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Lab resource

Comparison of the video head impulse test with the caloric test in patients with sub-acute and chronic vestibular disorders

Anne Burston [a], Stuart Mossman [a,b], Benjamin Mossman [a], Mark Weatherall [a,b,*]

[a] Department of Neurology, Wellington Hospital, Capital and Coast District Health Board, PB 7912, Wellington 6242, New Zealand
[b] Department of Medicine, University of Otago Wellington, PB 7343 Wellington South, Wellington 6242, New Zealand

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ABSTRACT

The aim of this prospective register-based study was to compare video Head Impulse Tests (vHIT) with caloric tests on 173 patients assessed by a tertiary Neurology referral centre who had been referred for investigation of dizziness or vertigo and whose symptom duration was one month or longer. Abnormal vHIT was defined as angular velocity gain (peak eye velocity/peak head velocity) less than 0.79 at 80 ms and 0.75 at 60 ms, which was two standard deviations below our institutions' lower limit of normal; together with refixation saccades. Abnormal bi-thermal caloric testing defined unilateral hypofunction as a 25% difference using Jongkee's formula and bilateral hypofunction was defined by the sum of the peak slow phase velocities over the four irrigations being <20°/s. Sixty patients had abnormal results on one or both tests, of whom 51 had unilateral and nine bilateral hypofunction. With caloric testing considered as the gold standard, the sensitivity (95% CI) of the vHIT was 18/52, 34.6% (22.0–49.1), and the specificity (95% CI) was 113/121, 93.4% (87.4–97.1). However vHIT was more sensitive in the nine patients with bilateral hypofunction with 100% abnormal vHIT results while only 4/9, 44% had abnormal caloric results. In conclusion these results support the continued use of both vHIT and caloric tests in patients with sub-acute and chronic vestibular symptoms, especially if the vHIT is normal.

1. Introduction

Portable video-oculography systems which measure the high frequency gain of the horizontal vestibulo-ocular reflex (HVOR) with the head impulse test have improved the diagnostic accuracy of suspected vestibular neuritis [1]. Although the video head impulse test (vHIT) is quick to perform, tightly fitting goggles, required to avoid goggle slippage, can be uncomfortable. Their use also requires care to avoid artefacts and good concentration by patients [2,3].

The bi-thermal caloric test, in use since the 1940s, has been the most common diagnostic test used to assess low frequency horizontal semicircular canal function. Disadvantages of caloric testing are that it is less physiological than high frequency testing [4], and responses to the caloric test are variable; being influenced by technique, patient alertness, the size of the external ear canal, and patient tolerance.

Although the caloric and the vHIT test different frequencies of the vestibular system the vHIT has lower sensitivity in detecting vestibular hypofunction than caloric testing in the following test situations: five days after recovery from an acute vestibular presentation [5], one month after vestibular neuritis [6], and in patients with chronic lesions, such as sporadic vestibular schwannoma [7].

The Vestibular Function Testing Unit of the Neurology Department at Wellington Hospital is a tertiary referral centre for the lower half of the North Island of New Zealand and has a catchment patient population of around 500,000. In this unit patients referred with dizziness routinely have both the caloric test and vHIT to measure HVOR gain.

1.1. Aim

To compare the sensitivity of the caloric test results with the vHIT results in patients with vestibular symptoms for one month or more, and to define the slow phase velocity on caloric testing at which a vHIT would be abnormal.

1.2. Hypothesis

That an impaired HVOR gain with an abnormal vHIT, with ipsilateral hypofunction, would only be seen with an ipsilateral caloric

* Corresponding author at: Department of Medicine, University of Otago Wellington, PB 7343 Wellington South, Wellington 6242, New Zealand.
E-mail address: mark.weatherall@otago.ac.nz (M. Weatherall).

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average peak slow phase velocity (aPSPV) ≤ 10°/sec as suggested on previous clinical observation.

2. Methods

A prospective register of all patients assessed by the Vestibular Function Testing Unit was reviewed for October 2011 to December 2015. Patients were included for analysis if they had been referred for investigation of dizziness or vertigo with symptom durations of one month or more. All patients had vHIT followed by caloric testing performed on the same day.

vHIT was performed using the EyeSeeCam VOG system (Manufacturer EyeSeeTec, Munich, Germany) to measure the HVOR gain of the horizontal semicircular canals. The clinical testing protocol included a minimum of ten unpredictable (timing and direction) head impulses performed in the horizontal plane to each side with the patient seated and fixating on a small target on the wall at eye level and 1.5 metres distant. An adequate head acceleration of 2300–5900°/s^2 was achieved in each HIT to ensure the detection of a high frequency vestibular deficit [8,9]. An adequate acceleration was monitored in real time by ensuring a peak head velocity of between 150°/s and 300°/s with low amplitude head movements.

Instantaneous HVOR velocity gains were calculated by the EyeSeeCam VOG software at 80 ms and 60 ms. An abnormal response was defined using normative data from our previous study with an abnormal vHIT angular velocity gain (peak eye velocity/peak head velocity) below the 2 standard deviation lower limit of normal at 0.79 at 80 ms and 0.75 at 60 ms as defined in 60 historical controls aged between 20 and 80 years of age [2] and consistent with the literature [1]. Covert and/or overt re-fixation saccades were also required when defining an abnormal vHIT result.

Although not used to define an abnormal vHIT result, gain asymmetry ratios were also recorded [2,7] and were used in support of abnormal VOR velocity gains to alert us to any possible questionable results. The gain asymmetry ratio is defined as:

$$\textit{Gain asymmetry ratio } \% = \left[\frac{(\textit{Gain unaffected side} - \textit{Gain affected side})}{(\textit{Gain unaffected side} + \textit{Gain affected side})}\right] \times 100$$

Caloric testing was performed using the Disoft infra-red video-oculography system (Instrumentation DIFRA, 84, Rue de l'Eglise, B-4840 Welkenraedt, Belgium) with cold and warm water irrigations to both ears. Unilateral hypofunction (UVH) was defined by bi-thermal caloric testing when there was a canal paresis (CP) greater than 25% difference between the two ear peak slow phase velocities (PSPV) using the Jongkees' formula [10]. The average of the peak slow phase velocities (aPSPV) of nystagmus from both the cold and warm water irrigations on the affected side was then calculated. Bilateral vestibular hypofunction (BVH) was defined by the sum of the peak slow phase velocities over the four irrigations being <20°/s [11].

When there were abnormal test results with either investigation the ipsilateral vHIT VOR gain was compared with the ipsilateral caloric aPSPV in patients with both UVH and BVH.

2.1. Statistical analysis

Comparison of paired proportions was by McNemar's test. Sensitivity and specificity were estimated by the Clopper-Pearson exact binomial method. A rank correlation coefficient estimates the strength of association between different measurements of vestibular function. Logistic regression was also used to estimate the diagnostic performance of caloric testing in those with UVH with vHIT treated as a gold standard and as summarised by the Area Under Curve for the Receiver Operator Characteristic curve and an illustrative sensitivity and specificity at particular cut-off values for caloric testing. In this analysis caloric testing for those with UVH was defined as greater than 25% on the Jongkees formula.

SAS version 9.4 was used.

3. Results

A total of 185 patients were investigated with both tests over 26 months with 12 patients excluded from analysis due to technically inadequate measurements with vHIT testing. No caloric test results were rejected. The mean (range) age of the remaining 173 patients was 52 years (19–87), 97 were female, and symptom duration ranged from 1 month to 50 years.

Of these 173 patients, 60 had abnormal results on at least one testing regime. The mean age (range) of these 60 patients was 57 (24–79) years, and 27 were female.

The 60 patients were referred for vestibular testing by Neurologists (N = 39), Physiotherapists (N = 14), General Practitioners (N = 5), Ear Nose and Throat specialists (N = 1) and General Medicine (N = 1). The referring clinicians suspected that all patients had a peripheral vestibular origin for all or some of their symptoms and included diagnoses of possible vestibular neuronitis (N = 29), Ménière's Disease (N = 3), Benign Paroxysmal Positional Vertigo (N = 3), gentamicin ablation (N = 1), acoustic neuroma excision (N = 1), gentamicin ototoxicity (N = 2) and bilateral vestibular hypofunction (N = 2). A normal central nervous system (CNS) examination was present in 37 patients at the time of referral from within the Neurology Department four of which had suspected vestibular migraine. Another 12 patients had both CNS as well as suspected peripheral vestibular conditions (including cerebellar degeneration (N = 6), stroke (N = 2), and one each of dementia, head injury, multiple sclerosis, and another CNS inflammatory condition). Symptoms consistent with Persistent Postural and Perceptual Dizziness (PPPD) were present in three patients.

Table 1 shows the contingency table of abnormal results by testing regime. Of the 60 patients with abnormal results on either or both of the vHIT and caloric test, 51 had partial or total UVH. Of

Table 1
Contingency table of vestibular function test outcomes.

vHIT[1]	Caloric test		Total
	Abnormal	Normal	
Abnormal	**18** (**14** UVH[2]/**4** BVH[3])	**8** (**3** UVH[2]/**5** BVH[3])	**26** (**17** UVH[2]/**9** BVH[3])
Normal	**34** (UVH[2])	**113**	**147** (**34** UVH[2])
Total	**52** (**48** UVH[2]/**4** BVH[3])	**121** (**3** UVH[2]/**5** BVH[3])	**173** (**51** UVH[2]/**9** BVH[3])

[1] Video Head Impulse Test.
[2] Unilateral Vestibular Hypofunction (UVH).
[3] Bilateral Vestibular Hypofunction (BVH).