Functional Assessment of Peripheral Vestibulopathy

Richard A. Roberts, Ph.D.
Alabama Hearing & Balance Associates
Disclosure Statement

I have no financial or nonfinancial interest in any organization whose products or services are described, reviewed, evaluated or compared in the presentation.
At the end of this presentation, attendees will be able to:

1. Identify common symptoms of impaired vestibulo-ocular reflex (VOR) and vestibulo-spinal reflex (VSR) function.

2. Apply appropriate diagnostic measures to assess VOR and VSR function.

3. Interpret functional results to improve diagnostic efficiency.
Overview

- Interpretation
- Vestibulo-ocular Reflex (VOR)
- Dynamic Visual Acuity
- Vestibulo-spinal Reflex (VSR)
- Postural Stability Testing
- Illustrative Cases
Interpretation

THE BLIND MEN AND THE ELEPHANT
Functional Assessment

• Dynamic _________ Acuity (DVA)
  – Vestibulo-________ reflex (VOR)

• __________Stability Testing
  – Vestibulo-________ reflex (VSR)
VOR

Purpose: Maintain gaze on visual target during head motion

Eye movement equal and _________ of head movement

Frequency Range
0.5 – 6 Hz
Foveola of Retina

Visual acuity decreases as image slips off ________.

http://www.agingeye.net/maculardegen/maculardegensymptoms.php
Oscillopsia

3° slip off foveola can cause vision to change from 20/20 to **20/200** – ___________: blurred vision with head movement
Common Symptoms of Impaired VOR

• Trouble reading or focusing with head motion
• May be provoked with specific direction or plane of movement
• Trouble reading signs when walking
• Side to side head turns i.e. sitting at a 4-way stop or shopping at the grocery store
• BVD may be so severe, symptoms provoked with gum chewing or eating
VOR Assessment

- Calorics – Horizontal Canal Reactivity
- Rotary Chair – Horizontal Canal Reactivity
- Vestibular Autorotation – Horizontal and Vertical VOR
- Calorics – May be Compensated
- Rotary Chair – Phase abnormalities may persist
- Vestibular Autorotation – Phase abnormalities may persist
Dynamic Visual Acuity

- Measure perception of a visual stimulus when the head is in motion
- Dynamic Visual Acuity Tests
  - Measure visual acuity with head still (Static)
  - Measure visual acuity with head moving (Dynamic)
- Compare Performance
  - **Normal VOR**: Static = Dynamic
  - **Abnormal VOR**: Static > Dynamic
Herdman et al. (1998)

- Optotype
- Rate Sensor (120°/s)
- Scored using \( \text{logMAR Visual Acuity} \) – log of minimum angle of resolution

<table>
<thead>
<tr>
<th>LogMAR</th>
<th>Visual Acuity</th>
<th>Font Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.097</td>
<td>20/16</td>
<td>12</td>
</tr>
<tr>
<td>-0.046</td>
<td>20/18</td>
<td>14</td>
</tr>
<tr>
<td>0</td>
<td>20/20</td>
<td>16</td>
</tr>
<tr>
<td>+0.097</td>
<td>20/25</td>
<td>18</td>
</tr>
<tr>
<td>+0.130</td>
<td>20/27</td>
<td>20</td>
</tr>
</tbody>
</table>
Hillman et al. (1999)

- Treadmill
  - Natural Head Movement
- Number Stimuli
- Percent Correct

- Volitional Head Movement
- Number Stimuli
- Percent Correct
- *No Difference between treadmill and volitional head movement*
Bhansali et al. (1993)

- Snellen Chart
- Static, then Dynamic
- >2 lines poorer = abnormal
Common DVA Findings

- **Normal VOR** –__________ between Static and Dynamic Visual Acuity measures

- **Abnormal VOR** – Dynamic Visual Acuity poorer compared to Static Visual Acuity

### Unilateral Vestibular Dysfunction

<table>
<thead>
<tr>
<th>Sub-Group</th>
<th>n</th>
<th>Static Seated</th>
<th>Dynamic Head Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVD</td>
<td>10</td>
<td>98.2</td>
<td>76</td>
</tr>
<tr>
<td>BVD</td>
<td>3</td>
<td>97.3</td>
<td>45.3</td>
</tr>
<tr>
<td>HFV</td>
<td>3</td>
<td>97.3</td>
<td>69.3</td>
</tr>
</tbody>
</table>

### Bilateral Vestibular Dysfunction

### High Frequency Vestibulopathy

Functional impact is _______ for BVD compared to UVD

ASHA 2010

Roberts & Gans (2007)

- DVA is more sensitive than Vertical DVA to Impaired VOR
- DVA does NOT appear to be sensitive to nonvestibular dizziness

Normal n=10

Impaired Vestibular n=33

Nonvestibular Dizziness n=55
Horizontal DVA More Sensitive

Schubert, Herdman, & Tusa (2002)
Roberts & Gans (2007)

- 2v to 1h issue
- Possible functional PC
  - 11/33 IVF had normal VEMPs \((Roberts & Gans, 2007)\)
- Some patients only show degradation with vertical head movement \((Roberts & Gans, 2007)\)
DVA Summary

- Sensitive to functional VOR deficit
  - uncompensated peripheral vestibulopathy
- Horizontal DVA more sensitive than Vertical DVA
- BVD performance poorer than UVD
- Snellen Chart 2 Hz head movement
- Horizontal & Vertical head movement
- Outcome measure
Vestibulo-spinal Reflex (VSR)

Sends descending motor control signal to musculoskeletal system for ___________control.

A response to sensory information is sent to the musculoskeletal system to maintain our center of gravity.
Common Symptoms of Impaired VSR

- Unsteadiness
- History of Falls
- Visual Preference
- Surface Dependence
  - Difficulty on dynamic or uneven surfaces
Measurement of VSR

• Computerized Dynamic Posturography
  – Sensory Organization Test (SOT)

• Gans Sensory Organization Performance Test (SOP)

• Clinical Test for Sensory Interaction on Balance (CTSIB) & mCTSIB
“Foam & Dome”

Shumway-Cook & Horak, 1986
Measurement of VSR

• Moderate to High correlation between postural stability results obtained with CDP and CTSIB
  el-Kashlan, Shepard, et al., 1998

• Excellent agreement between CDP & CTSIB and a 90% sensitivity and 95% specificity for ID of vestibular dysfunction
  Weber & Cass, 1993
Measurement of VSR

Must consider the independent effects and interaction effects of sensory, motor, and orthopedic problems and even patient ________ about potential falls when interpreting postural stability results.

Shumway-Cook & Horak, 1986; Roberts, 2009
Measurement of VSR

Point of these tests is to see how patient reacts to manipulating/eliminating sources of balance information

– Vestibular
– Visual
– Somatosensory
mCTSIB

Static Surface
Eyes Open
Vestibular
Visual
Somatosensory

Static Surface
Eyes Closed
Vestibular
Visual
Somatosensory

Dynamic Surface
Eyes Open
Vestibular
Visual
Somatosensory

Dynamic Surface
Eyes Closed
Vestibular
Visual
Somatosensory

Wrisley & Whitney, 2004
mCTSIB Patterns

NORMAL

NORMAL  NORMAL  NORMAL  NORMAL

NORMAL  NORMAL  NORMAL  FALL

CENTRAL

SWAY  SWAY  FALL  FALL
Postural Stability Summary

- Sensitive to functional VSR deficit
  - uncompensated peripheral vestibulopathy
- Consider pattern of results
- Interpret in light of co-morbid factors
- Reasonable alternatives to expensive solutions
- Outcome Measure
Case 1

Hx:
- 40 y.o. Male
- 1 Attack of Vertigo, Nausea, & Emesis duration = 1 day
- No Auditory Sx
- MRI Unremarkable

Sx:
- Disequilibrium
- Visual provocation
- Exacerbation while driving
- Clear-headed in a.m.
- Difficulty walking
- DHI = 72
mCTSIB

NORMAL  NORMAL  NORMAL  FALL

CDVAT
VEMP Responses

![Graph showing VEMP responses with peaks labeled A1 L VEMP, A2 L VEMP, N1, B1 R VEMP, and B2 R VEMP.](image-url)
Case 1

Hx:
- 40 y.o. Male
- 1 Attack of Vertigo, Nausea, & Emesis duration = 1 day
- No Auditory Sx
- MRI Unremarkable

Sx:
- Disequilibrium
- Visual provocation
- Exacerbation while driving
- Clear-headed in a.m.
- Difficulty walking
- DHI = 72

Dx:
- Fall Foam EC (Vestibular)
- Vestibular Neuritis with superior branch involvement on left.
- CDVAT and SOP results suggest patient is uncompensated
- 44% Left UVD
- RBN post-LLHFHS
- Degradation from 98% to 64% correct in Horizontal

Self-Directed VRT Adaptation
Habituation
Case Study 2

Hx:
46 y.o. Female
Single attack of Vertigo, Nausea, Emesis
Also diplopia & imbalance
Several days 9 months ago
MRI Unremarkable
Migraine

Sx:
Positional vertigo & nausea
Imbalance
No Auditory Sx
Case Study 7

**Hx:**
46 y.o. Female
Single attack of Vertigo, Nausea, Emesis
Also diplopia & imbalance
Several days
9 months ago
MRI Unremarkable
Migraine

**Sx:**
Positional vertigo & nausea
Imbalance
No Auditory Sx

**Differential Diagnosis**
- Vestibular neuritis
- BPPV
- CNS Involvement
Case Study 7

Hx:
46 y.o. Female
Single attack of Vertigo, Nausea, Emesis
Also diplopia & imbalance
Several days
9 months ago
MRI Unremarkable
Migraine

Sx:
Positional vertigo & nausea
Imbalance
No Auditory Sx

Dx:
VOR
VNG
VSR
SOP
VCR
VEMP

Abnormal Oculomotors
Downbeating Gaze
Nystagmus
Ageotropic Positional Nystagmus
Failed Fixation Suppression

Fall on 5 & 6 (Surface; CNS)

Reduced amplitude on Left

Central Findings
Cerebellar Stroke
Chiari Malformation
Paraneoplastic Cerebellar Degeneration Syndrome
Migraine

Refer back to PCP for repeat MRI
Paraneoplastic Cerebellar Degeneration

Abnormal immune system response to an underlying malignant tumor – Purkinje cells attacked

Key Considerations

- CNS symptoms
- Associated with breast or ovarian cancers
  - May be undetected
- Dizziness, vertigo, ataxia, dysphagia, blurred vision

Mehdi & Ko, 2009