Comparison of the Vestibular Evoked Myogenic Potential and the Blink Reflex in Cerebellar and Brainstem Infarction Patients

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**Objective:** This study investigated whether the blink reflex could be substituted for the vestibular evoked myogenic potential (VEMP), which has some limitations for use in stroke patients.

**Methods:** Thirty-four patients with cerebellar or brainstem ischemic stroke underwent VEMP and blink reflex testing. We compared the P13 latency of VEMP and the R1, R2, R2' latency of the blink reflex in stroke patients. Statistical analysis was conducted using the Fisher exact test and independent t-test, with a p-value < 0.05 indicating statistical significance.

**Results:** In 29 stroke patients, excluding those with bilateral lesions, the VEMP and the blink test did not show a statistically significant relationship (p = 0.27). In all 34 stroke patients participating in the study, including those with bilateral lesions, R2' mean showed a statistically significant difference (p = 0.008) according to the presence of normal or abnormal VEMP.

**Conclusion:** R2' of the blink reflex passes through more neural pathways and polysynaptic pathways than R1 and R2; therefore, it showed a more prominent difference between the normal and abnormal VEMP groups.

**Keywords:** Vestibular evoked myogenic potentials; Blink reflex; Brain Stem; Stroke; Poly-synaptic pathways

**Introduction**

Patients with cerebellar and brainstem stroke often complain of dizziness, nausea, or loss of balance. These symptoms are known to result from the involvement of the vestibular pathway, which affects the sense of balance. The vestibular evoked myogenic potential (VEMP) is a test that can evaluate the vestibular system in these patients. VEMP is used to determine whether the vestibular nerve pathway is abnormal by examining the inhibitory electromyography (EMG) response in the neck muscle or the excitatory EMG response in the extraocular muscle caused by auditory stimulation [1].

The blink reflex test is an electrodiagnostic test that can be used to precisely localize lesions in brainstem stroke patients. The blink reflex is a brainstem reflex triggered by electrical stimulation of the trigeminal supraorbital nerve, eliciting contraction of the orbicular muscles by the facial nerve. The waves of the blink reflex consist of the ipsilateral R1 response recorded initially and the ipsilateral R2 and contralateral R2' responses, which are recorded later [2,3].

To the best of our knowledge, the VEMP and blink reflex tests have not shown any relationship, since they test the vestibular nerve and trigeminofacial nerve pathways, respectively. However, the pathways of VEMP and the blink reflex share a common feature—namely, they pass through the brainstem. Therefore, we hypothesized that the VEMP and the blink re-
flex tests might have a correlation with each other. Moreover, because there are more neural pathways and synapses along R2’ than R2 and along R2 than R1, we hypothesized that the difference between normal and abnormal findings would be most prominent in R2’, followed in descending order by R2 and R1.

Because the VEMP test requires active cervical rotation or cervical flexion, it is difficult to use in unconscious or hemiplegic patients, whereas the blink reflex does not have those limitations. Therefore, if a significant correlation between the blink reflex and VEMP is confirmed according to our hypothesis, then we could substitute the blink reflex for VEMP in patients who are unable to cooperate with VEMP testing.

Materials and Methods

Thirty-four patients with cerebellar or brainstem ischemic stroke were prospectively enrolled in this study. The Institutional Review Board (IRB) of Wonju Severance Christian Hospital approved the study (IRB no. CR317055). Written informed consent was obtained. The patients were confirmed to have cerebellar or brainstem infarction, using magnetic resonance imaging and computed tomography imaging. Patients were excluded from the study if they had hearing problems, abnormalities in the visual or somatosensory system, or difficulty in performing an appropriate test due to other conditions such as poor cooperation or medications.

The parameters used to determine whether the VEMP was normal or abnormal were the presence of a response, latency to P13, amplitude of the P13 wave, and lowering of the threshold. The measurements may be affected by several variables, such as the subject’s posture, age, muscle contraction degree, the position of electrodes, and equipment [4].

The VEMP study was performed using a Nicolet Viking IV D device (Nicolet. Biomedical Inc., Madison, WI, USA). The patients were placed in a supine position, and then the active electrode was attached to the center of the sternocleidomastoid muscle, the reference electrode was attached to the sternum, and the ground electrode was attached to the center of the forehead. In order to reduce the false-positive rate due to muscle fatigue, the vestibular trigger potential on the contralateral side was measured in the same way following a 5-minute rest after testing the ipsilateral side. No response was defined as the inability to visually confirm a biphasic P13 to N23 waveform. A delay of latency was defined as an ipsilateral P13 latency longer than the normal control group by more than 2 standard deviations. No response was defined as an ipsilateral P13 latency longer than the normal or abnormal were the presence of a response, latency to P13, amplitude of the P13 wave, and lowering of the threshold.

The measurements may be affected by several variables, such as the subject’s posture, age, muscle contraction degree, the position of electrodes, and equipment [4].

The VEMP study was performed using a Dantec Keypoint Medtronics device (Alpine BioMed, Skovlunde, Denmark). The patients were placed in a supine position, and then the cathode ray of the positive electric stimulator attached to the supraorbital notch stimulated the supraspinatus nerve. An absent waveform, a difference in R1, R2, or R2’ latency of more than 2 ms relative to the contralateral side, or a difference in the ipsilateral R1, R2, or R2’ latency of more than 2 ms from the reference data was defined as abnormal. The reference data were obtained from previous studies [5,6].

In the statistical analysis, the P13 latency of VEMP and the R1, R2, R2’ latency of the blink reflex were compared with the Fisher exact test and the independent t-test using SPSS for Windows ver. 11.0 (SPSS Inc., Chicago, IL, USA). A p-value of 0.05 or less was considered to indicate statistical significance.

Results

Pontine, cerebellar, medullar, and midbrain infarctions were diagnosed in 23 (67.6%), 6 (17.6%), 4 (11.8%), and 1 (2.9%) patients, respectively. Twenty-two patients were men (64.7%) and 12 (35.3%) were women. The patients ranged in age from 33 to 100 years (mean age, 69.2 years).

The VEMP and blink reflex tests were compared in 29 of the 34 patients, with the exclusion of 5 patients with bilateral lesions. In the group with normal VEMP, 4 patients (25%) had normal blink reflexes, and 12 patients (75%) had abnormal blink reflexes. In the group with abnormal VEMP, 6 patients (46.2%) had normal blink reflexes and 7 patients (53.8%) had abnormal blink reflexes. These distributions did not show a statistically significant difference (p = 0.27 by the Fisher exact test). Therefore, the VEMP and the blink reflex tests were independent, and there was no statistically significant relationship between the 2 tests (Table 1).

Furthermore, as shown in Tables 2-4, the VEMP and blink tests showed no statistically significant relationships in subgroups defined according to the location of the infarction lesion

<table>
<thead>
<tr>
<th>VEMP</th>
<th>Blink reflex test</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Abnormal</td>
</tr>
<tr>
<td>Normal</td>
<td>4 (13.8)</td>
<td>12 (41.4)</td>
</tr>
<tr>
<td>Abnormal</td>
<td>6 (20.7)</td>
<td>7 (24.1)</td>
</tr>
<tr>
<td>Total</td>
<td>10 (34.5)</td>
<td>19 (65.5)</td>
</tr>
</tbody>
</table>

Values are presented as the number (%). The comparison between the VEMP and the blink test in 29 patients did not show a statistically significant relationship by Fisher exact test, p = 0.27.

*VEMP:* vestibular evoked myogenic potential.
### Table 2. Comparison of Abnormalities in Cerebellar Infarction Patients (n = 5)

<table>
<thead>
<tr>
<th>VEMP</th>
<th>Blink reflex test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Abnormal</td>
</tr>
<tr>
<td>Normal</td>
<td>2 (40.0)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>Abnormal</td>
<td>0 (0)</td>
<td>2 (40.0)</td>
</tr>
<tr>
<td>Total</td>
<td>2 (40.0)</td>
<td>3 (60.0)</td>
</tr>
</tbody>
</table>

Values are presented as the number (%). The comparison between the VEMP and the blink test in these 5 patients did not show a statistically significant relationship by Fisher exact test, p = 0.40. VEMP, vestibular evoked myogenic potential.

### Table 3. Comparison of Abnormalities in Medullar Infarction Patients (n = 4)

<table>
<thead>
<tr>
<th>VEMP</th>
<th>Blink reflex test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Abnormal</td>
</tr>
<tr>
<td>Normal</td>
<td>0 (0)</td>
<td>3 (75.0)</td>
</tr>
<tr>
<td>Abnormal</td>
<td>1 (25.0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>1 (25.0)</td>
<td>3 (75.0)</td>
</tr>
</tbody>
</table>

Values are presented as the number (%). The comparison between the VEMP and the blink test in these 4 patients did not show a statistically significant relationship (p = 0.25). VEMP, vestibular evoked myogenic potential.

*Tested by the Fisher exact test, p = 0.25.

### Table 4. Comparison of Abnormalities in Pons Infarction Patients (n = 19)

<table>
<thead>
<tr>
<th>VEMP</th>
<th>Blink reflex test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Abnormal</td>
</tr>
<tr>
<td>Normal</td>
<td>2 (10.5)</td>
<td>8 (42.1)</td>
</tr>
<tr>
<td>Abnormal</td>
<td>5 (26.3)</td>
<td>4 (21.1)</td>
</tr>
<tr>
<td>Total</td>
<td>7 (36.8)</td>
<td>12 (63.2)</td>
</tr>
</tbody>
</table>

Values are presented as the number (%). The comparison between the VEMP and the blink test in these 19 patients did not show a statistically significant relationship by Fisher exact test, p = 0.17. VEMP, vestibular evoked myogenic potential.

Values are presented as mean ± standard deviation. In all cerebral infarction patients (34 patients) participating in the study, including those with bilateral lesions, a statistically significant result was found for the relationship of R2’ mean with abnormal or normal VEMP (p = 0.008). VEMP, vestibular evoked myogenic potential.

*Tested by the independent t-test, p < 0.05.

### Table 5. Comparison between VEMP and R1 mean, R2 mean, and R2’ mean of the blink reflex

<table>
<thead>
<tr>
<th>VEMP</th>
<th>R1</th>
<th>R2</th>
<th>R2’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal VEMP (n = 15)</td>
<td>7.32 ± 2.82</td>
<td>8.21 ± 2.10</td>
<td>3.90 ± 4.61</td>
</tr>
<tr>
<td>Abnormal VEMP (n = 19)</td>
<td>34.28 ± 4.46</td>
<td>36.85 ± 4.48</td>
<td>38.90 ± 3.22</td>
</tr>
<tr>
<td>p-value</td>
<td>0.30</td>
<td>1.2</td>
<td>0.008*</td>
</tr>
</tbody>
</table>

*Tested by the independent t-test, p < 0.05.

### Discussion

VEMP was first described by Colebatch and Halmagyi in 1992 [7]. VEMP testing can be performed in 2 ways: cervical VEMP and ocular VEMP. Cervical VEMP is an inhibitory electromyographic response in the sternocleidomastoid muscle following auditory stimulation, and ocular VEMP is an excitatory electromyographic response in the extraocular muscle caused by auditory stimulation [8].

Some previous studies have analyzed VEMP in patients with cerebral infarction or hemorrhage. One study identified abnormal VEMP results in 12 of 29 patients with cerebral infarction [9]. In another study of 21 patients with lateral medullary infarction, abnormal VEMP results were confirmed in 9 patients [10]. However, a study investigating the correlation of VEMP with cerebellar lesions found that VEMP showed normal results in those patients [11].

A study investigated the association of the n10 component of ocular VEMP with R1 of the blink reflex, based on the fact that both the blink reflex and ocular VEMP are rested by applying electrical stimulation to the forehead and recording the response from the muscles of the infraorbital surface. That study did not find a statistically significant relationship between the 2 responses [12].

The present study found a statistically significant difference in R2’ of the blink reflex between the normal and abnormal VEMP groups. We suggest that pathological electrical conductivity would be more distinct in R2’ than in R1 or R2 due to the complex polysynaptic neurophysiologic pathway.

R1 of the blink reflex emerges as it passes through the pons. R2 and R2’ pass through the lateral aspect of the medulla, as well as the pons, and come out through complex synaptic reflexes [2,3].
Therefore, R2 and R2’ pass through more neural pathways and synapses than R1, and patients with abnormal VEMP may show a more prominent difference from the normal VEMP group in R2 and R2’ than in R1 and in R2’ than in R2. Although the anatomical structure of the VEMP neurotransmission process has not been fully elucidated, the most up-to-date knowledge on the neurotransmission pathway is that an electrical signal originating from the saccule is transmitted to the sternocleidomastoid muscle via the vestibular nerve, the vestibular nerve nucleus, and the medial vestibulospinal tract [1]. The vestibular nucleus is divided into the superior vestibular nucleus, the inferior vestibular nucleus, the lateral vestibular nucleus, and the medial vestibular nucleus. Anatomically, the superior vestibular nucleus is located in the pons, and the rest of the inferior vestibular nucleus, the lateral vestibular nucleus, and the medial vestibular nucleus are located in the medulla oblongata [13]. Therefore, when the blink reflex test is performed in patients with abnormal VEMP, R2 and R2’, which pass through the medulla as well as the pons, would show a more prominent difference from the normal group than R1, which only passes through the pons. Furthermore, R2’ of the blink reflex passes through more neural pathways and polysynaptic pathways than R1 and R2; thus, the difference is more prominent in patients with abnormal VEMP than in patients with normal VEMP.

In this study, although the VEMP and blink tests were independent in brainstem and cerebellar infarction patients, R2’ of the blink reflex showed a statistically significant difference according to whether the VEMP was normal or abnormal. Additionally, R1 and R2 of the blink reflex showed prolonged latency in the abnormal VEMP group compared to the normal VEMP group, although the relationship was not statistically significant. Since this study was conducted in only 34 patients, more cases from multiple centers would be needed in further studies, and it is reasonable to predict that R1 and R2 of the blink reflex may show statistically significant relationships with the VEMP in a larger study. This research suggests that the blink reflex may be a complementary test for VEMP, rather than a replacement. Further research should also compare the latency of VEMP and the blink reflex to show numerical correlations between these tests.

The limitations of this study include the fact that it was conducted at a single medical institution using a single machine among only 34 patients. In addition, the neurotransmission pathways of VEMP and the blink reflex have not been clearly identified. Finally, since this study was conducted with only cervical VEMP, it also seems necessary to conduct ocular VEMP in future studies.

Conclusion

R2’ of the blink reflex passes through more neural pathways and polysynaptic pathways than R1 and R2; therefore, it shows a more prominent difference in patients with abnormal VEMP than in those with normal VEMP. The blink reflex can complement VEMP, but larger studies should be performed to clarify whether the blink reflex could substitute for VEMP.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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