Pathophysiology of Concussion
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Objectives
- Review the anatomy and physiology of the proprioceptive, vestibular, and visual systems.
- Understand the mechanism of injury (MOI) and physiological response following acute concussion.
- Compare the MOI and physiological response following whiplash injury.
- Understand the neurophysiology of sensorimotor disturbances following concussion and whiplash injuries.

Anatomy and Physiology Review
- Proprioceptive System
  - Cervical Spine
- Vestibular System
- Visual System

Proprioceptive System
- Anatomy: 200 muscle spindles per gram
- Physiology: Relay info to and receive from the CNS
- Specific connections

Cervical Afferents
- Afferent nerves carry information TO the CNS
- Superior Colliculus
- Reflex center

HEAD Stabilizing Reflexes
- Vestibulo–collic reflex (VCR)
- Optokinetic Reflexes (OKR)
- Cervico–collic reflexes (CCR)
- Evoked by vestibular stimuli related to movement of head in space
- Evoked by movements of the visual field in relation to self
- Evoked by changes in length of neck muscles caused by the movement of the head relative to the body.
EYE Stabilizing Reflexes

- Vestibulo-ocular reflex (VOR)
  - Stabilizes images on the retina during head movement by producing an eye movement in the direction opposite to head movement
- Optokinetic Reflexes (OKR)
  - Allows the eye to follow objects in motion when the head remains stationary
- Cervical Ocular Reflexes (COR)
  - Assists clear vision with movement

QUESTIONS?

Vestibular Anatomy

Semicircular canals

Semicircular Canals
Where does all this information go?
Conjugate Movements
- Saccades
- Smooth pursuit
- Vergence Movements

Vestibulo-ocular Reflex
1. Detection of rotation
2. Inhibition of extraocular muscles on one side.
3. Compensating eye movement

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Summary

- Complex and integrated system controls balance, posture and the way we interpret our physical world
- Visual, vestibular and somatosensory senses must be integrated
- Disturbances in this system create a wide range of symptoms and far-reaching decreases in function

Concussion

- Direct or indirect force transfer to the head resulting in complex physiological processes affecting the brain

Pathophysiology of Concussion

- Acute Metabolic Cascade
  - Result from forces that produce axonal "stretching"
  - Initial depolarization of neuronal membranes
  - Release of excitatory amino acids
  - Hypermetabolic glycolytic state followed by vasoconstriction
  - Resultant state of metabolic depression
- Increased susceptibility to further injury
Whiplash

- Bi-phasic response to indirect force
  1. Spine forms an S-shaped curve: flexion at the upper levels; hyperextension at the lower levels.
  2. All levels of the cervical spine were extended; head reached its maximum extension.

Pathophysiology of PCS

- Tectum
- Foreman magnum
- Brains stem

Pathoanatomical Lesions
- Facets
- Dorsal Root Ganglia
- Nerve Roots
- Ligaments
- Disc
- Muscle
**Pathology of Whiplash**

- Capsular tears
- Articular cartilage damage
- Joint fracture
- Capsular rupture
- Afferent nerve fibers become sensitized or excited

**Facet Joints**

**Pathology of Whiplash**

- Vulnerable to excessive stretching
- Contains fibers that relay proprioceptive and pain information to the spinal cord and brain

**DRG and Nerve Roots**

**Pathology of Whiplash**

- Increased joint repositioning error
- Impaired Balance
- Disturbed neck-influenced eye movement control
- Dizziness

**Proposed Sensorimotor Impairments**

**Ligament, Disc, and Muscle**

**Summary**

- Complex reflexive interactions between the visual, vestibular, and somatosensory systems must be integrated for an accurate understanding of our surroundings.
- Acute concussion is a metabolic problem, chronic symptoms may be a result of cell death during this phase or other factors.
- Due to the mechanism of injury in concussion and whiplash, one or more of these systems may be affected.