Early Detection of Vestibular Dysfunction

Objectives

1. The learner will be able to identify anatomy and physiology of peripheral and central vestibular systems.
2. The learner will be able to identify common presentations of peripheral vs. central vestibular disorders.
3. The learner will be able to list contraindications for positional testing for peripheral vestibular disorders.
4. The learner will be able to identify appropriate assessment techniques for central vs peripheral impairments.
5. The learner will be able to identify appropriate treatments for a variety of disorders/impairments related to those with traumatic brain injury.
6. The learner will be able to apply knowledge to demonstrate understanding of material using multiple cases of patients with vestibular dysfunction.
Vestibular System Function

- Linear and angular accelerometer
- Rotational movements of the head
- Linear movements of the head
- Head position in space

- With this information...
  - Gaze Stability
  - Balance and Postural Stability
  - Orientation in Space

Vestibular System Dysfunction

- Oscillopsia
- Dysequilibrium
- Abnormal Sense of Movement/Orientation
- Decreased Visual Acuity with head movements and mobility
- Ataxia
- Imbalance

Anatomy: Peripheral Vestibular System

- Semicircular canals
  - Anterior
  - Posterior
  - Lateral
- Otoliths
  - utricle
  - saccule
- Vestibular ganglion
- Vestibular nerve
Epidemiology: Traumatic Brain Injury and Benign Paroxysmal Positional Vertigo

- Twenty out of 150 (13.3%) of patients with traumatic brain injury complained of positional vertigo and 10 of those patients had confirmed benign paroxysmal positional vertigo (Motin 2005)
- Of 247 patients with benign paroxysmal positional vertigo, twenty-one (8.5%) had a history of recent head trauma (Gordon 2004)
- BPPV caused by trauma accounts for 9%-20% of all BPPV cases. The most common mechanism of injury included MVA, falls and blows to the head. (Lippincott Williams/Wilkins 2011)

Trauma Induced Dizziness

- Inner Ear
  - BPPV (cupulo- or canal- lithiasis)
  - Post Traumatic Endolymphatic hydrops
  - Perilymphatic Fistula
  - Labyrinth concussion
- Fractures:
  - Temporal Bone (vestibular nerve)
    - Petrous Bone
  - Longitudinal Temporal/Parietal Blows
  - Frontal/Occipital Blows
- Blast Induced TBI
- Posttraumatic Vertigo
- Persistent Headaches: Migraine Syndrome

Anatomy: Peripheral Vestibular System

- Posterior Canal
  - 20° below horizontal
- Lateral Canal
  - 20-30° naso-occipital angle
- Anterior Canal
  - 70° from horizontal
Vestibular Examination

Subjective history can lead you...

- Acute Dizziness <3 days.... Vestibular neuritis
- Chronic Dizziness, induced by head movements and worsens in the dark/uneven surfaces..... Unilateral/Bilateral Vestibular Loss
- Sudden positional Dizziness..... BPPV
- Spontaneous Dizziness with Ear Fullness, Ringing in the ears...... Meniere's Disease
- Lightheaded when standing up..... Orthostatic Hypotension

Differential Diagnosis

Peripheral Signs and Symptoms
- Dizziness with positional changes
- Possible hearing loss
- Possible tinnitus
- May or may not have balance dysfunction
- Symptoms evoked by head movements
- Possible oscillosisna
- Acutely, nystagmus will be seen
- Nystagmus may or may not be present chronically
- Direction Fixed

Central Signs and Symptoms
- Possible downbeating nystagmus
- Cerebellar signs and symptoms
- Mild to severe headaches
- Associated head/cervical injuries
- Changes in pupillary size
- Positive upper motor neuron signs
- Balance and gait deficits are common
- Direction changing

Tilson, 2013
Oculomotor Exam

- Spontaneous Nystagmus
- Gaze Holding Nystagmus
- Eye Movement Range of Motion
- Vergence
- Smooth Pursuits
- Saccades
- VOR Cancellation

Examination: Contraindications and Precautions for Positional Testing

- Contraindications
  - Retinal detachment
- Precautions*
  - Vertebro-basilar insufficiency
  - Neck instability or recent neck trauma
  - History of Neck Surgery
  - Cervical myelopathy or radiculopathy
  - Carotid sinus syncope
  - Vascular dissection syndromes
  - Severe Rheumatoid Arthritis
  - Cranietomy

Examination: Dix-Hallpike

- Start with person in long sitting on the table so that when they lay back, their head will be off the table
- Turn the head 45 degrees toward the side least suspected as having displaced otoconia
- Secure the person’s head and torso and lay them back placing their neck in 20-30 degrees of extension
- Have person keep his/her eyes open so that you can observe for nystagmus.
- Positive test indicated by reports of vertigo and observation of torsional upbeat nystagmus
**Examination: Roll Test**

- With the person in supine, head flexed 20 degrees and facing forward, turn the head to one side and observe for nystagmus and corresponding symptoms.
- Hold the position for up to 1 minute to observe for symptoms.
- May perform to both sides.
- Categorize the nystagmus as apogeotropic vs geotropic to assist in deciding which is the affected side as you are stimulating both canals with this test.

**Lateral Canal Diagnosis**

- Geotropic - side of greatest intensity of nystagmus is the side involved
  - “towards ground”
- Apogeotropic - side of least intensity of nystagmus is the side involved
  - “Away from ground”

**Benign Paroxysmal Positional Vertigo Treatment in Traumatic Brain Injury**

- May require more sessions
  - 67% of patients with benign paroxysmal positional vertigo following traumatic brain injury required repeat PT sessions vs 14% of patients with idiopathic benign paroxysmal positional vertigo.
  - 57% of patients with benign paroxysmal positional vertigo following traumatic brain injury had recurrent attacks vs 19% of patients with idiopathic benign paroxysmal positional vertigo.

Gordon, 2004
Canalithiasis vs Cupulolithiasis: Test Results

<table>
<thead>
<tr>
<th>Canal</th>
<th>Canalithiasis</th>
<th>Cupulolithiasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>• Nystagmus- torsional to the involved side, upbeating</td>
<td></td>
</tr>
<tr>
<td>Dix-Hallpike</td>
<td>• Symptoms fatigue in &lt;60s</td>
<td>• Immediate onset of symptoms and nystagmus</td>
</tr>
<tr>
<td>Test Results</td>
<td>• Slight delay (5-30s) for onset of symptoms</td>
<td>• Will not fatigue with time</td>
</tr>
<tr>
<td>Horizontal</td>
<td>• Geotrophic nystagmus</td>
<td>• Ageotrophic nystagmus</td>
</tr>
<tr>
<td>Roll Test</td>
<td>• Symptoms fatigue in &lt;60s</td>
<td>• Symptoms will not fatigue</td>
</tr>
<tr>
<td>Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>• Nystagmus- torsional to the involved side, downbeating</td>
<td></td>
</tr>
<tr>
<td>Dix-Hallpike</td>
<td>• Slight delay (5-30s) for onset of symptoms</td>
<td>• Immediate onset of symptoms and nystagmus</td>
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Diagnosis and Treatment of Benign Paroxysmal Positional Vertigo: Special Considerations

• Excitatory vs Inhibitory direction of movement of particles
  – Posterior and anterior canal, flow of endolymph away from ampulla is *excitatory*
  – Horizontal canal, flow of endolymph away from ampulla is *inhibitory*

• Anterior and posterior canal
  – Flow of endolymph away from ampulla *excites* cranial nerve 7
  – Flow of endolymph towards ampulla *inhibits* cranial nerve 7

• Lateral canal
  – Flow of endolymph towards ampulla *excites* cranial nerve 7
  – Flow of endolymph away from ampulla *inhibits* cranial nerve 7

Diagnosis and Treatment of Benign Paroxysmal Positional Vertigo: Special Considerations

• Canal orientation
• Speed vs positioning
• How to eval and treat individuals who will not tolerate Dix-Hallpike or Roll Test
  – Use of bed positioning and wedges to achieve gravitational pull for each canal

Helminski, 2014

Tilson, 2013
Alternative Testing Positions

- Picture

Treatment: Canalith Repositioning for Posterior Canal Benign Paroxysmal Positional Vertigo

- For Canalithiasis
  - After completing the Dix-Hallpike maneuver, the patient is supine with the head turned 45 degrees to the involved ear and is in 20-30 degrees of extension
  - Hold this position 2x longer than length of observed symptoms
  - Maintain neck extension and rotate head 45 degrees to the opposite side. Hold this position 2x longer than duration of symptoms
  - Have the person roll onto their side (opposite of affected ear) and turn head down 90 degrees toward the ground, while keeping the chin tucked
  - Keep the head in this position and help the person slowly sit up at the edge of the table. Bring head into neutral once the person is in the full sitting position

Treatment: Canalith Repositioning for Posterior Canal Benign Paroxysmal Positional Vertigo

- For cupulolithiasis
  - Liberatory Maneuver/Semont Maneuver
    - Sidelying on involved ear
    - 180° turn to sidelying on uninvolved ear
    - **Change in position should take ~1.3 seconds
  - Goal is to convert to canalithiasis
    - Complete previously described posterior canal repositioning maneuver

Helminski, 2010
Treatment: Horizontal Canal BBQ Roll (Lempert Maneuver)

• Person starts in supine with the neck flexed 30 degrees (end of Roll Test)
• Slowly roll the head toward the affected ear (maintain neck flexion)
• Roll the head back to neutral and hold 2x longer than duration of symptoms
• Roll the head to the opposite side (involved ear up) and hold 2x longer than duration of symptoms
• Have the person roll onto their stomach propped on elbows and rotate the head until the person is face down with neck flexion maintained and hold 2x longer than duration of symptoms
• Help the person transition into sitting

Treatment of Benign Paroxysmal Positional Vertigo: Was I Successful?

• Re-test 24 hours after treatment
  – Reduces likelihood of false negative
• Treatment is more effective with repetition in same session
• Critical analysis of nystagmus during repositioning
  – Reversal of nystagmus during maneuver
  – Rotational vs horizontal

Importance of Early Treatment

• Generally good results with Canalith Repositioning Maneuver
• Allows for rehabilitation to focus on balance deficits that may linger after BPPV and/or vestibular dysfunction is managed
Outcome Measures

- Modified Clinical Test of Sensory Integration and Balance (CTSIB)
  - Good test-retest reliability in pediatric mild TBI
- Dynamic Gait Index (DGI)
  - Cut off of 19= 28% probability of falling in brain injured individuals (Medley 2006)
- Dizziness Handicap Inventory (DHI)
  - 5 item version demonstrates ability to predict likelihood of BPPV (Lopez-Escamez, 2003)
- Four Square Step Test (FSST)
  - >12 seconds= fall risk (Whitney, 2007)

Patient and Family Education App: aVOR

Case Example: DB

- History of Present Illness: 55 year old female admitted status post assault with sledge hammer
- Imaging: bifrontal SAH, multiple facial fractures
- Initial PT Evaluation:
  - N/V with all mobility and movement
  - Moderate Assistance for balance and gait
  - Initial Berg Balance 30/56
  - Initial gait speed: .69m/s
Case Example: DB

- **Vestibular Assessment**
  - (+) Dix-Hallpike on the left
    - Performed Canalith repositioning maneuver for left ear canalithiasis x2 with reduction in symptoms
    - Re-tested next day: nystagmus in 2nd position
  - (+) Dix-Hallpike on the Right
    - Performed Canalith repositioning maneuver for right ear canalithiasis x2 with reduction in symptoms
    - Initiated VORx1 in seated position
- **Functional Improvements at D/C**
  - Berg Balance improved 46/56
  - Gait speed 1.1 m/s

Case Example: MS

- **History Present Illness:** 81 year old female admitted status post mechanical fall
- **Imaging:** Subdural hematoma
- **Initial PT Evaluation:**
  - Minimal Assistance for all functional mobility
  - Multiple falls in the past year
  - Pt reports difficulty sleeping, double vision, headache with reading and sleeps with 5 pillows at night

Case Example: MS

- **Vestibular Assessment**
  - (+) Dix-Hallpike on the left
    - Performed Canalith repositioning maneuver for left ear canalithiasis x2 with reduction in symptoms
      - Completed 3 more times
  - (-) Dix Hallpike on the right
- **Functional Improvements at D/C**
  - Improved Sleep
  - Able to read a book without a headache
  - Can sleep with 1 pillow
Case Example: DB

- **History Present Illness:** 20 year old male admitted status post helmeted motor cycle accident
- **Imaging:** Right SDH, bilateral intraparenchymal hemorrhage, left temporal bone fracture, skull base fracture
- **Initial PT Evaluation:**
  - Nausea and vomiting with all mobility and movement
  - Minimal Assistance with functional mobility
  - Headache with movement

Vestibular Assessment

- (+) Dix-Hallpike on the left
- Performed Canalith repositioning maneuver for left ear canalithiasis x2 with reduction in symptoms
- Initiated VORx1 TE in seated position

Functional Improvements at Discharge

- Supervision for functional mobility
- Sudden discharge home – unable to test right ear

Case Example: CR

- **History of Present Illness:** 70 year old female sustaining a fall at home with trauma to the head
- **Imaging:** CT Scan demonstrated panhemispheric subdural hematoma (SDH) and 6mm midline shift
- **Initial PT Evaluation:**
  - Fall history
  - Normal smooth pursuits, saccades, delayed VOR
  - Gait speed .2m/s
Case Example: CR

- **Vestibular Assessment:**
  - Right Dix Hallpike (+)
    - Canalith repositioning maneuver performed twice with symptom resolution and no nystagmus after second maneuver
  - Bilateral Dix Hallpike and Roll tests (-) the next day

- **Functional Improvements:**
  - Able to get out of bed with supervision only
  - Gait speed .54m/s

Case Example: MM

- **History of Present Illness:** 38 year old female presenting after fall out of a moving bus

- **Imaging:** Right temporal non-displaced calvarial fracture extension into right temporal bone, left subarachnoid and intraparenchymal hemorrhages, left temporal hemorrhagic contusion and nasal fractures, right lateral malleolus fracture

Case Example: MM

- **Initial Evaluation:**
  - Unable to formally test balance secondary to non-weight bearing right lower extremity
  - Smooth pursuits, saccades normal, R beating nystagmus with R horizontal end gaze
  - Dizziness getting in and out of bed and with standing up
  - Having trouble reading
  - Orthostatic

- **Vestibular Examination:**
  - Right Dix-Hallpike (+)
    - Canalith repositioning maneuver completed 4x with improvement of nystagmus and patient reported dizziness
    - Recommended to remain upright
  - Retest next day (-)
References

- Helminski J, Holmberg J, Rabbitt R. Translating the biomechanics of benign paroxysmal positional vertigo to the differential diagnosis and treatment. APTA Combined Sections Meeting. 2014 Las Vegas NV.
- Tilson J. Vestibular Disorders. Physical Therapy Neurologic Education Consortium. 2013 Los Angeles CA