VESTIBULAR SCREENING

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Objectives

1. Review the anatomy and physiology of the vestibular system
2. Understand the pathophysiology of common vestibular disorders
3. Demonstrate an oculomotor exam and differentiate peripheral vs central involvement
4. Perform the canalith repositioning for treatment of BPPV
Vestibular System: Components

- Peripheral System
  - Motion Sensors

- Central System
  - Processing system

- Output System
  - Ocular muscles and postural muscles
VESTIBULAR NUCLEI
(Primary Processor)

CEREBELLUM
(Adaptive Processor)

VESTIBULAR
NUCLEI
(Primary Processor)

CEREBELLUM
(Adaptive Processor)

MOTOR NEURONS
TO EYE MUSCLES
AND POSTURAL MUSCLES
Peripheral System

- **EXTERNAL EAR**
  - Auricle

- **MIDDLE EAR**
  - Auditory ossicles
  - Semicircular canals
  - Tympanic membrane
  - Oval window
  - Round window

- **INNER EAR**
  - Petrous part of temporal bone
  - Facial nerve (VII)
  - Vestibulocochlear nerve (VIII)
  - Bony labyrinth of inner ear
  - Vestibule
  - Auditory tube
  - Cochlea
  - To pharynx
Peripheral System

- Otolith organs
  - Utricle
  - Saccule

- Semicircular canals
  - Anterior
  - Posterior
  - Horizontal
Otolith Organs

- **Structure:**
  - Hair cells
  - Gelatinous layer
  - Otoconia

- Detect acceleration/deceleration and changes in gravity
  - Saccule: vertical plane
  - Utricle: horizontal plane

**MEDIANTE THE VESTIBULO-SPINAL REFLEX**
Semicircular Canals

structure:
- Hair cells
- Cupula
- Endolymph

Detect angular velocity
- Anterior, Posterior, and Horizontal canals are at 90° to each other

Mediate the Vestibulo-Ocular Reflex
Semicircular Canals
Semicircular Canals

- Cupula
- INHIBITION
- EXCITATION
- Stereocilia
- Kinocilia
- Hair cell
- Vestibular afferents
Semicircular Canals: Functional Pairs
UNDERLYING CONCEPTS: NEURONAL FIRING RATE

- Peripheral vestibular system has a resting neuronal firing rate of approx 70-100 spikes/sec

- Left/Right systems act in a push/pull fashion
  - Side you turn towards - excitation
  - Side you turn away from - inhibition
Neuronal Firing Rate
Output System: Reflexes

- Vestibular Ocular Reflex (VOR)
  - Semicircular Canals
- Vestibular Spinal Reflex (VSR)
  - Otoliths
- Ocular-tilt Reflex (OTR)
  - Utricle
Output System: Reflexes

- **Purpose**
  - VOR and VSR work in conjunction with other motor systems to control gaze stability and whole-body equilibrium during head movements, posture, and walking.

- **VSR:** righting and equilibrium reactions
  - Postural stability

- **VOR:** eye adjustments to keep the visual world in focus
  - Gaze (visual) stability
Vestibular Ocular Reflex (VOR)

- Produces compensatory eye movements in response to head movement
  - Gain of the system is -1 (1:1 ratio)
  - Equal movement of eyes opposite to head
- Synonymous with gaze stabilization
  - Keeps things visually stable
- If deficient:
  - Impaired visual acuity
    - Particularly in response to head movements
  - Impact on balance
Central System

- Includes the vestibular nuclei

Central Processing System
- Located in the brainstem and cerebellum
  - Medulla / Pons
    - Superior Vestibular Nucleus
    - Inferior Vestibular Nucleus
    - Medial Vestibular Nucleus
    - Lateral Vestibular Nucleus
  - Cerebellum
Vestibular System: Components

- Peripheral System
  - Motion Sensors: semicircular canals, otolith organs (CN VIII)

- Central System
  - Processing system: vestibular nuclei, cerebellum (et al)

- Output System
  - Ocular muscles (VOR)
  - Spinal cord/postural muscles (VSR)
Signs/Symptoms of Vestibular Disorders

- Vertigo
- Dizziness
- Imbalance
- Nystagmus
- Oscillopsia
- Rocking
- Motion intolerance
- Nausea/vomiting
- Tinnitus/hearing loss
- Anxiety
Eye Movements and Special Tests

- Convergence/divergence
- Saccades
  - Center/right, center/left, right/left, up/down
- Smooth pursuit
- Extraocular ROM
  - CN III, IV, VI
- Gaze with and without visual fixation
  - Spontaneous, lateral gaze, superior/inferior gaze
- Head-shaking nystagmus test
- Head Impulse Test
- Dynamic Visual Acuity
Convergence/Divergence
Saccades
Smooth Pursuit

http://www.youtube.com/watch?v=gqCgzSSwPLk
Nystagmus

- Nystagmus has a quick phase and slow phase
  - Named for quick phase in relation to the patient
- If a peripheral lesion:
  - Unidirectional horizontal nystagmus
  - Quick phase beats towards the healthy ear
  - Nystagmus beats the same direction with lateral gaze
- If a central lesion:
  - Nystagmus changes direction; “direction changing nystagmus”
  - Horizontal and vertical
- If nystagmus present with fixation
  - Acute peripheral lesion (unidirectional nystagmus)
    \[ \text{OR} \]
  - Central lesion (direction changing nystagmus)
Nystagmus

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fixation in light
Central Lesions

- Saccades: abnormal (hypo- or hypermetric)
- Smooth pursuit: abnormal (over- or undershooting)
- Nystagmus: direction changing and/or vertical
- Impaired VOR bilaterally
- Significant balance deficits, perceptual deficits, visual deficits
- May have nausea/vomiting with position changes - acute
- Other neurological deficits may be present- impaired motor control, hypertonicity, decreased coordination, cranial nerves
Acute Peripheral Lesions

- Saccades: normal (speed and accuracy)
- Smooth pursuit: normal
- Nystagmus: unidirectional nystagmus with and without fixation
- Impaired VOR unilaterally
- Likely will have significant balance deficits
- May have nausea/vomiting with position changes
Benign Paroxysmal Positional Vertigo (BPPV)

- Pathophysiology: displacement of otoconia (calcium-carbonate crystals) into the semicircular canal(s)
- Symptoms: brief episodes of vertigo (less than 60 sec) triggered by head position changes; sit to supine, supine to sit, rolling in bed, bending over, cervical extension when upright; often a random initial onset
- Medical Management: wait to resolve spontaneously; antivert/meclizine often prescribed (not recommended); referral to PT
- Vestibular Rehab: Exercises to reposition the otoconia; “canalith repositioning”
BPPV: Types

• **Canalithiasis:**
  - Otoconia floating freely in endolymph
  - More common type
  - Treatment: Canalith repositioning
    AKA: Epley maneuver

• **Cupulolithiasis:**
  - Otoconia adhered to cupula
  - Treatment: Semont
BPPV: Diagnosis

- Dix-Hallpike:
  - Head rotated 45°
  - Patient placed in supine with head extended 20-30°
  - Observe for nystagmus and ask pt if experiencing symptoms
- Canalithiasis
  - Nystagmus: latency, lasts 5-45/60 sec
- Cupulolithiasis
  - Nystagmus: immediate, lasts >45-60 sec
BPPV: Diagnosis

• Roll Test
BPPV: Diagnosis

- Posterior canal: upbeatng and rotational nystagmus
  - Involved ~70-90%
- Horizontal canal: horizontal nystagmus
  - Involved ~1-20%
- Anterior canal: downbeating and rotational nystagmus
  - Involved ~0.1-5%

- Canalithiasis: nystagmus lasts <45-60 sec; latency
  - For HSCC nystagmus will be geotropic
- Cupulolithiasis: nystagmus lasts >45-60 sec; immediate
  - For HSCC nystagmus will be ageotropic
BPPV: Dix-Hallpike
BPPV: Canalith Repositioning (Modified Epley)
BPPV: Canalith Repositioning

http://www.youtube.com/watch?v=Ew7Tt5mJl
BPPV: Semont
BPPV: Treatment for HSCC
BPPV: Post-treatment

• Positional precautions post-treatment such as avoiding spine, bending, and cervical extension are not necessary
  
  
  
  
BPPV

- Some patients in the geriatric population may not c/o vertigo
- Oghalai JS et al (2000) in *Otolaryngology- Head and Neck Surgery* found 9% of patients that presented to a geriatric clinic tested positive for BPPV
- *These patients were not at the doctors office because of dizziness, vertigo, or imbalance*
Lab

- Convergence/divergence
- Smooth pursuit
- Saccades
- Extraocular ROM
- Gaze with fixation
- BPPV diagnosis and treatment
References