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Main Articles

Effect of anaesthetic agents on tympanometry and middle-ear effusions

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Abstract
Following informed parental consent 93 children underwent bilateral grommet insertion. Tympanometry was performed pre-operatively, and immediately prior to myringotomy. A standardized anaesthetic was used. At myringotomy the presence or absence of fluid was recorded, as well as the time since induction of the general anaesthetic.

A pre-operative type B tympanogram predicted a middle-ear effusion at myringotomy in 92 per cent of patients. A pre-operative type C_2 tympanogram predicted a middle-ear effusion at myringotomy in 39 per cent of patients. Sixty tympanograms (30 per cent) changed following a general anaesthetic. Fourteen type B tympanograms changed to type A and eight of these had effusions. The duration of the general anaesthetic did not influence the probability of a middle-ear effusion being present at myringotomy. A pre-operative type B tympanogram is a good predictor of middle-ear fluid. The duration of the general anaesthetic is not significant in predicting the presence of a middle-ear effusion.

Key words: Acoustic impedance tests; Otitis media with effusion; Anaesthesia

Introduction

The accuracy of pre-operative tympanometry in predicting middle-ear effusions has been questioned.[1,2] In addition, the length and type of general anaesthetic has been thought by some authors to influence the probability of a middle-ear effusion being present at the time of myringotomy.[3,4] This prospective study was designed to investigate whether general anaesthesia using nitrous oxide affected pre-operative type B and type C tympanograms using the Fiellau-Nikolajson classification (Table I), and whether the presence or absence of a middle-ear effusion at myringotomy was dependent on the duration of anaesthesia.

Materials and methods

Ninety-three patients were selected from children admitted for day-case grommet insertion with or without adenoidectomy. In these children middle-ear effusions had been documented for more than three months using at least two of the following: audiometry, tympanometry and otoscopy. Informed consent was obtained from the parents and only those children who tolerated otoscopy and tympanometry were included. Only children with type B or type C_2 tympanograms were included and any children with disorders that may have influenced middle-ear effusions such as cleft palate and Down's syndrome were excluded. All of the children underwent tympanometry on the morning of operation using a hand-held commercially available tympanometer which measured pressure from +200 to −400 mmH_2O. A standardized anaesthetic technique was employed (Table II) and tympanometry was repeated immediately prior to myringotomy on both sides. The time in minutes from the induction of anaesthesia to myringotomy was noted for each ear. At myringotomy the presence or absence of

TABLE I
FIELLAU-NIKOLAJSON CLASSIFICATION OF TYMPANOGRAMS[14]

Peak	
Type A	+200 to –99 mmH_2O
Type C_1	–100 to –199 mmH_2O
Type C_2	–200 to –300 mmH_2O
No peak	
Type B	Flat curve

TABLE II
ANAESTHETIC PROTOCOL[14]

I.V. induction – Propofol 3 mg/kg
N_2O/O_2/Halothane
Laryngeal mask or facemask and Guedel airway

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TABLE III
RESULTS

Post-anaesthesia		A		B		C_1		C_2	
Pre-anaesthesia	B	14	*6*	125	*5*	0		0	
	C2	21	*17*	19	*5*	6	*6*	0	

Figures in italics indicate number of ears dry at myringotomy.

fluid was noted and if no fluid was immediately obtained then a fine tip paediatric sucker was introduced into the middle ear. If fluid was still not obtained then the ear was said to be 'dry'.

Results

Our 93 patients yielded 185 ears as it was not possible to obtain a reading from one ear. The median age was five years and the male to female ratio was 2:1. Sixty tympanograms changed after anaesthesia; 14 type B traces changed to type A traces, of which six were dry. Forty-six type C_2 traces changed, 21 to type A, of which 17 were dry, 19 to type B, of which five were dry and six to type C1, all of which were dry (Table III).

The pre-operative finding of a type B tympanogram gave a 92 per cent correlation with middle-ear fluid found at operation, i.e. had a 92 per cent positive predictive value. The pre-operative finding of a type C_2 pre-operative tympanogram had a 39 per cent positive predictive value.

The duration of anaesthesia ranged from three to 16 minutes with a median of six minutes (Figure 1). The duration of anaesthesia, for those type B traces which changed, ranged from three to 11 minutes with a median of six minutes (Figure 2). The duration of anaesthesia, for those type B traces which remained unchanged, ranged from three to 16 minutes with a median of seven minutes (Figure 3). No significant difference was found when comparing the duration of anaesthesia between the changed and the unchanged type B tympanograms.

Discussion

We have found that a type B pre-operative tympanogram obtained using a tympanometer capable of measuring pressure from +200 to −400 mmH_2O has a positive predictive value for a middle-ear effusion at the time of myringotomy of 92 per cent. A type C_2 pre-operative tympanogram has a positive predictive value of only 39 per cent.

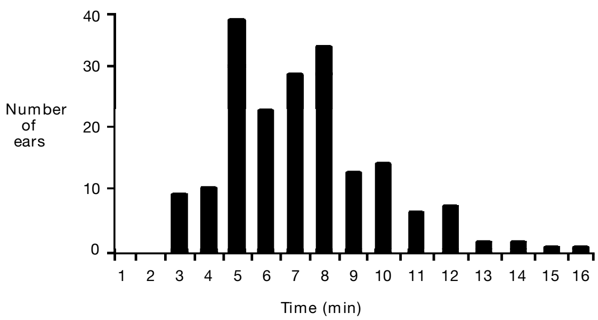

Fig. 1

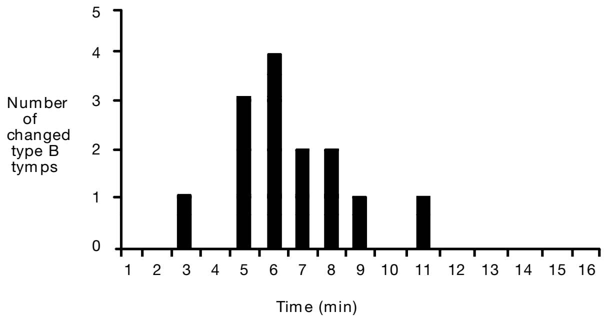

Fig. 2

Ever since grommets were first inserted as a treatment for otitis media with effusion, surgeons have noticed that no matter how thorough their pre-operative assessment, there is a proportion of 'dry taps'. With the advent of tympanometry it was felt that the proportion of dry taps would decrease or disappear entirely. However since tympanometers have been used the proportion of dry taps has remained significant.[1,2] It has been suggested that part of the reason for this is that the middle-ear pressure rises during anaesthesia and displaces fluid that had been present pre-operatively. This is not thought to be due to direct inflation via the eustachian tube. Rasmussen[3] in 1967 found no increase in middle-ear pressure using oxygen and halothane anaesthesia only. In 1983 Drake-Lee and Casey[5] showed that intermittent positive pressure ventilation prior to intubation in paralyzed patients may have increased the middle-ear pressure in normal ears via the eustachian tube, but in their group of children with a history of otitis media with effusion there was no evidence of gas being introduced into the middle ear even when paralyzed and ventilated. It appears that the use of nitrous oxide (N_2O) as the anaesthetic agent is responsible.

The pressure and volume changes in hollow gas-filled body spaces during N_2O anaesthesia has been studied;[6] it was found that spaces with expandable walls increased in volume and in non-expandable body spaces the pressure increased. This is due to the relative rates at which N_2O, nitrogen and oxygen exchange between the gas in the cavity and gases dissolved in the blood perfusing the cavity. The rates of exchange are a function of the blood/gas partitions coefficients, the partial pressure difference and the molar masses of the gases. For similar conditions the nitrous oxide will exchange 30 times faster than the nitrogen because its blood/gas partition is 30 times greater. Therefore, after induction of anaesthesia

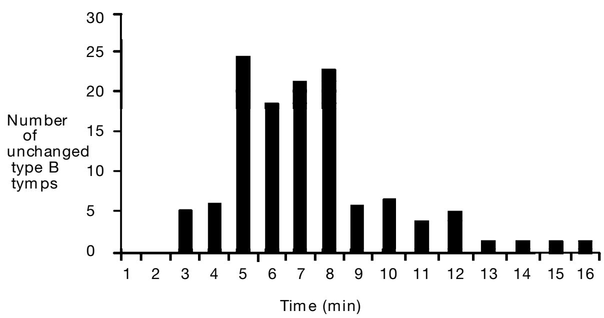

Fig. 3

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nitrous oxide diffuses into the middle ear more rapidly than nitrogen can leave and hence the middle-ear pressure increases. Once the anaesthetic has been completed the opposite applies and nitrous oxide diffuses out of the middle ear faster than nitrogen gets in resulting in a drop in pressure to sub-atmospheric levels.

It has been shown[7] that it is possible to predict the magnitude of post-operative pressure changes within an intact middle-ear cleft by measuring the middle ear during anaesthesia and using a mathematical model. Thomsen *et al.*[4] in 1965 measured middle-ear pressures in a normal adult who inhaled N_2O in differing concentrations. They found that the middle-ear pressure increased in a linear fashion and the rate at which it increased was proportional to the concentration of N_2O inhaled. Singh and Kirk[8] in 1979 found that once the middle-ear pressure reached a certain value, it dropped abruptly, which they attributed to the passive opening of the eustachian tube. This is one escape route for the fluid in children with middle-ear effusions. Should the tube remain closed then it is postulated that the fluid is displaced into the hypotympanum or the epitympanum and mastoid. Partial displacement of fluid would result in increased compliance of the tympanic membrane but also fluid being found at myringotomy. This would explain why some of our type B traces changed to type A traces and yet fluid was found at myringotomy.

In the last 15 years a number of authors have studied middle-ear pressures and fluid during anaesthesia. The significance of the results of some of the earlier studies could be questioned on the grounds of small sample sizes, e.g. Singh and Kirk[8] in 1979 studied 20 children and Marshall and Cable[9] in 1982 studied 12 children. In a much larger study by Rees and Freeland[10] in 1992, 155 patients were included. They found that 13 per cent of pre-anaesthesia type B tympanograms changed post-anaesthesia and were dry at myringotomy. They concluded from this that in these cases there had been displacement of fluid from the middle ear by N_2O during anaesthesia. Browning[11] disputed their conclusions on the grounds that the tympanometer they had used measured the pressure range +200 to -200 mmH_2O and therefore that their instrument could only correctly identify type A and type C_1 tympanograms; type C_2 and type B would be grouped together as type B. From several papers,[12,13] it is known that one third of type C_2 tympanograms will have middle-ear effusions and the other two thirds will be dry. Therefore in the Oxford study not all of the ears which their tympanometer registered as having ‘type B’ traces could have been expected to have effusions.

Our results show that 10 per cent of true type B traces changed to type A but not all of these were dry. This is probably due to a partial displacement of fluid. This is also probably true of the ears that were wet that had changed from C_2 to type A. All of our type C_2 traces changed; 46 per cent to type A and 41 per cent to type B. Sixty per cent of all pre-operative type C_2 ears were dry at myringotomy which is in line with previous studies[12,13] which have shown that two-thirds of type C_2 tympanograms will be dry. Four per cent of our type B tympanograms which did not change post-anaesthesia were also found to be dry. This is probably a true reflection of the sensitivity of a tympanometer of this kind. Drake-Lee and Casey[5] found that eight out of 19 ears with peaked tympanograms had a middle-ear pressure of -300 mmH_2O or below.

We have demonstrated that a pre-operative type B tympanogram is a good predictor of a middle-ear effusion and the greater the range of the instrument used the better a predictor it becomes. Type C_2 pre-operative tympanograms are a less reliable indicator of middle-ear effusions. The duration of anaesthesia does not influence whether or not a tympanogram is likely to change. Based on this we would suggest that the decision of whether or not to insert ventilation tubes into tympanic membranes should not be dictated by the presence or absence of middle-ear fluid at the time of myringotomy.

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