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Vestibular Rehabilitation: Differential Diagnosis

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Learning Outcomes

- Differentiate between central and peripheral diagnoses and origin of symptoms
- Identify key subjective findings to assist in choosing appropriate assessment measures
- Apply differential diagnosis concepts to subjective case study reports
Peripheral Vestibular System

- Located in inner ear
- Static and dynamic sensory inputs to provide position sense in space
- Linear and angular head velocity

(Herdman & Clendaniel, 2014; Alyahya et al., 2016)

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Peripheral Vestibular System

- Utricle and Saccule sense horizontal acceleration
  - Utricle senses linear, saccule senses vertical acceleration
  - Otoconia – calcium carbonate crystals attached to the floor of the utricle and medial wall of the saccule
  - Otolithic membrane or macula has hair cells embedded
  - Semicircular canals originate from the utricle
Peripheral Vestibular System

- Semicircular canals
  - 3 bony canals located within bony labyrinth
  - Positioned 90 degrees from one another
  - Endolymphatic fluid fills canals
  - Ampulla: enlarged space at the end of each canal that contains a cupula
  - Cupula: connective tissue located across the canal within the ampulla
    - Contains sensory hair cells
    - Senses movement of endolymph

Peripheral Vestibular System

- Semicircular canals are paired to sense motion in a plane
  - Anterior and opposite posterior canals
  - Horizontal canals
    - aVOR app for visualization (Apple devices)

- Constant, spontaneous firing of vestibular nerve (90 pulses/sec)

- Ewald’s second law: ability to excite the nerve is stronger than the ability to inhibit the nerve (vestibular hypofunction)
Reflexes

- Vestibulo-Ocular Reflex
  - Sensory: semicircular canals
  - Motor: ocular adjustments for gaze stability

- Vestibulocollic Reflex
  - Sensory: vestibular inputs
  - Motor: cervical muscle contraction for head stability

- Vestibulospinal Reflex
  - Sensory: vestibular inputs
  - Motor: postural adjustments for body and head stability

(Herdman & Clendaniel, 2014)

Central Vestibular System

- Vestibular nuclei in brainstem
  - Lateral nucleus: posture through vestibulospinal reflex
  - Medial and Superior nuclei: coordinate head, neck, and eye movements
  - Inferior nucleus: integrates information from sensory systems and cerebellum
Central Vestibular System

- Cerebellum
  - Modulation of oculomotor reflex
    - VOR vestibular input causes slow phase, cerebellum causes reset for fast phase
  - Vermis: narrow strip along the midline, controls balance and eye movement
  - Flocculonodular lobe or vestibulocerebellum: functions in balance and gait

Central Vestibular System

- Vascular supply
  Vertebral arteries (spine) → basilar artery → anterior inferior cerebellar artery (AICA) → Labyrinthine artery

  Labyrinthine artery splits:

  → anterior vestibular artery → anterior, horizontal SCC, utricle

  → common cochlear artery → posterior vestibular artery → posterior semicircular canal and saccule
Central Vestibular System

- Nerve Supply

CN VIII – vestibulocochlear nerve divides into:

- Superior portion: anterior and horizontal SCC and utricle
- Inferior portion: posterior SCC and saccule

Dizziness Diagnoses

Peripheral

- Benign paroxysmal positional vertigo or BPPV
- Vestibular hypofunction
  - Vestibular neuritis, labyrinthitis, Meniere’s disease, endolymphatic hydrops, acoustic neuroma
- Cervicogenic Dizziness

Central Vertigo

- Vestibular migraine, post-concussion syndrome, multiple sclerosis, TIA / CVA

Cardiovascular

- Orthostatic hypotension
- Postprandial hypotension
Benign Paroxysmal Positional Vertigo (BPPV)

- Otoconia are dislodged from utricle/saccule and move into semicircular canals
- Primary insidious onset 50-70% of cases, secondary due to head trauma including falls (7-17%), viral labyrinthitis (15%), Meniere’s disease (5%), migraine (<5%) (Parnes et al., 2003)
- 50% recurrence rate (Von Brevern et al., 2007)
- Anxiety is common
  - (Zapala, 2008; Parnes et al., 2003; Von Brevern et al., 2007; Bhattacharyya et al., 2008)

BPPV: Patient Presentation

- Age: 49-53 is average age of onset
- Onset: Woke up with dizziness
- Description:
  - Spinning, lightheadedness, feeling of being “off balance”
  - Patients >65, diabetic present with falls and imbalance
  - 50% experience imbalance between episodes of vertigo
- Associated symptoms: nausea, vomiting
- Triggers: positional changes, head movement
- Balance: declined, improving as patient learns to compensate
  (Bhattacharyya et al., 2008; Parnes et al., 2003)
BPPV: Patient Education

- **Anatomy**
  - Location of “crystals” on top of otolithic membrane, with hair cells to sense linear head movement
  - Location of semicircular canals – sense angular movement
  - Explain how crystals get into canals, and purpose of canalith repositioning maneuver
  - Treatment of Choice: Canalith Repositioning Technique
### Key Subjective Report for BPPV

- **Description:**

- **Hearing Loss:** Yes / No

- **History of falls?** Prior to onset / Since onset

- **Neck pain or headaches?** Prior to onset / Since onset

- **Cause:**

- **Treatment:**

- **Prognosis:**

### Vestibular Hypofunction: Vestibular Neuronitis & Labyrinthitis

- **Vestibular Neuronitis**
  - Viral infection of CN VIII – Vestibulocochlear nerve
  - Second most common cause of vertigo
  - May be preceded by upper respiratory or GI infection, perhaps up to 2 weeks

- **Vestibular Labyrinthitis**
  - Viral infection within bony labyrinth
  - Includes unilateral hearing loss

(Herdman & Clendaniel, 2014)
Vestibular Neuronitis & Labyrinthitis: Patient Presentation

- Age: 30-60 years, peak for women in 40's, men in 60's
- Onset: Any time day or night
- Symptoms: nausea, vomiting, constant spinning, nystagmus, unilateral hearing loss is possible
- Postural instability falling forward or to affected side
- Musculoskeletal: Neck pain: 27% at initial visit, 59% at 5 years
- Triggers: increased with movement, also present at rest

(Herdman & Clendaniel, 2014; Wilhelmsen & Kvale, 2014)

Vestibular Neuronitis & Labyrinthitis: Medical Management

- Early treatment: anti-inflammatory corticosteroids (Sealy, 2014)
- Vestibular suppressants - antivert, meclizine, valium
  - 3-5 days to minimize dizziness, nausea and vomiting
  - Evidence does not support use of medication for management of chronic patients (Hall et al., 2016)
  - Prolonged use of vestibular suppressants limits the vestibular sensory input into the brain, inhibiting compensation (Sealy, 2014)
Vestibular Hypofunction: Patient Education

- Symmetry of resting vestibular input
- Asymmetry indicates movement
- Damage to the vestibular system causes asymmetry, hypofunction of affected side
- Treatment of choice: vestibular rehabilitation
  - Goal: central compensation for unilateral vestibular loss

Vestibular Hypofunction: Prognosis

- Prognosis: excellent with proper diagnosis and vestibular rehab
- Age and gender do not affect potential for improvement
- Time from onset – earlier intervention improves outcomes
- Co-morbidities: anxiety, migraine, and peripheral neuropathy may negatively impact rehab outcomes
- Vestibular suppressants – long-term use may negatively impact patient recovery

(Hall et al., 2016)
Key Subjective Report: Vestibular Hypofunction

- Description:__________________

- Hearing Loss:
  - Neuronitis Yes / No
  - Labyrinthitis: Yes / No

- History of falls? Prior to onset / Since onset

- Neck pain or headaches? Prior to onset / Since onset

- Cause:_______________________

- Treatment:___________________

- Prognosis:___________________

Meniere’s Disease and Endolymphatic Hydrops

- Build up of endolymphatic fluid secondary to known triggers
  - Triggers – caffeine, high-sodium foods, barometric pressure changes, stress, fatigue, other illnesses

- Increased fluid places pressure on vestibulocochlear nerve

- As fluid lessens, symptoms decrease or resolve

- Nerve damage can occur causing long-term symptoms

- Fluctuating hearing loss can be formally assessed to monitor disease

(Sealy, 2014; Haybach, 2015; Herdman & Clendaniel, 2014)
Meniere’s Disease / Endolymphatic Hydrops: Patient Presentation

- Age: 40-60
- Onset: exposure to triggers
- Symptoms:
  - nausea, vomiting, violent, constant, severe spinning, nystagmus, unilateral, low-frequency hearing loss, roaring, ocean-like tinnitus, and aural pressure, present during vertigo episodes
  - Balance: unable to walk without assistance during episodes
- Duration: 20 minutes – 24 hours, total or partial resolution of symptoms between episodes

Meniere’s Disease / Endolymphatic Hydrops: Treatment

- Referral to ENT
- Medication – diuretics for long-term management, valium, ativan, phenergan, dramamine, meclizine hydrochloride (antivert)
- Hearing aids, limiting triggers, assistive devices
- Vestibular rehabilitation if symptomatic during periods of remission
- Prognosis: Good – Fair, progressive disease, requires ongoing medical management and limitation of triggers
- (Sealy, 2014; Haybach, 2015; Herdman & Clendaniel, 2014)
Key Subjective Report: Meniere’s / Endolymphatic Hydrops

- Description:__________________
- Hearing Loss: Yes / No
- History of falls? Prior to onset / Since onset
- Neck pain or headaches? Prior to onset / Since onset
- Cause: ________________________
- Treatment: ____________________
- Prognosis: ____________________

Acoustic Neuroma / Vestibular Schwannoma

- Third most common intracranial tumor, 8-10%
- Symptoms: progressive unilateral sensorineural hearing loss
- MRI with gadolinium contrast is gold standard for diagnosis
- Treatment: Monitor, microsurgical removal, stereotactic radiosurgery
  - Outcomes of surgery: hearing loss is common, transient facial paralysis with large tumors
  - Vestibular rehabilitation post-surgery

(Herdman & Clendaniel, 2014)
Key Subjective Report: Acoustic Neuroma

- Description:__________________
- Hearing Loss: Yes / No
- History of falls? Prior to onset / Since onset
- Neck pain or headaches? Prior to onset / Since onset
- Cause:______________________
- Treatment:__________________
- Prognosis:__________________

Cervicogenic Dizziness

- Theory behind cervicogenic dizziness is abnormal cervical afferents – sensory integration deficit

- Diagnostic criteria:
  - Other causes of dizziness have been ruled out
  - History of cervical spine injury such as whiplash, severe arthritis, HNP, head trauma
  - Dizziness associated with neck pain, head movement or with sustained head position

- Onset: following whiplash or closed head injury, not typically an initial symptom, occurs in 20-58% post-whiplash or CHI

(Wrisley et al., 2000)
Cervicogenic Dizziness: Patient Presentation

- **Symptoms**
  - Neck pain and decreased cervical ROM, headaches
  - Ataxic gait, imbalance with head movements

- **Duration of symptoms:** minutes to hours

- **Treatment**
  - Address the problem, which is the cervical spine – mechanics, strength, proprioceptive awareness
  - Vestibular rehabilitation as indicated by presence of motion sensitivity and balance problems

- **Prognosis:** good with proper assessment and treatment to include manual therapy and vestibular rehabilitation
  (Wrisley et al., 2000)

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**Key Subjective Report: Cervicogenic Dizziness**

- **Description:**

- **Hearing Loss:** Yes / No

- **History of falls?** Prior to onset / Since onset

- **Neck pain or headaches?** Prior to onset / Since onset

- **Cause:**

- **Treatment:**

- **Prognosis:**
Vestibular Migraine

- No specific test, diagnosis of exclusion
- Most common cause in children
- History of migraine per International Headache Society
  - No hearing loss
  - May occur with or without other migraine symptoms
- Triggers
  - Symptoms can be spontaneous or triggered by motion
  - Environmental – barometric pressure changes
  - Food – aged cheese, red wine, smoked or processed meats, MSG, chocolate
  - Stress, medication, lack of sleep

(Kramer and Buskirk, 2015; Herdman & Clendaniel, 2014)

Vestibular Migraine: Patient Presentation

- Symptoms: True vertigo, motion sensitivity, lightheadedness
- Duration of Symptoms: seconds to days
- Treatment
  - Medical management of migraines and management of known triggers
  - Vestibular rehabilitation for dizziness or balance problems persisting between attacks
- Prognosis: good, requires ongoing medical management of migraines, management of triggers

(Kramer and Buskirk, 2015; Herdman & Clendaniel, 2014)
Key Subjective Report: Vestibular Migraine

- Description:__________________
- Hearing Loss: Yes / No
- History of falls? Prior to onset / Since onset
- Neck pain or headaches? Prior to onset / Since onset
- Cause: ________________________
- Treatment: ____________________
- Prognosis: ____________________

Post-Concussion Syndrome

- Concussion = mild traumatic brain injury
  - Duration of recovery is longer with initial symptoms of dizziness, imbalance, oculomotor findings
- Consider:
  - BPPV due to force
  - Central processing / sensory integration
  - Balance difficulty
  - Musculoskeletal involvement: neck pain, headaches
- Symptoms: combination of central and peripheral
  - Post-Concussion Symptom Scale
Post-Concussion Syndrome: Patient Presentation

- Treatment
  - Sensory modifications
  - Canalith repositioning
  - Manual therapy and therapeutic exercise
  - Vestibular rehabilitation
- Treatment Considerations
  - Return to Learn
  - Return to Play
- Prognosis
  - Good – Fair – Poor
  - Improvements over multiple domains
  (Alsalaheen et al., 2010)

Post-Concussion Syndrome Updates: Ellis et al., 2016

- VOR dysfunction as a clinical predictor in pediatric sports-related concussion
- VOR dysfunction: abnormal findings in near point convergence, extraocular movements, smooth pursuit, horizontal saccades, vertical saccades, or VOR
- Patients with VOR dysfunction post-concussion took twice as long to recover
- Significant predictors of post-concussion syndrome included VOR dysfunction, post-traumatic amnesia, and pre-injury history of depression
Post-Concussion Syndrome

Updates: Pearce et al., 2015

- Examined near point convergence relationship to neurocognitive impairments and symptoms after sports-related concussion
- Testing included NPC, IMPACT testing, and Post-Concussion Symptom Scale (PCSS)
- Findings indicate:
  - A relationship exists between reaction time and NPC
  - Patients with convergence insufficiency are more symptomatic
  - Convergence insufficiency may be related to lower scores on certain cognitive tests
- Recommendations: academic accommodations and vision therapy

Post-Concussion Syndrome

- Armstrong, Richard, 2018 – of 212 TBI (post-concussion) patients, 54% had headache in the first week, 91% had headaches over 1 year. Of these headaches, 49% were migraine or potential migraine, 40% were tension headaches
- Schneider et al., 2014 – post-concussion headache has been reported as a predictor of longer time loss
  - Treatment of cervical spine has demonstrated improvement in:
    - neck pain, cervicogenic headache, and suspected cervicogenic dizziness
Post-Concussion Syndrome: When to treat

- Limited research on how early is appropriate
- Currently most referrals once chronic and not recovering spontaneously
- Lennon et al., 2018: recommend multi-modal PT intervention within first few weeks may facilitate recovery and mitigate onset of secondary effects
- Schneider et al., 2014: 73.3% of participants in vestibular rehab were medically cleared to return to sport within 8 weeks compared to 7.1% in control

Post-Concussion Syndrome: Treatment

- Vestibular rehabilitation
- VOR training:
  - Convergence
  - Smooth Pursuit
  - Saccades
  - Gaze stabilization
- Multiple sensory stimuli
  - Auditory
  - Cardiovascular
Central Vertigo: Multiple Sclerosis

- Diagnosed typically 30-40 years of age, female > male
  - Symptoms: Spinning, lightheadedness, diplopia, oscillopsia, balance problems, difficulty reading
- Findings of vestibular assessment: Central
- Treatment: medical management / neurology, vestibular rehabilitation to address findings of imbalance, dizziness, motion sensitivity
- Prognosis: guarded due
  - to progressive nature of disease

Central Vertigo: CVA / TIA

- CVA affecting brainstem or cerebellum
- Symptoms
  - Dizziness, central signs including findings in oculomotor exam, gait ataxia, diplopia, dysphagia, dysarthria, dysdiadochokinesia, coordination, skew deviation, coordination deficits
- Treatment will include vestibular rehabilitation to promote recovery of function through neuroplasticity
- Prognosis: Fair – Good
  - Improvement will be appreciated, however long-term dizziness, motion sensitivity and/or balance deficits may persist depending on multiple factors including comorbidities
- (Herdman & Clendaniel, 2014)
Orthostatic Hypotension

- Drop in blood pressure with positional changes
  - Systolic drop of ≥ 20 mmHg or diastolic drop of ≥ 10 mmHg
- Causes: Medications, hypovolemia, dehydration, cardiac pump failure, autonomic neuropathy
- Patient history and symptoms: Syncope, lightheadedness, falls with positional changes
- Assessment:
  - Blood pressure taken in supine and in sitting after one minute
  - Blood pressure taken in sitting and after standing for one minute
- Treatment: medical management, exercise, patient education
  - (Goldstein & Sharabi, 2009)

Postprandial Hypotension

- Drop in blood pressure within 2 hours of starting a meal
- History: HTN, Diabetes, Parkinson's Disease, CHF, dialysis, autonomic dysfunction
- Symptoms: falls, syncope, headache, sleepiness, chest pain
- Treatment: Limitation of diuretics and nitrates in treatment of HTN
- Adjust timing of blood pressure medication to not be taken prior to meals, recommend rest / limited activity following meals, decreased size of meals more frequently throughout the day, limit carbohydrates
  - (Jansen, 2005)
Chronic Motion Sensitivity

- Affects 20-30% of general population described as sub-clinical condition
- Motion sensitivity: visual-vestibular mismatch
- Long-term results: activity avoidance
- Benefit from vestibular rehab: improved sensory integration, re-weighting of sensory inputs to decrease motion sensitivity

(Alyahya et al., 2016)

Persistant Postural Perceptual Dizziness (3PD)

- Symptoms of rocking or swaying and/or vertigo >3 months
- Triggered by an event causing acute vertigo, unsteadiness, or imbalance
  - BPPV, vestibular neuritis, vestibular migraine, panic attack with dizziness, concussion, dysautonomia
- Physiologic disorder with psychological consequences
Persistent Postural Perceptual Dizziness (3PD)

- Symptoms present > 3 months
- Present more days than not, >15 days/month
- Worse with standing or walking, less with sitting
- Provoked by:
  - Exposure to visual stimuli
  - Busy environments
  - Movement of the patient

Differential Diagnosis: Central vs. Peripheral

- HINTS – more sensitive than MRI in 24-48 hours
  - Head Impulse
    - + peripheral
  - Nystagmus
    - Horizontal = peripheral
    - Vertical or torsional = central
    - Gaze-evoked direction-changing nystagmus = central
  - Skew Deviation
    - + vertical = central
Differential Diagnosis: Case 1

- 65 y/o female presents today with chief c/o dizziness described as spinning. Dizziness began upon waking in the morning. Patient states she rolled to her left to turn off the alarm clock and experienced spinning sensation lasting about 1 minute. She became nauseated and vomited. She continues to feel off balance throughout the day while walking and performing daily activities, and spinning with reaching into overhead cupboards, getting in/out of bed, bending over to tie her shoes, and rolling over to the left. She denies hearing loss, denies change in vision, denies pressure in the ear, denies tinnitus, denies neck pain and headache.

Differential Diagnosis: Case 2

- 40 y/o male presents with dizziness that began 8 days ago after working in the yard. He started to feel dizzy that became worse and has he experienced a constant spinning sensation with nausea and vomiting for 3 days. He reports declined balance, though denies falls. He states he holds onto the wall or other furniture while walking. He is unable to work at this time due to dizziness and imbalance. He reports a muted hearing in the left ear, pressure in the left ear, denies change in vision, denies tinnitus, reports neck pain and headache.
42 y/o female presents today with chief c/o dizziness described as imbalance. Onset was gradual with no prior history. She has been noticing some visual difficulty and has double vision while reading. She reports several falls with no precipitating factors.

50 y/o male presents with chief c/o dizziness that is episodic in nature. He states he is feeling great today, but had an episode last week that started while he was at work (carpenter) and continued through the night. He woke up in the morning feeling better. He had to call his wife to pick him up from work and help him into the house. He vomited 4 times on the way home and 3 more times that evening.
Differential Diagnosis: Case 5

- 23 y/o female presents with chief c/o dizziness / imbalance. She reports insidious onset 3 weeks ago and thought it would go away in time. She states sometimes are worse than others, especially while at work on her computer. She reports loss of balance when she turns her head while walking, though states she has not fallen.

What is important for differential diagnosis?

- Central:
  - Vision changes
  - Vertical/horizontal nystagmus
  - + Skew deviation
  - Imbalance

- Peripheral:
  - Hearing loss
  - Aural pressure
  - Tinnitus
  - + Head Thrust / Head Impulse Test
  - Spinning
References

- Vestibular EDGE: Shared with permission from The Academy of Neurologic Physical Therapy. VEDGE Taskforce Members: Mathew R. Scherer, PT, PhD, NCS, Chair; Linda B. Horn, PT, DScPT, MHS, NCS, Co-Chair; Elizabeth Dannenbaum, MScPT, Jennifer L. Fay, PT; Karen H. Lambert, PT, MPT, NCS; Teresa A. Rice, PT, MPH, NCS; Jennifer L. Stoskus, PT; Diane M. Wrisley, PhD, PT, NCS
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