Key Facts in the Head Injury Slides

CPP = MAP – ICP
CBF = 50-55ml/100 grams of brain/minute

Slide 1 (Battle's sign)

- 500,000 brain injuries/year in US
- 80% are mild
- 10% are moderate
- 10% are severe
- 100,000 have debilitating injury

Slide 2 (Objectives) – quickly cover

- Intracranial physiology – non-expansile space
- Prevent secondary brain injury – primary focus of ATLS in suspected brain-injured patient (maintain oxygenation and normal blood pressure)
- Focused neuro examination – Glasgow Coma Scale and Pupillary response interpretation
- Stabilize for definitive care

Slide 3 (Key questions) – more detail here –correlate with objectives

- Unique features – non-expansile space that can compensate to about 150 ml
- What is a focused neuro examination? (GCS and pupil response)
- Optimal management – or "How do I prevent secondary brain injury?"
- Diagnose brain death – First step toward Organ donation

Slide 4 (**Anatomy and Physiology of the brain and how is it affected by brain injury?**)

- Rigid skull filled with blood, brain, CSF
- Cerebral blood flow autoregulation (50-55 ml/100grams/brain/minute)
    - Controlled by vascular vasodilation/vasoconstriction
    - Necessary to maintain flow over a wide range of blood pressures
    - Arterial CO2 levels also affect vasodilation/vasoconstriction with low PaCO2 causing vasoconstiction
    - Cushing response to maintain CPP is another compensatory mechanism
- Injury affects autoregulatory mechanisms
    - Initial compensatory mechanisms to the intracranial hematoma mass effect include CSF absorbtion and venous constriction
    - Mass affect of intracranial hematoma interferes with brain vasculature to appropriately dilate or constrict
- Mass effect
    - Compensatory mechanism begin to fail at approximately 100-150 ml of intracranial hematoma volume
    - Failure of autoregulatory mechanisms can result in **reduced CBF** to the point of ischemic brain injury (secondary brain injury)

- *Hypotension and hypoxia will exacerbate the deleterious effects (brain injury/infarction) of reduced CBF all ready due to intracranial hematoma*

Slide 5 (Monro-Kellie Doctrine)

- Total volume of intracranial contents must remain constant
- Image 1 – normal state
- Image 2 – Intracerebral hematoma -> compensatory mechanism
  - Absorption of CSF
  - Decreased venous volume
  - No increase in Intracrainal Pressure (ICP), yet
  - Remember Cerebral Perfusion Pressure CPP= MAP – ICP
- Image 3 – Enlarging hematoma overtakes compensatory mechanism at 150ml
  - ICP rapidly increases

Slide 6 (Volume-Intracranial Pressure Curve)

- Brain-Blood-CSF autoregulatory mechanisms can compensate until a "critical mass" (approximately 100-150ml) is reached
- Intracranial pressure begins to rise rapidly after these autoregulatory mechanisms are overtaken

Slide 7 (Intracranial pressure)

- Ask **"What is normal ICP**?" ->10mmHg
- How does Increased ICP affect patterns of brain injury?
  - Sustained and unresponsive to treatment, ICP >20mmHg results in poor outcome
- >40mmHg severe ->herniation

Slide 8 (Cerebral Perfusion Pressure) CPP = MBP – ICP

- Increasing ICP due to increased volume due to expanding hematoma follows the Monro-Kellie Doctrine
- Cushing response (increasing blood pressure is a compensatory effort to maintain CPP with rising ICP
- If hypotension ensues (bottom row) CPP is reduced and brain injury is worsened

Slide 9 (Autoregulation)

- **Review the autoregulatory mechanisms of the brain**
  - Vasodilation/vasoconstriction
  - CSF absorbtion
  - Venous constriction
  - Cushing response
- If normal, autoregulatory mechanisms can maintain adequate CBF within a blood pressure range of 50-160mmHg
- Moderate to severe brain injury ->autoregulatory mechanisms are impaired
- Brain injury more sensitive to hypoxia and hypotension (secondary brain injury)
- Treatment of brain injury focuses on prevention of secondary brain injury which is maintaining blood pressure and oxygenation (ABCs)

Slide 10 (Classification of Brain Injury)

- By mechanism
    - Blunt
        - High velocity – MVC, Fall
        - Low velocity – assault, Fall
    - Penetrating
        - Trans-falcine GSW ->fatal

Slide 11 (Classifications of Brain Injury)

- By skull morphology: Skull fractures
    - Vault
    - Base
- Linear skull fractures increase liklihood of hematoma by 400x in awake patient and 20x in comatose patient
- Open fractures at risk for meningitis (see dural leak)
- Basilar skull fractures are at risk for CSF leak and CN 7 and 8 palsy
    - Battle's sign
    - Raccoon eyes
    - CSF rhinorrhea/otorrhea

Slide 12 (Classification of Brain Injury) Brief introduction – Don't dwell on this slide

- By Brain Morphology
- Focal
    - Epidural
    - Supdural
    - Intracerebral
- Diffuse
    - Concussion
    - Contusion
    - Ischemic injury – Hypoxic injury
    - Generalized Edema

Slide 13 (Diffuse brain injury)

- Range from concussion to sever ischemic insult
    - Concussion (symptoms)
        - Transient LOC
        - Retrograe or antegrade amnesia
        - Nausea, vomiting, headache
        - Post-concussive syndrome – difficulty concentrating
        - CT scan is normal – should be repeated for worsening symptoms or clinical change
    - Diffuse brain injury (causes)
        - Hypoxia
        - Hypotension

        - CT reveals generalized edema, blurring of gray-white interface, loss of distinction of gyri and suci

Slide 14 (Epidural Hematoma) **What are the clinical and CT features of an Epidural Hematoma?**

- Skull fracture
- Middle meningeal artery injury
- Actual minimal brain trauma (concussion)
- Can be rapidly fatal due to herniation
- Early evacuation can result in complete recovery

Slide 15 (Epidural Hematoma) CT scan findings

- Biconvex (lenticular) in shape
- Dura adheres to the calvarium
- Uncal herniation when the basilar cistern is effaced

Slide 16 (Subdural Hematoma) **What are the clinical and CT features of an Subdural Hematoma?**

- Bridging vein injury
- Brain laceration
- Outcome determined by underlying brain injury
- Evacuation decision determined by size of mid-line shift
- Follows skull convexitiy
- Density determines age

Slide 17 (Subdural Hematoma) CT scan findings

- Cresent shaped
- Follows skull convexity
- Density determines age
- Covers entire hemispheric surface

Slide 18 (Contusion / Hematoma) **What are the clinical and CT features of a Contusion / Hematoma?**

- Occur in up to 30% of severe brain injuries
- Coup injury (direct injury)
- Contracoup injury (bounce)
- Contusions may progress in size
- Usually occur in the frontal or temporal lobes

Slide 19 (Contusion / Hematoma) CT scan

- Large frontal contusion
- Mid-line shift
- Frontal contusion appears to be contracoup (occipital soft tissue swelling)

Slide 20 (Mild Brain Injury) **What GCS score might constitute a "mild brain injury?"**

- GCS as a may be a method to stratify brain injury

- 80% of brain injured patients
- At discharge, must be awake, understand instructions, companion for 24 hours

Slide 21 (Moderate Brain Injury) **What GCS score might constitute a "moderate brain injury?"**
- CT scan for all patients with GCS 9-13
- Represents 10% of patients with brain injury
- Admit/Observe
- 10-20% of these patients deteriorate

Slide 22 (Severe Brain Injury) **What GCS score might constitute a "severe brain injury?"**
- GCS of 3-8
- ABCs critical
- Cannot protect their airway
- Secondary brain injury from hypotension increases mortality from 27% to 60%
- Add hypoxia to hypotension in the severely brain injured patient = 75% fatal
- If hypotensive, must find cause (CT, FAST, DPL, CXR)
- Repeat head CT scans as needed

Slide 23 (Priorities) **How do I optimally manage the brain injured patient?**
- ABCDE
- Minimize secondary brain injury
    - Oxygen
    - Maintain normal blood pressure

Slide 24 (Focused Neurological Exam?) **What is a focused neurological examination?**
- **GCS**
- **Pupillary Response**
- **Lateralizing signs**
    - Pupil dilation
- Call neurosurgeon early

Slide 25 (Medical Management) **How do I medically manage the brain injured patient?**
- Focus on BP and oxygenation
- IVF
- Controlled ventilation
    - Avoid hyperventilation except in acute change in status
    - Hypocarbia may induce brain vasoconstriction and ischemia if prolonged

Slide 26 (Indications for CT Scan?) **What are the indications for obtain a CT scan of the brain or when do I need to obtain one?**
- Bottom line: Obtain a CT in patients suspected of brain injury

Slide 27 (Medical Management)
- What are the indications for mannitol?

    - Acute deterioration
        - Blown pupil
        - Acute hemiparesis
        - Becomes unconscious
- What is the dose of mannitol?
    - 1gm/kg over 5 min (bolus)
- What are the contraindications of mannitol?
    - Hypotension

Slide 28 (Medical Management: Other Drugs)

- **What other medications might be considered in the medical management of the brain injured patient?**
    - Phenytoin
    - Sedation – decreased ICP in the agitated patient
    - Paralytics – control the combative patient, to obtain diagnostic studies, complete resuscitation

Slide 29 (Surgical Management): Scalp injuries – **How do I manage scalp injuries?**

- May be a major site of blood loss in adults/especially children
- Damage control OK

Slide 30 (Surgical Management: Intracranial Mass lesion) **How do I surgically manage the patient with an intracranial mass lesion?**

- **Committee on Trauma** recommends no burr holes unless trained by and in consultation with a neurosurgeon
- Mannitol/hyperventilate
- Immediate neurosurgery consult

Slide 31 (**How do I diagnose brain death?)**

- Clinical findings?
- Ancillary Studies?
- Consider hypothermia or barbiturate coma