



Anatomy, Physiology & Pathology of BPPV

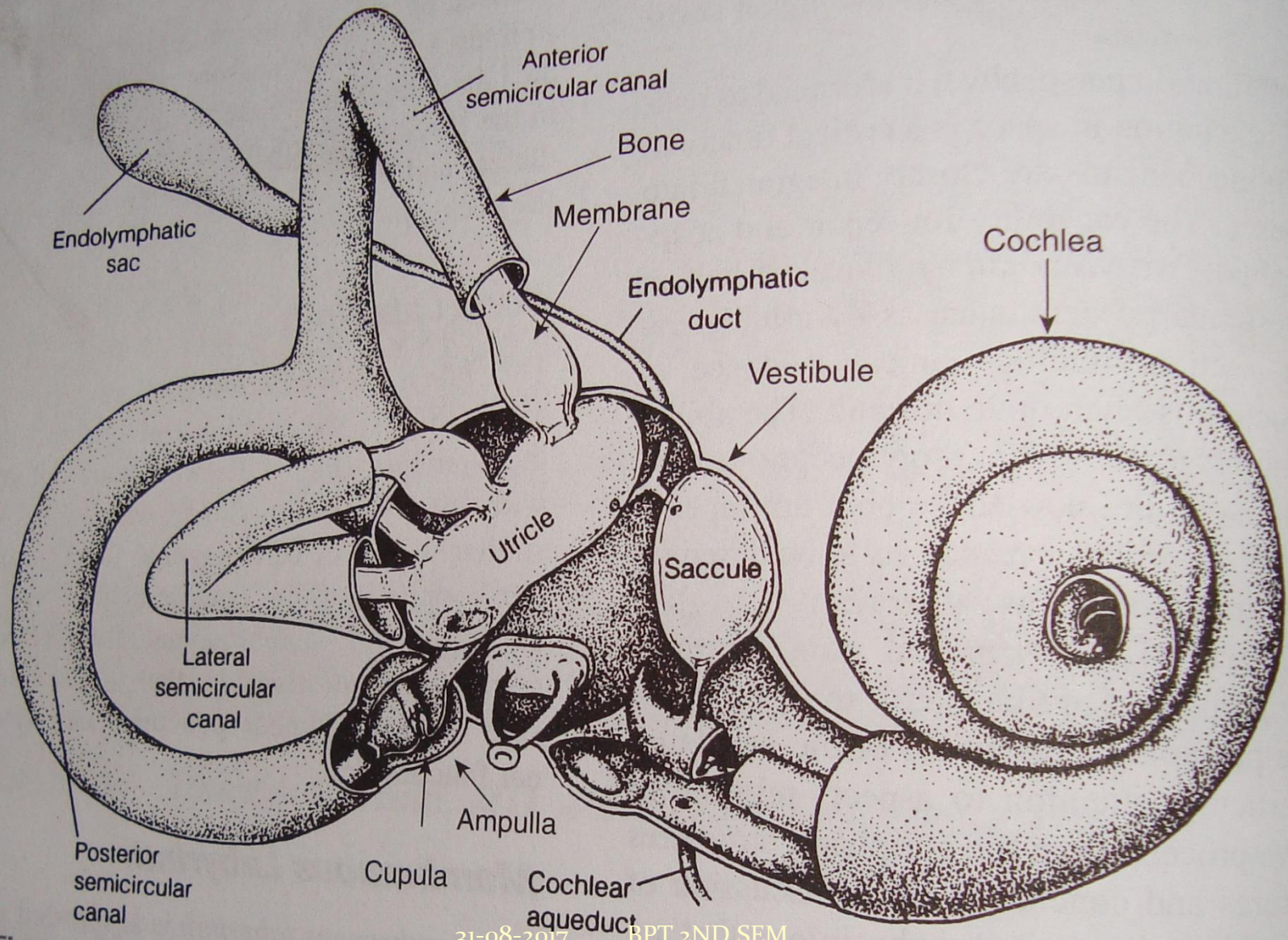
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Purpose of vestibular system

- Made up of 3 components: a peripheral sensory apparatus, a central processor, & a mechanism of motor neurons.
- Peripheral receptors send information about head angular velocity and linear motion.
- CNS combines this information with other sensory information to estimate head and body orientation.
- Output goes to ocular muscles and spinal cord to serve VOR, VSR & VCR.

The Peripheral Sensory Apparatus

Bony Labyrinth
Membranous Labyrinth
Hair Cells



Bony Labyrinth

- Consists of 3 semicircular canals, the cochlea, and a central chamber called vestibule.
- Bony labyrinth filled with perilymphatic fluid, with a high Na:K ratio.
- Perilymphatic fluid communicates with CSF via the cochlear aqueduct.

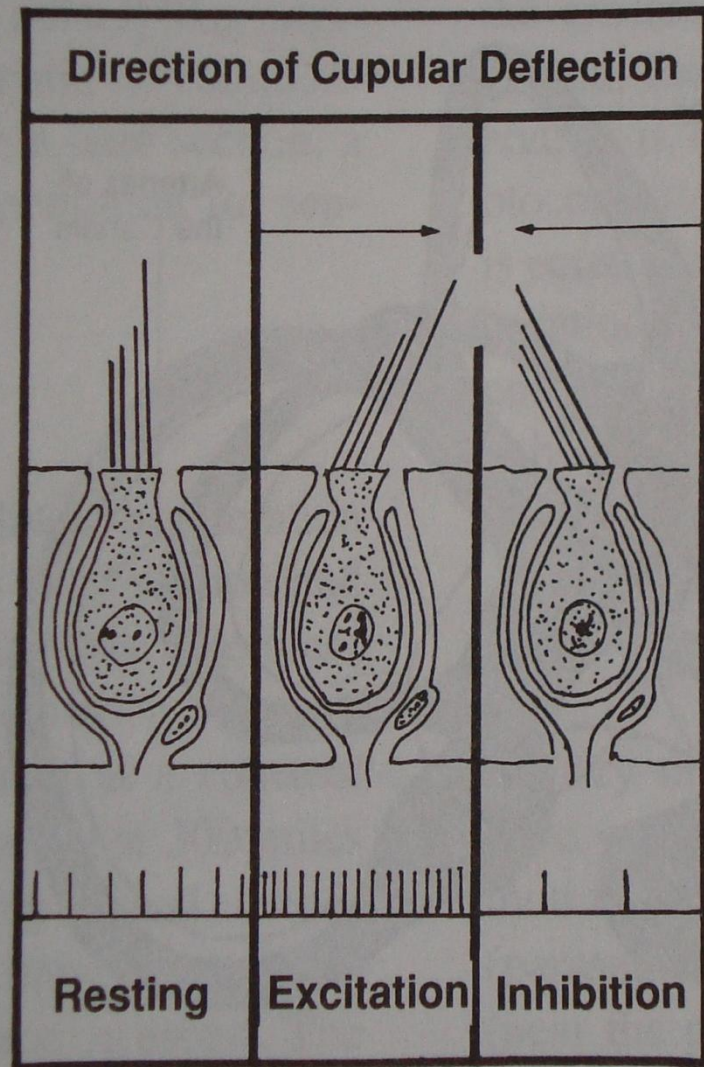
Membranous Labyrinth

- Suspended within bony labyrinth by perilymphatic fluid and supportive connective tissue.
- Contains 5 sensory organs, the membranous portions of 3 SCCs and 2 otolith organs, the utricle and saccule.
- One end of each SCC is widened in diameter to form the ampulla.
- Filled with endolymph, has high K:Na ratio.
- Normally, no connections exist with perilymph and endolymph compartments.

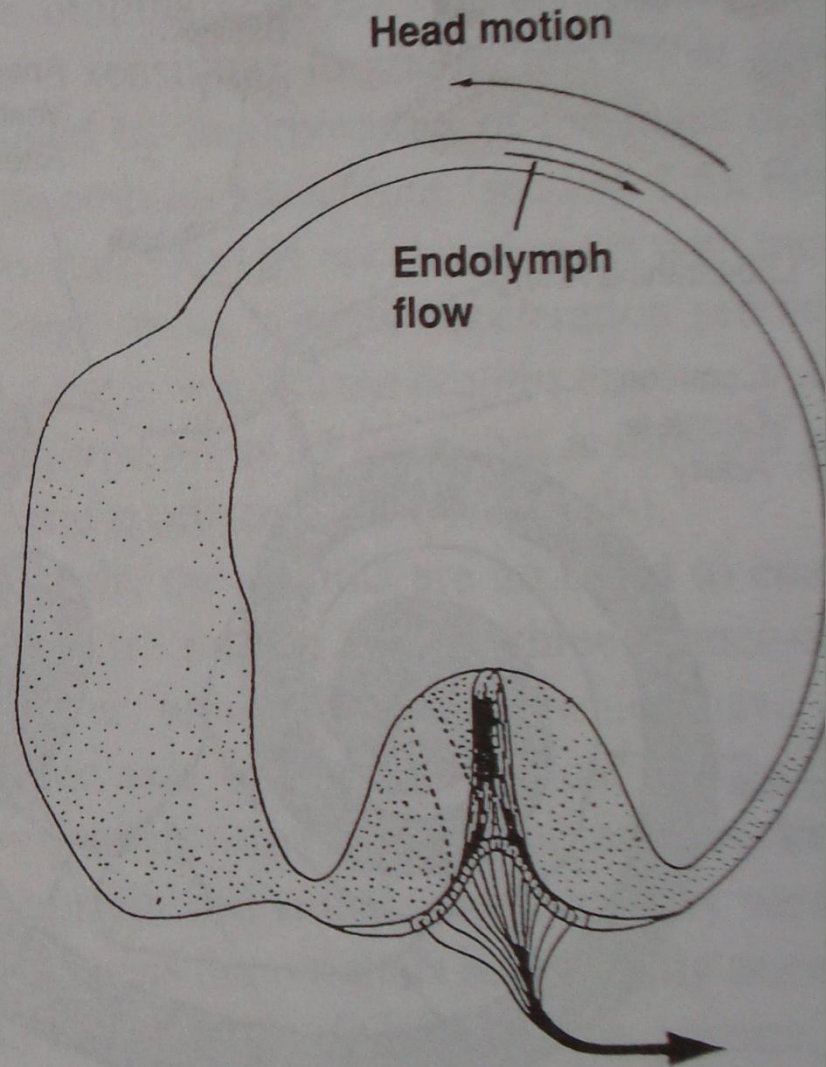
Hair Cells

- Biological sensors that convert displacement due to head motion in to neural firing.
- Hair cells of ampullae rest on a tuft of blood vessels, nerve fibers, and supporting tissue called crista ampullaris.
- Hair cells of Utricle & saccule, the maculae are located in the medial wall of the saccule and floor of the utricle.
- Each hair cell is located by an afferent neuron located in the vestibular ganglion.

- When hairs are bent towards or away from the longest process of hair cell, firing rate increases or decreases in the vestibular nerve.
- Cupula seals the ampulla from the adjacent vestibule.
- Endolymphatic pressure differentials across the cupula cause them to bend forth and back, stimulating hair cells.
- Otolith membranes contain otoconia and have more mass than the cupulae.
- This mass enables them to be sensitive to gravity and linear acceleration.
- In contrast, Cupulae normally have the same density as surrounding endolymphatic fluid and are insensitive to gravity.



A



B

Physiology of the Periphery

- Hair cells convert mechanical energy generated by head motion in to neural discharges directed to brain stem and cerebellum.
- By virtue of their orientation, the canals and otolith organs are able to respond selectively to head motion in particular directions.
- By virtue of differences in their fluid mechanics, the canals respond to angular velocity, and the otoliths to linear acceleration.

Semicircular Canals

- Provide sensory input about head velocity, which enables the VOR to generate an eye movement to the velocity of head movement - CLEAR VISION.
- Neural firing is proportional to head velocity (0.5 -7 Hz) – RATE SENSORS.
- During prolonged rotation at constant velocity, output decays exponentially at 7 seconds due to a spring like action of the cupula that tends to restore it to its resting position.
- Spatial arrangements characterize the alignment of SCC loops.

- Each canal plane within each labyrinth is perpendicular to the other canal planes.
- Paired planes of the SCCs conform very close to one another.
- The six individual SCCs become the following 3 coplanar pairs: 1) right and left lateral 2) left anterior and right posterior 3) left posterior and right anterior.
- Planes of canals are close to planes of the extraocular muscles, allowing relatively simple connections between sensory neurons of individual canals and motor output neurons of eye muscles.
- Coplanar pairing of canals is associated with a push-pull change in quantity of SCC output. For lateral canals, ampullopetal flow is excitatory.
- Advantages: 1) Sensory redundancy 2) Common mode rejection 3) Sensory overload

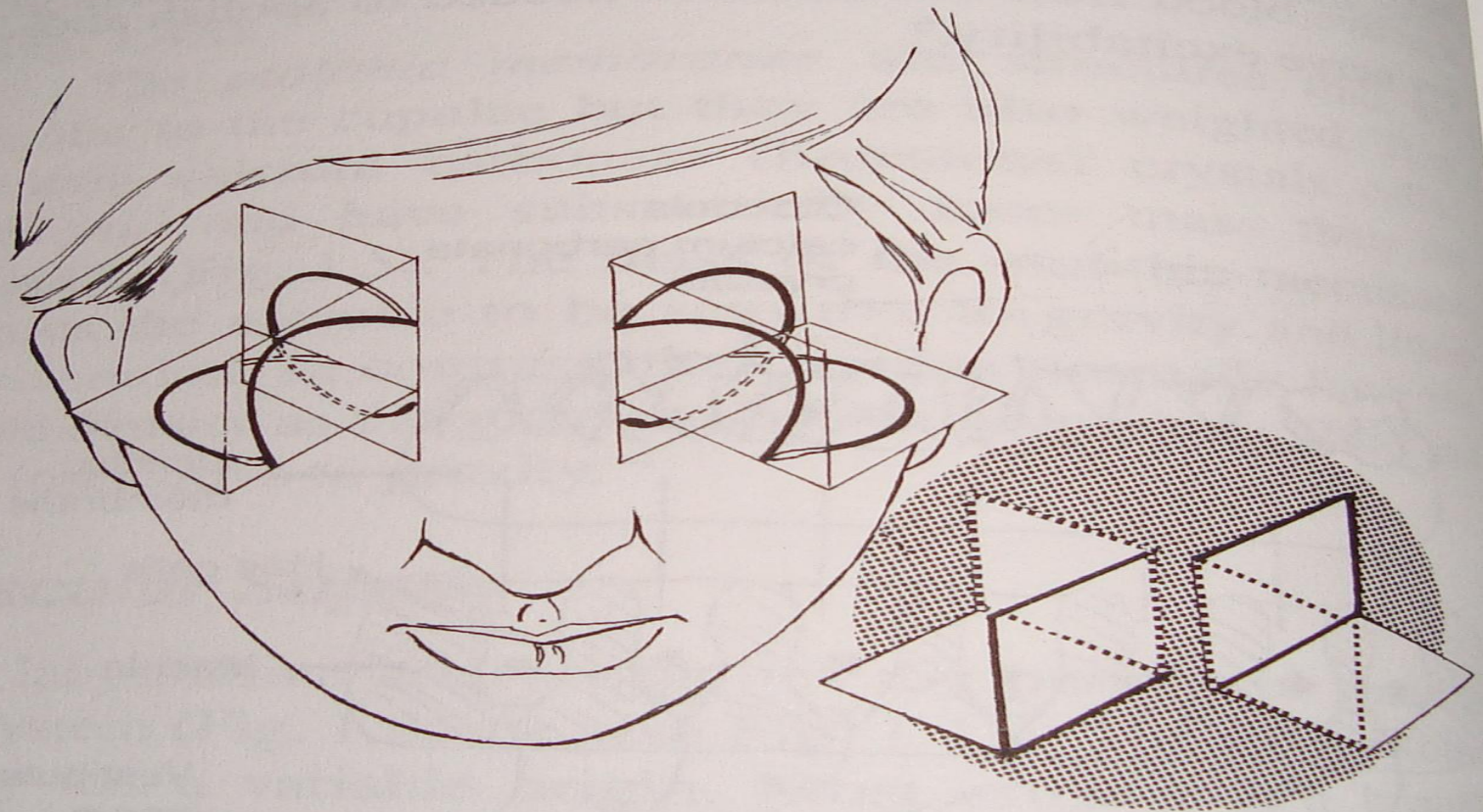


Figure 1.7 The spatial arrangement of the semicircular canals. The canals on each side are mutually perpendicular, are paired with conjugate canals on the opposite side of the head, and also are closely aligned with the optimal pulling directions of the extraocular muscles.

Otoliths

- Respond to linear head motion and static tilt with respect to gravitational axis.
- Differ from SCC in that otoliths respond to linear motion and acceleration.
- Need no special hydrodynamic system.
- Acceleration produces enough shearing force to make them extremely sensitive.
- Arranged to enable them to respond to motion in all 3 dimensions.
- In an upright individual, saccule is vertical(parasaggital) , whereas utricle is horizontally oriented (near the plane of lateral SCCs)

- Saccule sense the orientation along the occipitocaudal axis as well as in the A-P axis.
- Utricle senses the acceleration along the intraaural axis as well as A-P axis.
- There is redundancy in the otoliths with push –pull processing.
- A curving zone called the striola separates the direction of hair – cell polarization of each side.

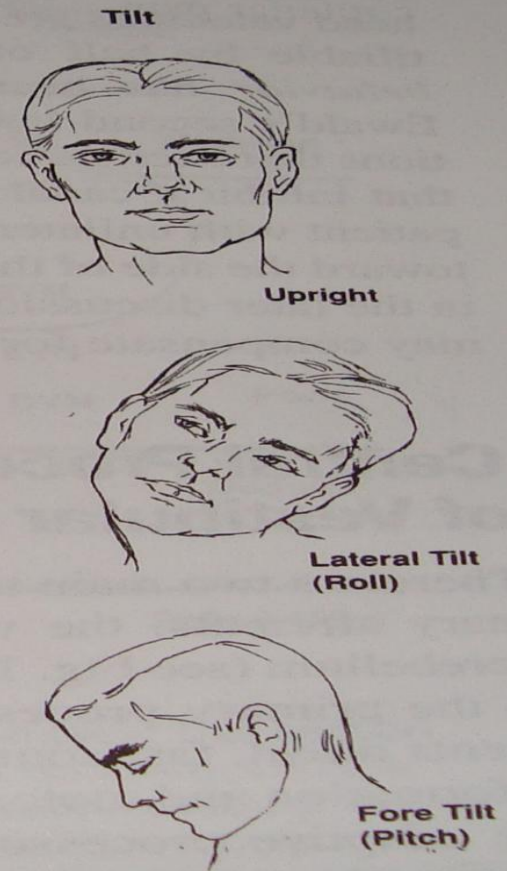
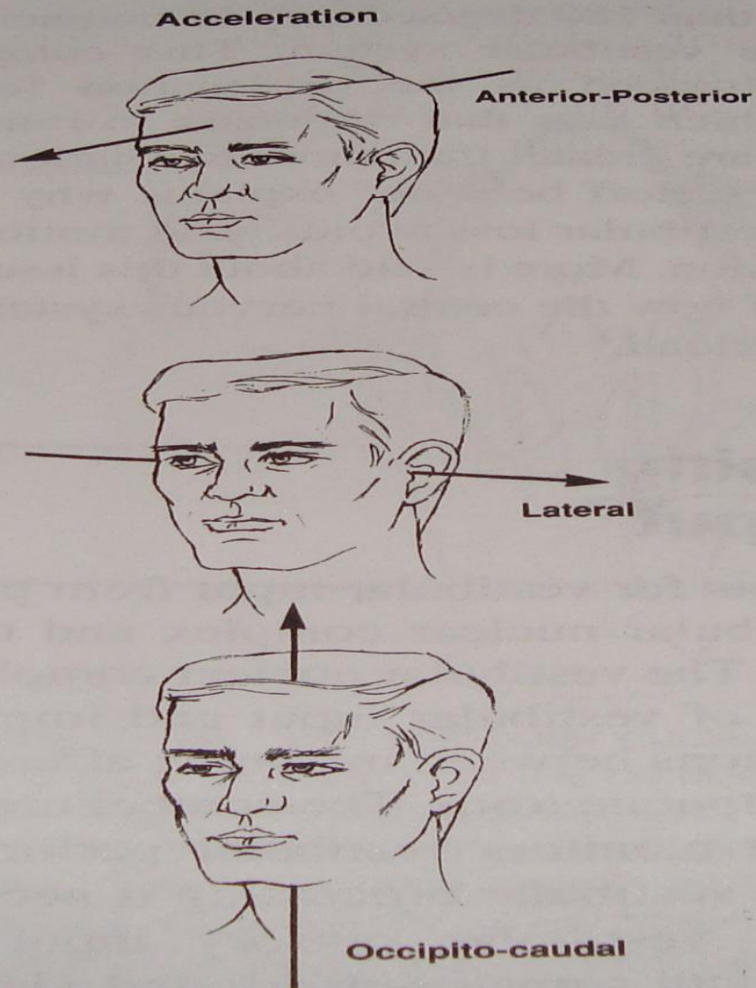


Figure 1.8 The otoliths register linear acceleration and static tilt.

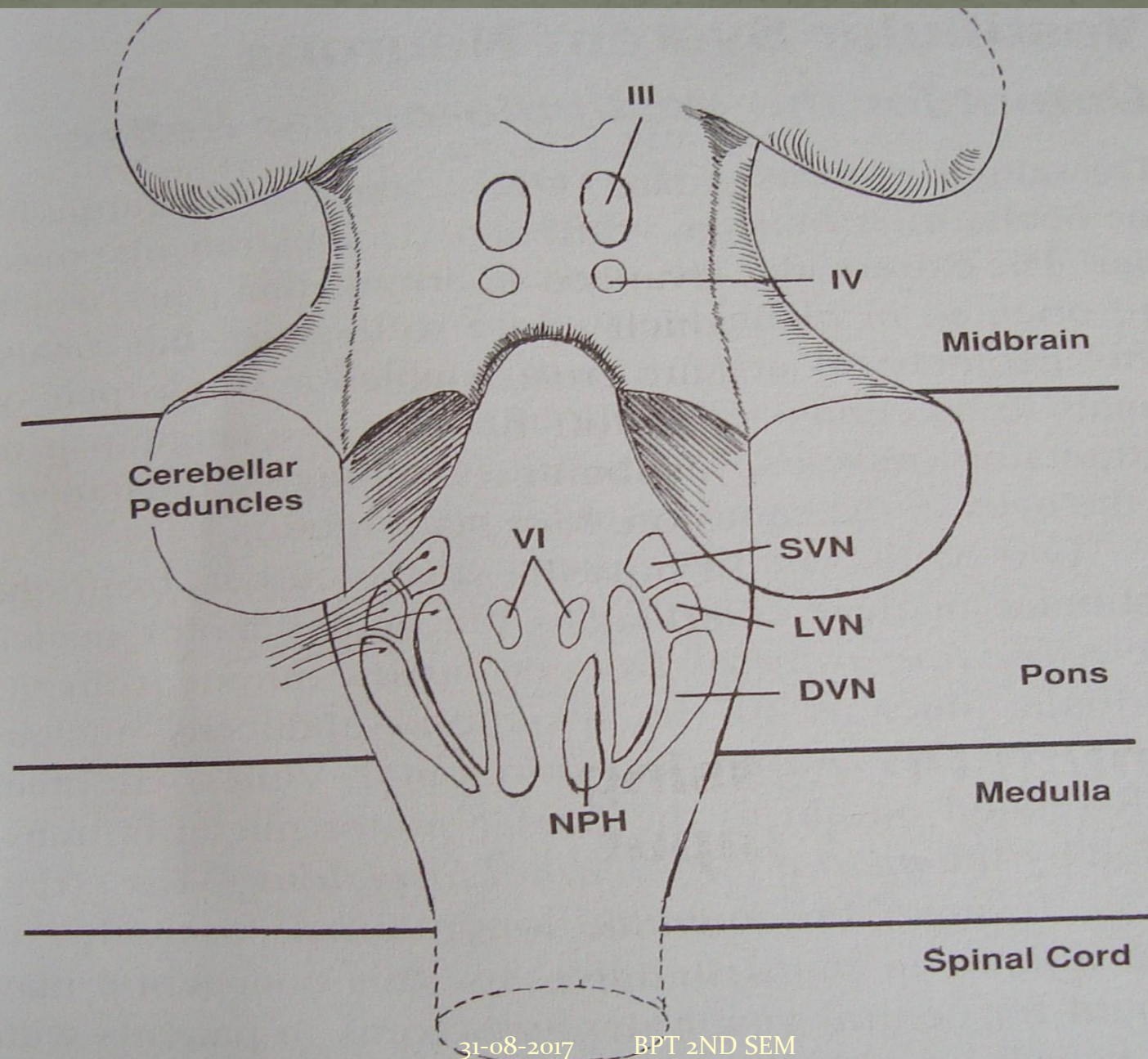
Central Connections

- There are 2 main targets for vestibular input from Primary afferents : the Vestibular nuclear complex and the Cerebellum.
- The vestibular nucleus complex is the primary processor of vestibular input and implements direct, fast connections between incoming afferent information and motor output neurons.
- The cerebellum is the adaptive processor.
- At both locations, vestibular sensory input is processed in association with somatosensory and visual sensory input.

Vestibular Nucleus

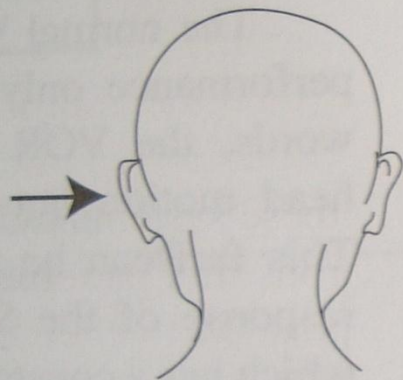
- The vestibular nuclear complex consists of 4 major and 7 minor nuclei.
- Located primarily in the pons, extending to the medulla.
- The 4 vestibular (Scarpa's) nuclei are located in the floor of medulla. (lateral, medial, superior & inferior nuclei)
- A portion of receptors goes in to the cerebellum, reticular formation, thalamus and cerebral cortex.
- The vestibular nuclei between 2 sides are laced together by commissures that are mutually inhibitory.
- Commissures allow sharing of information and push – pull mechanism.

- The lateral nucleus receives inputs from utricle, semicircular canals, cerebellum and the spinal cord. Output to the lateral vestibulospinal tract & vestibulo-ocular tracts.
- Inputs to the medial and superior nuclei from the semicircular canals. Output to the MVST & to the motor nuclei of eye muscles.
- Inputs to the inferior vestibular nuclei from the semicircular canals, utricle, saccule and cerebellar vermis. Outputs to the vestibulospinal and vestibuloreticular tracts.
- Ascending information to the oculomotor complex responsible for VOR.
- Vestibular apparatus has static and dynamic functions.



Benign Paroxysmal Positional Vertigo

DIRECTION OF VIEW
STRAIGHT LATERAL



POSTERIOR
SEMI-CIRCULAR CANAL

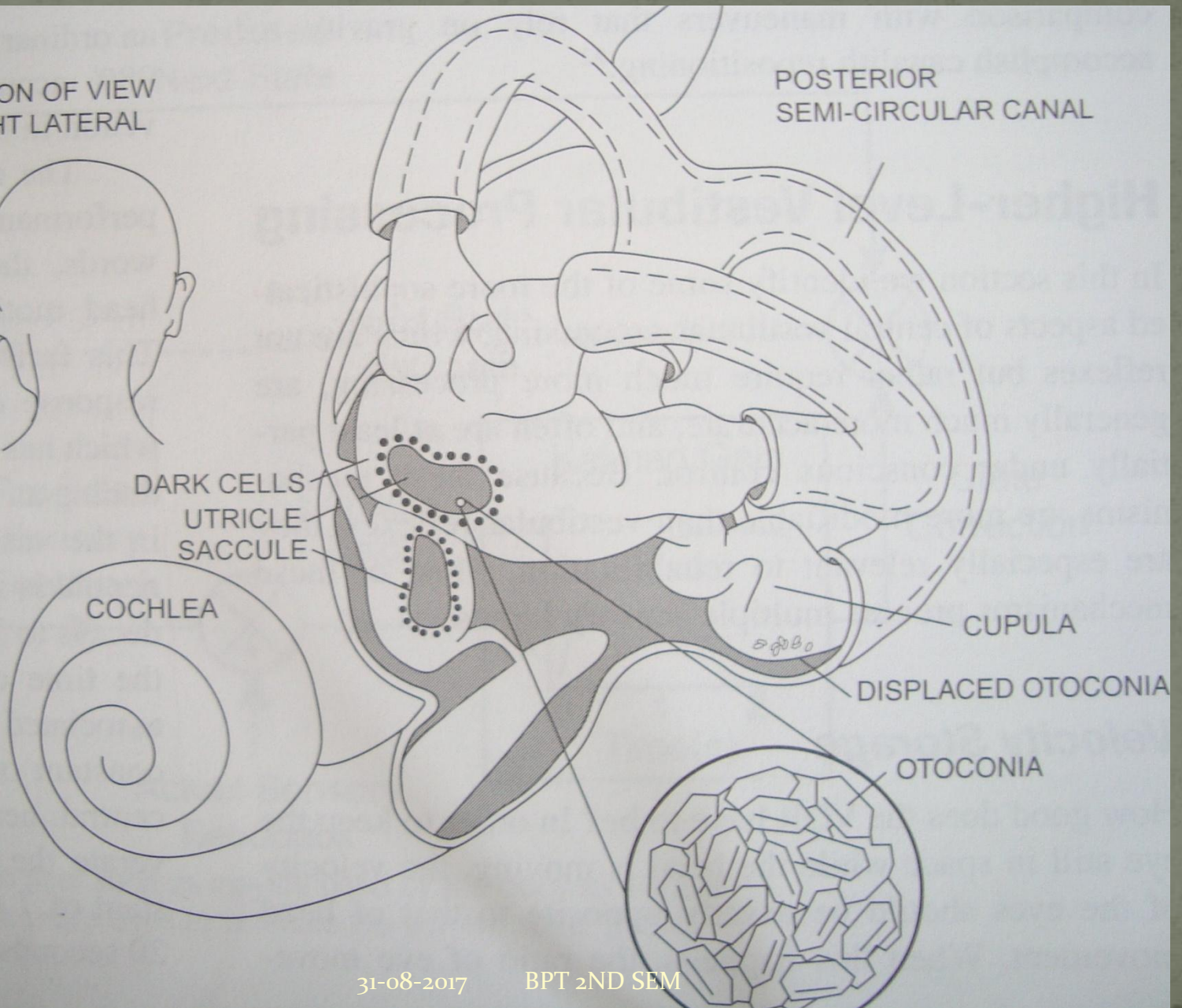
DARK CELLS
UTRICLE
SACCULE

COCHLEA

CUPULA

DISPLACED OTOCONIA

OTOCONIA



Characteristic Story

- Turn head
- After a few seconds delay, vertigo occurs
- Resolves within 1 minute if you don't move
- If you turn your head back, vertigo recurs in the opposite direction

Dissecting the acronym “**BPPV**”

- “B” = Benign
- Not a brain tumor
- Can be severe and disabling.

Dissecting the acronym “B**P**PV”

- “P” = Paroxysmal
- Episodic, not persistent
- Helpful feature in the differential diagnosis

Dissecting the acronym “BPPV”

- “P” = Positional
- Occurs with position of head
- Turning over in bed
- Looking up
- Bending over

Dissecting the acronym “BPPV”

- “V” = Vertigo
- An illusion of motion
- “The room is spinning”
- Other descriptions
- Rocking
- Tilting
- Somersaulting
- Descending in an elevator

Vertigo

Peripheral

- CN VIII
- Vestibular apparatus

Central

- Brain stem
- Vestibular nuclei in medulla and pons
- Cerebellum

Vertigo

Peripheral

Central

<i>Onset</i>	<i>Sudden</i>	<i>Slow, gradual</i>
Intensity	Severe	Ill defined
Duration	Paroxysmal	Constant
Nausea / Diaphoresis	Frequent	Infrequent
CNS signs	Absent	Usually present
Tinnitus /Hearing loss	Can be present	Absent
Nystagmus	Torsional / Horizontal	Vertical
Nystagmus	Fatigable	Non- fatigable

Physiology

- Normal situation
- As one turns head to the right
- Endolymph moves SCC → receptors fire → “head turning right”
- Stop turning head → endolymph stops moving → SCC receptors stop firing → “head has stopped moving”

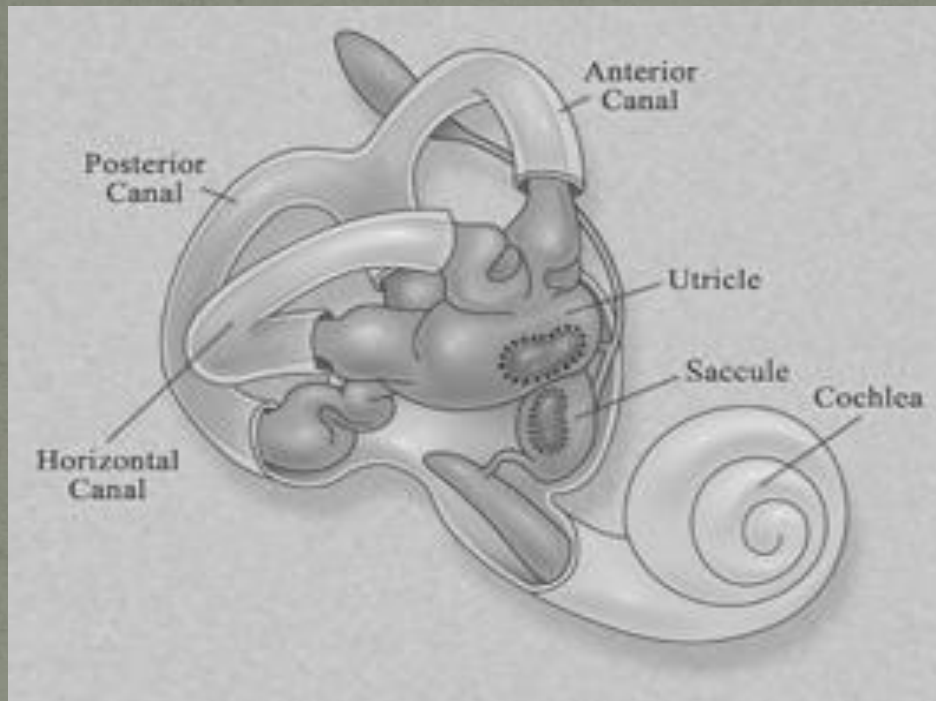
Neurophysiology of BPPV

- BPPV caused by canalithiasis or cupulolithiasis.
- Vertigo and nystagmus begin after a characteristic latency of 5 seconds. This delay is because the pressure caused by moving otoconia is negligible until it enters the narrow duct of SCC.
- Typical otoconia move at a rate of .2mm/sec under the influence of 1 gm of gravity.

Pathophysiology of BPPV

- Stop turning head → *otoliths keep moving* → drag endolymph → receptors continue to fire inappropriately → “head is still moving”
- Eyes → “head is NOT moving”
- Brain → room must be spinning in the opposite direction

BPPV Variants



Ewald's first law: eye movements occur in the plane of the canal being stimulated. Three canals → three vectors.

- Posterior canal
- Lateral canal
- Anterior canal

Mixed Canal Variant BPPV

- Debris in more than one canal
- Signature – Nystagmus reverts over time (i.e. starts posterior, changes to horizontal).

Vector of Nystagmus tells the variant of BPPV (and the treatment)

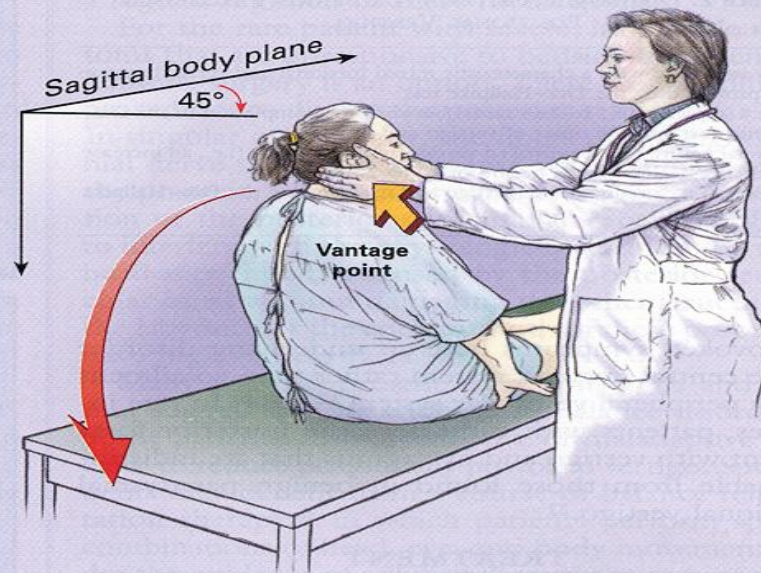
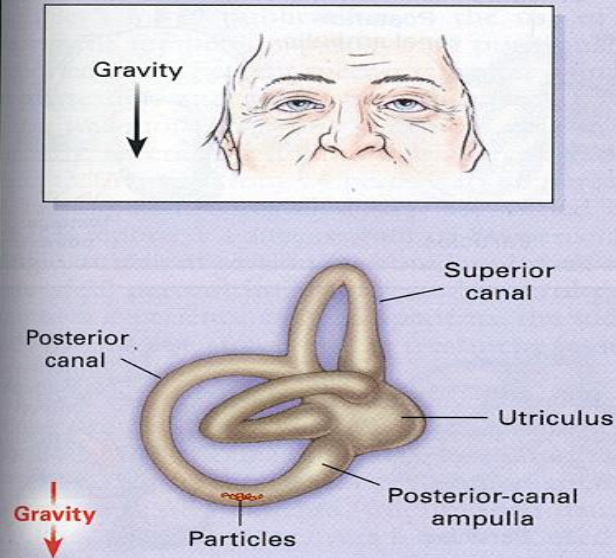
- PC – Upbeating or Torsion
- AC - Downbeating with/wo Torsion
 - LC - Horizontal

Dix – Hallpike Maneuver

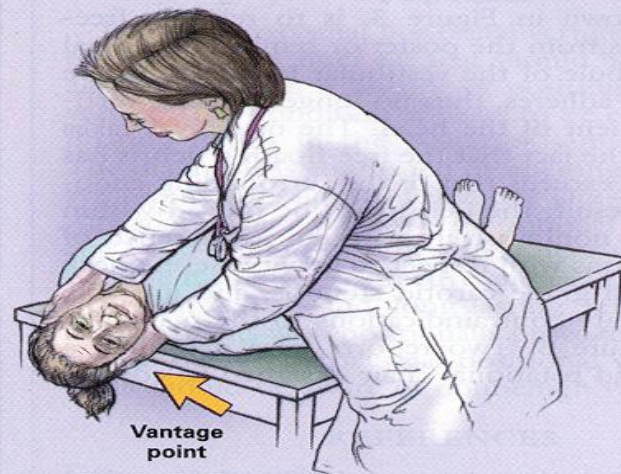
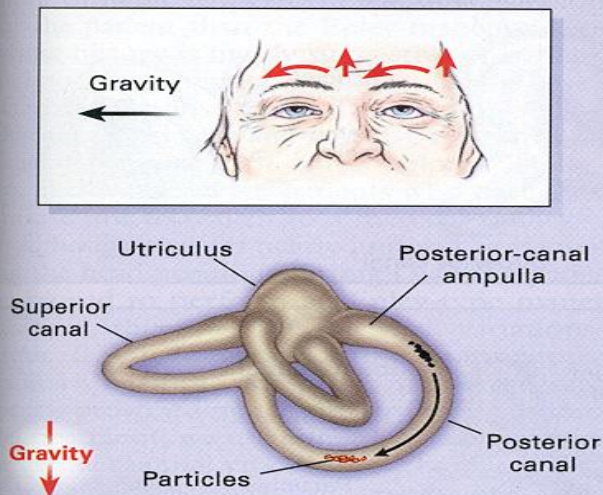
6 Ds

1. Delay seconds latency
2. Downward (Geotropic)
3. Duration <1 minute
4. Directional change
5. Dizziness (Subjective)
6. Disappear fatigable

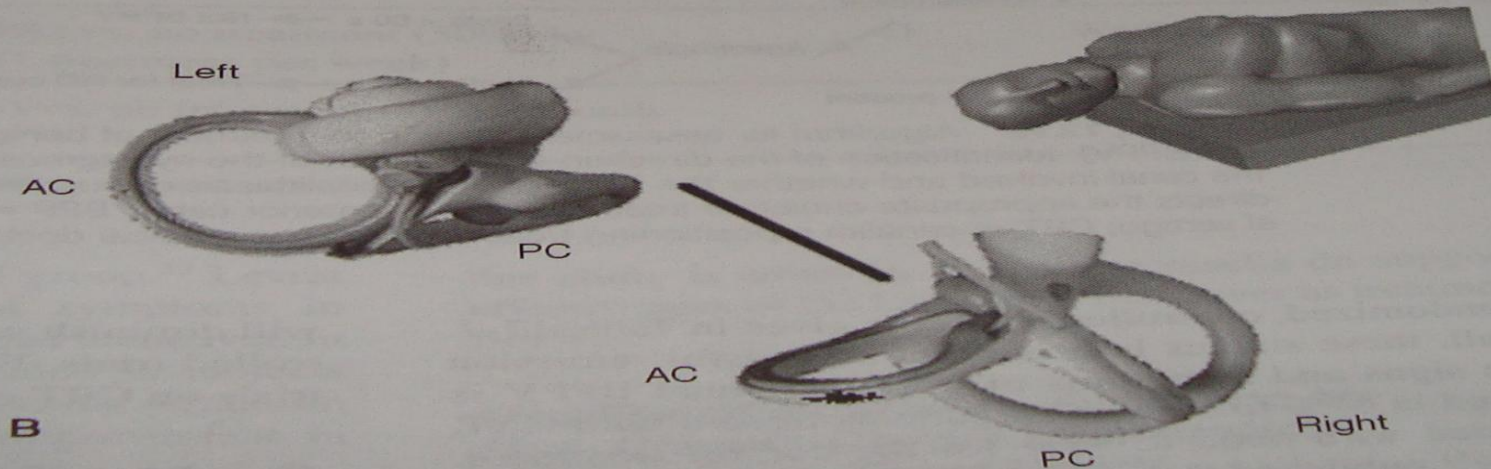
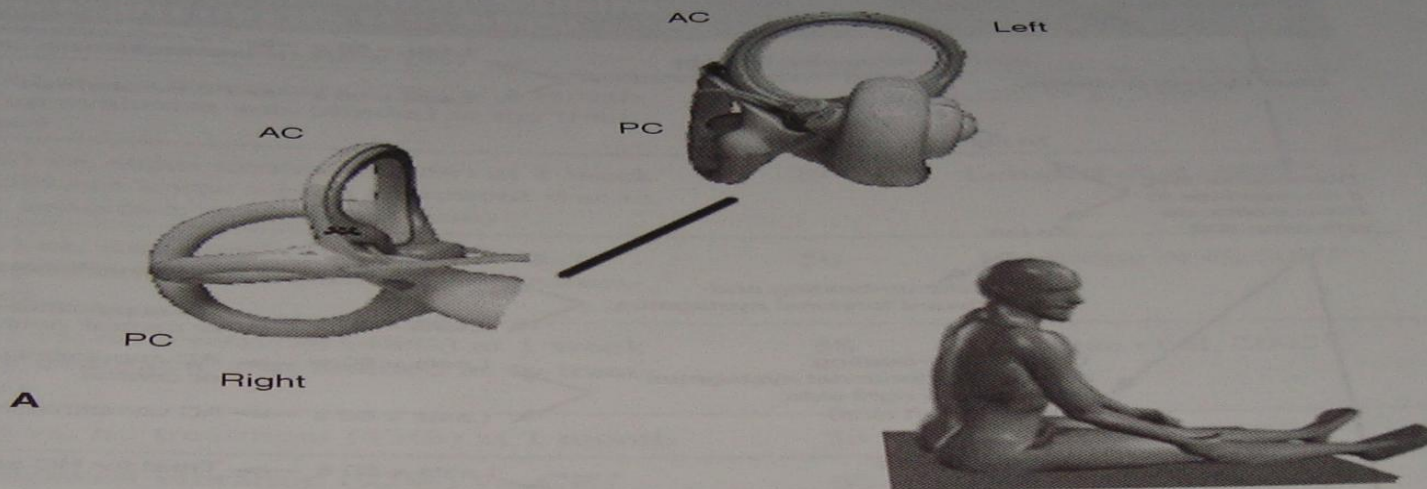
A



B



- Also called as Barany / Nylen –Barany maneuver.
- In sitting position patients head is turned 45 degrees horizontally.
- The patient then quickly lies down with the head hanging over the edge of treatment table approximately 30 degrees below horizontal.
- This maneuver places the posterior canal and the anterior canal on the downside ear in the plane of gravity.
- The patient needs to be placed for a period of 30 seconds for Nystagmus and vertigo to occur.
- Patient can be brought back slowly to the sitting position, which may result in vertigo.
- The test can be repeated with the head turned towards the opposite side.



Identification of canal involvement

Canal	Right Hallpike – Dix test	Reversal Phase	Return to sitting
Right Posterior	Upbeating and right upward torsional	Downbeating and leftward torsional	Downbeating and leftward torsional
Right anterior	Downbeating and rightward torsional	Upbeating and leftward torsional	Upbeating and leftward torsional
Left anterior	Downbeating and leftward torsional	Upbeating and rightward torsional	Upbeating and rightward torsional

Side- Lying Test

- Can be used inpatients who cannot extend the head sufficiently.
- Patient sits on the side of treatment table.
- Patient head 45 degrees to one side, and the patient lies down on the opposite side.
- This maneuver places the posterior canal and the anterior canal on the downside ear in the plane of gravity.
- Patient returns to sitting position.
- The test can be repeated to the opposite side, if there is no vertigo in sitting.

Roll Test

- For patients with horizontal canal problems.
- Patient lies supine with the head flexed to 20 deg.
- Head is rolled to one side and kept for 1 minute.
- The head in slight flexion is rolled back to midline and quickly rolled to the opposite side.
- Vertigo and Nystagmus occurs in both rotations.
- The slow-phase eye velocity, duration of Nystagmus and patients subjective complaint are worse when head is turned towards affected ear.
- Nystagmus is geotropic and fatigable in canalithiasis, while apogeotropic and persistent in cupulolithiasis.

Test Series

- Assuming a patient complaints of vertigo, when lying on right side, The test series is as follows:
 1. Perform Dix – Hallpike test on left side.
 2. Perform Dix – Hallpike test on right side.
 3. If patient has no vertigo: Before sitting the patient up from the right side, perform roll test by having the patient turn head quickly to left.
 4. After 30 seconds, quickly turn the patient's head back to right.
 5. After 30 seconds, have the patient sit up.
- If symptoms occur at any point of testing, stop the test and treat patient.

Treatment for BPPV

Semicircular canal involved	Severe Canalithiasis	Mild Canalithiasis	Cupulolithiasis
Posterior	<ul style="list-style-type: none"> •CRT •Liberatory maneuver •Brandt – Daroff exercises 	<ul style="list-style-type: none"> •Brandt – Daroff exercises •CRT •Liberatory maneuver 	<ul style="list-style-type: none"> •Liberatory maneuver •Brandt – Daroff exercises
Anterior	<ul style="list-style-type: none"> •CRT •Liberatory maneuver •Brandt – Daroff exercises 	<ul style="list-style-type: none"> •Brandt – Daroff exercises •CRT •Liberatory maneuver 	<ul style="list-style-type: none"> •Liberatory maneuver •Brandt – Daroff exercises
Horizontal	<ul style="list-style-type: none"> • Bar –B – Que roll treatment •Forced prolonged position 	<ul style="list-style-type: none"> • Bar –B – Que roll treatment •Forced prolonged position 	<ul style="list-style-type: none"> • Bar –B – Que roll treatment

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BPT 2ND SEM

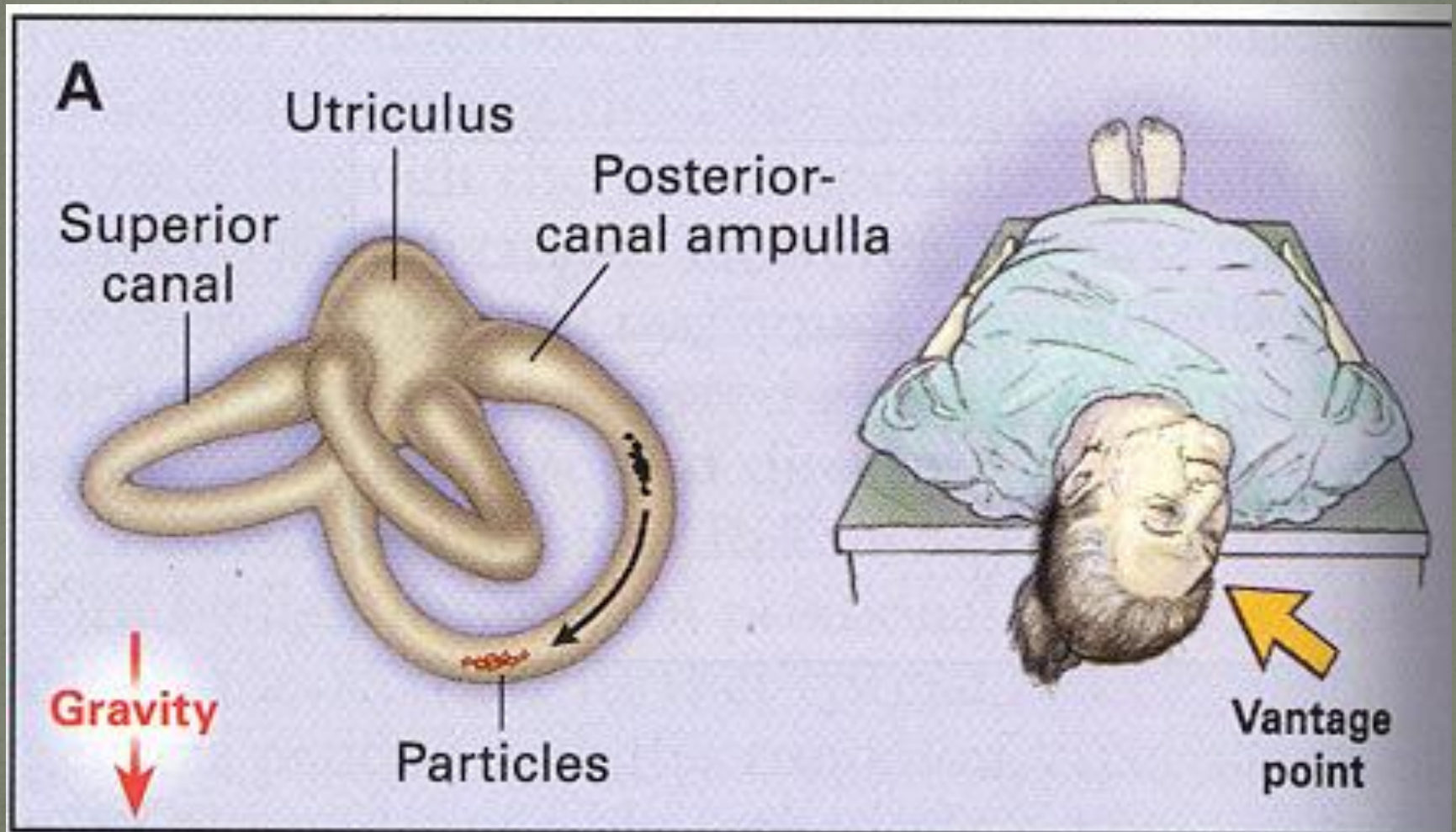


Epley maneuver

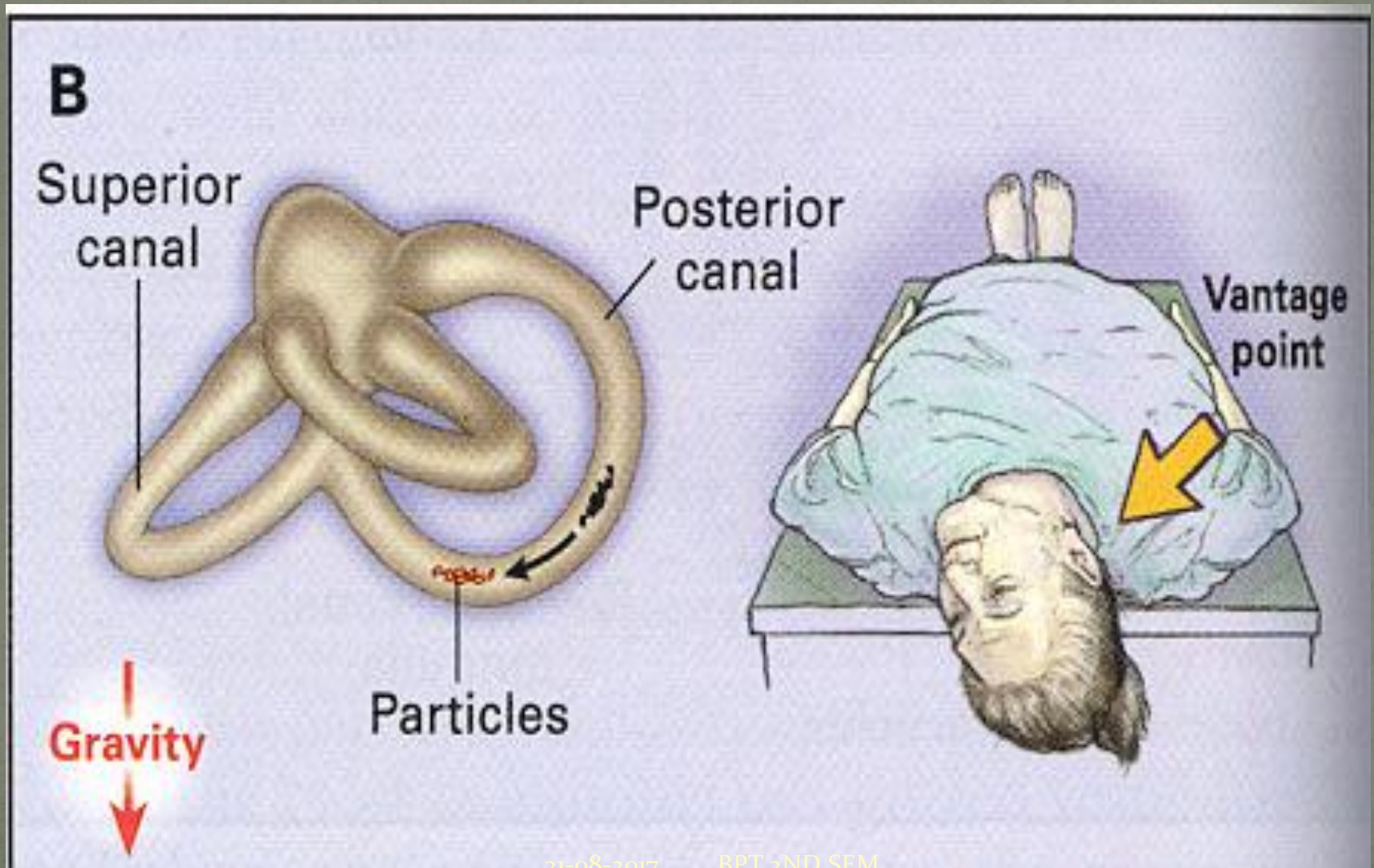
Dr. John M. Epley 1980

- Canalolith Repositioning
- Canalith debris → vestibule
- Single treatment = 95% remission

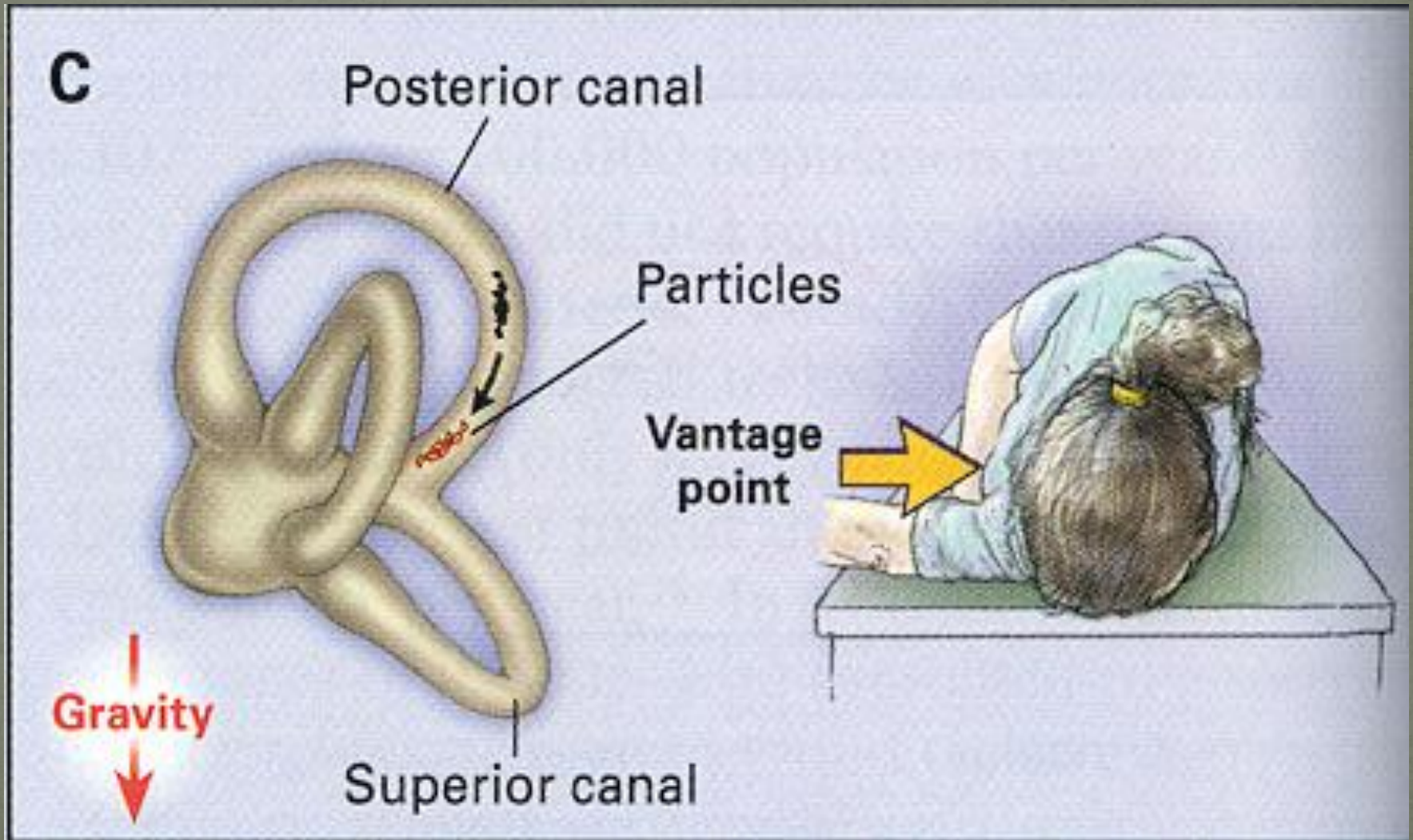
Reclined head hanging 45 degree turn



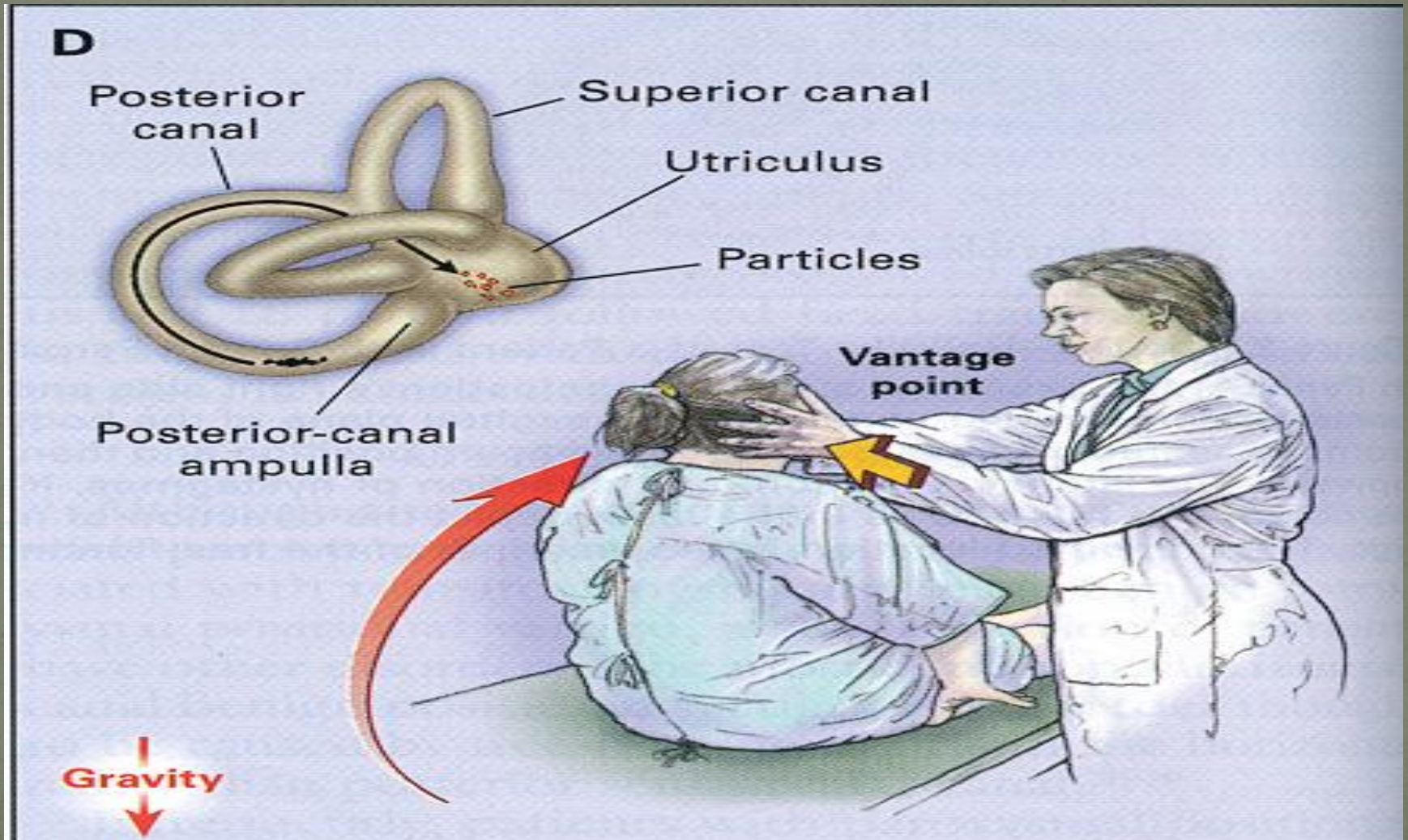
Rotate 45 degrees contralateral



Head and body rotated to 135 degrees from supine



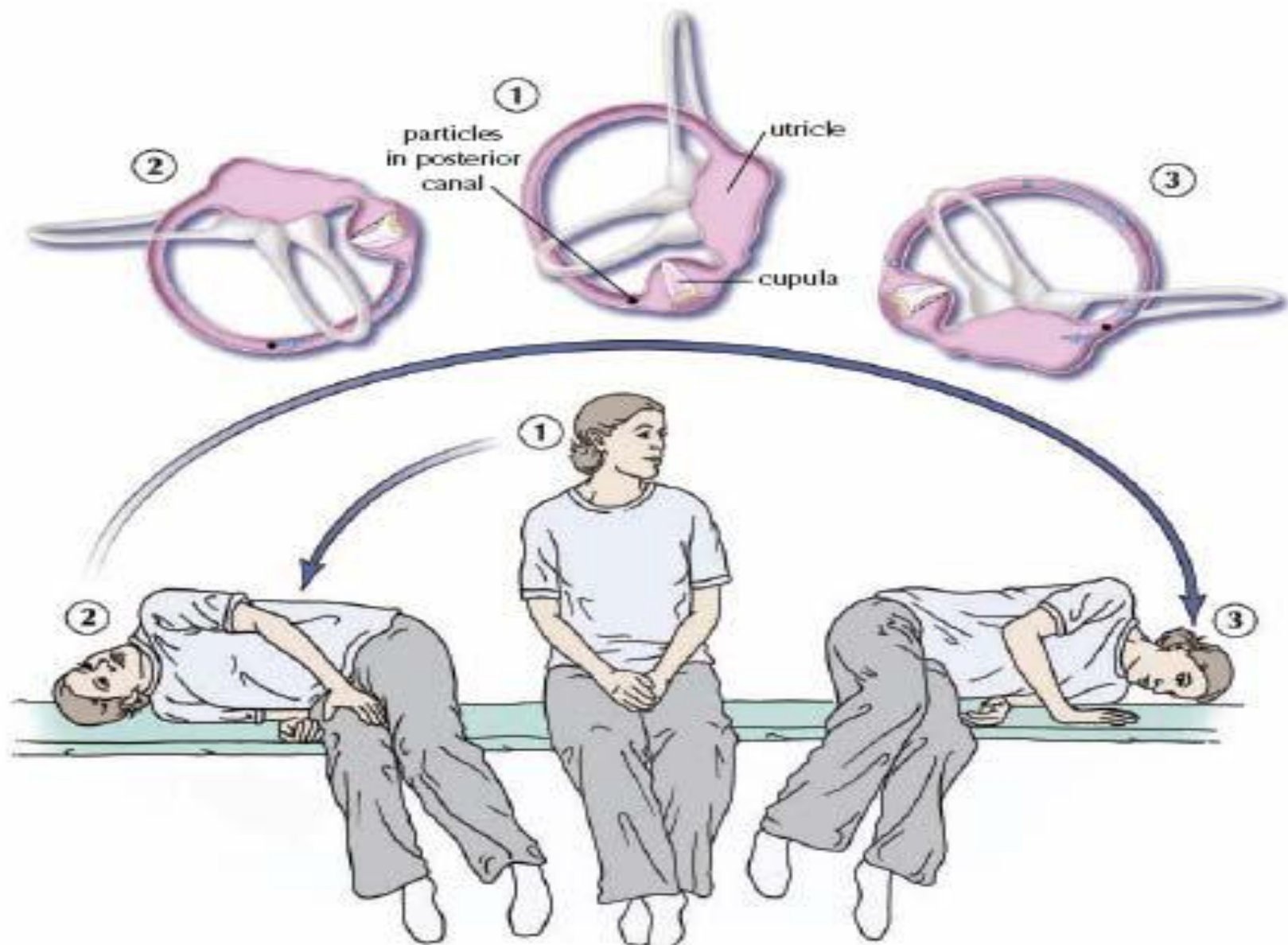
- Keep head turn and to sitting
- Turn forward chin down 20 degrees



The Liberatory maneuver

- Single treatment approach.
- Developed by Semont and associates.
- Assuming BPPV in right posterior canal:
 1. Patient told to sit sideways on table, and the therapist turns the head 45 deg. to left.
 2. Patient quickly moves to the right side while keeping the head turned to left; patient stays there for 2-3 minutes.
 3. Patient is then rapidly moved up through sitting position and down in the opposite side-lying position, as the therapist maintaining the alignment of head and neck. Final position will have the patient lying with the face at a 45 deg. Angle towards table.

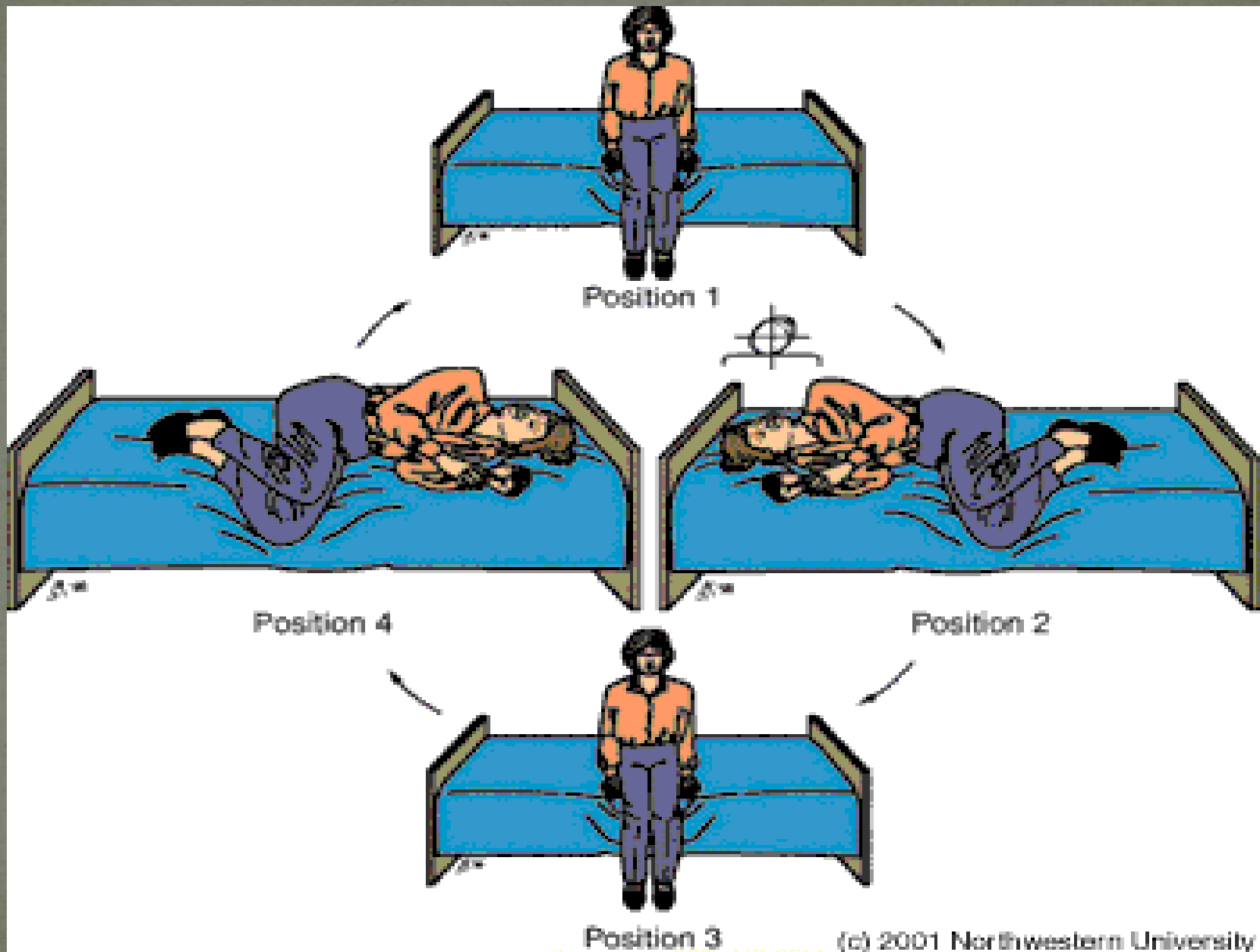
4. Typically, Nystagmus and vertigo appear in the second position. If patient does not experience, head is abruptly shaken once or twice, through a small amplitude, to free the debris. Patient stays for 5 minutes.
5. Patient then slowly moves in to a seated position.
 - Patients must remain in a vertical position for 48 hours (including sleeping) and must avoid the provoking position for 1 week.



Brandt – Daroff Habituation exercises

- Requires the patient to move in to the provoking position repeatedly several times a day.
- Performed as follows:
 1. Patient sits over the edge of the table and turns his/her head 45 deg. Toward the side that is symptom free and then is moved rapidly into the sidelying position that causes vertigo. A torsional and upbeatting nystagmus occurs with the onset of vertigo. Severity directly related to speed of patient movement in to the provoking position.

2. Patient stays in that position until the vertigo stops and then sits up again. Moving to the sitting position also results in vertigo, although less severe and of a shorter duration. Nystagmus, if occurs, will be in opposite direction.
3. Patient remains in the upright position for 30 seconds, turns his / her head 45 deg. to the opposite direction and rapidly moves in to the mirror- image position on the other side. Stays there for 30 seconds and sits up.
4. Patient repeats the entire maneuver till vertigo diminishes.
5. Entire sequence is repeated every 3 hours until patient has 2 consecutive days without vertigo.



CRP vs Semont Maneuver

- Efficacy is the same for CRP and Semont Maneuver.
- A comparison of the position of the head during the CRP and Semont Maneuver illustrates that the maneuvers are nearly the same.

A

Step 1



Step 2



Step 3



Step 4



Step 5



B

Step 1



Step 2



Step 3

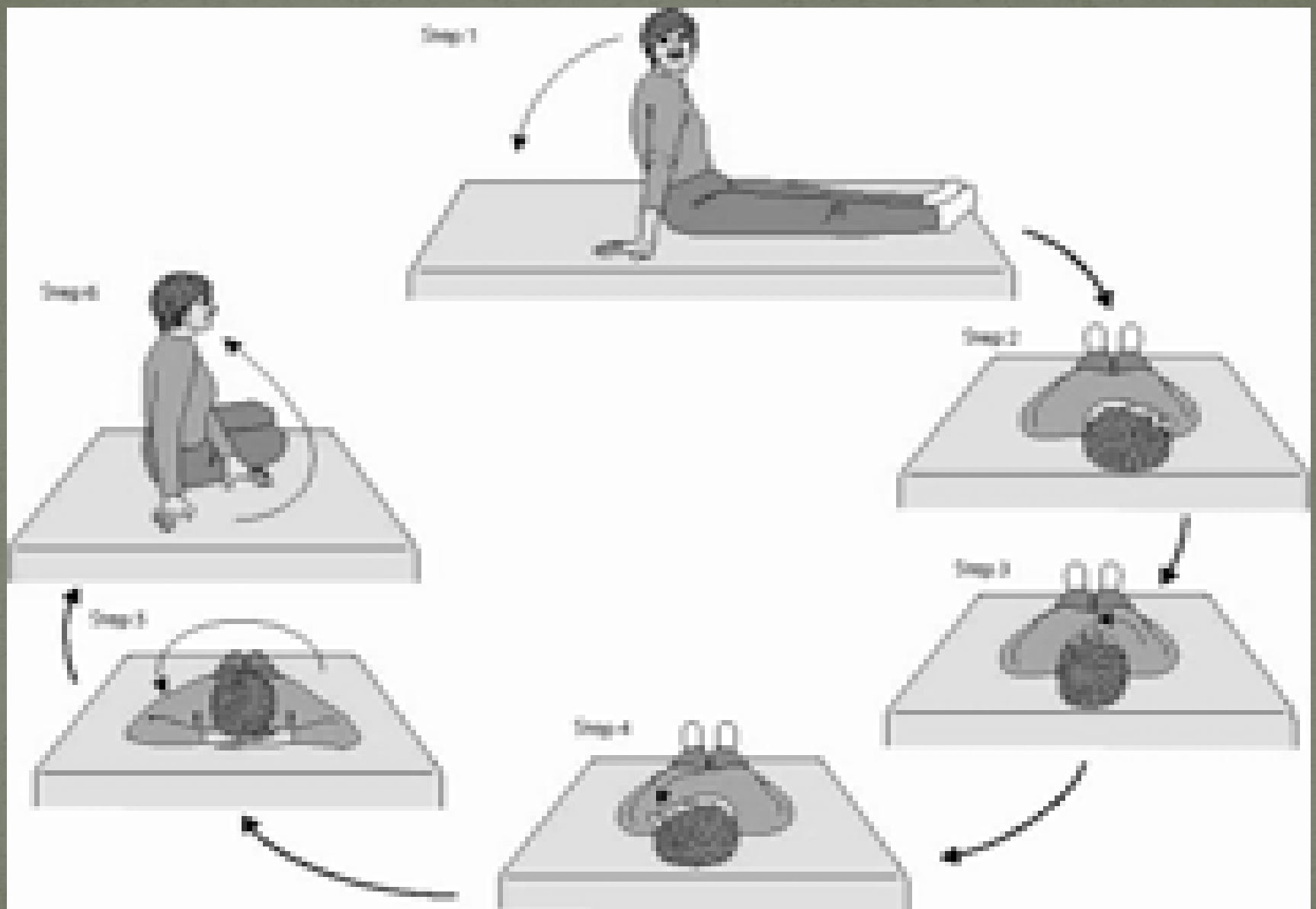


Step 4



Bar –B- Que Roll treatment

- Patient lies on his/ her back on the bed with the affected ear down.
- Patient moves from one position to another with the clinicians assistance as follows:
 1. Patients head slowly rolls away from the affected ear until the face is pointed up; this position is held for about 15 seconds, or until dizziness stops.
 2. Patient continues to roll the head in the same direction until the affected ear is up; this position is held for about 15 seconds, or until dizziness stops.
 3. Patient rolls the head and body in the same direction until face is down.
 4. After 15 seconds, patient slowly sits up, keeping head level or pitched down 30 deg.



Forced Prolonged Position

- Patient lies on the ear that contains the debris for 20 seconds
- Slowly rolls towards the healthy ear until the healthy ear is down.
- Patient remains in that position all night.
- Can be combined with the bar – b – que treatment, by having the patient perform the bar – b – que treatment the night before.

What differentiates BPPV from labyrinthitis and vestibular neuritis (VN)?

BPPV

- Requires head movement
- Duration of seconds
- Usually in elderly
- No relation to viral syndrome
- Responds to Epley maneuver

Labyrinthitis/VN

- No head movement needed
- Duration of hours/days
- Any age
- Viral syndrome usually precedes
- Epley maneuver is ineffective