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May Video Head Impulse Test and Cervical Myogenic Potentials Contribute to Caloric Test in the Diagnosis of Acute Unilateral Vestibulopathy?

Akut Unilateral Vestibülopatilerde Servikal Miyojenik Potansiyeller ile Video Baş Savurma Testlerinin Kalorik Teste Olan Katkılarının Değerlendirilmesi

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ABSTRACT Objective: The purpose of this study is to reveal the contributions of video head impulse test (vHIT) and cervical vestibular evoked mygogenic potentials (cVEMP) tests to bithermal caloric testing in the diagnosis of vestibular neuritis. **Material and Methods:** Charts of 518 patients admitted to Baskent University Hospital, Otolaryngology Department, between 2014-2018 with dizziness were examined retrospectively. Patients who underwent caloric testing, vHIT, and cVEMP and diagnosed with vestibular neuritis were included in the study. Patients with symmetric caloric responses were excluded. **Results:** Total of 32 patients included in the study, 18 were female, and 14 were male. The mean age of the patient group was 49.6 years. Abnormal vHIT findings in normal cVEMP cases were 100%, whereas the abnormal vHIT findings in abnormal cVEMP cases were 22.2%. According to cVEMP, there was a statistically significant difference in the abnormal percentage of vHIT ($p<0.05$). **Conclusion:** vHIT is a complementary test to caloric testing; however, vHIT is fast and well-tolerated. Saccades and gain asymmetry values should be jointly evaluated. In the diagnosis of acute unilateral vestibulopathy vHIT tests can be performed before caloric testing in the test sequence. cVEMP is valuable in supplying information about the inferior vestibular nerve and should be performed before caloric testing.

Keywords: Unilateral vestibulopathy; head impulse test; vestibular evoked myogenic potentials; caloric test

ÖZET Amaç: Bu çalışmanın amacı, video baş savurma testleri ve servikal miyojenik elektriksel potansiyellerin (cervical vestibular evoked mygogenic potentials-cVEMP) kalorik teste olan katkılarını araştırmak ve bu testlerin test bataryasındaki olası yerlerini araştırmaktır. **Gereç ve Yöntemler:** Bu çalışma, retrospektif olarak tasarlamıştır. 2014-2018 yılları arasında Başkent Üniversitesi Hastanesine baş dönmesi nedeni ile başvuran 518 hastanın dosyaları incelenmiş ve kalorik test, video baş savurma testi, servikal elektriksel miyojenik postansiyel testlerine girerek, vestibüler nörit tanısı alan hastalar çalışmaya dâhil edilmiştir. Simetrik kalorik test cevabı olan hastalar değerlendirme dışı bırakılmıştır. **Bulgular:** On sekiz kadın, 14 erkek olmak üzere toplamda 32 hasta çalışmaya dâhil edilmiştir. Ortalama yaş 49,6 olarak bulunmuştur. cVEMP yanıtı normal olan hastaların %100'ünde anormal vHIT yanıtı elde edilirken, anormal cVEMP yanıtı olan hastalardaki anormal vHIT yanıtları %22,2 olarak tespit edilmiştir. cVEMP gruplarındaki vHIT değerlerindeki bu farklılık istatistiksel olarak anlamlıdır ($p<0,05$). **Sonuçlar:** vHIT testi, kalorik teste göre daha hızlı ve daha kolay yapılabilen bir test olup, kalorik ile kombine olarak değerlendirilmelidir. vHIT testlerini değerlendirirken, seğirmelerin varlığı daha önemli olmakla birlikte kazanç asimetrileri birlikte dikkate alınmalıdır. Akut unilateral vestibülopatileri değerlendirirken, test sıralamasında vHIT kalorik testinden önce yapılmaldır. CVEMP, inferior vestibüler sinir fonksiyonu hakkında hızlı bilgi vermektedir ve bu test de kalorik testin önünde planlanmalıdır.

Anahtar Kelimeler: Tek taraflı vestibülopati; baş savurma testi; vestibüler uyarılmış elektriksel miyojenik potansiyeller; kalorik test

Acute unilateral vestibulopathy, known as vestibular neuritis (VN), accounts for 10-15% of all vertigo cases.[1] Its annual incidence is 3-5/100,000. Incidence increases with age and is most commonly seen between the ages of 40-50.[2] Patients present with sudden onset nausea, vomiting, dizziness, and bal-

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ance disorder, and the etiology of acute unilateral vestibulopathy is unknown.[1,3] Diagnosis is made with the exclusion of other diseases that can cause vertigo, absence of neurological deficit, symmetrical hearing, and the presence of spontaneous nystagmus.[4]

The caloric test is the primary diagnostic method in acute unilateral vestibulopathy. After the introduction of vestibular evoked myogenic potentials in clinical practice, it was found that the majority of VN involved with the superior branch of the nerve.[5,6] The video head impulse test (vHIT) contribution made it easy and fast to evaluate vestibular pathologies.[7] It gives detailed information on every single semicircular canal of the labyrinth.

This study aimed to evaluate the role of vHIT and cervical vestibular evoked myogenic potentials (cVEMP) for diagnosing VN in patients with an asymmetric caloric response and investigating the contribution of vHIT and cVEMP tests to caloric testing.

MATERIAL AND METHODS

This study was approved by Başkent University Medical and Health Sciences Research Committee and Ethics Committee (Project no: KA18/335). The study was conducted under the declarations of Helsinki. Chart reviews of five hundred eighteen patients presented to Başkent University Hospital, Department of Otorhinolaryngology with vertigo between 2014 and 2018, were analyzed retrospectively. Patients' histories and all the audio vestibular examinations were reviewed from the charts, and patients with asymmetric bithermal caloric responses and normal hearing were included in the study.

Patients with Meniere's disease, benign paroxysmal positional vertigo, vestibular schwannoma, chronic otitis media, sudden hearing loss, central nervous system diseases, and tinnitus were excluded from the study. All the tests were performed in the first week of acute unilateral vestibulopathy onset.

Bithermal Caloric Test

The caloric test was performed using the "Micromedical Spectrum ENG" (Micromedical Technologies, AQSTM2-0086, United States) device. In our study, canal paresis and directional control were calculated with the Jongkees' formula: (UW = ((RW + RC) - (LW + LC))/ (RW + LW + RC + LC) x 100), and values greater than 25% were considered as canal paresis.

cVEMP

Electromyography (EMG) was recorded with "EPA4V" (Interacoustics Co. Assens, Denmark). cVEMP test results were evaluated based on the interaural amplitude difference (IAD) ratio comparing both sides' amplitude. The following formula was used: IAD = ((Rt Amplitude - Lt Amplitude) / (Rt Amplitude + Lt Amplitude)) x100. When the interaural amplitude difference was more than 35%, or cVEMP waves could not be obtained unilaterally, cVEMP was considered abnormal.

vHIT

vHIT measurements were performed with the EyeSeeCam vHIT (Interacoustics, A/S DK-5610, Assens, Denmark) instrument and evaluated with the Oto Access computer program. Overt and covert saccades, mean vestibulo ocular reflex (VOR) gain, and lateral semicircular canal asymmetry were measured. Saccades formed during the head impulse were considered as covert, saccades formed after the end of head impulse were considered as overt saccades. Saccades that were systematically seen in one direction and seen in at least 80% of the head impulses were accepted as abnormal saccades. The reference values of VOR gain for the lateral semicircular canal were 0.8-1.2. vHIT was accepted as abnormal when gain asymmetry values equal to or greater than 8 percent (≥8%).[8] Abnormal vHIT was decided according to the existence of abnormal gain asymmetry or abnormal saccades.

STATISTICAL ANALYSIS

Number Cruncher Statistical System (NCSS) 2007 (Kaysville, Utah, USA) was used for statistical analysis. Descriptive statistical methods (mean, standard deviation, minimum, maximum, first quartile, third quartile, frequency, percentage) were used to evaluate the study data. Suitability of the quantitative data for normal distribution was tested with the Shapiro-Wilk test and graphical analysis. Mann-Whitney U

test was used to compare the quantitative variables that did not show normal distribution between the two groups. Pearson chi-square test and Fisher's exact test were used to comparing qualitative data. $p<0.05$ was accepted as statistically significant in all analyses.

RESULTS

Thirty-two patients were included in the study, 18 were female, and 14 were male. The mean age of the patient group was 49.6 years.

According to the vHIT, lateral semicircular canal asymmetry values were abnormal in 6 cases (18.8%). Abnormal saccades for lateral canal were detected in 71.9% (n=23) of the cases (Table 1, Figure 1).

Of the cases, 15.7% (n=5) were vHIT normal and 78.1% (n=25) were abnormal; 71.9% (n=23) of the cases were cVEMP normal and 28.1% (n=9) were abnormal. While 6.3% (n=2) of the cases were vHIT abnormal & cVEMP abnormal, 71.9% (n=23) were vHIT abnormal & VEMP normal, and 21.9% (n=7) were vHIT normal & cVEMP abnormal (Table 2).

TABLE 1: Lateral semicircular canal video head impulse test findings: Information on asymmetry and saccade.

Lateral canal asymmetry n (%)	Normal	26 (81.2)
	Abnormal	6 (18.8)
Lateral canal saccade n (%)	Normal	9 (28.1)
	Abnormal	23 (71.9)

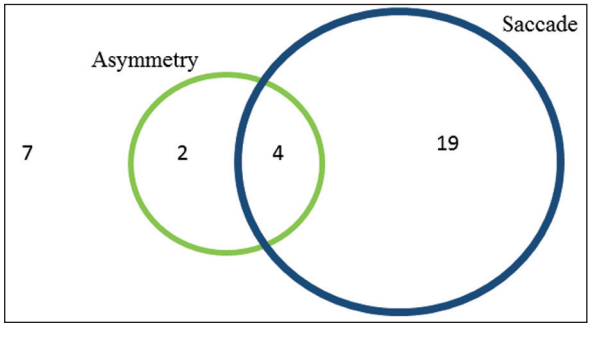

FIGURE 1: Lateral semicircular canal video head impulse results of the patients. Black sqaure: Whole patients. Green circle: Pathologic results according to lateral canal gain asymmetry. Blue circle: Pathologic results according to lateral canal vHIT catch-up saccades.

TABLE 2: Distribution of canal paresis, vHIT and cVEMP results.

Caloric/paresis; n (%)	No	0 (0)
	Yes	32 (100)
vHIT; n (%)	Normal	7 (21.9)
	Abnormal	25 (78.1)
cVEMP; n (%)	Normal	23 (71.9)
	Abnormal	9 (28.1)
Group; n (%)	vHIT(+) & cVEMP(+)	2 (6.3)
	vHIT(+) & cVEMP(-)	23 (71.9)
	vHIT(-) & cVEMP(+)	7 (21.9)

vHIT: Video head impulse test; cVEMP: cervical vestibular evoked myogenic potentials.

TABLE 3: Comparison of vHIT and cVEMP.

		vHIT		
		Normal	Abnormal	
		n (%)	n (%)	p
cVEMP	Normal	0 (0)	23 (100)	<0.001*
	Abnormal	7 (77.8)	2 (22.2)	

vHIT: Video head impulse test; cVEMP: cervical vestibular evoked myogenic potentials.
Fisher's exact test *p<0.05.

While 100% of cVEMP normal cases were vHIT abnormal, only 22.2% of cVEMP abnormal cases were vHIT abnormal. There was a statistically significant difference in vHIT abnormal percentage concerning cVEMP status ($p<0.001$). The percentage of vHIT abnormality was higher in cVEMP normal cases compared to cVEMP abnormal cases (Table 3).

DISCUSSION

The diagnosis of acute unilateral vestibulopathy is a clinical diagnosis, which is made by excluding other possibilities and detecting asymmetry in the caloric test, and the caloric test constitutes an important step in the direction of the diagnosis. Although it has been reported that the caloric test cannot be used as a guide for VN involving the inferior vestibular pathway, caloric tests are still performed in patients with suspected VN.

The cVEMP test revealed that VN might involve the superior vestibular nerve and the inferior vestibular nerve. Halmagyi et al. reported the term inferior VN for the first time and presented two cases with in-

ferior VN.[9] Normal caloric response and cVEMP response were not observed in these patients. They stated that VN could be divided into three groups according to caloric and cVEMP test results: Total VN (asymmetric response in caloric test and cVEMP), superior VN (asymmetric caloric response and symmetric cVEMP response), and inferior VN (symmetric caloric response and asymmetric cVEMP response).[9]

Zhang et al. aimed to specify the diagnosis of inferior VN in 216 VN patients who underwent caloric and cVEMP tests.[10] In the study, normal caloric response and abnormal cVEMP responses were obtained in 8 of 216 patients. Based on these findings, they diagnosed eight patients with inferior VN. Chihara practiced caloric and cVEMP tests to 71 patients with VN and based on the findings, 13 patients were diagnosed with inferior VN. Because of the difficulty in distinguishing inferior VN from total VN and superior VN in terms of symptoms, it was concluded that a combination of caloric and cVEMP tests are essential for accurate diagnosis.[11]

The patients with symmetrical caloric responses were not included in the study. Basically the caloric test does not supply information about inferior vestibular nerve.[9] Therefore patients with isolated inferior VN (whose caloric test results are normal) were not evaluated in this study. However, cVEMP tests were applied to have information about total vestibular involvement. We considered nine patients with abnormal cVEMP findings as total VN and 23 patients without abnormal findings as isolated superior VN. The present study evaluates patients with superior VN and total VN and differs from the above studies. Additionally, vHIT use for evaluation of the investigation of its contribution to our study is another difference. Lateral canal vHIT pathology was detected in 2 of 9 patients in whom cVEMP responses were abnormal.

In 2017, Guan et al. (4) measured the diagnostic value of vHIT in patients with acute vertigo. Thirty-three patients with VN were evaluated, and a significant difference in gain asymmetry was found in these patients compared to the patients in the other group with acute vertigo. Unfortunately, catch-up saccades were not evaluated in the study.

Although the lateral vHIT measures the same pathway with caloric testing, there were seven patients with an asymmetric caloric response but not detected by the vHIT test. It is well-known that the caloric test provides information on low-frequency stimuli fibers, while the vHIT test provides information on high-frequency fibers.[12,13]

We attribute this difference to the variation in VN involvement in selecting fast-slow fibers. This variety makes vHIT not an alternative to caloric testing but rather a complementary test for evaluating fast and slow fibers in the VN evaluation approach. In this way, vHIT can be performed before the caloric test in the test battery due to its smooth and rapid application, and patients with no pathology in the vHIT test can be subjected to a caloric test to evaluate the slow firing neural pathway.

There were certain limitations to our study.

The vHIT test was performed only for the lateral canal. This pathway only evaluates the VOR arch of the superior vestibular nerve. The anterior and posterior canals were not evaluated. Another limitation is the lack of measurement of ocular VEMP in patients. Unfortunately, we do not have an ocular VEMP infrastructure in the current laboratory settings. Therefore, not all neurons in the VOR arch could be evaluated. The exclusion of patients with VN without asymmetry in the caloric test can be considered another limitation. However, the present study demonstrates the need for a similar study involving patients without caloric asymmetry. Thus, electrophysiological findings of patients in whom neurons with low firing frequency are not affected will be better understood. With such a study, unnecessary caloric testing of these patient groups may be avoided.

In conclusion, since the vHIT test is fast and objective, it can be placed before the caloric test in the VN test battery, and the caloric test can be performed in case of clinical necessity. Caloric tests and vHIT tests are complementary tests. Besides, saccade presence in the vHIT test is more valuable in detecting pathology than gain asymmetry, and saccade presence should be evaluated together with asymmetry when evaluating vHIT. cVEMP is the only vestibular test supplying information about the inferior vestibu-

lar nerve branch if oblique canals cannot be evaluated with vHIT.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Gözde Akın, Levent N Özlüoğlu;* ***Design:*** *Gözde Akın, Osman H Çam, Levent N Özlüoğlu;* ***Control/Supervision:*** *Pelin Koçdor, Levent N Özlüoğlu;* ***Data Collection and/or Processing:*** *Gözde Akın, Osman H Çam;* ***Analysis and/or Interpretation:****Osman H Çam, Pelin Koçdor, Levent N Özlüoğlu;* ***Literature Review:*** *Gözde Akın, Osman H Çam;* ***Writing the Article:*** *Gözde Akın, Osman H Çam, Pelin Koçdor;* ***Critical Review: Pelin Koçdor,*** *Levent N Özlüoğlu;* ***References and Fundings:*** *Gözde Akın, Osman H Çam, Levent N Özlüoğlu;* ***Materials:*** *Gözde Akın, Osman H Çam, Pelin Koçdor, Levent N Özlüoğlu.*

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