How To Incorporate vHIT Into Your Practice

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Vestibulocular Reflex (VOR) allows visual stabilization during active head movement.
SCCs work in paired comparison, sensing the strength and direction of acceleration and deceleration.
VOR symptoms

- Vestibular system has 2 primary functions: detection of gravity and velocity
- Patient symptoms, therefore, are usually triggered by changes in head and/or body position or movement in specific directions at specific speeds (frequencies).
- Head and eye coordination is “out of synch”
Common Symptoms of Impaired VOR

- Trouble reading or focusing with head motion, i.e., oscillopsia
- May be provoked with specific direction or plane of movement
- Trouble reading signs when walking
- Side to side head turns, e.g., sitting at a 4-way stop or shopping at the grocery store
- Bilateral Vestibular Dysfunction (BVD) may be so severe that gum chewing or eating while watching T.V. may be bothersome
Oscillopsia is blurred vision that occurs with head movement

- Horizontal plane
- Vertical plane
- Both
VOR Slow Phase (Latency and Gain)

Three instances during an impulse should be defined in advance:

1. **the head impulse start**, which, for example, can be defined as the time when head velocity exceeds 20°/s (Glasauer et al. 2004)
2. **the head peak velocity or peak acceleration**, where velocity or acceleration reach their maximal values,
3. **the head impulse end**, when head velocity crosses 0°/s and typically rebounds (Weber et al. 2008)
Normal vHIT Finding

Gain = Eye velocity

Gain = Head velocity

Gain = 0.86

Normal Gain = 0.77 – 1.13
In contrast, unilateral vestibular lesion (UVL) patients show prolonged latency and deficient VOR slow phases during ipsilesional impulses. They also trigger saccades during and/or after the head impulse (Aw et al. 1996a; Tian et al. 2000; Weber et al. 2008).
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<td><strong>Vestibular Neuritis</strong></td>
<td>viral inflammation of balance portion of CN VIII</td>
<td>acute onset vertigo lasting 30 minutes to several hours</td>
<td>Reduced gain and corrective saccades</td>
<td>VRT when stabilized</td>
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<td><strong>Meniere’s Disease</strong></td>
<td>“glaucoma of inner ear”</td>
<td>vertigo 30+ minutes fluctuating hearing loss aural fullness roaring tinnitus</td>
<td>Reduced gain and corrective saccades</td>
<td>VRT when stabilized</td>
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<td><strong>Labyrinthitis</strong></td>
<td>bacterial or viral infection- long lasting over weeks</td>
<td>hearing and balance mechanisms with hearing loss and vertigo</td>
<td>Reduced gain and corrective saccades</td>
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<td>Disorders cont.</td>
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<td><strong>BVD (e.g. from aminoglycosides, solvents)</strong></td>
<td>vestibular toxin causes bilateral loss of peripheral function</td>
<td>no vertigo, imbalance with visual and surface dependence</td>
<td>Reduced gain and corrective saccades bilaterally</td>
<td>Substitution protocols (VRT), Fall Prevention, Assistive Device</td>
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<td><strong>Concussion (Cortical and Labyrinthine)</strong></td>
<td>direct or indirect headtrauma or whiplash</td>
<td>cognitive, balance, dizziness, irritability, sleep disturbance, etc.</td>
<td>Reduced gain and corrective saccades</td>
<td>VRT with cognition protocols</td>
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Acute Stage
Acute Stage
Why is vHIT better than HIT?

Because the human eye cannot see everything.

There are two types of ‘catch up’ saccade

1. Saccades that happen after the head had been moved. We can see these eye movements, these are known as overt saccades

2. Saccades that happen during the head movement. These are known as covert saccades. Even the most experienced clinician cannot see these as they happen so quickly.
Vestibular neuritis affects both superior and inferior vestibular nerves

ABSTRACT

Objective: To characterize the profiles of afferent dysfunction in a cross section of patients with acute vestibular neuritis using tests of otolith and semicircular canal function sensitive to each of the 5 vestibular end organs.

Methods: Forty-three patients fulfilling clinical criteria for acute vestibular neuritis were recruited between 2010 and 2016 and studied within 10 days of symptom onset. Otolith function was evaluated with air-conducted cervical and bone-conducted ocular/vestibular evoked myogenic potentials and the subjective visual horizontal test. Canal-plane video head impulse tests (vHITs) assessed the function of each semicircular canal. Patterns of recovery were investigated in 16 patients retested after a 6- to 12-month follow-up period.

Results: Rates of horizontal canal (97.7%), anterior canal (90.7%), and utricular (72.1%) dysfunction were significantly higher than rates of posterior canal (39.5%) and saccular (39.0%) dysfunction (p < 0.008). Twenty-four patients (55.8%) had abnormalities localizing to both vestibular nerve divisions; 18 patients (41.9%) had superior neuritis; and 1 patient (2.3%) had inferior neuritis. A test battery that included horizontal and posterior canal vHIT and the cervical/vestibular evoked myogenic potentials identified superior or inferior neuritis in all patients tested acutely. Eight of 16 patients who were retested at follow-up had recovered a normal vestibular evoked myogenic potential and vHIT profile.

Conclusions: Acute vestibular neuritis most often affects both vestibular nerve divisions. The horizontal vHIT alone identifies superior nerve dysfunction in all patients with vestibular neuritis tested acutely, whereas both cervical/vestibular evoked myogenic potentials and posterior vHIT are necessary for diagnosing inferior vestibular nerve involvement.

GLOSSARY

AC = anterior semicircular canal; cVEMP = cervical vestibular evoked myogenic potential; HC = horizontal semicircular canal; HINTS = head impulse, nystagmus, test of skew; HIT = head impulse test; sVEMP = saccular evoked myogenic potential; PC = posterior semicircular canal; SVH = subjective visual horizontal; VEMP = vestibular evoked myogenic potential; vHIT = video head impulse test; VN = vestibular neuritis; VOR = vestibulo-ocular reflex.

Vestibular neuritis (VN) is characterized by acute spontaneous vertigo lasting ≥24 hours, peripheral nystagmus, a positive head impulse test (HIT), symmetric hearing, and no other nonvestibular neurologic deficits. Presumed to arise from a viral infection of the vestibular ganglion, VN is the most common cause of an acute vestibular syndrome. VN has long been known to affect the superior vestibular nerve. After the introduction of vestibular evoked myogenic potentials (VEMPs) and HIT, it became evident that both nerve divisions could be affected, both together and independently. Cases involving only ampullary fibers or otolith afferents have now been described, yet the prevalence of these patterns is uncertain because of the small sample size and/or restrictive inclusion criteria that depended on an abnormal caloric test or a positive horizontal head impulse.

This study compares the diagnostic yield of VEMPs and video HITs (vHITs) in 43 patients with acute VN who were diagnosed on the basis of their clinical presentation. Our aim was to determine the prevalence of common and atypical patterns of nerve involvement that
Case Study 1
Left Inferior Vestibular Neuritis

- 45 YOF, works as a surgical nurse
- Episode of true vertigo lasting 24 hours
- Other associated symptoms include nausea and emesis
- No otologic symptoms
- Prior to onset, patient reports URI
Case Study 1
Left Inferior Vestibular Neuritis

Current symptoms
- Oscillopsia (blurred vision with head movement)
- Vertical head pitch affected
- Imbalance
Case Study 1
Left Inferior Vestibular Neuritis

Test Results
• VNG with 4 calorics: WNL
• ABR: WNL
• Electrocochleography: WNL
• Audiometry: WNL
• Kinetic Rotary Chair: WNL
• Gans SOP: Normal in conditions 1-5 and 7; Fall in condition 6
Case Study 1
Left Inferior Vestibular Neuritis

Test Results
• cVEMP: Right WNL; Left cVEMP absent
• Horizontal vHIT: Negative for corrective saccades in horizontal plane to either side
• RALP vHIT: Positive for corrective saccades and reduced VOR gain for left posterior canal
Case Study 1
Left Inferior Vestibular Neuritis

Vertical Impulses (RALP)
Case Study 1
Left Inferior Vestibular Neuritis

Treatment Plan
• Vestibular Rehabilitation Therapy with focus on vertical head pitch movements
• Return to normal daily activities, with the exception of work due to nature of her work as a surgical nurse
Case Study 1
Left Inferior Vestibular Neuritis

Follow Up
• Patient reports feeling 100% better
• Repeated vHIT- RALP showed no corrective saccades and return of VOR gain symmetry
Performing RALP head impulses

Head rotations should be:
- Rapid and unpredictable (in direction and time)
- Small amplitude 10-15°
- Peak head velocity 150 °/s +
RALP Video
Case Study 2
Right Vestibular Neuritis

- 67 YOM
- Symptoms began 2 weeks prior to visit
- Sudden onset of prolonged vertigo with emesis
- MRI of head unremarkable
- Prior to onset, patient reports cold sore outbreak
- Current symptoms: Oscillopsia and imbalance
Case Study 2
Right Vestibular Neuritis

Test Results:
- SOP: fall on condition 6
- CDVAT: significant degradation in horizontal plane from baseline
- VEMP: asymmetric; right absent
- vHIT: abnormal with right head thrust in horizontal plane
- Rotary Chair: abnormal VOR gain to the right
- VNG: direction fixed left beat nystagmus in gaze and positional studies, enhances with seated and lateral headshake, 79% right caloric weakness
Case Study 2
Right Vestibular Neuritis
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Right Vestibular Neuritis
Case Study 2
Right Vestibular Neuritis

Recommendations

- Return to normal daily activities
- Recommend VRT for uncompensated right vestibulopathy
- After 4 weeks, patient called and reported no further symptoms
Case Study 3
Pediatric Migraine

- 11 y.o. female
- Symptoms began January 2014
- Episodic headache, nausea, internalized sensation of motion, falls
- No provocation of symptoms
- Normal equilibrium motor milestones
- Mother and maternal uncle with migraine history
Case Study 3
Pediatric Migraine

Test Results:

- Gans SOP: Normal
- Kinetic Rotary Chair: Normal
- cVEMP: Asymmetric
- vHIT: Normal
# Case Study 3
## Pediatric Migraine

<table>
<thead>
<tr>
<th></th>
<th>Amplitude</th>
<th>P1 Lat</th>
<th>N1 Lat</th>
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<tr>
<td>100 R</td>
<td>359.0</td>
<td>11.33</td>
<td>18.33</td>
</tr>
<tr>
<td>100 L</td>
<td>117.3</td>
<td>13.00</td>
<td>19.33</td>
</tr>
</tbody>
</table>
Case Study 3
Pediatric Migraine
Case Study 3
Pediatric Migraine
Case Study 3
Pediatric Migraine

- Recommended follow up with pediatric neurologist
Case Study 4
Bilateral Vestibulopathy

- 68 YOM
- Sepsis following abdominal surgery
- I.V. gentamicin antibiotics administered
- Within 24 hours, symptoms of severe oscillopsia and imbalance began
- Patient spent 2 weeks in hospital and the past 4 weeks at an in-patient Rehab
- Currently using a walker due to imbalance
- Reports balance function is worse in dark or low-lighting
- No otologic concerns
Case Study 4
Bilateral Vestibulopathy

Test Results
• Kinetic rotary chair: no VOR responses bidirectionally
• VNG: Bilateral caloric weakness
• Gans SOP: Normal in conditions 1-4; Sway in condition 5; Fall in condition 6 and 7
• Dynamic Visual Acuity: Positive for oscillopsia in vertical and horizontal planes at 2 CPS
• vHIT: Reduced bilateral VOR gain with corrective saccades
Case Study 4
Bilateral Vestibulopathy
Case Study 4
Bilateral Vestibulopathy

Recommendations
• Continue use of assistive device
• Counseling on realistic expectations due to BVD
• Incorporate gaze stabilization exercises with VRT for oscillopsia symptoms
Bilateral Vestibulopathy
Where does vHIT fit into my assessment?

- vHIT may be performed bedside or as an initial step in the assessment process.
- vHIT may also be used to assess the compensation of a high frequency vestibulopathy.
- The most common findings are in the lateral canal so you can “screen” with lateral impulses. This takes 2 minutes or less.
- If your vHIT is normal, you will need to perform other vestibular function tests. A normal vHIT does not conclude normal vestibular function.
- If your vHIT is abnormal, you would use history, symptoms, medical history, and other testing completed for triage.
Performing vHIT

- 10-20 degrees of movement
- Keep movements unpredictable
- Movements must be fast, 150°/s to 300°/s
What about pediatrics?

vHIT can be performed with children as young as 10 months.
Reimbursement issues

- Unlisted otolaryngology service 92700
- Self pay
Vestibular Rehabilitation Therapy (VRT)

Definition of VRT:

- Systematic progression of exercise protocols which reduce or extinguish:
  - Hallucination of motion
  - Exaggeration of motion or after-motion
- Improves or restores:
  - Coordination of head and eye movement
  - Balance and equilibrium function
Benefits of VRT

1. May be the best or only management
2. Cost effective
3. Non-invasive
4. Short course of therapy
5. User friendly
6. Returns or restores everyday function
vHIT as a measure of compensation status

left Vestibular Neuritis
Total vestibular nerve pattern

Day 1
- Head impulses to the right
- Head impulses to the left

Day 8
- Head impulses to the right
- Head impulses to the left

Day 17
- Head impulses to the right

Day 31
- Head impulses to the right
Does NOT replace VNG

- It is important to note that to obtain a complete diagnosis further VNG testing may be necessary.

- Purpose of VNG: To provide guidance about where the problem comes
  - Oculomotor tests (Gaze, Saccade, Smooth Pursuit and Optokinetic testing).
  - Positional and Dix-Hallpike testing.
  - Bithermal Caloric
vHIT vs Caloric

When compared to vHIT, the caloric test presents a number of disadvantages when evaluating the angular VOR.

1. The caloric test evaluates VOR in a frequency domain below the physiological range (0.003 Hz) (Formby and Robinson 2000).

2. It induces an non-physiologic endolymphatic flow in the horizontal SCC due to a temperature gradient and it is characterized by considerable technique problems, such as failed irrigation, asymmetrical transmission of thermal energy or persistence of stimulation between irrigations and alertness.

3. It is a time-consuming test

4. May cause significant discomfort to patients

5. Finally, deficit results do not supply cues to compensation, restitution or substitution mechanisms taking place
vHIT vs Caloric

In contrast, vHIT

1. Evaluates the physiological high frequency range of the VOR in horizontal and vertical SCC planes (up to 5.0 Hz) (Jorns-Haderli et al. 2007).

2. With instantaneous gain analysis (Aw et al. 1996), there is no cortical or slower ocular motor system interference, in contrast to the more recent position gain analysis (MacDougall et al. 2013b).

3. The test is fast and well-tolerated, thus allowing re-testing.

Comparing Head Impulse and Caloric Tests
Differences in the Operational Frequency Range

The caloric and vHIT results should be considered complementary because they assess different frequency ranges of the vestibular function.
Concluding thoughts on vHIT

- vHIT is a great quick easy test that can tell us about the function of the VOR for all six SCCs, state of the superior and inferior vestibular nerves, and can indicate if the problem may be central.

- Can also provide information on compensation status.

- vHIT testing should NOT be relied upon by itself, but rather should be used in conjunction with other vestibular tests to formulate a complete diagnosis.
Education without Boundaries

References: visit dizzy.com

- Research and Publications
- Dr. Gans’ blog for video case studies and additional articles/references