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ANAESTHESIA FOR PAEDIATRIC TONSILLECTOMY

Comparison of Spontaneous Ventilation and Intermittent Positive Pressure Ventilation

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SUMMARY

Fifty children undergoing tonsillectomy were anaesthetized using either a spontaneous ventilation (SV) technique with halothane (and nitrous oxide in oxygen) or intermittent positive pressure ventilation (IPPV) (with nitrous oxide, in oxygen) facilitated by atracurium 0.5 mg kg^{-1}. Time to full recovery was significantly less in the IPPV group (1.8 ± 3.79 min) than the SV group (20.0 ± 6.77 min) (P < 0.001) and ventilated children had a better quality of long-term recovery (sleep score 1.02 for the SV and 1.44 for the IPPV groups) (P < 0.01). Apart from a significantly greater E'_{CO_2} in the halothane group (7.3 kPa ± 0.9 compared with 5.1 kPa ± 0.5) (P < 0.001), there was no significant difference in operative or postoperative morbidity.

Tonsillectomy in children requires an anaesthetic technique which allows rapid and smooth recovery of protective airway reflexes at the end of surgery. The majority of anaesthetists follow the recommendations of Doughty (1957a) and use a technique incorporating spontaneous ventilation and an inhalation agent. However, when used for ENT surgery in children, such a technique has been shown to be associated with unacceptable hypercarbia (Valentin, Lomholt and Thorup, 1982), arrhythmias (Lindgren, 1981a; Sigurdsson and Lindahl, 1983) and prolonged recovery (Lindgren, 1981b). The improved efficiency of artificial ventilation, particularly in infants, has been said to justify its frequent use during paediatric anaesthesia (Hulse, Lindahl and Hatch, 1984).

The present study was designed to compare, in children undergoing tonsillectomy, spontaneous ventilation (SV) and intermittent positive pressure ventilation (IPPV) with regard to intra-operative complications, quality and duration of recovery and postoperative morbidity.

PATIENTS AND METHODS

Patients

The study was approved by the local Ethics Committee. Fifty children were studied and all fulfilled the following criteria: ASA group I or II, age 3–12 yr and undergoing tonsillectomy either as a separate procedure or in combination with adenoidectomy or myringotomy, or both. All children were seen by one of the authors the day before surgery—which took place in the morning. Premedication was pethidine 1 mg kg^{-1} and atropine 20 μg kg^{-1} i.m. 1 h before operation. On arrival in the anaesthetic room each child was randomly allocated to receive either SV (group A) or an IPPV technique (group B).

Anaesthetic technique

Each child was anaesthetized by one of the authors. Induction was with thiopentone 4 mg kg^{-1} and in group A the trachea was intubated after the administration of suxamethonium 1.5 mg kg^{-1}. Ventilation was assisted until the return of normal neuromuscular function, after which 1–3% halothane and 66% nitrous oxide in oxygen were breathed spontaneously. In children weighing less than 20 kg, the Jackson–Rees modification of Ayre's T-piece was used with a fresh gas flow of 15 × ventilatory frequency × body weight (kg) ml min^{-1} (Hulse, Lindahl and Hatch, 1984). In children heavier than 20 kg a Bain system was used with a fresh gas flow of 150 ml kg^{-1}.

Children in group B received atracurium

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TABLE I. *A simplified anaesthetic recovery score (Steward, 1975)*

	Points
Consciousness:	
Awake	2
Responding to stimuli	1
Not responding	0
Airway:	
Coughing on command or crying	2
Maintaining good airway	1
Airway requires maintenance	0
Movement:	
Moving limbs purposefully	2
Non-purposefully	1
Not moving	0
TOTAL	

0.5 mg kg^{-1} and after 2 min of controlled ventilation by face mask the trachea was intubated. Throughout anaesthesia the lungs were ventilated by hand with 66% nitrous oxide in oxygen using the Jackson–Rees modification of Ayre's T-piece with a fresh gas flow of $0.8 \times \sqrt{}$body weight (kg) litre min^{-1} (Nightingale, 1982). Supplements of atracurium 0.1 mg kg^{-1} were given when necessary and after the completion of surgery, residual neuromuscular blockade was antagonized with neostigmine 50 µg kg^{-1} (plus atropine 20 µg kg^{-1}).

All children had the tracheal tube removed while in the left lateral position with slight head-down tilt.

Monitoring

Electrocardiogram (Roche 105) leads were attached to each child after transfer to the operating table. End-tidal carbon dioxide tension was monitored throughout anaesthesia using a calibrated capnograph (Gould Mark II) with the sensor placed adjacent to the tracheal tube.

The time of extubation was noted and the child transferred to a recovery ward where recovery was assessed by one of the authors, blind to the anaesthetic technique used. Children were ascribed a score of 0–6 at 5-min intervals according to the recovery scoring system described by Steward (1975) (table I).

The time taken to achieve a score of 6 was recorded, as was the time from extubation to opening eyes on command. Overall quality of recovery was assessed as "good", a child that recovered happily and with minimum distress; "satisfactory", a child that was settled during most of its stay in the recovery ward; or "poor", a child that was distressed or tearful throughout the majority of its recovery period.

Patients were then returned to the children's ward where trained nursing staff graded their recovery with respect to sleep, distress and pain with a score of 0, 1 or 2. Episodes of vomiting were also recorded. Each child was assessed for a period of 6 h.

Student's *t* test was used for the parametric data, and the Chi square and Mann–Whitney tests were used to assess statistical significance of the non-parametric data.

TABLE II. *Patient characteristics*

	Group A	Group B
No. of patients (M/F)	15/10	15/10
Average age (yr)	6.41	7.85
(range)	(3.3–11.8)	(4.2–11.5)
Average weight (kg)	23.9	24.7
(range)	(14.7–43.0)	(16.4–52.5)

TABLE III. *Surgical procedure*

	Group A	Group B
Tonsillectomy (T)	8	6
Adenotonsillectomy (T&A)	11	15
Myringotomy, T&A	5	3
Oesophagoscopy, T&A	0	1
Myringotomy, T&A and antral washout	1	0
Duration of anaesthesia (min)	30.8	29.4
(range)	(22–48)	(20–47)

RESULTS

The two groups were similar in terms of weight and duration of anaesthesia (table II). The type of surgery performed is shown in table III. Mean inspired halothane concentration for the period of anaesthesia in group A is shown in table IV.

There was no significant difference between groups A and B in peroperative heart rate, but the maximum end-tidal carbon dioxide concentration was significantly greater in group A ($P < 0.001$) (table V). No arryhthmias were seen in group A and only two short episodes of a sinus arryhthmia in group B. Operating conditions were satisfactory in both groups and there were no surgical complications.

At extubation a cough reflex was present in a significantly greater number of children in group B ($P < 0.001$). The mean time to achieve a score

TABLE IV. *Mean inspired halothane concentration (group A) (assuming MAC halothane = 0.75%)*

Mean "MAC minutes" of halothane	79.8
Mean duration of anaesthesia	29.4
Mean MAC halothane per minute of anaesthesia	2.54

TABLE V. *Per-operative measurements.* * $P < 0.001$

	Group A	Group B
Heart rate (beat min^{-1})	138.4	139.2
(SD)	(15.8)	(20.0)
End-tidal CO_2 (kPa)	7.27	5.13*
(SD)	(0.87)	(0.52)
Arrhythmias		
Nil	25	23
Sinus arrhythmia	0	2
At extubation:		
Coughing	1	16
Laryngospasm	0	0
No response	24	9

TABLE VI. *Observations on the recovery ward. EOC = Eye opening on command.* * $P < 0.001$

	Group A		Group B
Time to score 6	20.0	*	1.8
Mean (SD) (min)	(6.77)		(3.79)
Time to EOC	22.5	*	2.6
Mean (SD) (min)	(9.86)		(3.53)
Bleeding	3		0
Laryngospasm	1		0
Quality of recovery:			
Good	12		11
Satisfactory	9		4
Poor	4		10
Analgesia one dose	4		3
Retching	0		6
Vomiting	3		2

of 6 and the mean time to opening eyes on command were significantly shorter in group B ($P < 0.001$) (table VI).

The quality of recovery was judged as good in 48% and 44% of children in groups A and B, respectively, but 40% of children in group B were considered to have a poor recovery, compared with 16% in group A. However, there was no statistically significant difference between the two groups in terms of the quality of recovery.

The analgesic requirements in each group were similar, but there was a higher incidence of retching in the immediate recovery period in the ventilated children. The incidence of vomiting was similar in both groups (table VI). There was only one brief episode of laryngospasm in a child from group A, and three episodes of minor bleeding, which settled without intervention.

TABLE VII. *Observations on the children's ward.* * $P < 0.01$

	Group A	Group B
Sleep score		
a.m. 0	3	0
1	13	10
2	9	15
p.m. 0	8	3
1	14	11
2	3	11
Mean sleep score	1.02	1.44*
Distress score		
a.m. 0	6	10
1	15	14
2	4	1
p.m. 0	11	11
1	9	11
2	5	3
Mean distress score	0.84	0.66
Analgesia		
Two doses	1	0
One dose	1	3
Nil	23	22

TABLE VIII. *Incidence of vomiting. (*A number of children vomited in more than one category—for example early and late)*

		Group A	Group B
In recovery	Nil	22	23
	1/2	3	2
Early (6–9 h)	Nil	18	16
	1/2	4	8
	3+	3	1
Late (> 9 h)	Nil	19	17
	1/2	5	6
	3+	1	2
Overall percentage of children vomiting*			
	Mild	44%	68%
	Serious	16%	12%

Observation of longer-term recovery showed that children who had been ventilated were less distressed and more likely to sleep for longer periods than those who received halothane (table VII). The differences in sleep score were significant ($P < 0.01$).

The overall incidence of vomiting (during the first 24 h after anaesthesia) was 44% in group A and 68% in group B, the incidence of serious vomiting (three or more episodes) being similar in each group (table VIII). There was no significant

TABLE IX. *Surgical complications*

	Group A	Group B
Discharged at 48 h	23	22
Discharge delayed	2	3
Reason for delayed discharge	Clot in fossa Congested fossae and pyrexia	Clots in fossa (three patients)

difference in the incidence of surgical complications (table IX).

DISCUSSION

In otolaryngological surgery, particularly in children, rapid recovery of airway reflexes is essential: the upper airway is compromised by the presence of blood and secretions, and oedema of the oropharynx and increased laryngeal irritability may predispose to laryngospasm. Lindgren (1981b) compared halothane and enflurane anaesthesia using controlled or "assisted" ventilation in 132 children and found the mean time from extubation to opening eyes on command to be 29 min in the halothane group and 21 min in the enflurane group. These figures compare favourably with our mean value of 22.5 min in the SV group. Where there is a risk of bleeding in the oropharynx it is the time to control of the airway that is more important and the significance of time from extubation to opening eyes on command is perhaps debatable. By using a scoring system, such as Steward's, it is possible to compare this with the time to achieve airway control and, in our study, the mean time to achieve the latter in the halothane (spontaneous breathing) group was 18 min compared with 2.6 min in the ventilated group; 18 min still represents a prolonged recovery time.

There can be little doubt that IPPV results in rapid awakening in children, but there have been few studies to show that this is advantageous. In this unit it is the policy of the ENT surgeons to retain all children in the recovery room for a period of 1 h following tonsillectomy. Although not significantly different, the authors feel that children who received an IPPV technique, and who awoke rapidly, were more likely to be distressed by this period because of maternal separation. However, other factors must be considered and a child that has been anaesthetized using an IPPV technique may well be distressed by waking rapidly on a cold trolley and with a stomach containing quantities of gas. A child who has received halothane, on the other hand, may awaken more slowly and, with episodes of shivering, will be warm and, perhaps, more settled. Children in the IPPV group tended to be more settled on the ward and to sleep for significantly longer periods than children who received halothane. This finding suggests that the former children are content and more likely to sleep, which could be considered a natural reaction following surgery and anaesthesia, whilst children having received halothane remain irritable and restless for longer periods.

After the introduction of Doughty's modification of the Boyle–Davis gag in the late 1950's (Doughty, 1957b), tracheal intubation has justifiably become routine in anaesthetic practice for paediatric adenotonsillectomy. Doughty advocated spontaneous ventilation with nitrous oxide and oxygen plus a volatile agent and commented that "halothane... enabled a very light level of narcosis without coughing on the tube" and a very rapid recovery of consciousness. This is the technique which has probably been the most commonly used over the past 25 yr. In the only definitive study of ventilation during such a technique for tonsillectomy in children, Valentin, Lomholt and Thorup (1982) demonstrated a median maximum end-tidal carbon dioxide concentration of 7% with 41% of children having a value of greater than 7%. In their study they used the Bain system, but were unable to decrease the end-tidal carbon dioxide concentration by increasing the fresh gas flow or by changing to a non-rebreathing circuit, and recommended the use of assisted or controlled ventilation for tonsillectomy. The mean end-tidal carbon dioxide concentration of 7.3% in the children anaesthetized with halothane in our study was similar, and is a value which many anaesthetists would consider unacceptable. The high deadspace ventilation during spontaneous ventilation in small children undergoing general surgical procedures and its subsequent reduction by IPPV justifies the frequent use of controlled ventilation during anaesthesia in this age group (Hulse, Lindahl and Harch, 1984).

Two criticisms are often levelled against the use of IPPV and non-depolarizing myoneural blocking drugs for ENT surgery in children: first, the relatively prolonged duration of action of the neuromuscular blockers, and the need for antagonism with neostigmine (Hannington-Kiff, 1985); second, the risk of accidental disconnection during IPPV. Atracurium, which allows a mean time of recovery of 95% of twitch height of 29.0 min in children (Brandom, Cook and Rudd, 1983), would seem to have the ideal duration of action for this type of surgery and we have encountered no problems that could be attributed to its use. Although disconnection of the circuit from the tracheal tube remains a possibility, the use of manual ventilation minimizes the likelihood of this passing unnoticed.

The absence of arrhythmias in the halothane group in our study is perhaps surprising. Sigurdsson and Lindahl (1983) showed that the incidence of cardiac arrhythmia in children breathing spontaneously during halothane anaesthesia for adenoidectomy was as high as 72% compared with 32% during enflurane anaesthesia. In 20% of patients the arrhythmia was ventricular. Lindgren (1981a) demonstrated junctional rhythm in up to 33% of children undergoing tonsillectomy and adenoidectomy during halothane or enflurane anaesthesia. However, the mean heart rate in each group in our study was high, and this may be a reflection of increased catecholamine concentrations as a result of either hypercarbia or a light plane of anaesthesia. Sigurdsson, Lindahl and Norden (1984) measured catecholamine concentrations during adenoidectomy under halothane or enflurane anaesthesia and found that they were unchanged during enflurane anaesthesia, but were significantly higher during undisturbed halothane anaesthesia and increased by up to 300% during surgery. They postulated that the difference may be caused by a stimulating effect of halothane on the release of endogenous catecholamines. This observation correlates well with a high incidence of ventricular arrhythmia and one contributory factor may be hypercarbia. The highest mean PE'_{CO_2} in that study was 8.0 kPa.

In the present study the overall incidence of vomiting was greater in the ventilated group but, according to the criteria of Smith and Manford (1974), there was no difference in the incidence of "serious" vomiting. The greater incidence in ventilated children may, in part, be the result of the entry of nitrous oxide to the stomach at induction, and this is reflected in the number of children in this group who retched soon after reaching the recovery room. Passage of an orogastric tube and aspiration of gas from the stomach soon after intubation may have reduced the likelihood of this occurrence.

In conclusion, we feel that the use of IPPV for tonsillectomy in children is rational, and allows a significantly more rapid return of protective reflexes. However, rapid awakening may be associated with greater distress during initial recovery, which may be related to maternal separation, but seems to be followed by better long-term recovery. There was no difference in anaesthetic and surgical morbidity between the two groups.

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