ORIGINAL ARTICLE

A Comparison of the Induction and Emergence Characteristics of Sevoflurane and Halothane in Children

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Summary

This open labelled, randomised, controlled study was designed to compare the induction and recovery characteristics of sevoflurane and halothane anaesthesia in children. Forty American Society of Anaesthesiologist (ASA) physical status class 1 or 2 children (aged 1 - 10 year, weighed less than 25kg) scheduled for elective urological procedure lasting less than one hour were allocated randomly to receive either sevoflurane (group S, n=20) or halothane (group H, n=20). The induction time in children receiving sevoflurane was significantly shorter than in those receiving halothane (mean (SD) 46 (13.6) seconds vs 69 (19.4) seconds, $p<0.005$). The emergence from anaesthesia was also faster in children receiving sevoflurane than in those receiving halothane (mean (SD) 9 min (4.3min) vs 21min (8.9min), $p<0.001$). No major adverse effects were encountered in each group. We concluded that sevoflurane is comparable to halothane in Malaysian children.

Key Words: Anaesthetics, Volatile; Sevoflurane, Halothane; Induction, Recovery; Paediatric

Introduction

Halothane remains the main drug used for inhalational induction of anaesthesia in children despite its extremely rare but potentially fatal hepatitis[1]. Sevoflurane, a new inhalational anaesthetic recently introduced in Malaysia has several theoretical advantages over halothane. It has a lower blood gas solubility[2] allowing for more rapid induction and recovery. It is less extensively metabolised[3] thus making hepatitis less likely than halothane. In addition it has a pleasant smell and is non-irritant to the airway making it suitable for an inhalational induction of anaesthesia in children.

Many studies[4-11] from the West have confirmed its favourable induction and emergence characteristics in children when compared to halothane. No formal study comparing sevoflurane with halothane in children has been published in Malaysia. This open labelled, randomised, controlled study was designed to compare the induction and recovery characteristics of sevoflurane and halothane in Malaysian children.

Materials and Methods

Forty children 1 - 10 years of age, weighing less than 25kg, American Society of Anaesthesiologist (ASA) physical status class 1 or 2 were randomly allocated to receive anaesthesia by inhalational induction with either sevoflurane or halothane. All children were having elective urological procedures lasting less than one hour such as herniotomy, circumcision, excision of hydrocoele or orchidopexy. The study was approved by the hospital ethics committee and informed consent was obtained from the parents.

All children were anaesthetised by the same investigator and the induction technique was standardised. All children fasted overnight and was premedicated with

trimeprazine 2mg/kg orally one hour prior to the induction of anaesthesia. The inhalational agent was administered with 66% nitrous oxide in oxygen at standardised weight appropriate fresh gas flow via a Mapleson F breathing system. Inspired concentrations were steadily increased every 5 breaths, from 1%, 2%, 3% and 3.5% for halothane and 2%, 4%, 6% and 7% for sevoflurane. The incremental method of induction used in this study was designed to provide similar Minimum Alveolar Concentration (MAC) multiples of both drugs according to differences in blood solubility and MAC values[11]. Intravenous cannula was sited after loss of consciousness and lactated Ringer's solution was given at a maintenance rate appropriate for the child's weight and fasting interval. All children breathed spontaneously throughout the surgery via a face mask and oropharyngeal airway. Analgesia was administered soon after induction and included a local anaesthetic block appropriate to the surgery (either ilioinguinal or caudal, with up to 2.5mg/kg of plain bupivacaine 0.25%) and paracetamol suppositories 20 - 30mg/kg. No other drugs were administered during the induction period and throughout the surgery. Anaesthesia was maintained with end tidal concentration of between 1 - 2% for halothane and 2 - 4% for sevoflurane. End tidal concentration of anaesthetics were adjusted to about 1.5 MAC (1.4% halothane, 2.8% sevoflurane) for at least 10 minutes before the end of surgery. At the end of the surgery the vapour was turned off and 100% oxygen given.

Heart rate, systolic, diastolic, and mean arterial blood pressure, end tidal carbon dioxide, inspired and end tidal anaesthetic concentrations were recorded every minute during induction and every 3 minutes during maintenance of anaesthesia until the end of surgery.

Airway related complications, including breath holding (>15s), laryngospasm (inability to ventilate effectively in the presence of a patent pharyngeal airway associated with an oxygen saturation of less than 90%), and excitement (nonpurposeful movement requiring restraint), were noted during induction. The time from initiation of anaesthetic agent to loss of the eyelash reflex (induction time) was recorded by the same anaesthetist who induced the children. This anaesthetist was not blinded to the agent used. The interval from mask application to the discontinuation of the anaesthetic (duration of anaesthesia) was measured. The time from discontinuation of anaesthesia until the child responded appropriately to commands or demonstrated purposeful movement was recorded by a second investigator who was blinded to the agents used (emergence time). This same investigator also recorded any occurrence of untoward events during the recovery period such as nausea, vomiting, restlessness and agitation. Restlessness and agitation was evaluated by using the three subjective components of the Objective Pain Scale (Table I)[12]. If the child was crying inconsolably, thrashing and hysterical, he was reported to be agitated.

Based on the difference of previous studies, using Atlman nomogram, a sample size of 20 patients per group was estimated for a 80% power of detecting a difference of 30% in induction and emergence time.

Statistical analysis

Results are expressed as mean (Standard Deviation). Student's t test was used to analyse age, weight and duration of anaesthesia. Mean time to eyelash reflex and mean time to response to command was analysed using a non parametric test. Chi square test was used to analyse ASA, type of surgery, type of intraoperative analgesia, incidence of respiratory complications, incidence of nausea and vomiting and incidence of restlessness and agitation. A two tailed p value of less than 0.05 was the criterion for statistical significance.

Results

A total of forty patients were studied. Twenty patients were randomised to the halothane group and twenty patients to the sevoflurane group. The two study groups were well matched in terms of age, body weight, ASA status, type of surgery, type of analgesia and the duration of anaesthesia (Table II).

During induction of anaesthesia, the time to loss of the eyelash reflex with sevoflurane was significantly faster than with halothane [mean time of induction (SD)=46 (13.6)s vs 69 (19.4)s, $p<0.001$, Table III]. Emergence from anaesthesia as evidenced by the time to response to commands after sevoflurane was significantly more rapid than with halothane [mean time of emergence (SD)=9 (4.3)min vs 21 (8.9)min, $p<0.001$, Figure 1 and

Table I
Objective Pain Score

Observation	Criteria	Points
Blood Pressure	±10% preop	0
	>20% preop	1
	>30% preop	2
Crying	Not crying	0
	Crying but responds to tender loving care	1
	Crying and does not respond to tender loving care	2
Movement	None	0
	Restless	1
	Thrashing	2
Agitation	Patient asleep or calm	0
	Mild	1
	Hysterical	2
Posture	No special posture	0
	Flexing legs and thighs	1
	Holding scrotum or groin	2
Complain of pain (where appropriate by age)	Asleep, or states no pain	0
	Cannot localize	1
	Can localize	2

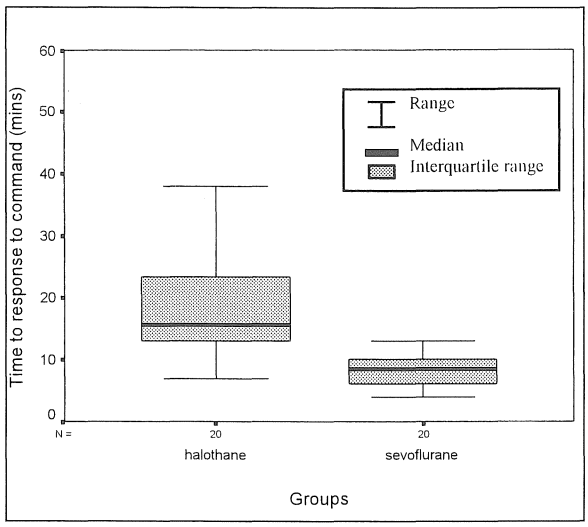

Fig. 1: Boxplot of speed of recovery from anaesthesia with halothane and sevoflurane.

Table III]. The complications noted are summarised in Table III and were similar for both sevoflurane and halothane. Neither breathholding, laryngospasm nor excitement occurred. Postoperative restlessness and agitation was observed in two patients in the halothane group (10%) and three in the sevoflurane group (15%). However all five children were later pacified by the presence of their parents in the recovery area without having to give more analgesic drugs. Nausea and vomiting was observed in two patients in the halothane group (10%) and one in the sevoflurane group (5%). The incidence of nausea and vomiting and restlessness and agitation between the two groups were not statistically significant.

Discussion

Induction and maintenance of general anaesthesia in children is often managed with an inhaled anaesthetic, which should provide rapid and smooth induction and

Table II
Demographic Characteristics of the Subjects and Duration of Anaesthesia

	Halothane N=20	Sevoflurane N=20
Mean age, years (SD)	4.2 (2.48)	4.8 (2.08)
Mean weight, kg (SD)	16.0 (4.67)	17.4 (4.23)
ASA I, no (%)	19 (95)	20 (100)
ASA II, no (%)	1(5)	0 (0)
Type of surgery, no (%)		
Herniotomy	9 (45)	6 (30)
Circumcision	5 (25)	4 (20)
Excision of hydrocoele	2 (10)	3 (15)
Orchidopexy	4 (20)	7 (35)
Type of intraoperative analgesia, no (%)		
Caudal	5 (25)	4 (20)
Ilioinguinal	15 (75)	16 (80)
Mean duration of anaesthesia, minutes (SD)	39.0 (16.5)	43.0 (16.4)

Table III
Induction and Recovery Variables Studied in Both Groups

Variables	Halothane N=20	Sevoflurane N=20
Mean time to eyelash reflex, seconds (SD)	69.3 (19.4)	45.6 (13.6)**
Mean time to response to command, minutes (SD)	20.9 (8.9)	9.0 (4.3)**
Respiratory complications, no (%)	0 (0)	0 (0)
Nausea and vomiting, no (%)	2 (10)	1 (5)
Restlessness and agitation, no (%)	2 (10)	3 (15)

***p<0.001, between the two groups*

emergence with minimal adverse effects. The result of this study supports the findings of other workers that sevoflurane allows more rapid induction[4-6] and emergence[7-11] than halothane in children.

Whilst a rapid and smooth induction is almost always preferred, rapid emergence may not necessarily be always of clinical benefit. Some workers[6-7] have found that rapid emergence with the use of sevoflurane in children was associated with higher incidence of postoperative restlessness and agitation. It has been suggested that this phenomenon is the manifestation of acute pain when the anaesthetic is rapidly and completely eliminated[6-7]. It is also possible that the rapid transition from anaesthesia to consciousness in a strange area with unfamiliar people taking care of the child results in fear and apprehension leading to postoperative restlessness and agitation[10]. In our study

we observed a low incidence of postoperative restlessness and agitation in both groups. This may be due to adequate pain relief provided by both a local anaesthetic block and paracetamol suppository administered shortly after induction of anaesthesia. Piat et al[11] used epidural injection as the method of peroperative analgesia and observed no postoperative restlessness and agitation. We believe it is vitally important to provide effective pain relief, administered well before recovery when rapid and complete emergence from anaesthesia is expected as in the use of sevoflurane. In order to prove that restlessness and agitation during emergence are manifestations of acute pain, further studies would be needed to compare the incidence of restlessness in two groups of children anaesthetised with sevoflurane, one with and one without intraoperative analgesia. However such a study is ethically questionable. In our study, all five children who experienced postoperative restlessness and agitation were successfully pacified once their parents were allowed to come in to the recovery room to be with them, without further requirement of analgesic drugs. We believe the presence of the parents may alleviate the fear and apprehension experienced by children waking up in a strange area with unfamiliar people. It would be interesting to conduct further studies to investigate the potential role of having parents present at awakening in controlling the postoperative restlessness and agitation.

The incidence of nausea and vomiting was low in patients anaesthetised with sevoflurane and this low incidence has been confirmed in a much larger clinical trial[13] of sevoflurane in paediatric anaesthesia. Although frequently described as "minor" postoperative complication, persistent nausea and vomiting may result in dehydration, electrolyte imbalance and delayed discharge, it can also cause tension on suture lines, venous hypertension, and increased bleeding under skin flaps, and can expose the subject to an increased risk of pulmonary aspiration of vomitus if airway reflexes are depressed from the residual effects of anaesthetic and analgesic drugs[14]. In addition to the physiological consequences postoperative nausea and vomiting also increase the economic cost to the hospital and the patients[15]. Thus the low incidence of postoperative vomiting in children with the use of sevoflurane should encourage its use in paediatric anaesthesia.

In conclusion, this study suggests that sevoflurane is a suitable inhalational induction agent for children in the Malaysian population and is comparable to halothane. This finding is in agreement with other studies[4-11].

Acknowledgement

We are grateful to Abbott (Malaysia) Sdn. Bhd. for the supply of sevoflurane.

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