Rapid inhalation induction in children: 8% sevoflurane compared with 5% halothane


Summary

Sevoflurane has a lower blood-gas solubility and a less pungent odour than halothane; this may allow more rapid induction of anaesthesia. In a randomized, blinded study, we compared the induction characteristics of maximum initial inspired concentration of 8% sevoflurane and 5% halothane using conventional vaporizers in children aged 3 months to 3 years. There was no statistically significant difference in induction times between the two groups: mean times to loss of consciousness were 1 min 12 s (SD 18 s, range 40 s–1 min 44 s) for sevoflurane and 1 min 16 s (SD 17 s, range 50 s–1 min 52 s) for halothane, although these times were shorter than in previous studies using a gradual increase in vapour concentration. A small number of complications were noted in both groups, although none interfered with induction of anaesthesia. Struggling scores were lower in the sevoflurane group than in the halothane group (chi-square for trends \( P < 0.02 \)). A significant number (11 of 15) of parents of children in the sevoflurane group who had previous experience of halothane induction preferred sevoflurane (chi-square for trends \( P < 0.05 \)). We conclude that with this technique, induction was rapid with both sevoflurane and halothane. Our assessment of patient struggling and parents’ perceptions suggests that induction with sevoflurane was more pleasant than with halothane. \(^{1-4}\) It is possible however that a technique using high initial inspired concentrations of sevoflurane may be very rapid and we have therefore compared sevoflurane with halothane using maximum initial inspired concentrations delivered by conventional vaporizers in a randomized, blinded study.

Patients and methods

We studied 52 patients, aged 3 months to 3 years, ASA I–III allocated randomly to receive either sevoflurane or halothane for induction of anaesthesia. Patients were excluded if they had significant cardiac, respiratory, hepatic, renal, neurological or neuromuscular disease. There were two ASA III patients who had recurrent chest infections/bronchiolitis from oesophageal stenosis secondary to previous tracheo-oesophageal fistula and oesophageal reflux, respectively. The study was approved by the local Ethics Committee and parents gave informed written consent.

All patients received atropine 20 \( \mu g \) kg\(^{-1} \) orally, 1 h before anaesthesia. No other premedication was prescribed and a parent was present at induction. Anaesthesia was induced by one of five anaesthetists using a standard technique. The anaesthetic was delivered by the use of a Mapleson F breathing system, with the anaesthetist holding the angle piece (without a mask) as close to the child’s face as could be tolerated. The selected inhalation agent was administered with 66% nitrous oxide in oxygen at a vaporizer setting of either 5% for halothane or 8% for sevoflurane. The times taken to loss of consciousness (loss of eyelash reflex), acceptance of face mask and end of induction (small pupils, no gross bodily movements and regular respirations) were recorded for all patients by a trained observer. The

Sevoflurane is relatively non-irritant, and because of its low blood-gas solubility, it may have a rapid effect. It has recently been licensed for use in many countries around the world, and could therefore become the preferred inhalation induction agent for children.

Previous studies comparing the induction characteristics of sevoflurane and halothane in children used a technique in which the inspired concentrations were increased gradually, and only two of four showed that sevoflurane induced anaesthesia more rapidly than halothane.\(^{1-4}\) It is possible however that a technique using high initial inspired concentrations of sevoflurane may be very rapid and we have therefore compared sevoflurane with halothane using maximum initial inspired concentrations delivered by conventional vaporizers in a randomized, blinded study.

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Sevoflurane compared with halothane induction in children

 vaporizers were concealed by a screen and adjusted by an anaesthetic assistant, with both the anaesthetist and the observer blinded to the selection of the anaesthetic vapour. During induction, the vaporizer setting could be reduced by stepwise reductions at the request of the anaesthetist if clinically indicated. When induction was complete, anaesthesia was continued with 2% halothane.

As soon as possible during induction of anaesthesia, which took place either on the parent's lap or on a trolley, pulse oximeter saturations (Ohmeda Biox 3740), heart rate (Simonsen & Weel Diascope DS 521) and non-invasive arterial pressure measurements (Dinamap 1640) were recorded at 1-min intervals. In some children it was possible to apply the pulse oximeter probe before induction, and in the remainder it was applied immediately after loss of consciousness. The first arterial pressure recording was obtained 1 min after loss of consciousness in the majority of cases. Any untoward events (cough, laryngospasm, secretions, breath-holding, vomiting, bronchospasm and excitement) were noted and scored (1 mild, 2 = moderate, 3 = severe). Movements before loss of consciousness were classified as struggling and those afterwards as excitement. A struggling score of 1 was given for head movement only, 2 for mild struggling with head and limb movements and 3 for more severe struggling. All observations and measurements were made and recorded by the same trained observer throughout the study. At the end of induction the anaesthetist was asked to give an opinion on which agent had been used.

Parents were interviewed the following day, either on the ward or by telephone if the child had already been discharged. They were asked specific questions where appropriate about how this induction compared with previous experience of inhalation induction of anaesthesia with halothane (How did this anaesthetic induction compare with previously? Better, identical or worse?).

Randomization was performed with random number tables. The Student’s unpaired t test was used for comparisons of induction times and lowest oxygen saturations. The chi-square test for trends was used to compare struggling scores and parental comparison with previous halothane anaesthesia. A test of the difference in proportions was used to compare the incidence of excitement with the two agents. Statistical significance was accepted when \( P < 0.05 \).

Results

Of the 52 patients studied, 27 received halothane and 25 received sevoflurane. One patient in the halothane group did not lose consciousness within 5 min, raising suspicion of equipment malfunction. The vaporizers were uncovered and the sevoflurane vaporizer was removed from the back bar. Induction then continued successfully with halothane. This patient was removed from the study, leaving complete data on 26 patients in the halothane group and 25 in the sevoflurane group. The distribution of age, weight and ASA grading was similar between the two groups (table 1). There were more boys because of inclusion of urological patients in the study.

Mean time to achieve loss of consciousness (loss of eyelash reflex) was shorter with sevoflurane (1 min 12 s; SD 18 s; range 40 s–1 min 44 s) than with halothane (1 min 16 s; 17 s; 50 s–1 min 52 s) but this small difference was not statistically significant (\( P = 0.43 \)) (fig. 1). Similarly, mean time to acceptance of the face mask (fig. 2) and mean time taken to complete induction (fig. 3) were slightly shorter in the sevoflurane group but the differences were not statistically significant between the two groups (\( P = 0.47 \) and \( P = 0.25 \), respectively). Loss of consciousness was achieved in less than 1 min in six patients in the sevoflurane group and in eight patients in the halothane group. In one patient in the...
Seventeen children who received halothane were classified as having severe struggling compared with 10 in the sevoflurane group (fig. 4). Struggling scores were significantly lower in the sevoflurane group than in the halothane group (chi-square for trends = 6.34, P < 0.02).

Complications are summarized in figure 5; all were short lived and did not interfere with induction of anaesthesia. Excitement, defined as movements occurring after loss of consciousness, occurred in four patients in the sevoflurane group, two episodes of which were classified as severe. One patient who received sevoflurane demonstrated mild excitement, breath-holding and laryngospasm. The difference in the incidence of excitement was not statistically significant (P = 0.11). No child vomited, had excess secretions, bronchospasm or coughed. Lowest and highest heart rates and arterial pressures were similar in both groups. Three patients had oxygen saturation values less than 94%, two in the sevoflurane group and one in the halothane group (fig. 6), but no patient had saturations less than 92%. Comparison of the lowest oxygen saturations showed no statistically significant differences between the two groups (P = 0.12). There were no clinically significant episodes of desaturation in any patient. During induction of five patients, after loss of consciousness, the anaesthetist requested a reduction in the inspired vapour concentration to 50% of the initial setting. In one case this reduction was because of bradycardia (heart rate decreased from 162 to 71 beat min$^{-1}$) while receiving halothane and in the other cases (two in each group), this reduction was in response to clinically assessed hypoventilation.

Twenty-nine patients had undergone previous gaseous induction with halothane (15 in the sevoflurane group). The parents of 11 sevoflurane patients and three halothane patients preferred the study induction to previous experience (fig. 7). This difference was statistically significant (chi-square for trends = 4.03, P < 0.05).

The anaesthetists’ opinions of which agent had been used were correct in 23 of 25 patients in the sevoflurane group, but in only 17 of 27 patients in the halothane group.
Discussion

Inhalation induction remains a widely used technique in paediatric anaesthesia, particularly for small children in whom i.v. cannulation may be difficult. Because of its lack of airway irritation and smooth, relatively rapid induction qualities, halothane has remained the preferred agent for inhalation induction in children, despite its unpleasant odour, potential for hepatic damage and increased incidence of arrhythmias. Sevoflurane has a lower blood-gas solubility and a less pungent odour, suggesting that induction may be more rapid than with halothane with a low incidence of complications during induction.

Our study demonstrated no significant difference between induction times for the two agents at maximum initial inspired concentrations. The sample size of 52 patients gave 80% power at the 5% level of detecting a difference in induction times of 14 s. However, the use of maximum inspired concentrations allowed us to achieve shorter induction times: 1 min 12 s and 1 min 16 s with sevoflurane and halothane, respectively, compared with 1 min 41 s and 2 min 17 s in a previous study undertaken at this institution using a gradual increase in vapour concentration. These short induction times are in keeping with previous studies examining the use of high initial inspired concentrations of sevoflurane.

The more rapid induction seen with sevoflurane compared with halothane in previous studies may reflect the fact that equivalent minimum alveolar concentrations were not used. We chose to compare inspired concentrations of 8% sevoflurane and 5% halothane, as these were the maximum concentrations that could be delivered by the vaporizers available to us. Based on published data, Lerman regards an inspired concentration of 7% sevoflurane as equivalent to 4.5% halothane, a similar ratio to that used in this study. He does not believe that induction with sevoflurane should be faster than with halothane when over-pressure techniques are used, and the results of this study appear to support this view. To confirm this point, however, the anaesthetic would need to be delivered via a mask that was applied firmly to the face from the beginning of induction. This would probably be unacceptable in children when over-pressure is used, at least for induction with halothane.

Sevoflurane was not associated with any major airway complications, with a few episodes of mild breath-holding and laryngospasm. Although the use of atropine is not universal in this age group, unpublished data from our own laboratory suggest that the incidence of airway complications is higher in infants when it is not used. It is possible that the use of atropine as a premedicant in this study was a factor in minimizing the incidence of airway problems during induction. Excitement, a term used to describe involuntary movements occurring after loss of consciousness, occurred exclusively in the sevoflurane group, but did not interfere with the course of induction. This excitement occurred with a lower frequency than documented in previous studies using a technique involving a gradual increase in sevoflurane concentration.

It is difficult to determine preference for any particular induction agent in patients of this age group, although adult volunteers have found the smell of sevoflurane more acceptable than halothane. We have attempted to assess this factor, by assessing the degree of patient struggling during induction, and questioning the parents on the following day. Our results demonstrated that struggling was more severe in the halothane group. The majority of parents whose children received sevoflurane felt that the present anaesthetic was preferable to their previous halothane anaesthetic. We believe that these two results suggest a more pleasant induction for children with sevoflurane.

We did not detect any significant difference in the time taken to induce anaesthesia with sevoflurane compared with halothane when used with high initial inspired concentrations. Although the trained observer was at a sufficient distance from the patient so as not to be able to detect the odour, we suspected that blinding of the anaesthetists would be confounded by their ability to detect which agent was being administered. This was found not to be the case. Despite Lerman’s prediction that induction times for the two agents would be similar when over-pressure was used, the speed of induction with halothane surprised us, and previously held assumptions may explain why the anaesthetists erroneously thought that 10 patients in the halothane group had been given sevoflurane.

The significant difference in struggling scores and in parental preference suggest that in children aged 3 months to 3 years, sevoflurane provided more pleasant induction.

Acknowledgements

We are grateful to Abbott laboratories for the supply of sevoflurane. Professor Hatch, Dr Sigston and Mr Jenkins were supported by a foundation grant from Portex.

References