Vestibular Evoked Myogenic Potentials in Patients With Acoustic Neuromas

Toshihisa Murofushi, MD; Masaki Matsuzaki, MD; Masahiro Mizuno, MD

Background: To diagnose acoustic neuromas (ANs), the auditory brainstem response test and the caloric test have been used in addition to magnetic resonance imaging. The auditory brainstem response and the caloric tests mainly reflect functions of the auditory pathway, ie, the cochlear nerve and the superior vestibular nerve, respectively. Because the vestibular evoked myogenic potential (VEMP) has been thought to originate in the inferior vestibular nerve, we hypothesized that the VEMP could provide different information from the auditory brainstem response and the caloric test and that it could be helpful in diagnosing ANs. In other words, we hypothesized that the VEMP could provide information concerning inferior vestibular nerve involvement in patients with ANs.

Objective: To find out if the VEMP could be useful in classifying ANs according to the involved nerves.

Design: We reviewed preoperative clinical tests, including VEMPs, in 21 patients (8 men, 13 women) with ANs confirmed surgically and histopathologically, comparing them with VEMPs in 8 normal subjects (5 men, 3 women).

Results: Whereas the first positive-negative peak of the VEMP, P13-N23, was ipsilaterally present on stimulation of the unaffected side in all patients with ANs and both sides in all normal subjects, it was absent on the affected side in 15 patients (71%) and significantly decreased in amplitude in 2 patients (9%). Thus, 17 (80%) of the 21 patients showed abnormal VEMPs. Three patients had abnormal VEMPs although they had normal caloric responses. Three patients had abnormal caloric responses although they had normal VEMPs.

Conclusion: These results suggest that the VEMP could be useful for the diagnosis of AN, especially for classifying ANs according to the involved nerves.


It has been known that loud monaural clicks evoke myogenic potentials in the tonically contracting ipsilateral sternocleidomastoid muscle (SCM). Clinical studies have suggested that these potentials are of vestibular origin, especially of the inferior vestibular nerve region. Neurophysiological experiments using guinea pigs and cats have shown that primary vestibular afferents, especially saccular afferents, respond to relatively loud clicks. These myogenic potentials are called vestibular evoked myogenic potentials (VEMPs). Only a few reports exist concerning the clinical application of VEMPs. Murofushi et al reported that in a third of patients with vestibular neuritis, VEMPs are absent on the affected side and that absence of VEMPs might indicate involvement of the inferior vestibular nerve. Colebatch et al reported that patients with torticollis could show abnormal VEMPs and that VEMPs elicited in a patient with the Tullio phenomenon had an abnormally low threshold.

Neuro-otologists often see patients with acoustic neuroma (AN). Whereas magnetic resonance imaging is the best tool for diagnosing AN, the auditory brainstem response (ABR) test and the caloric test have been used for the clinical neurophysiological diagnosis of ANs. Although the ABR and the caloric tests are useful, they are not perfect. Whereas the ABR is a clinical test of the auditory pathway, including the cochlear nerve, and the caloric test is a clinical test of the superior vestibular nerve, the VEMP is likely to be a clinical test of the inferior vestibular nerve. The VEMP might reflect different functions from those shown with the ABR and the caloric tests. We wondered whether the VEMP could be helpful in diagnosing AN, especially for classifying ANs according to the involved nerves. We report the findings of VEMP testing in patients with AN.

From the Departments of Otolaryngology, University of Tokyo (Dr Murofushi), Tokyo Metropolitan Bokuto Hospital (Dr Matsuzaki), and Tokyo University Branch Hospital (Dr Mizuno), Tokyo, Japan.

©1998 American Medical Association. All rights reserved.
PATIENTS AND METHODS

PATIENTS
The clinical neuro-otologic test results of 21 patients (8 men and 13 women; age range [median], 20-65 [53] years) who underwent VEMP testing preoperatively and were surgically and histopathologically diagnosed as having ANs (schwannoma) were reviewed. Eight normal volunteers (5 men and 3 women; age range [median], 25-37 [31.5] years) were also examined. They were on the medical staffs of our departments.

METHODS
Surface electromyographic activity was recorded in supine patients from symmetrical sites over the upper half of each SCM, with a reference electrode on the side of the upper sternum. During the recording, the patients were instructed to rotate their heads to the opposite side of the stimulated ear to activate the SCM.1 Electromyographic activities were monitored during the recording to maintain muscle activities at a constant level in each patient. Background electromyographic activities usually ranged from 50 to 200 µV. The electromyographic signal from the stimulated side was amplified and the bandpass filtered (20-2000 Hz). Rarefaction clicks (0.1 millisecond, 95-dB normal hearing level) were presented through a headphone. The stimulation rate was 5 Hz, and the analysis time was 50 milliseconds. The responses to 200 stimuli were averaged twice.

We analyzed the amplitude of the first positive-negative peak (P13-N23) of the VEMP (Figure 1) ipsilateral to the stimulated ear. The average of 2 runs was regarded as the amplitude. In patients with AN, the evoked potential ratio was evaluated as follows: 100 (Aa−Au)/(Aa+Au), where Au indicates the P13-N23 amplitude on the unaffected side; Aa, the P13-N23 amplitude on the affected side. In normal volunteers, the evoked potential ratio was evaluated as follows: 100|Ar−Al|/(Ar+Al), where Ar indicates the P13-N23 amplitude on the right; Al, the absolute value of (Ar−Al).

All patients also underwent pure-tone audiometry and ABR and caloric tests. The ABR test was also recorded using surface electrodes. The positive electrode was placed on the vertex and the negative electrode on the mastoid. The ground electrode was on the nasion. Clicks (0.1 millisecond, 80-dB normal hearing level) were presented through a headphone. The stimulation rate was 10 Hz, and the analysis time was 10 milliseconds. The responses to 1000 stimuli were averaged twice. Caloric responses were recorded using electronystagmography. Canal paresis was calculated using the maximum slow-phase eye velocity of caloric nystagmus.

RESULTS

NORMAL SUBJECTS
In all normal subjects, VEMPs were recorded on the SCM ipsilateral to the stimulated side on both sides (Figure 1, A). The evoked potential ratio ranged from 0.18 to 32 (average ±SD, 12.3 ±10.9). According to data of normal subjects, we defined 34.1 (average + 2 SDs) as the upper limit of the normal range of the evoked potential ratio.

PATIENTS WITH AN
Vestibular Evoked Myogenic Potential
Biphasic potentials (P13-N23) were observed on the SCM ipsilateral to the stimulated unaffected side in all 21 patients. When the affected side was stimulated, 15 patients (71%) did not show VEMPs (Figure 1, B). Two patients (9%) showed decreased responses on the affected side. Four patients (20%) showed normal responses on the affected side and on the unaffected side (Figure 1, C). As a result, 17 (80%) of the 21 patients showed abnormal VEMPs on the affected side.

VEMP vs Caloric Test
Seventeen patients (80%) had decreased caloric responses (canal paresis, >20%) on the affected side (Table). Whereas 14 patients (67%) had abnormal findings on both VEMP testing and caloric testing, 3 patients (14%) showed abnormal findings only on the VEMP, and 3 patients showed abnormal findings only on the caloric test. One patient (5%) did not show abnormal findings on VEMP testing or caloric testing.

VEMP Testing vs ABR Testing
Auditory brainstem responses were evaluated in patients whose hearing levels at 4 kHz were 65 dB or better (n=11). All 11 patients showed abnormal ABRs with stimulation of the affected side. Seven patients showed abnormal findings on both ABR testing and VEMP testing, whereas 4 patients had normal ABRs and normal VEMPs. Of the 11 patients, 3 had no response. Four patients showed only wave I, and 3 patients showed prolonged interpeak latencies (prolonged I-III or I-V). One patient had a prolonged wave V.

Of the 10 patients who were excluded from the evaluation of ABRs because of profound sensorineural hearing loss, 8 showed abnormal results on both VEMPs and caloric testing. Two patients showed normal results only on VEMP testing. Of the 10 patients, 8 showed no response in the ABRs. Of the 8 patients, 7 showed absent VEMPs on the affected side, and 1 patient showed decreased VEMPs on the affected side.

VEMP Testing vs Pure-Tone Hearing
Pure-tone hearing levels at 4 kHz ranged from 5 dB to above the scale (>110 dB) (Figure 2). We divided patients into 2 groups according to their hearing levels at 4 kHz. In the group of patients whose hearing levels at 4 kHz were 60 dB or better (n=10), 7 patients had normal VEMPs on the affected side (absent VEMPs in 6 patients, decreased VEMPs in 1 patient), and 3 patients had normal VEMPs. In the group of patients whose hearing levels were worse than 60 dB (n=11), 10 patients had abnormal VEMPs (absent VEMPs in 9 patients, decreased VEMPs in 1 patient). One patient showed normal VEMPs.
It has been reported that loud clicks evoke initial inhibitory potentials in the tonically contracting ipsilateral SCM. These potentials are thought to be of vestibular origin because they disappeared after a unilateral vestibular nerve section but were still present in a patient with a totally deaf ear. These potentials have been called vestibular evoked myogenic potentials. The VEMPs were also absent in a third of patients with vestibular neuritis. The study of patients with vestibular neuritis suggested that if VEMPs are absent from an ear that suffered from vestibular neuritis, benign paroxysmal positioning vertigo of the posterior canal is unlikely to develop as a consequence of the vestibular neuritis. It was thought that the absence of VEMPs is due to involvement of the inferior vestibular nerve or of the structures that it innervates.

Neurophysiological studies of guinea pigs showed results consistent with those of clinical studies. In guinea pigs, primary vestibular afferents respond to loud clicks (60-70 dB above the ABR threshold). Most click-sensitive primary afferents are saccular afferents. Uchino et al reported that the electrical stimulation of saccular afferents causes inhibitory inputs to ipsilateral neck flexor motoneurons in cats.

We thought that if patients with AN have substantial lesions of the inferior vestibular nerve, then they should show absent or decreased amplitude of VEMPs on the affected side, although they might show normal caloric responses due to superior vestibular nerve activities. In this study, as we hypothesized, some patients...
showed abnormal findings on VEMP testing although they did not show abnormal findings on the caloric test. On the other hand, some patients had normal VEMPs although they had abnormal caloric responses. These results confirm that the VEMP testing could reflect different functions from the caloric test.

The VEMP test showed abnormal findings in about 80% of patients with surgically confirmed AN. This rate of abnormal findings in ANs may be lower than that of abnormal findings in ABR testing.15 We thought, however, that VEMP testing could still be a useful neurophysiological test for diagnosing AN because VEMP testing and caloric testing could classify ANs according to the involved nerves: the inferior vestibular nerve or the superior vestibular nerve. Acoustic neuromas mainly originate in the inferior vestibular nerve or the superior vestibular nerve.16 Vestibular evoked myogenic potentials might be useful in classifying patients according to the origins of their ANs.

Accepted for publication November 10, 1997.

This research was supported in part by a grant provided by the Ichiro Kanehara Foundation, Tokyo, Japan.

Corresponding author: Toshihisa Murofushi, MD, Department of Otolaryngology, Faculty of Medicine, University of Tokyo, 7-3-1, Hongo, Tokyo 113, Japan (e-mail: toshi-tky@cc.umin.u-tokyo.ac.jp).

REFERENCES