COMPARISON OF HALOTHANE AND ENFLURANE ANAESTHESIA FOR OTOLARYNGOLOGICAL SURGERY IN CHILDREN

L. LINDGREN

SUMMARY

Halothane and enflurane were compared in 132 children undergoing adenoidectomy with or without tonsilllectomy. Anaesthesia for adenoidectomy was induced with thiopentone or Althesin and for tonsilllectomy with thiopentone. The response to surgery was minimal (0-5%) during both inhalation anaesthetics. During immediate recovery, respiratory depression was more profound after enflurane than after halothane. Both the i.v. and the inhalation anaesthetics had an influence on recovery. The total recovery scores (0-10) based on activity, respiration, heart rate, consciousness and colour improved most rapidly after Althesin + enflurane and most slowly after thiopentone + halothane in the adenoidectomy groups. In the tonsillectomy groups, the recovery scores were better after enflurane than after halothane. After both inhalation anaesthetics, the frequency of shivering ranged from 0 to 17%.

During operations for removal of tonsils and adenoids it is important that swallowing and coughing are abolished, although these protective reflexes should be present at the end of operation. Smooth recovery without side-effects is desirable because vomiting and retching can cause bleeding from the operation site (Smith and Manford, 1974).

Halothane obtunds laryngeal reflexes and inhibits salivation, laryngospasm, bronchospasm and coughing. Recovery from halothane is relatively rapid. Therefore it has been the inhalation anaesthetic of choice for tonsil and adenoid (T + A) surgery (Morrow and Morrison, 1975). Halothane may increase bleeding from the operating site by increasing the blood flow in peripheral tissues (Black and McArdle, 1962). Halothane has negligible analgesic properties and it may even increase postoperative discomfort.

Enflurane has all the advantages of halothane (Goodman and Gilman, 1975): a rapid and pleasant recovery (Dobkin et al., 1969; Söderberg and Grattidge, 1975) and, in children, the recovery after enflurane is shorter than after halothane (Govaerts and Sanders, 1975; Davidson, 1978). One disadvantage of enflurane is c.n.s. excitation (Lebowitz, Blitt and Dillon, 1972).

The present study compares halothane and enflurane as inhalation anaesthetics for T + A surgery in children. Thiopentone and Althesin were compared as induction agents with both inhalation anaesthetics. Althesin was included because it produces shorter recovery than thiopentone in these conditions (Saarnivaara, 1974).

PATIENTS AND METHODS

Patients

The characteristics of 132 children studied are shown in table I, which also shows the operation and anaesthetic groups. In 75% of the children undergoing adenoid surgery, bilateral myringotomy was performed and ventilating tubes inserted.

Anaesthesia

The children fasted overnight before the operation which was always performed between 8 and 11 a.m. Premedication consisted of triclofos 70 mg kg\(^{-1}\) with atropine 0.03 mg kg\(^{-1}\) given orally about 90 min before induction.

In the adenoid group, 39 children received halothane and 45 enflurane. In the halothane group, anaesthesia was induced with thiopentone 5 mg kg\(^{-1}\) in 20 children and with Althesin 0.06 ml kg\(^{-1}\) in 19 children (enflurane group: 24 and 21). In the T + A group all received thiopentone 5 mg kg\(^{-1}\). The trachea was intubated following i.v. injection of suxamethonium 1.5 mg kg\(^{-1}\). Halothane was administered from a Fluotec Mark II vaporizer (Cyprane Ltd, Keighley, England) commencing with a concentration of 2 vol% and reducing gradually to 0.5% towards the end of the operation. Enflurane was administered from an Enfluratec vaporizer (Cyprane Ltd, Keighley, London, England) commencing with a concentration of 1.5 vol% and reducing gradually to 0.5 vol% towards the end of the operation.
England) commencing with a concentration of 3.5% and reducing to 1%. Both vapours were delivered in 70% nitrous oxide in oxygen. A Rees system was used for children weighing less than 25 kg and a circle system with carbon dioxide absorption for the remainder. Ventilation of the lungs was controlled or, in a few cases, assisted. End-tidal carbon dioxide concentration (%) was monitored 3 cm proximal to the inflow of fresh gas in the Rees system and at the outer end of the endotracheal tube in circle system using a Datex CD-101-CO₂ analyser (Instrumentarium Ltd, Helsinki, Finland). End-tidal concentration of carbon dioxide was maintained at 5.5–6%. Blood was sampled from the radial artery 17 ±4.5 (SD) min from the start of anaesthesia. Mean (±SD) for pH was 7.38 ±0.04; \( P_{CO_2} \) 5.2 ±0.6 kPa; base excess -2.2 ±1.2 mmol litre⁻¹; \( P_{O_2} \) 16.9 ±4.9 kPa. End-tidal concentrations of halothane and enflurane were monitored continuously at the same point as end-tidal carbon dioxide using a Medishield Multi-gas monitor MS2 (Cyprane Ltd, Keighley, England) which was calibrated before the start of each case. The mean end-tidal concentration for halothane was 0.64 and for enflurane 1.3. At the beginning of the operation, the mean end-tidal concentration for halothane was 0.78 and for enflurane 1.54. The corresponding figures during extubation were 0.45 and 0.7, respectively. The systolic and diastolic arterial pressures were measured indirectly every 5 min during anaesthesia. Heart rate and e.c.g. were continuously displayed by means of an oscilloscope and recorded. During apnoea after cessation of controlled ventilation, the lungs were inflated every 30 s. Respiratory rate and end-tidal carbon dioxide were recorded 3 min after the start of spontaneous breathing. Side-effects during the operation and extubation were noted. At the end of the operation, the otolaryngologist classified the antisialagogue effect as satisfactory or unsatisfactory. Before extubation, suction was applied to the mouth and pharynx. The mean durations of the operation and anaesthesia for adenoids were 20±7 (SD) min and 31±7 min, respectively and were 24±8 and 35±9 min for T + A surgery. All the children were anaesthetized by the author.

**Recovery room period**

A modification of the method of Aldrete and Kroulik (1970) was used to score recovery (table II) immediately after entering the recovery room and every 10 min after extubation. The time from extubation to consciousness (opening eyes on command) was recorded. Side-effects during recovery were noted. The children were given paracetamol suppositories 10 mg kg⁻¹ if they complained of pain, were restless or crying. If this was inadequate, pethidine 0.5 mg kg⁻¹ i.v. was given.

**Laboratory tests**

Venous blood was sampled from the cubital vein immediately before induction, after surgery and 2 h after extubation. Blood sugar was determined by a photometric enzyme method (GOD-Perid, Boehringer, Mannheim GmbH, W. Germany).
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Table II. Recovery score: 10 = completely recovered; 0 = serious derangement

| Score | Activity | | | Respiration | | | Circulation | | | Consciousness | | | Colour |
|-------|----------|----------|----------|-------------|----------|----------|-------------|----------|----------|-------------|----------|----------|
|       | Able to move 4 | Able to move 2 | Able to move no | Breathes adequately | Dyspnœa or limited breathing | Apnoea | Heart rate ±20% | Heart rate ±21-50% | Heart rate ±51% | Fully awake | Arousable | Not responding | Pink | Pale | Cyanosed |
|       | 2 | 1 | 0 | 2 | 1 | 0 | 2 | 1 | 0 | 2 | 1 | 0 | 2 | 1 | 0 |

Statistics

Student's t test both for paired and unpaired data was used for the statistical analysis of the results. Analyses of variance were used for the recovery scores.

RESULTS

As regards responses during the operation, the methods of anaesthesia did not differ significantly (table III). During anaesthesia systolic and diastolic arterial pressures and heart rate did not change significantly in any of the groups. No signs of central nervous system excitation during enflurane anaesthesia were seen in the present study.

The duration of apnoea after cessation of controlled ventilation was significantly shorter in the halothane than in the enflurane anaesthesia both in the adenoid (P < 0.001) and in the T + A groups (P < 0.01) (table IV). The mean respiratory frequency in all the halothane groups (38 b.p.m.) was significantly greater than that in the enflurane groups (24 b.p.m.) (P < 0.001) and the mean end-tidal carbon dioxide concentration significantly less (6.1% cf. 7.4%) (P < 0.001). The frequency of sighing during spontaneous breathing was less in the halothane group after both types of operation.

Recovery of consciousness was shorter after enflurane in all treatment groups (table V). In the adenoid groups anaesthetized with enflurane, recovery was shorter after Althesin than after thiopentone (P < 0.02). This difference was not statistically significant in the halothane groups. Recovery was shortest after Althesin + enflurane anaesthesia (16 ± 1.4 (SEM) min) and longest after thiopentone + halothane anaesthesia (34 ± 3.7 (SEM) min) in the adenoid groups.

After adenoidectomy the recovery scores in the Althesin + enflurane group improved most rapidly (fig. 1). Scores on entering the recovery room were affected only by the inhalation anaesthetics (P < 0.001), both the i.v. and inhalation anaesthetics having an equal effect on the scores 10, 20 and 30 min after extubation (P < 0.001). At 40 min the i.v. anaesthetic had a greater influence than the inhalation anaesthetic (P < 0.001). Sixty minutes after extubation the differences between the methods of anaesthesia were negligible (P < 0.05) and

Table III. Side-effects during operation and extubation. Number of children in parentheses

<table>
<thead>
<tr>
<th>During operation</th>
<th>During extubation</th>
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<tbody>
<tr>
<td></td>
<td>Response to mouth gag</td>
</tr>
<tr>
<td>Halothane Adenoids</td>
<td>Thiopentone (20)</td>
</tr>
<tr>
<td></td>
<td>Althesin (19)</td>
</tr>
<tr>
<td>T + A</td>
<td>Thiopentone (24)</td>
</tr>
<tr>
<td>Enflurane Adenoids</td>
<td>Thiopentone (24)</td>
</tr>
<tr>
<td></td>
<td>Althesin (21)</td>
</tr>
<tr>
<td>T + A</td>
<td>Thiopentone (24)</td>
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</tbody>
</table>
the i.v. anaesthetic used still had a significant effect (P < 0.02).

Figure 2 shows that recovery scores after T + A were greater in the enflurane group and significantly so 10 min (P < 0.01), 20 min and 30 min (P < 0.05) after extubation.

Table VI shows that restlessness occurred in the same range in all treatment groups. Nausea and vomiting were not seen after enflurane anaesthesia. The postoperative shivering in the T + A groups was similar after both inhalation anaesthetics. Shivering after Althesin + enflurane anaesthesia was more common than in the other adenoidectomy groups, although the difference was not statistically significant. Bleeding from the site of operation occurred equally in all groups and did not require treatment.

Satisfactory antisialagogue effect ranged from 91 to 100% in different groups. There were no
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10.0
8.0
6.0
4.0
2.0
0.0

Time (min)

Recovery score

Thiopentone + Enflurane
Thiopentone + Halothane

FIG. 2. Recovery scores after T + A surgery. Mean values for 24 and 24 children. SEM% from the corresponding mean values ranged from 0.8% to 3.6%. Recovery scores were significantly greater in the enflurane group 10 min (P < 0.01), 20 min and 30 min (P < 0.05) after extubation.

TABLE VII. Changes in blood sugar concentration (mmol litre\(^{-1}\)). Mean value ± SEM. Number of children in parentheses. *P < 0.001 from the initial value. †P < 0.001 compared with value after extubation. ‡P < 0.02 from the corresponding halothane group

<table>
<thead>
<tr>
<th>Condition</th>
<th>Before induction</th>
<th>After extubation</th>
<th>2 h after extubation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halothane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adenoids</td>
<td>Thiopentone (18)</td>
<td>3.7 ± 0.1</td>
<td>5.3 ± 0.2*</td>
</tr>
<tr>
<td>Enflurane</td>
<td>Adenoids</td>
<td>Thiopentone (19)</td>
<td>3.9 ± 0.1</td>
</tr>
</tbody>
</table>

during the recovery period (4.2 mmol litre\(^{-1}\)) compared with the value after extubation (P < 0.001), but remained at the same value in the enflurane group. Blood sugar concentration was significantly greater in the enflurane (5.0 mmol litre\(^{-1}\)) than in the halothane group (4.2 mmol litre\(^{-1}\)) after the recovery period (P < 0.02).

DISCUSSION

The results show that enflurane is a suitable alternative to halothane as regards conditions during the operation and extubation. It is superior to halothane with respect to speed of recovery.

Side-effects during operation and extubation

At equivalent anaesthetic concentrations, enflurane depressed laryngeal reflexes as effectively as halothane. This agrees with Yakaitis, Blitt and

TABLE VI. Frequency (%) of side-effects in the recovery room. Number of children in parentheses. Moderate = two extremities, jaw shivering; violent = four extremities or the whole trunk shivering

<table>
<thead>
<tr>
<th>Condition</th>
<th>Restlessness</th>
<th>Nausea</th>
<th>Vomiting</th>
<th>Shivering Moderate</th>
<th>Shivering Violent</th>
<th>Bleeding from the operation site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halothane</td>
<td></td>
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<td></td>
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<tr>
<td>Adenoids</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Thiopentone (20)</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Althesin (19)</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>T + A</td>
<td>Thiopentone</td>
<td>17</td>
<td>8</td>
<td>4</td>
<td>17</td>
<td>4</td>
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<tr>
<td></td>
<td></td>
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<td>4</td>
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<tr>
<td>Adenoids</td>
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<tr>
<td>Thiopentone (24)</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Althesin (21)</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>T + A</td>
<td>Thiopentone</td>
<td>29</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>8</td>
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Side-effects during operation and extubation

At equivalent anaesthetic concentrations, enflurane depressed laryngeal reflexes as effectively as halothane. This agrees with Yakaitis, Blitt and
Angiulo (1977, 1979), who found that both halothane and enflurane provide acceptable intubating conditions in children. The changes in heart rate and arterial pressure were in the same range with both inhalation anaesthetics as was found by Davidson (1978) in children. In the present study, laryngospasm after extubation was not seen, indicating that, in the presence of either halothane or enflurane, the conditions for extubation were good. No central nervous system excitation was seen during enflurane anaesthesia in the present study in which end-tidal concentration of enflurane did not exceed 1.7%. Lebowitz, Blitt and Dillon (1972), however, have found excitation during enflurane anaesthesia when alveolar concentration of enflurane was 2.5%.

**Respiratory recovery after cessation of controlled ventilation**

Spontaneous breathing started significantly earlier and end-tidal carbon dioxide (%) was significantly less in the halothane compared with the enflurane groups. The conclusion that enflurane depressed respiration agrees with the results of Linde and others (1970), Söderberg and Grattidge (1975), Calverley and others (1978) and Wahba (1979) who all also found respiratory depression during enflurane anaesthesia. The finding in the present study that the respiratory depression caused by enflurane is more profound than that caused by halothane, confirms the results with halothane (Bahlman et al., 1972) and with enflurane (Calverley et al., 1978). Respiratory frequency in enflurane anaesthesia was normal (Ciba-Geigy Ltd, 1975) and this result confirms the results obtained by Söderberg and Grattidge (1975) in children. Tachypnoea caused by halothane (D'Arcy, Holmdahl and Payne, 1959) also occurred in the present study. Sighing during spontaneous breathing in enflurane anaesthesia occurred in the same range as found by Söderberg and Grattidge (1975). The older children in the T + A group did not sigh as frequently as the younger ones in the adenoidectomy groups. Neither Linde and others (1970) nor Calverley and others (1978) reported sighing in adults during enflurane anaesthesia. Our results suggest that sighing in enflurane anaesthesia diminishes in an age-dependent manner.

**Recovery**

Recovery of consciousness was significantly shorter and recovery scores significantly greater after enflurane than after halothane anaesthesia, as expected in the light of the blood-gas solubility coefficients of enflurane (1.9) and halothane (2.3). The more rapid recovery after enflurane than after halothane anaesthesia has also been found by Govaerts and Sanders (1975), by Davidson (1978) and by Hoyal, Prys-Roberts and Simpson (1980) in children. Steward (1977), however, did not find any difference in the recovery of children spontaneously breathing halothane or enflurane via a facemask. The dose ratio (1:2) of halothane and enflurane used by Steward (1977) was the same as used in the present study. On this basis, the reason for the difference in recovery between these studies remains unexplained. Recovery of consciousness after enflurane anaesthesia induced with Althesin was significantly shorter than that induced with thiopentone. The earlier results of Saarnivaara (1974) also show that the recovery after halothane anaesthesia induced with Althesin was significantly shorter than after that induced with thiopentone when the assessment or recovery was based on the Romberg test in children. Furthermore, Obdrzalek (1975) found that the recovery time after Althesin was one-third that after thiopentone in adults. In the present study, the total recovery scores also improved most rapidly after Althesin + enflurane anaesthesia, indicating that, of these methods, this combination of anaesthetics is the most suitable for outpatients.

**Side-effects in recovery room**

Nausea and vomiting were not seen after enflurane anaesthesia. This result is in agreement with the findings of Govaerts and Sanders (1975) and Davidson (1978) who found nausea and vomiting after enflurane anaesthesia less frequent than after halothane in children. In the present study, nausea and vomiting were not more frequent in the Althesin groups. In earlier studies on children (Saarnivaara, 1974, 1977), however, there was a tendency for more nausea and vomiting to occur after halothane and Althesin than after halothane and thiopentone. The difference between the present results and those of Saarnivaara (1974, 1977) may be attributable to pethidine premedication used by Saarnivaara (1974, 1977). Although Althesin combined with enflurane produced the shortest recovery, crying or confusion was not seen more often than in the other groups during the early recovery period. This may be the result of the good anxiolysis caused by triclofos
premedication (Lindgren, Saarnivaara and Himberg, 1980) used also in the present study. Shivering after operation occurred as often after halothane as after enflurane anaesthesia. The frequency of shivering seen after enflurane anaesthesia was in the range found by Alexander and others (1975) and by Söderberg and Grattidge (1975) in children.

**Laboratory studies**

In the present study, the mean preanaesthetic blood sugar concentration of the adenoidectomy groups ranged from 3.7 to 3.9 mmol litre⁻¹. Thus, before the start of anaesthesia, the children were not hypoglycaemic since the blood sugar was in the normal range (3.5-4.5 mmol litre⁻¹). After operation, there was a statistically but not clinically significant increase in blood sugar in both halothane and enflurane groups. This result with halothane is in agreement with that of Mäkeläinen (1974a) and of Hall and others (1978) who found increased blood glucose concentrations after general surgery in halothane anaesthesia in adults. The present result with enflurane also agrees with the earlier results obtained by Oyama, Matsuki and Kudo (1972) who found markedly increased blood glucose concentration after general surgery in enflurane anaesthesia in adults and with the results of Mäkeläinen (1974b) in rats. In the present study, the blood sugar concentrations after halothane anaesthesia decreased significantly during the recovery period whereas after enflurane anaesthesia, it remained at the level, immediately after operation. Postoperative shivering uses glucose as fuel (Mäkeläinen, Nikki and Vapaatalo, 1973) but occurred with equal frequency in both groups.

It is concluded that enflurane is a suitable alternative to halothane for children undergoing otolaryngological surgery. The advantages of enflurane over halothane were: shorter recovery and better maintenance of blood sugar during recovery. In the light of the present study, enflurane anaesthesia induced with Althesin can be recommended for children undergoing outpatient otolaryngological surgery.

**ACKNOWLEDGEMENTS**

I am grateful to L. Saarnivaara, M.D. for discussions. I wish to thank the nurse specialists in anaesthesia and the nurses in the recovery room as well as the laboratory personnel for their skilful assistance during this study. My thanks also to Miss Elizabeth Heap for the final checking of the English language.

**REFERENCES**


COMPARAISON DE L'ANESTHESIE A L'HALOTHANE ET A L'ENFLURANE POUR LES INTERVENTIONS CHIRURGICALES OTORHINOLARYNGOLOGIQUES SUR DES ENFANTS

RESUME

On a comparé l’halothane et l’enflurane sur 132 enfants subissant une excision des végétations adénoïdes avec ou sans amygdalotomie. L’anesthésie pour l’excision des végétations adénoïdes a été provoquée par le thiopentone ou l’Althesin, et dans le cas d’amygdalotomie par le thiopentone. La réaction à l’intervention chirurgicale a été minimale (0-5%) pendant l’inhalation des deux agents anesthésiants. Au cours de la période de reprise de conscience qui a immédiatement suivi l’intervention, la dépression respiratoire a été plus profonde après l’enflurane qu’après l’halothane. L’administration par voie intraveineuse et par inhalation des agents anesthésiants a eu une influence sur la reprise de conscience. Les cotations de reprise de conscience (0-10) basées sur l’activité, la respiration, la fréquence cardiaque, la conscience et la couleur se sont améliorées plus rapidement après l’Althesin + enfurane et plus lentement après le thiopentone + halothane dans les groupes subissant une excision des végétations adénoïdes. Dans les groupes "amygdalotomie", les cotations de reprise de conscience ont été meilleures après l’enflurane qu’après l’halothane. Après l’administration des deux agents anesthésiants par inhalation la fréquence des frissons s’est étalée sur une plage allant de 0 à 17%.

VERGLEICH VON HALOTHAN-UND ENFLURAN-NARKOSE BEI OTOLARYNGOLOGISCHEN EINGRIFFE BEI KINDERN

ZUSAMMENFASSUNG


COMPARACION DE LA ANESTESIA CON HALOTANO Y CON ENFLURANO EN LA CIRUGIA OTOLARINGOLOGICA EN NIÑOS

SUMARIO

Se compararon el halotano y el enflurano en 132 niños sometidos a adenoidectomia, tanto con tonsilectomia como sin ella. La anestesia para la adenoidectomia se indujo con tiopenton o con Altesin y para la tonsilectomia con tiopenton. La respuesta al tratamiento quirúrgico fue mínima (0–5%) durante la inhalación de ambos anestésicos. Durante el proceso inmediato de recuperación, la depresión respiratoria fue más profunda después del enflurano que cuando se usó halotano. Tanto la anestesia intravenosa como la de inhalación ejercieron influencia sobre la recuperación. El número total de recuperaciones (0–10), basado en la actividad, la respiración, el ritmo cardíaco, el conocimiento y el color, mejoraron mucho más rápidamente después de usar Altesin y enflurano juntos, y más lentamente después de usar tiopenton y halotano en los grupos sometidos a adenoidectomia. En los grupos sometidos a tonsilectomia, el número de recuperaciones fue superior después del enflurano que después del halotano. Después de ambas anestesias de inhalación, la frecuencia de los estremecimientos osciló de 0 al 17%.