

## Original Article

## Laryngeal Mask Airway Supreme in Children: A Retrospective Audit

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## ABSTRACT

**Background:** The laryngeal mask airway (LMA) Supreme (LMAS) is a sophisticated, second-generation supraglottic airway device, with an improved seal, and gastric access. It is a capable device for use in more complex procedures and in younger children. No study has been able to analyze a large pediatric sample of patients to assess how the LMAS is being utilized. In this retrospective audit, we evaluated the use of the LMAS in routine clinical practice. In addition to this, utilization of LMAS performance test was evaluated.

**Methods:** A retrospective audit was performed of a major tertiary children's hospital's electronic medical record database to identify all children in whom the LMAS was utilized for airway management over a two-year period. In addition to demographic data, we collected the following LMAS data: size of the LMAS, the number of insertion attempts, volume of air injected into the cuff, the cuff pressure, and the oropharyngeal leak pressure. We also recorded the performance of tests for proper position and function, the mode of lung ventilation, the use of muscle relaxants and use of any alternative airway devices.

**Results:** The LMAS was used in 418 children accounting for only 4% of all LMA usage and only 0.6% of all usage for general anesthesia. The first-attempt placement success rate was 96.4% (382/396). Five of 418 (1.2%) insertions were reported as failures. Mechanical ventilation was used in only 26% of cases with a vast majority (74%) breathing spontaneously. Cuff pressure was measured in 74/418 (18%) of cases. Oropharyngeal leak pressures were measured in 90/418 (21.5%) cases. Maneuvers performed to verify correct placement and performance of the LMAS were rarely performed. Use of the LMAS for invasive procedures occurred in only 5 cases (1.2%).

**Conclusions:** This study shows the LMAS to be highly successful in the hands of various cadres of anesthesia providers at a major tertiary hospital and performs reliably well. Our data reveals many areas of potential improvement for use of the LMAS in the pediatric population, as a device capable for usage in more invasive surgical procedures, younger patients, and mechanical ventilation.

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The laryngeal mask airway (LMA) Supreme (LMAS) (Teleflex<sup>®</sup> Inc., Morrisville, NC, USA; Figure) is a sophisticated, second-generation supraglottic airway device designed for single use, with an improved seal, gastric access, and easy insertion (1). It combines the features of the LMA Fastrach, LMA ProSeal, and LMA Unique. Like the LMA ProSeal, the LMAS has two lumens: an airway tube and a drain tube (DT). A correctly positioned LMAS functionally separates the alimentary and respiratory tracts, while the rigidity of the device facilitates quick and easy insertion. In comparison to other supraglottic airway devices, numerous studies have shown the LMAS to have improved outcomes in the pediatric population (1-5). Unfortunately, most of these studies have been comparative data with small sample sizes, reporting oropharyngeal leak pressure, ease of insertion, and the feasibility of gastric access and mechanical ventilation. The goal of our study was to build upon this foundation with a large sample size while focusing on LMAS use at a major tertiary children's hospital. To accomplish this goal, a retrospective audit of a large cohort of clinical anesthesia providers in our tertiary children's hospital was conducted over a two-year period. Various performance indices of the LMAS were measured by this descriptive retrospective audit.

## METHODS

Following approval by our Institutional Review Board (IRB), we searched our hospital's electronic medical record database (Epic EMR, Verona, WI, USA) to identify all children in whom the LMAS was utilized for airway management between October 4, 2010 and October 11, 2012, regardless of the surgical procedure or anesthetic approach. Given the retrospective nature of the study, informed consent was waived by our IRB. Of note, during the study period additional LMAS sizes (1.5 and 2.5) were introduced by the manufacturer for clinical use. We collected the following demographic data: age, gender, weight, American Society of Anesthesiologists (ASA) physical status classification, type of anesthesia provider and type of surgery. We collected the following LMAS data: size of the LMAS, the number of insertion attempts, volume of air

injected into the cuff, the cuff pressure, and the oropharyngeal leak pressure. We also recorded the performance of tests for proper position, the mode of lung ventilation, the use of muscle relaxants and the use of any alternative airway devices. The oropharyngeal leak pressure, obtained by closing the adjustable pressure limiter (APL) valve and auscultating for air escaping from the mouth, was recorded. The oropharyngeal leak pressure was not measured in all children. Data analysis was performed using Microsoft Excel (Redmond, WA, USA). The primary outcomes were first-attempt and overall placement success rates. Secondary outcomes were: oropharyngeal leak pressures, frequency of manufacturer-recommended tests for proper position, failure rate, and complication rate.

For standard references, we relied on the manufacturer's recommendations for deflation of the LMAS prior to insertion, weight-based selection of initial size, and cuff volumes and pressures (6). Successful placement of LMAS was defined as documentation of any one or more of the following: adequate chest rise upon initial manual ventilation, maintenance of normal saturation, a leak pressure adequate for the surgical procedure and mechanical ventilation, a positive suprasternal notch test (gel test) or passing of a gastric tube down the drain tube of the LMAS. Failure of insertion was defined as documentation of having to change the LMAS size to achieve adequate leak pressure and/or conversion to an alternative airway device. Leak pressure measurement was obtained by closing of the adjustable pressure limiter (APL) valve and auscultating for air escaping from the mouth.

## RESULTS

Of the 75,614 general anesthetics delivered during the study period, 10,499 (13.9%) included an LMA device. The distribution of the different LMA devices used is shown in Table 1. The LMAS was used in 418 children, accounting for only 4% of all LMAs and 0.6% of all general anesthetics. The LMAS devices used are further subcategorized by size in Table 2. LMAS sizes 3 and 4 were used in a total of 334/418 (80%) of cases. The half sizes (1.5 and 2.5) were used in only 7 children. Patient demographic data is shown in ta-

ble 2. The number of attempts at placement was documented in 396/418 (95%) of cases. The first-attempt success rate at placement was 96.4% (382/396), and the second and third-attempt success rates were 100%. Five of 418 (1.2%) insertions were reported as failures. Of the 5 failed insertions, the LMAS was replaced with a different size in 3 patients and with an endotracheal tube in 2 others. A vast major of the cases were general superficial procedures such as minor general surgery, urologic procedures, minor orthopedics and radiologic procedures. Only 5/418 (1.2%) LMAS were used for laparoscopic procedures. In regards to position, 23/418 (5.5%) of the cases were performed in a position other than supine, with only one in the prone position. Slightly more than half of the placements (228/418) were performed by a trainee (resident physician) or a mid-level provider (Certified Registered Nurse Anesthetist or Anesthesiologist Assistant) under the supervision of an anesthesiologist. A form of mechanical ventilation was used in only 107/418 (26%) of cases, while a vast majority 311/418 (74%) of the cases were breathing spontaneously.

Cuff pressure was measured in 74/418 (18%) of cases. Information on oropharyngeal leak pressures and cuff inflation volumes are shown in Table 3. Maneuvers performed to verify correct placement and performance of the LMAS are described in Table 4. The "bubble test or gel test" and the maximum minute ventilation (MMV) to resting minute ventilation (RMV) ratio were measured in 55/418 (13%). A gastric tube was attempted in 98/418 (23%) cases and was successful in all but one.

**DISCUSSION**

The first significant finding of this audit is the high LMAS placement success rate, regardless of provider skill-level. With a first-attempt placement success rate of 96.4%, this study in a large pediatric population replicates the LMAS ease-of-use seen in the adult population. This finding reaffirms the importance of supraglottic airways, and why they play an essential role in the difficult airway algorithm. More specifically, it proves the LMAS as a device with wide implications in the hands of all providers, a finding that builds upon similar data reported by Ja-



**Figure. Laryngeal Mask Airway Supreme.**

**Table 1. Description of LMA Airway Devices Used.**

Airway device	LMA devices	Total airway devices
LMA Unique	7,794 (74.2)	(10.3)
LMA Flexible	2,275 (21.7)	(3.0)
LMA Supreme	418 (4.0)	(0.6)
LMA ProSeal	10 (0.10)	(0)
LMA Classic Excel	2 (0)	(0)
Subtotal	10,499 (100)	(13.9)
ETT	65,115	(86.1)
Total	75,614	(100)

Values reflected in table are number (percentage).

gannathan, et al (2, 3).

The LMAS was overwhelmingly employed for minor surgical and radiological procedures, similar to the recommended indications for the LMA Classic or Unique. This seems to suggest that the LMAS was used as a substitute for the LMA Unique, despite its advanced features and functionalities. Our data shows that the LMAS was used for only five laparoscopic cases (1.2%), which is significantly lower than that reported by Sanders, et al, where 13% of their LMA ProSeal cases were laparoscopic procedures (7). Our finding may therefore reflect an unspoken reluctance on the part of pediatric anesthesiologists to rely on a supraglottic airway device for laparoscopic procedures. Recognizing this concern about the use of supraglottic airway devices in laparoscopic procedures is important since it might highlight a misconception about the LMAS. The purpose and design of the LMAS is to facilitate its use in more advanced

**Table 2. Patient Demographics, LMA Supreme Size, and Procedure Characteristics.**

Total (n=418)	
<b>Demographics</b>	
Male	244 (58)
Female	174 (42)
Age (years)	12 (4.6) 0.75-36
Weight (kg)	54.6 (25.9) 8-153
<b>LMA size</b>	
1	0
1.5	2 (0.5)
2	58 (13.9)
2.5	5 (1.2)
3	154 (36.8)
4	180 (43)
Unknown	19 (4.5)
<b>ASA status</b>	
1	155 (37.1)
2	160 (38.3)
3	102 (24.4)
4	1 (0.24)
<b>Type of surgery</b>	
Superficial or limb	413 (98.8)
Laparoscopic	5 (1.2)
<b>Patient position</b>	
Supine	395 (94.5)
Prone	1 (0.24)
Lateral	6 (1.4)
Lithotomy	16 (3.8)
<b>Provider</b>	
Attending	190 (45.4)
Trainee	128 (30.6)
Mid-level	100 (24)
<b>Type of ventilation</b>	
Spontaneous	311 (74.4)
Pressure control	88 (21)
Volume control	12 (2.8)
Pressure support	7 (1.7)
Relaxant used	23 (5.5)
<b>LMA success rates</b>	
First attempt	382 (96.4)
Second attempt	13 (3.4)
Third attempt	1 (0.2)
Not documented	22 (5)
Device failure	5 (1.2)
Cuff pressure measured	74 (18)

Values reflected in table are number (percentage) or mean (SD) range.

procedures. And if it is not being used in the cases for which it was designed, we must ask why the device is not being utilized to its maximum potential.

With mechanical ventilation used in only 26% of LMA cases, the avoidance of positive pressure ventilation is likely related to the limited use of this device for advanced procedures. The ability of LMA to provide effective positive pressure ventilation has been demonstrated by Verghese C, et al (1) and Hosten T, et al (8) with the LMA and ProSeal LMA in adult patients. In our study, the oropharyngeal leak pressure measured in 90 cases was on average 20.8 cm H<sub>2</sub>O. This is similar to previously reported data (2, 3), but greater than the values reported in a study that compared the LMA with the I-gel (9). Leak pressures were in the 20- 25 cm H<sub>2</sub>O pressure range for sizes 3 and 4, values that are consistent with those reported by Jagannathan, et al (3, 4). Mean leak pressures for size 2 were 17.2 cm H<sub>2</sub>O, which is slightly less than the 19.3 cm H<sub>2</sub>O reported by Jagannathan, et al (2). Sizes 1.5 and 2.5 had mean leak pressures of 18 and 17 cm H<sub>2</sub>O, respectively. Despite these discrepancies, these pressures were sufficient for effective positive pressure ventilation in those patients in which this ventilator mode was utilized. If usage of the LMA can be encouraged in more complex cases, we suspect that the use of mechanical ventilation with the LMA will proportionally increase too. The demographic data demonstrates that the LMA was used primarily in older children, with the average age being 12 years old. As a device capable of use in even the neonatal population with a high success rate, we would have hoped for a younger median age (10-12). This might simply reflect a lack of experience with the LMA in younger patients by anesthesia providers or some general unwillingness to utilize supraglottic airways in younger patients. Nonetheless, this aspect of LMA utilization requires further investigation for a better understanding of the device.

The relationship between cuff volume and pressure has important implications in regards to adverse events related to LMA placement (13). With LMAs associated with a 50% post-operative sore throat rate, and other much less common adverse events such as nerve palsy, dysphagia, and airway edema, it is important to understand cuff volume and its relation to cuff pressure (14). As highlighted by Bick et al, the recommended cuff pressures are not the ideal

cuff pressures, nor do the cuff volumes correlate well to a cuff pressure. Looking for instances of cuff over-inflation, our data shows that recorded cuff volumes were much less than those recommended by the manufacturer (15). A possible reason for these low cuff volumes is that many clinicians at our institution insert the LMAS directly out of the packaging without deflating the cuff or empirically inflating the cuff to achieve an adequate seal. This practice at our institution appears to prevent over-inflation of the cuff, something that has been reported to occur with over 70% of LMA (16). Cuff under-inflation may itself be associated with suboptimal performance of the LMAS.

The LMAS is safe for use in pediatrics. Only five of 418 (1.2%) insertions were reported as failures. For three of the five, the leak was significant enough to warrant a change in LMAS size. Two of the five were known complications in our study. One patient developed airway activation shortly after insertion and vomited. The LMAS was removed and the patient was promptly intubated. No particulate material or gastric content was noted when the endotracheal tube was suctioned. Gross blood-staining of the LMAS was reported in another patient due to traumatic insertion. The overall low incidence of LMAS complications may also be attributed to low adverse event reporting.

The limitation of this audit is the fact that LMAS sizes 3 and 4 accounted for the majority of cases in this study and no patient required a size 1 LMAS. In addition to this, sizes 1.5 and 2.5 were utilized in very few cases (n=7) since these sizes were not available for clinical use until a few months prior to the conclusion of this review. This study did not attempt to investigate user preference or why certain LMA devices were utilized. Also, in addition to being a retrospective study without postoperative follow-up, this was a single-site study and our findings may not necessarily reflect practice

**Table 3. LMAS Size and Performance Tests Conducted.**

LMAS size	Oropharyngeal leak pressure (cm H <sub>2</sub> O)	Cuff inflation volume (mL)
1 (n=0)	0	0
1.5 (n=2)	18 (2) 16-20	0
2 (n=58)	17.2 (3.7) 10-24	3.6 (1.7) 1.5-8
2.5 (n=5)	17 (3) 14-20	0
3 (n=154)	22.6 (5) 14-40	11 (3.3) 5-20
4 (n=180)	21.8 (5.2) 12-35	13.3 (5.6) 3-20
Unknown (n=19)	24 (3.7) 20-30	13.8 (4.1) 10-20
Total (n=418)	90 (21.5%)	62 (15%)

Values reflected in table are mean (SD) range.

**Table 4. LMAS Size and Maneuvers Attempted to Confirm Correct Device Placement.**

LMAS size	Bubble Test	Gastric tube placement	MMV/RMV ratio
1 (n=0)	0	0	0
1.5 (n=2)	2 (100)	2 (100)	2.85 (0.15)
2 (n=58)	19 (33)	20 (34)	3.2 (0.8)
2.5 (n=5)	2 (40)	3 (60)	2.3 (0.2)
3 (n=154)	15 (10)	39 (25)	2.5 (0.4)
4 (n=180)	15 (8)	29 (16)	2.8 (0.4)
Unknown (n=19)	2 (11)	5 (26)	2.9 (0.3)
Total (n=418)	55 (13)	98 (23)	55 (13%)

Values reflected in table are number (percentage) or mean (SD).

in other clinical settings or institutions.

In summary, this study shows the LMAS to be a highly successful and reliable device, regardless of user experience. Our audit shows that the LMAS was rarely used for more invasive surgical procedures or in young children and infants, despite its advanced features and functionality. The recommended tests to ensure proper positioning were rarely performed by providers. Further studies into the etiology of user LMA preference along with studies of the LMAS in difficult airways are needed to continue our understanding of the practical utilization of second-generation supraglottic airway devices in the pediatric population.

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One of the authors (PO) serves as a Consultant for Teleflex Medical, Inc., maker of the laryngeal mask airway. None of the additional authors of this study have any disclosures.

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