Caloric Test versus Rotational Chair Test in Patients with Peripheral Vestibulopathy

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ABSTRACT

OBJECTIVE: 1) To correlate caloric results with sinusoidal and step-velocity rotary chair gain, phase, asymmetry and time constant values in all patients; 2) To evaluate sensitivity, specificity, positive predictive value and negative predictive value of both tests in patients with vestibular dizziness.

STUDY DESIGN: Retrospective case review.

SETTING: Academic tertiary care vestibular function test center

PATIENTS: Two hundred randomly selected patients (132 with clinically suspected vestibular dysfunction and 68 with suspected non-vestibular dizziness) evaluated in the Dizziness and Balance Center with bithermal binaural caloric and sinusoidal and step-velocity rotary chair tests.

MAIN OUTCOME MEASURES:

1. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of caloric and rotational chair testing in patients with and without suspected vestibular dysfunction.

2. Correlation of the following measures in all patients: a) degree of caloric weakness versus 0.025 Hz vestibulo-ocular reflex (VOR) gain, b) degree of caloric asymmetry versus 0.025 Hz VOR phase, c) caloric asymmetry versus 100 deg/s step velocity time constants, d) total eye speed versus 0.025 Hz gain, and e) total eye speed versus 0.025 Hz phase.

RESULTS: In patients with a suspected diagnosis of vestibular dysfunction, caloric testing demonstrated 68% sensitivity, 86% specificity, 95% PPV and 31% NPV. In similar fashion, rotary chair testing showed 44% sensitivity, 84% specificity, 88% PPV and 23% NPV value. Combining the two tests resulted in a slight increase in sensitivity (73%) with a consequent decline in specificity (74%) and no substantial change in PPV (94%) or NPV (33%).

In all patients, significant correlations were noted between; 1) percentage caloric weakness and 0.025 and 0.05 Hz phase, 2) percentage caloric weakness and average step velocity time constant (Tc), 3) total eye speed and 0.025 and 0.05 Hz phase, and 4) 0.025, 0.05 and 0.25 Hz phase and Tc (Pearson coefficients, p<0.05). However, no significant relationships were noted with caloric testing and rotary chair gain, asymmetry or 0.5 Hz phase measurements.

CONCLUSIONS: Both caloric and rotary chair test abnormalities are quite specific with high positive predictive value but only moderately sensitive in identifying patients with suspected vestibular disease. There is agreement between caloric asymmetry and total eye speed with lower frequency phase and Tc but not gain or asymmetry values. These results support the notion that a positive finding in either test alone or in combination is consistent with a suspected clinical diagnosis of vestibular disease (high specificity and PPV) whereas normal tests do not rule out a vestibular problem (low sensitivity). Finally, caloric abnormalities positively correlate with lower frequency phase and time constant tests.
Introduction:

Dizziness is one of the most common complaints reported in physicians’ offices, with an increasing prevalence with age, almost 40% of the population over the age of forty experiences a dizziness disorder in their lifetime. There is wide range of laboratory tests to evaluate the balance system. Each test has its own advantages and drawbacks and must be considered in light of the patient's history and physical exam findings (1).

The two most common stimuli of the vestibular system for diagnostic purposes are caloric and rotational chair testing, which measure vestibular function in the horizontal semicircular canals (1). Both tests provide "site-of-lesion" information; however, they provide little information relative to the patient's functional problems (2). In studies that involve both tests, it is useful to evaluate the differences that exist between them to understand the expected diagnostic yield of each test (2). Such comparisons can help the clinician decide on appropriate test utilization in evaluating dizzy patients (3). Occasionally, however, these tests provide conflicting information regarding the presence or absence of documentable vestibular insult (4).

The bithermal caloric test has been the mainstay of vestibular function testing for the past 30 years. It is inexpensive, reproducible, and, most importantly, can test each ear separately. Because of these factors, it has become the gold standard in vestibular testing against which other tests are measured (5). Although caloric stimulation, by delivering thermal energy to the lateral semicircular canal, is an artificial method of reproducing a rotary stimulus in the irrigated ear, the resultant nystagmus slow-component velocity yields reliable information regarding vestibular system function (6). However, caloric testing is primarily a low-frequency (0.002 - 0.004 Hz) stimulus of the horizontal canal, which is less than the physiologic frequency range (0.5 - 7 Hz) in which the system functions (7).

In contrast to the caloric test, rotational testing provides physiologic stimuli and quantitative evaluation of the vestibulo-ocular reflex (VOR) function of the horizontal semicircular canals and expands the ability to investigate the peripheral vestibular system beyond the very low-frequency region. It uses a computer-controlled rotary stimulus of the VOR through a range of frequencies (most commonly 0.01-1.00 Hz) (3). Clinically, the rotational sinusoidal harmonic acceleration (SHA) and step-velocity (SV) tests are the most commonly used tests (8).

The purpose of this study is to do a comparative analysis of the bithermal binaural caloric testing with rotational low-frequency (0.025-0.5 Hz) SHA and SV responses in patients with and without a clinical diagnosis of peripheral vestibulopathy. The percentages of caloric weakness (CW) and total eye speed (TES) were derived from the caloric test and gain, phase, symmetry, and SV time constant (Tc) were measured for the rotary test. Specifically, the relative ability of each test for distinguishing peripheral vestibular disease from other causes, and the predictive capability of combining different parameters were examined.

Materials and Methods:

We retrospectively studied the results of the caloric and rotary Chair tests of 200 patients with and without suspected peripheral vestibulopathy. The clinical diagnosis was made independently of the caloric and rotary chair (RC) test results based on the combination of detailed history taking, physical examination, bedside neuro-otologic examination, audiologic evaluation, and radiologic studies as clinically indicated. Based on the clinical diagnosis as the gold standard, the laboratory data from 200 patients were divided into 2 groups: 132 dizzy patients with a clinical diagnosis of peripheral vestibulopathy (68 men and 64 women; age, 58.56 ± 15.86 yr) and 68 dizzy patients without peripheral vestibulopathy.
(27 men and 41 women; age, 60.19 ± 16.96 yr).

All patients were instructed to refrain from drinking alcoholic beverages, and caffeine containing soft drink, and from ingesting anti-vertiginous drugs for 24 hours before the tests. The criteria for inclusion in the study were as follows: Patients with suspected peripheral vestibular or non-peripheral vestibular dizziness referred over 6 years period to the hearing and balance center for caloric and rotational chair testing were considered. Patients with incomplete tests or uninterruptable data (due to poor recordings or eye movement artifacts) were removed from the analysis. These criteria resulted in the inclusion of 200 patients in the analysis.

Rotational chair testing was accomplished in a Micromedical 2000 (Chatham, IL, USA) rotary chair. Sinusoidal harmonic acceleration testing of the vestibuloocular reflex was performed for at least 6 different testing frequencies to be included in this study. Frequencies tested were 0.025, 0.05 and 0.25, and 0.5 Hz. Gain, phase, or asymmetry was considered to be abnormal if the results of at least 2 frequencies fell outside the range of the normative data supplied by the manufacturer.

Caloric testing was done on a Micromedical Visual Eyes 4-channel Videonystagmography system using a Brookler-Grams closed-loop irrigation unit with standard bithermal irrigations of 30-C and 44-C for 45 seconds each, unilateral caloric weakness was calculated by the Jonkees formula. Unilateral weakness was considered significant for any finding greater than 30%. A total eye speed of less than 20 was considered suspect for bilateral caloric weakness.

Statistical Analysis
Statistical analysis was performed using SPSS statistical software (SPSS, Inc., Chicago, IL, USA; version 15.0). The predictive power of caloric and rotational chair tests in diagnosing peripheral vestibulopathy was assessed by comparing the sensitivity, specificity, positive and negative predictive powers. Finally, in an attempt to correlate caloric results with sinusoidal and step-velocity rotary chair gain, phase, asymmetry and time constant values in all patients, correlation coefficient also was calculated.

Results:
Table (1) demonstrates the demographic characteristics and distribution of 200 patients according to the etiology of dizziness in the peripheral and non-peripheral vestibulopathy groups. The most common causes of dizziness in the group with peripheral vestibulopathy (n = 132) were definite Ménière’s disease (34.9%), followed by vestibular neuritis (31.1%), whereas the most common causes of dizziness in the group without peripheral vestibulopathy (n = 68) were migraine-associated dizziness (57.5%), followed by central vestibular (vascular or neoplastic) lesions (16.2%).
Table 1: Descriptive demographic features of the study groups,

<table>
<thead>
<tr>
<th>Features</th>
<th>Peripheral Vestibulopathy Group</th>
<th>Non-Peripheral Vestibulopathy Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong> (Years)</td>
<td>20 - 87</td>
<td>17 - 89</td>
</tr>
<tr>
<td>Range:</td>
<td>58.56 ± 15.86</td>
<td>60.19 ± 16.96</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong> (n.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>68</td>
<td>27</td>
</tr>
<tr>
<td>Women</td>
<td>64</td>
<td>41</td>
</tr>
<tr>
<td><strong>Causes of Dizziness</strong> (n. - %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ménière's disease, 46 (34.9)</td>
<td></td>
<td>Migraine-associated dizziness, 39 (57.4)</td>
</tr>
<tr>
<td>Vestibular neuritis, 41 (31.1)</td>
<td></td>
<td>Central vestibular lesions, 11 (16.2)</td>
</tr>
<tr>
<td>Unidentified, 20 (15.2)</td>
<td></td>
<td>Postural instability, 7 (10.3)</td>
</tr>
<tr>
<td>Labyrinthitis, 6 (4.6)</td>
<td></td>
<td>Normal pressure hydrocephalus, 4 (5.9)</td>
</tr>
<tr>
<td>Acoustic neuroma, 6 (4.6)</td>
<td></td>
<td>Multiple sclerosis, 3 (4.5)</td>
</tr>
<tr>
<td>Bilateral vestibulopathy, 13 (9.9)</td>
<td></td>
<td>Orthostatic, 2 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transient ischemic attacks, 1 (1.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anxiety-associated dizziness, 1 (1.5)</td>
</tr>
<tr>
<td><strong>Total Number</strong></td>
<td>132</td>
<td>68</td>
</tr>
</tbody>
</table>

In patients with a suspected diagnosis of peripheral vestibular dysfunction, caloric testing demonstrated 68% sensitivity, 86% specificity, 95% PPV and 31% NPV. In similar fashion, rotary chair testing showed 44% sensitivity, 84% specificity, 88% PPV and 23% NPV value. Combining the two tests resulted in a slight increase in sensitivity (73%) with a consequent decline in specificity (74%) and no substantial change in PPV (94%) or NPV (33%).

Table 2: Sensitivity, specificity, PPV and NPV of Caloric test, Rotary Chair and combined tests in subjects with Peripheral vestibular dizziness:

<table>
<thead>
<tr>
<th>Subjects with Peripheral Vestibular Dizziness</th>
<th>Caloric Test</th>
<th>Rotary Chair</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity</strong></td>
<td>68 %</td>
<td>44 %</td>
<td>73 %</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>86 %</td>
<td>84 %</td>
<td>74 %</td>
</tr>
<tr>
<td><strong>PPV</strong></td>
<td>95%</td>
<td>88%</td>
<td>94%</td>
</tr>
<tr>
<td><strong>NPV</strong></td>
<td>31%</td>
<td>23%</td>
<td>33%</td>
</tr>
</tbody>
</table>

**PPV:** Positive Predicative Value, **NPV:** Negative Predictive Value

As shown in Figure 1, significant correlations (Pearson coefficients, p<0.05) were noted between; 1) percentage caloric weakness and 0.025 and 0.05 Hz phase, 2) percentage caloric weakness and average step velocity time constant (Tc), 3) total eye speed and 0.025 and 0.05 Hz phase, and 4) 0.025, 0.05 and 0.25 Hz phase and Tc (Pearson coefficients, p<0.05). However, no significant relationships were noted with caloric testing and rotary chair gain, asymmetry or 0.5 Hz phase measurements.
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**Figure 1:** Significant correlations (Pearson coefficients, p<0.05) were noted between: (A) % of caloric weakness and average time constant; (B) % of caloric weakness and Phase at 0.025 Hz; (C) % of caloric weakness and Phase at 0.05 Hz; (D) Average time constant and Phase at 0.025 Hz; (E) Average time constant and Phase at 0.05 Hz; (F) Total eye speed and average time constant.
Discussion:
Both caloric and rotary chair test abnormalities are quite specific with high positive predictive value but only moderately sensitive in identifying patients with suspected peripheral vestibular disease. There is agreement between caloric asymmetry and total eye speed with lower frequency phase and Tc but not gain or asymmetry values. These results support the notion that a positive finding in either test alone or in combination is consistent with a suspected clinical diagnosis of vestibular disease (high specificity and PPV) whereas normal tests do not rule out a vestibular problem (low sensitivity). Finally, caloric abnormalities positively correlate with lower frequency phase and time constant tests.

Early diagnosis of dizzy patients has a major impact on the clinical course, management, and outcome of these challenging cases. Thus, the effort of many investigating groups has been to find a reliable test to discriminate peripheral vestibular lesions from other causes of dizziness. Since then, many studies have been performed to determine the accuracy of caloric and RC tests in detection of peripheral vestibular injury but have yielded conflicting results.

The present study demonstrated that caloric test was the single most promising marker for identifying peripheral from non-peripheral vestibulopathic patients. Caloric test yielded a specificity of 81% and sensitivity of 68%. The reasons for this high specificity and only moderate sensitivity for the caloric test include 1) caloric testing is limited to responses of the horizontal semicircular canals and, hence, peripheral lesions of the vertical canals or otolith organs may not be detected; 2) caloric testing may not detect early levels of dysfunction too small to be discerned within the inherent variability of the caloric normative value; and 3) because diagnosis of vestibular disease is heavily dependent on the historical nature of the spells, it seems logical that patients with suspected vestibular dysfunction based on history might have normal laboratory tests at some stage in their disease.

The results also indicated that the combination of caloric and RC testing produced the strongest predictive capabilities for identifying peripheral vestibular injury. This finding reinforces the common belief that the caloric and rotary chair tests are complementary tests when used to evaluate dizzy patients. One explanation for this finding may be that caloric stimulation is equivalent to a very low-frequency rotation of 0.002 to 0.004 Hz, which falls substantially below the lowest frequency of the RC testing (0.01-1.0 Hz) (7).

Surprisingly, this study also revealed that the combination of caloric and abbreviated RC (SHA and step velocity) testing yielded almost the same outcome as caloric and comprehensive RC testing. These results imply that testing every patient suspected of having peripheral vestibular lesion with caloric test first and then proceeding to rotational chair testing only in selected cases is a reasonable approach. Moreover, the combined abbreviated caloric rotary testing may be the ideal recommendation when time, cost, and ergonomic factors are considered.

Despite the encouraging results with the discriminating power of caloric testing, it should be emphasized that RC testing has its own unique capabilities such as 1) it is a physiologic stimulus whose frequency and amplitude can be varied precisely; 2) the stimulus is unrelated to physical features of the external ear or temporal bone; 3) it is useful in children who may not tolerate caloric testing; and 4) it is very useful in assessing patients receiving vestibulotoxic drugs (7,9).

Past studies have investigated the relationship between caloric and rotational testing of the VOR (3,5,10,11). The current findings are similar to those reported by Daniel et al., who investigated 198 dizzy patients with both caloric and rotational (high-frequency pseudorandom) testing and found that the rotational chair testing provided little
added diagnostic benefit to the caloric test especially if the bithermal water caloric test was completely normal (5). On the other hand, the current study differs, in part, with Arriaga et al. (3), who studied 478 patients with and without a clinical diagnosis of peripheral dysfunction and reported rotational chair testing to be more sensitive (71 vs. 44%) but less specific (54 vs. 84%) than caloric testing when using normative cutoff values.

However, their standard test protocol was to perform rotational testing first on all patients and reserve caloric testing on a selective basis, which may have contributed to a lower sensitivity (i.e. performing caloric tests primarily on suspected vestibular patients with normal rotary tests). In the present study, both caloric and RC testing were performed together, which reduced the possibility of bias. Furthermore, their study considered rotational gain, symmetry, and phase but not time-constant abnormalities. Palomar et al. (10) studied the caloric and rotational chair tests in 100 patients with unilateral Ménière's disease and reported that the caloric test was fairly specific for patients with unilateral peripheral vestibulopathy, whereas the RC test was more sensitive, which agree, in part, with the current study findings. They attributed these findings to the fact that the time constant of the VOR is more stable than the canal paresis of the caloric test in test-retest reliability studies.

Gianoli and Soileau (11) reported on the outcome of caloric and RC testing in 25 patients with chronic suppurative otitis media and reported that unilateral or bilateral CW was 80% accurate in predicting an RC abnormality, whereas the symptom of vertigo/dizziness was only 48% accurate in predicting an RC abnormality. This observation reinforces the current study findings regarding the high discriminating power of caloric test to identify peripheral vestibular deficits.

The present study reinforces the clinical use of the caloric test for identifying peripheral vestibular lesions. However, it should be noted that rotational chair testing offers a broader view of VOR function when compared with caloric responsiveness and should not be considered as merely redundant evidence of dysfunction. This is especially true in cases of bilateral vestibular injury where lack of caloric responsiveness might imply significant loss of function, whereas mid- to higher-frequency rotational chair responses may demonstrate that the labyrinths are indeed not "dead".

Aknoweldgement:

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References:


