Objective: To compare the use of flexible laryngeal mask airway (LMA) and endotracheal tube (ETT) in pediatric adenotonsillectomy.

Design: Prospective randomized trial.

Setting: Tertiary care hospital.

Patients: One hundred thirty-one children (aged 2-12 years). Exclusion criteria were body mass index (calculated as the weight in kilograms divided by the height in meters squared) greater than 35 and craniofacial anomalies. Obstructive sleep apnea was the most common indication for surgery.

Intervention: Children undergoing adenotonsillectomy were randomized to use of an LMA or ETT. A standardized anesthesia protocol was used.

Main Outcome Measures: Primary outcome measure was laryngospasm. Secondary measures included anesthesia, operative, and recovery times.

Results: Sixty children were randomized to the LMA group and 71 to the ETT group. There was no difference between groups with regard to age (P=.76), ethnicity (P=.75), body mass index (P=.99), or American Society of Anesthesiologists grade (P=.46). Incidence of postoperative laryngospasm between LMA (12.5%) and ETT (9.6%) was similar (P=.77). In 10 patients, the LMA was changed to ETT intraoperatively owing to tube kinking or difficulty with visualization. Mean (SD) surgical times for LMA and ETT groups were 33.35 (13.39) and 37.76 (18.26) minutes, respectively (P=.15). Time from surgery end to extubation was significantly shorter in patients who used LMA (P=.01) by 4.06 minutes. There were no differences (P=.49) in postanesthesia care unit recovery times.

Conclusions: An LMA is an efficient alternative to ETT in pediatric adenotonsillectomy. When comparing LMA and ETT, there is no difference in rates of laryngospasm. Time to extubation is significantly shorter in patients using LMA. Before adopting the routine use of LMA in pediatric adenotonsillectomy, further study is needed to address visualization and kinking issues associated with this device.

ited widespread use of the LMA in pediatric adenotonsillectomy. However, the potential for decreased upper airway reflex stimulation and shorter anesthesia times makes this device an appealing option for airway maintenance in adenotonsillectomy.

The aim of the present study was to compare the use of the flexible LMA and an endotracheal tube (ETT) in pediatric adenotonsillectomy. The primary objective was to assess the incidence of postoperative laryngospasm between the LMA and ETT. We also sought to compare anesthesia, operative, and recovery times in the LMA and ETT groups. To our knowledge, this is the first study to prospectively analyze perioperative complication rates and compare operative and anesthesia times between LMA and ETT in pediatric adenotonsillectomy.

METHODS

The protocol for this prospective randomized trial was approved by the institutional review board. Before participation in the study, consent was obtained from the parents. Children older than 7 years also provided assent.

Patients were consecutively recruited from an otolaryngology practice at a tertiary care hospital from December 1, 2007, through August 31, 2009. We included children aged 2 to 12 years undergoing elective adenotonsillectomy for obstructive sleep apnea or chronic tonsillitis. Exclusion criteria were body mass index (BMI; calculated as the weight in kilograms divided by the height in meters squared) greater than 35 and craniofacial anomalies. Children with asthma and gastroesophageal reflux were included in this analysis. One hundred thirty-one children met the inclusion criteria. A random number generator was used to randomize 71 children to the ETT group and 60 to the LMA group. The primary outcome measure was laryngospasm. Secondary outcomes included perioperative adverse events and anesthetic, operative, and recovery times.

Anesthesia was administered according to a standardized protocol. Patients underwent premedication with oral midazolam hydrochloride, 0.5 mg/kg, to a maximum dose of 10 mg. Inhalational induction was achieved with sevoflurane and oxygen. Intravenous propofol (2.5-4.0 mg/kg) was administered before insertion of a flexible LMA or a cuffed ETT. As recommended by the manufacturer, the size of the LMA was determined according to the patient’s weight. Fentanyl citrate (1-2 µg/kg) and dexamethasone sodium (Decadron; 0.5 mg/kg to a maximum dose of 10 mg) were also administered during the procedure. In the LMA group, fiberoptic examination of the airway was performed at the conclusion of surgery to assess for the presence of blood at the level of the larynx. Deep or anesthetized extubation (as opposed to awake extubation) was performed.

Demographic factors for patients, including age, sex, ethnicity, and American Society of Anesthesiologists (ASA) grade, were recorded. We calculated the BMI and used the Centers for Disease Control and Prevention BMI-for-age growth charts to categorize the children as underweight, healthy weight, overweight, or obese.6 The tonsils were assigned a grade of 1 to 4 according to the assessment proposed by Brodsky.7 The grading can be summarized as follows: grade 1 tonsils occupy less than half the transverse diameter of the oropharynx; grade 2 tonsils, half the transverse diameter; grade 3 tonsils, more than half the transverse diameter; and grade 4 tonsils, the entire transverse diameter of the oropharynx (kissing tonsils).

Pulse oximetry, electrocardiography, capnography, and systolic blood pressure were monitored and recorded perioperatively. A Crowe-Davis or ring-mouth gag was used to provide surgical exposure. All children underwent tonsillectomy using electrocautery, whereas adenoidectomy was performed using a combination of sharp dissection with a curette and electrocautery. All perioperative adverse events were recorded, including oxygen desaturation and laryngospasm.

We documented anesthesia, operative, and recovery times. Intubation time was defined as the time in minutes from removal of the face mask to insertion of the LMA or the ETT. Surgical time was calculated as the number of minutes from surgical start to end times. Total anesthesia time was defined as the number of minutes from the time the anesthetic face mask was placed on the child until operating room exit. Extubation time was the time in minutes from surgery end to extubation. Recovery time was defined as the time elapsed from arrival in the postanesthesia care unit (PACU) to discharge.

A power analysis was conducted. The sample size of 63 per group was calculated using an α level of .05 and a power of 80%, anticipating that laryngospasm would occur in 14% of children undergoing adenotonsillectomy. We used the Fisher exact test and the 2-sample t test to assess differences in perioperative adverse events and operative and recovery times between LMA and ETT. A P value less than .05 was considered significant. Unless otherwise indicated, data are expressed as mean (SD).

RESULTS

PATIENT DEMOGRAPHICS

A total of 131 children were enrolled in the study, of whom 56 (42.7%) were female. The mean (SD) age of children in our series was 5.6 (2.4) years. Most of the patients (60.3%) identified their ethnicity as African American. The most common indication for surgery was obstructive sleep apnea (n=106). Asthma was the most frequent comorbidity reported in the study population (n=35). Only 2 children in this study had a medical history significant for gastroesophageal reflux disease.

Seventy-one children were initially randomized to the ETT, whereas 60 were randomized to the LMA. However, 12 children in the LMA group required intubation with an ETT. Two of these children experienced bronchospasm during mask induction and were intubated with an ETT at the discretion of the anesthesiologist (J.K. and J.S.). In the other 10 patients, the LMA was converted to an ETT intraoperatively owing to kinking of the tube and poor visualization. Thus, the data from these 12 patients were included in the ETT group statistics for postoperative laryngospasm. In our final analysis of postoperative complications, there were 83 children in the ETT group and 48 children in the LMA group. The 12 patients who underwent conversion from LMA to the ETT were excluded from the total anesthesia time analysis to avoid artificially elevating the time in the ETT and LMA groups.

There were no statistically significant differences between the ETT and LMA groups in terms of age, sex, ethnicity, BMI category, surgical indication, tonsil grade, and ASA grade (Table 1).

DEVICE PLACEMENT AND POSITIONING

The intubation times for the ETT and LMA were similar (P=.67). The mean time for ETT insertion was 0.93 (1.41)
minutes, whereas the time for LMA placement was 0.83 (0.84) minutes. There was no significant difference (P = .76) between the LMA and ETT, with respect to the number of intubation attempts required to secure the airway.

Three complications associated with ETT placement were identified. One child was noted to have a lip abrasion after intubation. One ETT required replacement owing to kinking when the mouth gag was opened. A final patient experienced laryngospasm during an intubation attempt with an ETT.

In the LMA group, there were no complications associated with insertion of the device. Compression of the LMA tube that prevented adequate ventilation was the most common problem encountered. Kinking of the LMA occurred in 15 children when the mouth gag was opened. In 7 patients, obstruction of the LMA improved after the mouth gag was repositioned. The other 8 patients required the LMA to be changed to an ETT intraoperatively. In 45 patients (93.8%), the LMA provided adequate surgical access. However, poor visualization of the surgical field necessitated converting the LMA to an ETT in 3 patients. (In 1 child, the LMA was changed because of poor visualization and kinking of the device.)

Thus, the LMA was abandoned in favor of endotracheal intubation in a total of 10 children because of obstruction or inadequate exposure. Patient factors, such as BMI category and tonsil grade, did not correlate with whether the LMA was changed to an ETT. Of interest, overweight and obese children (P = .99) and those with grade 4 tonsils (P = .37) were not predisposed to LMA failure.

A flexible fiberoptic laryngoscope was passed through the LMA at the conclusion of adenotonsillectomy in 48 patients. Blood was noted at the laryngeal inlet in only 1 case. That patient did not experience postextubation laryngospasm or desaturation. In more than half the patients (n = 25), the fiberoptic view of the vocal cords was partially obstructed by a displaced epiglottis. The epiglottis completely blocked the fiberoptic view of the vocal cords in a single patient. However, there were no problems with ventilation during adenotonsillectomy in that child.

### ANESTHESIA, OPERATIVE, AND RECOVERY TIMES

Surgical times between the ETT and LMA groups were not significantly different (P = .15) (Table 2). When we compared the ETT and LMA, the extubation time for patients using the LMA was significantly shorter by 4.06 minutes. The total anesthesia times in the LMA and ETT groups were 67.72 (19.88) and 73.80 (22.59) minutes, respectively. Although there was a trend toward a shorter anesthesia time in the LMA group, this difference did not reach statistical significance (P = .14). The PACU recovery times were similar for both groups of children (P = .49).

### PERIOPERATIVE COMPLICATIONS

Eight of 83 children (9.6%) in the ETT group and 6 of 48 children (12.5%) in the LMA group experienced postoperative laryngospasm. This difference was not statistically significant (P = .77). Eighteen children in the study experienced oxygen desaturation and/or obstruction in the PACU that necessitated intervention. Interventions included nebulized albuterol sulfate or racemic epinephrine treatments, chin lift, supplemental oxygen, or nasal trumpet placement. No child required reintubation.
Twelve children in the ETT group had an episode of desaturation or obstruction in the PACU compared with 6 children in the LMA group (P = .99).

Use of LMA vs ETT did not affect the rates of laryngospasm or perioperative adverse events. Furthermore, factors such as age, surgical indication, history of asthma, ASA grade, surgical blood loss, and BMI did not affect rates of postoperative laryngospasm in this patient population (Table 3).

### COMMENT

Airway management during pediatric adenotonsillectomy can be challenging. The anesthesiologist and surgeon must share the airway and protect it from blood and secretions. Compared with other surgical procedures in children, adenotonsillectomy has the highest rate of laryngospasm. Endotracheal intubation has been the standard for general anesthesia. However, the LMA represents an alternative means to secure the airway during pediatric adenotonsillectomy. Ease of insertion and minimal stimulus of cardiac and respiratory response are advantages of the LMA that make this device ideal for short elective procedures in children.

Use of the LMA for adenotonsillectomy is widespread in Canada and Europe. In 1993, Webster et al conducted a study of 109 children to assess the suitability of the LMA for anesthesia during pediatric adenotonsillectomy. Although the rates of laryngospasm were similar between ETT and LMA, children in the LMA group were significantly less likely to have stridor after the procedure. The need for assisted ventilation during the procedure was reduced in the LMA group. Williams and Bailey published a series that included 100 patients (adults and children) who were assigned to receive ETT or LMA during adenotonsillectomy. There was no difference in laryngospasm between the 2 groups. However, the authors concluded that recovery was less eventful in the LMA group, with significantly less airway obstruction and better airway acceptance compared with the ETT.

The current prospective randomized trial demonstrates that the LMA is a safe alternative to ETT in pediatric adenotonsillectomy. The LMA did not interfere with surgical access, and the device provided adequate protection of the airway. The LMA and ETT groups had similar rates of postoperative laryngospasm and desaturation. Demographic factors such as age, surgical indication, BMI category, and ASA grade did not affect the rates of laryngospasm and desaturation. However, the number of children with comorbid disease processes in our subject population was small. Future studies should include larger numbers of patients with comorbidities that predispose to laryngospasm and bronchospasm, such as asthma and gastroesophageal reflux. It is possible that the LMA offers an advantage to the ETT in these select groups of patients because the LMA may decrease upper airway reflex stimulation.

Improving efficiency in the operating room has been a major focus of hospital administrators during the past decade. Our results suggest that LMA is more efficient than ETT in adenotonsillectomy. Time between the end of surgery and extubation was significantly shorter in the LMA group by 4.06 minutes. The total anesthesia time (the time from placement of the face mask for inhalation induction to operating room exit) was shorter in the LMA group by 6.08 minutes. However, this difference did not reach statistical significance (P = .14). The performance of flexible fiberoptic laryngoscopy at the conclusion of the procedure may have increased the extubation and total anesthesia times in the LMA group. In addition, the frequent adjustments and conversions of the LMA because of kinking of the tube may have lengthened the total anesthesia time. It is likely that the anesthesia time for the LMA group would be significantly shorter than that of the ETT group if adjustments to the device could be avoided.

In a study by Joshi et al, intraoperative narcotic requirement and duration of time spent in the PACU were significantly less in patients using the LMA compared with ETT. However, in our study, the PACU recovery times for the LMA and ETT groups were similar. A possible explanation for this finding involves the standardization of our anesthesia protocol. Children in the LMA and ETT groups received the same weight-appropriate dose of narcotic. It is possible that children in the LMA group may have required less narcotics, leading to a shortened PACU recovery.

The most common problem associated with the use of the LMA in pediatric adenotonsillectomy was obstruction of the tube when the mouth gag was opened. Webster et al reported a similar finding with 10 patients who developed obstruction on opening of the gag. The authors concluded that the obstruction was likely due to an inadequate depth of anesthesia with resultant reflex laryngeal closure. In our experience, the LMA tube was observed to kink with opening of the gag. We hypothesized that mechanical compression of the device tube was the cause of obstruction. Another potential cause of obstruction involves the displacement of the epiglottis by the LMA when the mouth gag is opened.

Further research is needed to address the etiology of obstruction of the LMA and to identify strategies to prevent this occurrence. A fiberoptic scope should be passed through the LMA with the mouth gag engaged to deter-
mine whether kinking of the tube or displacement of the epiglottis is responsible for obstruction. We did not standardize the type of mouth gag used in this study. It is possible that obstruction of the LMA correlated with the use of the Crowe-Davis or ring-mouth gag. Furthermore, the sizes of the mouth gag and LMA may contribute to kinking of the device. The use of smaller mouthgag blades and smaller LMA tubes may decrease the rate of obstruction. In our anecdotal experience, the use of a half-size smaller LMA was associated with improved surgical access and decreased rates of obstruction.

This is, to our knowledge, the first endeavor to prospectively compare LMA and ETT in terms of perioperative adverse events and operative, anaesthesia, and recovery times in pediatric adenotonsillectomy. The strengths of this project include a large, diverse subject population and a study design featuring a standardized anesthesia protocol. There are several limitations of the present study. This project was conducted at a tertiary care medical center. Thus, the results cannot be generalized to a community hospital setting or to an ambulatory surgery center. In addition, the participating anesthesiologists had additional training in pediatrics and were experienced in the use of the LMA in children. Finally, further research is necessary to determine the cost savings conferred by LMA vs ETT in pediatric adenotonsillectomy.

In conclusion, a flexible LMA is an efficient alternative to ETT in pediatric adenotonsillectomy. In a comparison of LMA and ETT, there were no differences in rates of postoperative laryngospasm and desaturation, and extubation times were significantly shorter in patients using the LMA. Before adopting the routine use of LMA in pediatric adenotonsillectomy, further research is needed to address the obstruction and kinking associated with this device. In the meantime, endotracheal intubation remains the standard means to secure the airway in children undergoing adenotonsillectomy.

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REFERENCES