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Forum

Induction and recovery characteristics of isoflurane and halothane anaesthesia for short outpatient operations in children

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Summary

Induction and recovery characteristics of isoflurane anaesthesia were compared with halothane anaesthesia during outpatient myringotomy and placement of Sheely ventilation tubes in 101 unpremedicated children. Compared with halothane, isoflurane resulted in prolonged induction times and inferior induction scores due to increased salivation, coughing, breathholding and laryngospasm. However, when modified by halothane induction, isoflurane anaesthesia decreased induction time and improved induction scores. Induction with thiamylal 4 mg/kg did not improve induction scores significantly. Recovery times from halothane plus isoflurane and pure isoflurane anaesthesia were quicker than pure halothane and thiamylal plus isoflurane, although this was not statistically significant. Compared to halothane, anaesthetic induction using isoflurane is associated with an increased incidence of respiratory problems in unpremedicated children.

Key words

Anaesthesia; outpatient, paediatric.
Anaesthetics, volatile; halothane, isoflurane.

Isoflurane, a relatively insoluble and inert volatile anaesthetic[1] with minimal cardiac depressant properties[2] and low potential for organ toxicity[3], would appear to be an agent of choice for repeated short outpatient paediatric surgical procedures. However, the rate of induction may be limited by the mildly pungent ethereal odour of isoflurane.[4] The aim of the study was to assess whether isoflurane anaesthetic alone or a modified isoflurane anaesthetic, using either halothane or intravenous barbiturates for induction, would be superior to the conventional halothane in nitrous oxide and oxygen anaesthesia for outpatient paediatric surgery.

Methods

We studied 101 unpremedicated ASA physical status 1 and 2 children between the ages of 8 months and 14 years, scheduled for myringotomy and Sheely tube placement. Institutional approval for the study was obtained. During the period of study, we included all the children who came for the above procedure and whose parents agreed to their participation; children with a history of asthma or significant cardiac disease were excluded. Children having upper respiratory symptoms or those who were recovering from them were not excluded.

Induction. The patients were randomly assigned to one of the first three groups by a draw from a hat. Group 1 ($n = 25$): anaesthesia was induced and maintained with halothane, nitrous oxide and oxygen. Group 2 ($n = 36$): anaesthesia was induced and maintained with isoflurane, nitrous oxide and oxygen. Group 3 ($n = 29$): anaesthesia was induced with halothane, nitrous oxide and oxygen; when the breathing became regular and pupils central and fixed at that point, isoflurane was introduced, halothane was stopped, and anaesthesia

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Table 1. Induction and recovery scores

Symptom	Worst 1	Fair 2	Best 3
Salivation	Pouring out	Little wet	None
Coughing	Persistent	Self-limiting	None
Breath holding	Persistent	Temporary	None
Laryngospasm	No air entering	Partial air entry	None
Bronchospasm	Unable to ventilate	Wheeze	None
Vomiting/retching	Persistent	Temporary	None
Excitement/restlessness	Severe problems	Some problems	Totally uneventful

Table 2. Demography

Group	Age (years) Mean (SD)	Weight (kg) Mean (SD)	Duration of anaesthesia (minutes) Mean (SD)
1 (Halothane)	4.08 (2.29)	17.97 (5.47)	20.26 (6.76)
2 (Isoflurane)	4.38 (2.53)	19.87 (11.1)	19.15 (6.38)
3 (Halothane + isoflurane)	3.92 (2.43)	17.95 (7.27)	19.96 (6.67)
4 (Thiamylal + isoflurane)	7.03 (4.70)	26.92 (12.58)	21.72 (8.78)
ANOVA p value	0.0140	0.0662	0.7335

continued with isoflurane, nitrous oxide and oxygen. Group 4 ($n = 11$): patients were not randomly assigned. These older children either agreed to intravenous induction or were chosen by anaesthesia staff, to be induced intravenously, and were first given 4 mg/kg of thiamylal and then given isoflurane in a nitrous oxide–oxygen mixture by mask. All the anaesthetics were administered by a trainee anaesthetist or a student nurse anaesthetist, under the close supervision of a staff (consultant) anaesthetist.

Anaesthesia was induced in the first three groups with a few breaths of nitrous oxide and oxygen at a flow rate of 6:2 litres/minute and the volatile agent was then slowly introduced with the facemask close to the face. After about 30 seconds, the nitrous oxide to oxygen ratio was changed to 4:2 litres/minute and the mask was then applied to the face tightly, increasing the concentration of volatile anaesthetic in a stepwise fashion. Nitrous oxide, oxygen and a volatile anaesthetic were introduced in the same way, following intravenous induction with thiamylal in the patients in Group 4. Anaesthesia was maintained in all patients with nitrous oxide and oxygen (4 and 2 litres/minute) and a clinically appropriate concentration of the volatile agent. We used a disposable modified Jackson Rees system for children weighing less than 20 kg and a paediatric circle system for those weighing 20 kg or more. No muscle relaxant was used except in one patient in Group 2, when suxamethonium was given to relieve severe laryngospasm.

Minute-to-minute vital signs (ECG, systolic and diastolic arterial pressure, pulse rate and respiration rate) were recorded throughout the induction of anaesthesia. The blood pressure and pulse rate were recorded with an automatic blood pressure measurement device (Dinamap). Both induction time and induction scores were noted. Induction time was defined as the time from placement of mask to the face to the time pupils became central and fixed, and breathing became regular.

Induction scores were given according to reactions categorised in Table 1. One of the authors, (U.P.), acted as the rater/observer who assigned all induction scores while a different person anaesthetised the children. The rater/observer was 'blind' to the anaesthetic agent used.

Maintenance. Nitrous oxide and oxygen were delivered at 4 and 2 litres/minute. The inspired concentration of volatile agents was monitored (it was between 1.5–2.5% for both halothane and isoflurane). End tidal concentration of volatile agent was not controlled, because it is not possible in clinical practice to maintain a constant alveolar concentration of the agents throughout the operation. Vital signs were recorded every minute. The duration of anaesthesia was also recorded.

Recovery. At the time of recovery, alert time and recovery scores were noted. Alert time was defined as the time from discontinuation of anaesthesia to the time the child was awake and appropriately rational in response to verbal commands; for the younger children, normal interaction with parents was the end point. Whenever possible (in older children), the orientation to place, day and date of birth were the criteria. Recovery scores were graded on the same scale as induction scores. These scores were given by two of the recovery room nurses who were unaware of the anaesthetic agent used.

Numerical data from each group regarding demo-

graphic characteristics, induction times and alert times were compared with each other, using one-way analysis of variance and then a multiple comparison between the groups was carried out using Scheffe's technique. Contingency tables, 4 and 6 from recovery and induction scores were analysed by generalised Chi square analysis of categorical data, using the computer package at the University of Michigan, called GEN CATS.

Results

Demographic data are shown in Table 2. Groups 1, 2, and 3 were comparable in age and weight, while Group 4 included older children with greater body weight. However, the duration of anaesthesia was similar in all the groups.

The number of children with upper respiratory symptoms or those recovering from them were 5, 6 and 6 in the first three groups, respectively. There was no statistically significant difference in terms of induction and recovery characteristics between those who had symptoms and those who did not in the three groups; we therefore combined them.

Induction time (Table 3) was shortest (3.36 minutes) in the pure halothane group and longest (5.42 minutes) in the pure isoflurane group ($p < 0.001$). Prior induction with halothane or intravenous thiamylal decreased induction time for isoflurane anaesthesia (4.46 and 3.90 minutes respectively, both significantly different from the induction time with pure isoflurane).

Table 3. Induction time

Group	Induction time (minutes) Mean (SD)
1 (Halothane)	3.36 (1.02)
2 (Isoflurane)	5.42 (2.03)
3 (Halothane + isoflurane)	4.46 (1.54)
4 (Thiamylal + isoflurane)	3.90 (2.07)

ANOVA $p < 0.001$: Scheffe's multiple comparisons p values; 1 versus 2 = < 0.001; 1 versus 3 = 0.0187; 1 versus 4 = 0.3726; 2 versus 3 = 0.0267; 2 versus 4 = 0.0113; 3 versus 4 = 0.3559.

Induction scores of individual groups are shown in Table 4. The highest score of 21 (i.e. the smoothest induction) was given to 18 out of 25 patients (72%) in the halothane group. In spite of the slow introduction of isoflurane and small step increases in concentration, only 14% (5 out of 36) of patients in Group 2 (isoflurane) had perfect induction scores. The reasons for inferior induction scores were that 67% of the patients in this group coughed, 50% had a mouth full of secretions, 33% held their breath intermittently, and 3 out of 36 (8.3%) went on to develop laryngeal spasm. On two occasions, the laryngeal spasm was partial and could be overcome by means of positive-pressure assisted ventilation with 100% oxygen. One patient's complete laryngeal spasm, i.e., inability to ventilate with positive pressure ventilation, was treated with suxamethonium and controlled ventilation. Children in Group 2 (pure isoflurane) lost control of their airways very quickly, by losing tone in their jaw muscles.

Halothane induction before the introduction of isoflurane in Group 3 did improve induction scores considerably; a perfect score was obtained in 72% of cases. However, intravenous barbiturate induction prior to isoflurane anaesthesia gave a perfect score in only 46% of cases. Thus, transition from halothane to isoflurane was smoother than from thiamylal to isoflurane.

There were no differences in heart rate or blood pressure in the various groups. However, during maintenance of anaesthesia three children developed ventricular dysrhythmia (premature ventricular contractions). Two of these belonged to Group 1 and one to Group 4. Of the two children in Group 1 (halothane), one required hyperventilation and the other, who had repeated installations of adrenaline drops in the ear, required a change of anaesthetic agent to enflurane. One child in Group 4 (thiamylal to isoflurane), required an increase in depth of anaesthesia. None of the three children required pharmacological treatment with intravenous lignocaine.

Alert times are shown in Table 5. Children given only

Table 4. Induction scores

Induction score	Group 1 (halothane)	Group 2 (isoflurane)	Group 3 (halothane + isoflurane)	Group 4 (thiamylal + isoflurane)
7–14	0	2	0	1
15–16	0	2	0	2
17–18	0	10	2	1
19	1	6	1	2
20	6	11	5	0
21	18	5	21	5
N	25	36	29	11

p values (Chi square) 1 versus 2 = < 0.001; 1 versus 3 = 0.5053; 1 versus 4 = 0.0084; 2 versus 3 = < 0.001; 2 versus 4 = 0.7981; 3 versus 4 = 0.0182.

isoflurane anaesthesia (Group 2) woke up slightly quicker than those receiving pure halothane anaesthesia (Group 1) (24 minutes compared to 27 minutes). Awakening was quickest after halothane plus isoflurane anaesthesia (Group 3, 22 minutes). Children who received barbiturates took the longest time to wake up (Group 4, 33 minutes). These differences in the recovery times, however, were not statistically significant (NOVA p = 0.1541).

Recovery scores are shown in Table 5. The smoothest recovery, i.e. a perfect score of 21, was obtained in 52% of the patients in Group 1 (pure halothane) but only in 8.3% of children in Group 2 (pure isoflurane). Perfect scores obtained in Groups 3 (halothane and isoflurane) and 4 (thiamylal and isoflurane) were 24.1% and 9.1% respectively. Soon after the termination of any isoflurane anaesthesia (Groups 2, 3 or 4), most of the children were awake, but were irrational and thrashed about on the bed (it was difficult to hold them still); they slept again and then woke up rational and alert. The incidence of coughing, drooling and spitting, nausea and vomiting was 75%, 33% and 22% respectively in Group 2 (isoflurane) as compared with 20%, 12% and 12% respectively in Group 1 (halothane). All the symptoms were self-limiting and did not require any treatment.

Discussion

Isoflurane is claimed to have several advantages, including low potential for organ toxicity, rapid elimination and less potential to disturb cardiac rhythm.[1,5,6] Moderate tachycardia and increased cardiac output associated with isoflurane (and not with halothane) could be an advantage in paediatric patients, because, in children, the cardiac output is mainly dependent on heart rate. Since potent volatile anaesthetics are still the mainstay of paediatric anaesthesia practice, we are thus very interested in this new product.

In our study of unpremedicated children, isoflurane anaesthesia was inferior to halothane anaesthesia, both in terms of induction and recovery characteristics for short paediatric surgical procedures. The ethereal odour and irritability of isoflurane to the respiratory tract[4] may be the cause for these low scores. The recovery room nurses, who assigned recovery scores blindly, were very often able to identify correctly the anaesthetic agent used, by the way in which the children behaved. Children receiving isoflurane anaesthesia were clearly more violent and had more upper respiratory tract problems in the recovery room, than those given halothane. The more rapid elimination of isoflurane may have made these children more prone to pain after the operation, more disorientated and irrational. The ethereal odour of isoflurane may have made their airways more irritable due to increased secretions.

While inducing anaesthesia with inhalation agents, we introduced both the inhalation agents slowly in a stepwise fashion, yet the reaction of the children to isoflurane was more turbulent than to halothane. However, it should be noted that all anaesthetics were administered by trainees (doctors or anaesthetic nurses). This may explain the greater incidence of respiratory problems that we experienced with isoflurane compared to those recently reported by Wren and his coworkers.[7]

It is possible that by using appropriate premedicants, such as narcotics and anticholinergics, one may be able to make both induction of and recovery from isoflurane anaesthesia more acceptable. However, many paediatric anaesthesiologists prefer not to premedicate children undergoing ambulatory surgery.

It is very likely that with more experience in the future, we will learn better techniques to make this new

Table 5. Alert time

Group	Alert time (minutes) Mean (SD)
1 (Halothane)	27.44 (12.86)
2 (Isoflurane)	24.36 (14.19)
3 (Halothane + isoflurane)	22.35 (12.25)
4 (Thiamylal + isoflurane)	33.00 (19.27)

ANOVA p value = 0.1541.

Table 6. Recovery scores

Recovery score	Group 1 (halothane)	Group 2 (isoflurane)	Group 3 (halothane + isoflurane)	Group 4 (thiamyl + isoflurane)
14	0	0	0	1
15–16	2	12	5	1
17–18	0	14	10	5
19	5	3	3	3
20	5	4	4	0
21	13	3	7	1
N	25	36	29	11

p values (Chi square groups 1 versus 2 = <0.001; 1 versus 3 = 0.0015; 1 versus 4 = <0.001; 2 versus 3 = 0.0421; 2 versus 4 = 0.9170; 3 versus 4 = 0.1482.

agent more acceptable for short paediatric surgical procedures. However, from our present study, we conclude that, when compared with isoflurane, halothane anaesthesia still provides smoother induction and recovery in unpremedicated children undergoing outpatient surgical procedures.

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