Persistent effusion following acute otitis media: tympanometry and pneumatic otoscopy in diagnosis

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SUMMARY. Children aged six months to 10 years in one practice who were diagnosed with acute otitis media were examined one, three, six and 12 months after diagnosis by a general practitioner and an otolaryngologist on the same day using pneumatic otoscopy. Tympanometry and pure tone audimetry were also carried out. Tympanograms were combined with the specialist's otoscopy findings to determine whether effusion was present. The outcome categories three months or longer after diagnosis were compared with the otoscopic findings up to that stage.

The tympanometry results showed that of the 29 children (31 affected ears), five had evidence of middle ear effusion on all occasions tested, while six were normal throughout, 10 fluctuated and eight followed a resolving pattern. Examination 10–14 days or one month after diagnosis was 75% accurate in predicting effusion after three months. Recommendations are made for the use of the pneumatic otoscope in follow up by general practitioners.

Introduction

SHOULD general practitioners re-examine children after an episode of acute otitis media in order to detect persistent middle ear effusion? A rational policy will depend both on the natural history of the complaint and on the accuracy of the methods used.[1-3] Doctors vary in their criteria for diagnosing acute otitis media[2-5] and in their ability to detect middle ear abnormalities, thus creating difficulties in the interpretation of findings of previous studies.[3,5-9] Overall about 50% of children are found to have effusions 10–14 days after the onset of acute otitis media,[6] although one group found a prevalence of 70% at this stage falling to 10% at 12 weeks.[7]

Tympanometry, the measurement of reflected sound energy at varying levels of ear canal pressure, is now widely used to investigate middle ear disorders.[6,10-15] While the technique is rapid and objective, there is no universally accepted system of classification of the traces obtained. Middle ear effusions can be diagnosed with greater accuracy when tympanometry results are combined with pneumatic otoscopy by an expert observer.[15] Community surveys have found tympanometric evidence of middle ear fluid in 20%[10] or 31%[11] of pre-school children and 12% of five year olds,[12] although the majority of these resolve over three months.

Two studies have compared the otoscopic signs at four to six weeks after diagnosis of acute otitis media with the hearing impairment at three months. Nearly all the children with a hearing deficit, whether the 21% with a 30 decibel loss[8] or the 45% with a 15 decibel loss,[9] had abnormal eardrums at the earlier stage.

We decided to determine the prevalence of middle ear effusion following acute otitis media in childhood, and the proportion of such cases which could be defined by an interested general practitioner. Our study incorporated the following features: rigorous clinical entry criteria; follow-up for one year; same-day examination by both an otolaryngologist and a general practitioner; and the use of both pneumatic otoscopy and tympanometry to determine outcome.

Method

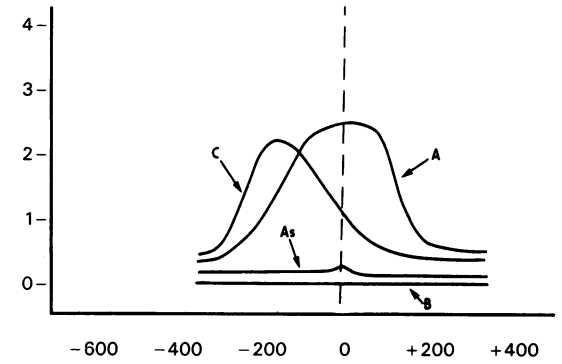
The study was carried out in a five-partner group practice with 12 700 patients. Children aged between six months and 10 years were eligible for the study when acute otitis media was diagnosed by one partner (J.F.W.). The diagnosis required all of the following: earache to be present for 48 hours or less (or crying as an 'earache equivalent' in children under two years of age); malaise, and either a purulent aural discharge, or an eardrum which was both red over two-thirds of its area, and wholly or partially bulging. Children with a diagnosis of acute otitis media or middle ear effusion during the previous 12 months, a tympanostomy tube present within 18 months, a cleft palate, Down's syndrome[2] or gross social difficulties likely to prevent attendance were excluded.

Patients were treated with a seven-day course of amoxycillin 125 mg three times daily, or co-trimoxazole paediatric suspension 5 ml twice daily if they were allergic to penicillin. Parents were asked to re-attend the general practitioner with their children after 10 to 14 days, bringing signed consent forms and questionnaires completed with family history and demographic details. One, three, six and 12 months after diagnosis the children were re-examined by the general practitioner at his practice and by an otolaryngologist at the district hospital on the same day. Both clinicians examined ears using an otoscope with pneumatic attachment, to test for eardrum mobility (Welch-Allyn Inc.), performed Rinne's test when possible, and tested hearing using age-appropriate clinical methods. Examination by the otolaryngologist was followed by tympanometry using a Peters AP 65 instrument, and pure tone audiometry in children old enough to cooperate (broadly those aged over four years), to identify clinically important hearing loss. Both clinicians recorded details of eardrum colour, contour and mobility on a form adapted from Bain,[7] adding their opinion regarding effusion (present, equivocal or absent).

A matched control group was identified using the practice age–sex register in order to determine the point prevalence of otoscopic and tympanometric abnormalities in the absence of a history of acute otitis media. These children were invited to attend both clinicians for examination of both ears on one day only, subject to the same exclusions as the study group.

Tympanograms were classified using Jerger's modified categories (Figure 1).[11,16] They were combined with the specialist's otoscopy findings using rules derived from the Pittsburgh algorithm[14] to produce outcome categories for examina-

tion at or after three months following diagnosis. Effusion was considered to be absent in ears producing a normal tympanogram (Type A, Figure 1). When the tympanogram was abnormal (Types As, B or C), ears were classified as effusion present, equivocal, or absent, depending on the otolaryngologist's otoscopic findings. Fluid levels or bubbles were considered as diagnostic of effusion whatever the tympanometric results.



Tympanogram type	*Definition*	*Associated pathology (refs 6, 10–14)*
A	Normal pressure and compliance	Normal (<3% have effusion)
As	Normal pressure, low compliance (peak ⩽0.3 ml)	Stiff middle ear system (8–75% have effusion)
B	Pressure ⩽−100 mmH$_2$O or indeterminate, low compliance (⩽0.3 ml)	Effusion probable (80–100% have effusion)
C	Negative pressure (peak ⩽−100 mm H$_2$O), normal compliance	Negative middle ear pressure — Eustachian tube dysfunction (16–33% have effusion)

Figure 1. *Tympanogram types together with definitions and associated pathology.*

Two by two tables were constructed to compare the outcome categories three months or longer after diagnosis with the otoscopic findings up to that stage. The sensitivity (proportion of abnormals detected) and specificity (proportion of normals correctly identified) were thus calculated for clinical examination before three months. The agreement between the two observers was calculated both in percentage terms and using Cohen's kappa coefficient.[17]

Results

Sixteen girls and 13 boys were admitted to the study over a 26-month period. Their mean age was 4.8 years (standard deviation 2.6 years), and five were aged under two years. Twenty-four control children including 11 boys were examined and their mean age was 5.8 years (SD 2.6 years). The two groups did not differ significantly in social composition from each other or from the practice: 15 (52%) of the study children were in social classes 1 and 2.[18]

Two children had bilateral infections so there were 31 affected ears among 29 study patients. Four had a purulent discharge, three had bullae present, three had patches of exudate on a red eardrum, one had a red tympanum with a bulging yellow area, and the remaining 20 eardrums were both red, and wholly or partially bulging. During the year after entry to the study two children had one further attack of otitis media, and another had three episodes. We were unable to complete one year's observations for five children because of removal (one child), parent's refusal (three) and bilateral tympanostomy tube insertion after six months (one).

When the general practitioner first re-examined the children, a mean of 12 days after diagnosis, he found otoscopic signs of effusion in 17 out of 30 (57%) ears examined at this stage, while six (20%) were equivocal and seven (23%) were normal.

Table 1 shows the results of the tympanograms classified as the different Jerger types[16] at each stage for the study children and also for controls. Table 2 shows the proportions of ears with definite and equivocal evidence of effusion based on a combination of tympanometry and the specialist's otoscopy results. While over 30% of the ears tested showed evidence of effusion at each stage by this definition, the composition of this group varied. Of 10 such ears showing effusion at one month, seven were

Table 1. Proportion of tympanogram types among study children one, three, six and 12 months after diagnosis and among controls.

	Number (%) of ears tested					
Tympanogram type	One month (*n* = 28)	Three months (*n* = 25)	Six months (*n* = 27)	Twelve months (*n* = 24)	All stages (*n* = 104)	Control (*n* = 48)
A	10 *(36)*	10 *(40)*	15 *(56)*	14 *(58)*	49 *(47)*	26 *(54)*
As	1 *(4)*	0 *(0)*	1 *(4)*	0 *(0)*	2 *(2)*	4 *(8)*
B	8 *(29)*	10 *(40)*	6 *(22)*	7 *(29)*	31 *(30)*	3 *(6)*
C	9 *(32)*	5 *(20)*	5 *(19)*	3 *(13)*	22 *(21)*	15 *(31)*

n = total number of ears tested.

Table 2. Proportion of ears of study children with definite or equivocal evidence of effusion (otoscopy and tympanometry results combined) one, three, six and 12 months after diagnosis.

	Number (%) of ears tested				
	One month (*n* = 30)	Three months (*n* = 30)	Six months (*n* = 26)	Twelve months (*n* = 23)	All stages (*n* = 109)
Effusion present	10 *(33)*	12 *(40)*	8 *(31)*	8 *(35)*	38 *(35)*
Equivocal evidence for effusion	9 *(30)*	5 *(17)*	1 *(4)*	2 *(9)*	17 *(16)*

n = total number of ears tested.

still affected at three months and five at one year. The children could be further classed into four groups: five with all tympanograms abnormal; six with all traces normal; eight with abnormal patterns which resolved; and 10 with initially normal tympanograms changing to abnormal patterns. Eighteen out of 20 tympanograms of the 'all abnormal' group were of type B which was most often associated with abnormal otoscopic results; abnormal patterns in the 'resolving' and 'normal to abnormal' groups were more often of type C.

The findings from affected ears were also compared with those from control subjects and the clinically unaffected ears of the study children. Abnormal patterns tended to resolve in both affected and unaffected ears. The proportion of abnormal tympanograms of all types combined was not significantly different in affected (52/101, 51%), unaffected (37/77, 48%), or control ears (22/48, 46%). Type B tracings were found in 26 (26%), 10 (13%), and three (6%) respectively of the tympanograms of these three groups (chi square = 10.2, 2 df, $P<0.01$). When abnormal tympanograms and the specialist's otoscopic results were combined, effusion was considered to be present in 28 affected (28%), 11 unaffected (14%) and seven (15%) control ears (chi-square = 6.1, 2 df, $P<0.05$).

The pure tone audiograms of individual cases varied, but both the two children who later received surgery had flat audiograms with all frequencies at 30 decibels or louder accompanying their abnormal eardrum findings. More generally, this level of hearing loss was only found in combination with abnormal eardrums.

Table 3 shows the accuracy of the examinations during the three months after diagnosis in predicting effusion (tympanometry and specialist's otoscopy findings combined). Sensitivity appeared greatest at the 10–14 day examination, while specificity was greater at one month. Overall accuracy was approximately 75% at both 10 to 14 days and one month.

Table 3. Accuracy of prediction of effusion after three months, by examination before three months.

	Examination by:		
	General practitioner at 10–14 days	General practitioner at 1 month	Otolaryngologist at 1 month
Sensitivity (%)[a]	*83.3*	*69.2*	*61.5*
Specificity (%)[b]	*64.7*	*83.3*	*88.2*
Overall accuracy (%)[c]	*74.3*	*76.6*	*74.9*

[a] No. of true positives/(No. of true positives plus no. of false negatives).
[b] No. of true negatives/(No. of true negatives plus no. of false positives).
[c] (Sensitivity plus specificity)/2.

The decisions of the two observers regarding effusion (abnormal, equivocal or normal) were in complete agreement in 69% of cases (kappa = 0.50). The agreement ranged from 63% at three months to 82% at six months (kappa = 0.41 and 0.66 respectively). These figures were all significant at the 0.05 level or greater,[17] representing fair to good agreement.[1]

Discussion

Tympanometry, especially combined with observations by both specialist and family doctor, offers unusual opportunities to clarify the natural history of otitis media and to assess the usefulness of otoscopy in clinical follow-up. The complexity of the relationship between acute infection and chronic middle ear effusions, however, makes straightforward conclusions difficult.

Outcome will be influenced by the choice of entry criteria. This study required signs of acute suppurative otitis media such as a bulging, inflamed eardrum,[2,6] while other authors rely on redness alone.[2,8,15] Redness is perhaps three times as common,[19] and is probably more typical of acute otitis media as generally diagnosed in primary care. We used wide exclusion categories to reduce the likelihood of pre-existing middle ear effusion. This affected the case-mix and reduced the numbers which could be recruited by a single practitioner.

The design of the study permitted close follow-up over one year, while the same-day observations were useful in assessing interobserver variation. One must, however, use caution in generalizing from this group with acute suppurative otitis media to the larger population of children with painful red ears.

We have shown that one-third of the ears of a group of children with acute otitis media had an effusion one month later; two-thirds of these had fluid present at three months and half at one year. The results are broadly comparable with similar American studies,[6,7] but contrast with those of Wheeler in Cardiff, who found that all tympanometric abnormalities resolved by 31 weeks after diagnosis.[15] Entry criteria to that study were much less stringent but this by itself is unlikely to explain all the difference. In both British studies abnormalities improved in both affected and unaffected ears.[15] Type C traces were the most likely to improve in our subjects, suggesting a bilateral subacute Eustachian tube dysfunction accompanying the infective process. The fluctuating abnormalities in our study resemble those found in community cohort surveys,[10-12] and probably represent the dynamic changes in middle ear function in normal children.

The findings of this study suggest that later outcome can be predicted from eardrum appearances during the six weeks following acute otitis media in about three-quarters of the cases. While there is no major advantage to examination at 10 to 14 days rather than one month, the higher sensitivity (or 'true positive' rate) of the earlier review suggests that abnormal ears can be better identified at this stage. The examiner should seek signs of middle ear effusion such as fluid levels, bubbles or dullness of the eardrum.[4] The colour varies, but may be pink, amber, grey-white or bluish.[3] A gentle puff of air from a bulb attached to the otoscope head should cause a brisk inward movement of a healthy drum, which is impaired or absent when fluid is present.[3,4] This technique can add substantially to accuracy of diagnosis,[11] and is described elsewhere, together with suggested management plans.[20] A clinically important hearing loss (30 decibels or greater at any frequency) in this study as in others[8,9] was only detected in children with abnormal eardrums. Therefore research has not shown that all children need audiometry following acute otitis media.

The two children with bilateral infections were those who eventually had tympanostomy tubes inserted. Clearly such patients need particularly close review. Although they were excluded from this study, this also applies to those with previous middle ear disease, cleft palate, cystic fibrosis or Down's syndrome.[3,6,20]

In conclusion, these results confirm other work in suggesting that practitioners can gain useful clues to prognosis by performing otoscopy, with the addition of pneumatic testing, following acute otitis media. This will enable them to identify those children who have a persistent effusion over several months, and to detect the smaller group who may benefit from specialist advice or surgical treatment.

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Acknowledgements

We are grateful to Mrs Janet Oakley and Miss Beverley Roberts for performing audiometry and tympanometry, to Mrs Joyce Parr and Mrs Janet Thornley for secretarial help and to Professor John Bain, Dr Martin Bass, Dr Paul Gulley and Dr Robin Hull for advice and encouragement. The study was partially supported by a grant from the Scientific Foundation Board of the Royal College of General Practitioners.

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