Laryngeal mask airway and other supraglottic airway devices in paediatric practice

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Since its introduction into paediatric anaesthesia in the late 1980s, the laryngeal mask airway (LMA) has been used increasingly to provide hands-free airway management in paediatric patients. However, several disadvantages of the LMA, notably compressibility of the breathing tube and a low cuff leak pressure, have led to the development of alternative supraglottic airway devices. The present article describes the current uses and limitations of the paediatric LMA and initial experiences with some of the newer supraglottic airways in paediatric patients.

Paediatric LMA

The original paediatric version of the LMA was a scaled-down version of the adult model, which was based on cadaveric studies of the adult larynx. Despite the fact that children’s airways differ anatomically from that of the adult, paediatric sized LMAs perform remarkably well.

Size selection

The size 1 LMA is recommended for use by the manufacturers in neonates and infants up to 5 kg (Table 1). Successful use has also been described in pre-term neonates weighing less than 1 kg. Size 1 and 1.5 LMAs have the highest incidence of perioperative problems, e.g. dislodgement and delayed airway obstruction (although it should be noted that all airway complications are more frequent in the neonate and infant population). In addition, fibreoptic assessment has demonstrated that there is a higher incidence of the epiglottis impinging on the grille of the LMA in small infants. However, there is no correlation between a clinically patent airway and the fibreoptic view, which suggests that when the epiglottis impinges on the grille of the LMA, the remaining space between the epiglottis and laryngeal aperture is usually large enough to allow unobstructed airflow. In the 10–20 kg group, the manufacturer recommends a size 2 LMA, but upsizing to a size 2.5 LMA may provide a better seal with higher oropharyngeal leak pressure. Care must be taken that the LMA is not too large as this may obstruct venous drainage.

The success rate of correct paediatric LMA placement at the first attempt varies greatly. Several techniques of insertion have been described, which reflect the fact that correct placement is not always easy. Examples include:

(i) Using the thumb and index finger to guide the LMA against the hard palate in the midline with cuff completely deflated or partially inflated allowing softer leading edge against posterior pharyngeal wall;
(ii) Using a modified preconfigured styletted LMA;
(iii) Inserting a partially inflated LMA laterally 45° against side of tongue, advancing until resistance is met and then rotating back into midline;
(iv) Inserting the LMA with its cuff facing the palate and turned 180° as entering hypopharynx—similar to inserting an adult Guedel airway.

The latter two techniques are intended to avoid pushing the tongue back into the hypopharynx and causing obstruction to passage. Multiple insertion attempts may increase the incidence of postoperative sore throat.

Cuff filling volumes and pressures

The manufacturer’s state that the maximum recommended cuff volume should ‘never be exceeded’ and inflation pressure should be

**Key points**

Successful placement of any supraglottic airway device depends particularly upon pharyngeal tone, and also on the position of head and neck, shape of the palato-pharyngeal curve, and depth of anaesthesia.

LMA cuff volumes should be adjusted to the minimum needed to achieve airtight seal. The optimal size of LMA must be selected rather than over inflating a small LMA.

The LMA has been shown to be useful to bypass pathology at supraglottic level and facilitate emergency oxygenation and ventilation for the difficult airway.

Complications are more likely when using the LMA in infants and small children, particularly sizes 1 and 1.5.

A learning curve exists for the use of LMAs in paediatric practice; early complications are encountered more frequently than in adult practice.

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<60 cm H\textsubscript{2}O (Table 1). However, \textit{in vitro} testing has shown that when completely deflated paediatric LMA sizes 1–3 were inflated with the maximum recommended volume, all cuff pressures exceeded 70 cm H\textsubscript{2}O.\textsuperscript{2} Furthermore, when the recommended volume was injected from resting cuff volume, the resulting pressures were >120 cm H\textsubscript{2}O, or twice the maximum recommended cuff pressure. As only one-tenth to one-third of the maximum recommended volume was required to achieve a pressure of 60 cm H\textsubscript{2}O in paediatric laryngeal masks from various manufacturers, the authors recommended that paediatric laryngeal mask cuff cuffs should be inflated only with the minimal amount of air necessary to form an effective seal.

Nitrous oxide diffuses into cuffs and will increase cuff pressures. In several adult studies, the incidence of sore throat was significantly reduced if ‘just-seal’ or half of the maximum recommended volume was used.\textsuperscript{3} A hyperinflated cuff may be displaced from the pharynx with loss of seal and be too rigid to adapt to the contours of the pharynx.

Hyperinflation of the LMA cuff, resulting in direct compression of pharyngeal structures, has been implicated in reports of recurrent laryngeal and hypoglossal nerve paralysis in children. This problem will be exacerbated if the LMA is too small and the cuff is overinflated to obtain an effective seal. In theory, a correctly positioned LMA should not be in contact with the area of the hypopharynx in which the vessels and nerves run.

Oropharyngeal leak pressures
Correct placement of the paediatric LMA is assessed by similar methods to those used in adults. Assessing oropharyngeal leak pressure is important in order to quantify the efficacy of the seal. If the oropharyngeal leak pressure is <15 cm H\textsubscript{2}O, the airway seal may be improved by injecting more air into the cuff (providing this has not exceeded the recommended volume and the cuff pressure is <60 cm H\textsubscript{2}O), adjusting the position of the LMA or by replacing it with the next size up. Failing this, use of the LMA may have to be abandoned. Neck flexion will increase oropharyngeal seal pressures compared with the neutral position, but will make the epiglottis cover a larger area of the LMA aperture.\textsuperscript{4}

Positive pressure ventilation
The LMA produces a low pressure seal around the larynx permitting positive pressure ventilation. Inspiratory pressure (P\textsubscript{insp}) should be less than the oropharyngeal leak pressure and 20 cm H\textsubscript{2}O.\textsuperscript{5} When the P\textsubscript{insp} is >20 cm H\textsubscript{2}O, there is a much higher risk of gastric insufflation and regurgitation. The risk is increased if the LMA is malpositioned, a common occurrence with the size 1 and 1.5 LMA, which also require a higher P\textsubscript{insp}. Muscle relaxants may reduce the P\textsubscript{insp} required for effective ventilation by increasing thoracic compliance. Pressure-controlled ventilation has been shown to result in significantly lower P\textsubscript{insp} compared with volumecontrolled ventilation in infants and children; this may improve the distribution of ventilation.

Prolonged periods of positive pressure ventilation with an LMA are not recommended. Clinically significant lingual oedema has been described in an infant ventilated with an LMA for 5 h; certainly, stromal oedema, capillary and epithelial breakdown has been shown in animal studies. Close monitoring of airway integrity, gas leak, and abdominal distension is essential throughout positive pressure ventilation with any LMA.

LMA removal
The manufacturer and inventor’s guidelines for removal of the LMA in adult practice is to administer oxygen continuously, leave the patient undisturbed until protective airway reflexes are restored, deflate the cuff, and simultaneously remove the LMA when the patient can open the mouth on command. Suction should be carried out prior to recovery of the reflexes or after removal of the LMA.

In paediatric practice, the issue is not so clear. ‘Deep’ removal (i.e. when airway reflexes are depressed at a surgical level of anaesthesia) is common practice. Those that favour this practice have found that oxygen desaturation, laryngospasm, coughing, salivation, clenching, and biting occur more frequently after awake removal. However, others have found that the incidence of complications following awake and deep removal to be similar. Even where there is risk of lower airway soiling, some anaesthetists prefer to remove the LMA deep, once blood and secretions have been suctioned.

Although coughing is an effective method of clearing the airway, it also increases oxygen demand and inhibits the ability to take an adequate tidal breath, leading to desaturation, especially in younger children. It also leads to venous congestion and potential for haemorrhage. Differing definitions of ‘awake’ also confuse interpretation and range between ‘the child begins to swallow’ to

### Table 1 LMA selection guidelines—The LMA Company Ltd. \textsuperscript{a}Maximum cuff volume that should never be exceeded. Cuff recommended to be inflated up to 60 cm H\textsubscript{2}O

<table>
<thead>
<tr>
<th>LMA size</th>
<th>Patient size, kg</th>
<th>Maximum cuff-inflation volume (air*), ml</th>
<th>LMA classic (mm)</th>
<th>LMA flexible (mm)</th>
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<tbody>
<tr>
<td></td>
<td>Patient size, kg</td>
<td>Maximum cuff-inflation volume (air*), ml</td>
<td>LMA classic (mm)</td>
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<tr>
<td>1</td>
<td>Upto 5</td>
<td>4</td>
<td>5.3</td>
<td>115</td>
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<tr>
<td>1½</td>
<td>5–10</td>
<td>7</td>
<td>6.1</td>
<td>135</td>
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<tr>
<td>2</td>
<td>10–20</td>
<td>10</td>
<td>7.0</td>
<td>155</td>
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<tr>
<td>2½</td>
<td>20–30</td>
<td>14</td>
<td>8.4</td>
<td>175</td>
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<td>3</td>
<td>30–50</td>
<td>20</td>
<td>10.0</td>
<td>220</td>
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\textsuperscript{a}Maximum cuff volume that should never be exceeded. Cuff recommended to be inflated up to 60 cm H\textsubscript{2}O.
complete expulsion of the LMA by the child. The present authors’ preference is for deep removal if direct personal supervision of recovery is not possible.

Difficult airway management

The LMA has revolutionized difficult airway management. It can bypass obstruction at supraglottic level and allow rescue oxygenation and ventilation, providing that mouth opening is sufficient. The LMA can be inserted completely deflated if space is limited. Head and neck vascular malformations, Pierre-Robin, Treacher-Collins, Goldenhar, cri-du-chat syndromes, and mucopolysaccharidoses are examples of conditions that have been successfully managed with the LMA. This approach avoids excessive airway instrumentation, minimizes the risk of trauma and further airway obstruction by bleeding or oedema, and circumvents the ‘can’t intubate can’t ventilate’ scenario.

The LMA can also act as a conduit to facilitate flexible fibreoptic bronchoscopy for diagnostic or interventional purposes and aid tracheal intubation.6,7 Tracheal intubation via the LMA should be carried out with the aid of a fibreoptic scope because ‘blind’ techniques may fail if the epiglottis is downfolded over the laryngeal aperture, as occurs commonly in children. Tracheal intubation may be accomplished by ‘railroading’ the tracheal tube over the fibreoptic scope, but this leaves the problem of removal of the LMA, so it is probably safer and easier to employ a guide wire technique. This technique has the additional advantage that it can be employed in infants and small children in whom the fibreoptic scope may be too large to pass through the vocal cords.

Apart from facilitating correct placement of the fibreoptic bronchoscope, the LMA provides a passage for continuous administration of oxygen and anaesthetic vapour during endoscopy, thereby avoiding the need for a modified face mask or the insertion of a nasal airway which may cause bleeding.

The intubating LMA is a rigid, anatomically curved, variant of the laryngeal mask designed to facilitate tracheal intubation. It is available in three sizes as a single use or reusable item. The paediatric version (size 3) can be used in children weighing 30–50 kg.

Resuscitation

Newborn resuscitation using the LMA has been reported in three case series comprising 220 neonates.8 The LMA was found to be easy to use with proper positioning at the first attempt. Adequate oxygenation was obtained in a short time (19–60 s). Although resuscitation guidelines do not currently recommend routine use of the LMA for newborn resuscitation, it is recommended when face mask ventilation and tracheal intubation fail. Effective suction of the airway will not be possible, nor will tracheal drug administration. LMA availability and user competence by paediatricians is, however, still low. There are no published series on the routine use of the LMA in older infants and children, although there are numerous case reports on its use for the emergency management of supraglottic airway obstruction in a variety of upper airway abnormalities.

Training issues

One of the key advantages of LMA usage in adult practice is that skill acquisition occurs much more quickly than it does for tracheal intubation. However, this may not be the case in paediatric practice. In one study of trainee anaesthetists, the average complication rate per patient was reduced from 62% to 2% only after 60–75 insertions.9 These data suggest that a greater degree of supervision may be required when trainees are using LMAs in paediatric practice.

Reinforced LMA

The reinforced LMA has a wire-reinforced flexible airway tube, reducing the risk of compression or kinking and allowing the tube to be positioned in a variable manner. Currently it is available in sizes 2 and 2.5. The internal diameter of the reinforced LMA is narrower and the length longer than those of the same sized classic LMA (Table 1) so the work of breathing is greater. Due to its increased flexibility, the reinforced LMA is more difficult to insert than the classic LMA. The reinforced LMA has been used successfully in paediatric practice in a number of ‘shared airway’ situations such as dental surgery and tonsillectomy. Although it is less likely to kink if flexed or compressed against a rigid mouth gag, it is still prone to damage by biting.

Proseal LMA

The Proseal LMA (PLMA) is a new version of the LMA with a modified cuff and an oesophageal drainage tube. The oesophageal drainage tube is connected to the tip of the cuff, which should lie above the oesophagus if correctly seated. This allows gastric contents to be passively channelled up out of the oropharynx and allow functional separation of the respiratory and gastric tract. Gastric insufflation should also be minimized and a nasogastric tube can be reliably passed through the drainage tube into the stomach to allow decompression when necessary. Upper gastrointestinal endoscopy can also be performed through the drainage tube.

The PLMA is available in paediatric sizes 1.5, 2 and 2.5 which, unlike the adult sizes, do not have an additional dorsal cuff (Fig. 1). As a result of this, insertion of the PLMA has been found to be easier in children compared with adults and the bougie-guided technique, which is well described in adults, is not usually required. When compared with the same sized LMA, the paediatric PLMA provided a better oropharyngeal seal, as demonstrated by a higher airway leak pressure.10 This and a reduced tendency to produce gastric insufflation, suggests that positive pressure ventilation (with and without positive end-expiratory pressure) is more likely to be effective with the PLMA than with the classic LMA.
Cobra Perilaryngeal Airway

The Cobra Perilaryngeal Airway (PLA) has a cylindrical cuff designed to seal the hypopharynx and a distal flat ‘cobra head’ with grill bars that sits close to or in direct contact with the glottic opening. The PLA is available in four sizes for paediatric patients and is a single use PVC device. A recent study in infants and children demonstrated that the PLA was in contact with the supraglottic structures in nearly all cases, and this was thought to have precipitated laryngospasm in patients in whom the PLA was left in situ during emergence from anaesthesia. Accordingly, it was recommended that the PLA be removed at a deep plane of anaesthesia. The same study demonstrated that the PLA provides an acceptable airway in infants and children but, as with the LMA, infolding of the epiglottis with obstruction of the glottic view was more common in children. The PLA has also been used successfully as a conduit for fibreoptic bronchoscopy in children.

Please see multiple choice questions 4–7

References


Laryngeal tube

The laryngeal tube (LT) is a supraglottic device that lies along the length of the tongue with a large proximal oropharyngeal cuff which stabilizes the tube and blocks the oro- and nasopharynx. A smaller distal cuff occludes the oesophagus. Both high volume cuffs are inflated with a single port. Two ventilation holes sit between the cuffs. Ring marks near the connector indicate the correct position of the LT when aligned with the incisors. A dual lumen version (LTS II) has a drain-tube orifice which should allow passive and active oesophageal drainage. These reusable silicone versions come in six sizes (0–5) and are suitable for neonates to large adults. Disposable PVC versions (LT-D and LTS-D) are available only for size 3 and above. There are mixed reports of the LT compared with the LMA but not the PLMA.

Single-use laryngeal masks

A variety of manufacturers are producing single-use paediatric-sized laryngeal masks. Most of these are PVC based, as opposed to the silicon of the LMA. The airway tubes may be angled and the cuff bowls have different depths and lack epiglottic bars. The internal diameters are different for the same-sized laryngeal masks, as are the maximum recommended cuff volumes and rates of nitrous oxide diffusion across the cuff walls. The clinical significance of these differences has yet to be evaluated. The recently introduced i-gel is unique in that it does not have an inflatable cuff. Instead, it relies on its anatomically correct shape and softness to provide a laryngeal seal. The currently available size 3 i-gel is suitable for children weighing over 30 kg.

Fig. 1 Proseal airway—sizes 1½, 2, and 2½.