Benign Paroxysmal Positional Vertigo (BPPV)

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Anatomy & Physiology
of the Vestibular System
(Relevant to BPPV)

What is the Vestibular System?

- “The human vestibular system is made up of 3 components:
  - Peripheral Sensory Apparatus
  - Central Processor
  - Mechanism for Motor Output”

Hain, et al, in Herdman 2007

Peripheral Sensory Apparatus

- Purpose: detect head position & acceleration / deceleration

- Components:
  - Otolith Organs: Utricle & Saccule
  - Semicircular Canals (SCC): Anterior, Posterior, & Horizontal
Otolith Organs

- Saccule = Detect **LINEAR VERTICAL** acceleration & deceleration
- Utricle = Detect **LINEAR HORIZONTAL** acceleration & deceleration
- Otoconia → Gelatinous Substance → Hair Cells → Fibers of Vestibular Nerve → Brain
  - Otoconia – irregular shape / size

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Semicircular Canals (SCC)

- Function: Provide sensory input about head velocity ("Rate Sensors")
  - Detect **ANGULAR VELOCITY** in 3-D space
  
  - have a dynamic function
  
  - Allows Vestibular Ocular Reflex (VOR) to generate eye movement matching head velocity
  
  - Result = gaze stabilization with head movement

SCC’s

- Alignment:
  - Ant & Post SCC’s = Vertical at roughly 45° from coronal & sagittal planes (90° angles from each other)
    - A/P SCC’s are paired & opposite
  
  - Horizontal SCC’s = 30° superior to horizontal plane

SCC’s

- Anatomy:
  - Both ends of each SCC terminate in Utricle
  
  - Ampulla on anterior side of SCC’s
  
  - Common Crus = Fusion of Superior ends of Ant & Post SCC’s
Ampulla & Cupula

- Ampulla = bulbous enlargement on **ANTERIOR** side of each SCC
- Inside each ampulla is crista
  - Crista = the sensory epithelium (hair cells & supporting cells)

- Cupula = gelatinous mass covering crista
  - Cupula is flexible & “bows” to one side with movement of the endolymph

Movement of Cupula

- Endolymph & Cupula & Hair Cells move in **OPPOSITE** direction of head movement

- Quick head turn to R → endolymph causes cupula to bend to L → hair cells bend to L
- Quick head turn to L → endolymph causes cupula to bend to R → hair cells bend to R
Hair Cells

- Function: Biological sensors that convert displacement due to head motion into neural firing
  - Innervated by Vestibular NN
    - Part of CN VIII Vestibulocochlear Nerve
- Location:
  - Each Otolith Organ (Saccule & Utricle)
  - Each Ampulla in each SCC (6 total ampulla)
    - Increases or decreases firing rate of Vest NN

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Labyrinth

- Bony Labyrinth = 3 SCC’s, cochlea, & central chamber called Vestibule
  - Filled with perilymphatic fluid (communicates w/ CSF in subarachnoid space)

- Membranous Labyrinth

  - Suspended within bony labyrinth by fluid & supportive connective tissue
  - Contains the 5 sensory organs
  - Filled with endolymphatic fluid
  - No direct connection with endolymph & perilymph compartments
Central Processor Centers

- Vestibular Nuclei
- Cerebellum

Vestibular Nuclear Complex

- Primary processor of vestibular input
- 4 Major Nuclei = Sup / Med / Lat / Inf
- Location = pons, & extends inferiorly into medulla
- Receives sensory info from SCC’s & otoliths

Cerebellum

- The Adaptive Processor
  - Monitors vestibular performance & readjusts central vestibular processing if necessary
  - Receives significant information from vestibular nuclei
Motor Output Components

- Reflex indicates sensory input **IN** & motor output **OUT**
- VOR – Vestibuloocular Reflex
  - Purpose: maintain stable vision during head movement
- VSR – Vestibulospinal Reflex
  - Purpose: stabilize body

What is nystagmus?

- Involuntary rhythmic oscillation of the eyes
- Typically has clearly defined fast & slow phase components beating in opposite directions
- Direction is named by the fast phase
### Normal Nystagmus
- Can be induced in normal subjects
- End-point: extreme lateral gaze
- Rotational-induced: spinning
- Optokinetic (OPK): counting moving objects
- Caloric-induced: hot/cold water/air in ears

### Pathological Nystagmus
- Spontaneous: head erect & gaze centered
- Gaze-Evoked: change in eye position
- Positional: change in head position
- Congenital

### Causes of Pathological Nystagmus
- Lesions of peripheral or central vestibular system
- Lesions of other CNS pathways involved in control of eye movements
- Visual-ocular (congenital)

### What does it mean?
- Aids in diagnostic process
  - BPPV
    - Will actually tell us which canal(s) in which ear(s) is affected
  - Peripheral Vestibular Disorder (non-BPPV)
  - Central Vestibular Disorder
Examples of Nystagmus

- Vertical →
- Horizontal →
- Torsional →

- Video examples of nystagmus
  - Many examples on You Tube to practice with

What is BPPV?

- Most common peripheral vestibular disorder

- **B**enign: not malignant
- **P**aroxysmal: sudden onset
- **P**ositional: position
- **V**ertigo: illusory sensation of movement

- **BPPV**=brief episodes of vertigo when head is moved in certain positions

What is BPPV?

- Otoconia is displaced from utricle into semi-circular canal
  - Normal sloughing & regeneration of otoconia
  - Symptomatic with excessive numbers
  - Movement of debris causes unwanted stimulation of sensory hair cells, causing illusory sense of movement

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2 Comprehensive BPPV Practice Guidelines


Patient Presentation & Etiology

Patient Complaints

- **Sudden** onset of vertigo with certain head movements
- **Brief** episodes: seconds vs. minutes
- Often crescendo-decrescendo pattern
- Common head mmts: ext + rot
  - Bed/sleeping (sit<-->sup, rolling), bending over, looking up, washing hair in shower, dentist, beauty shop "Shampoo Bowl Syndrome", "Top Shelf Syndrome", post-surgical

Patient Complaints cont’d

- Nausea/vomiting may be present, mild or intractable
- Imbalance persisting hours/days
- Vague sensations: lightheaded, floating, “off”
- Stop moving their heads
- May have hx of similar symptoms with spontaneous remission
What Causes BPPV?

- Idiopathic most common
- Aging
- Head trauma
- Infection (Neuritis/Labyrinthitis)
- Ischemia: Anterior Vestibular AA
- Denervation (Vestibular NN)
- 50% BPPV pts → other vestibulopathy
  (Roberts, Gans, Kastner, Lister)

Etiology

- Most common: Posterior SCC
  - 80-90% frequency
  - Most dependent position
- 2nd most common: Horizontal SCC
- Least common: Anterior SCC
- Relationship of cause & affected SCC
- Nystagmus will diagnose canal

2 Theories for BPPV

- Canalithiasis: most common
  - Debris free floating in endolymph in SCC
  - Head moved into provoking posn → debris moves to most dependent position in canal
- Cupulolithiasis: least common
  - Debris adherent to cupula, making the ampulla gravity sensitive
  - Cupula remains deflected as long as head is in provoking position
Canalithiasis

- Movement of otoconia results in movement of endolymph, which pulls cupula & increases firing rate of neurons in that canal
- So….symptoms will reflect this

Canalithiasis

1. Latency of nystagmus: 1-40 secs
2. Presence of nystagmus, with latency matching subjective c/o’s vertigo
3. Fluctuation in intensity of vertigo & nystagmus, crescendo-decrescendo, disappearing in ≤ 60 seconds

Cupulolithiasis

- Debris adherent to cupula → ampulla gravity sensitive
- Cupula remains deflected as long as head in provoking position
- So….symptoms will reflect this
  - Nystagmus & vertigo will persist
  - Intensity may decrease 2º central adaptation
Cupulolithiasis

1. No latency: immediate onset vertigo
2. Presence of nystagmus, matching latency & complaints of vertigo
3. Persistence of vertigo & nystagmus for duration of test: > 60 seconds

Nystagmus in BPPV

1. Torsional: rotating
   - Named for the superior pole of the eye
   - L torsional = clockwise
   - R torsional = counterclockwise
2. Vertical: upbeating / downbeating
3. Horizontal: geotropic / ageotropic
   - Geotropic = toward the earth
   - Ageotropic = away from the earth

Nystagmus in BPPV & Diagnosing BPPV

- Direction & duration of nystagmus will aid in diagnosis of:
  - Canal involvement: AC / PC / HC
  - Ear involvement: R vs. L
  - Canalithiasis vs. Cupulolithiasis
Diagnosis of BPPV

• Torsional nystagmus determines which ear:
  – R torsion = R ear
  – L torsion = L ear
• Up / Downbeating nystagmus determines which VERTICAL canal:
  – Upbeating = PC (PUP)
  – Downbeating = AC

Prior to All BPPV Testing…

Modified Vertebral AA Test

• Must be done before Hallpike-Dix to check integrity of Vert AA System
• Monitor for adverse symptoms:
  – Vision changes
  – Dizziness
  – Syncope
  – Paresthesias
  – Conversational changes

Diagnosis of BPPV

• Duration of symptoms determines canalithiasis / cupulolithiasis in VERTICAL canals:
  ▪ <60 sec = canalithiasis
  ▪ >60sec = cupulolithiasis

• Geotropic vs Ageotropic nystag determines canalithiasis / cupulo in HORIZ canals:
  ▪ Geotropic = HC canalithiasis
  ▪ Ageotropic = HC cupulolithiasis
Modified Vertebral AA Test
1. Pt sitting, fully supported
2. Lean forward with eyes still level
   • Forearms on knees, sub occipital ext (forward head)
3. Turn/rot head 45º & hold 60 sec
4. Turn/rot to opp side & hold 60 sec
   • If test is +, Hallpikes should be held until arterial system is evaluated & cleared by MD
   • “How does evidence on the dx'c accuracy of the Vert AA Test influence teaching of the test in a prof PT educ program?” (Richter, Reinking, PTJ 2005)

2 Tests for BPPV
• 1. Hallpike-Dix (H-D) Test
   – Tests vertical (anterior & posterior) canals
   – Canalithiasis / cupulolithiasis

• 2. Roll Test
   – Tests horizontal canals
   – Canalithiasis / cupulolithiasis

Hallpike-Dix Test
(for Vertical Canals)
• Testing both ant & post canals on the tested side (same side canals)
• Pt in long-sitting on mat, empty space behind less than trunk length
• PT on stool (lower than mat) behind pt, which is at head of mat
• Pt instructed to keep eyes open & report symptoms
Hallpike-Dix Test

- **Step 1:** Pt rot’s head 45° (to **same side** as test side)
- PT holds pt’s head B sides
- **Step 2:** Pt quickly moves into supine with neck ext’d 30° below mat with PT supporting head on leg
- PT observing pt’s eyes for nystagmus & asking pt to report subjective symptoms
- Hold test position ≥ 45 seconds if no positive symptoms are appearing

- **Step 3:** PT maintains pt’s head rot as pt returns to original long sit position, with PT standing during process
- **Step 4:** PT moves around to front of pt to observe for **reversal of nystagmus**

- **Always keep at least one hand in physical contact with pt!!**
  - During testing & during treatment
  - Pt fear
  - Unexpected sudden onset of vertigo
  - Pt becomes disoriented to space, esp. if visually suppressed with goggles

Roll Test (for HC’s)

- Moving pt’s head in plane of HC
- Pt long sitting on mat with **30° neck flexion**, with PT behind pt (sit or std)
- A pillow may provide adequate flex
- 3 basic positions in Roll Test:
  - Supine head center, keeping 30° flex
  - Supine head left with 30° flex
  - Supine head right with 30° flex
Roll Test

- In HC BPPV, vertigo & nystagmus may occur in both side head positions, $2^\circ$ debris moving back & forth in canal
- The side with the most subjective symptoms is the side to treat
- Geotropic nystagmus will fatigue
- Ageotropic nystagmus may not fatigue ($2^\circ$ debris adherent to cupula)

Treating BPPV

1. Epley Maneuver: CRM for AC / PC (vertical canals)
   - Canalithiasis
   - Evidence strong for efficacy (Hilton, Pinder 2002)
2. CRM for HC (aka “BBQ Roll”, or “Barrel Roll”) (horizontal canals)
3. Gufoni’s Maneuver: CRM for HC
   - Canalithiasis
4. Liberatory / Semont Maneuver: CRM for PC / AC (vertical canals)
   - Cupulolithiasis

Treating BPPV: CRM’s

Treating BPPV → Many names but they all mean the same!

- **CRM**: Canalith Repositioning Maneuver
- **CRT**: Canalith Repositioning Treatment
- **CRP**: Canalith Repositioning Procedure
- **PRM**: Particle Repositioning Maneuver
- Vary due to region, discipline, author, etc.
Treating BPPV: Not a CRM

- Brandt-Daroff Habituation Exercises
  - NOT repositioning otoconia into utricle
  - Efficacy not strong in research
  - Least effective self-administered treatment
  - Helminski, Zee, Janssen, Hain, PTJ, May 2010
  - Think about patient population you want to use these with

Modified Epley Maneuver

For **AC & PC Canalithiasis**
- Begins the same as Hallpike-Dix **toward side of affected ear**
- **Hold all positions** until all symptoms subside plus another 30-60 seconds → Don’t Rush!!!**
- **Step 1:** Bring pt into first Hallpike-Dix position
  - Hold position until symptoms subside (+30-60 secs)
  - PT holding/supporting pt’s head the entire time (head resting on PT’s lap)

Epley Maneuver

- **Step 2:** PT rotates pt’s head into posn of 45° rot in opposite direction (which is 90° from where you started, maintaining 30° neck ext
- Hold until all symptoms subside, + extra 30-60 seconds
Epley Maneuver

- **Step 3:** Pt rolls onto side (toward side of current head rot), while PT simultaneously moves pt’s head so pt’s nose is pointing 45° to floor
- This is going to bring pt’s head from extension into flexion
- Hold until all symptoms subside, + extra 30-60 secs

Epley Maneuver

- **Step 4:** Pt kicks legs off mat, & slowly sits up on edge of mat, while PT supports pt’s head, bringing pt up into neutral head position
- Always keep hands on pt at all times, as may be disoriented / off balance
CRM for HC

AKA BBQ Roll or Barrel Roll

• For **HC Canalithiasis**
• 60-90% success rate (Francesco et al, 2009)
• Begins the same as the Roll Test, but pt must be started further up on mat, so shoulders are at top of mat, & head/neck are off of mat
• PT must keep pt's **head flexed 30° at all times** during CRM
• **Hold ALL** positions until symptoms subside plus another 30-60 seconds → Don’t Rush!!!*

CRM for HC

• **Step 1:** Pt begins in supine with **affected ear down**
• **Step 2:** Rot head to opposite side (~180° from where pt started, affected ear now up), pt still supine
• **Step 3:** Pt rolls into matching sidelying position, PT maintaining head in same position as prior

CRM for HC

• **Step 4:** Pt rolls into prone, with PT moving pt’s head so it is facing floor (90° rot)
  – Pt can move into prone on elbows, if needed, to allow for 30° neck flex
• **Step 5:** Pt continues movement in same direction, moving into sidelying, & PT moves pt’s head into matching position (affected ear down, which is back to the **starting position** for the head)
CRM for HC

- **Step 6:** Pt sits up onto edge of mat, with PT holding pt’s head in neutral alignment
- Always keep hands on pt at all times, as pt may be disoriented / off balance

Gufoni’s Maneuver

- CRM for **HC Canalithiasis**
- 79% pts successfully cleared after first session *(Francesco et al, 2009)*
- 96% success when adding in pts who converted to PC during maneuver
- 4 Positions, & perform twice

Gufoni’s Maneuver

- **Position 1:** Pt sitting on side of plinth
  - Sit off center, to allow sidelying on **unaffected** ear side
  - Arms held close to body with hands resting on legs
Gufoni’s Maneuver

- **Position 2:** Pt quickly lies down into sidelying on unaffected ear side
  - No pillow
  - No rotation of head / neck
  - Maintain position for 2 minutes (until end of evoked geotropic nystagmus)

Gufoni’s Maneuver

- **Position 3:** Pt quickly rotates head 45° towards the mat / floor
  - Hold position 2 minutes
- **Position 4:** Patient slowly moves back up to starting sitting position, & returns head to neutral
- Repeat maneuver 1 more time

Liberatory / Semont Maneuver

- For **PC Cupulolithiasis**
- Pt sitting on side of mat, in middle
- PT standing in front of pt, on side to be tested, with hands on sides of pt’s head
- **Step 1:** Pt rotates head away from affected ear
**Liberatory / Semont Maneuver for Posterior Canal**

- **Step 2:** Pt quickly brought down onto side of affected ear, PT keeping head in proper position of 30° ext, & **nose pointed 45° up**
- PC perpendicular to mat. **Hold 2-3 minutes.**

**Liberatory / Semont Maneuver for Posterior Canal**

- **Step 3:** Pt quickly brought through sitting & across to opposite side of mat, now with **face down**, all in one continuous motion. PT holds pt’s head in same rotated position through motion. Hold position **5 minutes**.
- Pt’s **nose will be pointed 45° down**, & PC still perpendicular to mat

**Liberatory / Semont Maneuver for Posterior Canal**

- **Step 4:** Pt brought slowly back to sitting position.
- When head is moving one direction, fluid is moving in opposite direction, & that bangs the fluid up against cupula, which helps to knock debris off cupula.
- Speed of movement
- Not appropriate for many patients

**Liberatory / Semont Maneuver for Anterior Canal**

- For **AC Cupulolithiasis**
- Similar to maneuver for PC **except:**
  - Pt rotates head **toward** affected ear
  - First position is **face down** instead of face up
  - Second position is **face up** instead of face down
- **Ant canal** is perpendicular to mat
Brandt-Daroff Exercises

- NOT a CRM
  – just trying to break up otoconia
- Can be used for pts with BPPV when they can’t tolerate CRM’s
- Or, when pt has only minimal symptoms persisting after CRM
- Or, pt’s can use to self-manage recurrent symptoms
- ROM exercises for the SCC’s!

Brandt-Daroff Exercises

• Position of head during exercises changes depending upon what canal is affected
  – PC → Rotate 45° AWAY from side pt is going to lay down on
  – AC → Rotate 45° TOWARD side pt is going to lay down on
  – HC → Keep head looking straight forward
Brandt-Daroff Exercises

- **Step 1:** Pt sitting in middle of mat/bed, with pillows at each end of bed. Head position dependent upon canal affected
- **Step 2:** Pt quickly lies down onto side. Hold until symptoms subside, + 30 secs.
- **Step 3:** Pt sits up quickly, holding head in same position. Hold until symptoms subside, + 30 secs.

- **Step 4:** Pt rotates head 45° to opposite side (unless it is staying neutral for HC).
- **Step 5:** Pt quickly lies down to opposite side. Hold until symptoms subside, + 30 secs.
- **Step 6:** Pt quickly sits up, holding head in same position. Hold until symptoms subside, + 30 secs.

Brandt-Daroff Exercises

- Repeat 10-20x, 3x/day, until 2 consecutive days without symptoms
- Doesn’t matter which side they start on because they are doing it bilaterally

Post CRM Concerns
Post CRM Procedures

- Retest same canal to insure all debris is cleared.
- If not, repeat CRM.
- Some pts may refuse retest
- Also, can treat multiple canals at same treatment – pt dependent

Treat Multiple Canals? When Follow-Up with Patient?

- Treat multiple canals same day?
  - Yes – but dependent upon pt tolerance & your time
- When Follow-Up with Patient?
  - 2-3 days (Herdman, Tusa 2005)
  - We began to wait 5-7 days
  - Also dependent upon your setting (ie: acute care vs. outpatient) & pt presentation

Possible Post-CRM Occurrence

- **Tumarkin’s Crisis:**
  - Occurs 2° otoconia dumping down onto macula, or the fluid wave it causes
  - Anti-gravity mm’s engaged with pt flailing or moving into strong extension
  - Reason to **always** keep a hand on pt at all times!
  - Indicates BPPV is cleared 😊

Positional Restrictions after BPPV CRM Treatment

- Restrictions have changed dramatically over time
- Years ago….
  - No head movement → 48 hours
  - No bending over → 48 hours
  - Wear cervical collar → 48 hours
  - Sleep upright (45°) for → 48 hours
  - Then, no sleeping on affected side for 5 days
- Recent research → less restrictive
Positional Restrictions after BPPV CRM Treatment: Current Research

- Research on PC, 2\textsuperscript{nd} most common
- No restrictions (De Stefano, et al, 2011)
- No restrictions (Roberts, Gans, et al, 2005)
- Sit upright for 20 minutes, with cervical collar (Herdman & Tusa, 2005)

Beyond BPPV…

- If it doesn’t…
  - Look like BPPV
  - Sound like BPPV
  - Smell like BPPV
  - Taste like BPPV
- Then it isn’t BPPV!

Postural Restrictions after BPPV CRM Treatment: So, What Should I Do?

- Can determine restrictions based upon patient situation:
  - Simple vs. complex presentation
  - Initial vs. repeat occurrence
  - Individual patient situation
    - Leaving town
    - Significant life event
  - Dependent upon which canal also – does the anatomical alignment warrant the precaution?

QUESTIONS?

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References

• See Resource Packet for:
  – BPPV symptom pattern chart
  – CRM billing information
  – Enlarged anatomical diagrams
  – Reference list