Original Article/*Özgün Araştırma*

doi: 10.54875/jarss.2023.50103

The Role of Ultrasonography in Confirming the Position of the Laryngeal Mask Airway in Adult Patients

Erişkin Hastalarda Laringeal Maske Hava Yolu Pozisyonunun Doğrulanmasında Ultrasonografinin Rolü

Funda Atar, Gulsen Keskin, Filiz Akaslan, Asli Donmez

University of Health Sciences, Diskapi Yildirim Beyazit Training and Research Hospital, Department of Anaesthesiology and Reanimation, Ankara, Turkey

Presentation: 6th European Airway Management Congress on 28 September – 1 October Antalya -Turkey

ABSTRACT

Objective: The study aims to evaluate the Proseal laryngeal mask airway (PLMA) position with ultrasonographic imaging.

Methods: The study included American Society of Anesthesiologists I-III patients with Mallampati scores I-II and operated using PLMA as an airway device. Before PLMA insertion, the glottic aperture was assessed by ultrasonography (USG). After PLMA placement, the USG evaluation was repeated. The symmetry of the arytenoid cartilages was examined. Asymmetry of an arytenoid to the glottic midline and the other arytenoid was graded 0 to 3 (USG arytenoid grade). After PLMA was placed, fiber optic bronchoscopy (FOB) was done to evaluate the PLMA position (FOB LMA grade). The relationship between USG arytenoid grade and FOB LMA grade was examined.

Results: Forty-eight patients were included in the study. The mean age was 49 ± 15.8 (19-82), and 25 were female. It was determined that PLMA was in the correct position in 81.3% of the evaluation with USG and 68.8% of the assessment with FOB. USG arytenoid grade correlated with FOB LMA grade (r= -.582, p<.001). To detect a rotated LMA, USG had a sensitivity of 100% (%95 CI, 39.8 – 100.0) and a specificity of %80 (%95 CI, 22.8 – 99.8). The positive and negative predictive values were %97.7 (%95 CI, 88.0 – 99.9) and %100 (%95 CI, 91.8 – 100.0), respectively. The accuracy was %97.9 (%95 CI, 86.3 – 99.3).

Conclusion: Ultrasonografi can be a simple, noninvasive, and reliable method to confirm PLMA placement in anesthesia practice.

Keywords: Laryngeal mask airway, ultrasonography, airway management

ÖZ

Amaç: Çalışmamızın amacı, PLMA pozisyonunu ultrasonografik görüntülemeyle değerlendirmektir.

Yöntem: Çalışmaya, Amerikan Anestezistler Derneği (ASA) fiziksel durumu I-III, Mallampati skoru I-II olan ve havayolu gereci olarak PLMA kullanılarak ameliyat edilen hastalar dahil edildi. Standart anestezi indüksiyonunu takiben PLMA yerleştirilmeden önce ve sonra boyun anteriorundan aritenoid kıkırdakların simetrisi ultrasonografi (USG) ile değerlendirildi. Bir aritenoid kıkırdağın glottik orta hatta ve karşı aritenoid kıkırdağa göre asimetrik yükselmesi 0 ile 3 (USG aritenoid derecesi) olarak derecelendirildi. PLMA yerleştrildikten sonra PLMA pozisyonunu değerlendirmek için (FOB LMA derecesi) fiberoptik bronkoskopi (FOB) yapıldı ve USG aritenoid derecesi ile FOB PLMA derecesi arasındaki ilişki değerlendirildi.

Bulgular: Çalışmaya 48 hasta dahil edildi. Ortalama yaşı 49 ± 15,8 (19-82) olup 25'i kadındı. USG ile değerlendirmede %81,3, FOB ile değerlendirmede %68,8 oranında PLMA'nın doğru yerleşimde olduğu saptandı. USG aritenoid derecesi ile FOB PLMA derecesi arasında anlamlı bir korelasyon bulundu. (r= -,582, p<,001). PLMA'nın rotasyonda olduğunu saptamak için USG aritenoid derecesi %100'lük bir duyarlılığa sahipti (%95 CI, 39,8 – 100,0), suboptimal PLMA'nın tespiti için %97,7 (%95 CI, 88,0 – 99,9) pozitif öngörülebilirlik değere sahipti. Özgüllük değeri %80 (%95 CI, 22,8 – 99,8), negatif öngörülebilirlik değeri ise %100 (%95 CI, 91,8 – 100,0) bulundu. Doğruluk oranı %97,9 (%95 CI, 86,3 – 99,3) idi.

Sonuç: Ultrasonografi, anestezi pratiğinde PLMA yerleşimini doğrulamak için basit, invaziv olmayan ve güvenilir bir yöntemdir.

Anahtar sözcükler: Laringeal maske hava yolu, ultrasonografi, hava yolu yönetimi

Received/Geliş tarihi : 22.12.2022
Accepted/Kabul tarihi : 03.04.2023
Publication date : 28.04.2023

***Corresponding author:** Funda Atar • fundaatar81@gmail.com

Funda Atar 0000-0002-3534-2233 / Gulsen Keskin 0000-0002-9990-5533
Filiz Akaslan 0000-0001-7767-9929 / Asli Donmez 0000-0002-7378-1632

Cite as: Atar F, Keskin G, Akaslan F, Donmez A. The role of ultrasonography in confirming the position of the laryngeal mask airway in adult patients. JARSS 2023;31(2):128-133.

INTRODUCTION

The laryngeal mask airway (LMA) is frequently used as an effective and safe airway device in general anaesthesia practise (1). Correct placement of the LMA is essential to ensure the continuity of appropriate ventilation and prevent complications such as mucosal damage, glossoptosis, and gastric insufflation (2). Cook et al. reported the success rate of LMA placement as 80.6% on the first attempt (3). Successful insertion is usually assessed clinically, given appropriate chest excursion, using a capnogram, without an audible leak at a peak inspiratory pressure of 20 cm H_2O in routine anaesthesia practice (3). Clinical testing may, in some cases, detect that the LMA fails to provide adequate airway management. However, conventional tests fail to provide anatomic evidence of optimal LMA placement.

Fiberoptic bronchoscopy (FOB) and ultrasonography (USG) allow detailed imaging of airway structures (4). However, the fiberoptic examination requires ventilation to be interrupted, an invasive method (4). Therefore, although USG requires a learning process for image optimization, the definition of sonoanatomy, and the interpretation of images, it is used as an effective, reliable, and noninvasive method to confirm the correct placement of the LMA (5,6).

We hypothesized that USG would detect a malpositioned LMA through the positional change of the arytenoid cartilage. The primary aim of this study was to determine the diagnostic performance of USG in detecting LMA malposition. The secondary objective was to detect suboptimal LMA placement using USG and FOB and compare these 2 methods.

MATERIAL and METHODS

The current study was approved by the Ethics Committee (Ref: 139/43) on 6 June 2022. Written informed consent was obtained from all the patients participating in the trial, which was performed between 1 July 2022 and 31 August 2022. Patients with American Society of Anesthesiologists (ASA) physical status I-III, >18 years of age, and Mallampati score I-II, who were planned for elective uroterorenoscopic lithotripsy under general anaesthesia and Proseal™ laryngeal mask airway (PLMA) were included. The exclusion criteria were history of difficult intubation, unstable teeth, limited mouth opening (<3 cm), high risk of regurgitation or aspiration (e.g., gastro-oesophageal reflux, hiatus hernia), pulmonary diseases (e.g., asthma, pneumonia), recent upper respiratory infection, body mass index (BMI) of ≥ 35 kg/m^2 as well as refusal to participate in the study. Before starting the study, experts interpreted USG images in the first 50 patients to increase their education and experience. These patients were not included in the study.

Standard monitoring included noninvasive arterial blood pressure (NIBP), electrocardiography (ECG), and peripheral O_2 saturation (SpO_2). Induction was achieved with intravenous fentanyl 1 µg kg^{-1}, propofol 2 mg kg^{-1}, and rocuronium bromide 0.6 mg kg^{-1}. Two minutes after neuromuscular blocker administration PLMA (Proseal™ laryngeal mask airway; Intavent Orthofix, Maidenhead, UK) was lubricated with a water-soluble gel, and all insertions were performed with a standardised technique. The PLMA was held like a pen and inserted using the index finger, with pressure against the palate and posterior pharyngeal wall, and advanced until the mask tip reached the oropharynx. The PLMA size was chosen according to patient's weight and the manufacturer's recommendation. The PLMA cuffs that required inflation were inflated up to 60 cm H_2O using a cuff manometer (VBM Medizintechnik, GmbH, Germany). Successful insertion was judged by clinical tests (chest and bag movement with manual ventilation, no audible leak at 20 cm H_2O of airway pressure, and a squared wave capnogram). A maximum of 3 attempts were allowed if PLMA insertion failed on the first attempt. All the 3 attempts were planned to be done with the same anesthetist. Endotracheal intubation was planned for patients who could not undergo PLMA and were excluded from the study. In our study, no patient required intubation. Patients were ventilated with a tidal volume of 6-8 mL kg^{-1} at a rate of 10-15 breaths min^{-1} to maintain $ETCO_2$ between 35-40 mmHg. Anaesthesia was maintained with 2 to 2.5% sevoflurane in oxygen-air (50-50%) mixture and remifentanil infusion.

Two different anesthesiologists (none of them were anesthesia providers) assessed the placement of the PLMA in 2 different ways: one evaluated PLMA placement using an 8-13 MHz linear probe with B-mode USG (HFL 38X/13–6 MHz; SonoSite M-Turbo ultrasound machine; SonoSite Inc., Bothell, WA, USA) on the other side of a drape, and a second then used a FOB (Karl Storz /Germany, Tuttlingen, Germany, 11302BD2) to evaluate LMA placement.

Before LMA insertion, the glottic aperture was assessed by USG. After LMA placement, the USG evaluation was repeated. Vocal cords and arytenoids were visualised by performing transverse scans of the hyoid bone using an USG. USG images recorded before PLMA placement and USG images after PLMA placement were compared in terms of the position change of arytenoids. An imaginary vertical line was drawn from anterior to posterior commissures above both arytenoids on the USG image before PLMA placement. This vertical line was divided into 3 equal and parallel parts, starting from the line joining both arytenoids (Figure 1A). In the image after PLMA placement, the asymmetrical height of one of the arytenoids (USG arytenoid grade) according to its position along the vertical lines was graded from 0-3 (0, horizontal arytenoids;

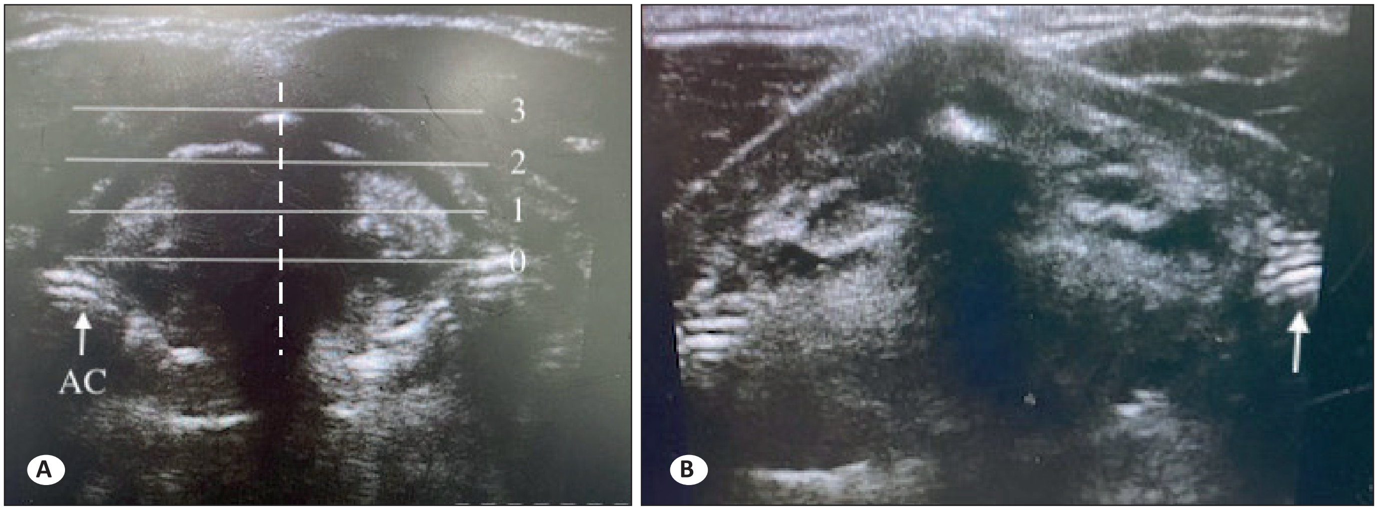

Figure 1. Ultrasound image of the glottis. **A)** The arytenoid elevation was graded from 0 to 3 in reference to the dashed lines of anterior–posterior commissure above the horizontal line of bilateral arytenoids; **B)** solid arrow indicates the elevated arytenoid cartilage in conjunction with the elevation of the thyroid cartilage on post-LMA USG. **LMA:** Laryngeal mask airway; **USG:** Ultrasound.

1, arytenoid in the lower 1/3 of the vertical line; 2, middle 1/3 of the vertical line; 3, in the upper 1/3 of the vertical line) (Figure 1B).

To assess PLMA positions, FOB was used after PLMA insertion. Fiberoptic assessments were performed while the tip of the bronchoscope was 1 cm above the terminal end of the PLMA's ventilation port. The position of the LMA was graded as per the fiber optic scoring system: 1- glottis only seen, 2- epiglottis and glottis seen, 3- epiglottis impinging on the grille, glottis seen, 4- epiglottis downfolded, glottis not seen (7).

Age, gender, BMI, ASA score, comorbidity, number of PLMA insertion attempts, leak volume, peak airway pressure values, FOB LMA grade, and USG arytenoid grades of all patients were recorded in the patient registration forms.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows v. 25.0 (IBM Corp., Armonk, N.Y., USA). Descriptive statistics were presented mean ± SD, median (IQR), frequency (n), and percentage (%) for numerical and categorical variables. The interrelationship of USG arytenoid grade and FOB LMA grade was analysed with Spearman's correlation coefficient, and the 95% CI and sensitivity, specificity, and positive and negative predictive values were calculated. P<0.05 was considered to be the statistically significant level for these tests.

A power analysis was conducted using MedCalc software. Assuming an alpha of .05 and power of 80% and area under ROC curve = .75, power analysis suggested that 38 participants are required.

Table I. Patients' Characteristics

Variable		Overall population (n=48)
Age (years)		49 ± 15.8
BMI (kg/m²)		28.1 ± 5.6
Sex	Male	23 (47.9%)
	Female	25 (52.1%)
ASA physical status	I	7 (14.6%)
	II	39 (81.8%)
	III	2 (4.2%)
Comorbidity	Yes/No	21 (43.8%) / 27 (56.3%)

Values are Anesthesiologists. mean SD or number (%). **BMI:** Body mass index; **ASA:** American Society of Anesthesiologists.

RESULTS

Ultrasonography images of a total of 56 patients were recorded. Eight patients with missing data were excluded from the study. Forty-eight patients with adequate USG images were included in the study. Demographic data, ASA score, and comorbidities of the patients are shown in Table I. The PLMA was successfully inserted at the first attempt in 41 patients. In 6 patients, the PLMA was placed at the second attempt and in 1 patient at the third attempt. These 7 patients did not have proper chest excursion after PLMA insertion and had an audible leak at a pressure of 20 cm H_2O. After completion of the FOB, the PLMA was repositioned in 4 patients with a FOB grade of ≥3. Mean peak airway pressures ranged from 10 mm Hg to 20 mmHg during 5 consecutive breaths.

Table II. Comparison of USG Grade and FOB LMA Grade after LMA Placement

		USG Grade			
FOB LMA Grade	**N**	**0**	**1**	**2**	**3**
1	33 (68.8%)	31	2	0	0
2	11 (22.9%)	8	2	1	0
3	4 (8.3%)	0	0	4	0
4	0	0	0	0	0
Total	48	39	4	5	0

FOB LMA grade: fiber optic grade of laryngeal mask airway position; **USG:** Ultrasonography.

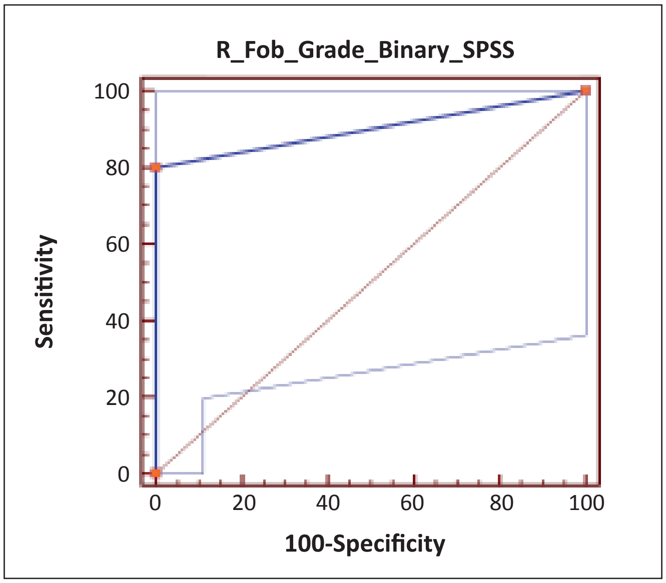

Figure 2. ROC analysis.

Table II presents the FOB LMA grade of the PLMA position. PLMA position was optimal in 33 (68.8%) patients according to FOB LMA grade and in 39 (81.3%) patients according to USG arytenoid grade. The USG arytenoid grade significantly correlated with the FOB LMA grade (p<.001, 95% CI 93%-53%). There was no patient with a FOB LMA grade of 4 or a USG arytenoid grade of 3 in this study. With regard to test performance, USG was found to have a sensitivity of 100% (95% CI, 39.8 – 100.0), with a positive predictive value of 97.7% (95% CI, 88.0 – 99.9) to detect a rotated PLMA of any number of degrees. The specificity was 80% (95% CI, 22.8 – 99.8), with a negative predictive value of 100% (95% CI, 91.8 – 100.0). The accuracy was 97.9% (95% CI, 86.3 – 99.3) (Figure 2).

DISCUSSION

Airway management provided by LMA in patients under general anesthesia was evaluated using USG. FOB evaluations confirmed adequate LMA positions, and the results indicate that USG was a practical method for affirming the position of LMAs. Using USG to confirm LMA placement was noninvasive, quick, and reliable.

In daily practice, a properly placed LMA is usually confirmed by clinical testing (8). Chandan et al. reported that although the LMA position is anatomically appropriate in only 56.7% of patients, ventilation can be achieved clinically in all cases (9). At the same time, the work of breathing may increase if the epiglottis obstructs the glottic aperture, specially in children or spontaneously breathing patients (2). However, a suboptimally positioned LMA may protect the airway to some extent but carries a risk of displacement during surgery (10). Our study observed that the PLMA was not ideally located in 15 (31.3%) patients according to the FOB LMA grade and in 9 (18.8%) patients according to the USG arytenoid grade. However, in these patients, no audible leak was detected at a pressure of 20 cm H_2O, no adverse effect on ventilation or complications related to LMA placement were observed. All of the patients in our cohort were adults, neuromuscular blockers were used, and spontaneous breathing was not allowed. Therefore, we believe that adhering to clinical ventilation parameters alone may not always guarantee appropriate and adequate PLMA placement and maintenance of airway protection.

The use of USG in airway management provides advantages because it is dynamic, safe, fast, reproducible, portable, and easy to access (11). Recently, several studies have evaluated sonographic confirmation of LMA location and compared it with other methods, and USG has been shown to be a suitable tool for confirming LMA location (1). In our study, in which we evaluated the arytenoid cartilages and the PLMA cuff ultrasonographically, we confirmed the optimal PLMA placement by visualising the PLMA cuff as a “reverse hanging drop” in the laryngopharynx, which was consistent with the literature (12). Studies have reported that the position of LMA cuff may vary depending on the patient’s epiglottis or pre-epiglottic space size, and sometimes, a large epiglottis or a pre-epiglottic space filled with fat may also obstruct the view of laryngeal structures (13). However, USG evaluates the LMA position along with the shape of the cuff and surrounding structures. Therefore, an appreciation of the detailed anatomy is not needed to confirm the position of the LMA (14). Various anatomical variations or possible laryngeal obstructions that are overlooked in clinical method evaluation can be detected non-invasively by USG (15). Our study observed that the FOB LMA grade was also high in patients with a high arytenoid grade on USG. Similarly, Gupta et al. reported that the USG grade of LMA position closely correlated with the FOB LMA grade in adult patients (16). Therefore, it can be considered that USG can be used as an alternative technique to FOB in confirming optimal PLMA placement.

Our study found that USG arytenoid grade showing PLMA rotation could predict a misplaced PLMA. Similarly, LMA placement was assessed by clinical tests, USG, and fibreoptic laryngoscopy, and USG was found to be useful (17). Kim et al. evaluated the location of the LMA with USG in 100 children. Unlike our study, USG could not detect the suboptimal depth of the LMA; however, they suggested that it may be an accurate tool for detecting a rotated LMA (1). The studies of Kim et al. were designed for children and used the classical LMA (CLMA). Pediatric CLMA is just the scaled-down version of adult LMA despite the differences in the airway anatomy of young children and infants compared to that of adults (10). However, pediatric PLMA is designed quite differently from adult size and is more suitable for pediatric anatomy because it lacks a dorsal cuff and has a relatively large drainage tube (18). Therefore a relatively frequent presence of tonsillar hypertrophy, a large tongue, a cephalad and more anterior larynx, a rather large and floppy epiglottis, and a more acute angle of the posterior pharyngeal wall to the floor of mouth than in adults may make an ideal placement of CLMA more difficult in pediatric patients (8). A study involving the adult patient group showed that PLMA has a better endoscopic appearance than CLMA (89% vs. 89%) (19). It has been reported that the gastric drainage tube and bite block in the PLMA provide an advantage in keeping the LMA position constant (20). For these reasons, we used PLMA in our study and found the FOB LMA grade to be correlated with USG. The use of age-appropriate size and type of PLMA may increase the correlation between USG and FOB. It could be possible that the PLMA position can be evaluated accurately and adequately by USG without interrupting ventilation.

The use of neuromuscular blockers can be considered as a limitation of this study. Therefore, we could not observe the effect of hypopharyngeal muscle tension on the LMA position in patients with spontaneous breathing. We used PLMA in our patient group. The clinical contribution of ultrasonographic evaluation can be evaluated using different LMAs.

CONCLUSION

Ultrasonography is noninvasive, fast, easily accessible, and reliable. Compared to clinical testing, the USG can provide more information about the cause of airway/ventilation events that may interfere with insertion and ventilation. As a result, USG is a promising alternative tool for confirming optimal PLMA placement or determining the need for repositioning. We recommend further use of this technique in the daily routine to improve the patient's safety.

AUTHOR CONTRIBUTIONS

Conception or design of the work: GK, AD
Data collection: FA, FKA
Data analysis and interpretation: FA, GK
Drafting the article: FA, GK, AD
Critical revision of the article: AD
All authors (FA, GK, FKA, AD) reviewed the results and approved the final version of the manuscript.

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