J Anesth (2004) 18:51–54
DOI 10.1007/s00540-003-0210-8

Journal of
Anesthesia

Volatile induction and maintenance of anesthesia using laryngeal mask airway in pediatric patients

Gönül Tezcan Keleş, Verda Toprak, Gülay Ok, and Nurettin Lüleci

Celal Bayar University, Faculty of Medicine Hospital, Department of Anaesthesia, 45000 Manisa, Turkey

Key words Sevoflurane · Halothane · Laryngeal mask airway · Pediatric anesthesia

Introduction

Inhalation of volatile anesthetics is the most common technique for the induction of general anesthesia in pediatric patients [1,2]. Volatile induction and maintenance of anesthesia (VIMA) has gained wide importance in anesthesia performance with the beginning of the use of sevoflurane in practice.

The laryngeal mask airway (LMA) provides an alternative to ventilation through a face mask or endotracheal tube. It has been used extensively in children since about 1990 [3,4].

Halothane was the most widely used volatile agent worldwide up to sevoflurane's clinical appearance [1]. Sevoflurane is well tolerated in terms of airway complications, causing minimal breatholding, coughing, excitement, or laryngospasm, with minimal changes in hemodynamics; its nonpungency and rapid increases in alveolar anesthetic concentration make sevoflurane an excellent choice for smooth and rapid inhalational induction in pediatric patients [5].

In this study we compared sevoflurane and halothane in terms of hemodynamic changes and anesthetic complications when these anesthetics were used in VIMA combined with LMA in pediatric patients.

Subjects and methods

After obtaining approval from the Celal Bayar University Hospital Ethics Committee, and after obtaining informed parental consent, 60 children, aged 2 to 8 years, American Society of Anesthesiologists (ASA) class I–II, who were scheduled for minor urogenital surgery were enrolled in this prospective, randomized study. Automated noninvasive blood pressure, ECG, and SpO_2 were monitored using a Criticare System 1100 monitor (Criticare System, Waukesha, WI, USA). Respiratory gases were monitored by infrared spectroscope S/5 (Datex-Ohmeda, Helsinki, Finland). Anesthesia was induced by mask with a mixture of O_2/N_2O by a pediatric Bain system at a fresh gas flow of $6\,l{\cdot}min^{-1}$. In both the halothane and the sevoflurane groups (group H and group S, respectively), inspired gas concentrations were increased in stepwise fashion; halothane in 0.5% increments, up to a maximum of 5%; and sevoflurane in 1% increments, up to a maximum of 7%. As soon as consciousness was lost, an intravenous catheter was inserted, after eyelash and protective airway reflexes were lost, and the percent concentration of inhaled anesthetic was decreased to keep hemodynamic stability; then the child was ventilated at that concentration of inhaled anesthetic for another 1 min. The LMA was chosen depending on the child's weight, and placed in the hypopharynx. Simultanously, end-tidal concentrations of the inhaled anesthetics and the percentage concentration of the vaporizer dial were recorded. Neuromuscular blocking drugs were not given. Ventilation was controlled to maintain normocapnia, and fresh gas flow was kept high enough to prevent rebreathing. Anesthesia maintenance was done with a total of 1 minimum alveolar concentration (MAC) of the volatile agent and 50% N_2O in oxygen in order to provide hemodynamic stability and LMA tolerance until the end of the surgery. Analgesia was provided by $2\,\mu g{\cdot}kg^{-1}$ i.v. fentanyl before skin incision. At the end of the surgery, all anesthetic agents were discontinued, 100% O_2 was administered, and the LMA was removed in the operating room when the patient was fully awake.

Address correspondence to: G.T. Keleş
Received: January 27, 2003 / Accepted: October 31, 2003

Table 1. Vaporizer-dial and end-tidal concentrations of volatile agents at each point in both groups

	T1	T2	T3	T4
Vaporizer dial setting (%)				
Group H	0	1.4 ± 1.7	0.4 ± 0.4	0
Group S	0	3.4 ± 0.5	1.5 ± 0.5	0
End-tidal concentration (%)				
Group H	0	1.3	0.3	0.1
Group S	0	2.4	1.1	0

Values are means ± SD
Group H, halothane group; group S, sevoflurane group; T1, just before starting induction of volatile anesthetic; T2, just after laryngeal mask airway (LMA) insertion; T3, 15 min after LMA insertion (during maintenance anesthesia); T4, at the end of the surgery during removal of LMA

The end-tidal concentrations of the volatile agents and the hemodynamic parameters were documented at four points:

T1, Just before starting induction of volatile anesthetic
T2, Just after LMA insertion
T3, 15 Min after LMA insertion (during maintenance anesthesia)
T4, At the end of the surgery during LMA removal.

Heart rate (HR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), and mean arterial pressure (MAP) were recorded at given times. Airway-related complications (a single cough, breathholding >20 s, laryngospasm, excessive salivation) and other complications (bradycardia, extrasystole) related to the insertion and removal of the LMA were recorded. Bradycardia was defined as a more than 20% decrease from the baseline HR. Values for results were reported as means ± SD. Statistical significance was accepted for a level of P less than 0.05. Hemodynamic variables were compared by repeated measures analysis of variance (ANOVA) and a post-hoc Tukey's test was used. The Mann-Whitney U-test was used for between-group differences, and complications were analyzed using the χ^2 test.

Results

The average ages of the children in groups H and S were 5.6 ± 2.3 and 5.5 ± 2.2 years, respectively, and their weights were 20.6 ± 7.0 and 19.7 ± 8.4 kg, respectively. LMA of sizes 1 to 2.5 were used. Types of surgery were not different between the groups. The induction of anesthesia and insertion of the LMA were smooth, and the laryngeal masks were succesfully inserted on the first attempt in most of the patients. A second attempt was needed in only three patients.

The concentrations of the vaporizer dial were 1.4 ± 1.7% and 3.4 ± 0.5% during LMA insertion (T2), and 0.4 ± 0.4% and 1.5 ± 0.5% during maintenance of anesthesia (T3) in groups H and S, respectively (Table 1).

SAP, DAP, and MAP were significantly lower in group H at T2 compared to group S ($P < 0.05$). SAP increased at T2, and HR decreased at T4, and DAP increased at T4 compared to baseline in group S ($P < 0.05$; Table 2).

During the LMA insertion, there were six (19.8%) cases of extrasystole in group H ($P < 0.05$). There were 3 (9.9%) cases of bradycardia together with extrasystole in the same group. During the removal of the LMA, there were 4 (13.3%) cases of breathholding in group H ($P < 0.05$; Table 3).

Discussion

In this study, the LMA was inserted after the induction of anesthesia with incremental concentrations of the inhalational agents (halothane and sevoflurane), without the use of neuromuscular blocking drugs. Only minor differences could be found between the two agents. An adequate depth of anesthesia was attained with both agents to suppress airway reflexes and to allow smooth insertion of the LMA, with the inhalation concentration of halothane at 1.4 ± 1.7% and that of sevoflurane at 3.2 ± 0.5%. The maintenance of anesthesia with the LMA was well tolerated, with the inhalation concentration of halothane at 0.4 ± 0.4% and that of sevoflurane at 1.5 ± 0.3%.

As patients tolerated the face mask during the induction of anesthesia, we could perform VIMA with a unique anesthetic agent. We think that monopharmacy and less drug usage are the advantages of VIMA. We emphasize that VIMA has superiority for day-case surgery in children. In previous studies, there were many reports [2,6] which compared halothane and sevoflurane. But we could find only one report [7] concerning VIMA and LMA in children in which these two anesthetic agents were used.

Table 2. Cardiovascular changes in both groups

	T1	T2	T3	T4
HR (beat·min^{-1})				
Group H	119.68 ± 18.0	113.92 ± 21.8	120.28 ± 35.0	108.88 ± 25.0
Group S	121.36 ± 22.3	118.12 ± 19.7	114.88 ± 21.5	94.16 ± 20.6**
SAP (mm Hg)				
Group H	103.24 ± 16.5	99.56 ± 12.2*	100.20 ± 13.9	101.60 ± 14.3
Group S	104.88 ± 15.5	116.52 ± 23.0**	104.72 ± 12.2	104.60 ± 13.4
DAP (mm Hg)				
Group H	59.96 ± 13.2	59.16 ± 8.4*	60.96 ± 8.4	61.32 ± 10.2
Group S	59.84 ± 11.8	66.40 ± 12.1	58.40 ± 10.4	68.64 ± 15.7**
MAP (mm Hg)				
Group H	78.40 ± 17.9	73.12 ± 11.7*	80.68 ± 7.6	81.20 ± 14.3
Group S	81.00 ± 14.0	86.76 ± 18.9	79.96 ± 13.1	83.36 ± 14.8

*$P < 0.05$ between groups (Mann-Whitney U-test); **$P < 0.05$ within group (Tukey's test)
Values are means ± SD
Group H, halothane group; group S, sevoflurane group; T1, just before starting induction of volatile anesthetic; T2, just after LMA insertion; T3, 15 min after LMA insertion (during maintenance anesthesia); T4, at the end of the surgery during removal of LMA; HR, heart rate; SAP, systolic arterial pressure; DAP, diastolic arterial pressure; MAP, mean arterial pressure

Table 3. Adverse experience rate (%) in the two groups

	LMA insertion		LMA removal	
	Group H (n = 30)	Group S (n = 30)	Group H (n = 30)	Group S (n = 30)
Coughing	2 (6.6%)	1 (3.3%)	0	0
Breathholding	1 (3.3%)	0	4 (13.2%)*	0
Bronchospasm	1 (3.3%)	2 (6.6%)	1 (3.3%)	2 (6.6%)
Retching	2 (6.6%)	0	0	0
Vomiting	1 (3.3%)	0	1 (3.3%)	0
Bradycardia	3 (9.9%)	0	0	1 (3.3%)
Extrasystole	6 (19.8%)*	0	0	0

*$P < 0.05$ between groups (χ^2 test)
Group H, halothane group; group S, sevoflurane group

All of the inhalation anesthetics have consistently exhibited dose-dependent myocardial depression [6]. In the present study, SAP, DAP, and MAP were significantly decreased in group H during the induction period. Sarner et al. [2] have shown that hemodynamic variables decreased significantly during induction with halothane, whereas there was no change with sevoflurane. Their results are similar to our results (Table 2).

Particularly in older children, sevoflurane has been reported to have a tendency to produce some tachycardia, and to preserve systolic arterial pressure [8]. Kern et al. [9] reported hemodynamic changes, characterized by increases in HR and SAP of up to 20% with sevoflurane. Our result was in the way that SAP increased significantly at T2 compared to T1. But HR did not accompany that increase. We have observed a similar effect in the fashion of increase in SAP in sevoflurane group as Kern. The reason for the elevated cardiovascular activity may be the inhibition of parasympathetic control, as suggested in a previous study carried out during inhalation induction with sevoflurane under assisted ventilation [10]. Calderon et al. [11] observed that supraventricular extrasystole appeared in 22.5% of patients with halothane and in 5% with sevoflurane during the insertion of LMA. We observed extrasystole in halothane group as Calderon. None of patient had extrasystole in group S.

We used both of these volatile agents without any adverse hemodynamic event for which medication was needed. However, we prefer VIMA with sevoflurane because sevoflurane has a less depressive effect on cardiovascular function. For LMA insertion in children, it has been reported that 7%–11% of cases were difficult and 2%–3% of cases failed [12]. In our study, LMA was inserted at the second attempt, without desaturation

($Sp_{O_2} < 90\%$), in only two children in group H and one child in group S.

A lower incidence of vomiting with sevoflurane (13%) than with halothane (30%) was reported by Vhtanen et al. [13] and in previous studies [5,14]. Our result was similar to this incidence, but the difference did not reach statistical significance.

We observed a higher incidence of breathholding in group H during LMA removal, but it was not serious, whereas some authors [13,15,16] have reported that the incidence of airway reflex responses such as cough, laryngospasm, and breathholding were similar in halothane and sevoflurane groups.

In conclusion, both sevoflurane and halothane are acceptable alternatives for VIMA with LMA in short-period pediatric anesthesia, though halothane has a somewhat higher incidence of cardiovascular and airway-related complications.

References

1. Cauldwell CB (1994) Induction, maintenance, and emergence. In: Gregory GA (ed) Pediatric anesthesia, 3rd edn. Churchill-Livingstone, USA, pp 239–240
2. Sarner JB, Levine M, Davis PJ, Lerman J, Cook DR, Motoyama EK (1995) Clinical characteristics of sevoflurane in children. A comparison with halothane. Anesthesiology 82:38–46
3. Morgan GE, Mikhail MS, Murray M (2002) Clinical pharmacology—inhalational anesthetics. In: Morgan GE, Mikhail MS, Murray M, Larson CP (ed) Clinical anesthesiology, 3rd edn. McGraw-Hill, USA, pp 127–128
4. Aantaa R, Takala R, Muittari P (2001) Sevoflurane EC50 and EC95 values for laryngeal mask insertion and tracheal intubation in children. Br J Anaesth 86:213–216
5. Goa KL, Noble S, Spencer CM (1999) Sevoflurane in paediatric anaesthesia: a review. Paediatr Drugs 1:127–153
6. Piat V, Dubois MC, Johanet S, Murat I (1994) Induction and recovery characteristics and haemodynamic responses to sevoflurane and halothane in children. Anesth Analg 79:840–844
7. Erb T, Christen P, Kern C, Frei FJ (2001) Similar haemodynamic, respiratory and metabolic changes with the use of sevoflurane or halothane in children breathing spontaneously via a laryngeal mask airway. Acta Anaesthesiol Scand 45:639–644
8. Greeley WJ, Steven JM, Nicolson SC, Kern FH (2000) Anesthesia for pediatric cardiac surgery. In: Miller RD (ed) Anesthesia, 5th edn. Vol 2; chapter 50, Churchill-Livingstone, USA, pp 1805–1848
9. Kern C, Erb T, Frei FJ (1997) Haemodynamic responses to sevoflurane compared with halothane during inhalational induction in children. Paediatr Anaesth 7:439–444
10. Constant I, Dubois MC, Piat V, Moutard ML, Murat I (1999) Changes in electroencephalogram and autonomic cardiovascular activity during induction of anesthesia with sevoflurane compared with halothane in children. Anesthesiology 91:1604–1615
11. Calderon E, Torres LM, Aguado JA, de Antonio P, Mora R, Almarcha JM (1998) Comparative study of sevoflurane and nitrous oxide versus halothane and nitrous oxide in pediatric anesthesia: efficacy and haemodynamic characteristics during induction. Rev Esp Anestesiol Reanim 45:126–129
12. Logan A, Morris P (1993) Complications following use of the laryngeal mask airway in children. Paediatr Anaesth 3:297–300
13. Vhtanen H, Baer G, Annila P (2000) Recovery characteristics of sevoflurane or halothane for day-case anaesthesia in children aged 1–3 years. Acta Anaesthesiol Scand 44:101–106
14. Lerman J, Davis PJ, Welborn LG, Orr RJ, Rabb M, Carpenter R (1996) Induction, recovery and safety characteristics of sevoflurane in children undergoing ambulatory surgery. A comparison with halothane. Anesthesiology 84:1332–1340
15. Villani A, Zuccoli P, Rovvella C, Laviani R, Gulli E, Guddo AM, Scoyni G, Casati A (1998) A prospective, randomized clinical comparison of sevoflurane and halothane in children. Minerva Anestesiol 64:3–10
16. Agnor RC, Sikich N, Lerman J (1998) Single-breath vital capacity rapid inhalation induction in children: 8% sevoflurane versus 5% halothane. Anesthesiology 89:379–384