A Clinical Trial of Sevoflurane in Children for Herniorrhaphy

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The new volatile anesthetic agent sevoflurane, fluoromethyl-1,1,1,3,3,3,-hexafluoro-2-propylether ($(CF_3)_2CHOCH_2F$), is quite stable and a non-explosive with air, oxygen and nitrous oxide[1]. Sevoflurane was first clinically tested in 1981[2] and has been studied in pediatric patients in Japan.

Its properities as an anesthetic agent are similar to those of halothane. However, the blood/gas partition coefficient of sevoflurane is much lower than that of halothane (0.60, 2.36, respectively.)[1] and its MAC value is reported as 1.71% in adults[3]. In addition, the biological transformation of sevoflurane is similar to enflurane and its rate is much less than halothane[2]. These findings indicate that sevoflurane would be more rapid in induction and recovery, and be an advantageous anesthetic for minor operations in pediatric patients.

We studied such hypothesis in fifty children undergoing herniorrhaphy, and compared its data with those of halothane anesthesia.

Methods

We studied one hundred children, aged 5 month – 11 years, classified as ASA I undergoing herniorraphy. Fifty children were anesthetized with sevoflurane (group S) and other 50 with halothane (group H). This study was approved by the institutional committee, and informed consent was obtained from their parents.

Anesthetic technique

None of the children received premedication. In the operating room, ECG and blood pressure were monitored, and breath's and heart sound were monitored by a precordial stethoscope.

After baseline values of blood pressure and pulse rate were measured, anesthesia was induced by experienced anesthesiologists by using a modified Ayre's T-piece with an unscented mask. Seventy percent nitrous oxide in oxygen was administered for one minute, and then sevoflurane or halothane was gradually administered. The concentration of anesthetics was increased by increment of 0.5% every 5–6 breaths up to 4.0% in group S, and increment of 0.25% up to 2.0% in group H. The final concentration was maintained until the skin incision. After the skin incision, the concentration was 3.0% in group S and 1.5% in group H in 70% nitrous oxide and balanced oxygen. All children breathed spontaneously through a face mask during the operation. Volatile anesthetic and nitrous oxide were discontinued after the hernia sac was ligated. Ileoinguinal block with 3 ml of 0.25% bupivacaine was performed in patients, 3 years or older.

Measurements

The sleep-onset time was defined as the time when eyelid reflex disappeared after

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Table 1. Patient characteristics and anesthesia and operation times

	Sevoflurane group	Halothane group
Sex (female/male)	26/24	27/23
Age (yr,m)	4 yr 0 m± 2 yr 8 m	4 yr 3m±3 yr 3m
Body Weight (kg)	15.6± 6.6	16.3± 7.5
Height (cm)	97.1±21.4	98.3±23.5
Anesthesia time (min)	20.3± 5.3	18.8± 6.4
Operation time (min)	9.7± 4.9	8.7± 5.7

Values are mean±SD. No significant difference between the groups

Table 2. Sleep-onset, induction, and recovery time

	Sevoflurane group	Halothane group
Sleep-onset time (sec)	107±29	117±32
Induction time (sec)	201±56	195±49
Recovery time (sec)	306±70	300±70

All values are mean±S.D. No significant difference between the groups

inhalation of the volatile anesthetic. The induction time was the interval between inhalation of sevoflurane or halothane and the time when the patient showed no response to painful stimuli. The recovery time was the interval between the cessation of the anesthetic agents and crying or awaking. The incidence of coughing, breath holding, arrythmia or other incidents were recorded.

Blood pressure and pulse rate were measured every minute and evaluated at three points: preinduction, immediately before incision, and the highest value during surgery. Postoperative incidence of nausea, vomiting, and changes in body temperature were recorded by the ward nurses.

Statistics

Statistical analysis was performed by analysis of variance and Student's t-test for unpaired data. The incidence of complications was evaluated by using the chisquare test. P-value less then 5% was considered as statistically significant. All values were given as mean ± standard deviation (S.D.).

Results

There was no significant difference in age, body weight, height and sex distribution between the two groups. There was also no significant difference in duration of anesthesia and operation (table 1).

Anesthetic Induction and Recovery

Sleep-onset and induction time were not significantly different between the group S and H (table 2). But we have an impression that the induction in group S was smoother, because there was no rejection of sevoflurane's odor especially in older children. The recovery time was not different between the groups (table 2), however, the children in group S recovered more clear-headedly and were not so excited as group H.

Blood pressure and Heart rate

In group S, systolic blood pressure did not fall during induction and increased 9.3 per cent during operation (table 3). In group H, the systolic blood pressure fell 11% during induction. The heart rate decreased 13.2% from preanesthetic value ($P<0.01$) in group S, but it did not change

Table 3. Changes in systolic blood pressure and heart rate

		Preinduction	Before incision	Highest value during operation
Systolic blood pressure (mmHg)	Group S	108±19	104±17	118±16*
	Group H	112±12	100±14*	114±11
Heart rate (beats/min)	Group S	129±39	112±19*	122±19
	Group H	126±35	112±21*	118±27

Values are mean±S.D. *$P<0.05$ when compared with preinduction
Group S: Sevoflurane group No significant differences between the groups
H: Halothane group

Table 4. Incidence of complications during induction

	Sevoflurane group	Halothane group
coughing	1	3
breath holding	2	2
hiccupping	2	2
arrhythmia	3	2
muscle rigidity*	9	0
respiratory depression*	5	0
nausea	3	3
vomiting	2	4
fever*	0	4

* $P<0.05$

significantly in group H (table 3).

Complications

During induction of anesthesia, a few children showed coughing, breath holding and hiccupping in both groups, but none of them developed severe laryngospasm. Five children (10%) in group S developed severe respiratory depression (almost apneic) and nine children (18%) developed transient muscle rigidity of the extremities. The rigidity disappeared spontaneously within 20–30 seconds. Postoperative nausea and vomiting occurred in 10% of group S and in 14% of group H. Fever above 37.5°C occurred in 8% of group H during the postoperative period (highest valule, 38.2°C) in contrast to 0% in group S (table 4).

Discussion

In pediatric cases, large number of the operations are minor surgey, and only overnight hospitalization is required in most cases. An inhalational anesthetics, which had low irritability to the airway, prompt recovery, and low incidence of postoperative nausea and vomiting is the choice of general anesthesia for such cases[4]. These are in addition to the usual conditions of inhalational anesthetic agents, such as non-flamability, absence of organ toxicity and cardiovascular depression, and rapidity of induction and recovery. But sevoflurane has not been evaluated in pediatric cases. The purpose of the present study was to evaluate the feasibility of sevoflurane, as an anesthetic agent for the pediatric cases compared with halothane.

The rapidity of induction depends on such factors as the blood/gas partition coefficient and alveolar ventilation. Since the induction of anesthesia in young children is carried out by inhalation of general anesthetics, respiratory depression such as reduced minute ventilation, high incidence of breath holding, or their rejection to the irritable odor will affect the rapidity of induction. Althouth we have the impression that induction with sevoflurane was much smoother, because older children without premedication accepted more easily the mask ventilation with sevoflurane, the

sleep-onset and induction time in group S were not significantly different from these with halothane in our study. Such result may be more likely dependent on the degree of respiratory depression by the two different agents. During induction in group S, coughing and breath holding occurred in 2 and 4%. They disappeared in several seconds without severe laryngospasms. This suggests that the odor of sevoflurane is less pungent than that of halothane and children's acceptance of sevoflurane is better.

Severe respiratory depression occurred in five children (10%) in group S. This disappeared soon after skin incision, but assisted or control ventilation would be required for much safer induction. Whereas, there was no severe respiratory depression in group H. This difference also affects most likely the sleep-onset and induction times. Transient muscle rigidity of the extremities occurred in 18% of the children in group S, in contrast 0% in group H. Spontaneous breathing was well maintained, even though this muscle rigidity occurred, and it disappeared in the deeper anesthetic level. Such muscle rigidity is not only due to the anesthetic plane, but also to the unknown exciting effect of sevoflurane.

The sleep-onset, induction, and recovery times with sevoflurane were no more rapid than those with halothane. The children in group S, however, were more calm and clear-headed after anesthesia than the group H. The children in group H tended to be more excited or asleep after anesthesia. Many of the older children in group S, however, were awake and could answer accurately to our questions.

The changes in blood pressure and heart rate during sevoflurane anesthesia were within 15%. It is reported that sevoflurane significantly decreases blood pressure and dose not affect heart rate in adults[2,5]. But in our study, the blood pressure was well maintained even before skin incision and the heart rate decreased 14%. The mechanism of such results is unclear, but may be due to no premedication in healthy children. Our study showed that sevoflurane (3–4%) is a safe anesthetic agent for healthy children, because of its low degree of cardiovascular depression.

The incidene of postoperative nausea and vomiting was low (about 4–6%) in both the sevoflurane and the halothane groups. None of group S demonstrated postoperative fever above 37.5°C. This may be the result of much earlier, and enough oral intake of clear water postoperatively in group S than group H, since they were more clear-headed in postoperative period.

In conclusion, the present study showed the clinical usefulness of sevoflurane in pediatric anesthesia, however further investigation is required to evaluate its MAC, the effects on metabolism, respiration, circulation and the central nervous system in children. The present study suggests that sevoflurane may be suitable for pediatric anesthesia for minor surgery.

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