Extraglottic Airway Devices in Pediatric Anesthesia

A
irway management is a major challenge in the practice of pediatric anesthesia. Adverse respiratory events have long been known to account for the largest proportion of critical perioperative episodes in children; recent studies reconfirm these findings despite the routine use of pulse oximetry and capnography.

During the past 2 decades, numerous new airway devices have been developed in an effort to improve the practitioner’s abilities to manage a difficult airway. For the proper characterization and classification of these devices, Brimacombe et al suggested that the term extraglottic airway device (EGAD) is more appropriate than supraglottic airway device (SGAD) because many have components that are infraglottic, yet all lie outside the glottis.

A large number of EGADs are available for clinical use in adults. However, many of these either are not made in pediatric sizes or come in only a few sizes for children. Moreover, far fewer validation and comparative clinical trials have been conducted of the use of EGADs in pediatric patients than in adult populations.

The Laryngeal Mask Airway (LMA, LMA North America, Inc.) and related devices have been used extensively in clinical practice since the first such product was introduced in 1988. Between 30% and 60% of all procedures involving general anesthesia are currently performed with a laryngeal mask device. A substantial literature supports the use of these devices—more than 2,500 publications deal with the laryngeal mask in various patient populations, including neonates and children, for a variety of surgical procedures and with different anesthetic agents. They appear to be extremely safe, having been used in an estimated 200 million patients with no directly attributable deaths.

Compared with the endotracheal tube (ETT), the laryngeal mask has certain advantages:
- insertion that is performed blindly and easy to learn;
- inclusion of the laryngeal mask in the American Society of Anesthesiologists difficult airway algorithm in cases in which both tracheal intubation and conventional mask ventilation are difficult;
- fast insertion time and airway control, even when...
used by inexperienced personnel;
• possible improved outcome in patients with upper respiratory infections;
• less laryngeal stimulation and fewer cardiovascular responses during insertion/induction and emergence;
• reduced anesthetic requirements for airway tolerance;
• lower incidence of airway morbidity (eg, laryngeal swelling) and postoperative sore throat.

Despite these advantages, the laryngeal mask has drawbacks. The airway is not secured, leaving a risk for regurgitation and aspiration. As a result, its use in patients with a full stomach or a history of gastroesophageal reflux is contraindicated.

The low sealing pressure of the laryngeal mask airway does not permit ventilation with high positive pressures. This fact is especially relevant in infants and children, in whom the small size and shape of the oropharynx make it particularly difficult to fit an airway device. It has been reported that more than 1 insertion attempt is required in 5% to 10% of cases in which the mask is used, thus increasing the patient’s risk for airway complications.

Controversy exists about whether the laryngeal mask airway can be a suitable alternative to the ETT in children with respiratory infections. Some studies have reported fewer adverse respiratory events, whereas others have found an increased incidence of airway complications with the laryngeal mask. Given these limitations, it is understandable that new airway devices have emerged. A wider choice of EGADs may decrease the incidence of complications, provide backup devices whenever the initial device fails, and offer alternatives for specific populations (eg, children, neonates) or procedures (head and neck surgery, bronchoscopy, difficult intubation).

**Use of the Laryngeal Mask Airway in Pediatric Patients**

Many studies in large numbers of children claim that laryngeal masks are safe and effective in this population.

**LARYNGEAL MASK AIRWAY AND AIRWAY SEAL**

An efficient seal of the laryngeal mask allows positive pressure ventilation without gastric insufflation, considered to indicate correct positioning of the device. Nevertheless, in children, a good airway seal does not guarantee a correctly positioned mask airway. Even when the mask is positioned correctly, air insufflation of the stomach may be unavoidable.

With the laryngeal mask in place, head and neck movements, except for neck flexion, rarely seem to affect airway patency in children. The airway seal can be quantified by different oropharyngeal leak tests, which have been shown to be reliable in children.

The high cuff inflation pressures necessary to achieve a good airway seal should be avoided with the laryngeal mask because in rare cases injury to the recurrent laryngeal nerve can occur. Consequently, cuff inflation pressure should be kept below 60 cm H₂O. Also, hemodynamic responses and activation of airway-protective reflexes are less pronounced during insertion of a laryngeal mask than during laryngoscopic intubation.

**Complications of Laryngeal Mask Airways**

Although relatively safe in adults, laryngeal masks may lead to more complications in infants and neonates as a result of anatomic differences and the deeper levels of anesthesia necessary for insertion, which are more difficult to achieve and maintain in younger children.

Positioning the laryngeal mask can be difficult, especially with sizes 1 and 1.5, which have been associated with rates of respiratory complications of up to 30%. Some of these problems result from distortion of the airway with epiglottic down-folding, which occurs in 90% of children after insertion of a size 2 or 2.5 mask. Such distortion may contribute to partial obstruction of the upper airway; this typically does not affect function during spontaneous breathing but can cause some difficulties with positive pressure ventilation.

Partial airway obstruction also is common with sizes 1 and 1.5 masks, especially in association with higher ventilatory pressures and a larger inspiratory leak that result in a lower effective tidal volume. Displacement of the laryngeal mask is considered a minor complication if the patient’s head is readily accessible. The incidence of active emesis and pulmonary aspiration with use of the laryngeal mask seems to be very low in children, although some events are limited. Frequent discrete episodes of gastroesophageal reflux (pH ≤4.0 in the distal esophagus) have been observed with continuous measurement of esophageal pH. Reflux was associated with longer operative procedures (>40 minutes) and controlled mechanical ventilation with the use of muscle relaxation.

In theory, the laryngeal mask should be removed while the patient is awake after protective reflexes such as swallowing reappear. Some investigators have found no differences between awake and deep-sedation removal of a laryngeal mask airway. However, a single study found that removal during deep sedation resulted in less coughing and hypoxia.

Laryngeal mask airways are increasingly being used in nonconventional circumstances, as in laparotomies and laparoscopies, although these uses are still controversial and their safety has yet to be proved in large prospective studies.

**Types of Laryngeal Mask Airways**

- LMA-Classic™ (cLMA; LMA North America, Inc)
- LMA-Unique™ (LMA-U; LMA North America, Inc)
- LMA-Flexible™ (LMA North America, Inc)
- LMA-FastTrach™ (intubating LMA; LMA North America, Inc)
• LMA-ProSeal™ (PLMA; LMA North America, Inc; Figure 2)
• Air-Q Laryngeal Mask (Cookgas/Mercury Medical; Figure 1)
• Portex® Soft Seal™ Laryngeal Mask (SSLM; Portex, Inc; Figure 2)

Few studies in children have attempted to compare the different SGADs. In a group of pediatric patients undergoing dental extractions, the LMA-Flexible was shown to be associated with a lower incidence of airway obstruction and to provide better surgical access than the cLMA. However, the LMA-Flexible was more difficult to insert.

Contrary to previous reports, insertion of the LMA-Flexible was found to be easy. Compared with the cLMA, the LMA-Flexible was associated with an increased incidence of postoperative coughing. Flynn et al compared the performance of the single-use LMA and the reusable LMA-Flexible in pediatric patients undergoing dental surgery and found them equivalent.

LMA-PROSEAL

The first pediatric-sized (size 2) PLMA became available in 2003, followed by sizes 1.5 and 2.5 in 2004. In contrast to the larger PLMAs (>size 3), the pediatric sizes do not contain an additional dorsal cuff (Figure 3). The most important new features of the PLMA are a softer cuff material, a deeper mask bowl, a special cuff shape designed to create a higher seal pressure, a gastric drainage lumen that runs along the barrel from the tip of the cuff, a built-in bite block, and a lack of aperture bars. Whereas it was difficult to insert a PLMA in adults, its ease of insertion in children was not different from that of the cLMA in a published study. This effect may be explained by the lack of a dorsal cuff in the smaller-sized PLMAs. Furthermore, the lack of a dorsal cuff does not appear to decrease the efficacy of the airway seal provided by the smaller PLMAs. Several studies have found a 20% to 30% higher oropharyngeal leak pressure with pediatric PLMAs than with the cLMA. A single study found no difference between the airway leak pressures of the 2 devices (Table 1).

The improved airway seal of the pediatric PLMAs and the ability to evacuate insufflated air make the device a potential alternative to the ETT. Moreover, the pediatric PLMA was found to enable pressure-support ventilation and pressure-controlled ventilation combined with positive end-expiratory pressure. Pressure-support ventilation was associated with reduced work of breathing and improved gas exchange compared with continuous positive airway pressure ventilation, although mild hypercarbia was still present.

Reliable functional separation of the respiratory and digestive tracts with the correctly positioned PLMA—achieved by the double-tube design—was illustrated by 2 important findings. First, gastric insufflation occurred in 6% to 27% of patients who received a cLMA but in none of those who received a PLMA; second, gastric tube placement was possible in the majority of patients.

Despite the separation of the respiratory and digestive tracts in correctly placed PLMAs, the device does not offer definitive protection against aspiration in all patients. A potentially dangerous problem of a malpositioned PLMA is glottic insertion, which was found to occur in 6% of adult patients managed with the devices in one study. The incidence of this complication in pediatric patients is not known, but it should always be considered a risk in children in whom PLMAs are used.

Other Extraglottic Devices and Their Use in Pediatric Anesthesia

LARYNGEAL TUBE

The Laryngeal Tube (LT; VBM Medizintechnik GmbH) and the King LT™ (King Systems) are SGADs designed for both spontaneous and positive pressure ventilation. The LT consists of a tube with 2 balloons (oropharyngeal and esophageal) and 2 oval apertures placed between the balloons, permitting ventilation. The distal tip is positioned in the esophageal inlet. Although the LT is available only in adult sizes in the United States, the disposable LT-D has adult and
pediatric sizes (Figures 4, 5). Also, a new version of the LT with a gastric drain, the LT Suction (LTS), is now available.

In children 10 years of age or younger, Bortone et al found the LT less effective than a laryngeal mask during both spontaneous and assisted ventilation and for fiber-optic evaluation of the airway.31 Because of the high rate of failure of the LT, Richebé et al do not recommend using the device in infants weighing less than 10 kg.32 In children weighing more than 10 kg, the LT has been found to be easy to insert, with a ventilation failure rate of 6% (Table 2).32 Recently, Genzwuerker et al compared the LT with a laryngeal mask airway in children aged 2 to 8 years and found a high insertion success rate with both devices.33 The airway leak pressure was approximately 7 cm H₂O (P<0.001) higher with the LT than with the mask airway.33

Insertion failure with the LT has been reported in 5% to 12% of cases, and the need for airway manipulation to maintain an open airway is required in as many as 20% to 35% of cases.14

Cobra Perilaryngeal Airway

The Cobra Perilaryngeal Airway (CobraPLA®; Engineered Medical Systems) consists of a breathing tube with a widened distal head. When the cuff of the CobraPLA is inflated, it seals the distal head from the upper airway, providing positive pressure ventilation (Figure 6,7). The distal Cobra head holds both the soft tissues and the epiglottis away from the airway opening, allowing unimpeded ventilation. The CobraPLA is manufactured in 8 sizes; 4 of them (0.5, 1, 1.5, and 2) are for pediatric patients.

The usefulness of the CobraPLA in pediatric patients was first demonstrated in a series of case reports. The fit and sealing characteristics of CobraPLA (sizes 1.5 and 2) in children undergoing mechanical ventilation were found adequate in 90% of cases at first attempt and in 97.5% at the second attempt.35 In another study, epiglottic down-folding causing nearly complete or complete obstruction was encountered in 77% of patients weighing 10 kg or less who were managed with the CobraPLA.36 In a prospective randomized comparison study of 200 pediatric patients aged 0 to 12 years, the CobraPLA performed as well as the cLMA during anesthesia in infants and children but proved superior with regard to anatomic fit, stability within the

Table 1. Seal Pressure and Gastric Insufflation in 5 Pediatric Studies With LMA-ProSeal

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients, No.</th>
<th>Age, mo</th>
<th>PLMA Size</th>
<th>cLMA Size</th>
<th>PLMA Seal Pressure, cm H₂O</th>
<th>cLMA Seal Pressure, cm H₂O</th>
<th>Gastric Tube Placement, %</th>
<th>Gastric Insufflation, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shimbori et al, 2004</td>
<td>60: 30 PLMA 30 cLMA</td>
<td>12-72</td>
<td>2</td>
<td>2</td>
<td>19</td>
<td>18</td>
<td>90</td>
<td>PLMA-0 cLMA-26.6</td>
</tr>
<tr>
<td>Goldmann et al, 2005</td>
<td>30: 30 PLMA 30 cLMA</td>
<td>18-81</td>
<td>2</td>
<td>2</td>
<td>18.8</td>
<td>15.0</td>
<td>100</td>
<td>PLMA-0 cLMA-6</td>
</tr>
<tr>
<td>Lopez-Gil et al, 2005</td>
<td>240: 120 PLMA 120 cLMA</td>
<td>12-192</td>
<td>2-3</td>
<td>2-3</td>
<td>33</td>
<td>26</td>
<td>100</td>
<td>PLMA-0 cLMA-6</td>
</tr>
<tr>
<td>Lopez-Gil et al, 2005</td>
<td>80 PLMA</td>
<td>20-168</td>
<td>2-3</td>
<td>—</td>
<td>18-40</td>
<td>—</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Goldmann et al, 2006</td>
<td>30: 30 PLMA 30 cLMA</td>
<td>2-30</td>
<td>1.5</td>
<td>1.5</td>
<td>26.7</td>
<td>18.9</td>
<td>96.6</td>
<td>PLMA-0 cLMA-26.6</td>
</tr>
<tr>
<td>Wheeler et al, 2006</td>
<td>120 PLMA</td>
<td>4-156</td>
<td>1.5-3.0</td>
<td>—</td>
<td>16-40</td>
<td>—</td>
<td>100</td>
<td>—</td>
</tr>
</tbody>
</table>

* Crossover study.

cLMA, LMA-Classic; PLMA, LMA-ProSeal
in infants, distal site sampling of end-tidal carbon dioxide with the CobraPLA may be more accurate than the standard measurement from the “Y” piece of the anesthesia circuit.38

**Conclusion**

SGADs are increasingly employed in airway management during anesthesia. The variety of SGADs suitable for children is still limited compared with what is available for adults. Nevertheless, 4 different SGADs are available for the pediatric anesthesiologist to consider in pediatric airway management.

A greater variety of SGADs for children will allow safer positive pressure ventilation, better chances of success in patients with a difficult airway, easier fiberoptic intubation through the SGAD in such patients, and the ready application of new airway gadgets in special surgeries, such as ear, nose, and throat surgery and ophthalmic surgery.

**References**


**Table 2. Seal Pressure and Gastric Insufflation in 3 Pediatric Studies With Laryngeal Tube**

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients, No.</th>
<th>Age, mo</th>
<th>Laryngeal Tube Size</th>
<th>Insertion Success Rate, %</th>
<th>Mean Peak Airway Pressure, cm H2O</th>
<th>Adequate Ventilation Success Rate, %</th>
<th>Gastric Insufflation, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genzwuerker et al, 2005</td>
<td>80</td>
<td>24-144</td>
<td>2-3</td>
<td>96</td>
<td>15.6</td>
<td>96.3</td>
<td>0</td>
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<tr>
<td>Richebé et al, 2005</td>
<td>70</td>
<td>1-180</td>
<td>0-3</td>
<td>100</td>
<td>19.2±4</td>
<td>85.5</td>
<td>11.4</td>
</tr>
<tr>
<td>Bortone et al, 2006</td>
<td>15</td>
<td>3-120</td>
<td>0-3</td>
<td>100</td>
<td>-</td>
<td>73.3</td>
<td>-</td>
</tr>
</tbody>
</table>

**Figure 4. The King Disposable Laryngeal Tube.**

**Figure 5. Laryngeal tube insertion.**


