European Archives of Oto-Rhino-Laryngology (2019) 276:3513–3517
https://doi.org/10.1007/s00405-019-05626-y

MISCELLANEOUS

The association between video-nystagmography and sensory organization test of computerized dynamic posturography in patients with vestibular symptoms

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Received: 31 July 2019 / Accepted: 29 August 2019 / Published online: 7 September 2019

Abstract

Objective Vertigo is a complex symptom which imposes diagnostic and treatment challenges. Laboratory evaluation of vertigo includes video-nystagmography (VNG) and computerized dynamic posturography (CDP) for the evaluation of different aspects of this complaint. There are vague indications for each test and potential disagreements between them. The aim of this study is to examine the association between the test results of the VNG and sensory organization test (SOT) of CDP in patients referred for both vestibular tests.

Methods Retrospective data regarding 56 patients age 17–82 years were collected. Patients suffered vestibular complaints and were referred for VNG and CDP evaluation on the same day. The level of agreement between VNG (including caloric test) and the vestibular input of the SOT for each patient was calculated.

Results Among the study group, 10 showed abnormal caloric test results, of which 3 (5.4%) had normal vestibular input in the SOT, and 7 (12.5%) had impaired input ($p=0.724$). Spontaneous nystagmus was recorded in 13 patients by VNG, of which 2(3.6%) had normal vestibular input and 11(19.6%) had impaired vestibular input ($p=0.056$).

Conclusions This study shows no statistically significant association between the VNG test and SOT test results. Our results emphasize the difference between the tested aspects in each laboratory test, and the need to define specific indications for each of them. There is a marginally significant association between impaired vestibular input and spontaneous nystagmus, demonstrating the non-localizing nature of this sign.

Keyword Video-nystagmography · Computerized dynamic posturography · Sensory organization test · Dizziness · Vertigo

Background

The subjective nature of vertigo necessitates the use of laboratory tests [1]. Among those are the video-nystagmography (VNG) including caloric testing and the computerized dynamic posturography (CDP). The use of laboratory tests for vertigo evaluation must consider the limitations and strength of each test.

VNG is a common laboratory test used for evaluating vertigo and balance disturbances. Keim suggests that the use of the electronystagmography (ENG) test should be expended beyond the evaluation of obvious vertigo and include the evaluation of the more general complaint of "disturbance of balance" [2]. VNG has the unique capacity to evaluate lateral semicircular canal separately and is, therefore, able to locate vestibular lesions. While the caloric test of the VNG provides information on the whereabouts of possible lesions, it creates a non-physiological situation. The natural vestibular stimulus is at a much higher frequency and always involves both ears, raising doubts regarding the clinical meaning of ENG results [3].

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The CDP test evaluates the synthesis of the visual, proprioception, and vestibular systems in response to different stimuli. Therefore, the CDP is not limited to the vestibular apparatus as the ENG test, and it allows for the evaluation of a balance systems integration. CDP enhances the identification of balance abnormalities in patients with and without vertigo. It also has a role in the identification of malingering, due to its partly conscious nature [4]. The sensory organization test (SOT) is one of the CDP test protocols that can assess a subject's ability to employ inputs from visual, vestibular and somatosensory systems to keep balance under different stimulating conditions and monitor central compensatory state [5].

A recent study showed that SOT could principally reflect utricular function, and the indicator of inputs from the vestibular system in balance performance in SOT could help to screen patients with unilateral peripheral vestibular dysfunction in non-fallers [6].

The aim of this study is to examine the association between VNG and SOT tests results in vertigo patients referred to both tests on the same day at a tertiary medical center.

Patients and methods

Patients

56 patients aged 17 years and above suffering vestibular symptoms were referred for VNG and CDP evaluations in succession (on the same day, in the same institution). Exclusion criteria included subjects who are not allowed to perform the caloric test of the VNG battery (active heart disease, pregnancy), use of vestibular suppressant or alcohol consumption during the 48 h prior to testing.

Computerized dynamic posturography (CDP)

The CDP evaluation was done using the EquiTest (NeuroCom International, Clackamas, OR) balance assessment system. The patient was secured into a safety harness during the entire test. The feet were placed on the forceplate, with the medial malleolus centered over a marking stripe that laterally transects the two forceplates, to align the ankle joints with the platform axis. The SOT of the CDP is composed of 6 tests. During tests 1–3, the platform is stable. In the first test, the visual field is stable as well (normal vision, fixed support). In the second test, the patient's eyes are closed (absent vision, fixed support). During the third condition, the surrounding skyline is moving according to the anterior–posterior movements of the patient (sway-reference vision, fixed support). During tests 4–6 the platform moves according to the anteroposterior sway of the patient. During test 4, the visual skyline remains constant (normal vision, sway-reference support). During test 5, the patient's eyes are closed (absent vision, sway-reference support). In the test 6, both the platform and the visual skyline sway in reference to the patient's sway (sway-reference vision, sway-reference support). During the tests, excessive sway was documented, as well as sways outside the limits of stability that would have resulted in a fall without the safety harness.

VNG and Caloric tests

The evaluation of eye movements was done using CHARTR VNG for Windows Version 4.1, by the ICS medical company Schaumburg Illinois 2003. VNG tests performed for each subject included: oculometric tests (horizontal saccades, horizontal pursuit, optokinetic nystagmus and gaze nystagmus test), and vestibular tests (spontaneous nystagmus, Dix-Hallpike test, positional nystagmus, caloric test). To detect spontaneous nystagmus, VNG was performed with the patient seated in the upright position with open eyes for 30 s, and then with eyes closed for the next 30 s. Pathological nystagmus without gaze fixation was considered as nystagmus equal to or more than 6 degrees/second of consecutive nystagmus observed with eyes closed. Positive Dix-Hallpike test was considered if the patient fitted the criteria for BPPV: A latent period of at least 1 s between the head tilt and the appearance of the nystagmus; the nystagmus decays gradually until its disappearance during less than a minute; The nystagmus is vertical and rotatory in nature, and beats towards the ground; The nystagmus is reversible, and has fatigability. Paroxysmal nystagmus was defined as nystagmus equal to or more than 7 degrees/sec, during Dix-Hallpike test, and without the characteristics of BPPV as described above. A positional test was considered positive if the nystagmus was at least 4 degrees/sec in three positions, or at least 7 degrees/sec in one position. Recording was made with closed and open eyes. Recording with closed eyes was made while the patient was mentally distracted by performing simple math exercises. Caloric nystagmus was recorded using VNG electrodes. Alternate water irrigator (Otometrics, Denmark) was used for bi-thermal caloric tests (cold − 30 °C and hot − 44 °C, 250 ml for 40 s in each temperature). In our laboratory, canal paresis greater than 20% and directional preponderance greater than 30% were defined as abnormal, as defined by Jacobson et al. [7, 8]. Bilateral hypofunction was considered if the average response of the hot and cold irrigation from each ear was less than 6 degrees/sec.

Statistical analysis

To analyze the association between two categorical variables (VNG and SOT results), either the χ^2 test or the Fisher's

Table 1 Demographic characteristics of the study group ($N=56$)

Age (Year)	
Mean	43.1
Range	17–82
Gender	*n* (%)
Female	30 (53.5)
Male	26 (46.5)

Table 2 Video-nystagmography (VNG) test results of the study group ($n=56$)

Video-nystagmography tests	Abnormal (%)	Normal (%)
Pursuit eye movements	Saccadic 8 (14.3%)	46 (82.1%)
	Decreased 2 (3.6%)	
Optokinetic nystagmus	0 (0.0%)	56 (100.0%)
Spontaneous nystagmus	13 (23.2%)	43 (76.8%)
Dix-Hallpike (BPPV)	0	56 (100%)
Paroxysmal nystagmus	12 (21.4%)	44 (78.6%)
Positional test	Directional fixed 14 (25.0%)	39 (69.6%)
	Directional changing 3 (5.4%)	
Caloric test[a]	10 (17.9%)	46 (82.1%)

[a]Abnormal caloric test included canal paresis, directional preponderance, and bilateral canal hypofunction

exact tests were used. All tests applied were two-tailed, and a p-value of 0.05 or less was considered statistically significant. All statistical analyses were performed with SPSS Statistical software version 23 (IBM SPSS Statistics 23; Chicago, IL, USA).

Ethics

The study was approved by the ethics committee of the Hadassah Hebrew-University Medical Center (0486-17-HMO).

Results

Demographics characteristics and vestibular tests results

Demographic characteristics of the patients are presented in Table 1. The mean age was 43 years (43 ± 16.7, age range 17–82); 30 (53.6%) women and 26 (46.4%) men.

Table 2 demonstrates the VNG results of the study population. The most common VNG abnormalities included abnormal positional test (30.4%), spontaneous nystagmus (23.2%), and paroxysmal nystagmus (21.4%). 17.9% of the patients had abnormal caloric test.

Table 3 Sensory organization test test results of the study group ($n=56$)

Sensory organization test	Results (%)
Impaired vestibular input	16 (28.6%)
Impaired visual input	2 (3.6%)
Impaired proprioceptive input	0
Impaired proprioceptive and vestibular inputs	1 (1.8%)
Impaired visual and vestibular inputs	11 (19.6%)
Impaired visual and proprioceptive inputs	2 (3.6%)
Impaired input from three systems	6 (10.7%)
Normal result of all three systems	18 (32.1%)

Percent's are calculated as part of the entire study group

Table 4 The association between VNG test result and vestibular input status by SOT ($n=56$)

VNG test results		SOT results		*P* Value
		Vestibular input		
		Normal (%)	Impaired (%)	
Paroxysmal nystagmus	Normal	18 (32.1%)	26 (46.4%)	0.746
	Abnormal	4 (7.1%)	8 (14.3%)	
Positional test	Normal	18 (32.1%)	21 (37.5%)	0.143
	Abnormal	4 (7.1%)	13 (23.2%)	
Caloric test	Normal	19 (33.9%)	27 (48.2%)	0.724
	Abnormal	3 (5.4%)	7 (12.5%)	
Pursuit eye movements	Normal	17 (30.4%)	29 (51.8%)	0.491
	Abnormal	5 (8.9%)	5 (8.9%)	
Spontaneous nystagmus	Normal	20 (35.7%)	23 (41.1%)	0.056
	Abnormal	2 (3.6%)	11 (19.6%)	

Percent's are calculated as part of the entire study group

CDP test results of the study population are presented in Table 3. 28.6% of the patients had isolated impaired vestibular input. 25% of the patients had impaired input from two systems, and 10.7% of the patients had impaired input from all 3 systems.

Association between the VNG and CDP tests results

Table 4 demonstrates the relationship between VNG test results and vestibular input status evaluated by the CDP test in the study group. Among patients with decreased vestibular input, 8 (14.3%) had an abnormal paroxysmal nystagmus test, 13 (23.2%) had an abnormal positional test, and 7 (12.5%) had an abnormal caloric test. Marginal statistical significant connection was observed between spontaneous nystagmus test of the VNG and the vestibular input of the

CDP test. 11 (19.6%) patients who had spontaneous nystagmus showed decreased vestibular input ($P=0.056$).

The relationship between VNG test results and visual input status evaluated by CDP test in the study group is presented in Table 5. Among the patients with decreased visual input, 2 (3.6%) had abnormal pursuit eye movements and 5 (8.9%) had spontaneous nystagmus.

Discussion

VNG including the caloric testing is an objective and extremely valuable diagnostic tool in assessing the anatomic and functional integrity of the central and peripheral vestibular systems. VNG is superior to ENG as VNG tracings are more detailed and can capture subtle clinical findings. However, the sensitivity and specificity of VNG are limited because it provides information primarily regarding the lateral semicircular canal and limited insight into overall balance function. The CDP test strength lays with its ability to quantify imbalance in different systems and not only imbalance that is directly related to the vestibular organs. However, it lacks the ability to test the ears separately.

Our study did not show any association between the VNG and CDP tests results that were performed on the same day. However, it showed marginally significant association between spontaneous nystagmus test in the VNG and the vestibular input of the CDP test. This may be explained by the fact that spontaneous nystagmus is a non-localizing sign of asymmetry in the vestibular system that may reflect on the vestibular input. In contrast, stimulation tests such as paroxysmal test, positional test and the non-physiological caloric test may not reflect on the vestibular input as it is measured by the CDP test. Interestingly, our study population did not include subjects with positive Dix-Hallpike test by its full criteria. The reason might be that subjects with positive Dix-Hallpike test during physical examination are diagnosed with benign paroxysmal positional vertigo (BPPV) and are referred for vestibular physiotherapy for positional vertigo, without the need for further evaluation.

Table 5 The association between VNG test results and visual input by SOT ($n=56$)

VNG test results		SOT results		*P* Value
		Visual input		
		Normal (%)	Impaired (%)	
Pursuit eye movements	Normal	29 (51.8%)	17 (30.4%)	0.746
	Abnormal	8 (14.3%)	2 (3.6%)	
Spontaneous nystagmus	Normal	29 (51.8%)	14 (25.0%)	0.745
	Abnormal	8 (14.3%)	5 (8.9%)	

Percent's are calculated as part of the entire study group

As for lack of association between the two tests; Sataloff et al. showed abnormal results on CDP testing among 33 patients, with dizziness and normal ENG test [9]. Lipp and Longride evaluated ENG with caloric testing and CDP test in 375 patients with dizziness [10]. They reported that CDP findings were abnormal in approximately 40% of patients who had normal ENG and caloric testing, and only 10% of dizzy patients with normal CDP test results had an abnormal ENG with caloric testing. In our study, we found similar outcomes, in which subjects had impaired vestibular input during SOT but showed normal VNG test results (Table 4).

VNG tests and CDP tests provide different types of information, both of which assist in the diagnosis and management of vertigo patients. The VNG test measures the vestibular-ocular function and can assist with lesion localization. However, the CDP test measures the vestibule-spinal function and is more useful for the information regarding functional status of a patient. Controversy exists as to whether the CDP test offers any additional information from a VNG test or other assessment tools such as the Dizziness Handicap Inventory (DHI) questionnaire, Vestibular Myogenic Potentials (VEMP's), and whether this information is justified by the cost of such testing [11]. A few authors have shown that the CDP test does indeed offer additional information and can be extremely valuable in facilitating therapeutic decisions for patients with disequilibrium [12–18].

Furthermore, Goebel et al. demonstrated that CDP test can help distinguish between organic and nonorganic balance complaints such as malingering and hysteria [4]. In our study 6 (10.7%) patients showed abnormal input in 3 sensory systems and were defined as having non-organic symptoms, demonstrating the CDP abilities to identify non organic sway.

CDP test assesses a patient's functional deficits. It is non-localizing, with respect to lesions. The value of doing both tests is especially evident in individuals who are symptomatic but have normal or borderline VNG findings. Therefore, both types of tests are necessary for the diagnosis and subsequent therapeutic management of balance disorders.

Not all vertigo has a vestibular cause. Our results showed isolated decreased visual input in 2 (3.6%) patients and decreased combined visual and proprioceptive inputs in 2 (3.6%) with normal vestibular input. If these individuals had been tested with only a VNG test, they would have been labeled normal. However, on the basis of CDP test results, they have non-vestibular cause in which physical and occupational therapy interventions are warranted.

Although this study did not show a significant association between the VNG test and the CDP test, and the indication to perform them are not clear, we recommend referring patients to a posturography test in addition to a VNG test in symptomatic cases with normal VNG test results or suspected malingering in medicolegal cases. The CDP is

recommended for the evaluation of other stability compensation mechanisms as well.

Conclusions

The study shows no statistically significant association between the VNG test and the CDP test results. This emphasizes the difference between the tested aspects in each assessment, and therefore the need to define indications to perform each of them. Although the VNG is the most common laboratory test in vertigo evaluation, the CDP test examines different aspects in balance function, and aids in its comprehensive evaluation. Further research is needed to better understand and define the clear indications to use posturography in dizziness or vertigo.

Acknowledgements The authors thank Sara Malachi and Vladimir Rodionov from the ENG/VNG laboratory of the Department of Otolaryngology – Head & Neck Surgery, Hadassah Hebrew-University Medical Center, Jerusalem, Israel, for their great contribution throughout this study.

Funding No funding was used in this research.

Compliance with ethical standards

Conflict of interest This study was not sponsored by any organization. The authors have no conflict of interests.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The data were gathered retrospectively, and without mentioning any details regarding the subjects.

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