Diagnostic Value of Prolonged Latencies in the Vestibular Evoked Myogenic Potential

Toshihisa Murofushi, MD; Ken Shimizu, MD; Hideki Takegoshi, MD; Po-Wen Cheng, MD

Background: As a parameter for the evaluation of the vestibular evoked myogenic potential (VEMP), amplitude has been used clinically. However, the significance of latency has not been considered.

Objective: To clarify the diagnostic value of latencies of the VEMP.

Design: We reviewed records of the VEMP of patients with various diseases and compared them with records of healthy volunteers.

Setting: Data were collected from patients in an outpatient clinic of a tertiary care center and healthy volunteers.

Subjects: Clinical records of 134 patients (61 men and 73 women, aged 20-75 years) were reviewed. Diagnoses were Meniere disease in 43 patients, acoustic neuroma in 62 patients, vestibular neuritis in 23 patients, and multiple sclerosis in 6 patients. Also, 18 healthy volunteers (13 men and 5 women, aged 25-38 years) were enrolled.

Intervention: Diagnostic.

Main Outcome Measures: Click-evoked myogenic potentials were recorded with surface electrodes over each sternocleidomastoid muscle. Latencies and amplitudes of responses were measured.

Results: Vestibular evoked myogenic potentials were absent or decreased in 51% of patients with Meniere disease (n=22), 39% with vestibular neuritis (n=9), 77% with acoustic neuroma (n=48), and 25% with multiple sclerosis (3 of 12 sides of 6 patients). Concerning latency, patients with Meniere disease or vestibular neuritis hardly showed any latency prolongation. Four patients with acoustic neuroma showed prolonged p13; all had large tumors. All patients with multiple sclerosis showed prolonged p13.

Conclusion: Prolonged latencies of the VEMP suggest lesions in the retrolabyrinthine, especially in the vestibulospinal tract.


CLICK-EVOKED myogenic potentials on the sternocleidomastoid muscle have been used as a clinical test of the vestibulospinal reflex. This response is known as the vestibular evoked myogenic potential (VEMP).1-3 Although we have mainly used the amplitude of the first positive-negative response (p13-n23) for the evaluation of VEMP, we have not used the peak latency (p13 and/or n23). Recently, Shimizu et al4 reported that latencies of p13 and n23 were prolonged in 3 patients with multiple sclerosis (MS) who are included in this study and that latencies could be a useful parameter for the evaluation of lesions in the vestibulospinal tract. We speculated whether the prolongation of the latencies was pathognomonic for MS or lesions in the vestibulospinal tract. However, there are no reports concerning latency in other diseases. To clarify the diagnostic value of VEMP latencies, we reviewed VEMP recordings from patients with Meniere disease (MD), vestibular neuritis (VN), acoustic neuroma (AN), and MS and compared their results with those of healthy subjects.

RESULTS

HEALTHY VOLUNTEERS

Clear responses were obtained on both sides from all healthy subjects. The mean ± SD latencies of p13 and n23 were 11.8 ± 0.86 and 20.8 ± 2.2 ms, respectively. When we defined the mean latencies ± 2 SDs as the upper limits of the normal ranges, the upper limits were 13.5 ms (p13) and 25.2 ms (n23). When the
SUBJECTS AND METHODS

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Clinical records of 134 patients (61 men and 73 women, aged 20-75 years) were reviewed. Diagnoses were MD in 43 patients, AN in 62 patients, VN in 23 patients, and MS in 6 patients. Both MD and VN were diagnosed according to standard neurologic criteria.5-6 Diagnoses of AN were confirmed by neurosurgery. In other words, AN in this article represents vestibular schwannoma. The diagnosis of MS was made by standard neurological criteria.7 In patients 11, 12, 13, and 14, T2-weighted magnetic resonance imaging showed high-intensity lesions in the pontine tegmentum involving the vestibular nuclei and vestibulospinal tract bilaterally (Figure 1). In patients 15 and 16, T2-weighted magnetic resonance imaging did not show high-intensity lesions in these areas. Except for patients with MS, patients had unilateral diseases. Also, 18 healthy volunteers (13 men and 5 women, aged 25-38 years) underwent VEMP testing.

METHODS

The methods for recording VEMPs are described elsewhere.2,3 Briefly, surface electromyographic activity was recorded in the supine patient from symmetrical sites over the upper half of each sternocleidomastoid muscle, with a reference electrode on the lateral end of the upper sternum. During recording, the patients were instructed to rotate their heads to the opposite side to the stimulated ear as much as possible to activate the sternocleidomastoid muscle. Electromyographic activities were monitored on a display during the recording to maintain muscle activities at a constant level in each patient. The electromyographic signal from the stimulated side was amplified and bandpass filtered (20-2000 Hz). Rarefaction clicks (0.1 millisecond [ms], 95-dB normal hearing level) were presented through a headphone (type DR-531, Elega Acous. Co Ltd, Tokyo, Japan). The stimulation rate was 5 Hz, and the analysis time was 50 ms. The responses to 100 stimuli were averaged twice.

We analyzed the amplitude of the first positive-negative peak, p13-n23 ipsilateral to the stimulated ear and the latencies of p13 and n23.8 The average of 2 runs was taken for the amplitudes and latencies.

For the evaluation of the amplitude, the percentage of VEMP asymmetry (VA) was calculated as 100[(Au−Aa)/(Aa+Au)], where Au is the p13-n23 amplitude on the unaffected side and Aa is the p13-n23 amplitude on the affected side. In healthy volunteers, the percentage of VA was evaluated as 100|Ar−Al|/(Ar+Al), where Ar is the p13-n23 amplitude on the right and Al is the p13-n23 amplitude on the left and |Ar−Al| is the absolute value of (Ar−Al).3

As parameters of the latency, we measured the peak latencies of p13 and n23. p13 is the first positive peak of VEMPs, and n23 is the first negative peak following p13.8 We defined the latency as the time from the onset of the stimulus to the peak (Figure 2).

PATIENTS

Meniere Disease

Fifteen of the 43 patients showed absence of p13-n23 on the affected side, 7 showed decreased responses, and 21 showed normal responses. In other words, 22 (51%) of 43 showed abnormal amplitudes on the affected side latency of p13 or n23 was longer than the mean latency +2 SDs of healthy volunteers, we regarded the latency as prolonged.

Because the mean±SD of the percentage of VA was 12.5%±8.7%, the upper limit was 30.0%. When the percentage of VA was greater than the mean +2 SDs of healthy volunteers, we regarded the amplitude of the smaller side as decreased.

Vestibular Neuritis

Nine (39%) of the 23 patients showed absence of p13-n23 on the affected side, and 14 showed normal responses (Figure 3). Concerning latencies, only 1 of the 14 patients showed prolonged p13 (13.7 ms) (Figure 4). None of the patients with VN showed prolongation of n23.

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Vestibular Neuritis

Nine (39%) of the 23 patients showed absence of p13-n23 on the affected side, and 14 showed normal responses (Figure 3). Concerning latencies, only 1 of the 14 patients showed prolonged p13 (13.7 ms) (Figure 4). None of the patients with MD showed prolongation of n23.
Acoustic Neuroma (Vestibular Schwannoma)

Thirty-nine of the 62 patients showed absence of responses on the affected side, 9 showed decreased responses, and 14 showed normal responses. In other words, 48 patients (77%) showed abnormal amplitudes (Figure 3). Concerning latencies, 4 (17%) of the 23 patients with responses showed prolongation of p13 (Figure 4). Three of the 4 patients also showed prolongation of n23 (Table 1, Figure 5).

We classified patients into 2 groups according to their tumor sizes. Twenty-nine patients had small tumors, which protruded from the porus of the internal auditory meatus less than 2 cm. Among the 29 patients, 16 showed absent VEMP, 4 showed decreased VEMP, and 9 showed normal VEMP. None of them showed prolongation of the latency of p13 or n23. Thirty-three patients had large tumors, which protruded from the porus of the internal auditory meatus equal to or more than 2 cm. Among the 33 patients, 23 showed absent VEMP, 5 showed decreased VEMP, and 5 showed normal amplitudes of VEMP. All 4 patients who showed prolongation of p13 had large tumors (Table 1). Prolongation of p13 latency was significantly greater in the group of large tumors than the group of small tumors (Fisher exact test, \( P < .05 \)).

Multiple Sclerosis

Among 12 sides of the 6 patients with MS, 3 sides showed absence of responses. All of the other sides (9 sides) showed prolongation of p13, and 4 showed prolongation of n23 (Table 2, Figure 4).

STATISTICAL ANALYSES

The mean latencies and SDs of p13 and n23 are summarized in Table 3. Concerning latencies of p13 and n23, significant differences were found among 5 groups (control, MD, VN, AN, and MS) (\( P < .001 \), 1-way analysis of variance). Significant differences of p13 latencies were found between the MS group and each of the other 4 groups (\( P < .001 \), Scheffe test). Significant differences of n23 latencies were also found between the MS group and

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Table 1. Patients With Acoustic Neuroma and Prolonged p13 and/or n23

<table>
<thead>
<tr>
<th>Patient No./</th>
<th>Sex/Age, y</th>
<th>Amplitude</th>
<th>p13, ms</th>
<th>n23, ms</th>
<th>I-V (ABR), ms</th>
<th>Tumor Size, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/F/51</td>
<td>Normal</td>
<td>14.9</td>
<td>31.2</td>
<td>4.92</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2/M/54</td>
<td>Decreased</td>
<td>14.6</td>
<td>21.2</td>
<td>Only wave I</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3/M/43</td>
<td>Normal</td>
<td>14.4</td>
<td>27.4</td>
<td>5.2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4/M/48</td>
<td>Decreased</td>
<td>15</td>
<td>26</td>
<td>5.48</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

*Four (17%) of the 23 patients with acoustic neuroma showed prolonged p13. All had large tumors. I-V (ABR) indicates interpeak interval between waves I and V (normal, < 4.4 ms). Patient 2 showed only wave I. Tumor size is the length of the tumor protruding from the porus of the internal auditory meatus. Boldface values indicate prolonged latencies.

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Figure 3. Amplitudes of p13-n23 on the affected side. Responses were absent or decreased in 22 (51%) of the 43 patients with Meniere disease (MD), 9 (39%) of the 23 patients with vestibular neuritis (VN), and 48 (77%) of the 62 patients with acoustic neuroma (AN).

Figure 4. Latencies of p13 patients with Meniere disease (MD) or vestibular neuritis (VN) hardly showed any prolonged p13. Among patients with acoustic neuroma (AN), 4 patients showed prolonged p13. All had large tumors. All patients with multiple sclerosis (MS) showed prolongation of p13 if they showed any response. No. represents the number of patients in the MD, VN, and AN groups and the number of sides in the MS group.

Figure 5. Vestibular evoked myogenic potentials of patient 3 (a 43-year-old man with right-sided acoustic neuroma). Latencies of p13 and n23 on the right were prolonged significantly.
In this study, we reviewed the results of VEMPs in patients who had MD hardly showed any prolongation of VEMP latency, whereas many patients showed decreased amplitudes or absent responses. It is unlikely that prolonged VEMP latencies are a sign of inner ear lesions. Patients with VN did not show latency prolongation either. To explain this, we can consider 2 possibilities. First, some patients may have complete damage in the inferior vestibular nerve, resulting in absence of the VEMP, whereas in other patients the inferior vestibular nerve could be spared as reported by Murofushi et al and Fetter and Dichgans. In other words, patients with VN may have complete damage or no damage to the inferior vestibular nerve. Second, damage only to the vestibular nerve may be insufficient for VEMP latency prolongation beyond the normal range. In fact, all patients with AN who showed latency prolongation had large tumors that compressed the brainstem. The most marked findings were obtained in patients with MS. All subjects showed latency prolongation if they showed any responses. These results suggest that brainstem lesions, especially those in the vestibulospinal tract, are required for the prolongation of p13.

From the practical viewpoint, p13 showed prolongation of the latency more frequently than n23. As we showed, the SD of n23 was greater than that of p13, resulting in a wider normal range of n23 than p13. Therefore, p13 is a better parameter for evaluation of the latency of VEMP.

In conclusion, prolonged VEMP latencies, especially prolonged p13, would strongly suggest lesions in the vestibulospinal tract, although they are not pathognomonic for MS.

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REFERENCES


Table 2. Latencies of Patients With Multiple Sclerosis

<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>Side</th>
<th>p13, ms</th>
<th>n23, ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/F/30</td>
<td>L</td>
<td>19.8</td>
<td>29.2</td>
</tr>
<tr>
<td>12/F/36</td>
<td>L</td>
<td>16.5</td>
<td>23.1</td>
</tr>
<tr>
<td>13/M/34</td>
<td>R</td>
<td>15.3</td>
<td>20.8</td>
</tr>
<tr>
<td>14/M/50</td>
<td>R</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>15/F/33</td>
<td>L</td>
<td>21.2</td>
<td>28.2</td>
</tr>
<tr>
<td>16/F/46</td>
<td>L</td>
<td>20.9</td>
<td>29.1</td>
</tr>
</tbody>
</table>

Table 3. Mean Latencies of p13 and n23

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>Mean ± SD Latency, ms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p13</td>
<td>n23</td>
</tr>
<tr>
<td>Control</td>
<td>36</td>
<td>11.8 ± 0.86</td>
</tr>
<tr>
<td>MD</td>
<td>28</td>
<td>11.9 ± 1.1</td>
</tr>
<tr>
<td>VN</td>
<td>14</td>
<td>12.0 ± 0.81</td>
</tr>
<tr>
<td>AN</td>
<td>23</td>
<td>12.4 ± 1.3</td>
</tr>
<tr>
<td>MS</td>
<td>9</td>
<td>17.3 ± 2.6</td>
</tr>
</tbody>
</table>

* MD indicates Meniere disease; VN, vestibular neuritis; AN, acoustic neuroma; and MS, multiple sclerosis.

For clinical evaluation of VEMP, amplitude has been mainly used. In patients with the Tullio phenomenon, the threshold has also been used for evoked potentials. The latency is a useful parameter in other types of evoked potentials such as auditory brainstem responses. However, latency was seldom used for the evaluation of VEMP, although Shimizu et al reported that 3 patients with MS showed prolongation of p13 latency. It was not yet clear if prolonged VEMP latencies are pathognomonic for MS.

In this study, we reviewed the results of VEMPs in patients with MD, VN, AN, and MS. Meniere disease is a representative disease of labyrinthine lesions, and VN is a representative disease of the vestibular nerve. Acoustic neuroma is a disease in which the vestibular nerve and brainstem can be involved, whereas MS is a representative disease of the central nervous system.

In this study, patients who had MD hardly showed any prolongation of VEMP latency, whereas many patients showed decreased amplitudes or absent responses. It is unlikely that prolonged VEMP latencies are a sign of inner ear lesions. Patients with VN did not show latency prolongation either. To explain this, we can consider 2 possibilities. First, some patients may have complete damage in the inferior vestibular nerve, resulting in absence of the VEMP, whereas in other patients the inferior vestibular nerve could be spared as reported by Murofushi et al and Fetter and Dichgans. In other words, patients with VN may have complete damage or no damage to the inferior vestibular nerve. Second, damage only to the vestibular nerve may be insufficient for VEMP latency prolongation beyond the normal range. In fact, all patients with AN who showed latency prolongation had large tumors that compressed the brainstem. The most marked findings were obtained in patients with MS. All subjects showed latency prolongation if they showed any responses. These results suggest that brainstem lesions, especially those in the vestibulospinal tract, are required for the prolongation of p13.

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