Quiz 2, Thursday, February 28

Chapter 5: orbital geometry (all the Laws for ocular motility, muscle planes)

Chapter 6: muscle force mechanics- Hooke’s law

Chapter 7: final common pathway- III, IV, VI

Chapter 9: Pre-motor sites and interconnections.
   riMLF (vertical), PPRF (horizontal saccades)
   VI (horizontal binocular yoking)
   MLF & MLF lesions and disorders
1. Oculomotor Ophthalmoplegia
2. Abducens palsy
3. Unilateral INO (InterNuclear Ophthalmoplegia)
4. One and a Half Syndrome
5. Foville's Syndrome (Posterior INO)
Vestibular system- the sixth sense
Static senses head orientation- Otoliths
Dynamic senses head rotation- Canals

Evolution of the vestibular system (the sixth sense) from the lateral line of fish.

Cochlea (high frequency)
Otoliths (low frequency)
Canals (mid frequency)

**Common disorders:**
Benign Positional Vertigo: Meniere’s syndrome
Story about Jack Crawford
VOR holds gaze steady

\[ \text{EYE}_{\text{space}} = \text{EYE}_{\text{orbit}} + \text{HEAD}_{\text{space}} \]
Vestibular System components

- Sup. Semicircular Canal
- Ampulla
- Post. Semicircular Canal
- Horizontal Semicircular Canal
- Utriculus
- Sacculus
- Ampulla

Membranous labyrinth
Semicircular Canal detail

Utricular sac of vestibule

Crista ampullaris

Relative endolymph motion

Cupula

Ampulla

To CNS
Cupula
VOR- 3 synapses
  bipolar cells
  Vestibular nuclei
  Motor neurons III and IV
Short latency- 16 msec
Bipolar Cells

- Receptor
- I. Neuron
- Depolarization
- Hyperpol.
- Action potential
- Potential
Horizontal VOR
Angle at which the plane of the anterior semicircular duct crosses the midsagittal line.
Canal planes

A

Left and right LC

30°

B

Right PC
Left PC
Left AC
Right AC
Canals & Muscle Planes

Rabbit

Cat

midsagittal plane

optic axis

extracocular muscle planes:
vertical recti
horizontal recti
obliques

semicircular canal planes:
  anterior
  horizontal
  posterior

earth horizontal plane

midsagittal plane

extracocular muscle planes:
vertical recti
horizontal recti
obliques

semicircular canal planes:
  anterior
  horizontal
  posterior

earth horizontal plane
Canal-muscle pairings during head rotation

- LHC
- LMR
- LAC
- RIO, LSR
- RIR, LSO
- LPC
Calcium Carbonate Crystals

Otoliths
Benign Positional Vertigo

Show Epley Maneuver film
Benign Positional Vertigo

Show Epley Maneuver film
Head Posture for Caloric Nystagmus

Bedside clinical evaluation of VOR
Test for Vestibular Function

Patient’s head is tilted back 60 degrees so that Horizontal Canal is roughly vertical.

Endolymph circulation produces VOR. Fast phase for Cold caloric is toward Opposite ear, for Warm caloric it is toward Same ear. COWS

Cold water in the left ear canal makes endolymph sink and circulate CCW.

Warm water in the left ear canal makes endolymph rise and circulate CW.
Aviation Otolith illusions

The Death spiral - roll illusion

While banking to the right the pilot senses a left roll because centripital force stimulates the left utricle.

Compensate by banking plane more to the right to correct attitude. This causes a clockwise descending spiral. The centrifugal force increases the sensation of a left roll and it ends in a big splash.
Ocular Corellas upward pitch illusion

During takeoff from the deck of an aircraft carrier, the forward thrust acceleration stimulates Sacculus to sense upward pitch.

Pilot compensates by pitching the nose down and flies into the ocean in a parabolic flight.

Try this out during takeoff on a passenger jet. Notice if you think the nose is up along the isle and compare to the visible horizon seen outside the window.
VOR can be reversed by adaptation

In the dark, subject was rotated about 360 degrees first one way, then the other. Arrows show where head rotation changed direction. Stimulus was the same for both traces, but movement was reversed after adaptation. Note the fast phases mixed in with slow phases.
VOR Adaptation
OKN supplements the VOR at low velocities and constant velocities

Body sway
Constant rotation velocity
OKN Jerk Nystagmus

Observed by Purkinje in early 19th century
Examples of Visual Vestibular interactions

Mystery spot- Santa Cruz
   Otolith-visual conflict- otolith dominates

Linear Vection- cinerama, boat docks, stop lights
   Canal-visual conflict- vision dominates
Active and Passive OKN

Active optokinetic nystagmus

Active and Passive OKN

Passive optokinetic nystagmus

Arrows show where Drum changed direction
Cortical and Subcortical OKN Pathways

Left side NOT

Gets direct subcortical visual input only from Right eye and indirect cortical input from Left eye.

Subcortical input drives slow phase to the Left in both eyes
Asymmetric OKN in normal infants and strabismus
Latent Nystagmus

A

RE viewing

Time

B

LE viewing

C

Binocular viewing
Latent Nystagmus
Hair Cell Sensory Endings in the Cristae

Primary Vestibular Nerve

Vestibular Nuclei

Secondary Vestibular Neurons
via Medial Longitudinal Fasciculus

Oculomotor Neurons

Extraocular Muscles
Retina

Visual Cortex

Dorsal Terminal Nucleus of the Optic Tract (DTN)

Nucleus of the Optic Tract (NOT)

Inferior Olive

Nucleus Reticularis Tegmenti Pontis (NRTP)

Cerebellum

Vestibular Nuclei

Oculomotor Nuclei
Accessory Optic Tract Nuclei

Diagram showing the connectivity of various nuclei involved in the accessory optic tract, including LGNv, LGNd, MTN, LTN, DTN, NOT, and SC.
Infants OKN Pathways

N

CX

NOT

LGN

VC

CC
Visual Angles
Angle Lambda (Kappa)