# The Laryngeal Mask Airway in Infants and Children

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The laryngeal mask airway (LMA) is recommended when positive pressure ventilation (PPV) is necessary; however, studies about LMA insertion, its position, and its effect on controlled ventilation in paralyzed pediatric patients are lacking. This study compared the effectiveness of various LMA sizes and their performance during PPV in 158 children weighing <30 kg and ranging in age from 1 to 98 months.

After paralysis, an LMA of the recommended size (1, 1.5, 2, or 2.5) was inserted and connected to a volume ventilator. Fiberoptic bronchoscopy (FOB) was performed and graded as follows: grade 1, larynx only seen; grade 2, larynx and epiglottis posterior surface seen; grade 3, larynx and epiglottis tip or anterior surface seen (visual obstruction of epiglottis to larynx <50%); grade 4, epiglottis down-folded and its anterior surface seen (visual obstruction of epiglottis to larynx (>50%); grade 5, epiglottis down-folded and larynx cannot be seen directly. Inspiratory and expiratory tidal volumes and airway pressure were measured and the fraction of leakage was calculated. In 79 children, LMA was used for airway maintenance throughout surgery.

Successful LMA placement was achieved at the first attempt in 153 patients; 2 placements were successful at the second attempt. Three failures were due to gastric insufflation. Continuous leakage occurred in 7 cases. Cuff volumes used were 80% (16 of 155), 90% (16 of 155), or 100% (123 of 155) of the maximum recommended volumes.

The peak inspiratory pressure varied with the LMA size; PIP of smaller LMAs was higher than that of the larger LMAs. The fraction of leakage of the 1, 1.5, 2, and 2.5 size LMAs were, respectively, 12.0 ± 3.4, 7.8 ± 3.6, 11.4 ± 7.6, and 7.2 ± 2.4%. In smaller LMAs, the cuff more often enclosed the epiglottis than in larger LMAs.

In the 79 patients in whom an LMA was used for airway maintenance throughout the procedure, 9 had continuous increases in end-tidal $CO_2$ partial pressure. The FOB grade was 3 in 6 patients, 4 in 2 patients, and 5 in a single patient. The FOB findings at the end of surgery did not change when compared with the initial findings. The number of patients experiencing complications decreased as LMA size increased.

Use of the LMA in smaller children results in more airway obstruction, higher ventilatory pressures, larger inspiratory leak, and more complications than in older children. Because of the occurrence of partial airway obstruction by the epiglottis while using the LMA in young children, the risk/benefit ratio should be carefully evaluated before using an LMA with paralysis and PPV in this age group.

**Comment: The laryngeal mask airway (LMA) is often used in children. We have on several occasions now successfully used it emergently even in small premature infants in the "cannot intubate" scenario. This study evaluated the ease, efficacy, and safety of the LMA in a group of young children and infants. They studied insertion and a period of positive pressure ventilation. They specifically studied paralyzed infants. Also, with the addition of the size 1.5 LMA, they wished to evaluate the full ranges of sizes currently available. The following sizes were used: #1 for <5kg, #1.5 for 5 to 10 kg, #2 for 10 to 20 kg, and #2.5 for 20 to 30 kg. LMAs were placed after muscle relaxation. Success was judged clinically. In addition, LMA position was determined by fiberoptic bronchoscopy and air leak determined by a pneumotachometer (inspiratory vs. expiratory tidal volumes).**

**Unfortunately, and for reasons that are not explained, only a subset of patients had the LMA throughout the surgery. More often than not (though supposedly randomized), LMAs were replaced by endotracheal tubes after the initial part of the study, limiting the denominator for analysis during positive pressure ventilation. Also, children with intraabdominal surgery were excluded. In our practice, these probably account for the largest number of neonates to whom we would administer relaxants. Muscle relaxants are not part of our routine anesthetic for most neonates and young children.**

**The authors are to be congratulated in that the LMA was correctly inserted 97% of the time on the first attempt, with only 3/158 failures after three attempts (owing to gastric distension). There was a continuous gas leak in 7/158. Most children (123/155) required 100% of the maximum recommended cuff volume. The remainder required 80 to 90%.**

**The authors report some changes in peak inspiratory pressures during surgery, but it seems that this would be patient-related, not LMA-related, in the absence of completely terrible placement significantly occluding the airway. Here are some data and the authors' interpretation. Leak volumes (as percent of inspiratory volume) of the LMAs were #1, 12.0; #1.5, 7.8; #2, 11.4; #2.5, 7.2. Their conclusion was that the leak "of LMA 1 was higher than those of LMA 1.5 and LMA 2.5…and LMA 2 was higher than LMA 2.5." My conclusion is that there is no effect whatsoever of size, as there is no progression as size increases.**

**Generally speaking, the larger LMAs were associated with fewer complications (laryngospasm, vomiting, or increasing $PETCO_2$), but the incidence of all of these was low, and quite frankly may have had nothing at all to do with the size of the baby or the LMA size.**

**Fiberoptic positioning scores were generally better in the larger infants, but this did not appear to significantly impede adequate ventilation. Overall, to my reading, LMAs can be used quite successfully in paralyzed infants and young children, but certainly not all the time. However, because of the incidence of partial airway obstruction by the epiglottis while using the LMA in these smallest children, the authors caution, "The risk-benefit ratio should be carefully evaluated." A rule to live by.**

**Victor C. Baum, M.D.**

## Bacterial Colonization of Endotracheal Tubes in Intubated Neonates

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In vivo bacterial colonization profiles were obtained at different sites in the neonatal airway in an effort to more effectively characterize one potential element of chondritis in a case series in which cultures were obtained from calculated segments of 33 endotracheal tubes right after extubation. This enabled sampling at specific levels of the airway corresponding to the trachea, the subglottis, and the oropharynx. Data were collected on gender, race, duration of intubation, use of antibiotic therapy, comorbidities, gestational age at birth and extubation, crown-rump length, weight, radiographic distance from tube tip to carina, and culture results. The study was conducted in the newborn intensive care unit of a tertiary care medical center and included 29 neonates who were intubated for longer than 24 hr (range, 24 hr to 15 days). The principal outcome measures were bacterial and fungal cultures obtained from three endotracheal tube segments for each extubation. A statistically significant difference was noted in colonization rates between patients who were intubated for less than 4 days and those who were intubated for longer periods. No marked difference was seen in the bacterial proliferation profile among the three sites. Data show that bacterial colonization of an indwelling object in the neonatal airway increases with the duration of intubation. In addition, 4 days seem to represent a critical period in the formation of such colonization (possibly as a biofilm). These bacteria may contribute to the chondritis that is known to precede the development of subglottic stenosis. Further studies are warranted to suggest ways to interrupt this process and reduce the incidence of airway injury.

**Comment: I grew up learning to care for airways in the neonatal intensive care unit where meticulous aseptic technique is maintained during airway manipulations, such as suctioning. Since I have been doing anesthesia, I have been impressed that many anesthesiologists, or at least my residents, must think that hair tonic is antibacterial, at least by the way they carelessly leave the endotracheal tube lying in patients' hair while they get ready to intubate. So I've always had a certain interest in airway bacteriology. I thought this article would be informative and helpful. Not completely.**

**This study looked at bacterial growth on endotracheal tubes that had been placed in neonates. In particular, the investigators were interested in the colonization in the subglottic area. Subglottic stenosis is a well-recognized complication of prolonged endotracheal intubation in young children. The thought was that the initiating event is pressure necrosis at the subglottis, with a subsequent bacterial chondritis leading eventually to stenosis. The authors carefully stained and cultured three pieces of endotracheal tube following withdrawal, corresponding to the pharynx, the subglottis, and the distal trachea.**

**Here are the results: Approximately 50% of samples had bacterial growth, but there was no difference among the three sites in incidence or organisms of colonization. A variety of organisms was cultured; most only a single time, with the exception being Staphylococcus epidermidis, which was the most frequent organism cultured. Generally, the culture results of the subglottic area were similar to the distal tracheal segment. Of some interest, the incidence of multiple organisms cultured from one patient was very uncommon. The use of antibiotics did not statistically affect the results. In children who had a positive blood culture, that organism was not cultured from the endotracheal tube.**

**Perhaps the most important finding was that the period for the development of endotracheal tube colo-**

**nization in this study was four days, although there was a significant incidence of colonization even at less than four days (39% at less than four days, 80% at greater than four days). Bottom line of the study: no unique microorganisms reside in the neonatal subglottis (agreeing with previous studies by others using bronchoscopy), and longer intubation results in a higher incidence of colonization (hands of all those surprised by this?) My bottom line: I am not convinced of their technique, because all endotracheal tubes had to be withdrawn through the pharynx during removal. Most importantly, none of their patients (presumably) developed subglottic stenosis, and they examined no children for evidence of subglottic inflammation or chondritis. Finally, let me leave you with their concluding sentence: "Further, the role of endotracheal tube bacterial colonization in the development of subglottic stenosis remains unproven at present."**

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## Dose-Response Relationship and Infusion Requirement of Cisatracurium Besylate in Infants and Children During Nitrous Oxide-Narcotic Anesthesia

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The effect on the dose-response relationship and infusion requirements of cisatracurium besylate was ascertained in pediatric infants (mean age, 0.7 yr; range, 0.3–1.0 yr), and 32 children (mean age, 4.9 yr; range, 3.1–9.6 yr) who were studied during thiopentone-nitrous oxide-oxygen-narcotic anesthesia. Potency was determined with a single-dose (20, 26, 33, or 40 μg/kg) technique. Assessment was made of neuromuscular block by monitoring the electromyographic response of the adductor pollicis to supramaximal train-of-four stimulation of the ulnar nerve at 2 Hz. Least-squares linear regression analysis of the log-probit transformation of dose and maximal response yielded effective median dose ($ED_{50}$) and 95% effective dose ($ED_{95}$) values for infants (29 ± 3 μg/kg and 43 ± 9 μg/kg, respectively) that were similar to those for children (29 ± 2 μg/kg and 47 ± 7 μg/kg, respectively). The mean infusion rate needed to maintain 90% to 99% neuromuscular block during the first hour in infants (1.9 ± 0.4 μg/kg/min; range, 1.3–2.5 μg/kg/min) was similar to that in children (2.0 ± 0.5 μg/kg/min; range, 1.3–2.9 μg/kg/min. It was concluded that cisatracurium is equally potent in infants and children when the dose is referenced to body weight during balanced anesthesia.

**Comment: Differential effects of the various nondepolarizing neuromuscular blockers in infants, children, and adults have been reported. This article reports on a study of the $ED_{50}$ and $ED_{95}$ doses, as well as the infusion rate required to maintain neuromuscular blockade, in a group of infants (aged 4 mo–1 yr.) and children (3–10 yr. of age). All infants and children were anesthetized with nitrous oxide, thiopentone, and fentanyl, and no volatile agents were used. This was a well-done study.**

**The results are straightforward. Both infants and children had the same $ED_{50}$ (29 μg/kg) and $ED_{95}$ (43 and 47 μg/kg). There was no effect of age. Interestingly, this relationship did not hold if data were normalized for body surface area rather than weight. In the latter case, the effective doses for the infants were less than those for children. The doses in this study approximate those reported by others in adults (mg/kg). Infusion rates to maintain neuromuscular blockade were similar in the two groups at 1.9 and 2.0 μg/kg/min, with a range of 1.3 to 2.9 μg/kg/min.**

**Two classes of children are specifically not reported on in this study. The first is neonates. The youngest child here was four months old. Previous studies by others of additional neuromuscular blockers have shown consistency of dosing down to two months of age, but neonates and premature infants are not reported. Also specifically excluded are children who are receiving volatile anesthetics. As an example, the result reported here (the $ED_{50}$) is approximately 25% higher than that reported in an earlier study on the dose required in children during halothane anesthesia.**

**Changes in physiologic pharmacokinetic parameters in the first year of life include increasing effective plasma concentration and decreased volume of distribution (when normalized for weight but not body surface area). Presumably, based on these current data, any increases in the effective plasma concentration of cisatracurium in children are offset by an opposing effect on the volume of distribution. Interestingly, the mechanism of "metabolism", namely Hoffman degradation, a physicochemical degradation that would presumably be insensitive to age, is not discussed.**

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# Undiagnosed Cardiomyopathy in a Neonate: Significance of Low Oxygen Saturation During Anaesthesia

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A case study is presented of a 7-day-old full-term infant with bilateral congenital cataracts who underwent surgical removal of both cataracts 2 days apart. Problems with oxygen saturation before and after the first anesthetic led to further investigation, which revealed a nonobstructive hypertrophic cardiomyopathy. The significance and possible causes of low oxygen saturation in a previously healthy neonate during anesthesia are discussed, as are the probable diagnosis of Sengers syndrome and the evaluation of asymptomatic infants with cardiac pathology.

**Comment: To be honest, there's not much to this article. Briefly, the authors report on a single term infant who developed mild intraoperative hypoxemia (oxygen saturations 85–92%). Upon further evaluation, the infant was found to have hypertrophic cardiomyopathy. Unfortunately, this article lacks many things, including:**

**1) Preoperative and postoperative oxygen saturations;**

**2) A diagnosis ( they suggest a mitochondrial disease, but do not confirm it);**

**3) A pathophysiologic mechanism for the right to left shunt. They correctly exclude a ductal level shunt and ascribe the shunt to the foramen ovale, but neither confirm that (by Dopper or contrast echo) or give a reasonable pathophysiologic explanation. Typically, in cases of left ventricular diastolic dysfunction such as this, left atrial pressures are elevated, resulting in closure of the patent foramen, or in a left to right atrial shunt, if anything. Although hypertrophic cardiomyopathy can uncommonly involve the right ventricle in neonates, this child only had involvement of the left ventricle (by their echo);**

**4) A reasonable discussion of the myocardial depressant effects of anesthetics. Although they avoided Pentothal during this child's second surgery, and they discuss the relative safety in the (normal) neonate, it apparently did not occur to them that sevoflurane might be problematic in the patient (child or adult) with a severely myopathic ventricle;**

**5) A good differential diagnosis. Diseases presenting with neonatal hypertrophic cardiomyopathy are presented as a table, but it does not include what is probably the most common associated disorder, namely infants of diabetic mothers. Of course, we do not know if this child's mother was diabetic.**

**Overall, there is little here save for the authors' notation that there is no reliable means of clinically detecting (mild to moderate) cardiac pathology in apparently healthy neonates.**

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