

## Economic Testing of Unilateral Vestibular Failure

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### Abstract

Identifying unilateral vestibular failure of the semicircular canals (SCC) is important in vertigo and dizziness disease. There are different vestibular tests available: rotatory testing (RT), bithermal caloric irrigation (CI) and the video-head-impulse test (vHIT). This review comments on the current knowledge and on economic aspects of the testing methods. RT are a very special tests and should be only used in specialized vertigo/dizziness centres. It is recommended to use both, vHIT and CI to identify unilateral vestibular failure as the methods do not replace each other.

**Keywords:** Video-head-impulse test; Bithermal caloric irrigation; Vestibular tests; Vertigo; Dizziness; Vestibular disease

### Introduction

Sensors in the labyrinth that identify rotation of the body or head in space are the semicircular canals (SCCs). The SCCs are necessary to drive the vestibulo-ocular reflex (VOR) which compensate the head by short latency eye movements in the plane of the SCCs, but in opposite direction [1]. The VOR is quantified as a gain, the ratio of eye to head velocity, which is one in healthy subjects; eye and head move in opposite direction but at equal velocity. Failure of this pathway often leads to vertigo or dizziness. Testing the horizontal SCCs could be technically obtained by the bithermal caloric irrigation (CI), the modern video head-impulse test (vHIT) and passive rotational testing (RT) using a motor driven rotatory chair. In contrast, to CI and vHIT, RT tests both labyrinths at the same time.

To test VOR one has to be aware of the continuous firing rate of the vestibular nerve at rest of about 100 spike/s [2]. A rotation around an earth vertical axis to the right, increases neuronal firing on the right side and decreases it to the left. To test just one SCC, e.g. the right, the left SCC should have zero spike/s. To achieve this the stimulus has to be very fast, of a stimulus velocity of 200-250°/s and acceleration of 2000-5000°/s<sup>2</sup> [3]. Such a stimulus could be reached during the vHIT but not during RT based on technical restrictions of conventional rotatory chairs. In contrast, CI just excites or inhibits the right or left SCC by thermal energy.

The most common test to test the horizontal SCCs unilaterally is CI. CI tests a very low frequency range, is not physiological, but important in a vestibular test battery. The response of the horizontal SCCs to thermal irrigation depends on the amount of thermal energy which reaches the inner ear to elicit the VOR. Depending on the anatomy or disease the thermal conductance through the middle and inner ear could be different [1].

The most recent test is known as the 'Halmagyi-test', the 'Halmagyi-Curthoys test' or the 'head-impulse test', which tests the VOR unilaterally. This test uses the inhibitory cut-off of the firing rate as described before. The test applies high-acceleration, small-amplitude

head-pulses around an earth-vertical axis while the patient is fixating a stationary target. In a pathological case, the eye no longer compensates the head movements anymore and a correcting saccade is observed. This bedside test (bHIT) has a moderate sensitivity (35-45%) and high specificity (90%) [4,5]. To improve the sensitivity and specificity than the bHIT, the vHIT was developed [6-8]. From this finding I would recommend using the vHIT instead the bHIT if available.

RT has been applied for years, but the sensitivity to identify unilateral vestibular failure is low and tests both labyrinths at the same time. The test depends on the velocity profile, the disease itself, the stage of the disease, the cooperation and alertness of the patients [1,9-14]. For routine examination of a unilateral failure the value is very limited and only applicable if CI or vHIT could not be obtained or if information on central vestibular processing needs to be gained. For details I refer to standard textbooks [1,15].

The three tests measure unilateral the HC in different ways and have different overall sensitivity and specificity for a unilateral failure. A detailed study of the additional value of RT to vHIT and CI is missing so far. As RT is not very important, except in specialized vertigo-dizziness clinics, I will focus on the vHIT and CI. The sensitivity of the vHIT compared to the CI is 41% and the specificity 92% [4,5]. It is known that the probability to find a pathologic vHIT or bHIT increases with a unilateral weakness (UW) and that a UW of 42.5% ensures a pathologic vHIT or bHIT [8,16].

One reason for the differences are that the vHIT tests high frequencies up to 5 Hz [17] and the CI tests lower frequencies (about 0.003 Hz). In vHIT a very fast unilateral velocity pulse is applied and in CI thermal energy, which causes an endolymph flow and a direct stimulation of the vestibular nerve [18]. Another explanation is that during endolymphatic hydrops the diameter of the semicircular duct expands, which might lead to an endolymphatic circulation in the duct itself and a lowered or absent caloric response, but an unremarkable vHIT [19].

Furthermore depending on the aetiology of the unilateral failure and stage of the disease CI and vHIT and RT do not measure comparable results [3,8]. It is important to note, that vHIT and CI do not replace each other [3,8]. Accordingly, to identify a unilateral vestibular failure a must is to have a CI and a vHIT.

There are several economic aspects to consider as has been analysed before [3]. First, equipment has to be financed. At current knowledge, as mentioned, a vHIT and CI including a video-oculography or electronystagmography are necessary to efficiently diagnose a unilateral vestibular failure. A rotatory chair is far too expensive and is not advised to be in cooperated in a more general outpatient setting. But RT should be available in specialized vertigo-dizziness centres which high patient numbers.

Second, examination takes time. I have to emphasize that not only technical but also clinical neuro-otological and neurological examination and a good and extended medical history are necessary to diagnose a vertigo or dizziness disease. These aspects are not considered here as they are relatively fixed in time and have to be performed by the clinician itself.

The technical examination should help in this context to identify the disease but might be time consuming and costing additional time of technicians and the clinician. On the average the time needed to perform a horizontal vHIT is  $6 \pm 1$  min (mean  $\pm$  standard deviation), 3-D vHIT  $10 \pm 2$  min and a caloric irrigation  $22 \pm 2$  min. The examination and documentation of the results by the clinician including removing error traces and setting markers right was estimated at 5 to 10 min for each test [3]. Rotatory tests which are more time consuming (10-20 min) might be important in only limited number of disease, e.g. bilateral vestibular failure or central vestibular disease, which are not reviewed here.

In certain disease and depending on the question not all tests have to be applied, to save time. The saved time could be used to diagnose additional patients. From an economic point of view, just to identify a unilateral vestibular failure and with the mixture of diagnosis in a specialized vertigo/dizziness clinic, I recommend using the vHIT-first approach. In case of an unremarkable vHIT you additionally should use the CI. There is one exception, if you clinically suspect a MD, you should use the CI first [3]. From this data I suggest a disease dependent approach to save diagnostic time and decrease stress of the patient.

## Conclusion

In summary, I recommend in addition to a thorough clinical work up, the vHIT and CI. The methods do not replace one each other and are both necessary. A rotatory chair is necessary for special questions, e.g. a bilateral vestibular failure and deficits in central vestibular processing in a more specialized setting. Using the vHIT approach first before applying a CI could save time and money and decrease the diagnostic load of the individual patient.

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