Correlation of o-VEMP and v-HIT Test Results with Caloric Test Results iSn Peripheral Vestibular Disorders

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ABSTRACT

Objective: To investigate the correlation of ocular vestibular evoked myogenic potential (o-VEMP) and video head impulse (v-HIT) test results with caloric test results in peripheral vestibular disorders, and to define an algorithm for investigating vestibular disorders.

Methods: All patients underwent an ENT physical examination, an MRI scan, videonystagmography, an o-VEMP test, and a v-HIT test. The patients who had central-type vertigo, PBBV, and vestibular migraine were excluded from the study. Overall, 30 patients were included in the study.

Results: Canal paralysis was observed in 22 patients (73.3%). Pathological o-VEMP and v-HIT test results were obtained in 19 (63.3%) and 8 (26.7%) patients, respectively. Pathological o-VEMP or v-HIT was observed in 17 of 22 (77.3%) patients with canal paralysis. Sensitivity and specificity of a combination of o-VEMP and v-HIT test results for detecting canal paralysis were 77.3% and 80.1%, respectively.

Conclusion: It does not seem that o-VEMP and v-HIT tests can replace the caloric test to detect vestibular hypofunction. However, these two tests can be used as first-line tests to initiate vestibular evaluation. If one of these two tests shows vestibular hypofunction, there is no need to perform a caloric test.

Keywords: Caloric test, ocular VEMP, video head impulse test, peripheral vestibular disorder, vestibular hypofunction, canal paralysis

INTRODUCTION

The assessment of vestibular disorders requires various vestibular tests in addition to history taking and physical examinations. The main purposes of performing vestibular tests are to distinguish whether the disease is peripheral or central-originated, to detect the localization of the lesion, and to make the definite diagnosis of the disease. Clinicians may not always reach all these goals, despite taking all efforts. Because the vestibular system has a very complex structure and there is no single test that can examine the entire vestibular system, clinicians must perform many vestibular tests and interpret the results accurately and reach the correct diagnosis by combining them with the findings of patients.

The caloric test has been used for many years in the detection of vestibular damage and is accepted as a reference standard. The caloric test is the most widely used test to assess the function of the semicircular canals. Although the stimulation applied in the caloric test is not physiological, it enables the evaluation of both labyrinths separately (1). The caloric test primarily evaluates the function of the lateral semicircular canals, and the stimulus that is used has a very low frequency (0.003 Hz). Daily stimuli have a higher frequency, and all components of the vestibular system are stimulated (2). For this reason, tests in which other parts of the labyrinth are evaluated are needed, and vestibular evoked myogenic potential (VEMP) and video head impulse (v-HIT) tests have started to be used for this purpose.

The VEMP test was first described by Colebacht and Halmagyi (3) in 1992 and has been widely used in recent years. There are two different tests for clinical use: cervical-VEMP (c-VEMP) and ocular-VEMP (o-VEMP). While c-VEMP mainly assesses saccular function and the vestibulo collic reflex, o-VEMP assesses utricular function and the vestibulo-ocular reflex (VOR). The inclusion of the VEMP test into the neuro-otological test battery enables a better evaluation of otolithic organ functions (4).

The v-HIT test, which has recently become clinically available, evaluates the VOR and is easy to apply. The v-HIT tests the VOR that is at higher frequencies in comparison to the caloric test. It also enables the individual evaluation of each semicircular canal (5).

The caloric test, o-VEMP test, and v-HIT test are the most commonly used tests for evaluating the VOR. Each test has its own advantages and disadvantages. The aim of this study was to compare o-VEMP and v-HIT test results with the caloric test results in peripheral vestibular diseases and to create a sequence algorithm for the test batteries to be used.

METHODS

After taking the approval of the Local Ethics Committee, this prospective study was conducted in patients who applied to

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the Ear Nose and Throat Clinic of the Ministry of Health Dışkapı Yıldırım Beyazıt Training and Research Hospital between January 1, 2015 and December 31, 2015, with the complaint of dizziness. Written informed consent was received from the patients included in the study.

After the patients who applied with the complaint of dizziness underwent a complete otolaryngologic examination, videonystagmography and o-VEMP and v-HIT tests were conducted and all their temporal MR examinations were performed. After audivestibular examination and radiological imaging, the patients who were considered to have a central pathology, those with benign paroxysmal positional vertigo, those who were diagnosed with vestibular migraine, and those for whom the planned test battery could not be performed were excluded from the study. The first 30 patients meeting the criteria were included in the study.

The Caloric Test

The patients were placed in the supine position with the head in 30-degree flexion, and the binaural bithermal air caloric test was performed. In the patients, air caloric stimulation was performed using Micromedical Air Fx caloric irrigator (Micromedical Technologies, Illinois). During the test, the eye movements of the patients were recorded and analyzed using Visual Eyes Nystagmography System (Micromedical Technologies, Illinois, USA). Canal paresis with a value of 25% and over was accepted as pathological.

The o-VEMP Test

The VEMP test was performed using the Neuro-Audio device (Version 2010, Neurosoft, Ivanovo, Russia). The test was performed while patients were in the sitting position, looking at a target stuck 30 degrees above the eye level and at a distance of 1.5 m. For electromyographic recordings, the active electrodes were stuck 1 cm below the lower eyelid of both eyes. The reference electrodes were stuck 1 cm below the active electrodes. The ground electrode was stuck on the forehead. The EMG signals were amplified, and a 1–1000 Hz filter was used. A tone burst acoustic stimulus was applied to both ears with ER3A insert headphones. The stimulation rate was 5 Hz, and the analysis time window was 50 ms. A total of 128 stimulations were applied. The test was performed twice for each ear to ensure that the VEMP wave was repeated. The tone burst acoustic stimulus was applied at 105 dB nHL, and EMG recording was taken from the contralateral side. The test was performed separately for each ear. N1 and P1 peak latencies and asymmetry rates were determined.

N1 latency longer than 10.8 and P1 latency longer than 16.5 were considered to be indicate prolonged latency in accordance with the normal o-VEMP data of our laboratory. The rate of asymmetry of more than 40.3% was considered to be increased asymmetry. Cases in which the wave latencies were prolonged, the rate of asymmetry was increased, or the VEMP wave could not be obtained were accepted to be pathological.

The v-HIT Test

The v-HIT test was performed using the VorteQ-VHIT device (Micromedical Technologies, Illinois, USA). Binocular high speed (150–250 Hz) eye video recorder glasses were used. During the test, patients were told to fix their gaze on a small, fixed target at a distance of 1.2 m. While they were steadily staring at the target, their heads were pushed at a peak speed of 150°/s at an angle of 10–20 degrees in the horizontal plane. Pushing motion was made at a time and direction that patients could not predict. A total of 10 head-push operations were applied in both directions. Patient's VOR gains were automatically calculated by the device. VOR gain less than 0.8 or the presence of covert and/or overt saccades was accepted as a pathological v-HIT response.

Statistical Analysis

The statistical analysis of the data was done using the IBM Statistical Package for the Social Sciences statistics version 20 (New York, USA). The correlation between dependent groups was calculated using the Spearman test. A p-value below 0.05 was considered statistically significant.

RESULTS

Of the 30 patients included in the study, 17 were women and 13 were men. The mean age of the patients was found to be 34±10 y (range, 18–59 y). The diagnosis of Meniere's disease was made in 16 patients (53.3%) and vestibular neuronitis in 11 patients (36.7%). While ototoxicity was detected in one patient (3.3%), no diagnosis could be made in two patients (6.7%).

Twenty-two (73.3%) of the patients had canal paralysis. While VEMP test was found to be pathological in 19 patients (63.3%), v-HIT test was found to be pathological only in eight patients (26.7%). The test results of the patients are summarized in Table 1.

While no pathology could be detected in four of the patients in any test, all three tests were found to be pathological in six patients. In nine patients, VEMP pathology was detected in company with canal paralysis. In two patients, v-HIT test was found to be pathological in company with canal paralysis. In four patients, only VEMP pathology was detected. These findings are summarized in Figure 1.

There was canal paralysis in 15 of 19 patients whose VEMP test was pathological. VEMP was detected as pathological in 15 of 22 patients with canal paralysis. The sensitivity of the VEMP test was found as 68% and specificity as 79%.

Canal paralysis was found in all eight patients whose v-HIT test was pathological. v-HIT was found to be pathological in eight of the 22 patients with canal paralysis. The sensitivity of the v-HIT test was determined as 36% and the specificity as 100%.

Table 1. Patients' findings in the caloric test, VEMP test, and v-HIT test

	Canal paralysis	VEMP pathology	v-HIT pathology	VEMP +/- v-HIT pathology
1	+	+	-	+
2	+	+	+	+
3	+	-	-	-
4	+	-	-	-
5	+	+	-	+
6	+	+	+	+
7	+	+	+	+
8	-	+	-	+
9	+	+	-	+
10	+	-	+	+
11	+	+	-	+
12	+	+	-	+
13	+	+	-	+
14	+	-	-	-
15	-	-	-	-
16	+	-	-	-
17	-	-	-	-
18	+	+	-	+
19	-	+	-	+
20	-	-	-	-
21	-	+	-	+
22	-	-	-	-
23	+	-	-	-
24	+	+	-	+
25	+	+	-	+
26	+	+	+	+
27	+	+	+	+
28	-	+	-	+
29	+	+	+	+
30	+	-	+	+
%	73,3	63,3	26,7	70

VEMP: Vestibular Evoked Myogenic Potentials; v-HIT: video head impulse

When the situation in which any one of the VEMP test or the v-HIT test was pathological was compared with the canal paralysis, the findings obtained are as follows: (i) There is VEMP ± v-HIT pathology in 17 (77.3%) of 22 patients with canal paralysis. (ii) When the two tests were evaluated together, the sensitivity was found as 77.3% and the specificity as 80.1% in detecting vestibular hypofunction. (iii) There is VEMP ± v-HIT pathology in four (50%) of the eight patients without canal paralysis. These findings are summarized in Table 2.

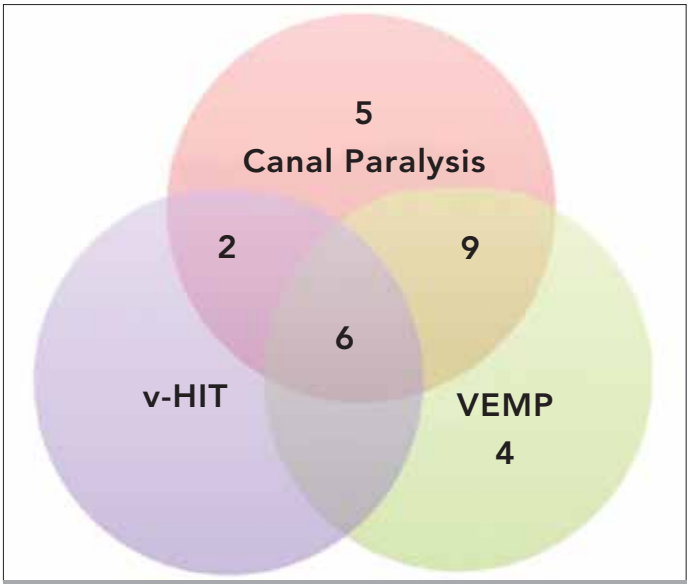

Figure 1. Distribution of canal paralysis, pathological VEMP results, and pathological v-HIT results in patients.
VEMP: vestibular evoked myogenic potential; v-HIT: video head impulse

Table 2. Comparison of pathological v-HIT and VEMP test results with caloric test results

	VEMP +/- v-HIT Pathology	
Canal paralysis	Yes	No
Yes	17	5
No	4	4

VEMP: Vestibular Evoked Myogenic Potentials; v-HIT: video head impulse

The caloric test, v-HIT test, and o-VEMP test results of a patient with Meniere's disease are shown in Figure 2.

DISCUSSION

The main purpose in the implementation of vestibular tests is to detect the condition that causes the vestibular disorder. However, when we consider the complex anatomy and physiology of the vestibular system, it is not possible to do this in a single test method. The basic principle of many vestibular tests is to compare the functions of both vestibular organs. Because the complaints result from asymmetric vestibular function in most patients, for this reason, in vestibular tests, both labyrinths are usually stimulated equally and the responses obtained are tried to be compared. Many tests have been designed to evaluate the VOR (1).

The caloric test, o-VEMP, and v-HIT tests are the main tests evaluating the VOR. The caloric test is a reliable test that has

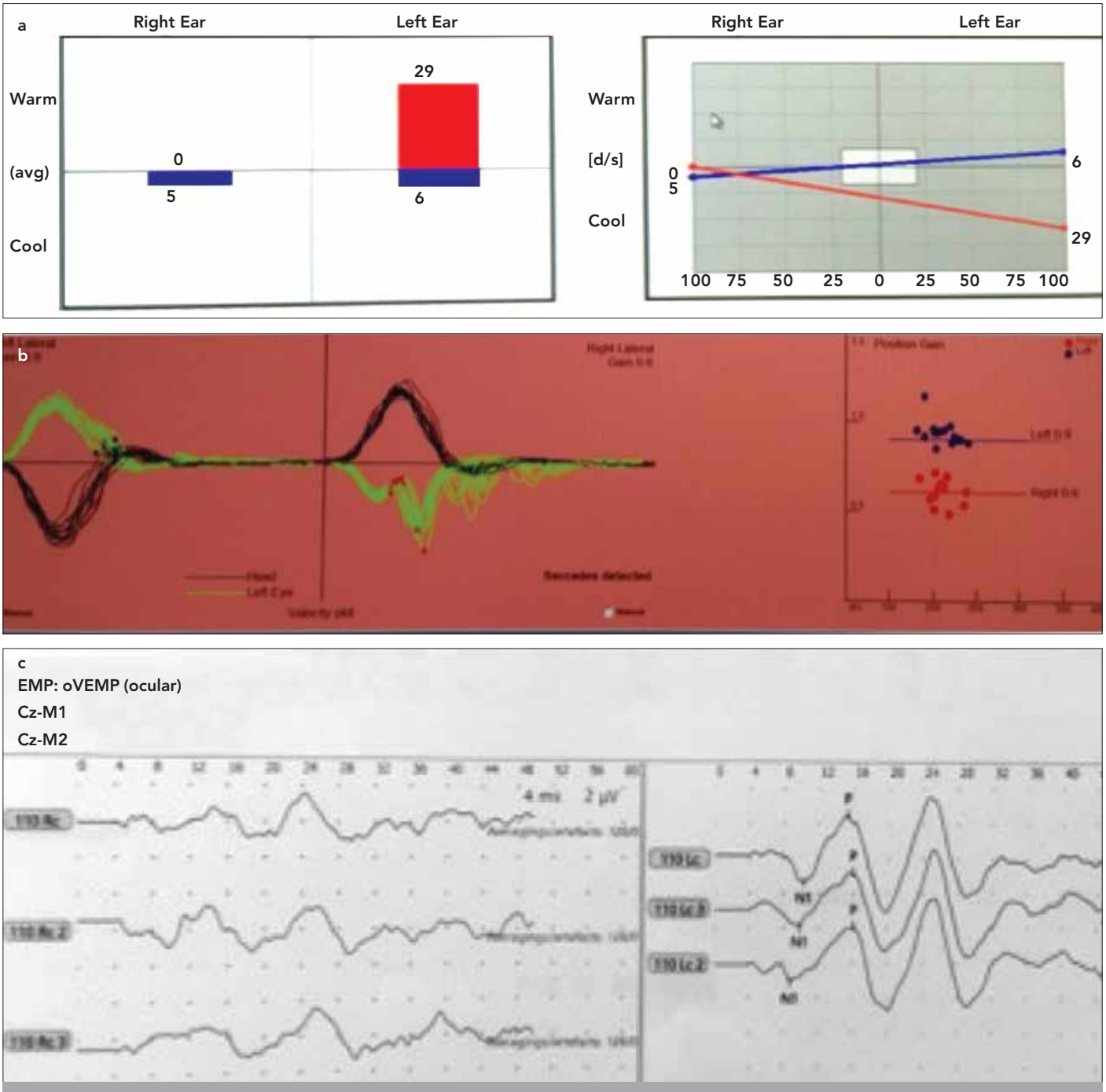

Figure 2. a-c. The caloric test, v-HIT test, and o-VEMP test results of a patient with Meniere's disease. (a) Caloric test revealed 75% canal paralysis in the right ear. (b) In the same patient, while VOR gain was detected to be 0.9 in the left ear, it was 0.6 in the right ear in the v-HIT test. The patient has overt and covert saccades in the right side. (c) In the VEMP test of the patient, while a normal wave was obtained in the left ear, no wave was obtained in the right ear.

been used for many years. The caloric test allows each labyrinth to be tested separately. However, the caloric test tests the VOR originating from only the horizontal canal at very low frequencies and this frequency is not physiological. In addition, the caloric test is a very uncomfortable and time-consuming procedure for many patients (2, 6, 7).

o-VEMP and v-HIT are new tests that have been added to the neuro-otological test battery in recent years to evaluate the VOR. One of the issues that is being investigated today is whether these tests can be used in place of the caloric test.

While the caloric test assesses the rotational VOR system through the canal-ocular reflex, o-VEMP evaluates the translational VOR system through the otolithic-ocular reflex (8). While Huang et al. (9) detected a strong correlation between o-VEMP responses and caloric test responses in patients with

acoustic neuroma, they could not find any similar correlation in patients with Meniere's disease. The authors reached the conclusion that o-VEMP can be used in place of the caloric test in patients with acoustic neuroma to determine the nerve from which the tumor originates. Chiarovano et al. (10) found no correlation between the o-VEMP results and the caloric test results in their study.

Contrary to other researchers, Murofushi et al. (11) found a strong correlation between o-VEMP responses and caloric test responses in patients with Meniere's disease. In our study, we obtained results similar to those obtained by Murofushi et al. (11). When we compared the o-VEMP test results with the caloric test results in our study, the sensitivity of the o-VEMP test was determined found to be 68% and the specificity was found to be 79%. The VEMP was found to be pathological in 15 of 22 patients with canal paralysis.

The v-HIT test is a vestibular test that has recently been started to be used. It is performed by recording the eye movements during high-speed sudden head movements. Responses obtained by the head-push motion in the horizontal plane test the VOR originating from horizontal canal. However, unlike the caloric test, it has a higher frequency, and thus, it is a more physiological measurement (12, 13).

Bell et al. (5) reported that v-HIT results did not correlate with the caloric test results and that v-HIT is not sensitive to peripheral vestibular diseases. Nunez et al. (13) stated that there is no significant correlation between the v-HIT test and the caloric test in their study but stated that the v-HIT test can be used as an initial test during vestibular examinations. van Esch et al. (14) recently compared v-HIT and caloric test results in a series of 324 patients. While the v-HIT test was found to be pathological in 12% of the patients, canal paralysis was found in 35% of the patients via the caloric test. In that study, the sensitivity was determined to be 31% and the specificity was determined to be 98% for the v-HIT test to detect canal paralysis. The authors concluded that additional caloric testing was needed in patients with normal v-HIT results and that the v-HIT test cannot take the place of the caloric test. However, they indicated that the likelihood of canal paralysis is very high when v-HIT is pathological and that an additional caloric test will not be required in such patients. As a result of that study, the authors stated that the v-HIT test can be used as an initial test to determine vestibular hypofunction.

In our study, when we compared the V-HIT test results with the caloric test results, we obtained findings consistent with those in the literature. v-HIT was found to be pathological in eight (36.3%) of the 22 patients who had canal paralysis. All eight patients in whom v-HIT was found to be pathological had canal paralysis. In our study, the sensitivity of the v-HIT test was determined to be 36% and the specificity was determined to be 100%. When we used the v-HIT test and the VEMP test together, we found the sensitivity to be 77.3% and the specificity to be 80.1% in detecting the vestibular hypofunction.

To conclude, the VEMP test and the v-HIT test do not appear to be sufficient to take the place of the caloric test for the purpose of determining vestibular hypofunction. However, both tests can be used as initial tests in the evaluation of vertigo patients. The caloric test will not be necessary if any of the two tests is found to be pathological. However, if the results of both tests are within the normal limits, an additional caloric test is required.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Ministry of Health Dışkapı Yıldırım Beyazıt Training and Research Hospital.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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