An Introduction to Vestibular Rehabilitation

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Objectives:

• Describe Vestibular System Function, Anatomy and physiology
• Identify evaluation components
• Identify common causes of dizziness
• Demonstrate Vestibular treatment and exercises
  • BPPV testing and treatment.
• Considerations for Concussion
Anatomy

Semicircular canals

Tubular ducts containing endolymph

Utricle

Saccule

Cochlea

Ampullae

Figure 2: The Vestibular System - semicircular canals and otolith organs
Semicircular Canals

• Filled with endolymph with a density slightly greater than water and moves freely within each canal in response to the direction of head rotation. (Schubert MC 2004)
• Act in pairs.
• Each semicircular canal is sensitive to motion in the plane of that canal.
Semicircular Canals

Detect changes in angular acceleration of the head in three dimensional planes.
A) Lateral (Horizontal) Canal
B) Anterior Canal
C) Posterior Canal
Semicircular Canal

(a) Semicircular canal

(b) Ampulla
Cupula
Kinocilium
Endolymph
Stereocilia
Support cells
Hair cell
Afferents of the vestibular nerve

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Utricle and Saccule
• Detects changes in linear acceleration

Detects head position relative to gravitational forces
Vestibular Processing

Primary Processor: Cerebellum

Interpretation Process: Vestibular Nuclear Complex

OUTPUT: Oculomotor VESTIBULAR OCULAR REFLEX (VOR)

OUTPUT: Postural Control VESTIBULAR SPINAL REFLEX (VSR)

Input: Vision Vestibular Somatosensory

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Vestibular

Vision

Somatosensory

BALANCE
Neuroanatomy

- Vestibular nerve transmits afferent signals from the labyrinths along its course through the internal auditory canal.
- Superior vestibular nerve innervates the lateral and anterior SCC as well as the utricle.
- The inferior vestibular nerve innervates the posterior SCC and the saccule. (Naito Y 1995)
Vestibular ocular reflex
Vestibulo-ocular reflex

- As the head is rotated to the left, the left vestibular nerve is stimulated.
- The right vestibular nerve is inhibited.
- This results in an excitation of the right abducens nerve fibers innervating the right lateral rectus muscle and the left oculomotor nerve fibers innervating the left medial rectus muscle.
Vestibular spinal reflex
Medial Vestibulo-spinal tract
Medial Vestibulospinal tract mediates head righting in response to semicircular canal input, and ongoing postural changes.
Lateral Vestibulospinal Tract
Lateral vestibulospinal tract receives majority of its input from otoliths and the cerebellum. Generates antigravity postural control, or protective extension in the lower extremities in response to head position changes.
Nystagmus

• The vestibular system is a balanced system.
• Effects of activity from one vestibular organ are balanced by effects from the other.
• A vestibular imbalance will cause overstimulation on one side and slow tonic deviation of the eyes away from that side.
• The tonic nature of the movement induced by the vestibular system causes this slow movement followed by a rapid or saccadic return to be repeated over and over.
• **Nystagmus will always beat to the side of increased neural activity**
• Named relative to the fast phase relative to the patient.
Peripheral Causes of Dizziness

• Benign Paroxysmal Positional Vertigo
• Vestibular neuritis/labyrinthitis
• Meniere’s Disease
• Ototoxicity (chemotherapy/IV antibiotics)
• Acoustic Neuroma
Central Causes of Dizziness

- Concussion
- Cerebrovascular disorders
- Migraine
- Multiple sclerosis
- Epilepsy
- Craniocervical junction disorders
- Neoplastic: primary, metastatic or paraneoplastic
- Inherited ataxias
- Psychogenic
- Neurodegenerative disorders: parkinsonism, normal pressure hydrocephalus
Concussion

• 43 working definitions of concussion. Only one is evidence based.

43rd Working Definition of Concussion
Concussion is:
• A change in brain function following a force to the head, which may be accompanied by temporary loss of consciousness, but is identified in awake individuals, with measures of neurologic and cognitive dysfunction.
Risk Factors for More Complicated Recovery

• Age
  • Younger athletes had more complicated recovery

• Migraine History and Symptoms
  • Prior history of migraine or migraine symptoms post concussion

• History of Learning Disability

• Repetitive Concussion

• Gender
  • Females had longer recovery
Dizziness following Concussion

• **Prevalence**
  Reported to occur in 23% to 81% of cases in first days after injury (Alsalaheen et al 2010)

• **55% of concussed athletes** report dizziness as an early symptom (Lovell 2004)

• **32% of 141 patients with mild TBI** report dizziness after 5 years.
Aural Symptoms

• Ringing, pressure, fullness or hearing changes
• Patients with mixed central and peripheral vestibular dysfunction recover more slowly and incompletely. (Brown 2006)
• Could also have labyrinthine concussion.
• Warrants referral to Otology or Neuro-otology
Postural Control

• 43% of athletes report balance dysfunction following sports related concussion. (Lowell 2004)
• May resolve more quickly than other symptoms following concussion. (Catena 2011)
Space and Motion Sensitivity

• Problems
  • Walking in supermarket or crowded places?
  • Heights?
  • Wide open spaces?

• Clinical Assessments:
  • VOR Cancellation
  • SOT (conditions 3,6)
  • DHI Items 4 and 12
  • Increased dizziness with surround moving
Vestibular Evaluation
Subjective History

• Specific Questions
  • Aural Symptoms
    • Hearing loss, fullness
  • Positioning Symptoms
    • BPPV
  • Motion Sensitivity
    • Head
    • Visual
    • Balance
  • Headaches-migraines?
    • Photophobia and phonophobia
    • Nausea/vomiting
• History of Concussion or ever hit their head?
Characterizations of Symptoms

• Temporal course:
  • paroxysmal lasting seconds, minutes, hours, days, weeks
  • OR continuous with exacerbation lasting seconds minutes, hours, days, weeks

• Type of dizziness: vertigo, imbalance, lightheadedness, falls, disorientation
  • Nausea & vomiting, headaches, any of the “Ds” = diplopia, dysphagia, dysarthria, dysmetria, asymmetric muscle weakness

• Onset of symptoms - spontaneous OR head motion or visual motion provoked

• Hearing - involvement in the auditory system e.g. tinnitus, aural fullness, progressive or fluctuant hearing loss
Clinical Exam:

- Oculomotor exam in room light
  - Ocular motility (ROM)
  - Convergence
  - Nystagmus
  - Saccades
  - Smooth Pursuit
  - VOR
- Head Thrust Test
- Dynamic Visual Acuity
Clinical Exam

• Oculomotor exam with vision blocked (frenzels or infrared)
• Spontaneous and gaze evoked nystagmus
• Post head shaking nystagmus
• BPPV
  • Dix-Hallpike
• Balance Exam:
  • Romberg
    • EO, EC, Foam EO, Foam EC
    • Sharpened Romberg EO, EC
  • Ambulation
  • Ambulation with Head Rotation
• Dynamic Gait Index/Functional Gait Assessment
• BESS Test for concussion
SPONTANEOUS NYSTAGMUS
GAZE HOLDING NYSTAGMUS
RAPID HEAD THRUST
Balance Testing
POSTUROGRAPHY

• Sensory Organization Test
Functional Gait Assessment

- Modification of the Dynamic Gait Index developed to improve reliability and decrease the ceiling effect.
- Added gait with narrow base of support, ambulating backwards, and gait with eyes closed.
Ambulation with Head Turns
TREATMENT
Principles of Treatment

• Habituation
• Adaptation – retinal slip
• Substitution
Habituation

• Asymmetry in labyrinth function results in “sensory mismatch”.
• Repeated exposure to a provocative stimulus will result in a reduction in the pathological response to that treatment.
Adaptation

• Refers to long term changes that occur in response of the vestibular system to input.

• In acute injury the gain of the VOR is reduced (eye movement velocity is less than head movement velocity).
  • Resulting in retinal slip (blurred vision)
  • Retinal slip causes an error signal resulting in a change in the gain of the VOR.
Substitution

• Compensation for lack of vestibular function through use of visual and somatosensory systems.
Gaze Stability/VOR

• Have the patient focus on one letter and turn their head as fast as they can while keeping letter in focus and still.

• Progression:
  • Duration
  • Velocity
  • Position
  • Target distance
  • Background
  • Frequency
Vestibular-Ocular Reflex (VOR)
Sensory Organization and Postural Control

• Static and Dynamic Balance training:
  • Decreasing base of support
  • Perturbing visual and somatosensory cues
  • Head rotation
  • Changing direction
  • Stair climbing
  • Dual task
    • Cognitive
    • Manual

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Recovery Depends On

• Central verses Peripheral
• Unilateral verses Bilateral
• Age
• Time from onset
• Comorbidities
• Use of medications (meclizine, antivert)
Vestibular Treatment

• Systematic monitoring **throughout session** of symptoms
• Incorporate ocular motor training when needed and/or make referrals
• Proceed at a slower rate with central injuries than with peripheral injuries ("less is more")
LAB

• Practice VOR
• Practice Sharpened Romberg with Eyes Closed
Benign Paroxysmal Positional Vertigo (BPPV)
BPPV

- Most common vestibular disorder in adults (Bhattacharyya, Baugh et al. 2008)
- Most common cause of vertigo resulting from head trauma (Fife and Giza 2013)
  - “BPPV should always be considered in patients with head trauma with complaints of positional vertigo.” (Fife and Giza 2013)
- Recurrence rates similar to idiopathic BPPV Liu 2012:
  - May take more maneuvers to achieve success
  - More likely to be bilateral occurring in 25% vs 2% in idiopathic
  - 35% of patients with post-traumatic bppv were cured after one maneuver vs. 85% in idiopathic bppv.
Benign Paroxysmal Positioning Vertigo (BPPV)

• Classic symptom:
  • Brief (typically <1 minute) episodes of vertigo associated with changes in head position relative to gravity
    • Lying down-rising from horizontal orientation
    • Rolling over in bed
    • Bending over
    • Looking up
Fig. 4: Left inner ear. Depiction of canalithiasis of the posterior canal and cupulolithiasis of the lateral canal. Photo: Christine Kenney

(Parnes, Agrawal et al. 2003)
DIX-HALLPIKE TEST

Canalithiasis

A Head upright-sitting to Hallpike-Dix position

Posterior SCC
Dix-Hallpike Test

• 45 degrees cervical rotation
• Sit to supine with 20 degrees cervical extension
• Look for nystagmus and symptoms of vertigo
  • Latency
  • Direction
  • Duration
  • Fatigues
Left Dix-Hallpike Test
## Clinical Exam

<table>
<thead>
<tr>
<th>Canal</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>Up &amp; Right Torsion</td>
<td>Up &amp; Left Torsion</td>
</tr>
<tr>
<td>Anterior</td>
<td>Down &amp; Right Torsion</td>
<td>Down &amp; Left Torsion</td>
</tr>
<tr>
<td>Horizontal Cupulolithiasis</td>
<td>Left ageotropic (to the sky)</td>
<td>Right ageotropic</td>
</tr>
<tr>
<td>Canalithiasis</td>
<td>Right geotropic (to the floor)</td>
<td>Left geotropic</td>
</tr>
</tbody>
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Left Posterior Canalithiasis Nystagmus
Treatment

- Epley or Canal repositioning Maneuver
  - Each position is held for 30 sec-2 min
  - Designed to treat canalithiasis
- Semont Maneuver
  - Designed to treat cupulolithiasis
References: