

## PERSONAL PRACTICE

# The laryngeal mask airway: potential applications in neonates

D Trevisanuto, M Micaglio, P Ferrarese, V Zanardo

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The laryngeal mask airway is a safe and reliable airway management device. This review describes the insertion techniques, advantages, limitations, and potential applications of the laryngeal mask airway in neonates.

The ability to maintain a patent airway and provide effective positive pressure ventilation (PPV) is the main objective of neonatal resuscitation and all anaesthesiological procedures.<sup>1–6</sup> This is currently achieved with the use of a face mask or an endotracheal tube. Both of these devices have major limitations from a strictly anatomical point of view and require adequate operator skills. In certain situations, both face mask ventilation and tracheal intubation may prove difficult to establish, especially in patients with congenital abnormalities of the upper airway.<sup>1–7</sup>

In 1981, Archie Brain designed the laryngeal mask airway (LMA) with the aim of producing an airway device that would be more practical than the face mask and less invasive than the tracheal tube. The functional elegance of the LMA is that it forms a low pressure airtight seal against the glottis rather than plugging the pharynx, thus combining ease of insertion and adequate airway patency.<sup>8–9</sup>

## RANGE, SIZES, AND INSERTION TECHNIQUES OF THE LMA

The standard version, made of medical grade silicone, consists of an oval shaped mask with an inflatable outer rim; a wide bore airway tube, which originates from the back plate, is joined at the proximal end with a 15 mm standard connector. The two aperture bars in the middle of the mask lumen, opposite to the distal end of the airway tube, are intended to prevent obstruction of the tube by the epiglottis. The black line running along the shaft helps to detect any subsequent rotation of the mask on the tube axis (fig 1).

Although alternative insertion techniques have been reported,<sup>10</sup> that described by Brain<sup>8</sup> is the one that we favour. This technique mimics the action of swallowing a bolus of food with the index finger pressing the mask against the hard palate, and posterior pharyngeal wall mimics the action of the tongue.

For proper positioning of the LMA in infants, the following steps must be followed.

- (1) Use the correct size of LMA for the patient. Size 1 is suitable for neonates weighing 2.5–5 kg.<sup>11</sup> It has been postulated that a smaller size (0.5) could be useful in preterm newborns. However, there are reports of successful use of size 1 in preterm neonates weighing 0.8–1.5 kg.<sup>12–15</sup>
- (2) Fully deflate the cuff as described in the manual, and lubricate the back of the mask tip (for neonates in the labour ward, lubrication may not be necessary, as oral and pharyngeal secretions may reproduce this function).
- (3) Press (flatten) the tip of the LMA against the hard palate. During this manoeuvre, the operator should grasp the LMA like a pen with the index finger at the junction between the mask and the distal end of the airway tube.
- (4) Gently advance the LMA with one single movement, applying continuous pressure against the palatopharyngeal curvature with the index finger. The vector of the force applied must be directed cranially and not caudally.
- (5) Continue pushing the LMA against the soft palate so that the cuff passes along the posterior pharyngeal wall and the tip locates itself in the hypopharynx—that is, it cannot be pushed further inwards.
- (6) Inflate the mask to the minimum air volume necessary to establish an adequate seal. The maximum recommended volume for each size is rarely required. Do not hold the shaft of the LMA during cuff inflation, as the shaft may be observed to move outwards during cuff inflation allowing correct positioning.
- (7) Connect the proximal end of the airway tube to a device (bag, ventilator) for PPV.
- (8) Correct LMA positioning (fig 2) can be evaluated by observing synchronous movements of the chest and by neck auscultation.

The most common problem encountered during this manoeuvre is obstruction at the base of the tongue. In this case, the mask must be removed and the procedure reviewed in all its phases. Failure to follow the recommended insertion technique strictly may result in malposition of the LMA. Specifically, the epiglottis may be “downfolded”, the mask lumen may not be correctly aligned with the laryngeal inlet, or the cuff may fold inwards or lie too high in the pharynx.<sup>16–18</sup>

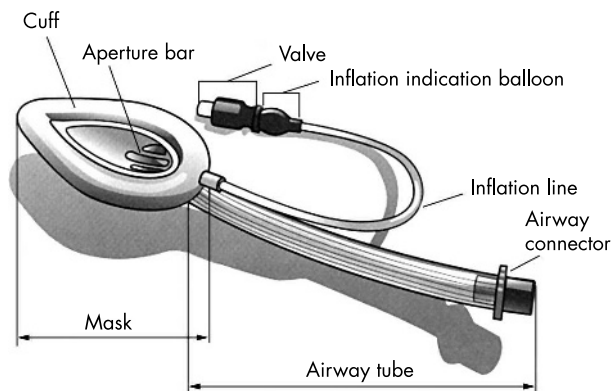
**Abbreviations:** LMA, laryngeal mask airway; PPV, positive pressure ventilation

See end of article for authors' affiliations

Correspondence to:  
Dr Trevisanuto,  
Department of Paediatrics,  
University Hospital of  
Padova, Via Giustiniani, 3,  
35158 Padova, Italy;  
[trevo@pediatria.unipd.it](mailto:trevo@pediatria.unipd.it)

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- (1) Use the correct size of LMA for the patient. Size 1 is suitable for neonates weighing



**Figure 1** Basic laryngeal mask airway design. Reproduced by permission from Dr A I J Brain. *Laryngeal mask instructor manual*, 2000. Courtesy of The Laryngeal Mask Company Limited.

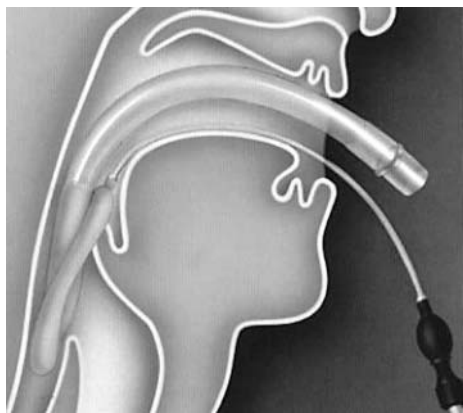
After correct insertion and use, the LMA is left in place, until spontaneously ejected by the patient. The overall incidence of complications after removal of the LMA is about 10–13%, including coughing, laryngospasm, retching, breath holding, vomiting, stridor, desaturation, and excessive salivation.<sup>19</sup> Many of these complications are caused by overinflation of the LMA cuff and inadequate analgesia. A survey of almost 12 000 patients of all ages managed with the LMA over a two year period reported only 18 (0.15%) critical incidents related to airway management, and none required intensive care management.<sup>20</sup>

Since its first commercialisation in the United Kingdom in 1988 and in the United States in 1991, the LMA has gained widespread popularity, initially in adult and then in paediatric patients.<sup>16–19</sup> The American Society of Anaesthesiologists has included the LMA in the algorithm for difficult airway management.<sup>21</sup>

Over the last 10 years, the original prototype, LMA-Classic, which has been used in thousands/millions of patients, has been modified and improved. There are currently five different versions of the LMA, although only the classic model is currently available in a neonatal size.<sup>19 22–24</sup> LMA-ProSeal is shortly to be made available in paediatric sizes and awaits evaluation (A I J Brain, personal communication).

### ADVANTAGES OF THE LMA OVER THE FACE MASK

Bag-mask ventilation is a technique requiring a high and continuous level of training. Incorrect positioning of the face



**Figure 2** Demonstration of correct anatomical positioning of the laryngeal mask airway cuff around laryngeal inlet. Reproduced by permission from Dr A I J Brain. *Laryngeal mask instructor manual*, 2000. Courtesy of The Laryngeal Mask Company Limited.

mask can cause gas leakage around the rim, and the use of excessive pressure may result in injuries to facial soft tissues.<sup>1–6</sup> Laboratory studies have shown that most devices commonly used for PPV with bag and mask may be unable to provide adequate tidal volumes during neonatal resuscitation.<sup>25 26</sup> It has also been shown that the efficacy of bag-mask ventilation depends on operator skill.<sup>27</sup>

The LMA offers many advantages over the face mask.<sup>13 16 28</sup> Its use does not require manipulation of the patient's head, neck, and jaw. It also avoids compression of facial nerves. After positioning, the LMA is quite stable and frees the operator's hands for other important tasks. A better airtight seal is achieved with the LMA, providing more effective PPV.<sup>8 9 29</sup> Its insertion technique, stable positioning, and function is not influenced by anatomical factors<sup>8 9</sup> that may make face mask ventilation difficult, especially in cases of congenital pathologies such as Pierre-Robin and Treacher Collins syndrome.<sup>7 30</sup> Less skill is required to achieve and maintain effective PPV with the LMA compared with the face mask.<sup>29</sup> In a meta-analysis including 52 randomised prospective trials, the advantages of the LMA over the face mask included: easier placement by inexperienced personnel; improved oxygen saturation; less hand fatigue; improved operating conditions during minor paediatric otological surgery.<sup>31</sup>

It has been shown that the incidence of hypoxia is lower in infants with the use of the LMA than with the face mask.<sup>32</sup> However, a study on 49 anaesthetised infants aged less than 1 year reported a higher incidence of complications with the LMA (55.5%) than with the face mask (22.7%).<sup>33</sup> These airway complications occurred more often during the intraoperative phase and emergence (13 out of 15) than during the time of LMA insertion (two out of 15). The most important finding was the incidence of intraoperative airway obstruction. An explanation may be the use of an inappropriate size of LMA.<sup>34</sup> In a prospective survey of LMA use in 1400 infants and children, the overall problem rate was 11.5%, and no major morbidity was associated with the use of the device.<sup>35</sup>

### ADVANTAGES OF THE LMA OVER ENDOTRACHEAL INTUBATION

Laryngoscopy and tracheal intubation are often associated with a number of adverse effects such as local trauma, the stress-response reflex, and malpositioning of the tracheal tube in the oesophagus or in the bronchial tree.<sup>36</sup> These manoeuvres may also cause hypertension and cyanosis of the patient.<sup>37</sup>

The LMA avoids laryngoscopy and all of its related adverse effects; it is also less invasive with respect to the respiratory tract. In comparison with the endotracheal tube, the patient is subjected to a lower haemodynamic stress response during LMA positioning and removal.<sup>37 38</sup> This could theoretically reduce the incidence of cerebral haemorrhage in neonates. In addition, tracheal oedema, which may be caused by tracheal intubation, is avoided by using the LMA.<sup>39</sup>

Its use may be life saving in patients with malformations of the upper airway when tracheal intubation and mask ventilation fail.<sup>3–7 30</sup>

Whereas successful intubation may require more than one attempt, the LMA is easily inserted by non-anaesthetist personnel.<sup>40</sup> LMA insertion does not require the use of neuromuscular blocking agents, further diminishing pharmacological risk in neonates.

In summary, the advantages of the LMA over the tracheal tube include: increased speed and ease of placement by anaesthetists, non-anaesthetist medical personnel, and trained non-medical personnel; improved haemodynamic stability during insertion; minimal increase in intraocular

**Table 1** Evaluation of laryngeal mask airway for neonatal resuscitation in three studies

	Gandini & Brimacombe <sup>15</sup>	Paterson <i>et al</i> <sup>42</sup>	Trevisanuto <i>et al</i> <sup>43</sup>
Study design	Observational, prospective	Observational, prospective	Observational, retrospective
Study period	2 months	5 years	12 months
No of patients	21	104 (29+75)*	95
No of operators	3	1	10
Training (uses/operator)	8	5	10
Gestational age (weeks)	38 (2)	37 (34–42), 32 (28–37)	39 (29–42)
Birth weight (kg)	3.3 (0.6)	3.7 (2.7–4.7), 2.0 (1.2–2.4)	3.1 (0.9–4.9)
Caesarean section (%)	NA	78	45
Apgar score (5 min)	8 (5–10)	9 (7–10), 8 (6–10)	9 (5–10)
Indication for LMA use	Apnoea/HR<100/min	Apnoea/HR<100/min	Apnoea/HR<100/min
Insertion attempts (1/2)	21/0	104/0	95/0
Time for LMA insertion (seconds)	8.6 (1.4)	NA	NA
Duration of LMA placement (seconds)	80 (61) (PPV) 55 (28) (CPAP)	42 (19–408)	74 (32–904)
Efficacy (%)	95	99	99
Time to reach adequate oxygenation (seconds)	<60	19	<30
Late intubation	1 (4.7%)	6 (5.7%)	5 (5.2%)
Audible peak pressure (cm H <sub>2</sub> O)	22 (3)	22 (15–32), 24 (16–36)	NA
Peak pressure obtained (cm H <sub>2</sub> O)	37 (3)	NA	NA
Admission to NICU (%)	15	NA	21
No of complications			
Pneumothorax	1	0	1
Gastric insufflation	0	0	0

Unless otherwise indicated, data are expressed as mean (SD) or median (range).

\*Data are for two groups of patients (low birthweight and term infants respectively).

CPAP, Continuous positive airway pressure; HR, heart rate; LMA, laryngeal mask airway; NA, not available; NICU, neonatal intensive care unit; PPV, positive pressure ventilation.

pressure after insertion; reduced anaesthetic requirements for airway tolerance and lower incidence of coughing during emergence; improved oxygen saturation during emergence; a lower incidence of sore throat in adults.<sup>31</sup>

## DISADVANTAGES OF THE LMA

Potential disadvantages are mainly the following.<sup>13 17 41</sup>

- (1) Gastric insufflation and aspiration. The LMA does not separate the respiratory and alimentary tracts, thus exposing the patient to the risk of aspiration and gastric insufflation during PPV; this fact may limit the efficacy of ventilation. Meticulous attention to the insertion and fixation of the LMA and avoidance of excessive positive pressure may eliminate this, as has been reported in adult studies.<sup>18 20</sup>
- (2) Inadequate alveolar ventilation. The LMA cuff forms a low pressure seal against the larynx. The maximum seal pressure is 20–25 cm H<sub>2</sub>O.<sup>8 9 11</sup> It is known that, during the first breaths at birth, or for some specific pulmonary diseases, pressures required to achieve effective ventilation can be higher, and in these cases the LMA may be ineffective.<sup>1 5 6</sup> The recently introduced LMA-ProSeal, now available for paediatric use, may alleviate this problem.
- (3) Impossibility of suctioning the airway or administering drugs endotracheally. Depressed neonates with meconium aspiration syndrome require tracheal intubation and suctioning.<sup>1 5 6</sup> The latter cannot be performed by means of the LMA, as the passage of suctioning tubes may be partially or totally impaired or cause laryngeal spasm. Administering of drugs through the LMA may also be not possible.<sup>13 17</sup>

## POTENTIAL APPLICATIONS IN NEONATES

### Resuscitation

Official Scientific Societies such as the International Liaison Committee on Resuscitation, American Academy of Pediatrics, and American Heart Association have stated that the LMA may be useful when face mask and endotracheal

intubation fail, although they do not recommend its routine use because of the lack of clear scientific evidence (Class Indeterminate).<sup>5 6</sup>

Studies on the efficacy of ventilation by medical and paramedical personnel in neonatal training models have shown that the LMA allows a patent airway to be obtained in a shorter time than the endotracheal tube. They also show that the incidence of failure is lower with the LMA.<sup>40</sup>

The use of the LMA for neonatal resuscitation has been reported in three case series.<sup>15 42 43</sup> Altogether 220 neonates were included in these three observational studies (table 1). The most important results are as follows.

- (a) Baseline characteristics. The clinical characteristics of the patients were similar among the three studies, even though a subgroup of low birthweight infants was considered in the study of Gandini and Brimacombe.<sup>15</sup> A low number of operators was involved in two of the three studies.<sup>15 42</sup>
- (b) The ease of use of the LMA. In the three studies, training included use of the LMA only a few times (5–10 per operator), and, in all the neonates, the LMA was properly positioned at the first attempt. The time required for LMA insertion reported in the study of Paterson *et al*,<sup>42</sup> was very short (8.6 (1.4) seconds).
- (c) Efficacy of the LMA. An effective PPV was obtained in most of the treated patients (range 95–99%); in particular, adequate oxygenation was obtained in a short time (19–60 seconds) in all the studies.
- (d) Technical aspects. Two studies reported the audible peak pressure (22–24 cm H<sub>2</sub>O),<sup>15 42</sup> and one registered the peak pressure obtained (37 (3) cm H<sub>2</sub>O).<sup>42</sup> These high levels may be explained by the fact that the operators “held the LMA in situ by gently applying a constant pressure on the airway tube”.<sup>42</sup> The mean/median duration of the LMA placement was less than two minutes.<sup>15 42</sup>
- (e) Outcome. Fifteen and twenty one percent of the resuscitated patients were admitted to the neonatal intensive care unit in the studies of Paterson *et al*<sup>42</sup> and

Trevisanuto *et al*<sup>43</sup> respectively.<sup>42-43</sup> Two patients developed pneumothorax which, however, was not clearly linked to the LMA use.<sup>42-43</sup> No study reported gastric insufflation in the treated patients.

In a recent regional survey, the LMA was used in 101 out of 1526 (6.6%) neonates needing PPV at birth.<sup>44</sup> Among them, however, 95 were from a single centre, indicating that there is still little awareness of this treatment modality. In addition, the LMA availability and perceived value were different between anaesthesiologists and paediatricians.<sup>44</sup>

### Neonatal intensive care

Some authors have suggested that the LMA may have a role in some emergency situations. Recently, we studied the feasibility and practicality of administering surfactant using the LMA in eight preterm infants with respiratory distress syndrome. The mean arterial to alveolar oxygen tension ratio significantly increased (50%) from before to three hours after the surfactant therapy.<sup>45</sup> These data indicate that the LMA can be used as a conduit to obtain rapid and non-invasive access to the trachea of preterm infants to administer surfactant. This would encourage the policy of "minimal handling" and could avoid respiratory and extra-respiratory complications such as stress and intraventricular haemorrhage associated with tracheal intubation.

The LMA has also been used in neonates affected by malformations of the upper airway in emergency situations and during laryngoscopy and bronchial endoscopy. In particular, the LMA has proved useful in the intubation manoeuvre in this group of patients.<sup>7 46 47</sup>

Neonates affected by multiple congenital arthrogryposis and micrognathia,<sup>48</sup> and patients with bronchopulmonary dysplasia<sup>14</sup> undergoing cryotherapy for retinopathy of the prematurity have been ventilated with the LMA.

The use of the LMA for long periods, described in adult patients,<sup>49</sup> has been recently reported in a 10 day old neonate with airway obstruction and severe Treacher Collins syndrome.<sup>50</sup> Theoretically, the LMA may have a role in the weaning of patients with good pulmonary compliance.

The efficacy of the LMA has also been reported in a case in which ventilation of a neonate with face mask had failed during helicopter transportation.<sup>51</sup>

### CONCLUSIONS

Since its introduction into clinical practice, the LMA has gained increasing popularity for resuscitation of both adult and paediatric patients. Some authorities have added the use of this device to their guidelines, at least as an aid in cases of difficult airway management or failure of conventional manoeuvres.

There are currently no randomised, controlled trials on the use of the LMA during neonatal resuscitation. Although this device cannot be considered a substitute for the tracheal tube, it could, at least theoretically, play an ancillary role, particularly in situations where assistance to the asphyxiated neonate is offered by paramedical staff or doctors who, because of the rarity of the event, may have difficulty maintaining a high level of skill.<sup>52</sup>

Further studies are necessary to compare the advantages and limits of the LMA with conventional methods currently used in neonatal resuscitation and intensive care.<sup>53</sup>

Features of more recent LMA versions appear to overcome the limits of the classic device, thus producing optimal conditions for use in neonatal patients.

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### Authors' affiliations

**D Trevisanuto, P Ferrarese, V Zanardo**, Department of Paediatrics, University Hospital of Padua, Padua, Italy  
**M Micaglio**, Department of Pharmacology and Anaesthesiology, E Meneghetti Section of Anaesthesiology and Intensive Care, University Hospital of Padua

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