

The Important Upper Third – Pediatric Head Trauma

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I. Head Injury

a) Description

i) Mechanism of Injury

- (1) 25% of all trauma deaths
- (2) > 50% are part of multiple trauma
- (3) Boys are twice as likely, except in infant population
- (4) Mechanism of injury is related to patient

ii) Pathophysiology of Head Injury

(1) Primary Injury

- (a) Occurs within milliseconds of event
- (b) Consists of damage to all layers

(2) **Secondary Injury**

- (a) Begins with event and progresses over time
- (b) Usual time line is a few hours to 3- 5 days
- (c) Can include bleeding, cerebral edema and increased ICP
- (d) May also include post-resuscitation
- (e) Children are more susceptible due to increased water content of brain
- (f) **Management of head trauma is the prevention of secondary injury**

II. Anatomical/Physiological Review

a) Infant Skull

- i) Thin and pliable
- ii) Sutures until @ 18m
- iii) Fontanelle
- iv) Inner surface very smooth
- v) Skull and subarachnoid space offer less tolerance to shift

b) Infant Brain – 80%

- i) 80% of intracranial volume is brain
- ii) Brain growth is incomplete at birth
- iii) 5/6 of growth occurs postnatally!
- iv) Infant brain is 25% of adult brain
- v) weight at birth
- vi) It is 75% of adult weight by age of 4

c) Cerebral Blood Flow – 10%

- i) Cerebral blood flow is not well established
- ii) Blood is 8 - 10% of the intracranial volume
- iii) Most cerebral blood is in thin walled vessels
- iv) Cerebral blood flow uses 20% of the body's total oxygen supply

d) Cerebral Spinal Fluid – 10%

- i) Approximately 10% of the intracranial space
- ii) Made in lateral and 4th ventricles
- iii) When ICP increases, much is pushed into the spinal subarachnoid space
- iv) Early important buffer in the control of ICP
- v)

- e) Meninges
 - i) Three layers covering the brain - PAD
 - (1) Pia Mater – thin mesh with tiny blood vessels in contact with the neural tissue
 - (2) Arachnoid – transparent layer covering the gyri of the brain, cerebral veins located in the arachoid space
 - (3) Dura – “tough mother” lining of the skull

- f) Cerebral Perfusion Pressure
 - i) A relationship between:
 - (1) Arterial Pressure and
 - (2) Intracranial Pressure that tells us
 - (3) How much Cerebral Perfusion is taking place
 - ii) Cerebral Perfusion Pressure (*CPP*)
 - (1) Net flow of blood to the brain
 - (2) Balances ICP and MAP
 - (a) Intracranial Pressure (*ICP*)
 - (i) Increases with injury
 - (ii) Pushes blood out of the brain
 - (b) Mean Arterial Pressure (*MAP*)
 - (i) Mean of the body’s blood pressure
 - (ii) Trying to force blood into brain
 - iii) Affected by:
 - (1) Systemic Blood Pressure
 - (2) Metabolic demands on brain
 - (3) Obstructive processes
 - (4) Intracranial Pressure
 - (a) Normal in children 5 – 20 mm Hg
 - iv) Calculation of Cerebral Perfusion Pressure
 - (1) $CPP = MAP - ICP$
 - (2) Should be kept around 40-60mm Hg
 - (a) Studies show that low CPP in children (< 40) is generally lethal
 - v) Signs and Symptoms of Increased Intracranial Pressure (*ICP*)
 - (1) Headache
 - (2) Nausea/vomiting
 - (3) Seizure activity
 - (4) Firm, bulging fontanelle
 - vi) Cushing’s Triad
 - (1) Bradycardia
 - (2) Hypertension (widening pulse pressure)
 - (3) Irregular respirations

III. Pediatric Neurological Assessment

- a) Documenting Neurological Status
 - i) Level of Consciousness
 - (1) AVPU
 - (a) Alert
 - (b) Responder to Verbal stimuli
 - (c) Responds to Painful stimuli
 - (d) Unresponsive
 - (2) Glasgow Coma Scale
 - (a) Scoring the “best” response for:
 - (i) Motor
 - (ii) Verbal

- (iii) Eye
 - (b) If < 8, consider intubation
 - (c) Highest – 15 (fully awake/aware)
 - (d) Lowest – 3 (coma/impending death)
 - ii) Observational Response
 - (1) Posturing
 - (a) Decerebrate – disconnect at upper brainstem
 - (b) Decorticate – damage to the pathway between brain and spinal cord
 - (2) Reflexes
 - (a) Babinski
 - (i) Normal < 2 years
 - (ii) Otherwise brain/spinal cord injury
 - (b) Moro (startle)
 - (i) Normal < 4 months
 - (ii) Brain Stem reflex
 - (iii) Otherwise suppressed by frontal lobe
- b) Common Injuries
- i) Common Injuries – Concussion
 - (1) A diffuse brain injury that results in no identifiable lesion
 - (2) Mild
 - (a) No loss of consciousness
 - (b) Headache
 - (c) Confusion/Disorientation
 - (d) Possible memory loss
 - (3) Classic
 - (a) Temporary loss of consciousness (< 6 hours)
 - (b) Nausea/vomiting
 - (c) Confusion/disorientation
 - (d) Dizziness
 - (e) Loss of memory
 - ii) Common Injuries – Cerebral Contusion (bruising)
 - (1) More frequently seen in older children
 - (2) Begins as primary injury and progresses
 - (3) May occur at site of impact or opposite the impact
 - iii) Common Injuries – Diffuse Axonal Injury (DAI)
 - (1) Defined by diffuse, microscopic, hemorrhagic lesions
 - (2) Brain stem may be involved, leading to prolonged coma or death
 - (3) Injuries begin at surface and extend to center and base
 - (4) Leakage and diffuse cerebral edema which is worse in first two weeks
 - (5) Signs and Symptoms
 - (a) Immediate Loss of Consciousness
 - (b) Prolonged/indefinite unconscious state
 - (c) Hypertension
 - (d) Hyperthermia
 - (e) Posturing
 - iv) Common Injuries – Epidural Hematoma
 - (1) Disruption of middle meningeal artery
 - (2) Blood collects between skull and dura mater
 - (3) Often associated with fracture
 - (4) S/S
 - (a) Initial loss of consciousness possible
 - (b) Transient “classic” lucid phase
 - (c) Ipsilateral pupil dilation

- (d) Signs of increased ICP
- v) Common Injuries – Subdural Hematoma
 - (1) Venous bleeding
 - (2) Blood collects between the dura and arachnoid mater
 - (3) May be caused by violent shaking
 - (4) Consider shaken baby syndrome
 - (5) S/S
 - (a) Rapid deterioration in level of consciousness
 - (b) Signs of increased ICP
 - (6) Facts Regarding Non-accidental Head Injury
 - (a) The most frequent cause of death in children who are victims of physical abuse is head injury
 - (b) The average age of victims of abusive head trauma is between five and ten months
 - (c) One third of all the children younger than three years with head injury were abused
 - (d) Two primary types of head injury
 - (i) Violent shaking of the baby causing a “whiplash” effect (SBS)
 - (ii) Violent impact as the infant’s head is slammed against a firm surface
 - (7) Facts About Shaken Baby Syndrome
 - (a) SBS accounts for the majority of severe head injuries in less than one year of age
 - (b) 1/3 of SBS patients are missed by their first point of care
 - (c) In the U.S. every year an estimated 1,200 - 1,400 children are shaken for whom treatment is sought
 - (d) < 10 – 15% of patients fully recover
 - (8) Scenario of Shaken Baby Syndrome
 - (a) The usual trigger for shaking a baby is inconsolable crying in the infant
 - (b) The perpetrator loses control and grabs the infant, either by the chest, under the arms, or by the arms and violently shakes the baby
 - (c) The time of shaking varies, usually ranging from around 5 seconds to 15 or 20 seconds
 - (d) During shaking, the head rotates wildly on the axis of the neck creating multiple forces within the head
 - (e) The infant stops crying and stops breathing, causing decreased oxygen supply to the body, particularly to the brain
 - (9) Mechanism of Shaken Baby Syndrome
 - (a) The veins that bridge from the brain to the dura, which is fixed to the inside of the skull, are stretched and, exceeding their elasticity, tear open and bleed, creating the subdural hematoma or subarachnoid hemorrhages (characteristics of the syndrome)
 - (b) The brain strikes the inner surfaces of the skull, causing direct trauma to the brain substance itself
 - (c) The deeper structures of the brain, the axons, can be broken, shearing off during the commotion to the brain
 - (d) The lack of oxygen during shaking causes further irreversible damage to the brain substance
 - (e) Damaged nerve cells release chemicals which add both to oxygen deprivation to the brain and also cause direct further damage to the brain cell
 - **Subdural Hematoma (1)**
 - o Collection of blood beneath the dura
 - o The dura is a fibrous membrane that surrounds the brain and attaches to the skull
 - **Retinal Hemorrhages (2)**
 - o Bleeding in the back of the eyeball
 - **Cerebral Edema (3)**
 - o Swelling of the brain
 - Diffuse Axonal Injury
 - o Shearing of nerve fibers in the white matter of the brain that destroys brain tissue
 - Skull Fracture

- “Black Brain”
 - Wasting away of the brain due to lack of blood supply
 - Seen on CT or MRI scan
- c) Pre-Hospital Interventions
 - (1) The Primary Goal
 - (a) Prevent secondary brain injury by restoring
 - (i) Oxygenation
 - (ii) Ventilation
 - (iii) Perfusion
 - (2) Intubation?
 - (a) It is clear that hypoxemia is related to poorer neurological outcomes in TBI
 - (b) There is no research to support ETI over bag-valve-mask
 - (c) If ETI is established, an end tital CO2 detector is necessary
 - (d) Airway management is indicated with GCS - 8
 - (3) Hyperventilation?
 - (a) Increases O2 – decreases possibility of anaerobic metabolism
 - (b) Decreases CO2 – vasoconstricts
 - (c) Hyperventilation temporarily decreases ICP, but may increase ischemia
 - (4) Blood Pressure Management?
 - (a) Hypotension should be identified and managed in the TBI patient ASAP
 - (b) Definition of pediatric hypotension
 - 1. < 5th % for age