Pure tone audiometry: comparison of general practice and hospital services

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SUMMARY. Pure tone audiometry was obtained for both ears of 32 children by a general practitioner using a simple audiometer in his surgery, and by audiometricians in a hospital department on the same day. Comparing the worst hearing threshold at any of the three tested frequencies, the general practitioner did not find any ears to hear more than 10 dB better than the hospital (no false negatives). However, there were six false positives (9%) where the general practitioner identified an apparent hearing loss of greater than 15 dB. It is concluded that pure tone audiometry could be carried out accurately in the practice.

Introduction

DURING the course of a study of middle ear disease in children,[1] pure tone audiometry was obtained in general practice and in a hospital audiometric department on the same day for 33 children. Twenty six children were suspected by the general practitioner of middle ear disease; the other seven had no such history. This study aims to determine the accuracy of the measurements in general practice and the implications of this for under or over diagnosis of hearing loss. There do not appear to have been any previous studies comparing the two services directly in this way.

Method

Audiometric results were obtained in general practice and a hospital audiometric department on the same day for 33 children. The mean age of the children was six years seven months (range four years one month to 10 years one month) and 18 were boys. Neither the practice nor the hospital was aware of the other's findings at the time of testing.

General practice

A Delmart Products screening audiometer C51B MkII was used. This is a small, portable and reasonably priced machine. It generates tones of 500, 1000 and 4000 Hz at intensities of 5–35 dB hearing level in 5 dB steps and also at 60 dB hearing level using a monaural headphone. In two years of use by the general practitioner (J.F.W.), it was serviced and calibrated once and its function was otherwise checked only by his own ear (normal hearing). All audiograms were performed by the general practitioner in the standard descending and ascending intensity manner. Ambient noise levels were measured in the non-soundproofed surgery room in which all tests were performed. The background noise level was 30–35 dB sound pressure level, which increased with voices and movement in the nearby corridor to about 40 dB sound pressure level occasionally peaking to 50–55 dB sound pressure level.

Hospital

A Peters AP6 clinical audiometer was used in a soundproofed room. Audiograms were performed by one of three full-time audiometricians. All are qualified technicians of the British Society of Audiology with a minimum period in service of five years. The audiometer is calibrated yearly by the manufacturers and checked daily by the technicians. A full pure tone audiogram across frequencies 250–4000 Hz in 5 dB steps was performed with headphones in the standard descending and ascending intensity manner. Only the thresholds at 500, 1000 and 4000 Hz have been used in comparing the results with those of the general practitioner. Ambient noise levels were generally less than 24 dB sound pressure level, occasionally rising to 30–35 dB sound pressure level.

The hearing in both ears of all 33 children was tested. In all cases, the general practice audiogram was carried out earlier in the day than the hospital audiogram. All of the children had had previous audiograms. The hospital audiogram was taken to be the more accurate result because the audiometer, technicians and soundproofing were all likely to be more reliable than these parameters in general practice. The accuracy of the general practice audiometry has been evaluated in terms of the mean hearing threshold and the worst threshold at any of the three tested frequencies.

Results

The results for one girl were excluded from the study because the hospital audiometry appeared to show a severe hearing loss bilaterally. The result was thought to be unreliable and on repeat testing her hearing was shown to be normal. The general practitioner had obtained a normal result when he tested her.

Figure 1 shows the mean threshold on hospital testing across the three tested frequences of 500, 1000 and 4000 Hz for the left and right ears of the 32 children, arranged in ascending order. The difference, if any, between this threshold and that obtained in general practice is superimposed. A negative value indicates that the general practitioner found the hearing to be better than the hospital; such a result indicates that a true hearing loss may have been missed. A difference of 10 dB or less is an acceptable error in a child, even on re-test in a single department.

Figure 2 shows the worst hearing threshold for left and right ears on hospital testing at any one of the three tested frequencies, and superimposed is the difference, if any, between the hospital threshold and that obtained by the general practitioner at that frequency.

Table 1 gives the number of ears with thresholds differing by less than 5, 10, 15 or 20 dB on general practice testing compared with hospital testing. For example, on general practice testing

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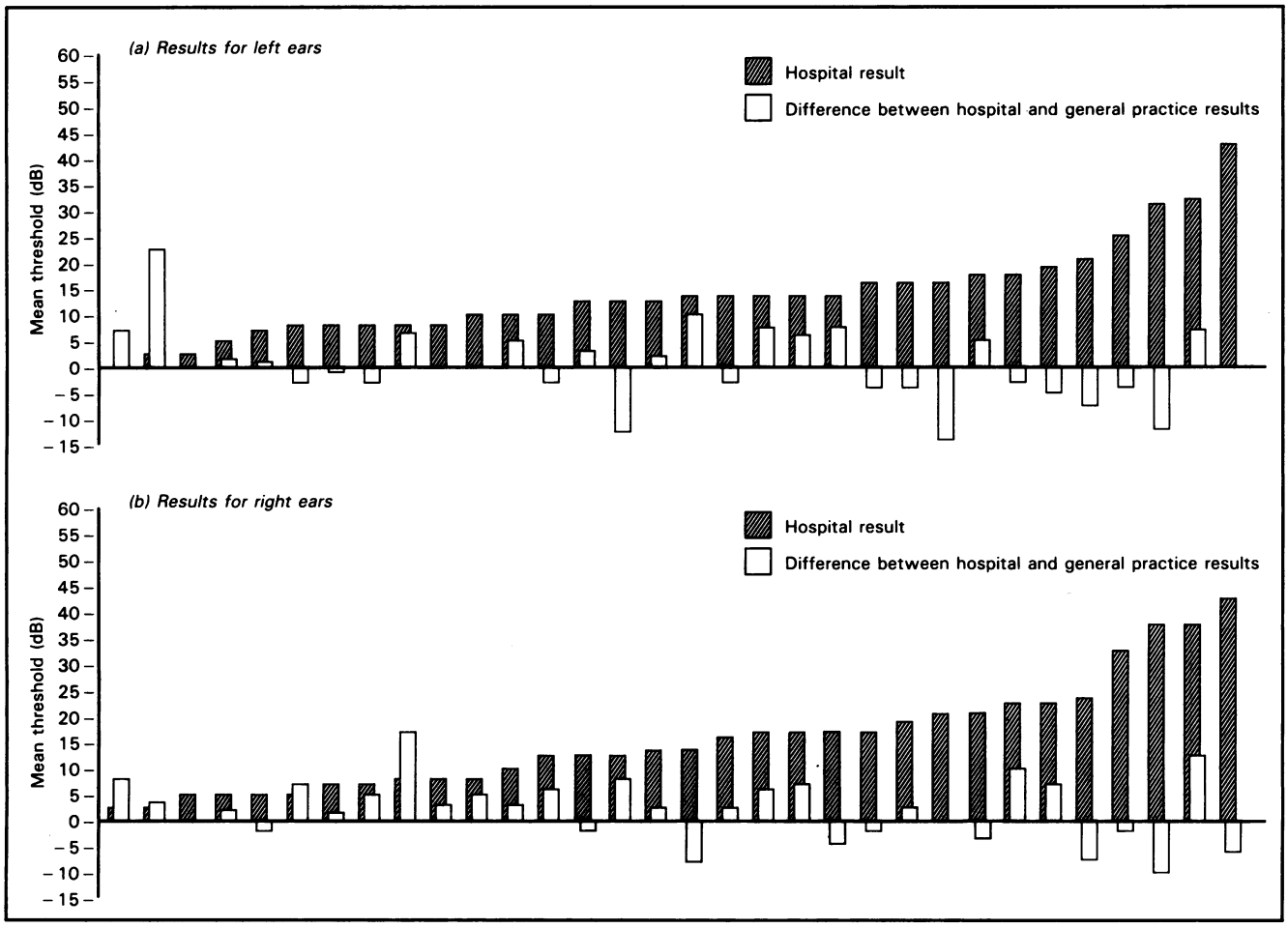

Figure 1. *Mean thresholds on hospital testing for (a) the 32 left ears and (b) the 32 right ears. The differences between the thresholds obtained in hospital and general practice are superimposed.*

29 left ears differed by less than or equal to 10 dB from the mean hospital threshold. The numbers of ears with positive (safe) and negative (unsafe) general practice errors greater than 10 dB are also recorded. It can be seen that 59 ears (92%), using mean thresholds, or 56 ears (88%), using worst thresholds, tested in general practice were accurate to within 10 dB of the hospital results while 98% and 89%, respectively, were accurate to within 15 dB, and 98% and 100% to within 20 dB. On this basis, the mean appears to be the more accurate value on which to judge the child's hearing in general practice. However, the only two negative (unsafe) errors of greater than 10 dB occurred when hearing was assessed by looking at the mean threshold.

Table 1. Differences between general practice and hospital testing in mean and worst thresholds.

Difference between GP and hospital (dB)	Mean threshold		Worst threshold	
	No. of left ears	No. of right ears	No. of left ears	No. of right ears
≤5	20	20	19	20
≤10	29	30	27	29
≤15	31	32	27	30
≤20	31	32	32	32
>10 (positive)	1	2	5	3
>10 (negative)	2	0	0	0

Table 2. Details for ears where general practice and hospital thresholds differed by more than 10 dB.

	GP threshold (dB)	Hospital threshold (dB)	Difference (dB)
Mean threshold			
Left ears	25	3	22
	20	32	-12
	3	17	-14
Right ears	50	38	12
	23	8	15
Worst threshold			
Left ears	30	10	20
	35	15	20
	35	15	20
	35	15	20
	60	40	20
Right ears	30	15	15
	30	10	20
	60	40	20

Table 2 gives details for the ears with differences in thresholds between general practice and hospital of more than 10 dB. Two had negative errors greater than 10 dB. In many ear, nose and throat clinics a hearing threshold level in a child of up to 20

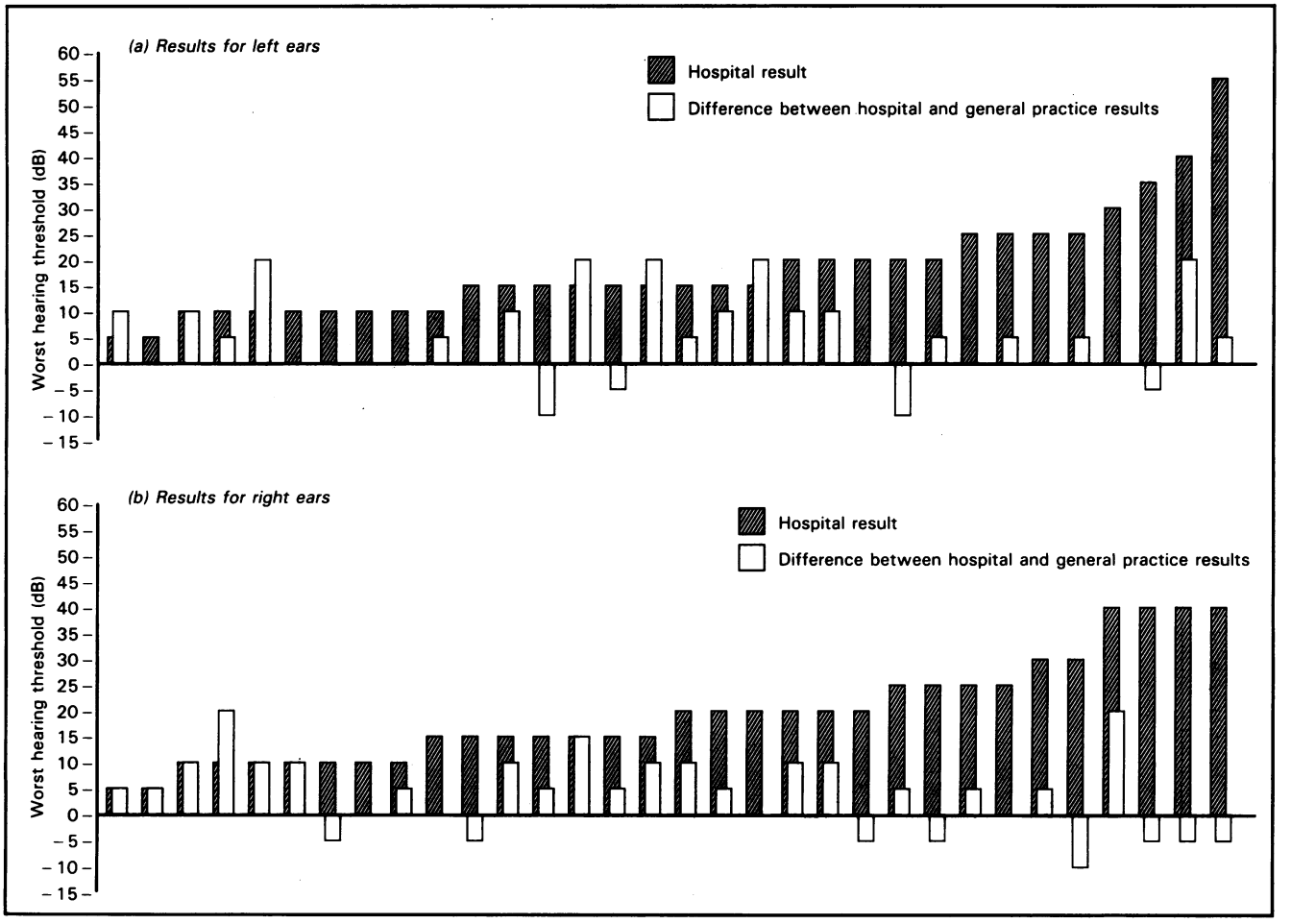

Figure 2. *Worst hearing threshold on hospital testing for (a) the 32 left ears and (b) the 32 right ears. The differences between the thresholds obtained in hospital and general practice are superimposed.*

dB would be regarded as within normal limits, although follow up may be appropriate for thresholds between 10 and 20 dB, particularly if there are other indications of hearing difficulty. It is evident that only one of these two ears had a loss on hospital testing of a significant extent (mean threshold 32 dB) which may have been missed by the general practitioner (mean threshold 20 dB). Using mean thresholds, two ears were found to be deaf by the general practitioner (thresholds 25 and 23 dB), but acceptable by the hospital (3 and 8 dB, respectively). Using worst thresholds, there were two ears judged deaf by the general practitioner (thresholds 30 dB) but normal by the hospital (10 dB) and another four where the hospital threshold was 15 dB and the general practice threshold 30–35 dB.

Discussion

There is considerable literature on the subject of pure tone screening audiometry, particularly in schools.[2-5] Generally, a sweep screen technique is used across several frequencies at a given intensity. Failure to hear the tone at one or more of these frequencies results in referral or repeat testing and then possible referral. In this study, a more formal air conduction audiogram was made in the general practice, giving the potential for determinig changes in the threshold as well. Gomez[6,7] described the use in general practice of a pure tone audiometer similar to that used in this study and gave valuable practical advice. He found it to be a useful tool in assessing the hearing of his patients of all ages. Dinwoodie[8] compared five portable audiometers for their relative practical merits in general practice but he did not come to any conclusions about the accuracy of the results obtained. The audiometer used in this study was similar to but not one of the types he tested.

In this study, the general practitioner obtained no audiograms indicating a worst threshold at any of the three tested frequencies of 500, 1000 or 4000 Hz more than 10 dB better than the threshold found on hospital testing (no false negatives). The technique, therefore, seems to be safe. He did, however, have six (9%) false positives among the 64 ears, where he found by an error of more than 10 dB an apparently significant hearing loss, that is a threshold greater than 15 dB. In these, the hospital threshold was 15 dB or better, so that in the absence of other features of hearing disability or ear disease, referral at that time would have been inappropriate.

The mean thresholds obtained by the general practitioner across the three frequencies were a more accurate guide to hearing than worst threshold, with 92% of ears having thresholds within 10 dB of the hospital results, but there was one false negative where the general practitioner may have missed a significant (32 dB) hearing loss.

Clearly, the results described here are from two specific departments but, given the technical details set out above, the results should be applicable elsewhere and be of value in assessing the accuracy and usefulness of general practice audiometry. It would seem likely that a practice nurse could, with training, carry out audiograms with similar results.

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