The Use of the Laryngeal Mask Airway in Pediatric Anesthesia

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Laryngeal mask airway (LMA) insertion was tried in 120 pediatric cases, from 2 months to 12 years of age. Initial indications for LMA were the same as for a face mask, except for two additional conditions; anticipation of difficulty with intubation and difficulty in management by a face mask. Size 2 LMA was used in the vast majority of cases. The insertion was successful on the first trial in 108 cases. More than one trial was necessary in 9 cases but only 3 cases required more than 3 trials. Insertion could not be completed in 3 cases. The relationship between the depth of LMA at the front teeth and age could be roughly described by "depth = 10 cm + 0.3 × Age".

LMA was found to provide a better and more secure airway than the face mask without direct tracheal intervention. Heart rate did not increase with LMA insertion. It is easy to use and can be used in place of the face mask, but complications such as stomach air inflation due to too vigorous manual ventilation, slight pharyngeal injury, and airway obstruction due to kinking of LMA can occur. These complications can be avoided and must be kept in mind during it's use.

LMA itself can be used to obtain a patent airway where an endotracheal airway is difficult to obtain. LMA-aided tracheal intubation can be extremely useful in obtaining endotracheal airways. Non-blind techniques can be used with LMA to increase safety. LMA is a very useful addition to pediatric anesthesia practice. (Key words: pediatric, complication, laryngeal mask airway, intubation)

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The laryngeal mask airway (LMA), originally described by Brain was introduced into our pediatric anesthesia practice in late 1989 and immediately accepted as one of our routine tools. Although its simplicity in application is certainly attractive, certain precautions should be taken for pediatric use. This is a report of our initial experience with LMA in pediatric anesthesia.

Methods

A prospective study of pediatric LMA usage was performed over a period of 6 months. The protocol was approved by the institutional Clinical Research Comittee. All the anesthetists involved were given brief verbal instruction and a specially made LMA manual (2 pages) before usage.

Initial indications for LMA were the same as for a face mask, except for two additional conditions; anticipation of difficulty with intubation and difficulty in management by a face mask. All the patients received atropine (0.02 $mg{\cdot}kg^{-1}$) im and diazepam (0.7 $mg{\cdot}kg^{-1}$) po for preanesthetic medication. Anesthesia was induced with halothane in nitrous oxide and oxygen. Routine anesthesia monitors including the precordial stethoscope, BP sphygmomanometer, temperature probe, ECG, pulse oximeter and capnometer

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Table 1. LMA size used and body weight

Size	Cases used	Body weight (kg)
1	10	5.3–9.3
2	99	6.5–26.2
3	11	28.5–56.4

were attached. In certain cases a halometer was used.

When a sufficient depth of anesthesia was achieved and an iv catheter was inserted, the child's head (not shoulder) was set on the pillow in the usual neck flexed but head extended pediatric intubation posture. After a few breaths of 100% oxygen, a fully deflated and lubricated LMA was inserted with the right hand while the left wrist held the forehead to keep the head extended and the fingers of the left hand held the mouth open without the use of laryngoscope.

A fully deflated LMA was first pushed in gently along the hard palate until slight resistance was felt, then it was pushed further steadily in one motion until another resistance was felt. A cuff was then inflated with the appropriate (determined mainly by the size of LMA) amount of air. The anesthesia circuit with capnometer was attached and the correct position of LMA was initially confirmed by observing chest movement and manually squeezing an anesthesia bag. The depth of the LMA was noted and the LMA was fixed with adhesive tape. Anesthesia was maintained with halothane, nitrous oxide and oxygen without the use of muscle relaxants. A critical pressure which caused an audible air leak around LMA was measured at the beginning and a gentle manual assist was given every two to three breaths below this pressure throughout the procedure. The head was kept in an extended position to prevent the LMA from kinking. Abdominal distension was continuously monitored.

After completion of the surgical procedure, anesthesia was deepened briefly with halothane and oxygen, and the oropharynx and stomach were aspirated. The LMA was then deflated and removed. The patient was kept in a lateral position or had an oropharyngeal airway inserted while being spontaneously awakened in the recovery room with supplemental oxygen.

The number of LMA insertions and ease of insertion was noted and judged by the anesthetists themselves. More than 3 trials were judged "difficult". If the anesthetist could not complete LMA insertion, regardless of the number of trials, or did not feel comfortable with keeping LMA, the attempt was abandoned. Post anesthetic complications were reviewed from nursing records of the recovery room.

Because of the difficulty in observing and comparing hemodynamic response to intubation and LMA insertion in routine clinical cases, the effect of LMA insertion and tracheal intubation on heart rate was compared in 10 separate uncomplicated cases (ages 1 to 5 years) who were scheduled to have anesthesia and intubation. All of these patients received atropine im (0.02 $mg \cdot kg^{-1}$) and diazepam po (0.7 $mg \cdot kg^{-1}$) for preanesthetic medication. Anesthesia was induced with pentothal iv (5 $mg \cdot kg^{-1}$) and vecuronium bromide (0.1 $mg \cdot kg^{-1}$) while ventilation was controlled with 100% oxygen by mask for 90 sec. LMA was inserted, kept in for 30 sec and removed. The patient was hand-ventilated with 100% oxygen for another 30 sec and tracheal intubation was performed in the usual manner. ECG heart rate information was stored in a digital data aquisition system (YHP-78354A) and analyzed. Paired t test was used for the statistical analysis.

In 7 other cases, LMA was used to aid difficult intubation. After LMA insertion, a small bore (2.4 mm outer diameter) flexible fiberbronchoscope was threaded through an endotracheal tube before being inserted into LMA to guide the endotracheal tube into the trachea. The maximum size of endotracheal tube (Portex Blue Line) which fits into size 1 LMA is 3.5 mmID, size 2 LMA is 5.5 mmID, and size 3 LMA is cuffed 6.5 mmID.

Results

LMA insertion was tried in 120 selected cases during the 6 month study period. Cases ranged in age from 2 months to 12

Table 2. Success rate of LMA insertion (120 cases)

One trial	108 cases
Two or more	9 cases
(more than 3 trials	3 cases)
Incomplete	3 cases

Table 3. Complications encountered (120 cases)

Slight pharyngeal bleeding	2 cases
Abdominal distension	4 cases
Kinking of LMA	1 case
Laryngospasm	3 cases

years, body weight from 5.3 kg to 56.4 kg, and height from 55 cm to 151 cm. Duration of LMA use ranged from 7 min to 160 min. Size 2 LMA was used in the vast majority, 99 cases out of 120 (table 1). The insertion was successful on the first trial in 108 cases but more than one trial was necessary in 9 cases. Only 3 cases required more than 3 trials and were judged difficult. LMA insertion could not be completed in 3 cases. A junior resident was involved in all these 3 cases and the insertion was given up after 1 or 2 trials just because the anesthetist involved did not feel comfortable. The insertion of LMA was not considered impossible but no attempt was made to take over these cases by the senior anesthetist because of the nature of this study (table 2).

Complications encountered are summarized in table 3. None of our cases developed laryngospasms during insertion but they were observed in 3 cases at the beginning of the series by one anesthetist who attempted to remove the LMA when the level of anesthesia was not deep enough. Slight pharyngeal bleeding due to tonsil injury was noted in 2 cases but required no special treatment. Airway obstruction, confirmed by a capnometer was noted in a case (5 years old) with myringotomy immediately following head position change. This situation was rectified by extending the patient's head and was thought to be caused by the kinking of LMA (see figure 1). Excessive abdominal distension probably due to overly vigorous manual ventilation was observed in 4 cases but in no case was the use of LMA discontinued in the middle of the procedure. Records by recovery room nurses showed no increased incidence of pharyngeal discomfort or delay in swallowing.

Figure 2 shows the relationship between the depth of LMA at the front teeth and age in 78 patients of 10 years and less. A rule of thumb of "depth = 10 cm + 0.3 × Age" can be derived from this data.

Audible air leaks around LMA occurred at a critical pressure ranging from 8 to over 30 cmH_2O, with a median of 18 cmH_2O. In general inflation pressure of less than 15 cmH_2O is recommended to avoid stomach air inflation.

Figure 3 shows a comparison of the effect of intubation and LMA insertion on heart rate in 10 cases. Base line heart rate (an average over 15 sec) prior to LMA insertion or intubation and highest heart rate during and 30 sec after the procedure were compared. A statistically significant ($P < 0.002$) increase in heart rate (from 143.5 ± 12.0 to 154.7 ± 12.0) was observed following endotracheal intubation but not following LMA insertion (from 141.9 ± 13.7 to 144.4 ± 12.1).

Endotracheal intubation aided by LMA and a flexible fiberbronchoscope was tried in 7 cases because of the possibility of having difficulty in intubation (table 4). Although intubation was possible or seemed possible in all of these cases, the maintenance of adequate ventilation with LMA alone was not possible in 2 cases with subglottic stenosis due to the required high ventilation pressure. Smaller endotracheal tubes were used to manage their airway.

Discussion

Reports on the use of LMA in adults and children have focused mainly on its usefulness in special situations and Caucasian populations, but this is the first report of its routine use in a non-caucasian pediatric anesthesia practice[1–10]. It is well known that

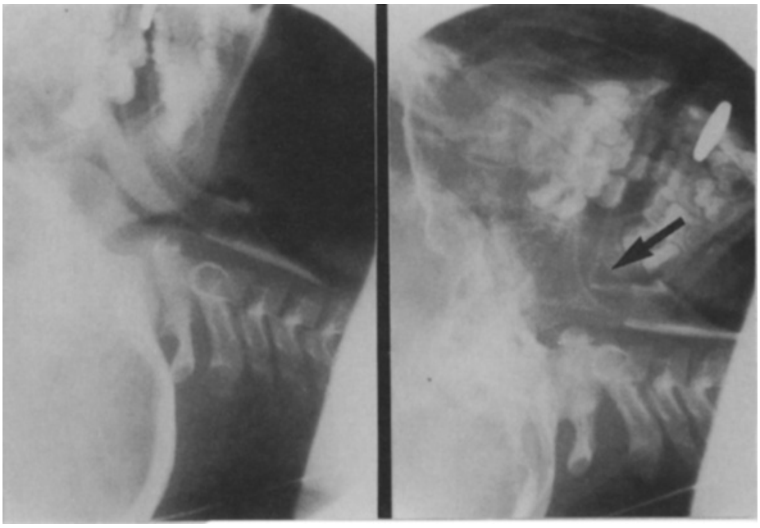

Fig. 1. Lateral x-ray view of 5-year old boy who has a size 2 LMA in place.

Left: LMA is patent and in a good place.

Right: LMA kinking caused by head flexion (arrow) is evident.

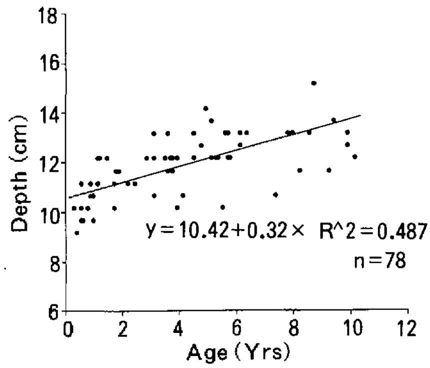

Fig. 2. The relationship between the depth of LMA and age.

The relationship between the depth of LMA at the front teeth and age is plotted. The formula can be simplified as "depth = 10 cm + 0.3 × Age".

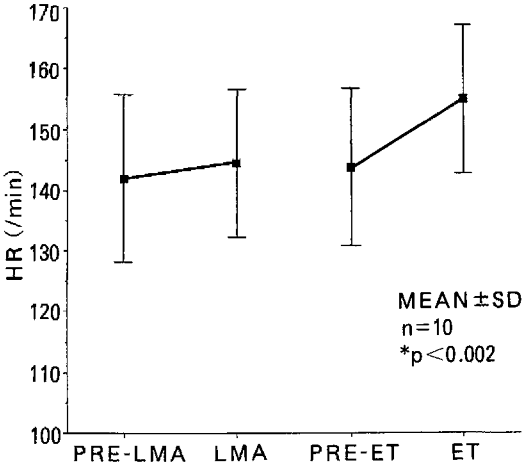

Fig. 3. Effect of LMA and ET (endotracheal tube) insertion on heart rate.

A statistically significant ($P < 0.002$) increase in heart rate was observed following endotracheal intubation but not following LMA insertion.

PRE-LMA: Base line heart rate prior to LMA insertion.

LMA: Highest heart rate during and 30 sec after LMA insertion.

PRE-ET: Base line heart rate prior to ET insertion.

ET: Highest heart rate during and 30 sec after ET insertion.

some anesthesia masks made for Caucasians do not fit Orientals well, however the dimensions of LMA developed by Brain functioned well on Japanese children. Size 2 LMA was found to be almost universal LMA in the pediatric age group.

Blind insertion of LMA was, in general, very easy as is claimed by Brain and others[5,10]. However in certain pediatric in-

Table 4. Endotracheal intubation aided by LMA

Pierre Robin syndrome	2 cases
Russell-Silver syndrome	1 case
Jaw joint conracture (also had subglottic stenosis)	2 cases
Intubation difficulties	2 cases

stances where extreme tonsillar hypertrophy or unusual oral anatomy are anticipated, LMA insertion should be performed with the aid of a laryngoscope to avoid untoward trauma[11,12].

Since LMA does not provide a completely sealed airway like an endotracheal tube, air inflation into the stomach is a possible complication. This is especially true in pediatric patients because of a shorter esophageal length and lower critical pressure[13]. Stomach air inflation may trigger regurgitation and the resulting abdominal distension may decrease lung volume. We found it important to keep ventilation pressure below audible leak pressure and to observe abdominal distension during LMA anesthesia. Stomach air can be emptied by inserting a well-lubricated gastric tube nasally without deflating the LMA cuff. The routine use of LMA on paralyzed pediatric patients or prone patients is not advisable because of the possibility of higher stomach air inflation and safety.

One possibly serious complication we encountered was airway obstruction due to kinking of the LMA. This can be easily detected by basic anesthesia monitoring including use of a capnometer and can be rectified by extending the head. Avoiding head flexion during LMA use and awareness of the possibility of kinking is important. Improvements in the design and material are advisable in the future.

Laryngospasms were experienced in 3 cases during emergence from anesthesia in the early stages of our trial. Since then we have made it a custom to remove LMA at a sufficiently deep level of anesthesia, only after adequate oropharyngeal suction. Many have claimed that LMA can be left in place until protective reflexes return, however since direct laryngeal irritation cannot be totally eliminated during the vulnerable awakening period, such precautions may be necessary in pediatric patients[10,14].

We found minimal changes in heart rate with LMA insertion and removal compared to endotracheal tube insertion, making LMA useful in cases where the pressor response is best avoided[15]. LMA should also be useful in cases of repeated anesthesia because there is less likelihood of causing laryngotracheal injuries[10]. All these characteristics may be shared with the use of a face mask, however LMA offers a definite role in the maintenance of a patent airway and in aiding tracheal intubation for cases with intubation difficulties[4,6]. LMA is also extremely useful for keeping an adequate depth of anesthesia during flexible laryngoscopy or bronchoscopy under spontaneous ventilation. A flexible bronchoscope can be used in certain cases for the confirmation of correct position and patency of LMA.

In conclusion, LMA was found to provide a better and more secure airway than the face mask without causing direct tracheal intervention. It is easy to use and can be used in place of the face mask, but complications such as stomach air inflation, pharyngeal injury, and airway obstruction due to kinking of LMA can occur. These complications cannot simply be avoided by improving insertion technique and must be kept in mind during pediatric use. LMA itself can be used to obtain a patent airway where an endotracheal airway is difficult to obtain. In addition LMA-aided tracheal intubation can be extremely useful in obtaining endotracheal airways. Non-blind techniques can be used with LMA to increase safety. LMA is a very useful addition to pediatric anesthesia practice.

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