Sevoflurane compared with halothane for tracheal intubation in children

K. O'BRIEN, R. KUMAR AND N. S. MORTON

Summary
We have studied 40 healthy children, aged 3–10 yr, undergoing adenotonsillectomy, in a double-blind, randomized study. Intubating conditions were assessed when the pupils had become small and central after inhalation induction with either 5% halothane and 60% nitrous oxide in oxygen or 8% sevoflurane and 60% nitrous oxide in oxygen. The quality of tracheal intubation was graded according to ease of laryngoscopy, position of the vocal cords, coughing, jaw relaxation and movement of limbs. Fewer children had significant vocal cord movement on laryngoscopy (P<0.01) and more had ideal intubating conditions when halothane was used (12 of 20 compared with seven of 20; ns). Time to reach the clinical end-point for intubation was reached sooner with halothane (P=0.015). In all children the trachea was intubated successfully at the first attempt and all remained haemodynamically stable throughout induction. (Br. J. Anaesth. 1998; 80: 452–455)

Keywords: intubation tracheal; anaesthesia, paediatric; anaesthetic techniques, induction; anaesthetics volatile, halothane; anaesthetics volatile, sevoflurane

Tracheal intubation may be facilitated in children by succinylcholine, non-depolarizing neuromuscular blocking agents or by using a combination of propofol and alfentanil. Inhalation induction is often used in paediatric practice and there is renewed interest in the technique since the introduction of sevoflurane. Sevoflurane is non-irritant to the airway, non-pungent and provides rapid induction because of its low blood:gas solubility. Many studies have demonstrated the acceptability and rapidity of inhalation induction with sevoflurane in children. The ED95 end-tidal sevoflurane concentration for tracheal intubation has been reported as 4.68% (mean) but with wide 95% confidence intervals (3.91–12.74%). The decision on when the child is ready for intubation is based on clinical indicators of depth of anaesthesia. Constriction and centralization of the pupils and the presence of a regular diaphragmatic respiratory pattern (automatic breathing) indicate that the plane of “surgical anaesthesia” has been reached.

Halothane has been used worldwide for many years and provides smooth inhalation induction and good intubating conditions. It remains the intubating agent of choice for the difficult airway but may produce myocardial depression and cardiac arrhythmia. It undergoes significant metabolic breakdown and may cause the rare, but serious, complication of hepatitis. Intubating conditions have been compared after inhalation induction with halothane and sevoflurane in one Japanese study but assisted ventilation via a face mask was used before intubation. Our study was designed to assess the performance of the two agents in elective cases while maintaining spontaneous respiration before a formal assessment in children with airway compromise. Our aim was to mimic as far as possible the technique which would be used in children with airway obstruction but ethical considerations determined that we had to include nitrous oxide in the induction gas mixture.

Patients and methods
After obtaining local Ethics Committee approval and informed written consent from the parents or from the child if appropriate, we studied 40 ASA I or II children undergoing elective adenotonsillectomy. Children with significant airway, cardiac, respiratory, renal, hepatic or central nervous system diseases were excluded. No child had received a general anaesthetic within the past 2 weeks, and any child with a history of an unusual response to a halogenated anaesthetic was excluded. Each child was allocated randomly to undergo inhalation induction with either halothane or sevoflurane using a computer-generated randomization programme (Triallaid; Dr G. Hutchison, Dundee).

All children received sedative and antiemetic premedication with trimiprazine 2 mg kg$^{-1}$, 1–1.5 h before induction, and EMLA cream (eutectic mixture of local anaesthetics) was applied 1 h before induction. On arrival in the induction room, initial non-invasive measurements were performed. These included: heart rate (HR), arterial oxyhaemoglobin saturation by pulse oximetry ($Sp_O_2$) and arterial pressure by automatic oscillometry (MAP). The arterial pressure reading was omitted before induction in some children if they found it upsetting.

Each child received inhalation induction with either halothane or sevoflurane and 60% nitrous oxide in oxygen. Incrementally increasing doses of volatile agent were used until the child was breathing 8% sevoflurane or 5% halothane. The rate of
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Table 1 Scoring system for intubating conditions

<table>
<thead>
<tr>
<th>Score</th>
<th>Laryngoscopy</th>
<th>Vocal cords</th>
<th>Coughing</th>
<th>Jaw relaxation</th>
<th>Limb movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy</td>
<td>Open</td>
<td>None</td>
<td>Complete</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Fair</td>
<td>Moving</td>
<td>Slight</td>
<td>Slight</td>
<td>Slight</td>
</tr>
<tr>
<td>3</td>
<td>Difficult</td>
<td>Closing</td>
<td>Moderate</td>
<td>Stiff</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Impossible</td>
<td>Closed</td>
<td>Severe</td>
<td>Rigid</td>
<td>Severe</td>
</tr>
</tbody>
</table>

Results

The 40 children enrolled in the study were allocated equally between the halothane and sevoflurane groups. All children easily tolerated inhalation induction and all completed the study. There were no significant differences in patient characteristics between the two groups (table 2).

Intubation was successful in all children at the first attempt, without the need for other interventions, and all had grade 1 laryngoscopies. In each group, only one patient had a score of 3 in any one category (i.e. 19 of the 20 children in each group were assessed as having acceptable intubating conditions). One patient in the sevoflurane group had excessive cord movement at laryngoscopy making intubation difficult, while in the halothane group one patient had moderate coughing after intubation. The scores for each category are shown in figure 1. Twelve of 20 children who received halothane had ideal intubating scores of 5 compared with only seven of 20 who received sevoflurane (ns). There was no significant difference between mean total intubation score per patient in the two groups (mean score in the halothane group 5.5; mean score in the sevoflurane group 5.85). There were no significant differences between the groups in assessments of laryngoscopy, coughing, limb movement or jaw relaxation. However, the vocal cords were more likely to be moving or closing in the sevoflurane group (P=0.01). Time to reach the clinical end-point for intubation was reached significantly more rapidly in the halothane group (P<0.015, table 3) and there was no relationship between intubation time and total intubation score (fig 2).

All patients remained haemodynamically stable during the study with no significant differences between the two groups in HR or MAP before intubation, immediately after intubation, or at 1, 2 or 3 min after intubation. Oxyhaemoglobin saturation remained greater than 95% in all patients throughout the study.

Discussion

Inhalation induction with sevoflurane is undoubtedly a useful addition to the techniques available to the paediatric anaesthetist and has been studied and reviewed extensively.8–22 Recent studies have noted that induction was more rapid with sevoflurane and halothane when an “overpressure” technique was used rather than using incremental increases in inspired concentration.12 As part of a meticulous dose-finding study4 to calculate the ED95 and ED5 end-tidal sevoflurane concentrations for tracheal intubation, the mean time to reach the ED95 value was comparable (213 (sd 23) s) with the times in our study (table 3), despite the fact that the previous study used an overpressure method without nitrous oxide. The overpressure technique has been associ-

incremental increase was determined by tolerance to the face mask which in practice implied every three breaths (an increase of 0.5% in the halothane vaporizer setting or 1% for sevoflurane). I.v. access was established and the vaporizer was covered. One of two senior anaesthetists were allowed into the induction room where they assessed continuously pupil size and position. When the pupils were deemed to be small and central, the trachea was intubated. Having entered the room only when the patients were asleep, and with all gases scavenged where possible, the intubating anaesthetist was unaware, as far as possible, of the induction agent used. We did not record the concentration of end-tidal volatile agent or time breathing the maximum available vapour concentration.

The quality of the intubating conditions was assessed and recorded immediately by the senior intubating anaesthetist. The scoring system used was that devised by Helbo-Hansen, Ravlo and Trap-Anderson18 and revised by Steyn and colleagues.7 Variables assessed were ease of laryngoscopy, vocal cord position, coughing on laryngoscopy or on intubation, jaw relaxation and presence or absence of limb movement on intubation. All variables were allocated a score of 1–4, with 1 being ideal conditions. Therefore, the best possible score was 5. Intubating conditions were considered unacceptable if a score of 3 or 4 was recorded in any individual category (table 1).

When the trachea was intubated, the child continued to breath 1 MAC of the volatile anaesthetic until all measurements were complete, at which point patients were transferred to the operating room and maintained on isoflurane and nitrous oxide in oxygen until the end of surgery. Opioids were administered only when recordings were complete. Recordings of HR, SpO2, and MAP were obtained when the eyelash reflex was lost, immediately after intubation, and at 1, 2 and 3-min intervals after intubation. The study ended at this point.

Statistical Analysis

The chi-square test and Mann–Whitney U test were used for non-parametric data and the Student’s t test for parametric data. Minitab v 11 was used for data handling and statistical analysis. Prospective power analysis (Triallaid) revealed that a group size of 16 would be required to detect a 20% difference between groups with 95% power and P = 0.05.
ated with restlessness and agitation during induction, which is improved by adding nitrous oxide. The MAC-reducing properties of 60% nitrous oxide are less for sevoflurane (20–25% vs 60% for halothane) which may explain the more rapid induction with incrementally increasing doses of halothane in nitrous oxide, as was seen in our study.

The clinical end-point used in our study was reached in a similar time in a previous study, but sevoflurane-treated children in that study reached the end-point significantly more rapidly (238 (SD 68) s) than halothane-treated patients (290 (SD 87) s) (P=0.027). That study included infants as young as 6 months. Another comparative paediatric study of sevoflurane and halothane included a formal assessment of intubating conditions. In that study, children became apnoeic after approximately 3 min and were not deemed to be ready for intubation until approximately 10 min whether the child received halothane or sevoflurane. Nitrous oxide was used and intubating conditions were assessed using a different, unvalidated scoring system. Although intubating conditions were deemed to be better with halothane, the authors commented that viewing of the vocal cords was difficult in a significant number of patients in both the halothane and sevoflurane groups. Limb movement occurred in 25% of patients in each group. These findings suggest that the induction technique was unsatisfactory in both groups. In our study, we found satisfactory intubating conditions in 38 of 40 patients using the clinical end-point of small centralized pupils. This was achieved within 100–335 s in all cases while maintaining spontaneous ventilation. This end-point was reached significantly earlier with halothane and more ideal intubating conditions were found in children who had received halothane. This may reflect the greater potency of halothane amplified by the larger MAC-reducing effect of nitrous oxide.

Although at 1 MAC inspired concentrations, sevoflurane and halothane cause comparable respiratory depression, this has not been confirmed for deep levels of anaesthesia. A significant proportion of children attending for adenotonsillectomy have a history of sleep-obstructed breathing and induction time may be longer in this population. The use of a pupillary end-point provides a consistent and reliable clinical sign of readiness for intubation and was achieved in our study relatively quickly. This may be because we used up to 8% sevoflurane or 5% halothane whereas previous studies of time to intubation used lower inspired concentrations.

In view of the reported high incidence of restlessness with oxygen–sevoflurane mixtures, we felt it was unethical to omit nitrous oxide for elective cases but we recognize that 100% oxygen is needed for induction of anaesthesia in children with airway compromise. Although the results of this study suggest a higher percentage of patients reach ideal intubating conditions more rapidly with incremental halothane than with incremental sevoflurane induction, in all children the trachea was intubated and 38 of 40 children had satisfactory intubating conditions. It is important to formally compare the intubating conditions of sevoflurane–100% oxygen with the gold standard of halothane in oxygen in children with airway compromise.

![Figure 1](image1.png) Intubation assessment scores: number of patients with scores of 1, 2 or 3 in each assessment category (laryngoscopy (lar.), vocal cords (cords), cough, jaw relaxation (jaw), limb movement (limb)) for children receiving halothane (hal.) or sevoflurane (sevo.). There were no scores of 4.

![Figure 2](image2.png) Total intubation scores for each patient vs time to reach the clinical end-point for intubation. There was a broad spread of times for each total score.

**Table 3** Time to reach clinical end-point for intubation (pupils small and central) (mean (SD) [range])

<table>
<thead>
<tr>
<th></th>
<th>Halothane</th>
<th>Sevoflurane</th>
<th>P</th>
</tr>
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<tbody>
<tr>
<td>Time (s)</td>
<td>200.25</td>
<td>243.4</td>
<td>0.015</td>
</tr>
<tr>
<td>(53.9) [100–277]</td>
<td>(52.9) [125–335]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References