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End-tidal Sevoflurane Concentrations for Laryngeal Mask Airway Insertion and for Tracheal Intubation in Children

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Background: **Sevoflurane, a new inhalational anesthetic agent characterized by a low blood–gas partition coefficient and nonpungent odor, appears suitable as an induction agent for children. The laryngeal mask airway is a new device for maintaining airway patency during anesthesia. This study was conducted to determine the sevoflurane concentrations required for insertion of a laryngeal mask (MAC_{LMI}) and for tracheal intubation (MAC_{TI}) in children.**

Methods: **Forty-two patients, aged 1–9 yr, scheduled for surgery during general anesthesia were randomly assigned into two groups: MAC_{LMI} (n = 21) and MAC_{TI} (n = 21). After the predetermined end-tidal concentration had been established and maintained for 20 min, laryngeal mask insertion or tracheal intubation was attempted without neuromuscular relaxants or other adjuvants. Each concentration at which laryngeal mask insertion or tracheal intubation was attempted was predetermined by the up-and-down method (with 0.5% as a step size).**

Results: **Sevoflurane MAC_{LMI} was 2.00 ± 0.28%. Sevoflurane MAC_{TI} was 2.83 ± 0.34%, significantly greater than MAC_{LMI}.**

Conclusions: **Laryngeal mask insertion can be performed at a lesser sevoflurane concentration than that required for tracheal intubation. (Key words: Anesthetic techniques: laryngeal mask insertion; tracheal intubation. Anesthetics, volatile: sevoflurane.)**

THE laryngeal mask airway, a new device for maintaining airway patency during anesthesia,[1] is associated with fewer hemodynamic changes than is tracheal intubation (TI).[2–4] There are no data concerning the anesthetic concentration required for laryngeal mask insertion (LMI). Yakaitis *et al.*[5,6] defined MAC_{TI} as the end-tidal concentration of an inhalation agent at which smooth TI is possible in 50% of patients. Similarly, we designated sevoflurane MAC_{LMI} as the end-tidal concentration of sevoflurane at which smooth LMI is possible in 50% of patients.

This study was conducted to determine sevoflurane MAC_{LMI} and MAC_{TI} in children.

Materials and Methods

Informed consent was obtained from the parent or guardian of each participant. The study protocol was approved by the institution. Forty-two patients, ASA physical status 1, aged 1–9 yr, scheduled for elective plastic or reconstructive surgery during general anesthesia were randomly assigned into two groups: MAC_{LMI} (n = 21) and MAC_{TI} (n = 21).

The patients received no premedication. A precordial stethoscope was used to monitor heart and breath sounds. Blood pressure was measured indirectly, and lead II of the electrocardiogram (heart rate) was continuously monitored (BP-308ET, Nippon Colin, Aichi, Japan). Venous access was obtained for infusion of 2% dextrose in Ringer's lactate solution at 6 $ml \cdot kg^{-1} \cdot h^{-1}$ after inhalation induction with oxygen and sevoflurane *via* face mask. An oral airway (Berman airway) was inserted when necessary.

Breath-by-breath end-tidal sevoflurane and carbon dioxide concentrations were measured with a Raman scattering gas monitor (Rascal-1, Albion Instruments, Salt Lake City, UT) precalibrated with a standard gas mixture. A Mapleson-D system with a fresh gas flow of at least 200 $ml \cdot kg^{-1} \cdot min^{-1}$ through a vaporizer (PPV Σ, Penlon, Abingdon, UK) was used. (Penlon test-and-calibration documentation states that 6.13–7.88% was obtained at a dial setting of 7% and a total flow rate of 4 l/min.) End-tidal gases for measurements were sampled from the angle piece placed between the face mask and the fresh gas inlet. Accuracy of end-tidal measurements was maximized by confirming the return of the end-tidal carbon dioxide trace to zero.

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Table 1. Clinical Characteristics of Patients in the Two Study Groups

	LMI (n = 21)	TI (n = 21)
Gender (M/F)	14/7	15/6
Age (yr)	4.4 ± 2.2	4.9 ± 2.3
Weight (kg)	18.8 ± 6.0	19.0 ± 4.9
Height (cm)	103.3 ± 13.8	107.1 ± 13.8

Values are mean ±SD.

Determinations of Sevoflurane Concentration for Laryngeal Mask Insertion and for Tracheal Intubation

The test concentration of sevoflurane (starting with 2.0% and 3.0% for MAC_{LMI} and MAC_{TI}, respectively) for each patient was determined by a modification of Dixon's up-and-down method[7] (with 0.5% as the step size). A single measurement was obtained from each patient. After the ratio of alveolar to predetermined inspiratory concentration of sevoflurane had been maintained at 0.95 or more for 20 min, LMI (with a size-2 laryngeal mask) or TI (with noncuffed tracheal tubes, ID 3.5–6.0 mm) was attempted without neuromuscular relaxants or other adjuvants. The laryngeal mask was inserted without instrumentation and then inflated.

Patient's responses to LMI or TI were described as "no movement" or "movement." "No movement" was defined as the absence of bucking or gross purposeful muscular movements after laryngeal mask inflation for MAC_{LMI} determinations and after TI for MAC_{TI} determinations. "Movement" was recorded when mouth opening was difficult, when gross purposeful muscular or vocal cord movements during instrumentation or coughing or straining occurred after laryngeal mask inflation, or when bucking occurred after TI. Patients moving during LMI or TI were immediately administered an intravenous bolus dose of thiamylal 3 mg/kg and succinylcholine 1 mg/kg. The presence or absence of any positive responses was determined by consensus among the anesthesiologist, the surgeon, and the nurse in charge of the case.

Values for MAC were obtained by calculating the midpoint concentration of all independent pairs of patients involving a crossover (*i.e.*, movement to no movement). MAC_{LMI} and MAC_{TI} were defined as the average of the crossover midpoints in each crossover subgroup. Statistical analysis was determined by the chi-squared test and Student's *t* test. The level of significance was assigned at $P < 0.05$. Data were expressed

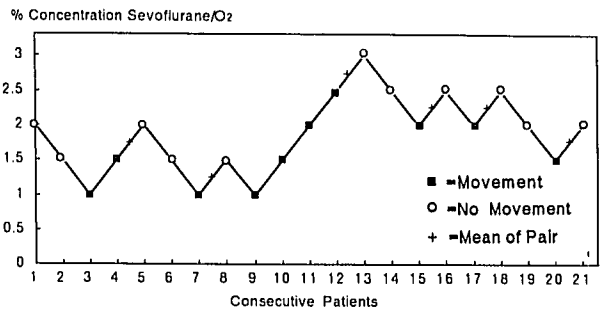

Fig. 1. The responses of the 21 consecutive patients in whom laryngeal mask insertion was attempted and the end-tidal concentrations of sevoflurane in oxygen. Crosses = average of six crossover (movement–no movement) patient pairs. The concentration of sevoflurane required for laryngeal mask insertion was calculated to be 2.00.

mean ± SE. We also analyzed our data by a probit test (proprietary software, SAS, Cary, NC) to obtain 95% confidence limits, and a logistic regression test to obtain the probability of no movement *versus* end-tidal sevoflurane concentration, the maximum likelihood estimators of the model parameters, and a goodness of fit.

Results

There were no significant differences in demographic data between the two groups (table 1).

Sevoflurane MAC_{LMI} was 2.00 ± 0.28% (95% confidence limits 0.43–2.98%) (fig. 1). Sevoflurane MAC_{TI} was 2.83 ± 0.34% (95% confidence limits 1.87–3.78%) (fig. 2). The difference between these two values was statistically significant ($P < 0.05$).

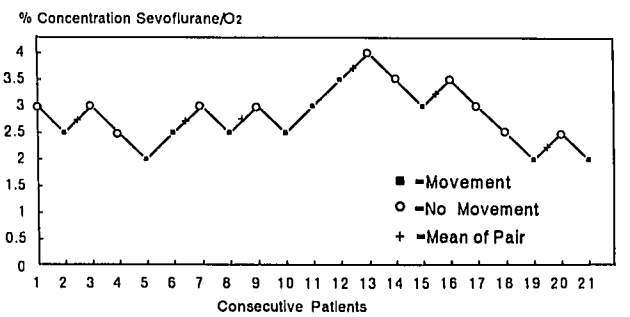

Fig. 2. Responses of the 21 consecutive patients in whom tracheal intubation was attempted and the end-tidal concentrations of sevoflurane in oxygen. Crosses = average of six crossover (movement–no movement) patient pairs. The concentration of sevoflurane required for tracheal intubation was calculated to be 2.83.

Logistic regression curves of the probability of no movement are shown in figure 3. Maximum likelihood estimators of the logistic regression model parameters and assessment of goodness of fit are shown in table 2.

Ten patients moved during LMI (difficult mouth-opening in two and gross purposeful muscular movement in eight). Ten patients moved during laryngoscopy. Those in whom no movement was seen when the LMI was inserted or in whom laryngoscopy was performed remained unresponsive after laryngeal mask airway inflation or TI, respectively.

In no patient did dysrhythmia, such as bradycardia, necessitating drug administration occur.

Discussion

The results of this study reveal that the laryngeal mask may be inserted at a lesser sevoflurane concentration than that required for TI.

Although we used a sufficiently large fresh gas flow, controlled ventilation manually to reduce the likelihood of rebreathing, and ensured that inhaled carbon dioxide was zero at the beginning of inspiration, the MAC_{TI} in this study, 2.83%, is slightly greater than that measured in a previous study.[8] The difference in these MAC_{TI} values may be attributed in part to differences in study design: In this study, TI was initially attempted at higher end-tidal concentrations than that for LMI because we anticipated that the trachea would be more sensitive than the oral cavity and pharyngeal mucosa to foreign bodies. In addition, to reduce the possibility that the end-tidal gas concentration measured close to a face mask was substantially contaminated by and thus falsely increased by inspired gas, a 0.95 or greater ratio of alveolar to predetermined inspiratory concentration was achieved and maintained for 20 min.

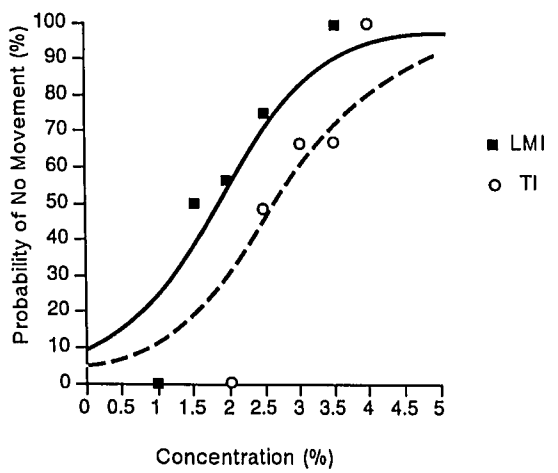

Fig. 3. Dose–response curves for sevoflurane plotted from logit analyses of individual end-tidal concentrations and the respective reactions to laryngeal mask insertion and tracheal intubation.

Table 2. Estimated Values of the Coefficients of Logit $(p/1 - p) = B_0 \pm B_{1X}$

	Intercept	Slope	MAC	*P*
LMI	−2.0492	1.1651	1.7946	0.1879
TI	−3.0825	1.1376	2.7326	0.1916

Goodness of fit chi-squared LMI = 0.8685, TI = 0.7442, $(p/1 - p) = B_0 + B_{1X}$, B_0 = Intercept, B_1 = slope, X = $ET_{sev\%}$.

Previously we reported a sevoflurane MAC of 2.03% and a MAC_{TI} of 2.69%[8] in children of a similar age and weight range as those in this study. Based on data from the current study MAC_{LMI} is similar to MAC. This implies that when skin incision occurs shortly after LMI in patients finding breathing sevoflurane alone, patients may respond to skin incision.

There are some limitations to this study. First, the 95% confidence limits of MAC_{LMI} and MAC_{TI} overlapped, and logistic regression curve-fitting was acceptable. This result may be attributed to the limited size of study population. However, interpreting these results also to mean that there is no statistically significant difference between these two values and thus no difference in sensitivity between the oral cavity and upper tracheal mucosa is not consistent with clinical observations. Second, maintaining the ratio of alveolar to inspired concentration at 0.95 or more implies that a value of 1.0 would have been accepted as well as 0.95 and does not rule out the possibility of contamination of alveolar gas with expired gas. However, these factors should have been minimized by the 20-min duration of administration of a given concentration.

In conclusion, MAC_{LMI} of sevoflurane was 2.00% and MAC_{TI} of sevoflurane was 2.83% in children.

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