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Role of video-head impulse test in lateralization of vestibulopathy: Comparative study with caloric test

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ABSTRACT

Objective: To evaluate the lateralization value of video head-impulse test (vHIT) for the diagnosis of vestibulopathy and to analyze cases showing dissociated results with caloric test.
Methods: In total, 19 healthy volunteers and 92 dizzy patients who underwent both a caloric test and a vHIT were enrolled. Patients were divided into two groups depending on their fluctuating pattern of vertigo. The vestibulo-ocular reflex (VOR) gain and gain asymmetry (GA) of a vHIT as well as unilateral weakness (UW) and the sum of the slow-phase velocities (SPVs) of warm and cold irrigation of the same side were compared. A cutoff value of VOR gain of a vHIT was also calculated using a receiver-operating characteristic curve.
Results: A VOR gain in an affected ear and GA of a vHIT showed a statistically significant correlation with UW in a caloric test. The cutoff value of a vHIT was determined to be 0.875, derived under the assumption that UW of a caloric test $\leq$25% is normal. However, the parameters of the two tests were dissociated in 18%.
Conclusion: A VOR gain of vHIT is a valuable objective parameter with a lateralization value determining vestibular hypofunction. However, considering substantial dissociation between a vHIT and a caloric test, these tests can be complementary tools for the lateralization of vestibular impairment for the comprehensive evaluation of patients' VOR.

1. Introduction

Several laboratory diagnostic tests are clinically used to demonstrate unilateral vestibular hypofunction. Among them, the caloric test [1] and head impulse test (HIT) [2] are valuable tools with lateralization values determined by measuring the vestibulo-ocular reflex (VOR) in response to horizontal semicircular canal stimulation for evaluating patients with dizziness. The caloric test has been the gold standard method of demonstrating unilateral or bilateral vestibular hypofunction by measuring VOR response to ear specific irrigation with warm and cold water. In the HIT, the presence of refixation saccades is a positive sign of inappropriate VOR when a patient is instructed to stare straight ahead during a brief impulse head rotation to the lesion side [2,3]. Although the HIT is a simple bedside test, compared with the caloric test, it has moderate sensitivity (35%–45%) and high specificity (90%) [4]. To increase its sensitivity, a video system that can follow reflexive eyeball movement during impulse head rotation was introduced, because such a system can capture very early corrective

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saccades, known as covert saccades, during head rotation [5]. Moreover, HIT using a video system showed results comparable to those using sclera search coils [6].

In this study, parameters of a video-head impulse test (vHIT) and a bithermal alternating caloric test were compared in patients with dizziness and healthy volunteers to evaluate the role of vHIT in the lateralization of vestibular impairment.

2. Materials and methods

2.1. Study population

This study recruited 92 patients who underwent bithermal caloric tests and vHIT because of dizziness from May 2012 to June 2013 retrospectively (47 male patients; age range, 9–87 years, mean age of 55 years). The study population included patients diagnosed with vestibular neuritis (VN), Ménière's disease (MD), recurrent vestibulopathy (RV), and bilateral vestibular hypofunction (BVH) and patients who underwent cerebellopontine angle (CPA) tumor surgery and vestibular hypofunction after intratympanic gentamicin (ITG) injection. Diagnoses of VN [7], MD [8], RV [9], and BVH [10] were made based on diagnostic criteria published previously.

Patients with unilateral vestibular hypofunction were divided into two groups according to the course of their vertigo: a fluctuating and a non-fluctuating group. The fluctuating group included 57 patients with MD (31 patients) and RV (26 patients), and the non-fluctuating group included 26 patients with VN (15 patients), CPA tumor removal (7 patients), and ITG injection (4 patients). There were 9 patients with bilateral vestibular hypofunction.

In addition, 19 healthy volunteers (6 male subjects; age range, 20–43 years, mean age of 31.5 years) were enrolled in the same period. The vHIT and the bithermal caloric tests were performed on the same day. The study protocol was approved by the Seoul National University Bundang Hospital Institutional Review Board (No. B-1305-202-106) and informed consent was obtained from all healthy volunteers.

2.2. Bithermal caloric test

The bithermal caloric test was performed in the supine position with an upward head flexion of 30° [1]. Eye movements were recorded using a binocular video oculography system (I-Portal®, Neuro Kinetics Inc., Pittsburgh, USA) to track the horizontal eye movements. Caloric irrigation was performed using binaural alternate irrigation for 30s with 300mL of cold (30°C) and warm (44°C) water (ICS NCI-480®, GN Otometrics, Taastrup, Denmark). There was an interval of at least 5min between individual irrigations. A unilateral weakness (UW) in the caloric irrigation was calculated using Jongkees' formula [1], and a response difference >25% between the ears was defined as abnormal [11].

2.3. Video head impulse test

The examinees were instructed to stare at a stationary target at a distance of 1m in front of them while short lasting head rotations around an earth-vertical axis were randomly applied from behind the examinees. A vHIT system was used for acquisition and analysis of the eyeball and head movements (ICS impulse® ver. 1.0, GN Otometrics, Taastrup, Denmark). The test was repeated at least 10 times on each side in an unpredictable direction with 5°–10° and peak accelerations of 750°–6000°/s^2 [6,12]. Only head rotations with a defined waveform within a predefined velocity and acceleration window were accepted. The vHIT was performed by one expert technician in our vestibular laboratory. The movements of the right eyeball and the head were recorded. The area under the velocity curves of these two movements was obtained from head-impulse onset to the back crossing of zero. A VOR gain on vHIT was defined as the ratio of the area under the velocity curves of the right eye to that of the head [13]. Another parameter, gain asymmetry (GA) was defined as follows: GA=$(R-L)/(R+L)$, where R and L indicate the mean gain values for impulses to the right (R) and left (L) side [14].

2.4. Statistical analysis

The sum of the slow phase velocities (SPVs) of a warm and a cold irrigation in each ear was compared with a VOR gain on vHIT. The UW of bithermal caloric test was compared with GA of vHIT. In comparison of vHIT gain of an affected ear with UW of bithermal caloric test, we converted the negative value of UW in case of right vestibulopathy to positive value assuming left vestibulopathy to reduce the confusion. Statistical analysis was performed using Spearman's correlation analysis between parameters; $p<0.05$ was considered as statistically significant.

A receiver-operating characteristic (ROC) curve was plotted to determine the comparative diagnostic performance of vHIT, based on the results of the bithermal caloric test. The mean value of UW was also compared depending on the pattern of reflexive eye movement to impulse head rotation: pathological reflexive saccades were classified as "covert", if they occurred before the end of the head rotation, and classified as "overt" afterwards in patient group (Fig. 1). Significant differences among the groups were evaluated using a post hoc ANOVA. All statistical analyses were conducted using the same software (SPSS® v22.0, IBM, New York, USA).

3. Results

3.1. Comparison of VOR gain on vHIT with sum of peak SPVs in warm and cold irrigation

The results of all ears of the subjects in this study (222 ears of 111 subjects) were plotted (Fig. 2A). There was a statistically significant positive correlation between the two parameters with a correlation coefficient of 0.556 ($p<0.0001$). However, the two parameters were not correlated with each other in healthy volunteers (38 ears of 19 subjects, $\rho=-0.250$, $p=0.130$). The VOR gain on vHIT ranged from 0.86 to 1.22 (mean=1.064, SD=0.092), while the sum of SPVs of warm and cold irrigation ranged from 17 to 83°/s (mean=41.6, SD=19.0). The lower value of normal VOR gain of vHIT was defined as the mean minus 2 SD of the VOR gain in healthy volunteers (0.88).

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