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Predicting Neuroradiologic Outcome in Patients Referred for Audiovestibular Dysfunction

Richard A. Levy and H. Alexander Arts

PURPOSE: To relate clinical presentation and results of audiovestibular testing to neuroradiologic outcome in patients with audiovestibular dysfunction. **METHODS:** We retrospectively reviewed the neuroimaging studies, results of audiometric and vestibular testing, and medical records of 118 patients referred for imaging over a 2-year period for evaluation of sensorineural hearing loss, dizziness, and/or vertigo, and to rule out acoustic neuroma. Patients' presentation and results of audiometric and vestibular testing were associated with either a positive or negative neuroimaging outcome. Discriminant analysis was performed to identify variables related significantly to imaging results. Two-way cross-tabulation of these significant variables was performed to assess their sensitivity and specificity in predicting imaging outcome. **RESULTS:** Fifteen (13%) of 118 patients had neuroimaging findings related to presenting symptoms. Discriminant analysis identified vertigo, dizziness, and dysequilibrium as corresponding to negative radiologic outcome. Nonvestibulocochlear cranial nerve involvement correlated significantly with positive neuroimaging results. Of all audiovestibular testing, only vestibular testing results correlated significantly with neuroimaging outcome. In conjunction with the results of vestibular testing, the symptoms and signs identified above yielded a sensitivity of 57% and specificity of 93% in predicting neuroradiologic results. In the absence of vestibular testing, sensitivity and specificity were 29% and 98%, respectively. **CONCLUSIONS:** Clinical presentation and audiovestibular testing could not sensitively predict the outcome of neuroimaging in our cohort of patients referred for audiovestibular dysfunction.

Index terms: Efficacy studies; Temporal bone, computed tomography; Temporal bone, magnetic resonance

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The clinical evaluation of patients with auditory and/or vestibular dysfunction represents a large proportion of the practice of the typical otolaryngologist. Magnetic resonance (MR) imaging has become an important element in this evaluation owing to its ability to portray the auditory pathway from the cochlea to the auditory cortex. In this type of evaluation, MR imaging is principally used to exclude the possibility of a retrocochlear lesion in patients with asymmetric sensorineural hearing loss, unilateral tinnitus or vestibular paresis, or other vestibular findings consistent with such a lesion. The most common retrocochlear lesion is a vestibular schwannoma (acoustic neuroma); less common lesions include other cerebellopontine angle or internal auditory canal tumors (facial schwannoma, meningioma, hemangioma, paraganglioma, cholesteatoma, and metastatic neoplasms), and demyelinating, ischemic, or vascular lesions. MR imaging has been considered to have a high sensitivity and specificity for diagnosis of these lesions as compared with audiometric testing, vestibular testing, auditory evoked potential testing, and other radiologic studies such as computed tomography (CT), pneumocisternography, or polytomography. The high cost of MR imaging, however, precludes its routine use for screening all patients with auditory and vestibular disorders. MR imaging is currently used for patients who are believed to be at high risk for a retrocochlear lesion. The determination of factors that constitute a high risk is therefore an issue of signifi-

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cant clinical relevance. Many investigators have assessed neuroimaging outcomes in patients referred for audiovestibular dysfunction. These series typically have focused on one pathologic entity (ie, acoustic neuroma) and have not specifically endeavored to correlate a broad range of presenting symptoms or results of audiometric and vestibular testing with imaging outcomes (1–3). In keeping with the current era of increased use review, we undertook to make this correlation with a view toward possible modification of the evaluation protocol.

The examination of patients with auditory pathway disease is complex and controversial, and warrants a brief review. The patients in question present with any combination of hearing loss, tinnitus, and/or dizziness. Patients who report primarily auditory symptoms undergo a physical examination with special attention to the ear, head and neck, and nervous system. An audiogram is then obtained, which typically includes pure tone thresholds, speech discrimination testing, and tympanometry with acoustic reflex testing (including acoustic reflex decay testing). Patients with asymmetric sensorineural hearing loss are clearly at increased risk for a retrocochlear lesion; however, there is no agreement on what constitutes a significant degree of asymmetry. Furthermore, the presence of a retrocochlear lesion is clearly not incompatible with completely normal audiometric test results, and these lesions can be found incidentally in completely asymptomatic patients (4). Many different strategies for determining the significance of an asymmetric sensorineural hearing loss have been described (5). At our institution, we generally consider a sensorineural hearing loss to be significantly asymmetric if it meets any of the following criteria: 15 dB or more difference in pure tone, bone conduction thresholds at 2 or more frequencies between 1 and 8 kHz; 20% or more difference in speech discrimination score; an absent or attenuated ($\geq$ 100 dB hearing level threshold) acoustic reflex with an afferent lesion pattern; or the presence of acoustic reflex decay at 500 or 1000 Hz. Other clinical presentations considered high risk include persistent, unilateral, nonpulsatile tinnitus (even in the absence of abnormal audiographic findings); any sudden sensorineural hearing loss (even if recovered to normal hearing); and the presence or suspected presence of conditions associated with a high risk for retrocochlear involvement, such as neurofibromatosis.

Dizziness is loosely defined as vertigo, dysequilibrium, balance difficulty, gait difficulties, and/or incoordination. Patients presenting with these disorders also undergo a physical examination with special attention to the ear, head and neck, and nervous system, followed by audiometric testing. This group of signs and symptoms is obviously associated with a wide range of etiologic possibilities, and frequently other disorders become apparent early in the history and physical examination. If abnormalities are found on the audiogram, they are evaluated as described above. If vestibular system disease is suspected, either with or without abnormal audiographic findings, quantitative vestibular testing is usually obtained. At our institution this includes electronystagmography, rotary chair testing, and platform posturography. In brief, these tests help to confirm the presence or absence of a lesion in the peripheral vestibular system, quantitate the degree of the abnormality in the case of many unilateral or asymmetric bilateral peripheral lesions, and evaluate the integrity of the relevant central pathways by assessment of the ocular motor system, including the vestibuloocular reflex. (In standard parlance with regard to the vestibular system, the term *peripheral* refers to the brain stem vestibular nuclei, vestibular nerves, and the vestibular receptor apparatus.) An otherwise unexplained *unilateral* peripheral vestibular lesion or evidence of central nervous system disease are considered findings at high risk for being associated with a retrocochlear lesion.

High-risk findings indicate the need for further evaluation. This generally consists of either auditory brain stem response (ABR) testing or neuroimaging. The neuroimaging study of choice is MR with contrast enhancement, and is preferred over CT unless otherwise contraindicated or unavailable. If ABR testing is initially performed and the results are abnormal, neuroimaging is obtained. ABR testing is highly sensitive for retrocochlear lesions (6), although recent reports clearly document a reduced sensitivity for small ($<$1 cm) vestibular schwannomas (4, 7–11). These facts have led to several important clinical controversies that have yet to be resolved. Should all patients be screened with both ABR testing and MR imaging, or are there subsets of patients who are more appropriately screened only with ABR

testing or MR imaging? Completeness of evaluation versus cost-effectiveness issues obviously drive this debate, and, presently, poorly defined "clinical judgment" is widely used to make these decisions.

Materials and Methods

Neuroimaging studies, audiometric and vestibular test results, and medical records of 118 patients examined during a 2-year period were reviewed retrospectively. All neuroimaging studies were performed at our institution and interpreted by experienced neuroradiologists. Audiometric and vestibular testing were performed in our otolaryngology department, and audiometric data were collected and reported in accordance with procedures established by the American National Standards Institute. These tests were interpreted by experienced audiologists and vestibular physiologists, and their original interpretations were used for purposes of this study. All patients were referred for imaging in order to rule out acoustic neuroma and/or for evaluation of sensorineural hearing loss, dizziness, and/or vertigo, and were entered into this study on the basis of the original imaging request. Audiometric, ABR, and vestibular testing results were available for review from the records of 100, 24, and 47 patients, respectively.

As previously indicated, established audiometric criteria exist for referral of patients for further evaluation for potential retrocochlear lesions. Our criteria are liberal, and there is no consensus regarding their appropriate implementation. For purposes of this study, we chose more conservative criteria. Positive audiographic findings, indicating a need for further diagnostic studies, included asymmetric hearing loss of 25 dB or more at 2 or more frequencies between 1 and 8 kHz, absent acoustic reflex thresholds, positive acoustic reflex decay, and/or a 20% or more difference in speech discrimination scores. Positive vestibular test findings, indicating a need for further testing, included objective indications of central vestibulooocular involvement not explained by age (such as impairment of ocular tracking or saccadic movement) or severe (> 60%) unilateral weakness on caloric testing without indications of a classic vestibular crisis at onset of symptoms or repeated spontaneous attacks of vertigo.

We used our institution's standard criteria for determining whether results of an ABR study were judged normal or abnormal, as follows. Click stimuli were presented at intensities ranging from 75 to 95 dB normalized hearing level. The study was considered abnormal if any of the following were true: I to III interpeak latency (IPL) of more than 2.30 milliseconds, III to V IPL of more than 2.10 milliseconds, I to V IPL of more than 4.4 milliseconds, interaural wave V latency difference (ILD_V) (after correcting for hearing loss at 2 to 4 kHz) of more than 0.40 millisecond. Tone pip stimuli of 1 kHz were then presented at 75 dB normalized hearing level. The study was also considered abnormal if any of the following were true: absolute wave V latency with insert earphones was more than 7.75 milliseconds or ILD_V was more than 0.60 millisecond (provided that pure tone thresholds at 1 kHz differed by less than 15 dB). Finally, the study was considered abnormal if waveform morphology was poor or if no waves were detected.

No attempt was made to correlate the individual components of the audiometric or vestibular test batteries with neuroimaging outcomes. We attempted to set our threshold criteria for labeling a test result as positive to a level consistent with generally accepted clinical standards. It must be emphasized, however, that this is an issue of significant debate (5).

Medical records were reviewed to assess presenting symptoms, character of presenting symptoms, duration of presenting symptoms, laterality of presenting symptoms, patient age at presentation, and sex. The symptoms and their characteristics were taken literally from the attending otolaryngologist's notes. Presenting symptoms included hearing loss, vertigo, dizziness, tinnitus (including "roaring/rushing"), balance difficulty, incoordination, nonvestibulocochlear cranial nerve involvement, hyperacusis, unsteadiness, dysequilibrium, "ear trouble," otalgia, or infection. There is considerable overlap between many of these terms, and these terms do not always have broadly accepted, specific definitions. For instance, most clinicians, but not all, would define vertigo, dysequilibrium, and unsteadiness as subsets of the broader category of dizziness. For the purpose of the present statistical analysis, balance difficulty, incoordination, and unsteadiness were grouped as one entity, as were hyperacusis, "ear trouble," otalgia, or infection. Character of symptoms included sudden onset, intermittent, severe, progressive, episodic, constant, chronic, occasional, acute, gradual, fluctuating, and recent, with sudden and acute grouped as one, episodic and intermittent grouped together, and progressive and gradual considered as one, again, for the purpose of statistical analysis.

Duration of symptoms was divided into four groups: 1 month or less, more than 1 month but not more than 1 year, more than 1 year but not more than 5 years, and more than 5 years. Laterality of symptoms included right, left, and both. Patients' age at presentation was divided into four groups: 20 years old or younger, 21 to 40 years old, 41 to 60 years old, and older than 60. Patients with neurofibromatosis or congenital sensorineural hearing loss were excluded from the study.

Most patients (n = 98) underwent routine MR imaging on a 1.5-T scanner with the use of a posterior fossa protocol, consisting of axial (2500–5600/18,90/1 [repetition time/echo time/excitations]) fast spin-echo images of the brain, and axial T1-weighted (with and without contrast enhancement) spin-echo images of the brain, and axial T1-weighted (with and without contrast enhancement) spin-echo images of the posterior fossa (400–650/11–18/2–4). For the axial fast spin-echo images, matrix size was 256 × 256, section thickness 5 mm with 1- to 2-mm intervals. For the T1-weighted images, matrix size was 256 × 192, section thickness 3 to 5 mm with 0- to 3-mm

TABLE 1: Presenting symptom versus imaging outcome in 118 patients with audiovestibular dysfunction

Symptom	Imaging Outcome	
	Positive	Negative
Hearing loss	12	53
Vertigo	1	43
Dizziness	1	12
Tinnitus	8	47
Balance difficulty (includes incoordination and unsteadiness)	4	5
Nonvestibulocochlear cranial nerve dysfunction	4	2
Hyperacusis	1	14
Dysequilibrium	0	5

intervals. Field of view was 20 cm for all studies. Occasional sagittal and coronal T1-weighted images of the brain were obtained. One patient was not given contrast material. Patients who were claustrophobic or obese, or those with metallic implants incompatible with MR imaging, underwent contrast-enhanced CT. Fifteen such patients had contrast-enhanced high-resolution CT of the temporal bones. One had contrast-enhanced head CT with 3-mm axial cuts through the posterior fossa, three had enhanced head CT with 5-mm axial sections through the posterior fossa, and one had high-resolution CT cisternography of the posterior fossa.

We performed independent two-way cross-tabulation of symptoms versus imaging outcome, symptom character versus imaging outcome, symptom duration versus imaging outcome, symptom laterality versus imaging outcome, patient age versus imaging outcome, patient sex versus imaging outcome, as well as results of audiometric and vestibular testing versus imaging outcome. Discriminant analysis with a linear model was used to identify variables related significantly to imaging results. Two-way cross-tabulation of these significant variables was done to assess their sensitivity and specificity in predicting neuroimaging outcomes.

Results

Two-way cross-tabulation of presenting symptoms versus imaging outcome appears in Table 1. The presence of vertigo corresponded significantly to a negative imaging outcome ($P < .001$), as did dizziness ($P < .04$) and dysequilibrium ($P < .05$). Nonvestibulocochlear cranial nerve dysfunction (four patients with positive and two patients with negative imaging outcomes) corresponded significantly to a positive imaging outcome ($P < .001$). The clinical presentation and imaging findings of the 15 patients with positive imaging outcomes are presented in Table 2. Nine patients had subsequently proved acoustic neuromas at the time of presentation, one had a presumed small acoustic neuroma, three had presumed inflammatory lesions, one a midbrain hemorrhage in association with posterior fossa vascular malformations, and one had either a small acoustic neuroma or an inflammatory lesion.

No statistical significance was observed for any symptom character versus imaging outcome. Duration of symptoms was essentially evenly distributed among the four categories (see above), with the group in which duration was 1 month or less having approximately one third the number of patients as the other groups. No significance was observed for any symptom duration group versus imaging outcome. There was no statistical significance regarding symptom laterality versus imaging outcomes. The male/female distribution in the studied population was without significant correlation to imaging outcome. The age distribution in the studied population showed no significant relationship to imaging outcome. A trend toward a greater percentage of positive imaging outcomes with increasing age was observed: (0% in the 20 years old or younger group; 20% in the 21- to 40-year-old group; 47% in the 41- to 60-year-old group; and 33% in the older than 60 group).

Audiograms from 100 patients, ABR examinations from 24 patients, and vestibular test results from 47 patients were available for interpretation. Fifty-three audiograms were negative for further retrocochlear work-up and 47 were positive. Of the 53 patients with negative audiographic findings, six had positive imaging outcomes; of the 47 patients with positive audiographic findings, eight had positive imaging outcomes. Fifteen ABR studies were abnormal and nine were normal. Of the 15 patients with abnormal ABR examinations, four had positive imaging outcomes; of the nine patients with normal ABR studies, one had a positive imaging outcome. Twelve vestibular test results were positive and 35 were negative for further (neuroradiologic) evaluation. Of the 12 patients with abnormal vestibular test results, seven had positive imaging outcomes; of the 35 patients with normal vestibular test results, one had a positive imaging outcome (Table 3).

Of the subgroup of patients with proved acoustic neuromas, five (56%) of nine had both positive audiometric and vestibular test results. Only one other patient in this study had both positive audiographic and vestibular test findings. This patient, who had sustained a head

TABLE 2: Clinical presentation and radiologic findings in patients with positive neuroimaging outcomes

Age, y	Sex	Symptoms	Duration	Initial Diagnosis Follow-up	Radiologic Findings	Audiometric Test Result	Vestibular Test Results	Auditory Brain Stem Response
74	M	Sudden R SNHL Sudden L SNHL	24 y 8 y	Autoimmune hearing loss/ inflammatory	MR: brain stem (including bilateral inferior collicular) and cerebral white matter signal aberration consistent with ischemia	+	...	...
55	M	R hearing loss, intermittent tinnitus	3–4 y	R translabyrinthine resection of AN	MR: 1.3-cm R cerebellopontine angle cistern mass	+	+	...
38	M	Ear trouble Balance and coordination problems Decreased R hearing, R facial numbness, R upper extremity incoordination	7–8 y Recent Recent Recent	AN resected	CT: 4 × 4 × 5-cm R lAC mass	−	...	...
57	F	Progressive L hearing loss L tinnitus	1 y 10–15 y	AN resected	MR: 2-cm L cerebellopontine angle cistern and lAC mass	+	+	...
64	F	Balance difficulty Hearing loss L facial twitching, decreased facial sensation, coordination difficulty	15 y 10 y 1 y	AN resected	CT: 3.5-cm mass centered in L porus acousticus	+	+	...
63	F	L hearing loss and tinnitus, Progressive L hemifacial numbness and paresthesia	1 y	AN resected	CT: 2-cm L cerebellopontine angle cistern mass	+	+	+
50	M	Tinnitus, L more than R	2 y	...	MR: 3 × 2-mm enhancing mass RlAC consistent with AN versus neuritis	−	...	−
59	F	Episodic imbalance	2 y	AN resected	MR: 1-cm L cerebellopontine angle cistern lesion with lAC extension	−	+	...
65	F	Progressive L hearing loss with tinnitus	7 mo	AN resected	MR: 1.5 × 2.5 × 1.5-cm L cerebellopontine angle cistern/lAC mass	−	+	+
55	M	lntermittent dizziness L tinnitus Decreased L hearing, diplopia, nausea, balance difficulty	10 y 5–6 y 2 y	AN resected	MR: 4 × 3 × 3-cm L cerebellopontine angle cistern mass with widened porus acoustics	+	+	+
57	M	Progressive L hearing loss with mild tinnitis	5–10 y	AN resected	CT: 10 × 12-mm L cerebellopontine angle cistern mass with widened porus acousticus	+	...	...
36	M	R SNHL	3 y	Viral cochleitis/ inflammatory	MR: enhancement of basal turn of R cochlea	+	...	...
46	M	Sudden onset hearing loss	1 mo	Responded to steroids/ inflammatory	MR: findings consistent with multiple sclerosis	...	...	...
78	M	Hearing loss, R more than L	...	...	MR: Midbrain hemorrhage, cerebellar vascular malformations	−	...	+
31	M	L tinnitus, vertigo, ear fullness	6 mo	Minimal enlargement at 1.5 y follow-up	MR: 4-mm enhancing lesion at the fundus of the left lAC, suggestive of AN	−	...	...

Note.—SNHL indicates sensorineural hearing loss; AN, acoustic neuroma; lAC internal auditory canal; +, positive; and −, negative.

TABLE 3: Audiometric, auditory brain stem response (ABR), and vestibular test results versus imaging outcome

Test Result	Imaging Outcome	
	Positive	Negative
Positive audiogram	8	39
Negative audiogram	6	47
Abnormal ABR	4	11
Normal ABR	1	8
Abnormal vestibular test	7	5
Normal vestibular test	1	34

injury 5 years earlier, had progressive hearing loss, vertigo, and bilateral tinnitus. MR findings were negative.

No statistical significance for the results of audiometric testing versus imaging outcome was obtained. Results of vestibular testing were significantly related to neuroimaging outcomes ($P < .0001$). The combined significant clinical variables of vertigo, dizziness, dysequilibrium, and nonvestibulocochlear cranial nerve dysfunction, along with results of vestibular testing (all identified by the discriminant model) yielded a sensitivity of 57% and a specificity of 93% in predicting imaging outcome. Without vestibular testing, sensitivity and specificity were 29% and 98%, respectively. Sample size was too small to assess further interaction of variables by means of the linear discriminant model.

Discussion

It has been suggested that preselection of patients should increase the yield of neuroimaging studies in the evaluation of auditory pathway disease (2). In this study, we retrospectively examined 118 patients with auditory and vestibular dysfunction and attempted to identify factors based on the clinical presentation and the results of audiometric and vestibular testing that might correspond significantly to either a positive or negative neuroimaging outcome. The results indicate that the presence of vertigo ($P < .01$), dizziness ($P < .04$), and dysequilibrium ($P < .05$) correlated with negative imaging outcomes, and that nonvestibulocochlear cranial nerve dysfunction ($P < .001$) correlated with positive imaging studies. Vestibular testing results were identified by the discriminant model as relating significantly ($P < .0001$) to imaging outcomes. However, the low sensitivity (0.57), and marginal specificity (0.93) of these results indicate that presenting symptoms and vestibular testing could not be used for the purpose of increasing the diagnostic yield of neuroimaging in retrospectively applying these criteria to our group of patients. It must be emphasized that, owing to sample size limitations, this analysis did not assess the relationship of interaction of variables to imaging outcomes. Thus, it cannot be excluded that certain interactions of significant symptoms and the results of vestibular testing could result in greater sensitivity and/or specificity in a larger patient population.

Several similarities to previous inquiries are worth mentioning. The frequency of acoustic neuroma in this series was 8% (9 of 118). Previous radiologic series have demonstrated similar frequencies of 10% (17 of 176) (2) and 6% (9 of 157) (3). In the former series, sensorineural hearing loss was the reason for patient inclusion in the study. In the latter, evaluation of suspected acoustic neuroma was the criterion. These results, coupled with the broader inclusion criteria in the present study of evaluation for acoustic neuroma, sensorineural hearing loss, vertigo, and dizziness, suggest that vertigo and dizziness are less commonly associated with acoustic neuroma as presenting symptoms than is sensorineural hearing loss. This is further borne out by the present study (Table 2) in which seven (78%) of nine patients with acoustic neuroma initially had sensorineural hearing loss, none initially had vertigo, and one (11%) of nine initially had dizziness, as well as by other series (12).

The role of neuroimaging for patients referred for the evaluation of dizziness is less clear cut. In one series of 20 elderly patients (mean age, 82 years), MR findings were no different from those in an age-matched control group (13). In another series of 79 patients referred for dizziness or rotatory vertigo (age range, 19 to 59 years), neuroimaging studies were positive in 34% (14). In the present series of 118 patients, one patient with dizziness had a positive imaging result of an acoustic neuroma. If the broader category of dizziness/balance difficulty, incoordination, and unsteadiness is used, five (4%) of the 118 patients (all with acoustic neuromas) had positive imaging results.

We did not identify any presenting symptoms, with or without the results of vestibular testing, that could sensitively predict imaging outcome in patients with audiovestibular dys-

function. Nonvestibulocochlear cranial nerve dysfunction, identified only in patients with acoustic neuroma and never present without other symptoms in this series, is classically a late finding in patients with acoustic neuroma, associated with larger tumors (15), and as a result had a low sensitivity. Vertigo, dizziness, and dysequilibrium proved only marginally significant in predicting negative neuroimaging outcomes.

It must be emphasized that only 98 (83%) of the 118 patients in this series initially underwent MR imaging, the current radiologic technique of choice for evaluating audiovestibular dysfunction. Surprisingly, the diagnostic yield for those patients initially evaluated with CT was 20% (4 of 20) versus 11% (11 of 98) for those evaluated with MR imaging. This may be because CT is frequently ordered before surgery for acoustic neuromas already diagnosed by outside MR imaging.

In this study, no attempt was made to correlate the individual components of the audiometric and vestibular testing batteries with neuroimaging outcomes. We chose very liberal criteria for designating an audiometric test battery as positive and moderately conservative criteria for designating a vestibular test battery as positive. The selection of these criteria clearly had a strong effect on the interpretation of the data. Had more conservative criteria been chosen for audiometric testing, a significant correlation with imaging outcome may have been found, although the sensitivity would have been low. We wanted to correlate presenting symptoms, signs, and test results with imaging outcomes in a manner consistent with the generally used clinical protocol within our institution.

Some aspects of our patient population deserve comment. As a tertiary care referral facility, many of our patients are referred after extensive evaluations have been performed elsewhere. Patients may be referred to our neurosurgeons or neurootologists for treatment of an already diagnosed acoustic neuroma, who then may order a neuroimaging study for preoperative delineation of the lesion. Many of the presenting disorders may not be well delineated in the medical record, as they may have been already clearly stated in correspondence with the referring physician. As a tertiary care institution, we may have a lower threshold for obtaining neuroimaging studies because all other appropriate diagnostic studies have already been obtained and the patient still has no satisfactory explanation for his or her symptoms. We were particularly surprised to see how few of these patients had been given an ABR test before neuroimaging. In the second author's neurootology practice, nearly all patients being referred for neuroimaging will have had an ABR study first. In the presence of normal ABR test results, MR imaging is obtained only in circumstances otherwise highly suggestive of retrocochlear lesions. Perhaps the low number of ABR studies in our series is due to the fact that many of the patients referred for neuroimaging were done so by nonneurootologists. Limiting the neuroimaging studies to patients with positive ABR studies would very likely change our results. The recent reports of a significant prevalence of small acoustic neuromas in patients with normal ABR studies has most likely resulted in a lower threshold for referral for neuroimaging (10–12). A well-designed prospective study will be required to delineate indicators that can predict neuroimaging outcomes in a clinically significant fashion.

In conclusion, the results of this study indicate that, in our cohort of 118 patients, clinical presentation alone or in conjunction with the results of audiometric and vestibular testing could not sensitively predict neuroimaging outcomes.

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