over time.

Keywords

Anesthesia, general · Airway management · Perioperative care · Emergency medicine · Inservice training

Entwicklung der Fertigkeit der Laynxmaskeninsertion. Prospektive monozentrische Untersuchung

Zusammenfassung

Hintergrund. Die Insertion einer Larynxmaske (LMI) stellt eine fundamentale Fähigkeit des Anästhesisten sowohl im Routinemanagement als auch im Rahmen einer schwierigen Atemwegssituation dar. Ziel der vorliegenden Untersuchung war es, das von Erstjahresweiterbildungsassistenten benötigte Zeitintervall bis zu Durchführung von 40 LMI und die hiermit assoziierte Erfolgsrate sowie die Zahl der notwendigen Versuche bis zur erfolgreichen LMI zu evaluieren.

Methoden. In der prospektiven monozentrischen Untersuchung wurden die Zahl der Arbeitstage, die Erfolgsraten und die zur erfolgreichen LMI (LMA ProSeal™) benötigten Versuche in konsekutiven Blocks von 5 LMI-Prozeduren ebenso wie die entstandenen Schwierigkeiten und Komplikationen erfasst.

Ergebnisse. Von 2007 bis 2010 wurden 10 anästhesiologische Erstjahresweiterbildungsassistenten konsekutiv evaluiert. Die Weiterbildungsassistenten benötigten durchschnittlich 18,3±4,1 Arbeitstage (Mittelwert ± Standardabweichung) für 40 LMI. Die Erfolgsrate der LMI stieg nach den ersten 5 LMI stetig bis zu den 40 LMI/Weiterbildungsassistent an (Erfolgsrate der LMI im 1. Versuch: 72 vs. 86%, p=0,09; Erfolgsrate der LMI bei allen Versuchen: 74 vs. 96%, p=0,001). Die Anzahl der benötigten Versuche bis zur erfolgreichen LMI verringerte sich von 1,45±0,82 nach den ersten 5 LMI auf 1,16±0,37 nach 40 LMI (p=0,03). Die häufigsten Schwierigkeiten, die mit einer nichterfolgreichen LMI durch die Weiterbildungsassistenten einhergingen und zur Übergabe der LMI an einen erfahrenen Kollegen führten, waren schmale Mundöffnung (9,8%), kurzer/dicker Hals, große Zunge, Blut/Sekret im Mund-Rachen-Raum (je 7,3%) und Retrognathie (4,9%).

Schlussfolgerung. Die ansteigende Erfolgsrate der LMI und die sinkende Anzahl an benötigten Versuchen bis zur erfolgreichen LMI korrelierten mit der Lernkurve und der entwickelten Sicherheit der LMI über die Zeit.

Schlüsselwörter

Allgemeinanästhesie · Luftwegmanagement · Perioperative Versorgung# · Notfallmedizin · Praktische Übung

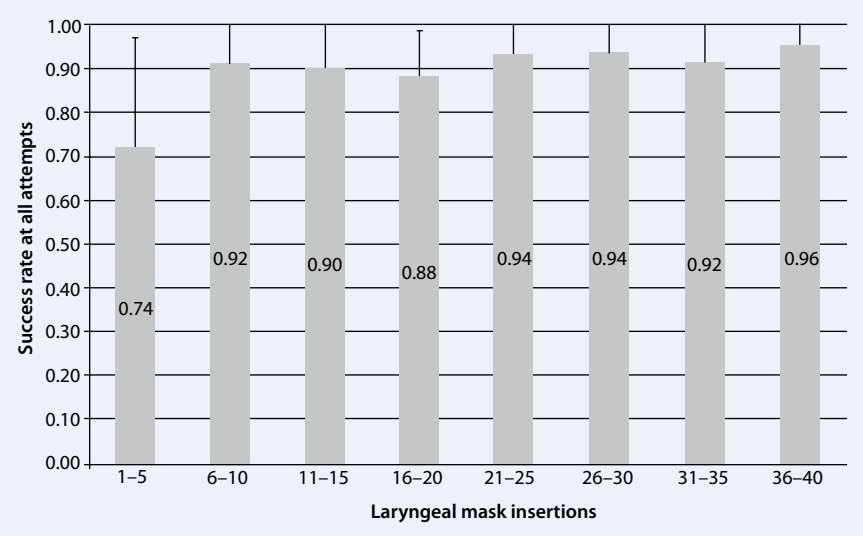

Fig. 3 ▲ Success rate of all laryngeal mask insertion (LMI) attempts in 394 patients with respect to the number of LMIs previously performed (blocks of 5 LMIs mean value ± standard deviation)

cessfully insert the laryngeal mask in the majority of cases (86.5%). Placement of an endotracheal tube only became necessary (n=9) in 2.3% of all 394 patients and in 13.5% of cases handed over to the attending physician. Other airway techniques (e.g. fiber optic intubation and glide scope) were not employed in these cases.

Obstacles to laryngeal mask insertion

A total of 42 obstacles to LMI were reported, i.e. in 10.7% of all 394 LMI procedures performed by residents. Details are shown in **Tab. 1**.

Discussion

Laryngoscopy, ETI and other alternative airway devices (including SAD) are essential skills for successful and safe airway management [5, 8, 11]; therefore, direct laryngoscopy with ETI as well as proficiency with alternative airway devices (such as the laryngeal mask) are essential skills for both routine and emergency airway management in anesthesia, emergency medicine and critical care medicine [11]. The laryngeal mask airway is part of national and international airway and difficult airway algorithms around the world [6, 8, 9].

Skill development in airway management is subject to a learning curve as has been shown for ETI [2, 3, 4, 12]; however, there is a paucity of data with regard to the acquisition of LMI skills during residency training. Such information can have a significant impact on training protocols. Some studies investigated the skill of LMI in mannequins and airway trainers [13]; however, these results have to be interpreted with caution as the use of mannequins and airway trainers for skill development has been questioned [14, 15].

Alexander et al. [16] compared the results of ten inexperienced volunteers who managed the airway in each of ten adult healthy patients with LMI versus a combination of oropharyngeal airway (Guedel airway) and bag and facemask for manual ventilation (success rates 87 versus 43%, respectively, p<0.001). The success rates reported by Alexander et al. [16] were in line with the success rate found in this study with 80% on the first LMI attempt and 87% within 2 attempts. However, ventilation of the lungs using LMI was not possible in 13 patients. Klaver et al. [17] also showed comparable success rates of LMI done by first month anesthesiology residents in 78 patients on the first attempt and in the same patients after three attempts (73 versus 95%, respectively).

Another study investigated LMI by 11 medical students in 10 patients each. This investigation showed in contrast to the results of this study a higher success rate for LMI of 94% within the first attempt [18].

Lower success rates were reported by Stones et al. [19] where 134 volunteer nurses with prior theoretical and practical training used laryngeal masks during cardiopulmonary resuscitation (CPR). The total number of LMIs under the supervision of an anesthesiologist during the training phase was not reported; however five successful LMIs were required for certification of competence. The success rates on the first, second and third attempts were 71, 26 and 3%, respectively. However, the success rate of 71% in the first LMI attempt corresponded excellently with the results of the present study with 72%. In line with these results Tan et al. [20] presented an investigation with SADs (LMA Classic™, single-use LMA Unique™ and Soft Seal) inserted by novice medical officers in anesthesiology with a first attempt success rate of 80, 77 and 62%, respectively. It should be kept in mind, however, that in this investigation only LMA ProSeal™ devices were investigated and the study was not designed to compare results between different types of SADs.

Another study investigated the use of i-gel supraglottic airway by inexperienced novices in mannequins and in anesthetized healthy patients [22]. Of the i-gel SGAs 88% were placed successfully in the mannequins on the first attempt. The success rate was 82.5% on the first attempt in real patients, which is comparable to the results of this study; however, these success rates are lower in comparison to the results in mannequins.

Up to now studies investigating the learning curve for LMI were lacking. The present investigation closes an existing gap in this research field using the LMA ProSeal™. The increasing LMI success rates and the decreasing rates of attempts necessary for successful airway management in the present investigation suggest a steady improvement in LMI dexterity. A total of 40 LMIs was achieved in an average of 18±4 days after the residents began working in the operation room. This time interval for up to 40 LMI procedures per resident (0.45 LMIs per resident per day) is in line with data extrapolated from Clarke and Gardner (0.52 LMIs per trainee per day, [23]).

With respect to the results in the presented investigation, one could be tempted to assume that an acceptable success rate is reached earlier with an 80% success rate on the first attempt and 94%

Tab. 1 Difficulties in laryngeal mask insertion by residents

Difficulty	All LMI[a] (n=394)		Successful LMI[a] by residents (n=353)		Unsuccessful LMI[a] by residents (n=41)	
	Number (n)	Percentage (%)	Number (n)	Percentage (%)	Number (n)	Percentage (%)
Small oral aperture	11	2.8	7	2.0	4	9.8
Large tongue	10	2.5	7	2.0	3	7.3
Short/thick neck	5	1.3	2	0.6	3	7.3
Blood/mucus in the mouth	3	0.8	–	–	3	7.3
Retrognathy	2	0.5	–	–	2	4.9
Insufficient depth of anesthesia	5	1.3	5	1.4	–	–
Defensive movements	2	0.5	1	0.3	1	2.4
Desolate dental chart	2	0.5	2	0.6	–	–
Head/neck immobilization	1	0.3	–	–	1	2.4
Blocked jaw	1	0.3	1	0.3	–	–

[a] *LMI* laryngeal mask insertion.

overall success rate at 21–25 LMIs. However, the importance of progressive experience with LMI was demonstrated by Brimacombe et al. [21] who reported that anesthesiologists who had placed about 200 LMAs had first attempt success rates for LMA Classic™ and LMA ProSeal™ between 91 and 82% and on the 3rd attempt between 100 and 98%, respectively. This study concluded that significant experience with LMI (>200 uses) is associated with a high success rate >98% [21]. It should be kept in mind that in this investigation 37 out of 394 LMIs (9.4%) had to be handed over by the first year residents to an attending physician with a subsequent success rate of 86.5%. Endotracheal intubation instead of LMI by the attending physician was necessary only in a small number of patients.

In line with the literature the leading patient-related difficulties for LMI in the present investigation were small oral aperture, large tongue, short/thick neck, blood/mucus in the mouth and retrognathy (**Tab. 1,** [17, 22, 24, 25, 26]). Additionally, with increasing Mallampati scores there was a higher rate of unsuccessful LMI by first year residents (**Fig. 1**).

The laryngeal mask airway is recommended as a backup device in difficult airway situations [6, 8, 27]; however, as shown in the present study, the skill of LMI develops over time. Use of the LMA without prior practical training did not secure the airway in every case. In line with the recommendations from the national German guidelines for emergency medical service physicians and paramedics, a certain number of LMIs is mandatory before laryngeal masks may be reliable used as an alternative airway device in critical airway situations [9]. Moreover, Timmermann [29] argued that there is not enough evidence to support the routine use of any specific SAD in (prehospital) airway management. The best technique depends on the exact circumstances and the competence of the healthcare provider, which is achieved by training in patients in a controlled environment and under close supervision [29].

There are some limitations of the present study. Firstly, the investigation was conducted at a single center and certain factors may influence the generalizability of the results. The data are from a university hospital where residents performed LMI under supervision by board-certified anesthesiologists. Due to deficits in the documentation of preoperative assessment, the Mallampati score was only reported in 293 of the 394 patients (74%).

It is known that different insertion techniques may lead to different insertion success rates [28]; however, the insertion technique of the laryngeal mask in this study was neither fixed nor documented, therefore, a comparison of the success of different insertion techniques could not be performed.

It could be criticized that the results of the LMA Proseal™ are not comparable to other types of laryngeal mask airway. Cook et al. [24] calculated a first time success for the LMA ProSeal™ of 85% in 723 patients versus a first time success of the classic LMA of 93% in 713 patients ($p<0.0001$). However, in this meta-analysis, within 3 attempts the insertion success of LMA ProSeal™ versus LMA Classic™ was comparable with 99.3 versus 100%, respectively ($p=0.076$, [24]). It should be kept in mind that most of these studies involved experienced operators [24].

Moreover, one could question the basis of the predefined number of 40 LMIs as an endpoint and sample size of the evaluation. The sample size was derived from the national recommendations that rescue providers should perform at least 10 uses of SADs under controlled circumstances and supervision in order to become proficient [9]. In comparison to conventional bag-mask ventilation and ETI, the use of SADs is quicker and safer by inexperienced providers [30]. Up to now, a specific clear number of performed SADs to become proficient has not been established in the literature, only Stones et al. [19] defined a total number of 5 successful LMIs for certification of competence during cardiopulmonary resuscitation (CPR) in their study.

Moreover, the time to achieve 40 LMIs will be variable from institution to institution and depends more on working schedules and patient properties than on skill acquisition. This study represents a single center study, which may limit generalization of the results. Also, the density of exposure to LMI is just as important as the number LMIs in total, i.e. if a provider performs 5 LMIs in 5 consecutive days the learning curve is probably steeper than if the provider performs 5 LMIs over a period of 20 days. However, this remains speculative and this article reported the shortest possible time period to perform the 40 LMIs within the clinical relations of this department. Also, cumulative sums methods could be a better statistical way to draw results from this investigation. However, extensive groups of 394 patients and 10 operators should

compensate for confounding variables that could exist in smaller cohorts. Another criticism might be that the residents documented LMI themselves, which may theoretically have allowed them to potentially falsify the results. However, the reports and the quality of the data collection were reviewed at regular intervals to ensure consistency of the data. Therefore, the results seem to be based on relatively sound data. The comparability of the findings with data from the literature also leads to the assumption that the findings are representative. Finally, most residents had a certain amount of previous experience in performing LM I before participating in the study; however, the prior experience was relatively sparse. The results from the ten residents still provide representative findings for a large group of operators.

Investigating the learning curve of LMI proficiency and time to archive an acceptable rate of success in LMI is relevant as there is still an on-going debate as to how much training is needed to become a proficient practitioner of this airway procedure. This study addresses an area in which the literature is deficient and one which has current importance both for the training of anesthesiologists and the practice of anesthesia. The results of the presented study did not decide at which time a new candidate is actually ready for handling LMI procedures; however, this study provides clear evidence about the learning curve of LMI in inexperienced providers. These data may help to determine when residents are proficient enough to perform LMI in a less supervised setting (e.g. night calls and prehospital). Moreover, the results of this investigation may influence the minimum requirements for certification in anesthesiology and emergency medicine.

Conclusions

The increasing LMI success rate and the decreasing rate of attempts necessary to successfully secure the airway suggest a steady improvement in operator skills. The results and difficulties during the first 40 LMI procedures justify supervision by a senior physician.

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