

Safety and efficacy of the laryngeal mask airway

A prospective survey of 1400 children

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Summary

A survey of laryngeal mask airway usage in 1400 infants and children by ten trainee anaesthetists was undertaken to provide information about insertion and complication rates using the standard insertion technique and a limited range of standardised anaesthetic techniques. Placement was successful in 90% (1258/1400) at the first attempt, 8% (112/1400) at the second attempt and 2% (29/1400) required an alternative technique of insertion. One patient vomited during insertion and the procedure was abandoned, but aspiration did not occur. The overall problem rate was 11.5% and there were significantly more problems during induction of anaesthesia ($p < 0.02$). Oxygen saturation decreased below 90% briefly on 23 occasions (1.7%). The incidence of problems was unrelated to the mode of ventilation, or whether isoflurane or total intravenous anaesthesia with propofol was used for maintenance. Most problems came with use of the size 1 laryngeal mask ($p < 0.001$). The subspecialty with the highest problem rate was ear, nose and throat surgery ($p < 0.001$). There was a significant decrease in problems with increasing experience ($p < 0.001$). There was no major morbidity associated with use of the device. We conclude that the laryngeal mask provides a safe and effective form of airway management for infants and children in the hands of supervised anaesthesia trainees both for spontaneous and controlled ventilation using either isoflurane or total intravenous anaesthesia.

Key words

Equipment: airway, laryngeal mask.
Anaesthesia: paediatric.
Complications.

The role of the laryngeal mask airway in children is supported by numerous papers ($n = 20$), abstracts ($n = 33$), and other reports ($n = 88$), but there are only a few large scale studies (> 1000 patients) assessing its safety and efficacy [1–3] and none in which anaesthetic management was standardised. In addition, concerns have been raised that placement may be more difficult in children [4] and it has been suggested that the standard insertion technique recommended by Brain may be suboptimal in infants and children [5, 6].

Recently we conducted a trial assessing the rate of skill acquisition of trainee anaesthetists in 600 children [7]. We have continued to gather data about LMA usage by trainee anaesthetists paediatric anaesthetic practice and would like to present data from a further 1400 LMA uses. The primary aim of this further study was to provide information about insertion and complication rates using the standard recommended insertion technique. A secondary aim was to assess factors leading to an increased risk of problems with LMA usage in infants and children using a limited range of standardised anaesthetic techniques.

Methods

A prospective survey of 1400 consecutive paediatric anaesthetics given by trainee anaesthetists in which the LMA was the planned form of airway management was undertaken at the Maranon University Hospital. Data from a previous prospective study determining skill acquisition were excluded from the analysis [7]. Ethics committee approval was not obtained since all aspects of management were part of routine practice.

Detailed records were kept of all LMA uses by trainee anaesthetists using a predesigned data sheet. All obser-

vations were made by the supervising consultant involved in the case who was trained in the study protocol and problem definitions. The supervising consultants only intervened if the oxygen saturation decreased below 90%. All trainees were individually instructed in LMA usage and the study protocol by one of the authors, who also ensured that the study protocol was adhered to by constant education and supervision. The decision to use the LMA in each patient was made by the supervising consultant, as was the mode of its use. These decisions were based on the requirements of individual patients and the preferred choice of the supervising consultant within the confines of the study protocol. The LMA was not used in patients at risk of aspiration or for intra-abdominal, thoracic, major head and neck or vascular surgery, or patients who were ASA grade 4 or 5.

Data obtained included age, sex, ASA grade, anaesthetic technique, type and duration of surgery, LMA size and the number of attempts required for successful placement. The cumulative experience of the trainee with the LMA in paediatric practice and predefined problems occurring during induction, maintenance and recovery were also documented. Induction was defined as the start of injection of propofol until the beginning of surgery. Maintenance was the time during which surgery was being performed. Recovery was the time from completion of surgery until the LMA was removed and the patient left the recovery unit. Problems were defined as follows: upper airway reflex stimulation—coughing/gagging/retching/laryngospasm, bronchospasm; difficulty with placement—requiring use of alternative technique; airway obstruction (air entry poor in absence of upper airway reflex activation); aspiration/regurgitation/vomiting; trauma (blood identified on the LMA

Table 1. Problems occurring during insertion, maintenance and recovery.

| | Insertion | Maintenance | Recovery | Total |
|-----------------------------------|-----------|-------------|----------|-------|
| Airway obstruction | 24 | 15 | 16 | 55 |
| Upper airway reflex stimulation* | 14 | | 24 | 38 |
| Difficulty with placement | 30 | | | 30 |
| Aspiration/regurgitation/vomiting | 1 | | | 1 |
| Trauma (blood identified) | 3 | | 8 | 11 |
| Displacement of LMA | 3 | 21 | | 24 |
| Gastric distension | | 2 | | 2 |
| Persistent oro-pharyngeal leaks | | 4 | | 4 |
| Total | 75 (45%) | 42 (25%) | 48 (29%) | 165 |
| SpO ₂ < 90% | 11 | 12 | | 23 |

*coughing/gagging/retching/laryngospasm/bronchospasm.

surface); displacement of the LMA from the pharynx; gastric distension (visible increase in abdominal girth with air entry into the stomach detected using a stethoscope); persistent leaks (persistent peak airway pressure with leak < 8 cmH₂O after insertion of larger size). One problem was allowed for each phase of anaesthesia and, when several occurred, the most serious was documented. The maximum number of problems per patient was three. If the minimum oxygen saturation was less than 90% at any time during the anaesthetic this was also documented.

Anaesthetic management was standardised according to the following protocol. Monitoring was applied preinduction and included an ECG, pulse oximeter, capnograph and noninvasive blood pressure monitor [8]. The size of LMA was selected according to manufacturer's instructions and lubricated on its posterior surface with water-based KY jelly [9]. All patients were unpremedicated, pre-oxygenated and anaesthesia was induced with propofol 3 mg.kg⁻¹ given over 1 min. Additional boluses of propofol were given as required. The LMA was inserted using the standard recommended technique with the cuff fully deflated [9] when the jaw was relaxed. Rolled gauze swabs were used as bite guards and the LMA fixed according to manufacturer's instructions. The LMA was then connected to the anaesthetic breathing system and successful placement was judged by observation of chest wall movement, auscultation of the chest and neck and capnography. Two attempts with the standard technique were allowed followed by use of an alternative insertion technique if a third attempt was needed—either the Guedel [10] or laryngoscope technique [11]. Between attempts patients' lungs were ventilated with the face mask. Anaesthesia was maintained with either 1) propofol 10 mg.kg⁻¹.h⁻¹ reducing after 15 min to 5 mg.kg⁻¹.h⁻¹ or 2) isoflurane 0.5–1.0%. A non-depolarising muscle relaxant, either vecuronium (0.1 mg.kg⁻¹) or atracurium (0.6 mg.kg⁻¹), was given following LMA insertion and additional boluses were given as clinically indicated following successful LMA insertion in patients undergoing intermittent positive pressure ventilation (IPPV). The choice of maintenance agent and ventilation mode was made according to clinical requirements. At the end of the procedure any residual neuromuscular blockade was reversed with neostigmine 0.05 mg.kg⁻¹ and atropine 0.02 mg.kg⁻¹ and the anaesthetic agents discontinued.

Table 2. Problems according to the duration of the procedure.

| | Duration (min) | | | Total |
|--------------------|----------------|-------|-----|-------|
| | 1–30 | 31–60 | >60 | |
| Number of patients | 572 | 617 | 211 | 1400 |
| Maintenance | 15 | 22 | 5 | 42 |
| Recovery | 18 | 22 | 8 | 48 |
| Overall | 33 | 44 | 13 | 90 |

Patients were given 100% oxygen during emergence and were not moved or disturbed. The LMA was removed in the operating theatre when the patient was fully awake and supplementary oxygen given via a Hudson face mask. Statistical evaluation was with the Chi-squared test. Significance was taken as $p < 0.05$.

Results

A total of ten anaesthetists participated in the study and had a range of experience from 0 to more than 250 uses in children. All patients were ASA grade 1–3 and the male to female ratio was 1.9:1. The mean (range) for age and weight was 6.25 (0–18) years and 28.9 (2–70) kg respectively. The mean (range) duration of procedures was 40 (5–260) min. Four hundred and forty eight (32%) patients breathed spontaneously and 952 (68%) received IPPV. Six hundred and ninety one (49%) patients received isoflurane and 709 (51%) propofol for maintenance. The overall problem rate was 11.5%: 5% during induction, 3% during maintenance and 3.5% during recovery (Table 1). There was a significant increase in problems at induction compared with either the maintenance (Chi-squared = 9.71, $p < 0.01$) or the recovery (Chi-squared = 6.2, $p < 0.02$) phase of anaesthesia. Oxygen saturation decreased below 90% on 23 occasions (1.7%); 0.8% of patients during insertion, 0.9% during maintenance and in no patient during recovery. The commonest three problems were airway obstruction, difficulty with placement and upper airway reflex activation. Placement was successful in 90% (1258/1400) at the first attempt, 8% (112/1400) at the second attempt and 2% (29/1400) required an alternative technique of insertion. One patient vomited during insertion of the LMA and the procedure was abandoned. There was no evidence of aspiration. In no instance was the LMA changed to a tracheal tube or face mask and suxamethonium was never required. Gastric distension was

Table 3. Problems according to the agent used for maintenance.

| | Propofol | Isoflurane | Total |
|--------------------|----------|------------|-------|
| Number of patients | 691 | 709 | 1400 |
| Maintenance | 19 | 23 | 42 |
| Recovery | 24 | 24 | 48 |
| Overall | 43 | 47 | 90 |

Table 4. Problems according to LMA size.

| LMA size | Patients | Problems | Problems (%) |
|----------|----------|----------|--------------|
| 1 | 245 | 55 | 22.4 |
| 2 | 372 | 23 | 6.2 |
| 2.5 | 304 | 21 | 6.7 |
| 3 | 265 | 45 | 16.9 |
| 4 | 214 | 21 | 9.8 |
| Total | 1400 | 165 | |

detected during maintenance on two occasions and was managed uneventfully with a nasogastric tube.

The problem rate was unaffected by the duration of the procedure (Table 2) or the agent chosen for maintenance (Table 3). The problem rate was similar for spontaneous ventilation (13%) and IPPV (11%). Most problems came with use of the size 1 LMA (Chi-squared = 30, $p < 0.001$) and size 3 LMA (Chi-squared = 8.9, $p < 0.01$) (Table 4). The subspecialties with the highest problem rate was ENT, which included 18 adenoidectomies (Chi-squared = 34, $p < 0.001$), and urology (Chi-squared = 19, $p < 0.001$) (Table 5).

A learning curve could not be constructed because of the uneven distribution of LMA experience, but there was a significant reduction in problems with increasing experience. The problem rate during the first 40 uses was 22% (123/560) and 5% (42/840) subsequently (Chi-squared = 93, $p < 0.001$).

Discussion

The correct path followed by the LMA during insertion closely parallels the process of deglutition and in principle relies on sliding the deflated cuff along the palato-pharyngeal curve whilst avoiding anterior pharyngeal structures [12]. Successful placement depends on the geometric relationship between the palatopharyngeal curve and the cuff, the shape and tone of the pharynx, the position of the head and neck, the extent to which anterior structures obliterate the curve, the efficacy of digital manipulation, the anatomical fit of the device once in the pharynx, the depth of anaesthesia and/or the degree of muscle relaxation. Although there are significant differences between the infant and adult larynx, anatomical studies have shown that the pharyngeal sack is essentially similar [13]. This partially explains why a scaled down version of the adult device works effectively in children. Wilson has suggested that the standard technique is probably superior in children [14], but this has not been demonstrated in controlled trials. First time insertion rates in children vary between 67 and 90% depending on the level of experience [15-17]. We have shown that the success rate for the standard technique is 90% at the first attempt and 98% within two attempts. We had no failures within three attempts when an alternative technique of insertion was used for the third attempt. Some authors have suggested that the semi-inflated technique [6] or use of the Guedel airway [5, 18] may be superior in children. O'Neill *et al.*, for instance, compared the semi-inflated versus full deflated technique and found the semi-inflated technique to be superior [6]. However, the success rate for the standard technique was 85.5% suggesting that the standard technique was not correctly applied. Oxygen saturation decreased below 90% in only 1.7% of children in the current study. This compares favourably with data obtained from two large scale studies of adult patients. Van Damme reported that 1.5% (77/5000) of patients briefly registered an oxygen saturation of <90%, and that the LMA was subsequently abandoned in 0.16% (8/5000) [19]. Brimacombe reported that 0.6% (10/1500) of adult patients registered an oxygen saturation <90% with an overall failure rate of 0.4% [20]. Watcha *et al.* showed that there were fewer hypoxic episodes with the LMA compared with the facemask for myringotomy [21]. Braun and Fritz reported its use in 3000 children with a 0.1% incidence of serious complications [1]. Moylan and Luce reported minimal incidents occurring in 145 children undergoing 2500 radiotherapy procedures [2]. Other general large scale studies have included substantial numbers of children with no apparent increase in problem rates compared with adults [3, 22].

It has been suggested that the complication rate increases with decreasing LMA size [15] and our study suggests that there is a higher complication rate when using the size 1 LMA. This may be related to the increased anaesthetic requirement of children [23, 24] or to a smaller margin of error for accurate placement. Much of it is probably related to the well known difficulties of anaesthetising children under the age of one [25]. One study has shown that the complication rates occurring between the size 1 and size 2 LMA were similar [26]. It is difficult to explain why use of the size 3 LMA had a significantly high complication rate. Although the LMA was used in only 23 patients undergoing ENT procedures there was a significantly high complication rate. This may be related to the higher incidence of airway problems associated with ENT procedures or more likely the lack of availability of the reinforced LMA which is more suitable for the shared airway. It may also be related to a lack of experience of the LMA for ENT surgery in which special considerations are required for skill acquisition [27]. It is difficult to explain why patients undergoing urological procedures had a higher problem rate. A detailed analysis of the learning curve was not possible since the extent of experience with the device was highly variable, but the majority of problems occurred during the first 40 uses, confirming the findings of our previous study [7].

There have been no controlled studies comparing the problems in adults and children, but a large prospective survey failed to show an increased incidence of problems compared with adults [3]. Some authors consider that experience with the LMA in adults is essential before attempting its use in children because difficulties are encountered more commonly [4]. The results from the current study suggest that the incidence of problems and desaturation events is similar to those in adults.

In summary, we have shown that the LMA provides a safe and effective form of airway management in children in the hands of supervised anaesthesia trainees. This study also demonstrates that high success rates are achievable using the standard insertion technique in children. The incidence of problems appears unrelated to the mode of ventilation, or whether isoflurane or total intravenous anaesthesia is used for maintenance. Our data also suggest that there is a higher incidence of problems with the size 1 LMA and confirms that there is a reduction in problems with increasing experience.

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The laryngeal mask airway for thyroid and parathyroid surgery

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Summary

The rôle of the laryngeal mask airway for thyroid and parathyroid surgery was studied in 97 consecutive patients. In 50% the technique combined electrical stimulation of the recurrent laryngeal nerve with visualisation of vocal cord movement via a fiberoptic bronchoscope. Stimulation was required in 10% to assist in identifying recurrent laryngeal nerve position during difficult surgical dissection. In the remaining 40% stimulation was used to confirm nerve integrity and for teaching purposes. Tracheal intubation was required for seven patients but in only two of these was intubation unplanned. The incidence of postoperative recurrent laryngeal nerve dysfunction was zero. These data suggest that the technique offers a safe alternative in airway management and may provide advantages in terms of preservation of recurrent laryngeal nerve function.

Key words

Equipment; airway, laryngeal mask.
Surgery; thyroidectomy, parathyroidectomy.
Nerve; recurrent laryngeal.

Thyroid surgery is responsible for a significant number of postoperative complications and in 1989 in the UK 4% of the general surgical settlements by the Medical Defence Union involved thyroidectomy. All included injury to the recurrent laryngeal nerve [1]. The frequency of injury to this nerve should, ideally, be less than 4%, although this figure

may be greater in cancer operations and re-explorations and will depend upon the experience of the surgeon [2]. As a result of anatomical variations and pathological distortion, identification of the nerve during surgery may not always be straightforward.

Anaesthesia for thyroid surgery has traditionally