British Journal of Anaesthesia 98 (6): 802–5 (2007)
doi:10.1093/bja/aem070 Advance Access publication April 7, 2007

BJA

Removal of the laryngeal tube in children: anaesthetized compared with awake

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Background. Laryngeal tube (LT) is a useful airway device in children, but there is no objective evidence that removal of LT in awake state is better than in anaesthetized state. So, we compared the incidence of respiratory adverse events after the removal of LT, either under anaesthesia or on awakening.

Methods. Seventy healthy children between 1 and 12 yr of age were enrolled in this study. Anaesthesia was induced and maintained with sevoflurane. After induction of anaesthesia, patients were randomized into two groups: removal of LT in anaesthetized state (Group A: 2% sevoflurane) and in awake state (Group B). During and within 1 min of the removal of LT, airway complications such as upper airway obstruction, cough, vomiting, teeth clenching, hypersalivation, desaturation <90%, and laryngospasm were recorded.

Results. Cough (37.1 *vs* 2.9%), hypersalivation (28.6 *vs* 5.7%), desaturation (20 *vs* 0%), and LT dislocation during emergence relating to the patient's movement (26.5 *vs* 0%) occurred more frequently in Group B ($P<0.05$). Upper airway obstruction occurred more frequently (68.6 *vs* 31.4%) in Group A, and it was easily resolved by chin or jaw lifting.

Conclusion. LT removal in anaesthetized state reduced cough, hypersalivation, and prevented tube displacement and hypoxia. Upper airway obstruction in the anaesthetized state should be predicted and managed with chin or jaw lifting.

Br J Anaesth 2007; **98**: 802–5

Keywords: anaesthesia, paediatric; airway, laryngeal tube, removal

Accepted for publication: February 16, 2007

Laryngeal tube (LT, VBM Medizintechnik, Sulz, Germany) is a recently developed extraglottic airway device that provides patent airway rapidly in children with low complication rate.[1 2] LT consists of an airway tube with a small cuff attached at the tip (distal cuff) and a large balloon cuff at the middle part of the tube (proximal cuff). The small cuff at the distal tip is positioned in the hypopharynx, which seals the oesopharyngeal inlet, and the proximal cuff provides a seal in the upper pharynx. Recent reports have proved the benefits of LT with a higher airway leak pressure,[3] lower postoperative laryngeal complications,[4] in an emergency situation,[5] or with swollen tonsils[6] compared with laryngeal mask airway (LMA®†).

However, there are still several unresolved issues with regards to its optimal use. For example, timing of removal of LT in children should be considered in anaesthetic practice. Therefore, it is a question of whether or not the removal of LT in deep anaesthesia is better than in an awake state. In addition, there is no objective evidence that suggests that removal of LT in a conventional manner is better than that in deep anaesthesia.

The main aim of this study was to compare the incidence of adverse respiratory events during or immediately after removal of LT when the child was anaesthetized or awake.

Method

Institutional Ethics and Research Clinical Investigation Committee approved the study protocol and informed consent was obtained from the parent or guardian of each participant. We studied 70 children between 1 and 12 yr of age, ASA I, undergoing elective minor urologic, orthopaedic, or plastic surgery, in whom the use of LT was indicated. Patients with abnormal airway, gastroesophageal

†LMA® is the property of Intavent Ltd.

reflux, reactive airway disease, or a history of a respiratory tract infection in the preceding 6 weeks were excluded.

The patients were not premedicated. In the operating theatre, monitoring consisted of ECG, noninvasive blood pressure, Sp_{O_2}, end-tidal CO_2, and inspired and expired sevoflurane concentration (Solar 8000 M, GE, Milwaukee, WI, USA). Anaesthesia was induced using an inhalation technique with sevoflurane 8% in oxygen via a paediatric circle system. After loss of consciousness, sevoflurane was adjusted to 2–3% according to the vital signs and was maintained for several minutes until adequate jaw relaxation was attained. LT was inserted by the method described in the manufacturer's instruction manual. LT size was determined by the manufacturer's guidelines, size 1 for <12 kg and 2 for 12–25 kg. For children weighing 25–35 kg, or who were 125–155 cm tall, 2.5 of LT suction (LTS, VBM Medizintechnik) was used. We used the smallest LTS instead of LT, because there was a considerable discrepancy between LT size 2 and 3. Basic structures of LT and LTS were the same. Balloon pressure of LT was adjusted between 60 and 70 cm H_2O during anaesthesia by checking intermittently. After induction, anaesthesia was maintained with sevoflurane in approximately 50% oxygen in air, and the concentration of sevoflurane was adjusted in response to clinical signs. Spontaneous ventilation was maintained in most patients, and simultaneous intermittent mandatory ventilation rate and pressure support were adjusted according to the patient's weight and end-tidal CO_2. Neither regional anaesthetic techniques nor local anaesthetics were used after induction. We did not use additional opioids after surgery.

Patients were randomized into two groups of 35 each. In Group A, LT was removed in anaesthetized state, and in Group B, it was removed in awake state. At the end of surgery, the oropharynx was gently suctioned and LT was removed using study group-specific LT removal guideline. In Group A, anaesthesia was maintained with sevoflurane 2% for at least >10 min, and the LT was removed after ensuring adequate spontaneous ventilation. In Group B, sevoflurane was turned off and LT was removed when end-tidal sevoflurane concentration was <0.5% and the patient satisfied the criteria for being awake; adequate ventilation (symmetric chest expansion without retraction or tidal volume >6 ml kg^{-1} on the monitor), facial grimace, spontaneous eye opening, and purposeful arm movement.[7] After LT was removed, a different anaesthesiologist who did not remove the LT recorded all the study variables including upper airway obstruction in need of jaw assistance, cough, vomiting, clenched teeth, hyper-salivation, desaturation (Sp_{O_2} <90%), laryngospasm immediately after or within 1 min after LT removal, or tube dislocation. If the LT was dislocated because of the patient's movement and ventilation became difficult, the LT was removed and facemask ventilation was applied.

All patients received a facemask with 100% oxygen after removal of LT and were transferred to the post-anaesthesia care unit (PACU) when they had room air, and maintained oxygen saturation of >94% without signs of airway obstruction without jaw support. At PACU, pain was controlled with nonsteroidal analgesics and emergence delirium was controlled with i.v. nalbuphine 0.1 mg kg^{-1}.

Patient characteristics and LT insertion times were analysed using Mann–Whitney test. We compared the airway complications between the groups with Fisher's exact test of Chi-square analysis, where SPSS package (ver 12.0, SPSS Inc., Chicago, IL, USA) was used for statistical analysis. $P<0.05$ was considered statistically significant.

Results

The age, sex distribution, height, and weight of patients in both groups were comparable (Table 1). The number of patients with airway complications in each group is shown in Table 2. Cough, hypersalivation, and desaturation occurred significantly more frequently in awake children (Group B) than those who were anaesthetized (Group A). Hasty removal before fully awakening because of LT dislocation with difficulties in ventilation developed in nine patients in Group B, but none in Group A ($P<0.01$). LT dislocation caused desaturation in three patients and laryngospasm in four. However, in Group A, upper airway obstruction occurred more frequently, although it was easily resolved by chin lift or jaw lift. Vomiting developed in five patients and laryngospasm developed in five patients in Group B and none in Group A; there was no statistical significance. Patients with laryngospasm were treated with application of sustained positive pressure with 100% oxygen, and no further treatment was required.

The characteristics of complications in size 1 and 2 LT or 2.5 LTS were different. In Group B, we used size 1 LT in three patients. Two of these patients presented complications: only cough in one patient, and cough, hypoxia, laryngospasm, and movement in the other patient. In Group A, four patients required size 1 LT. Three of these patients showed complications: upper airway obstruction in one patient and upper airway obstruction and biting simultaneously in the other two patients. However, in size

Table 1 Patient characteristics. Values are median [range]. Group A, removal of LT in anaesthetized state; Group B, removal of LT in conscious state

	Group A	Group B
Age (yr)	4 [1–12]	3 [1–12]
Gender (M/F)	26/9	25/10
Height (cm)	105.2 [75.6–150]	98.3 [66.6–142.6]
Weight (kg)	16.8 [9–40.5]	17.8 [9.6–34.4]
LT insertion time (min)	77 [40–130]	74.5 [30–125]

Table 2 Number of patients and per cent incidence of airway complications during and after the removal of the LT. Group A, removal of LT in anaesthetized state; Group B, removal of LT in conscious state. $^*P<0.05$ between groups, $^{**}P<0.01$ between groups

	Group A		Group B	
	Number of patients	Per cent incidence	Number of patients	Per cent incidence
Upper airway obstruction	24*	68.6	11	31.4
Cough	1	2.9	13**	37.1
Vomiting	0	0	5	14.3
Biting	4	11.4	11	31.4
Hypersalivation	2	5.7	10*	28.6
Desaturation	0	0	7*	20
Laryngospasm	0	0	5	14.3
Tube dislocation	0	0	9**	26.5

2 LT or 2.5 LTS, upper airway obstruction was the most common complication regardless of the removal techniques.

Discussion

In this study, we found that LT removal in deep anaesthesia (2 vol% of sevoflurane) presented significantly fewer respiratory complications than LT removal in awake state in children.

Studies have shown the removal of LMA or extubation in anaesthetized state to be associated with lesser complications than in awake state.[8–10] Along with these studies, our results suggest that young children may respond to laryngeal stimulation more frequently and severely than adults; sometimes it is difficult to distinguish between lightly anaesthetized state and awake state because of agitation during emergence. However, other studies showed no difference in complications after removal of LMA or tracheal tube between anaesthetized or awake state.[11–14] This difference might have been because of the timing of recording the complications, characteristics of operations, use of opioids, or anaesthetic depth in the anaesthetized group.

From the results of our study, excitability and movement during emergence in paediatric patients should be considered during LT removal. During emergence, excitability and movement might cause LT migration that would result in dislocation of LT leading to loss of airway patency, followed by desaturation or laryngospasm as shown in this study. LT requires frequent re-adjustment of its position[15] and may be easily displaced during the patient's movement; possibly LMA is more stable in this regard. It would be a different point to consider from those in previous studies regarding the removal of LMA that could maintain airway patency despite patient's movement.

There was an interesting difference in complications between the groups regarding LT size. Previous study reported that size 1 presented less effective ventilation and more complications than size 2 or 3.[2] Richebe and colleagues[2] explained these differences on the basis of differences in anatomy. LT size was chosen by body weight, and body weight was related with age. As the respiratory system developed with age, the respiratory response would be different to the same stimulus.[16] Therefore, respiratory complications would be different according to LT size, as has been shown by our results.

We used sevoflurane 2% in anaesthetized state. In a preliminary study, we found that EC_{95} of sevoflurane in LMA removal was 1.96%; therefore, this concentration was anticipated to give adequate conditions for LT removal in anaesthetized state. This concentration of sevoflurane can reduce airway irritability, but may result in upper airway obstruction. Although upper airway obstruction in this study was well controlled by slight chin or jaw lifting and did not lead to oxygen desaturation lasting more than a few minutes, the possibility of this condition should be taken into consideration when the removal of LT in anaesthetized state is considered. Moreover, fast return of airway reflex is critical in operations such as dental surgery that irritate upper airway or increase secretion, therefore these operations are an exception.[17 18]

There are some limitations in this study. In the awake group, there were several patients who showed LT dislocation followed by inadequate ventilation, so LT was removed not satisfying all of the awake criteria. We classified these patients into the awake group, and therefore the conditions for the removal of LT would be heterogeneous in this group. However, we were sure that the presence of LT during emergence gave patients discomfort that caused movement and dislocation of LT. Another limitation was bias by the observer. As deep or awake patients could be clearly distinguished from one another, the observers could not be blinded to the technique of removal of LT. However, we did our best to remove this bias by recording the respiratory complications by an observer different from the anaesthesiologist removing the LT.

In conclusion, the removal of LT in anaesthetized state reduced cough, hypersalivation and prevented tube displacement and hypoxia. Upper airway obstruction after the removal of LT in the anaesthetized state should be predicted, and managed with jaw or chin lifting.

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