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Main Articles

Magnetic resonance imaging screening for vestibular schwannoma: analysis of published protocols

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Abstract

This study seeks to define the most appropriate guidelines for selection of patients for magnetic resonance imaging (MRI) to exclude a vestibular schwannoma. Improved selection may reduce patient anxiety and improve resource utilization.

All MRIs of the internal auditory meatus, performed during the year 2000, were reviewed. Audiograms and symptoms were collated for all 'positive' scans and 100 negative scans. Information was analysed using seven published protocols and other defined frequency specific criteria.

A diagnosis of vestibular schwannoma was made on 36 scans. Four criteria had a sensitivity of >95 per cent; of these the highest specificity (49 per cent) utilized an interaural difference at two adjacent frequencies of 15 dB in unilateral hearing loss and 20 dB in bilateral asymmetric loss.

Applying our best protocol would have reduced the number of scans performed from 392 to 168. The one patient with a vestibular schwannoma who was excluded had trigeminal paraesthesia, an independent indication for investigation.

Key words: Vestibular Schwannoma (Acoustic Neuroma); Magnetic Resonance Imaging

Introduction

The presentation of a patient with a vestibular schwannoma is classically with unilateral or asymmetric bilateral sensorineural hearing loss (SNHL) with, or without, unilateral tinnitus. However, only one to two per cent of patients presenting with these symptoms are ultimately found to have a vestibular schwannoma. Approximately 10 per cent of lesions will present with atypical symptoms or be a chance finding.[1–3] MRI is now the investigation of choice, with sensitivity approaching 100 per cent and very high specificity.[4] A number of protocols have been published to guide patient selection, but their differing guidelines reflect a failure to identify the most suitable criteria. There is thus an ongoing debate over the indications for the investigation of possible vestibular schwannoma.

Improved patient selection saves money and resources. The process of selection itself produces anxiety and distress. The patient is likely to experience a significant wait for the test, which many find claustrophobic and may be unacceptable, and must then wait for the results.

The following examples demonstrate the variation in guidelines. Welling and co-workers arbitrarily suggested investigating patients with any 15 dB (or greater) difference in thresholds at any single frequency from 500 Hz to 4 kHz.[5] The otolaryngology and radiology departments in Oxford have suggested a protocol of investigating patients with a minimum 15 dB difference between the averages of all frequencies between 250 Hz and 8 kHz.[6] In addition they included all patients with unilateral tinnitus alone, but recommended an upper age limit of 70 years. They have justified this scheme on the basis of its pick-up rate for cerebellopontine angle (CPA) lesions of approximately five per cent. Mangham suggested a different approach to this problem.[7] He collected the audiograms from his own series of vestibular schwannomas and also collected data on patients attending a non-selective audiology clinic ('the non-tumour patients'). For a variety of protocols he found out how many of the tumour patients it identified (true positive rate) and how many of the non-tumour patients it would also have included (false positive rate). He represented his results in a receiver-operator characteristic curve that plots for each criterion the true against false positive rate for a range of interaural threshold differences. For single frequencies he found the

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TABLE I
PUBLISHED PROTOCOLS

Asymmetry of thresholds	History	Source
⩾20 dB at any single frequency between 0.5 and 4 kHz	Vertigo	Department of Health
⩾15 dB between average of 0.5, 1, 2 and 3 kHz	Vertigo	AAO-HNS
⩾15 dB between average of 0.5 to 8 kHz	Unilateral tinnitus, age 70 or less	Oxford[6]
⩾20 dB at 2 neighbouring frequencies	Unilateral tinnitus or symptoms of Ménière's disease	Sunderland[8]
⩾15 dB at any single frequency between 0.5 and 4 kHz		Nashville[5]
⩾15 dB between the average of 1 and 8 kHz		Seattle[7]

worst to be 250 Hz and the best to be 2 kHz but when he combined his best four frequencies (1, 2, 4 and 8 kHz), he did better yet and he found the best asymmetry to be of the order of 15 to 20 dB. The specificity varied significantly between the two thresholds, and so he favoured investigating those patients with a 15 db difference with the auditory brainstem response test and those with a 20 dB difference by using MRI, reflecting the limited availability of this resource. He drew no distinction between unilateral and asymmetrical bilateral hearing loss, but it seems rational that a small unilateral deficit should be more significant than an asymmetry in a patient with established bilateral hearing loss.

We have identified a range of protocols published to aid the selection of patients for investigation of possible vestibular schwannoma and applied them to a patient cohort derived from those who received MRI of the internal auditory meatus in two hospitals in a given year. The protocols considered a difference of either 15 or 20 dB significant (Table I) and for the purpose of this study all protocols were applied using both thresholds. We have also applied a 15 dB threshold in those whose better hearing ear had a mean PTA (250 Hz–8 KHz) of ⩽30 dBHL (considered a unilateral hearing loss) and a 20 dB threshold if the better mean was >30 dB (asymmetric hearing loss).

Methods

Data were collected from Charing Cross Hospital and St. Bartholomew's Hospital. A list of all patients referred by the departments of ENT and neurosurgery for MRI of the internal auditory meatus during the year 2000 was obtained from the radiology department. The radiologist's reports of all the scans were reviewed. The majority of patients were investigated by ENT teams, with no established selection guidelines in place.

The notes of all patients who had vestibular schwannomas and those of the last 100 'negative' scans were requested. Included in the analysis were patients known to have a new diagnosis of vestibular schwannoma referred from other institutions. The presenting symptoms and pure tone audiograms were then entered into a spreadsheet. The data were analysed comparing the sensitivity and specificity of differences in hearing loss at each specific frequency, at any two and any three frequencies, and utilizing six published protocols (Table I).[5–8] Protocols were identified by performing a 'Medline' search, using the keywords 'vestibular schwannoma' and 'screening'. The Department of Health and the AAO-HNS have previously distributed guidelines for audiologists for the identification of patients for referral to ENT departments for further investigation. As described above the protocols were run using thresholds of both 15 dB and 20 dB and applying a differential threshold of 15 dB for those in whom the better hearing ear had mean thresholds of less than 30 dB and 20 dB if greater than this.

Results

The reports of 392 MRI scans were reviewed. Thirty-six patients with vestibular schwannomas were included and 92 without, eight case notes were unavailable. Thirty-two of the 36 presented with asymmetrical hearing loss, 19 of whom also had tinnitus. Vertigo or 'dizziness' was present in 11 patients. Two patients presented complaining only of tinnitus and one of dizziness, but had asymmetrical hearing loss. One patient had trigeminal paraesthesia with a symmetrical audiogram and no other symptoms. The calculated sensitivity and specificity of the individual frequencies, combinations of frequencies and published criteria are demonstrated in Table II. Unilateral or asymmetrical tinnitus was present in 45 per cent of those with vestibular schwannomas and

TABLE II
SENSITIVITY AND SPECIFICITY FOR INDIVIDUAL FREQUENCIES, COMBINATIONS, AND PUBLISHED CRITERIA

DBHL		250	500	1K	2K	4K	8K	Any freq	Any 2 freq	2 adj. freq	Any 3 freq	3 adj. freq	Average 250–8K	Average 1–8K Seattle	Oxford	U.S. AAO	Nash-ville	Sunder-land	DOH
15	Sensitivity	83	72	78	92	89	89	100	97	97	92	92	92	92	86	92	100	97	97
	Specificity	58	60	63	60	53	49	27	44	47	53	65	60	62	35	62	36	11	29
20	Sensitivity	75	70	75	86	83	89	97	94	92	89	89	86	83	89	89	94	97	97
	Specificity	67	69	68	68	62	56	36	54	58	66	70	70	68	42	73	49	15	37
15/20	Sensitivity	83	72	78	89	89	89	100	97	97	92	92	92	89	86	92	100	97	97
	Specificity	63	62	66	63	54	53	29	47	49	57	66	65	63	38	67	37	15	31

Column 1 indicates the interaural difference considered significant, 15/20 refers to the use of a 15 dB difference in those patients with unilateral hearing loss and a 20 dB difference in asymmetric hearing loss (see text).

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47 per cent of those without (no significant difference, odds ratio 0.952).

Analysis of individual frequencies revealed that a 15 dB difference at 2 KHz was most sensitive (91 per cent) with a specificity of 60 per cent. The most sensitive criterion was a difference of 15 dB at any frequency (sensitivity 100 per cent and specificity 29 per cent). The optimal combination of sensitivity and specificity was achieved using a criterion of >15 dB difference at two adjacent frequencies if the mean threshold in the better ear was ⩽30 dB, and 20 dB if greater than 30 dB. This produced 97 per cent sensitivity and 49 per cent specificity. The one patient not identified by this protocol presented with trigeminal paraesthesia, and symmetrical hearing without tinnitus or disequilibrium. The application of this protocol would have reduced the number of MRI internal auditory meatus scans requested from 392 to 218, saving 174 patients' scans.

- **This study seeks to define the most appropriate guidelines for selection of patients for magnetic resonance imaging (MRI) to exclude vestibular schwannoma**
- **Audiograms and symptoms were collated for all 'positive' scans and 100 negative scans. This information was analysed using seven published protocols**
- **A diagnosis of vestibular schwannoma was made on 36 scans. Four criteria had a sensitivity of >95 per cent of these the highest specificity (49 per cent) utilized an interaural difference at two adjacent frequencies of 15 dB in unilateral hearing loss and 20 dB in bilateral asymmetric loss.**
- **Applying best protocol would have reduced the number of scans performed in the year 2000 from 392 to 168**

Discussion

Although there is debate about the management of early tumours, prompt diagnosis is clearly desirable.[9,10] If the diagnosis is not made early the lesion may reach a size at which there is significantly increased morbidity associated with surgery and the opportunity for hearing preserving surgery may have been lost. All the major series have shown that the facial nerve outcome and the risk of brainstem injury correlate with the size of tumour removed.[10,11] Failure to identify a tumour at the earliest opportunity may therefore adversely affect outcome and may be difficult to defend medico-legally, particularly as an MRI scan represents a non-invasive, sensitive and specific test for excluding this diagnosis.

Approximately 90 per cent of patients with vestibular schwannomas will have audio-vestibular symptoms. The remaining 10 per cent may be chance findings or present with symptoms including headache, a vague and poorly predictive symptom, and non-VIIIth nerve cranial neuropathies, which are highly predictive of pathology.

Tinnitus alone is a rare presentation. In a review of 542 patients with vestibular schwannomas and symmetrical hearing, Lustig *et al.* found only four patients with asymmetric tinnitus, and it is unlikely, although not specified, that this was their only symptom.[1] Tinnitus is commonly associated with sensorineural hearing loss[12], and unilateral tinnitus is included in several of the protocols reviewed in this study. For this purpose it is necessary to clarify what is to be considered significant. Variables include the degree to which symptoms are unilateral or asymmetric, whether it is consistently present, occasionally present or is present only in a quiet environment, and its relationship to factors such as exogenous stress and other causes of disturbed sleep. There is also a concern that patients presenting primarily with tinnitus may be displaying illness behaviour, which will be reinforced by further investigation.

Vestibular schwannomas have been associated with a range of vestibular symptoms, from light headedness and dysequilibrium to true rotatory vertigo mimicking either benign positional paroxysmal vertigo (BPPV) or Ménière's disease. The incidence of dysequilibrium is approximately 50 per cent, and true vertigo is present in nine per cent.[13,14] In view of the relatively high incidence of these symptoms in the population, in isolation they are poorly predictive of vestibular schwannoma.[11]

Selection for imaging in the majority of patients is therefore dependent on audiometry. In the absence of other indications the degree of asymmetry in an audiogram that warrants further investigation is unclear. MRI is relatively expensive as a screening tool and it is associated with patient morbidity. It is therefore not suitable for universal screening. It performs targeted screening on a population defined by the presence of unilateral or asymmetrical hearing loss. Clinical acumen is clearly of importance and may override any guidelines.[15] However, using a protocol to select these patients provides guidance in the recognition of this rare tumour, standardization of care within departments, and, if evidence based, may aid a medico-legal defence for not screening a patient.

Conclusion

This study supports the use of a protocol utilizing interaural asymmetry at two neighbouring frequencies of >15 dB if the mean threshold in the better ear was ⩽30 dB (i.e. unilateral hearing loss), and an interaural difference of 20 dB if the mean threshold is greater than 30 dB in the better ear (i.e. bilateral asymmetrical hearing loss). This has the advantage of being a simple calculation. The application of this protocol would result in significant savings of cost, resources and patient morbidity.

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References

1 Lustig LR, Rifkin S, Jackler RK, Pitts LH. Acoustic neuromas presenting with normal or symmetrical hearing: factors associated with diagnosis and outcome. *Am J Otol* 1998;**19**:212–8

2 Beck HJ, Beatty CW, Harner SG, Ilstrup DM. Acoustic neuromas with normal pure tone hearing levels. *Otolaryngol Head Neck Surg* 1986;**94**:96–103

3 Roland PS, Glasscock ME, Bojrab DI, Josey AF. Normal hearing patients with acoustic neuroma. *South Med J* 1987;**80**:166–9

4 Sidman J, Carrasco V, Whaley R, Pillsbury H. Gadolinium – the new gold standard for diagnosing cerebellopontine angle tumours. *Arch Otolaryngol Head Neck Surg* 1989;**115**:1244–7

5 Welling DB, Glasscock ME, Woods CI, Jackson CG. Acoustic neuroma: a cost-effective approach. *Otolaryngol Head Neck Surg* 1990;**103**:364–70

6 Sheppard IJ, Milford CA, Anslow P. MRI in the detection of acoustic neuromas – a suggested protocol for screening. *Clin Otolaryngol* 1996;**21**:301–4

7 Mangham CA. Hearing threshold difference between ears and the risk of acoustic tumour. *Otolaryngol Head Neck Surg* 1991;**105**:814–7

8 Dawes PJD, Jeannon JP. Audit of regional screening guidelines for vestibular schwannoma. *J Laryngol Otol* 1998;**112**:860–4

9 Cox GI. Intracanalicular acoustic neuromas: a conservative approach (Editorial). *Clin Otolaryngol* 1993;**18**:153–4

10 Ramsden RT, Moffat DA. Intracanalicular acoustic neuroma: the case for early surgery (Editorial) *Clin Otolaryngol* 1994;**19**:1–2

11 Thomsen J, Tos M. Acoustic neuroma: clinical aspects, audiovestibular assessment, diagnostic delay and growth rate. *Am J Otol* 1990;**11**:19–21

12 Harcourt JP, Frosh A, Vijaya-Sekaran S, Mollar H, Toss M, Thomson J. Development of a simple and highly predictive screening protocol for cerebellopontine angle lesions; Part 1 identification of predictors. *Otol Neurotol* (In press)

13 Morrison G, Sterkers J. Unusual presentations of acoustic tumours. *Clin Otolaryngol* 1996;**21**:80–3

14 Kentala E, Pyykko I. Clinical picture of vestibular schwannoma. *Auris Nasus Larynx* 2001;**28**:15–22

15 Moffat DA, Baguley DM, Beynon GJ, Da Cruz M. Clinical acumen and vestibular schwannoma. *Am J Otol* 1998;**19**:82–7

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