Minimum Alveolar Concentration of Sevoflurane for Laryngeal Mask Airway Removal in Children; the Effect of Caudal Anesthesia

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Objective: There has been no study evaluating sevoflurane minimum alveolar concentration for the laryngeal mask airway (LMA) removal (MAC-LMA removal) in children whom caudal anesthesia was performed. The aim of this study is to determine the MAC-LMA removal of sevoflurane in children caudal anesthesia was performed.
Materials and Methods: Fifty-six children undergoing elective urologic surgery for <2 h under general anesthesia were studied. After sevoflurane induction, children were randomized to receive LMA insertion with or without caudal anesthesia. The LMA was removed at the end of surgery when the end-tidal sevoflurane concentration had reduced to a predetermined level with 0.2% as a step size by an anesthesiologist blinded to group allocation. When LMA removal was accomplished without coughing, teeth clenching, gross purposeful movement, breath holding or laryngospasm, during or within 1 min after removal, it was considered successful.
Results: The MAC-LMA removal of sevoflurane was 1.60% in the group with caudal anesthesia and 1.72% in the group without caudal anesthesia.
Conclusion: Caudal anesthesia did not reduce the MAC-LMA removal of sevoflurane in children aged 2 mo and 8 yr. Further studies are necessary to establish whether caudal block effect the removal of LMA in infant and children during sevoflurane anesthesia.
Key Words: Sevoflurane, Laryngeal Mask Airway, Caudal Anesthesia

Çocuklarda Laringeal Maskenin Çıkarılması İçin Gerekli Sevofluran Minimum Alveoler Konsantrasyonuna Kaudal Anestezinin Etkisi

Amaç: Kaudal anestezi uygulanan çocuklarda laringeal maske (LMA) çıkarılması için gerekli sevofluran minimum alveolar konsantrasyonunu (MAK) değerlendiren bir çalışma bulunmamaktadır. Çalışmanın amacı kaudal anestezi uygulanmış çocuklarda LMA çıkarılması için gerekli sevofluran MAK'ını belirlemektir.
Materyal ve Metod: Genel anestezi ile ürolojik cerrahiye giden (<2 saat) 56 çocuk çalışmaya alındı. Sevofluran indüksiyonundan sonra LMA yerleştirilen çocuklar kaudal anestezi yapılan ve yapılmayan grup olarak ayrıldı. Cerrahi işlemin sonunda LMA; grupları bilmeyen bir anestezist tarafından, end-tidal sevofluran konsantrasyonu önceden belirlenen % 0.2'lik konsantrasyonlarla azaltılarak çıkartıldı. LMA çıkarılması sırasında veya çıkarıldıktan sonra 1 dakika içinde, öksürük, diş sıkma, amaçlı hareket, nefes tutma veya laringospazm eşlik etmiyorsa LMA çıkarılması başarılı olarak kabul edildi.
Bulgular: Çocuklarda LMA çıkarılması için gerekli sevofluran MAK'ı kaudal anestezi uygulanan grupta %1.60, kaudal anestezi uygulanmayan grupta %1.72 idi.
Sonuç: İki ay-8 yaş arası çocuklarda kaudal anestezi; LMA çıkarılması için gerekli sevofluran MAK'ını azaltmadı. Kaudal bloğun infant ve çocuklarda LMA çıkarılması için gerekli sevofluran MAK'ına etkisini araştıran ileri çalışmalara ihtiyaç olduğu kanaatine varıldı.
Anahtar Kelimeler: Sevofluran, Laringeal Maske, Kaudal Anestezi

INTRODUCTION

The laryngeal mask airway (LMA) has been used to secure the airway in pediatric patients with or without regional anesthesia[1,2] Removal of the LMA can be performed while patients are deeply anesthetized or awake. In children, removal of a LMA is preferred when the patient is in deeply anesthetized state in certain clinical situations, such as asthma, plastic surgery operations, as it reduces the incidence of airway complications.[3,4] This technique carries disadvantage of remaining suppressed active laryngeal reflexes due to deep anesthesia in which upper airway obstruction may occur.[5] Sevoflurane is suitable for LMA removal during deep anesthesia, since recovery from sevoflurane allows a brisk return of airway reflexes[6] There is evidence that neuroaxial anesthesia potentiate sedative drugs in humans and significantly decrease the minimum alveolar concentration (MAC) of sevoflurane, suggesting that neural blockade may itself have sedative properties[7,8] A previous study by Xiao and colleagues has outlined caudal anesthesia

reduces the MAC-LMA removal of enflurane[9] There has been no study evaluating of MAC-LMA removal of sevoflurane in children whom caudal anesthesia was performed. The aim of this study is to determine MAC-LMA removal of sevoflurane in children caudal anesthesia was performed in double blind, prospective manner.

MATERIALS AND METHODS

Fifty-six children undergoing elective urologic surgery (hydrocelectomy, orchiopexy, or circumcision) for < 2 h under general anesthesia were included in this prospective, randomized study. The study was approved by the Ethics Committee of Inonu University. Written informed consent was obtained from the parent of the child. The children were between 2 mo and 8 yr of age; and ASA Status was I. Children with an abnormal airway, gastroesophageal reflux, reactive airway disease, a history of upper respiratory tract infection in the previous six weeks, or skin infection of the caudal area were excluded from the study.

Children were randomized, using a systematic random-sample technique, to one of two treatment groups to receive LMA with or without caudal anesthesia after induction of general anesthesia. The children were evaluated by an independent anesthesiologist blinded to group allocation.

The children were not premedicated. Upon arrival at the operating room, the children were monitored with electrocardiogram, pulse oximetry, capnography, inhaled and exhaled end-tidal sevoflurane concentrations, and non-invasive arterial blood pressure. Heart rate and blood pressure were recorded within five minutes intervals during the procedure. Anesthesia was induced using an inhaled technique with 5% volume of sevoflurane in oxygen and 60% nitrous oxide via a pediatric circle system. After insertion of an intravenous (i.v.) line, normal saline 0.9%, 4 ml/kg, was administered to correct volume deficit from fasting and for maintenance. After loss of consciousness, sevoflurane was adjusted to 2-3% and the same concentration of sevoflurane was maintained for several minutes until adequate jaw relaxation was attained for LMA insertion. The LMA size was determined by the manufacturer's guidelines, which suggests size 1.5 for 5-10 kg, size 2 for 10-20 kg, size 2.5 for 20-30 kg. Anesthesia was maintained with sevoflurane in approximately 60% nitrous oxide in oxygen with a total inflow of 2 L/min, and the concentration of sevoflurane was adjusted in response to clinical signs. After successful LMA insertion the child was turned in the left lateral position and a caudal injection of bupivacaine 0.25%, 1 mL kg^{-1} was administered in the LMA with caudal anesthesia group (Caudal group, n = 28), using a short B bevel, 22-gauge needle by the attending anesthesiologist. The adequacy of the caudal block was confirmed by the absence of any increase in the heart rate or blood pressure following skin incision. No caudal anesthesia was performed in the LMA without caudal anesthesia group (Non-caudal group, n = 28). All children were breathed mechanically with simultaneous intermittent mandatory ventilation. Ventilation rate were adjusted according to the patient's weight and end-tidal carbon-dioxide concentration (ranging 35-45 mmHg during the procedure). Nitrous oxide was discontinued before the end of surgery. At the end of surgery, the predetermined exhaled end-tidal sevoflurane concentration was maintained for at least 15 min to allow equilibrium between the alveolar and brain concentrations and LMA was removed.

The test concentration of sevoflurane for each patient was determined using a modified Dixon's up-and-down method[10] starting with 2% with 0.2% step size for both groups. The rationale for sevoflurane concentration tested in the first patient of the Non-caudal group was based on the previous report[11] At the time of LMA removal, no residual nitrous oxide >3% was detected in the end-tidal sample. The LMA was removed with cuff inflated, and jaw lifted. A facemask was routinely applied with 100% oxygen for 5 min for each child. If breath holding persisted for more than 30 sec or if tidal volumes were <6 mL/kg, ventilation was manually assisted. Unsuccessful LMA removal was defined as the development of coughing, clenching, or gross purposeful movement during or within 1 min of LMA removal, development of breath holding, laryngospasm, or desaturation to SpO_2 <90%. After such an unsuccessful removal, the sevoflurane concentration was increased by 0.2% in the next patient. Conversely if LMA removal was successful, the sevoflurane concentration was decreased by 0.2% in the subsequent patient. The result of failure or success was recorded for each patient. The children were transferred to the recovery room when they were full awake. At the recovery room, postoperative pain was controlled with nonsteroidal analgesics and emergence delirium was controlled with i.v. fentanyl.

Statistics

Demographic data were collected and presented as mean ± SD. Normality for continued variables in groups was determined by the Shapiro Wilk test. The variables showed normal distribution ($p>0.05$). The Dixon's up-and-down method needs six pairs of failure-success for statistical analysis, and sample size came from the basis of Dixon's method. The up-and-down sequences were analyzed with probit test, which enabled us to derive the sevoflurane concentration for LMA removal, with 95% confidence limits of the mean. Unpaired-t test was used for comparison of

variables between the studied groups. Categorical variables were analyzed using the chi square test or Fisher's exact test. A value of $p < 0.05$ was considered statistically significant.

RESULTS

Demographic data and the duration of the surgery and the LMA insertion are presented in Table 1.

Demographic and hemodynamic variables did not differ significantly between the two groups. No patient required supplemental analgesia. Failure to place the LMA on the first attempt occurred in two patients in caudal group and in one patient in non-caudal group. The sequences of successful and unsuccessful LMA removal are shown in Figures 1 and 2.

The required concentration of sevoflurane was 1.60% (95% confidence limits, 1.26%-1.95%) in Caudal group and 1.72% (95% confidence limits, 1.37%-2.06%) in Non-caudal group. Caudal anesthesia did not reduce significantly the MAC-LMA removal of sevoflurane. LMA removal was unsuccessful in 13 patients in Caudal group with movement in 11 patients (1 at 1.2 %, 4 at 1.4%, 5 at 1.6%, 1 at 1.8%), clenching in 4 patients (1 at 1.4%, 3 at 1.6%), and caughing in 2 patients (1 at 1.2%, 1 at 1.4%). LMA removal was unsuccessful in 13 patients in Non-caudal group with movement in 8 patients (2 at 1.4%, 3 at 1.6%, 2 at 1.8% and 1 at 2%), clenching in 7 patients (2 at 1.4%, 4 at 1.6% and 1 at 1.8%), and breath holding in 2 patients (1.6 and 1.8%). Breath holding in 2 patients was easily treated with continuous positive airway pressure and assisted positive pressure ventilation with 100% oxygen. There were 3 patients with caughing at 1.6% in Non-caudal group. Within 5 min of jaw lifting, all patients were able to maintain upper airway patency by themselves, and there were no additional complications.

DISCUSSION

The results of our study show that the sevoflurane MAC-LMA removal is 1.72% in children caudal anesthesia was not performed and 1.60% in the presence of caudal anesthesia during the operation. Caudal anesthesia did not reduce significantly the MAC-LMA removal of sevoflurane.

The optimal time to remove the LMA airway is unknown. Although several authors[12,13] recommend removal of the LMA should be done after the patient's consciousness and protective upper airway reflexes returned because of the possibility of complications such as airway obstruction, regurgitation and aspiration, some authors[4-14] suggest that it may be safer to remove the LMA while patients are deeply anesthetized, especially for pediatric patients because of the reduced risk of coughing, laryngospasm, biting and hypoxia. Another advantage of removing LMA before emergence is that it would reduce the chances of patient clenching and biting the airway thereby reducing complications from a damaged airway device[15] However, another study performed in 1.5-15-yr-old children, reported that; removal of the LMA before or after return of airway reflexes resulted in a similar incidence of postoperative airway problems[16]

When LMA is removed in a deeply anesthetized state, prolonged upper airway obstruction and delayed return of protective reflexes are the main concerns. It may be more appropriate to preserve the advantage of deep extubation while reducing the interval between LMA removal and the return of consciousness and protective airway reflexes. An adequate concentration of sevoflurane, with its rapid recovery profile, is useful in this regard. In this study, the sevoflurane concentrations for successful LMA removal were between 1.26%-1.95% in Caudal group, and 1.37%-2.06% in Non-caudal group. All patients could preserve their airway patency with slight support, such as chin or jaw lift, at these concentration and that could maintain their airway patency spontaneously within 5 min.

Previous studies have shown that neuraxial blockade using local anesthetics has a sedative effect or enhances the hypnotic effects of anesthetic drugs and reduced anesthesia requirement following neuraxial blockade, which suggest that neural block may itself have sedative properties.[7,8-17] In addition, caudal blockade has also been described as a technique to provide sedation for infants during magnetic resonance imaging[18] Caudal blockade decreases input from sensory and motor afferents. Eappen *et al.*[19]

Table 1. Patients' characteristics and duration of surgery and proseal laryngeal mask airway insertion. data are presented as number of patient or mean±SD.

	Group Caudal (n=28)	**Group Non-caudal (n=28)**
Gender (Male/Female)	23/5	24/4
Age (yr)	3.66±2.44 (2 mo-8 yr)	4.36±2.34 (4 mo-8 yr)
Weight (kg)	15.89±6.66 (6-30)	16.61±5.39 (5-27)
Duration of surgery (min)	38.54±17.98 (15-95)	30.85±14.76 (20-85)
Duration of LMA insertion (min)	52.68±17.17 (25-105)	45.04±15.69 (30-100)

proposed that a decreased afferent input to the brain could lessen excitatory descending modulation of spinal cord motor neurons and suppress motor

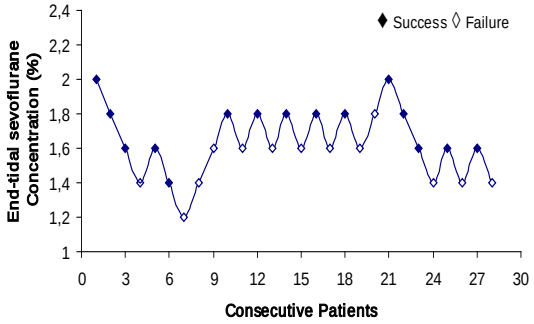

Figure 1. The end-tidal sevoflurane concentration in the 28 consecutive patients in whom laryngeal mask airway (LMA) with caudal group (Group Caudal) removal was attempted.

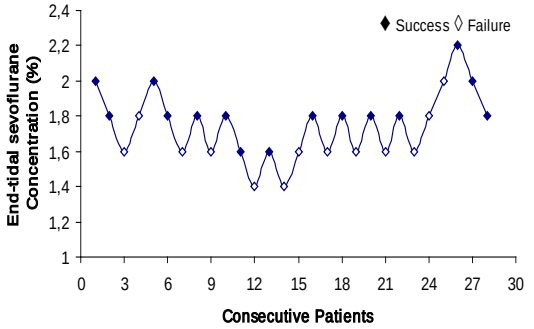

Figure 2. The end-tidal sevoflurane concentration in the 28 consecutive patients in whom laryngeal mask airway (LMA) without caudal group (Group Non-caudal) removal was attempted.

function. Xiau et al,[9] reported that caudal blockade reduced the enflurane MAC-LMA removal in children. As distinct from our study, they have studied children aged three to ten years which may have had an influence on their results. According to a study by Davidson and colleagues[20] caudal blockade decreased the degree of arousal, as measured with BIS, in unstimulated children aged 2-5 years and no change in arousal was detected in infants. The EEG changes with brain maturation and these age specific EEG changes may affect the ability of BIS to measure arousal.

We studied with children between 2 mo and 8 yr of age. There were 11 patients under two years old in Caudal group and 6 patients in Non-caudal group. The number of children under two years old were greater in group caudal anesthesia was performed, and this may effect the sevoflurane MAC-LMA removal on the basis of Davidson and colleagues study[20] pointed out the caudal anesthesia have not any effect at sedation level in infants under 2 years old.

In summary, our results suggest that caudal anesthesia did not reduce the sevoflurane MAC-LMA removal in children aged 2 mo and 8 yr. Further studies are necessary to establish whether caudal analgesia effect the removal of LMA in infant and children during sevoflurane anesthesia.

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