“The Current State of Video Head Impulse Testing”

Devin L. McCaslin, Ph.D.
Division of Audiology
Division of Vestibular Sciences
Vanderbilt Bill Wilkerson Center for Otolaryngology and Communication Sciences
Vanderbilt University Medical Center

Introduction

• We cannot use imaging or any other sort of anatomical evidence to confirm an impairment in the vestibular system
• The clinicians interpretation of findings from tests of peripheral vestibular function are critical to achieving a correct diagnosis.

Introduction

• The clinical assessment of the peripheral vestibular system often consists of comparing the level of function from similar end-organs.
• In order to correctly interpret tests of vestibular function, the clinician must thoroughly understand the anatomical and physiological underpinnings of the tests.
Semi-Circular Canals

© Vanderbilt University 2013
Polarization

Ewald’s Laws

MacDougall et al., Otology & Neurotology, 2013
VOR: Frequency and Gain
Gain is best above .1 Hz and poorest below

Responses from the Semicircular Canal Afferents
The dynamic range is different for excitatory and inhibitory responses (Ewald 1892).
Goldberg and Fernandez, 1971

Background of the Head Impulse Test

• Halmagyi and Curthoys (1988)
• Doll’s eye test
HIT Technique

- Patients are asked to maintain gaze on an earth-fixed target (1 meter away).
- The head is grasped by the examiner and moved in a high acceleration low amplitude movement (10-20 degrees-horiz).
- A patient with intact vestibular function will be able to maintain their gaze on the target.
- A patient with an impairment will generate one of two types of saccades.

Vestibulo-ocular Reflex (VOR)
“Catch-up saccade”

Normal HIT

Abnormal HIT

Technique

• Must be an abrupt impulse/acceleration (i.e. > 50 degrees per second) since the oculomotor system can compensate for head movement at low frequencies).
• When a head velocity exceeds approximately 100 degrees per second the VOR is the sole contributor to the corresponding eye movement.
Technique is Critical

Why it matters...

- Low noise of the coil method allows for high spatial (< 1 degree) and temporal (less than 1 msec) resolution.

Comparison of Techniques

Bartl et al., Annals of the New York Academy of Sciences, 2009
Video-oculography

What is Measured?

- Position of the eye
- Head velocity in 3-dimensional space

RALP and LARP

- Spatial Arrangements:
  - The three SCC are at right angles to each other so that they lie in the three planes of space (corner).
Right Anterior - Left Posterior

Left Anterior – Right Posterior
Vertical HIT

Saccade Classification

MacDougall et al. 2009
“The video head impulse test”

Eyes move perfectly out-of-phase with the head with few, if any, catch-up saccades
MacDougall et al. 2009
“The video head impulse test”

Factors Considered for Interpretation

- Vestibulo-ocular Reflex Gain
  - Speed or position of the eye vs. head
- Catch-up saccades (direction, velocity, timing)
  - Overt
  - Covert
- Gain Asymmetry
  - Impulses to the left vs. right

Patient with left-sided impairment of, at least, the HSCC (or superior vestibular nerves)

Calculation of VOR Gain

Head Velocity
Eye Velocity

Factors Considered for Interpretation
- Vestibulo-ocular Reflex Gain
  - Speed or position of the eye vs. head
- Catch-up saccades (direction, velocity, timing)
  - Overt
  - Covert
- Gain Asymmetry
  - Impulses to the left vs. right
Factors Considered for Interpretation

Abnormal vHIT

Unilateral Vestibular Lesion
vHIT and Compensation

Initial head impulse test  
Impulse test hours later


Variations of Responses

Blodow et al., Ausis Nasus Larynx, 2013

Absent Covert Saccades
Clinical Application for Audiology

- We now have tools to assess low frequency (caloric) and high frequency function in the vestibular system.
- HIT testing and caloric testing can be different thus each provides unique information
- Good for bedside testing (e.g. inpatients)
- Well-tolerated
- Is relatively quick to do.

vHIT and Peripheral Vestibular Impairments

Vestibular Neuritis

- Ipsilesional gains were low.
- Contralesional gains were reduced by approximately 20%.

Chen et al., Neurology, 2014
Unilateral Peripheral Vestibular Impairments

Objectives

- To determine if a predictable relationship existed between self-reported dizziness handicap and vHIT.
- Describe the characteristics of vHIT ipsilesional and contralesional vestibulo-ocular reflex slow phase velocity in patients with varying levels of canal paresis.

Objectives (con’t)

- Determine the sensitivity and specificity of the vHIT for detecting horizontal semicircular canal impairment using the caloric test as the "gold standard."
Design

- Subjects were 115 adults 65 years were included in the study (mean age 45.63 years [sd = 14.91], 58 males) presenting to a tertiary medical care center with symptoms of dizziness.
- Participants were administered a measure of self-report dizziness handicap (i.e. Dizziness Handicap Inventory DHI) and underwent caloric testing and vHIT at the same appointment.

Design

- Extensive data cleaning was imposed to eliminate artifacts.
  - Blinks and miniblinks
  - Excessive oscillations (tracking system loses the pupil)
  - Delay responses or phase shifts
  - Multi-peak responses (examiner contacts goggles)
  - Head bounce
  - Responses that go in the wrong direction

Design

- Caloric UW categories:
  - 0-26%
  - 26%-50%
  - 51%-75%
  - 76%-100%
- VOR responses from impulses with a velocity of less than 150 deg/sec were discarded.
Mean DHI Total Score and vHIT Outcome

Ipsilesional VOR Gain and CA

Contralesional VOR Gain and CA

(F = 50.51, df = 3, p ≤ 0.000)

(F = 4.097, df = 3, p ≤ 0.008)
Effect of UW on vHIT examination

vHIT Outcome and Caloric Asymmetry Category

Results-Peripheral Impairments

• A cut-off point of 39.50 percent caloric asymmetry optimized best sensitivity and specificity.
• Using a >39.5% caloric asymmetry as the normal upper limit the positive predictive value of the vHIT was 0.93 and the negative predictive value 0.85.
Conclusions

• The level of self-reported dizziness handicap is not predicted by the outcome of the vHIT.
• vHIT and caloric data are not redundant
• Each test provides unique information regarding the functional integrity of the horizontal semicircular canal at different points on the frequency spectrum.

Conclusions

• However, our data shows that a caloric asymmetry of 39.5% is required to optimize discrimination between an abnormal and normal vHIT in cases of unilateral peripheral impairment.
• It is our contention that the vHIT is a complementary test to the balance function examination and should viewed as such rather than as a replacement for caloric testing.
Can Abnormal vHITs be Recorded in Patients with Central Impairments
YES!

Posterior Fossa

Posterior Circulation Stroke

Edlow et al., Lancet Neurol, 2008
Abnormal vHIT Due to Posterior Circulation Strokes

Chen et al., Neurology, 2014
Edlow et al., Lancet Neurol, 2008

What is the HINTS exam

• Three step clinical decision rule:
  – Composed of three eye movement exams that have been suggested to be critical in differentiating peripheral from central impairments of acute continuous vertigo/dizziness (not transient-BPPV).
  • Head impulse
  • Nystagmus type
  • Test of skew

HINTS

• HINTS:
  – Head Impulse
  – Nystagmus
  – Test of Skew
  – hearing.
• 99% sensitivity
• 97% specificity for central vestibular disorders

Newman-Toker et al., Acad Emerg Med, 2013
The HINTS Exam

• Is the HINTS exam (Head-Impulse—Nystagmus—Test-of-Skew)
• A negative HINTS examination has been suggested to be able to rule out a stroke better than a negative MRI with DWI in the first 24 to 48 hours after symptom onset with a specificity of 96%.

Newman-Toker et al., Acad Emerg Med., 2013

Meniere’s Disease

McCaslin et al., 2014, American Journal of Audiology

HIT and Meniere’s Disease

• HIT Abnormal – 29%
• Caloric Abnormal- 42%
• Both Abnormal- 18%

Park et al., Acta Oto-Laryngologica, 2005
HIT and Meniere’s Disease

Significant Caloric UW  Normal Side

Audiometry

Abnormal Caloric Response

Park et al., Acta Oto-Laryngologica, 2005
Bilateral Meniere’s
A new saccadic indicator of peripheral vestibular function based on the video head impulse test

Saccade

HIMP-SHIMP

Normal HIMP-SHIMP
Abnormal HIMP-SHIMP

Questions