Evaluation of the diagnostic value of pneumatic otoscopy in primary care using the results of tympanometry as a reference standard

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SUMMARY. The aim of this study was to determine the value of pneumatic otoscopy in diagnosing otitis media with effusion in primary care. Pneumatic otoscopy was carried out for 111 children aged one to 16 years and the results obtained compared with those obtained from tympanometry. The children were those who had attended for a regular ear, nose and throat check up in the health centre of a school for the deaf during the period November 1989 to January 1990. Pneumatic otoscopy and tympanometry with the GSI 28® instrument (Grason-Stadler) were carried out by a trained ear, nose and throat nurse. All relevant features determined using otoscopy — the colour, position and mobility of the tympanum — and an overall assessment were recorded. The results of tympanometry were evaluated independently of the otoscopic findings. In the population examined the predictive values of positive and negative results of pneumatic otoscopy for diagnosing effusion were high; the sensitivity was low. Serious retraction of the eardrum and absence of mobility under positive pressure were the most predictive features but the colour of the tympanum did not show any relation to effusion. In the youngest age group (one to five years) 56% of the children had abnormal otoscopic findings in either one or both ears (odds ratio for this group versus remaining children 3.75; 95% confidence interval (CI) 1.75 to 15.2). The odds ratios of past and present history of upper respiratory tract infection with respect to abnormal results from otoscopy were 2.41 (95% CI 1.05 to 5.53) and 2.95 (95% CI 1.17 to 7.45), respectively.

Pneumatic otoscopy carried out by an experienced health care worker is of high diagnostic value when compared with the results of tympanometry. Pneumatic otoscopy can improve the diagnostic capabilities of general practitioners and other primary care workers with regard to otitis media with effusion.

Keywords: otitis media; otoscopy; tympanometry; diagnostic techniques; children and infants.

Introduction

OTITIS media with effusion is a major health problem in children and will occur in between 50% and 60% of children aged two to six years.[1-3] About 5% of five year olds have persistent otitis media with effusion and thus risk having their development disturbed.[4-6] The diagnosis of persistent otitis media with effusion at an early stage is an important step in preventing such complications and in serious cases adenoidectomy or insertion of grommets can be carried out. Pneumatic otoscopy and tympanometry are the major diagnostic techniques used to identify otitis media with effusion[7-10] as the diagnostic value of the child's history is limited.[11-13] The diagnostic value of pneumatic otoscopy has been questioned,[7-9] but it has a higher sensitivity than visual otoscopy, which does not allow an assessment of the mobility of the tympanum.[8-10] Diagnostic studies of otoscopy and pneumatic otoscopy have been mainly limited to hospital populations.[7-9]

The aim of this study was to determine the value of the overall results of pneumatic otoscopy and of the relevant features examined compared with tympanometry carried out using the GSI 28® instrument (Grason-Stadler) as the instrument of reference for diagnosing otitis media with effusion in a primary care setting. This instrument has been well validated in hospital and primary care populations.[11-14]

Method

The study population consisted of 111 children aged one to 16 years attending a school for the deaf, who had been asked to attend a regular ear, nose and throat check up at the primary care health centre of the school in the period November 1989 to January 1990. Eleven of the children also suffered morbidity other than ear problems (pathology from birth or genetic defects). Primary health care was provided by two nurses, who were supported by a general practitioner and a paediatric otolaryngologist.

Pneumatic otoscopy was carried out by a trained ear, nose and throat nurse in accordance with the routine procedure of the check up. Where cerumen was present, the auditory canal was cleaned. Relevant features of the tympanic membrane — colour, position and mobility — and an overall assessment were recorded. The nurse then performed tympanometry with the GSI 28 instrument, which has a test tone of 226 Hz and a peak pressure range of +200 to −400 dPa. The classification of the tympanometry results was carried out by R M independently of the tympanum assessment. The children's past and present history of upper respiratory tract infection were determined from the records in the health centre.

A slightly modified version of Jerger's classification for tympanometry results was used.[13]

Normal

Type A — maximum compliance the same or more than 0.2 ml with a middle ear pressure of −99 to +200 dPa.

Type C1 — maximum compliance the same or more than 0.2 ml with a middle ear pressure of −199 to −100 dPa.

Abnormal

Type C2 — maximum compliance the same or more than 0.2 ml with a middle ear pressure of −399 to −200 dPa.

Type B — maximum compliance less than 0.2 ml or middle ear pressure less than −400 dPa.

For analysis, type A and C1 curves were classified as 'normal', because of the low predictive value of C1 curves for effusion.[10-12] Type B and C2 curves were defined as 'abnormal'. Type B curves have a high predictive value for effusion, while C2 curves indicate high negative pressure with a 50% chance of effusion.[10] The tympanograms were classified by R M after he

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had received training at the Otitis Media Research Centre of the Children's Hospital in Pittsburgh, United States of America. A 25% sample of the tympanometry results was classified independently by another trained general practitioner and there was a high interobserver reliability (kappa = 0.95).[15] The overall results of pneumatic otoscopy were classified by the nurse as 'highly probable effusion', 'probable effusion' or 'no effusion'. The position of the tympanum was classified as 'serious retraction', 'moderate retraction' or 'no retraction'; the mobility under positive and negative pressure as 'no mobility', 'small mobility' or 'normal mobility'; and the colour as 'abnormal' or 'normal'. A positive past history was defined as 'chronic or recurrent episodes of otitis media with effusion'. A positive present history was defined as 'any upper respiratory tract infection on the day of examination'.

Analysis

The sensitivity, specificity and predictive values of positive and negative results were calculated for the overall assessment and for the relevant features of the tympanic membrane determined by pneumatic otoscopy.[15] Sensitivity is the proportion of people in the population with the disease who have been identified as having the disease by the test. Specificity is the proportion of people without the disease who have been so identified by the test. Sensitivity and specificity are measures indicating the probability of a diseased or non-diseased person having been correctly diagnosed by a diagnostic method.[16] The predictive value of a positive test outcome is the probability that a person with a positive result is truly positive. The predictive value of a negative test outcome is the probability that a person with a negative result is truly negative.[16]

For age and past and present history with respect to the pneumatic otoscopy results, odds ratios with 95% confidence intervals were calculated. The odds ratio is the ratio of the probability that something is true to the probability that it is not true.[16] Confidence intervals indicate the precision of the sample study estimates as population values.[17] Missing data are due to failures of tympanometry or in recording the results of pneumatic otoscopy.

Results

The overall results of pneumatic otoscopy and tympanometry are shown in Table 1. When considering only 'highly probable effusion' as a positive result the sensitivity of pneumatic otoscopy was low (45%) and the specificity very high (99%); the predictive value of positive and negative results were high at 94% and 91%, respectively. If 'probable effusion' was also interpreted as a positive result, the sensitivity increased to 88% but the specificity decreased to 88% and the predictive value of a positive result was also lower at 59% (predictive value of negative result 97%).

Of all the features of pneumatic otoscopy 'serious retraction' was the most predictive (Table 1). The predictive value of positive results when only 'serious retraction' was considered as a positive result was 100%; the predictive value of a negative results was 90%, the specificity 100% but the sensitivity was low at 47%. If 'moderate retraction' was also interpreted as an abnormal test result, the sensitivity increased to 72% but the predictive value of a positive result decreased to 52%; the specificity was 86% and the predictive value of a negative result 94%.

The results for mobility under positive pressure were slightly less predictive than those of retraction (Table 1). Considering 'no mobility' only as a positive result gave a low sensitivity (47%), a very high specificity (97%) and high predictive values (77% for a positive result and 90% for a negative result). However, the sensitivity of absence of mobility, if only B curves were considered to be abnormal, was high (83%). If 'small mobility' was also considered to be a positive result the sensitivity increased to 97% but the specificity decreased to 54%; the predictive value of a positive result was 30% and that of a negative result 99%. The results of mobility under negative pressure were comparable to those for mobility under positive pressure. The colour of the tympanum did not show any relation to effusion.

Table 1. Results of pneumatic otoscopy and tympanometry.

	No. of ears with tympanometry result		
	Abnormal	Normal	Total
Overall pneumatic otoscopy result			
Highly probable effusion	15	1	16
Probable effusion	14	19	33
No effusion	4	153	157
Total	33	173	206
Position of eardrum			
Serious retraction	17	0	17
Moderate retraction	9	24	33
No retraction	10	149	159
Total	36	173	209
Mobility under positive pressure			
No mobility	17	5	22
Small mobility	18	76	94
Normal mobility	1	94	95
Total	36	175	211

In the youngest age group (one to five years) 56% of the children showed abnormal otoscopic findings in one or in both ears (Table 2). The chance of abnormal findings from otoscopy in this age group is four times as likely as in the older age group (odds ratio 3.75; 95% confidence interval (CI) 1.75 to 15.2). The pneumatic otoscopy results for children with and without a past or present history of upper respiratory tract infection are also shown in Table 2. The odds ratios of past and present history with respect to abnormal results from pneumatic otoscopy were 2.41 (95% CI 1.05 to 5.53) and 2.95 (95% CI 1.17 to 7.45), respectively. Thus, for a child with a positive past history the chance of an abnormal finding is twice as likely as for a child with no past history, and for a child with a present history the chance of an abnormal finding is three times as likely as for a child with no present history.

Table 2. Pneumatic otoscopy results by age and by past and present history of upper respiratory tract infection.

	No. (%) of children		
	Bilaterally abnormal	Unilaterally abnormal	No effusion (normal)
Age (years)			
1–5 (*n* = 27)	8 *(30)*	7 *(26)*	12 *(44)*
6–9 (*n* = 39)	4 *(10)*	8 *(21)*	27 *(69)*
10–16 (*n* = 41)	3 *(7)*	5 *(12)*	33 *(80)*
Past history[a]			
Yes (*n* = 40)	6 *(15)*	12 *(30)*	22 *(55)*
No (*n* = 67)	9 *(13)*	8 *(12)*	50 *(75)*
Present history[b]			
Yes (*n* = 25)	7 *(28)*	6 *(24)*	12 *(48)*
No (*n* = 82)	8 *(10)*	14 *(17)*	60 *(73)*
Total (*n* = 107)	15 *(14)*	20 *(19)*	72 *(67)*

n = number of children in group. [a] Chronic or recurrent episodes of otitis media with effusion. [b] Any upper respiratory tract infection on the day of examination.

Discussion

This study of pneumatic otoscopy compared with tympanometry as the 'gold standard' shows that pneumatic otoscopy is of high diagnostic value in diagnosing effusion, with the position and mobility of the eardrum found to be the most important diagnostic factors.

The study population is comparable with other populations of schoolchildren, except that a minority of the children attending the school for the deaf had multiple pathology, and these children would have a relatively high chance of effusion. The school's health centre is a primary care institute with special facilities for deaf children, such as a specially trained nurse.

For practical reasons the normal check up procedures were carried out by an ear, nose and throat nurse, with experience in the field, thus ensuring that the measurements of pneumatic otoscopy and tympanometry were reliable. For primary health care workers with no training or experience less reliable results could be expected. The application of a genuine 'gold-standard', the results of myringotomy (effusion or no effusion), is not possible in a primary care setting for ethical and practical reasons. However, tympanometry is a valid and reliable test for the diagnosis of effusion,[7,10] and Jerger's classification seems appropriate in primary care.[13]

The finding that the position of the eardrum is the most important diagnostic feature of pneumatic otoscopy does not agree with the results of studies of hospital populations,[9] where cloudiness and mobility of the tympanum show the highest sensitivity and specificity.[8,9] In order to interpret the results regarding the position of the tympanum the definition of abnormal results of tympanometry have to be taken in account. Since a type C2 curve means high negative pressure, a retraction can be expected. However a type C2 curve also means effusion in about 50% of cases.[10]

This study clearly shows that pneumatic otoscopy is an adequate, inexpensive method of diagnosing effusion in children. Tympanometry is not frequently used in general practice,[18-20] but has the advantage of objectivity. However, it is more expensive than pneumatic otoscopy.[18] Pneumatic otoscopy should always be carried out before tympanometry in order that the course and cleanness of the auditory canal can be checked. In other words the tests are complementary.

Whether 'moderate retraction' and 'small mobility' of the tympanum are judged to be normal or abnormal results, depends on the reason for the test. Sensitivity and specificity are functions both of the population under scrutiny and of the test. The predictive values of the test have to be considered carefully because these are closely related to the *a priori* chance of effusion.

It is well known that the problem of impaired hearing is underestimated and difficult for a parent to identify.[6,8] The general practitioner should be aware of this when dealing with children that have problems at school or in development after acute otitis media or recurrent episodes of upper respiratory tract infection.[3,6] As age and past and present history of upper respiratory tract infection have some predictive value for positive results of otoscopy, these factors can be used to make the decision of whether or not to carry out pneumatic otoscopy. If these factors are considered, a positive result from pneumatic otoscopy will be more predictive of effusion.

In order to diagnose otitis media with effusion, repeated tests (two or three tests over three months) are required.[3,6] In serious cases, that is continuous effusion for three months, referral may be necessary.[3,5,6] For reliable results from pneumatic otoscopy the otoscopist needs training and experience; in a recent study, the clinical skills of a group of 23 general practitioners were found to be no better than those of inexperienced medical students.[21] The authors concluded that 'there is room for improvement in general practitioners' training in otoscopy'. They recommend more involvement in ear, nose and throat problems in vocational training and more attendances at continuing education courses.[21] Special attention should be paid to careful cleaning of the auditory canal and a systematic assessment should be made of the important features of the eardrum. In particular, a reliable assessment of the retraction and mobility of the eardrum is necessary. There is a need for reliability studies to ensure that the training of general practitioners and other health care workers is adequate. Specific training courses designed to improve and ensure the reliable application of pneumatic otoscopy are recommended for all primary health care workers.

This study justifies the conclusion that pneumatic otoscopy can be recommended as a possible method of diagnosing effusion in primary health care and as an alternative for tympanometry if this is too expensive.

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