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Traumatic Brain Injury

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Objectives

At the conclusion of this presentation the participant will be able to:

- Identify the functional anatomy of the brain and the effects of traumatic brain injury (TBI).
- Describe the neurologic assessment and initial management of the TBI patient.
- Identify management strategies to reduce the risk of secondary injury and minimize complications.

Traumatic Brain Injury

Definition:

Disruption in the normal function of the brain that can be caused by a bump, blow, jolt or penetrating head injury

Epidemiology

- 2.9 million TBIs
- 224,000 hospitalizations
- 61,000 deaths
- Long-term disability

CDC.gov

Epidemiology

- Highest rates in the elderly (>75 years)
- More common in males
- Concussions in children

Mechanisms of Injury

Blunt

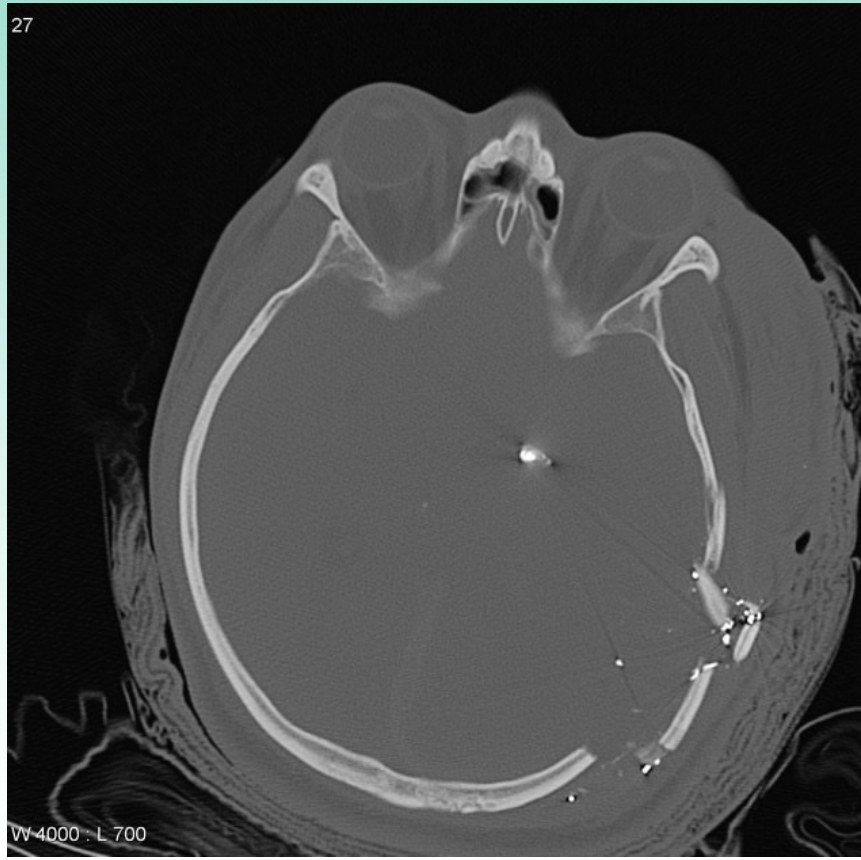
- Falls
- MVC
- Bicycle crash
- Pedestrian
- Assault

Cuete, D. Epidural hematoma. Case study, Radiopaedia.org. (accessed on 07 Dec 2021) https://doi.org/10.53347/rID-29440

Mechanisms of Injury

Penetrating

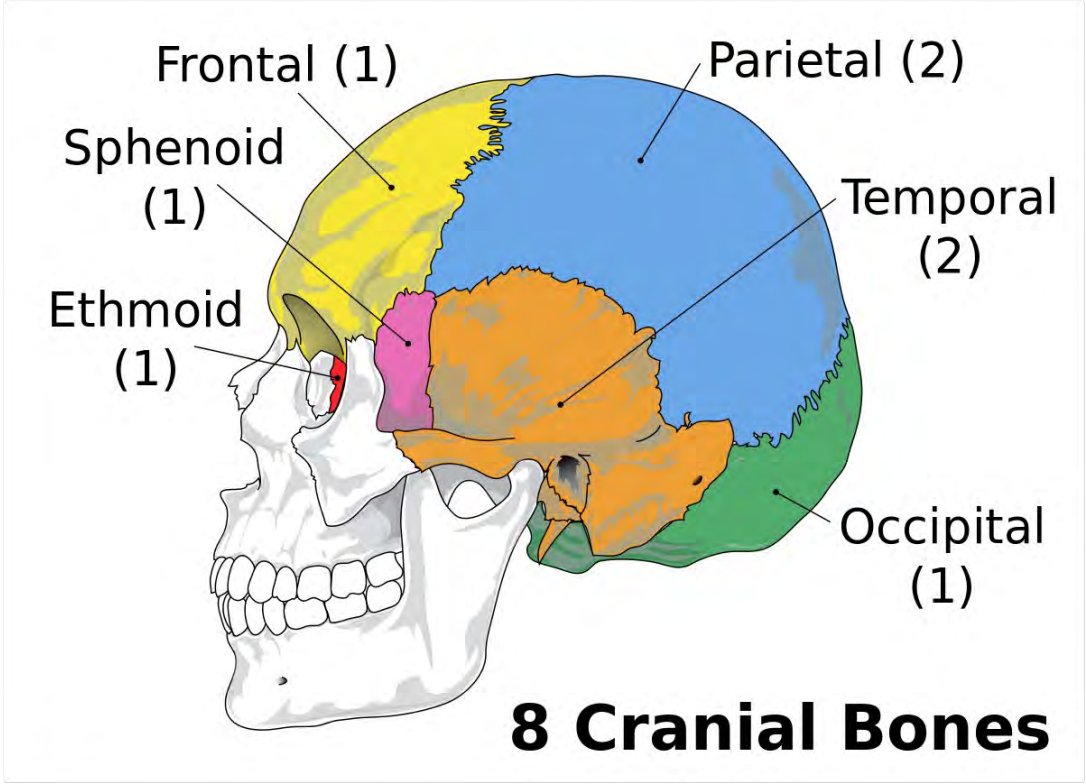
- Gunshot wounds
- Other penetrating



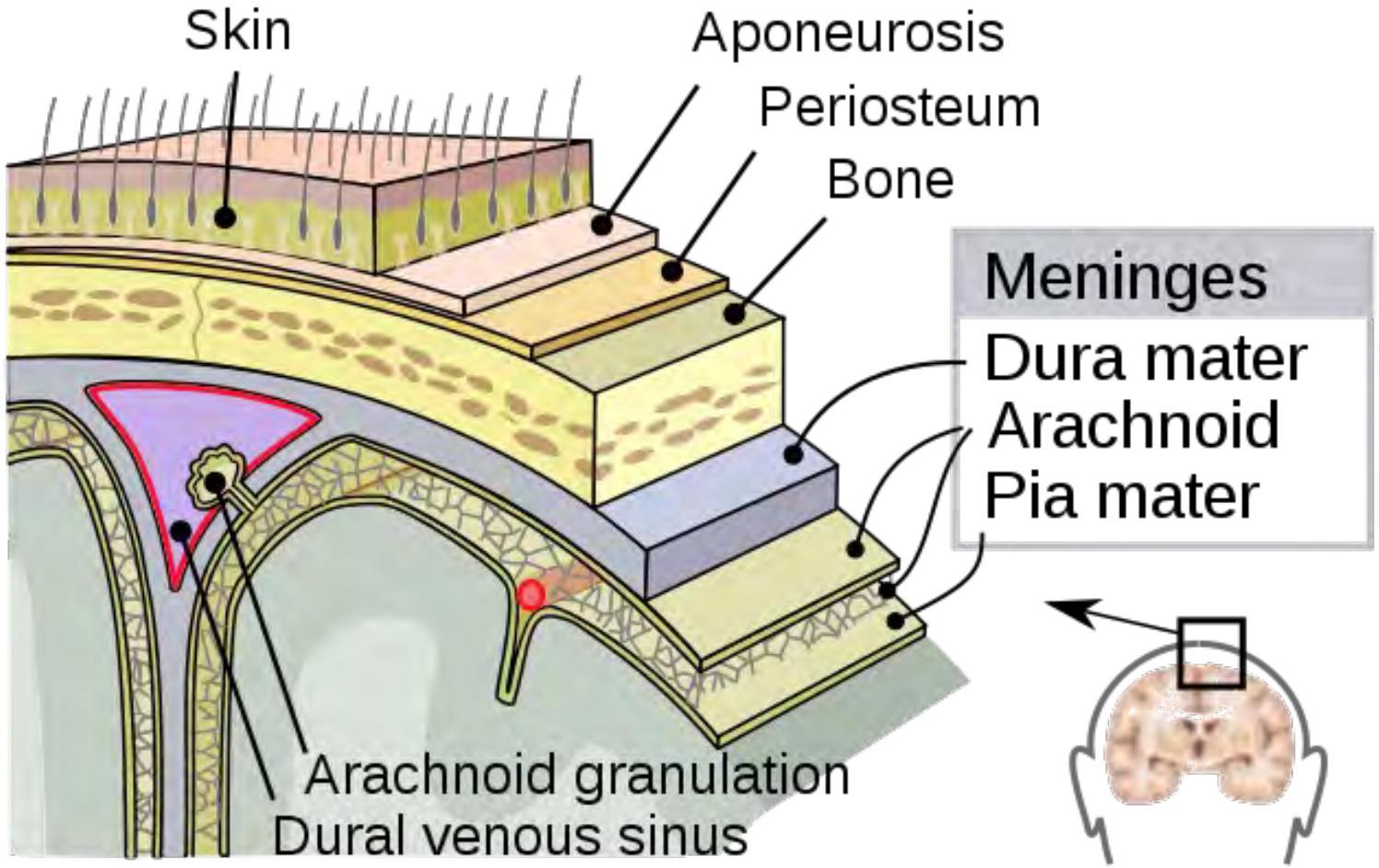
Gaillard, Radiopaedia.org

Skull

- Eight major bones
- Bones rigidly joined together
- Sutures allow for expansion in infants but are fused by adulthood
- The scalp covers the skull and consists of skin, connective tissue fibers, blood vessels and nerves. The scalp has a rich blood supply.

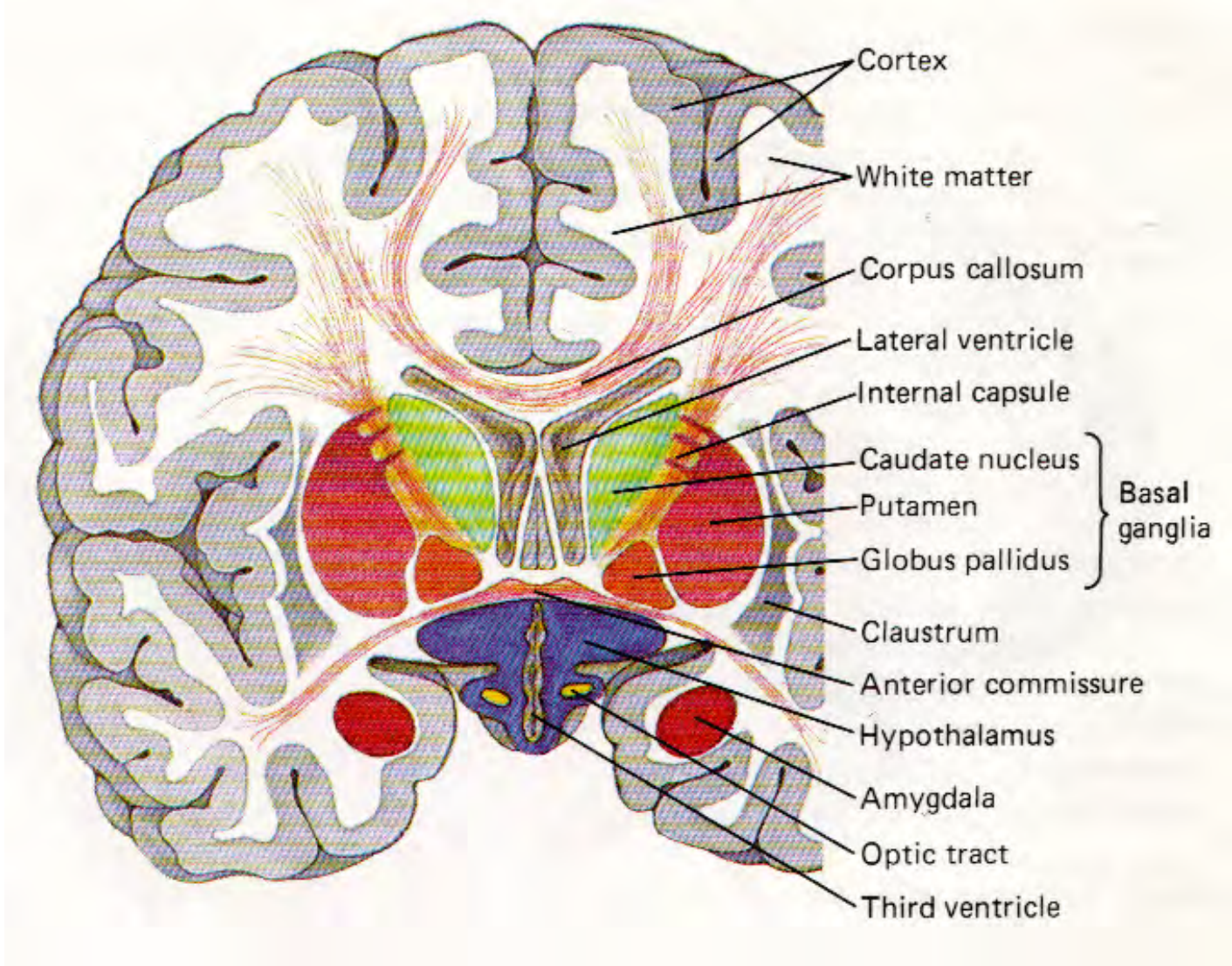


Meninges

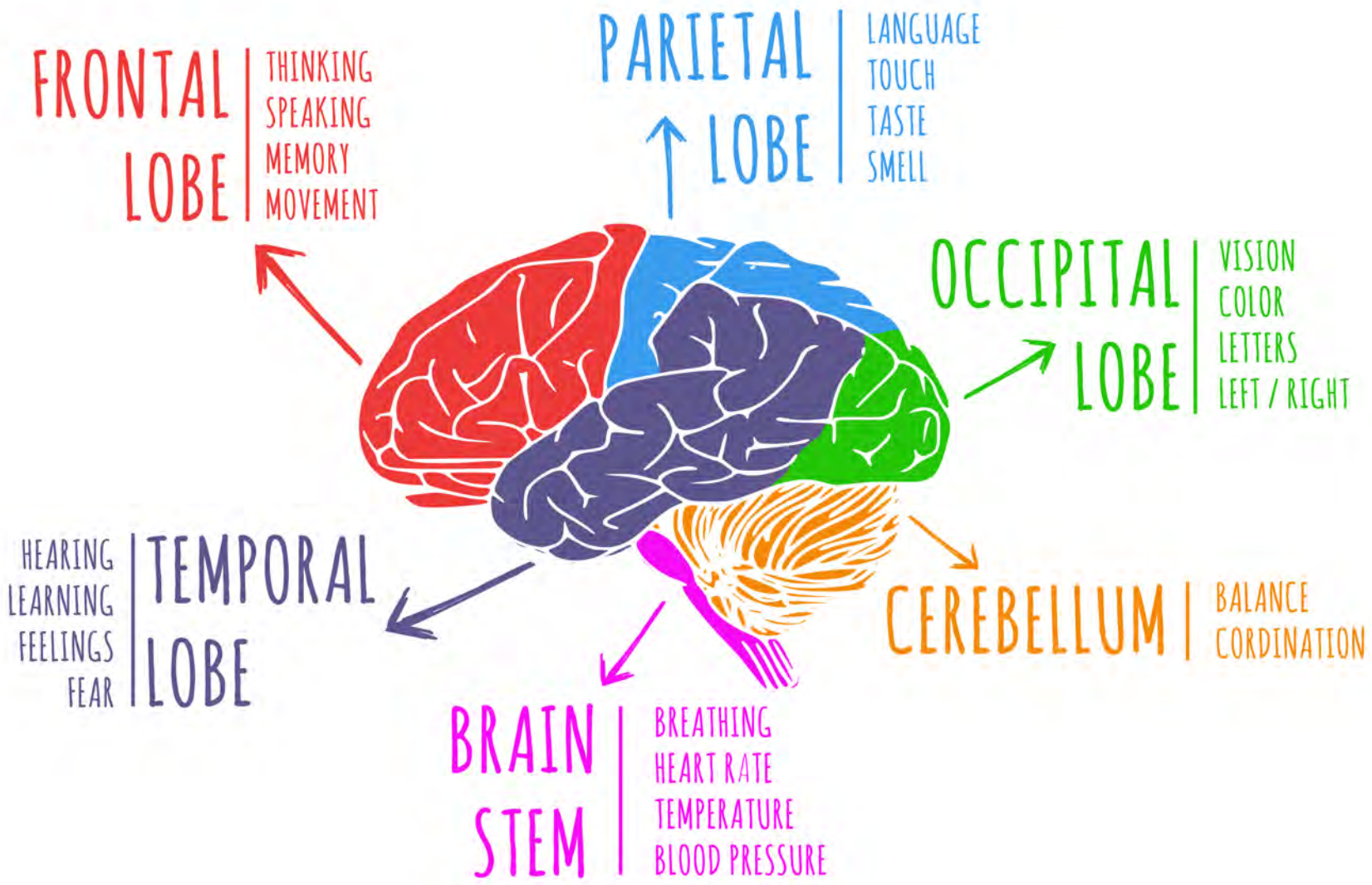


SVG by Mysid, original by SEER Development Team [1], Jmarchn, CC BY-SA 3.0,via Wikimedia Commons

Brain


Cortex
White matter
Corpus callosum
Lateral ventricle
Internal capsule
Caudate nucleus
Putamen
Globus pallidus
Basal ganglia
Claustrum
Anterior commissure
Hypothalamus
Amygdala
Optic tract
Third ventricle

Functions of the Cerebral Lobes



Primary Injury

- Primary injury occurs at impact or in the minutes following the blunt or penetrating injury.
- Primary injuries include:
  - Vascular compromise
  - Diffuse axonal injury
  - Cellular injury

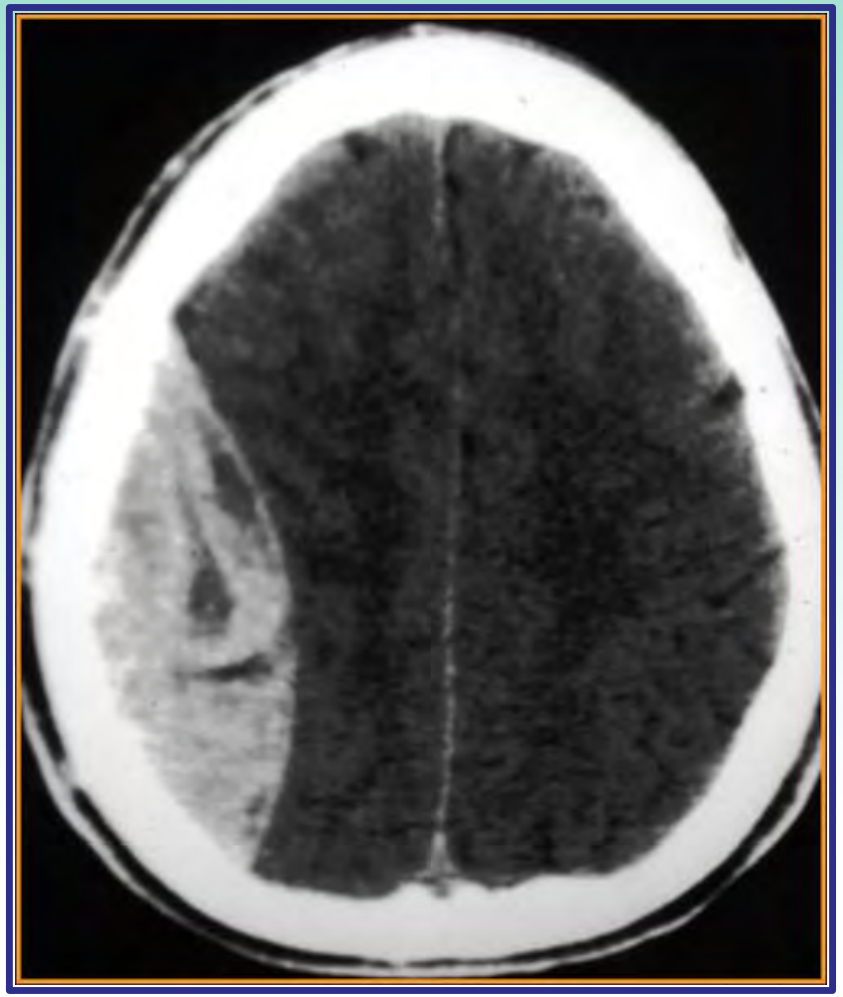
Primary Injury - Prevention

Prevention strategies include:

- Fall prevention
- Bicycle helmets
- Pedestrian safety awareness
- Gun violence awareness
- Motor vehicle safety

Focal Injury

- External
- Skull Fracture
- Contusions
- Intracranial Hemorrhage

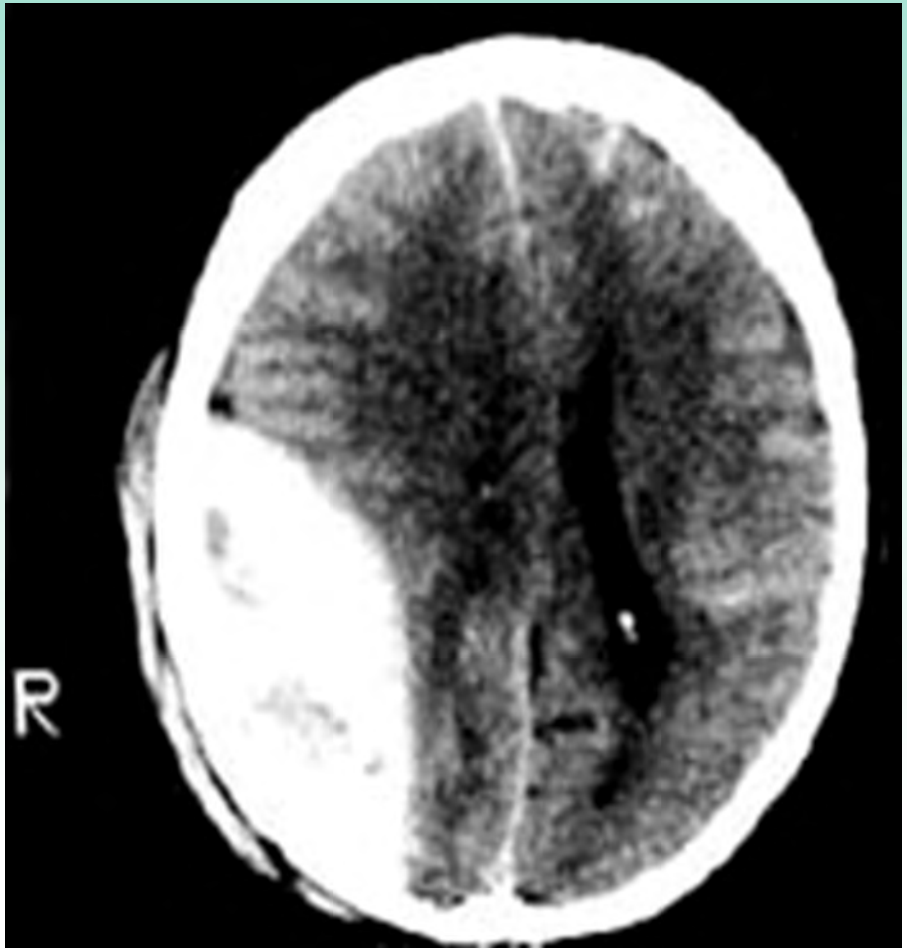


Subdural Hematoma

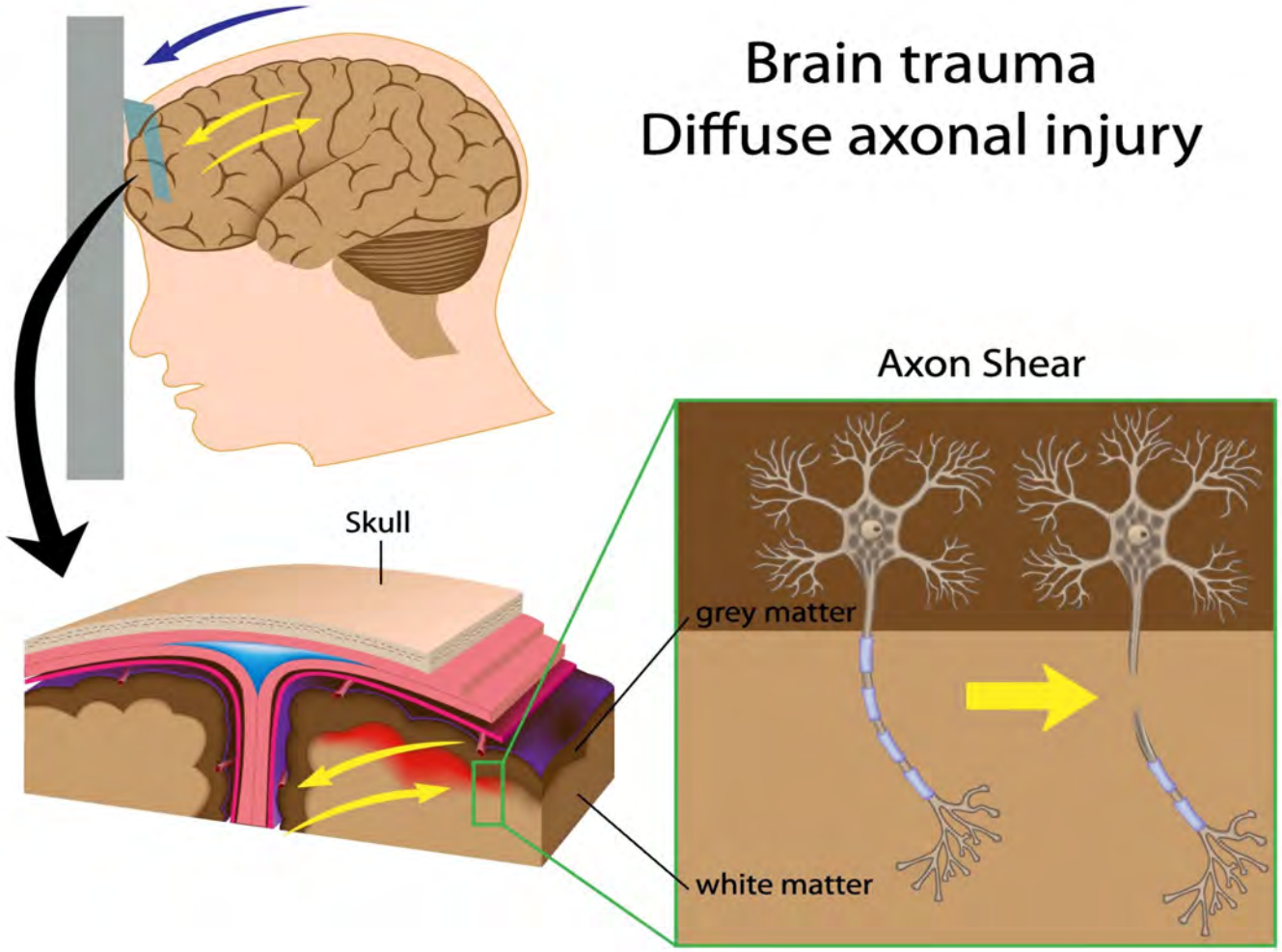
- Acute, subacute, chronic
- Stretching or tearing of bridging vessels
- Presentation varies

Epidural Hematoma

- Direct blow
- Overlying skull fractures
- Arterial bleed- Middle meningeal artery
- Variable levels of consciousness



Diffuse Injury



Salam, Radiopaedia.org

TBI Recognition and Management

- Prehospital care
- ABCDE management
- Mitigating secondary injury

Prehospital Care

- Timing and transport
- Oxygenation
- Intubation
- ETCO2
- Blood Pressure
- Transport decisions

Glasgow Coma Scale (GCS)

Points	Best Eye Opening	Best Verbal Response	Best Motor Response
6			Obeying commands
5		Oriented	Localizing
4	Spontaneous	Confused	Normal Flexion
3	To speech	Words	Abnormal Flexion
2	To pressure	Sounds	Extension
1	None	None	None
NT	Non-testable	Non-testable	Non-testable

Pupil Reactivity Score

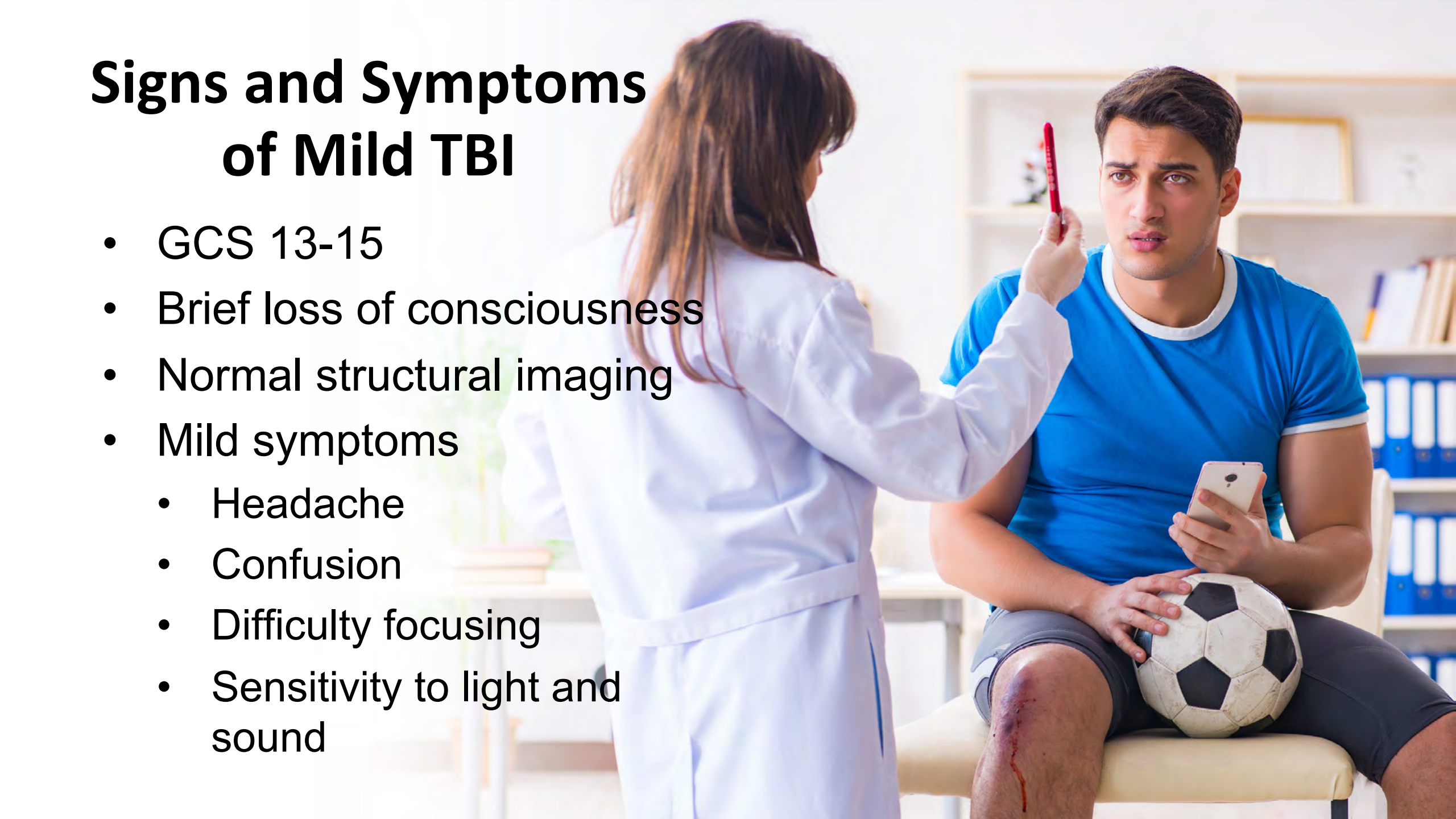
Pupils Unreactive to Light	Pupil Reactivity Score
Both Pupils	2
One Pupil	1
Neither Pupil	0

Classification of TBI

- Mild
  - GCS 14 - 15
- Moderate
  - GCS 9 -13
- Severe
  - GCS 3 - 8

Signs and Symptoms of Mild TBI

- GCS 13-15
- Brief loss of consciousness
- Normal structural imaging
- Mild symptoms
  - Headache
  - Confusion
  - Difficulty focusing
  - Sensitivity to light and sound



Heads Up: Concussion in Youth Sports

If you think your athlete has sustained a concussion

Take athlete out of play

Be alert for signs of concussion

Seek the advice of a health care professional

CDC Fact Sheets

SIGNS OBSERVED BY PARENTS/ GUARDIANS/ COACHES

- Appears dazed or stunned.
- Is confused about assignment or position.
- Forgets sports plays, is unsure of game, score, or opponent.
- Moves clumsily.
- Answers questions slowly.
- Loses consciousness (even briefly).
- Shows behavior or personality changes.
- Can't recall events prior or after hit or fall.

SYMPTOMS REPORTED BY THE ATHLETE

- Headache or "pressure" in the head.
- Nausea or vomiting.
- Balance problems or dizziness.
- Double or blurry vision.
- Sensitivity to light.
- Sensitivity to noise.
- Feeling sluggish, hazy, foggy, groggy.
- Concentration or memory problems
- Confusion.
- Does not "feel right".

Management of Mild TBI

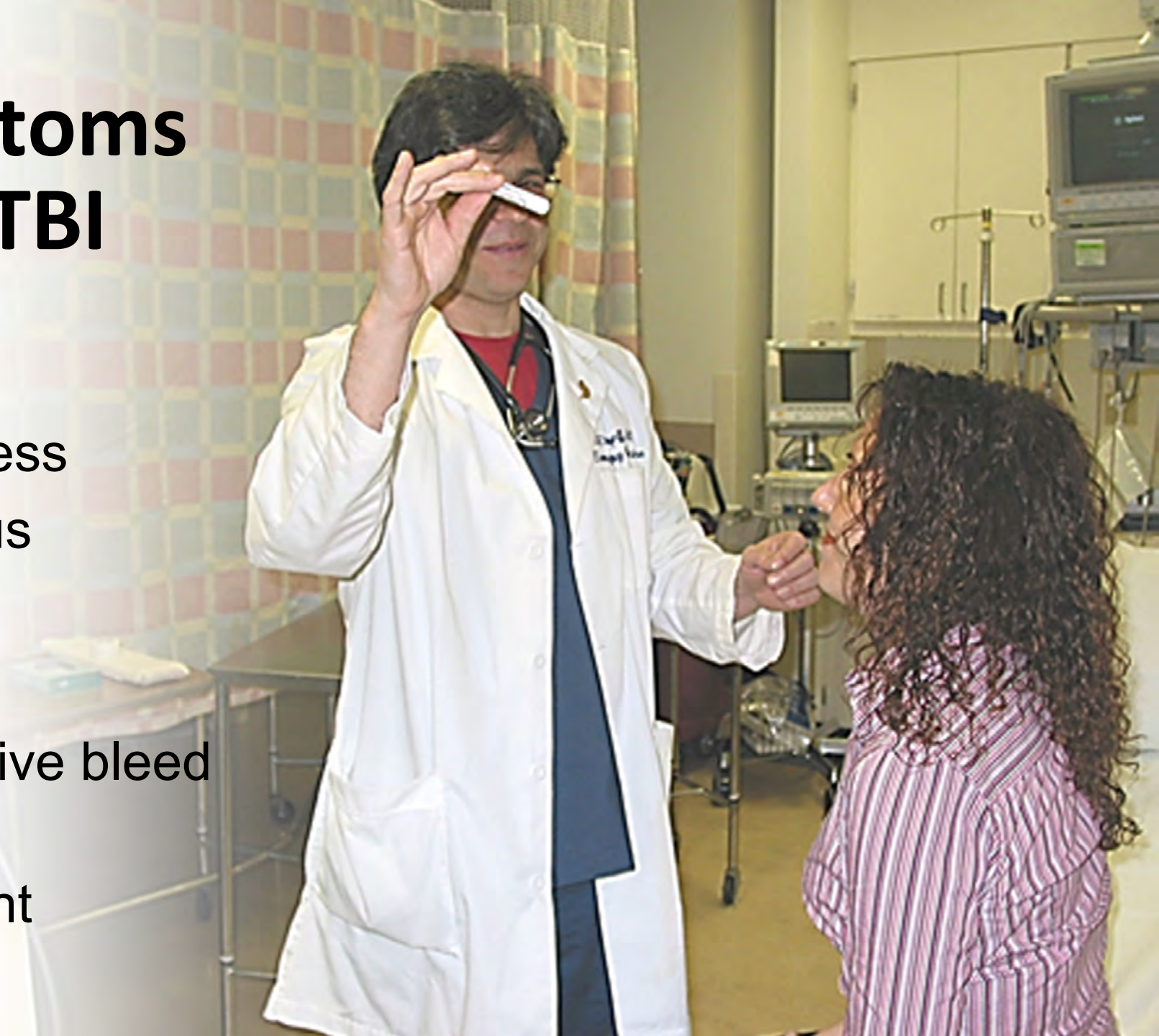
- Assessment
- Diagnostics
- Discharge education

Parents may specifically request to be cleared by EP

- Advise NO return to contact sports until cleared by an HCP familiar with concussion management.
- RTP is a 3-step, multi-day process.
  - Symptom-free off concussion-related medications
  - Cognitive performance back to baseline
  - Successful completion of 6-step (6 day) Return to Play progression
- These cannot be accomplished in an ED setting.

Signs and Symptoms of Moderate TBI

- GCS 9-13
- Loss of consciousness
- Altered mental status
  - Mild confusion
  - Lethargy
  - Positive or negative bleed on CT
- Ongoing assessment



Management of Moderate TBI

- ABCDE
- History
- Labs
- Prevent secondary injury
- Ongoing management

Signs and Symptoms of Severe TBI

- GCS 3-8
- Prolonged loss of consciousness
- Abnormal neurological signs
  - Posturing
  - Pupillary changes

Initial Management of Severe TBI Patient

- Primary survey and resuscitation
  - ABCDE
- Secondary survey
  - Head-to-toe assessment
  - AMPLE
  - Diagnostics

Gaillard, Radiopaedia.org

Initial Management - ABCDE

A- Airway

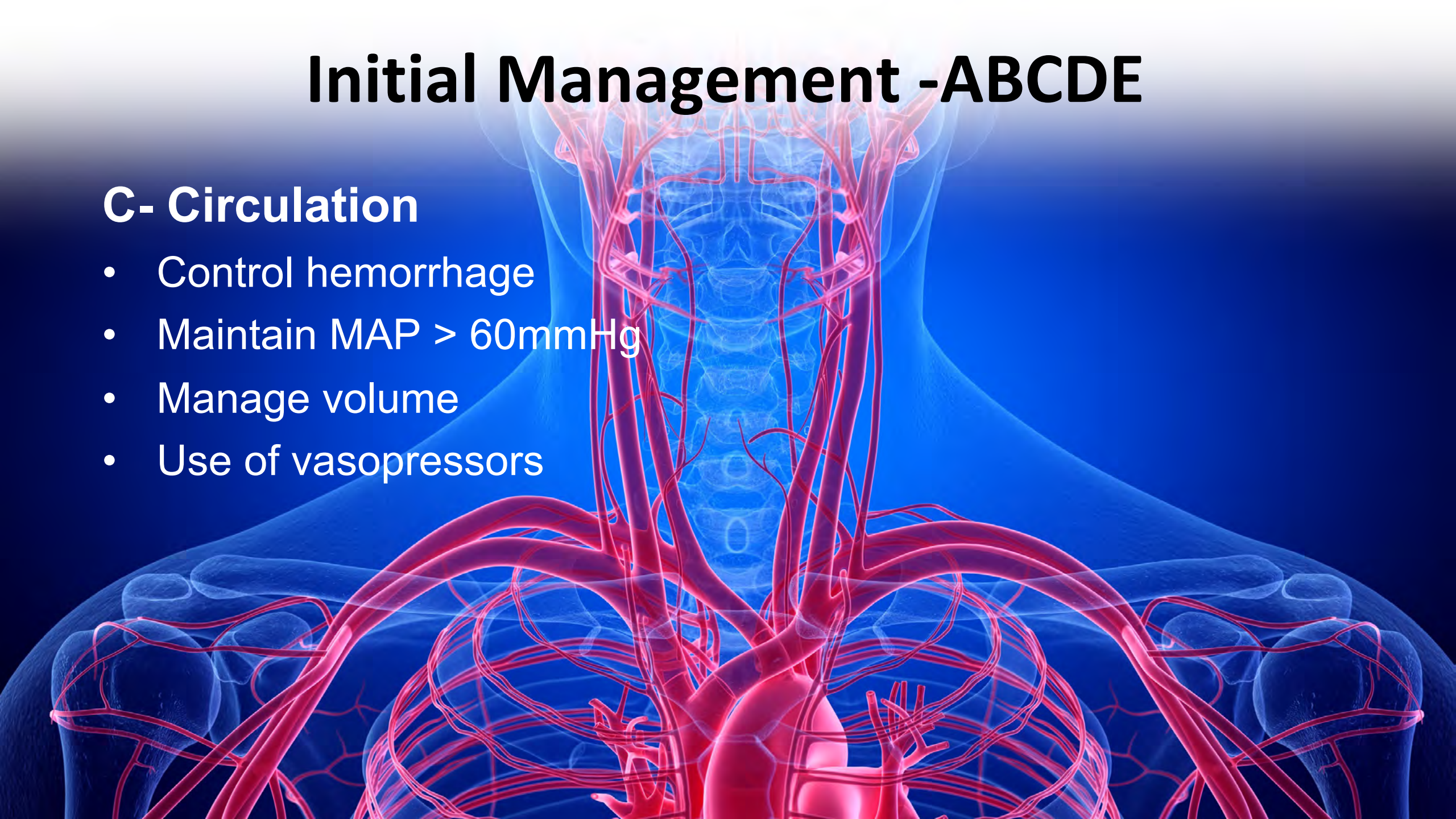
- Obtain definitive airway
  - Cervical spine immobilization
- GCS ≤ 8- intubate
  - Rapid Sequence Intubation (RSI)
  - The seven Ps

Initial Management - ABCDE

B- Breathing

- Goals
  - Pa O2 > 60mmHg
  - O2 sat > 90%
  - ETCO2 35-45mmHg
- Avoid hyperventilation

Initial Management -ABCDE



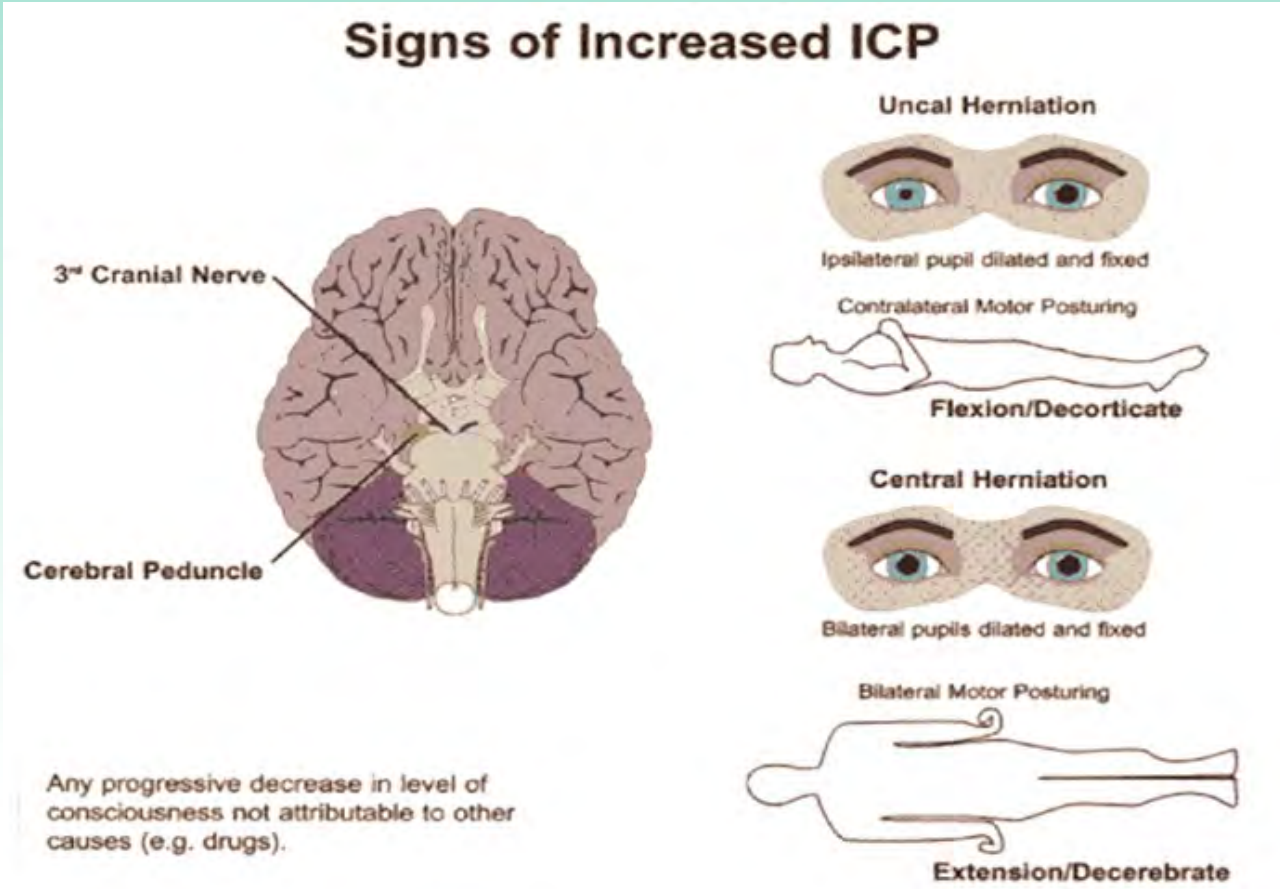
C- Circulation

- Control hemorrhage
- Maintain MAP > 60mmHg
- Manage volume
- Use of vasopressors

Initial Management - ABCDE

D - Disability

- GCS
- Ongoing assessment
  - Pupils
  - Motor function



Pupils

Both dilated

- Nonreactive: brainstem
- Reactive: often reversible

- Slow: cranial nerve III
- Fluttering: often hysteria

Unilaterally dilated

- Reactive: ICP increasing
- Nonreactive (altered LOC): increased ICP
- Nonreactive (normal LOC): not from head injury

Initial Management - ABCDE

E – Exposure/Environment

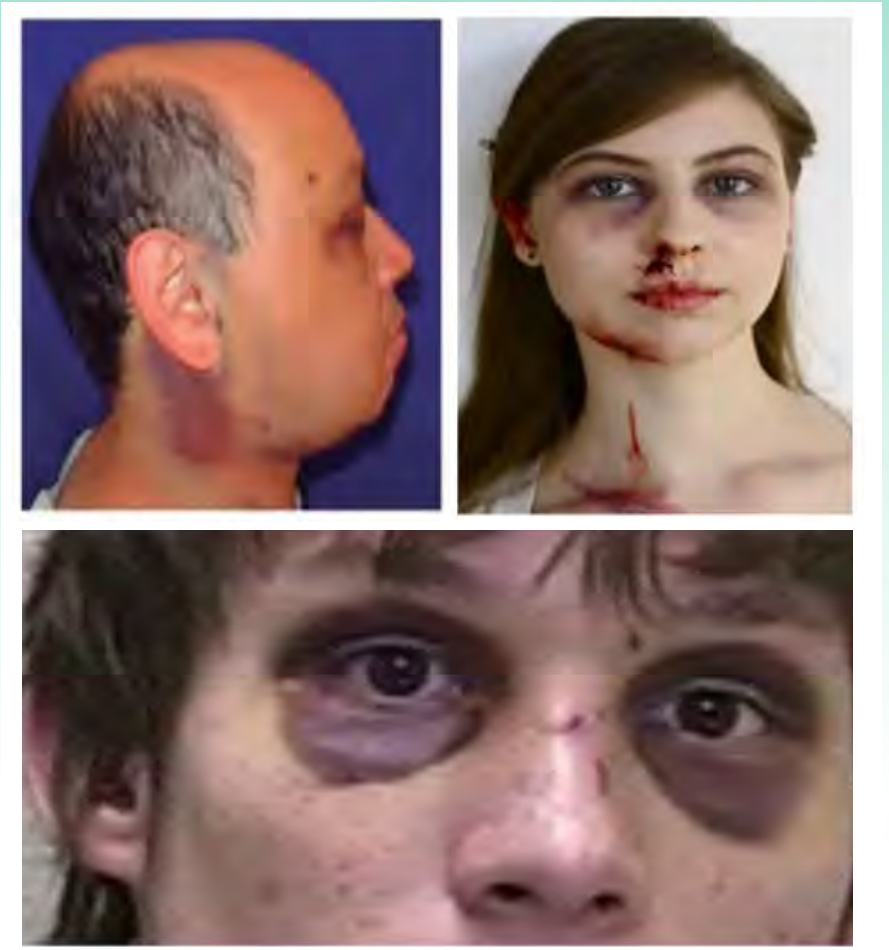
- Expose to identify all injuries
- Maintain normothermia

https://discountcardiology.com/GE-Dash-4000-Patient-Monitors.

Initial Management – Secondary Survey

Systematic assessment

- Battles sign
- Raccoon eyes
- Rhinorrhea / Otorrhea
- Motor and sensory deficits
- Pupillary response
- Reflexes



Retrieved December 6, 2021 from https://www.slideshare.net/rozymea/head-injuries-58458547

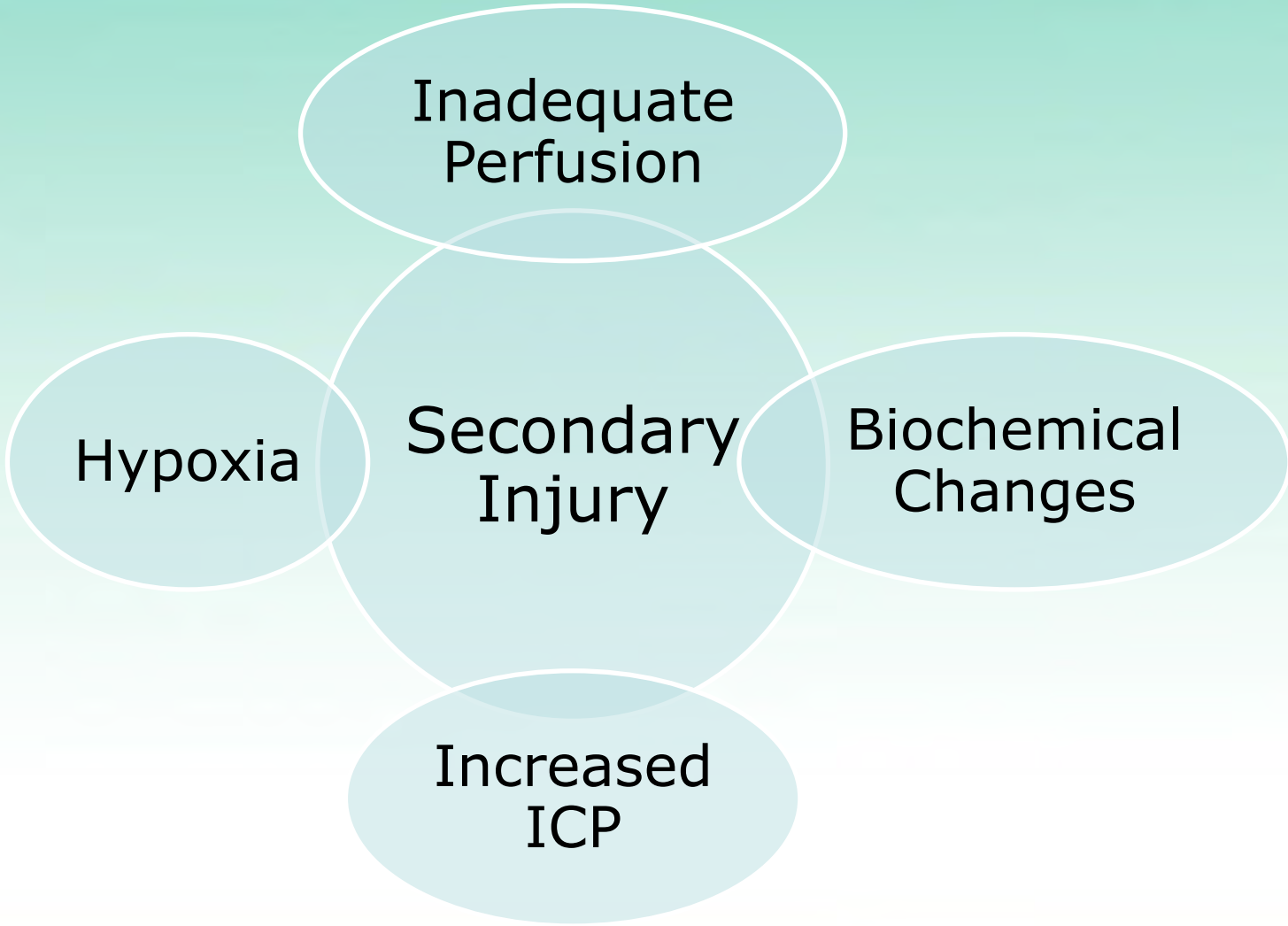
Initial Management – Secondary Survey

Adjuncts:

- Labs
- Neurologic/ICP Monitoring
- Cardiac Monitoring
- Arterial Line
- Pulse Oximetry/ Capnography
- Core Temperature

https://www.rescue-essentials.com/easy-cap-ii-end-tidal-co2-detector/

Secondary Injury



Secondary Injury

- Edema
- Infarction
- Secondary hemorrhage
- Herniation
- Changes to the brain:
  - Neurochemical
  - Metabolic
  - Cellular

Anticoagulation Reversal

- Identify anticoagulation medications
- Blood testing
- Indications for reversal
- Choose the appropriate reversal agent

Some Common Examples

- Coumadin (warfarin): Vitamin K, 4-factor prothrombin complex concentrate (PCC) such as Kcentra, plasma if 4-factor PCC not available
- Pradaxa (dabigatran): Praxbind (idarucizumab)
- Xarelto (rivaroxaban), Eliquis (apixaban), Savaysa (edoxaban):
- Andexxa (andexanet alfa), FEIBA (anti-inhibitor coagulant complex), activated charcoal if other options are not available
- Lovenox, unfractionated Heparin: Protamine sulfate
- Aspirin: DDAVP (desmopressin)

Cerebral Perfusion Pressure

$$CPP = MAP - ICP$$

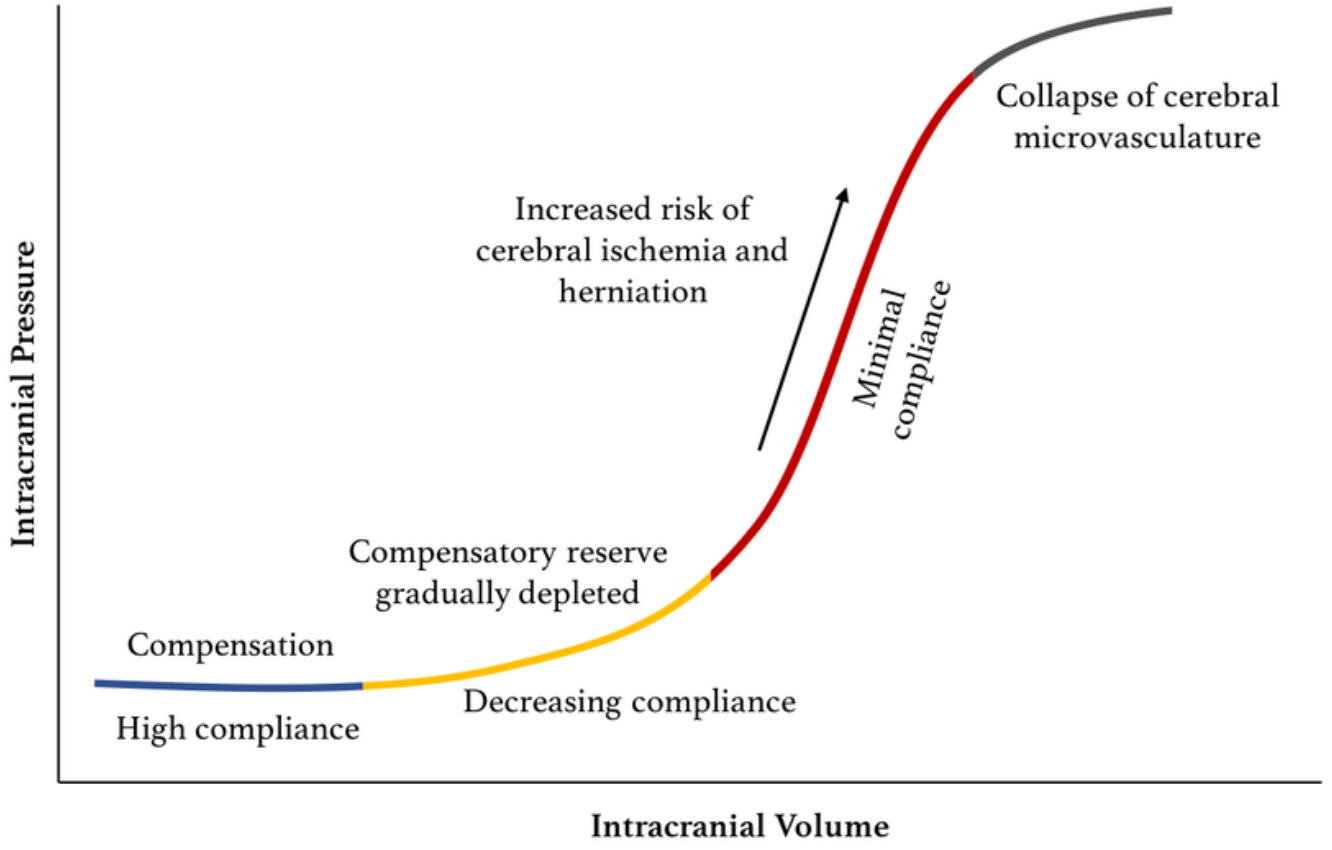
Cerebral Perfusion Pressure (CPP) = Mean Arterial Pressure (MAP) – Intracranial Pressure (ICP)

Represents the pressure gradient driving cerebral blood flow and oxygen and metabolite delivery

Goal = 60-70mmHg

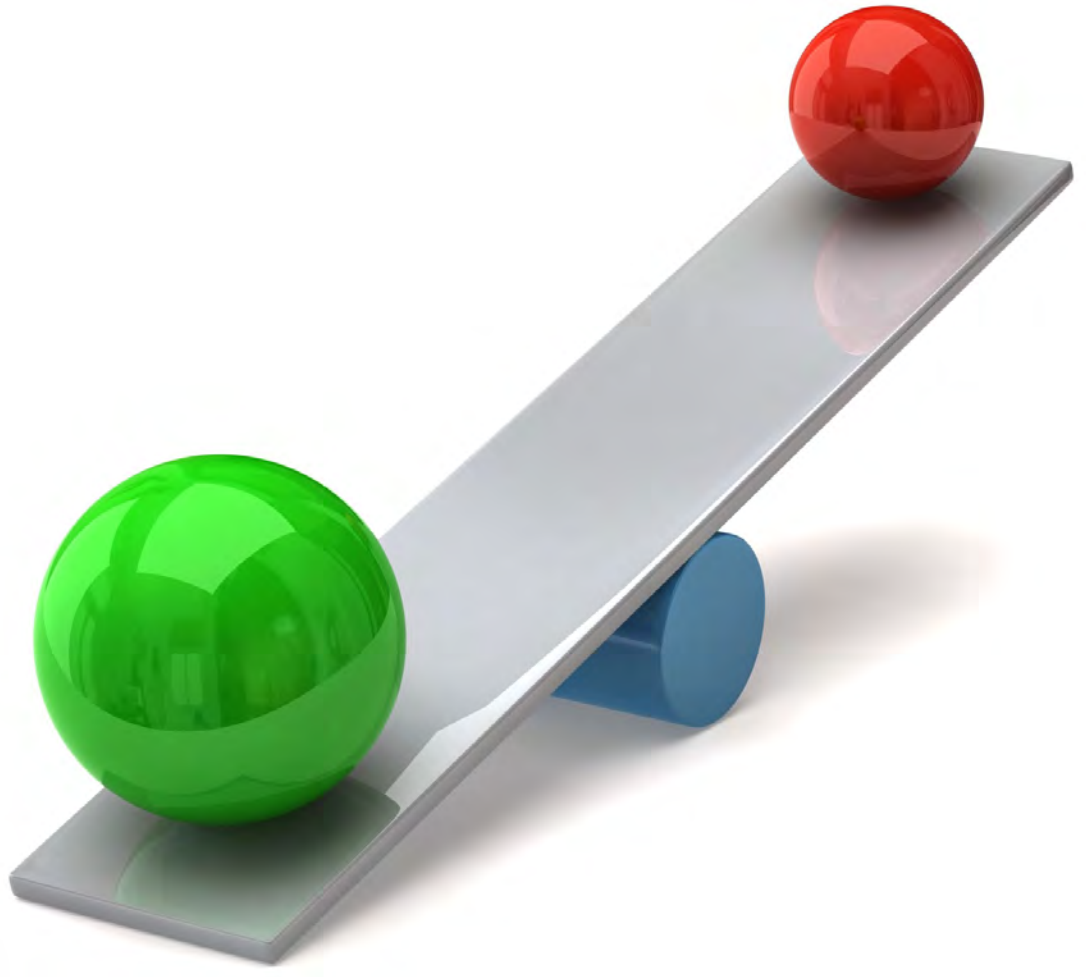
Monro- Kellie Doctrine

- The skull is a non-expandable vault.
- The total volume of intracranial contents must remain constant.
  - Brain - 80%
  - Blood - 10%
  - CSF - 10%
- An increase in one results in a decrease in one or two of the remaining components.



Autoregulation

- The intrinsic ability of the cerebral blood vessels to dilate or constrict in response to changes in the brain environment.
- Enables cerebral blood vessels to maintain cerebral blood flow in presence of wide fluctuation in mean arterial pressure.



Autoregulation - Impaired

- Autoregulation fails if MAP is < 50 or > 150 mmHg.
- Autoregulation failure affects CPP by impacting the pressure gradient that drives cerebral blood flow.

Intracranial Pressure (ICP) Monitoring

- ICP reflects the pressure inside the head
- Normal ICP: < 15mmHg
- Monitoring devices
  - External ventricular drain
    - Allows for drainage of CSF to lower ICP
  - Subarachnoid screw or bolt
  - Subdural catheter
  - Intraparenchymal fiberoptic catheter

Photo credit: Diane Floyd

Intracranial Pressure (ICP) Monitoring

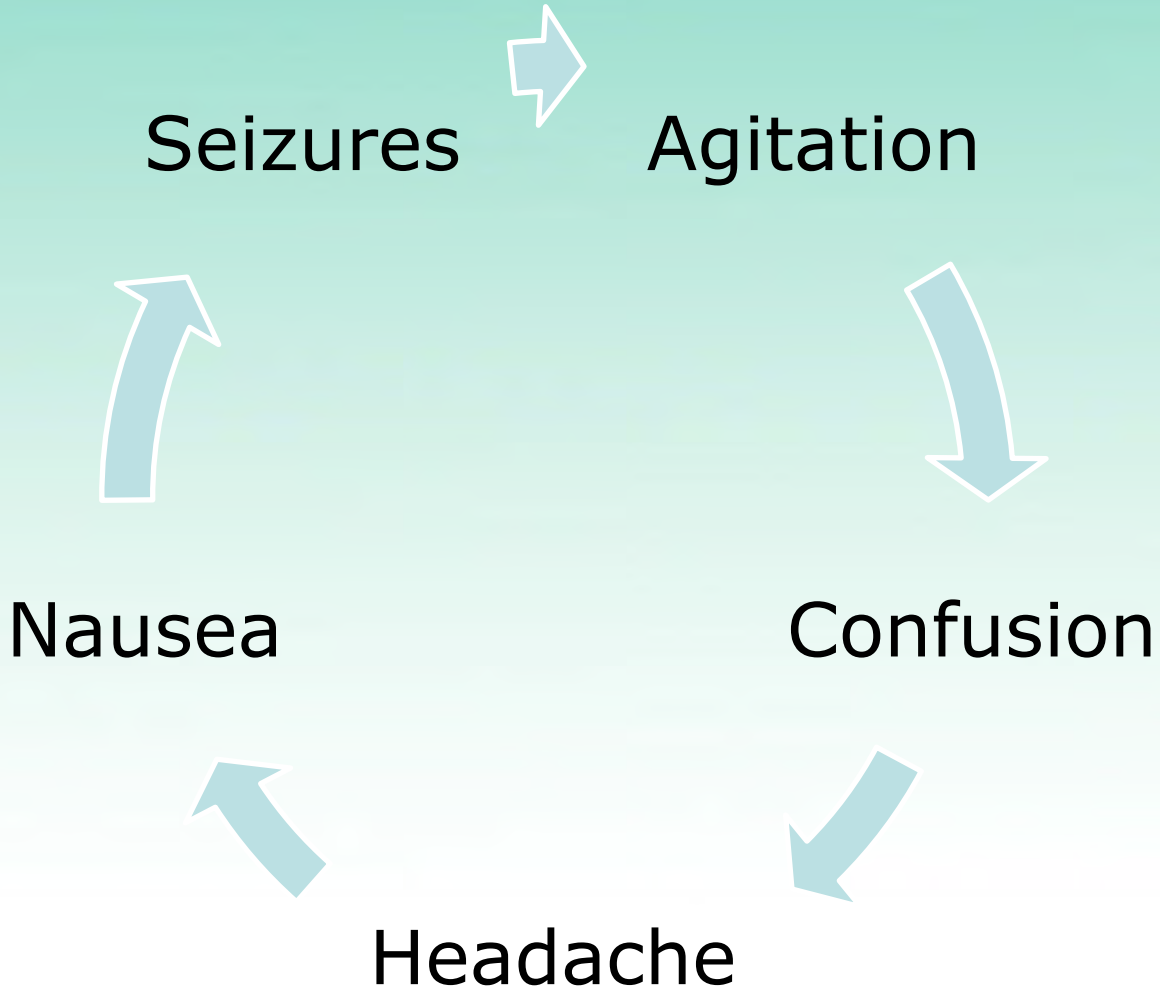
- Indications:
  - All salvageable patients with GCS 3-8 and abnormal CT
  - Patients with normal CT and two or more of the following:
    - Over 40 years of age
    - Unilateral or bilateral motor posturing
    - SBP < 90mmHg
- TBI management using ICP monitoring is recommended to reduce mortality.

Advanced Monitoring

- $PbtO_2$
- Licox therapy
- Transcranial doppler (TCD)
- $SjVo_2$
- $AVDO_2$

CAMINO® ICP Monitoring Catheter with Integrated Bolt Fitting; Integralife.com

Clinical Manifestations of Secondary Injury



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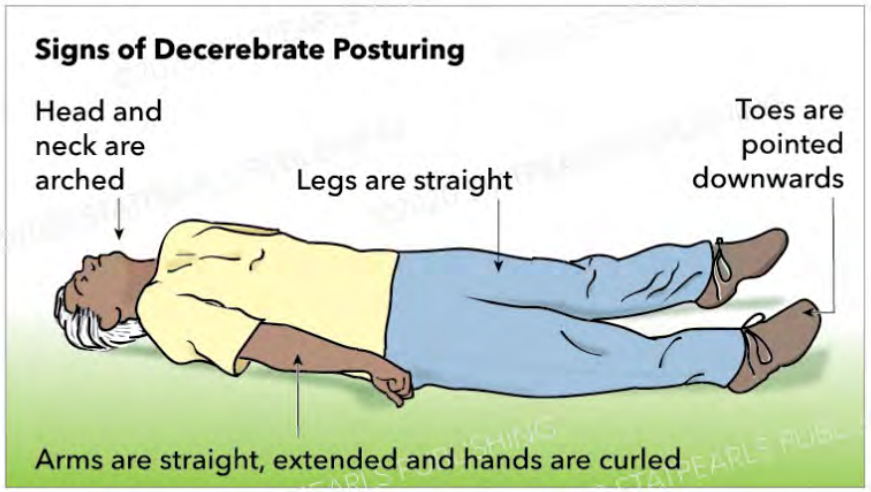
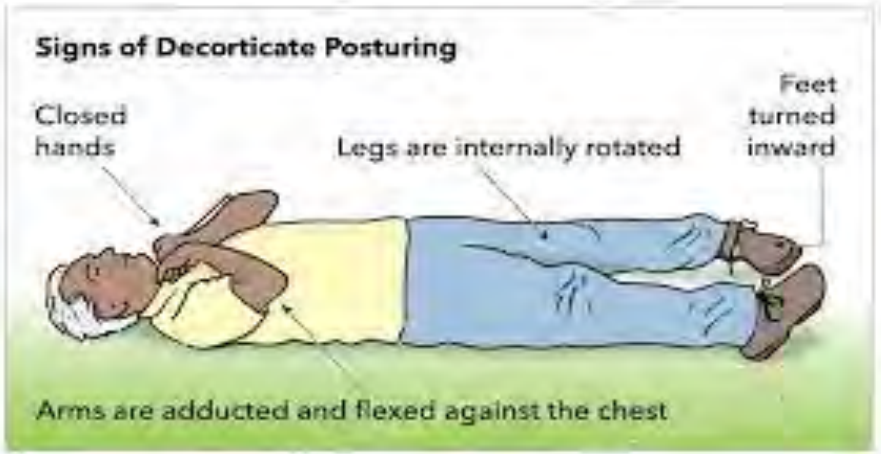




Late signs and symptoms of increased ICP:

- Posturing
- Bradycardia
- Altered respiratory patterns
- Hypertension
- Unilateral or bilateral pupil dilation

NCBI.NLM.NIH.gov

Cushing's Triad

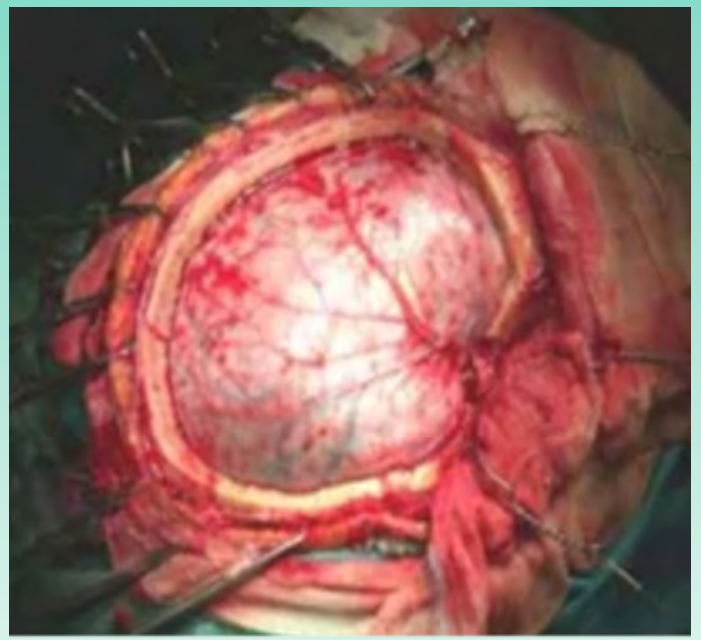
Three signs of an increase in ICP:

- Increased SBP (with widening pulse pressure)
- Bradycardia
- Irregular respirations

Last attempt of the brain to compensate during the process of herniation.

These signs are opposite of HYPOVOLEMIC SHOCK:

- Decreased SBP
- Tachycardia
- Increased respiratory rate



Surgical Intervention

- Burr Holes
- Craniotomy
- Decompressive Craniectomy

Das, slideshare.net

Medical Management

- Maintain normal ICP
  - CSF drainage
  - Hyperosmolar therapy
    - Mannitol
    - Hypertonic Saline
- Maintain normal BP- Goal SBP
  - > 100mmHg for 50-69 years
  - > 110 mmHg for 15-49 and > 70 years
- Ventilation
  - Goal PaCo2 of 35-45 mmHg

Medical Management

Seizure Management

- Prophylactic use of phenytoin or valproate is not recommended for preventing late PTS.
- Phenytoin is recommended to decrease the incidence of early PTS (within 7 d of injury), when the overall benefit is thought to outweigh the complications associated with such treatment.
- At the present time, there is insufficient evidence to recommend levetiracetam (Kepra SR) compared with phenytoin regarding efficacy in preventing early post-traumatic seizures and toxicity.
- Barbiturates are not recommended to induce burst suppression measured by electroencephalogram to prevent the development of intracranial hypertension.

Medical Management

Pain and Sedation Management

- Pain control impacts ICP management
- Minimal dose possible
- Monitor sedation levels

Medical Management

- Early tube feeds: Obtain basal caloric replacement by the fifth day.
- Transgastric jejunal feeding is recommended to reduce the incidence of ventilator associated pneumonia.
- Venous thrombus event prophylaxis.
- Monitor blood glucose.
- Early tracheostomy.

Therapies to Avoid

Prophylactic Hypothermia

- Early, short-term prophylactic hypothermia is **not** recommended to improve outcomes in patients with diffuse injury.
- Hypothermia risks include coagulopathy, immunosuppression and cardiac dysrhythmias.

Steroids

- High-dose methylprednisolone is associated with increased mortality and is contraindicated.

Nursing Interventions

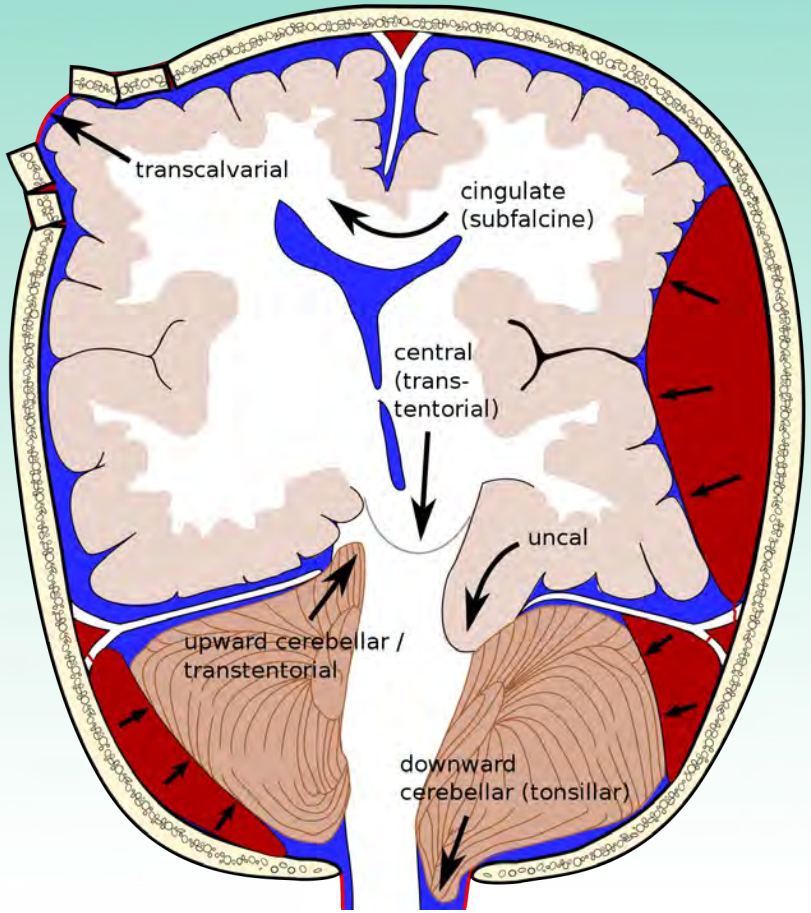
Patient Positioning

- Elevate head of bed
- Maintain neutral alignment of head and neck
- Avoid elevating legs at the knees

Environmental Control

- Avoid overstimulation
- Bundle care to provide periods of rest
- Comfort measures

Herniation



Supratentorial

1. Uncal
2. Central
3. Cingulate
4. Transcalvarial

Infratentorial

5. Upward Cerebellar
6. Tonsillar

Brain Death

- Irreversible loss of all functions of the brain, including brainstem.
- Legally and clinically dead.
- Essential findings:
  - Coma
  - Lack of brainstem reflexes
  - Apnea

End of Life

End of Life Decisions

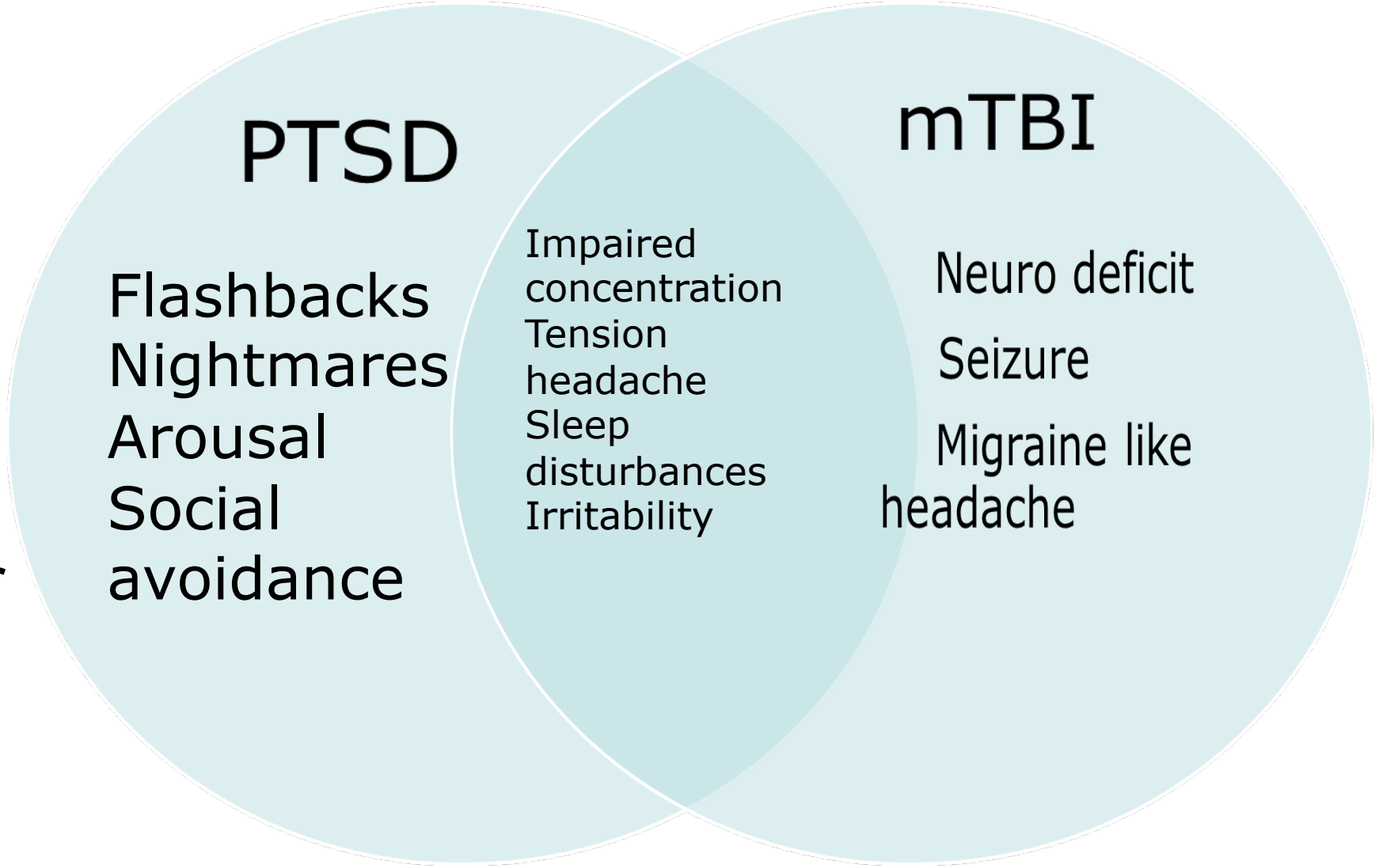
- Family support
- Palliative Care
- Organ Donation

Post-Acute Care

- Early discharge planning
- PT and OT consults
- Speech consultation
- Physical Medicine and Rehabilitation consults
- Inpatient/outpatient rehabilitation

Risks for Post-Acute Complications

- Depression
- Dementia
- Alcoholism / Drug abuse
- Post traumatic stress disorder



Summary

- TBI is a major healthcare problem.
- The initial management of the TBI patient is critical to mitigate secondary injury and complications.
- Nursing interventions are valuable in management and outcomes of TBI patients.

Traumatic Brain Injury

1. A trauma patient presents s/p assault to the head with LOC. Patient is mumbling and incoherent, eyes open to painful stimuli and withdraws to pain. What is the next step for this patient?

a. Call a Neurosurgical consult
b. Given one amp of IV dextrose
c. Prepare for intubation
d. Give valium 5mg IV

2. How would you assess that the ordered rate of ventilation for a TBI patient in a safe range as to not contribute to secondary brain injury?

a. Capnometer
b. Capnography
c. Pulse Oximetry
d. Serial ABG's

3. Hyperventilation in severe TBI patients causes:

a. Increase in delivery of oxygen to damaged brain tissue
b. Manages metabolic acidosis, thus assisting with oxygen delivery
c. Cerebral vasodilation and increases cerebral perfusion
d. Cerebral vasoconstriction and reduced cerebral perfusion

4. The recommended range for PCO2 in a patient with a severe traumatic brain injury is:

a. 10-15mmHg
b. 30-40 mmHg
c. 25-35mmHg
d. 35-45mmHg

5. During transport of a traumatic brain injured patient who is intubated and on a ventilator, the pulse oximeter shows 97% and the ETCO2 shows 26. You would:

a. Reduce the ventilator rate slightly until I reach my goal
b. Leave things alone – everything is o.k.
c. Increase the ventilator rate slightly until I reach my goal
d. Reduce the tidal volume slightly until I reach my goal

6. A patient presents s/p fall with a head injury. On arrival his eyes open to painful stimuli, he is confused and withdraws to pain. What is the GCS for the patient?

a. 7
b. 9
c. 10
d. 11

7. The severity of head injury for this patient would be classified as:

a. Severe
b. Moderate
c. Mild
d. Concussion

8. Normal ICP ranges are:
    a. 1-20mmHg
    b. 0-5mmHg
    c. 25-35mmHg
    d. 0-15mmHg

9. The Monroe Kellie doctrine describes:
    a. Cerebral perfusion
    b. Pressure volume relationship within the intracranial cavity
    c. Physiological electrical function of the brain cells
    d. Classification of injury

10. The most prevalent traumatic brain injury is?
    a. Minimal
    b. Mild
    c. Moderate
    d. Severe

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References
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