From Bumps to Bleeds: Management of Pediatric Head Trauma

Kristi Westphaln RN MSN CPNP
Trauma Program Nurse Practitioner
Division of Pediatric Surgery

Objectives

1. Identify at least 3 factors that predispose children to head injuries.
2. Discuss the current guidelines for concussion management in children.
3. Explain the rationale behind utilization of various imaging modalities such as CT scans and MRIs in relation to pediatric head injuries.
4. Verbalize the plan of care for the spectrum of pediatric head injuries discussed during this talk.
5. List age appropriate injury prevention strategies to decrease pediatric head injuries.

Acknowledgements

Thank you to the following for their support and assistance:

Nancy McGrath, MSN CPNP-AC/PC

Cat Goodhue MSN CPNP- PC

Drs. John Grimm, Karen Imagawa, Paritosh Khanna

The staff of the Emergency Department at Rady Children's Hospital in San Diego

The staff of the Trauma Program at Children's Hospital Los Angeles

CANP: thank you for the opportunity to present today

I have nothing to disclose.

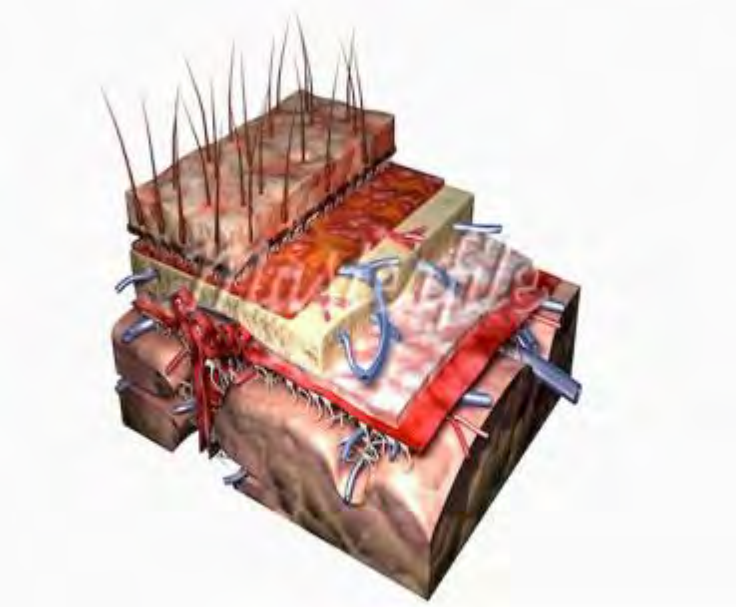
Anatomy/Physiology Review

SCALP: skin, connective tissue, galea, loose areolar tissue, pericranium

SKULL: cranial vault(calvaria) + base

MENINGES: dura, arachnoid , pia

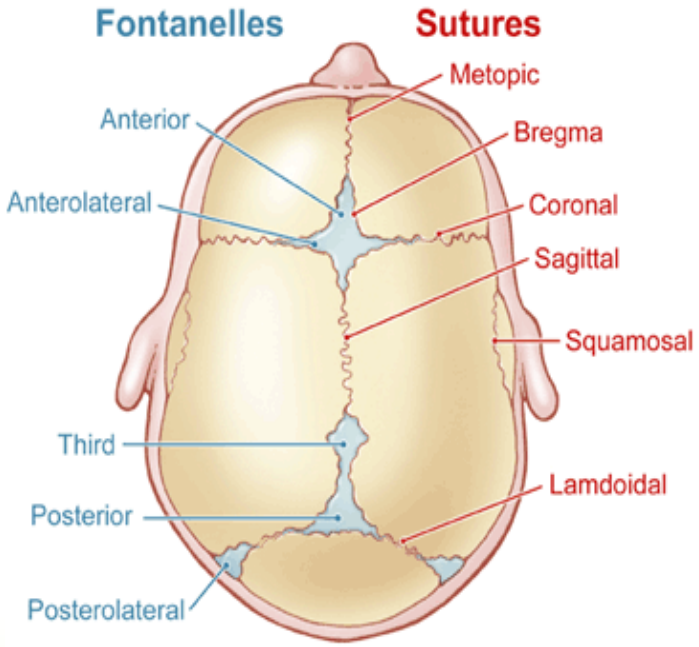
BRAIN: cerebrum, brainstem, cerebellum



Anatomical Considerations

- Size matters
- Gravity
- Incomplete myelination
- Smaller subarachnoid space
- Infant brain = higher concentration of water than an adult brain = softer, more gelatinous, higher susceptibility to injury

- Flexible skull
- Anterior and posterior fontanels:
  - Anterior closes at 9-18 months
  - Posterior closes at 6-8 weeks



How does the brain of a child differ from an adult?

- Doubles in size during the first 6 months of life
- Double the amount of water content than an adult until 2 years old
- Smaller subarachnoid space
- Increased sensitivity to cerebral hypoxia
- Incomplete myelination and synapse formation
- Achieves 80% adult brain size by 2 years old

Forces of Injury

- Blunt vs penetrating
- External forces: acceleration, deceleration, or both
- Internal forces: tearing/shearing/rupture of tissue
- Axial load: pressure exerted on skeleton when victim of a fall lands directly onto head or feet

Developmental Milestones

- 5 months: roll front to back
- 6 months: roll back to front
- 8 months: sit unsupported, crawling, responds to name
- 9 months: understands “no” in all tones, pull to standing position
- 10 months: creeps and cruises
- 12 months: walking, can follow simple 1 word commands accompanied by gestures
- 12-18 months: depth perception and distance vision remain underdeveloped, vision at 1 year typically 20/180

Children's Hospital LOS ANGELES
We Treat Kids Better

Common mechanisms of head trauma in children:

- Failure to fly: windows
- MVC/no car seat
- Shopping carts
- NAT
- Furniture/television
- Assault
- Bicycles/ no helmet
- Playground equipment
- Staircases
- Sports

NON-FATAL HEAD TRAUMA

Abrasions/lacerations

Hematomas

Concussions

Wound repair: assess,medicate,irrigate,repair, educate!

steristrips vs dermabond vs staples vs sutures

1. Dermabond

- Tissue adhesive aka cyanoacyrlate
- Antidote is aquaphor(in case a sticky situation presents)
- Typically remains intact for 2 weeks

Discharge instructions : keep dry for first 48 hours, no immersion in water, no adhesive dressings, no topical medications, no removal needed

2. Staples

- Scalp wounds only
- Pain medication needs to be on board: motrin and a topical such as
- LET(leave on at least 20 minutes)
- Send home with a staple remover
- Follow up in 1 week for staple removal –
- Thin layer of polysporin over staples is appropriate
- Do not immerse for 24-48 hours, then is okay for showers

3. Sutures

Nonabsorbables include: **prolene** and ethilon

Absorbables: **fast gut**, chromic gut, vicryl

Basic tray set-up/supplies: suture selection, suture kit, sterile gloves, 30cc syringe with splash guard, pain medication(lidocaine with or without epi and bicarb: buffered at a 9:1 or 4.5:0.5 ml concentration), small gauge needle to administer pain medication,absorbent underpadding, towels, an extra set of hands

- Removal per location

Wound care education principles

- Keep clean and dry
- Immobilization of wounds over joint surfaces
- Scars/protection
- Attention to infection
- Tetanus prophylaxis recommendations

2011 Updates on pediatric concussions

- Approximately **3.8 million recreation and sport-related concussions** occur annually in the United States
- **Concussions account for 8.9% of all high school sport related injuries**
- Females have higher rate of concussion than males

Top 5 sports that demonstrate most at risk: football, girls' soccer, boys' lacrosse, boys' soccer, girls' basketball

Who has a headache? : Challenges in pediatric concussion management

- Multiple symposiums to address definition of "concussion": Vienna(2001), Prague(2004), Zurich(2008)
- Multiple concussion grading scales: American Academy of Neurology, Cantu, Colorado Medical Society
- Late presentation of symptoms

Children are not always forthcoming about injuries if they want to continue to play

Key features of concussion consideration via the Zurich Statement

1. cause= direct blow to head or body that results in force transmitted to head
2. Short lasting neurologic impairment that rapidly appears and spontaneously resolved
3. Acute clinical symptoms reflect disturbance of function vs insult to structure
4. Multiple symptom possibilities that may or may not include LOC and/or prolonged post-concussive symptoms
5. Neuro-imaging studies to evaluate concussion do not typically demonstrate structural abnormalities

Concussion assessment

- History/mechanism of injury
- Head and neck exam
- Neurologic exam
- Gait and balance assessment
- Assess cognitive function
- Physical, cognitive, emotional, sleep

Feeling foggy? Post Concussive Syndrome

Not clearly defined: WHO vs DMS-MMHD

- Persistent concussion symptoms lasting approximately 1-6 weeks s/p initial event
- Includes physical, emotional, and cognitive concussion sequelae that last longer than expected

Second Impact Syndrome

- acute brain swelling due to second head trauma is sustained prior to full recovery from an initial concussion.
  - rare, non-treatable, fatal
- vascular auto regulatory mechanisms in the brain need time to heal and recover functions

Concussion pearls for Clinicians

- Sports related concussions are common in kids
- LOC >30 seconds is a red flag
- CT/MRI generally normal with a concussion
- Cannot return to play on the same day or until the symptoms go away!
- Typical recovery is 7-10 days, can be longer
- Concussion recovery should include both physical and cognitive rest
- Partner with primary care providers to ensure safe transition to return to play

Children's Hospital LOS ANGELES
We Treat Kids Better

http://www.cdc.gov/concussion/

Steps to return to play

0: 24 hours remaining asymptomatic with no pharmacotherapy
1: Light aerobic exercise: 5-10 minutes only/no strenuous running, weightlifting, or jumping
2: Moderate exercise-brief running, moderate weightlifting
3: Non-contact exercise- running, weightlifting
4: Return to sport practice
5: Return to competition/play

POTENTIALLY FATAL PEDIATRIC HEAD TRAUMA

Fractures

Increased intracranial pressure(ICP)

Intracranial hemorrhages

Cerebral edema

Diffuse axonal injuries(DAI)

ATLS Primary Survey

1. Airway/Breathing
- Spontaneous respirations with protected airway?
- Unstable/unresponsive?
- Intubation: oral versus nasal?
- Hyperventilation?

2. Circulation
- Hypotensive?
- Active bleeding?
- IV access?

3. Disability

- Neurologic exam: pupils and GCS
- C-spine immobilization
- Distracting injuries?

Children's Hospital LOS ANGELES
We Treat Kids Better

Table 2. Pediatric Glasgow Coma Scale For Pre-verbal Children.

Eye opening	
Spontaneous	4
To speech	3
To pain	2
No response	1
Verbal response	
Coos, babbles	5
Irritable cry	4
Cries to pain	3
Moans to pain	2
No response	1
Motor response	
Follows commands	6
Localizes pain	5
Withdraws to pain	4
Decorticate flexion	3
Decerebrate extension	2
No response	1

To scan or not to scan: Who needs brain imaging?

- LOC > 30 seconds
- Behavior changes
- Boggy hematoma on scalp
- Persistent emesis
- Questionable GCS

Skull fracture, intracranial hemorrhages, signs of increased intracranial pressure, intubated after poly-trauma including head injury, concern for child abuse…

Imaging modalities for pediatric head injuries:
plain films vs US vs CT vs MRI

1. Plain skull films
2. Ultrasonography
3. CT scan
4. MRI

Pediatric brain imaging considerations that can fool you…

- anatomy: consider fontanels and sutures
- consider accessory sutures vs fractures
- dense dural venous sinuses and high baseline hematocrit
- in infants can mimic SDH
- unmyelinated white matter can mimic parenchymal
- edema in newborns
- bilateral chronic SDH: consider birth history, metabolic
- syndromes, blood dyscrasias

Skull fractures

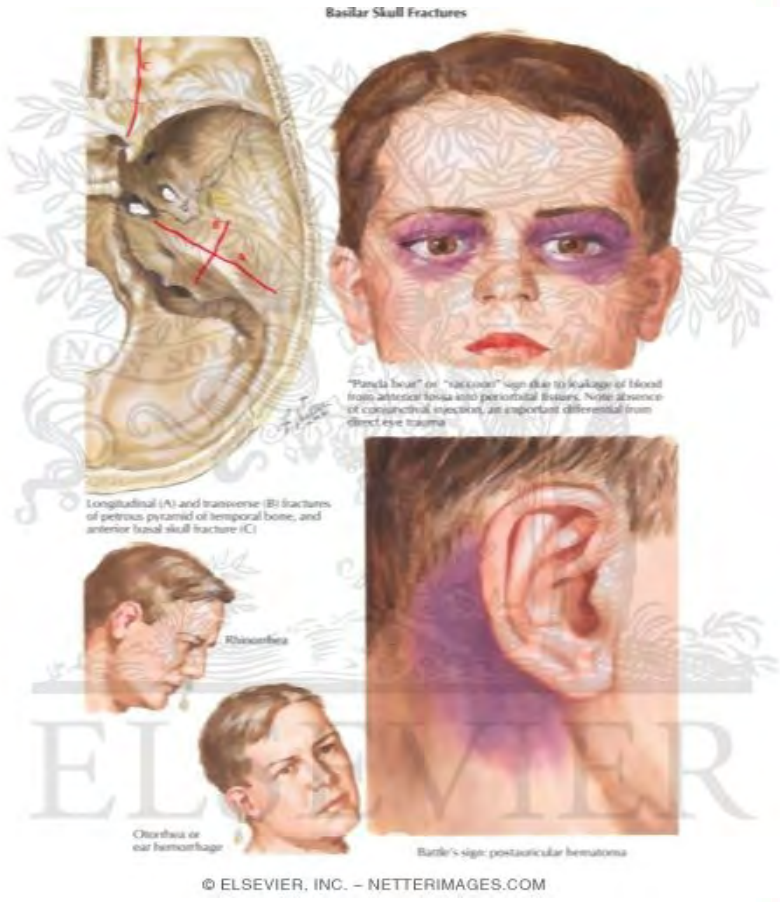
A) Non-depressed linear skull fracture: non-displaced, most common site is parietal bone, heal well in 6-8 weeks without complications

B) Depressed skull fractures: dural lacerations, cosmetic deformity, compression of brain parenchyma, floating bone fragments, palpable crepitus, bony step off, increased ICP

C. Basilar skull fractures

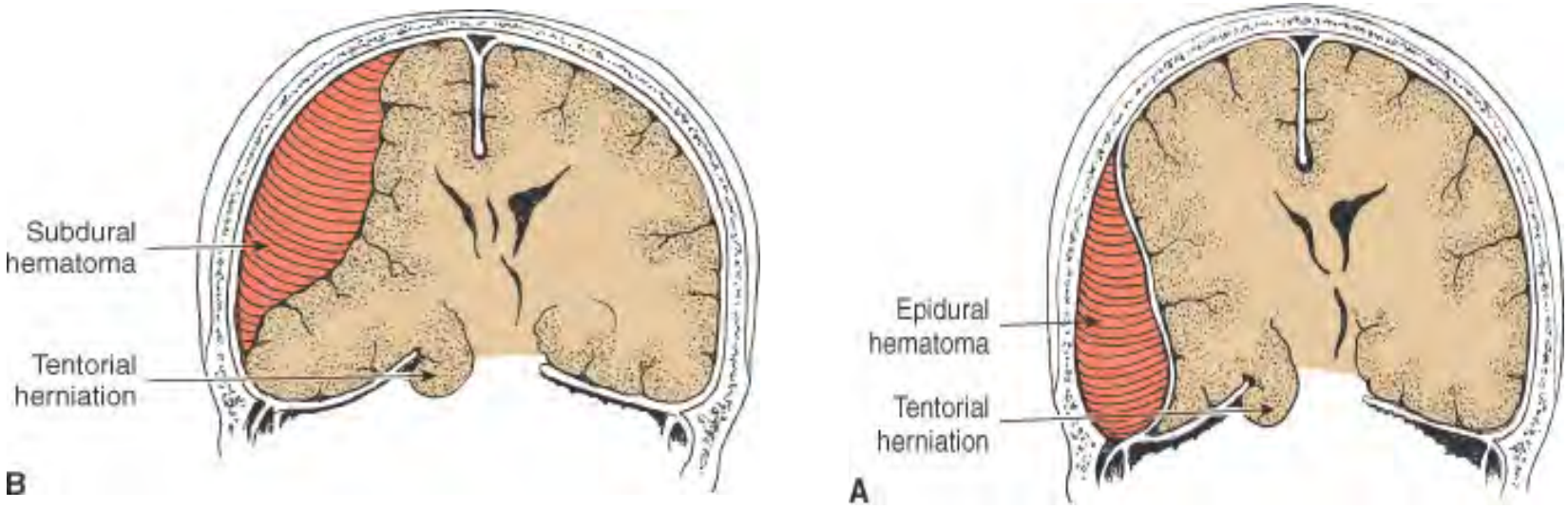
battles sign(mastoid ecchymosis),raccoon eyes...not subtle

- 10-40% intracranial injury
- 15-30% CSF leak
- 1-23% CN VI, VII, VIII impairment



Increased Intracranial Pressure: Monro Kellie Doctrine

Volume of intracranial vault= 70% brain,20% CSF, 10% blood



Early signs and symptoms of increased

Irritability, poor feeding
High-pitched cry, difficult to soothe
Fontanels: tense, bulging
Cranial sutures: separated
Eyes: setting-sun sign
Scalp veins: distended

Signs of increased ICP in older children

EARLY

- headache
- nausea/vomiting
- ALOC/behavior changes

LATE

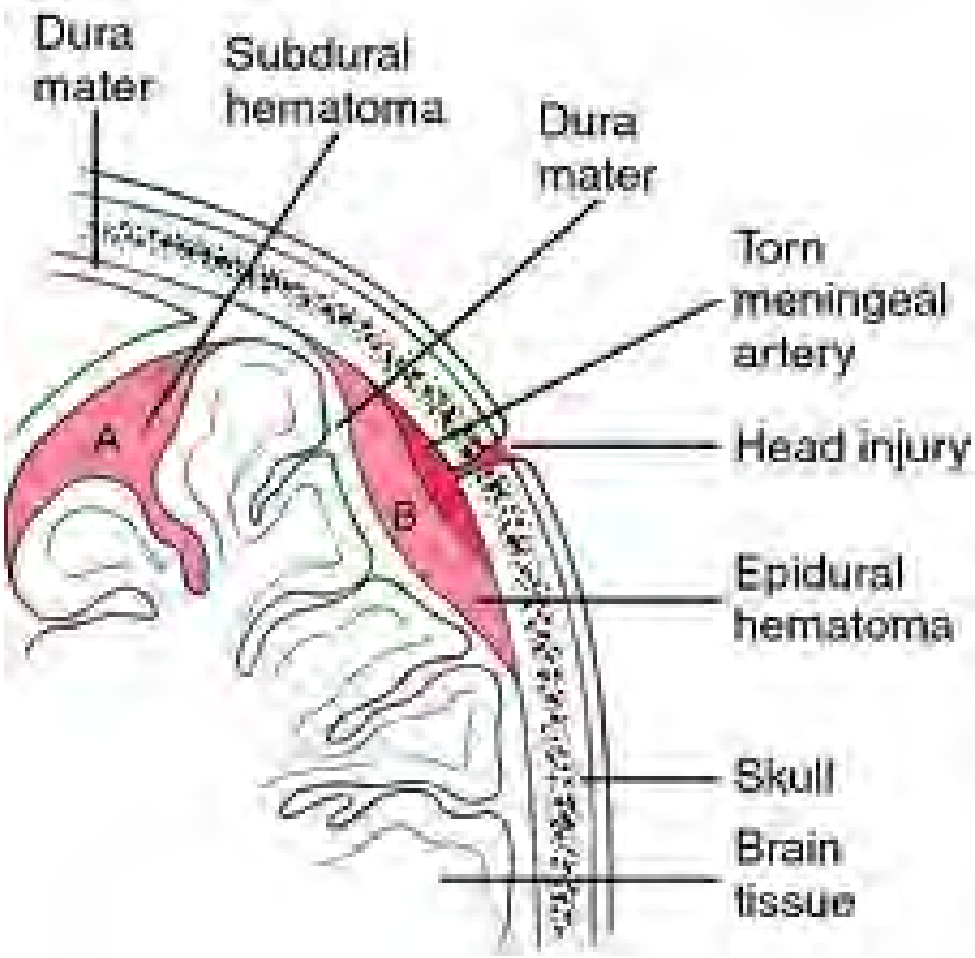
- CUSHINGS TRIAD
- unresponsive to painful stimuli
- posturing
- dilated, non-reactive pupils

Intracranial hemorrhages

1. Epidural Hemorrhage:collection of blood between skull and dura mater, typically arterial, rapid changes in LOC as ICP rises

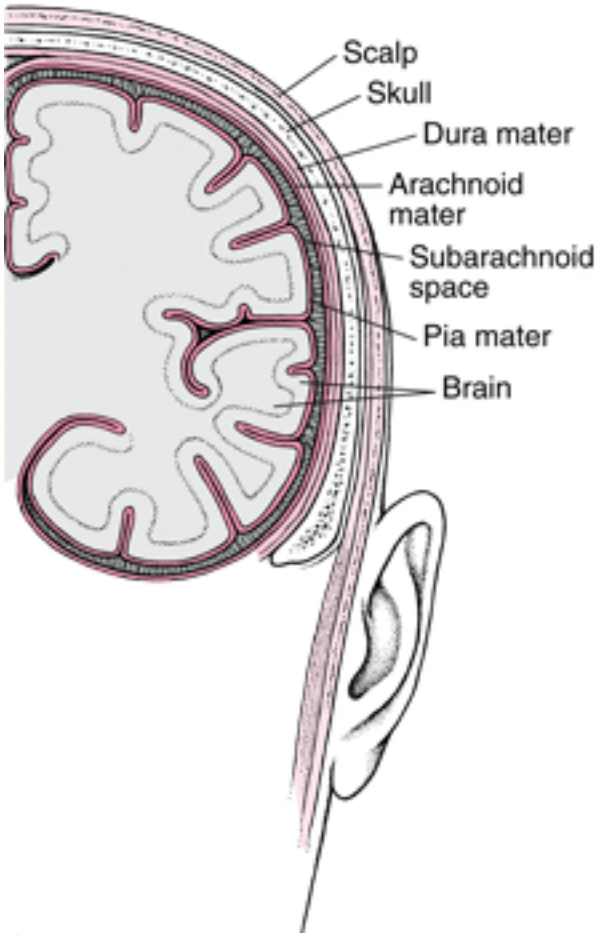
2. Subdural Hemorrhage: bleeding between dura and cerebrum, secondary to venous sinus injury, usually slowly accumulating venous blood

3. Subarachnoid Hemorrhage: seen in brain contusion or when injury occurs to main vessels at base of the brain


Dura mater
Subdural hematoma
Dura mater
Torn meningeal artery
Head injury
A
B
Epidural hematoma
Skull
Brain tissue

Children's Hospital LOS ANGELES
We Treat Kids Better

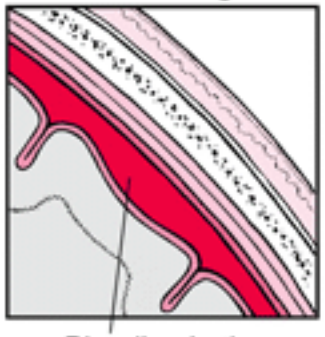
Cross Section of the Brain



Intracerebral Hemorrhage

Bleeding inside the brain

Subarachnoid Hemorrhage



Bleeding in the subarachnoid space

Pathophysiology in pediatric abusive head trauma

- Rupture of bridging veins
- Coup,contre-coup mechanism
- Traumatic DAI
- Neuron rupture triggers enzyme release that contributes to vicious cycle: hypoxia, cerebral edema, increased intracranial pressure

Acute care management principles: severe TBI with GCS < 8

Suboptimal survival equation:

(hypoxia + hypotension) + head injury = 75% mortality

GOALS:

1. **<u>Identify direct cause of increased ICP: NEUROSURGERY intervention</u>**

A. Burr Hole: drainage for EDH or SDH

B. Shunt placement

C. Decompressive craniectomy

2.ICP < 20mm Hg

elevated ICP = decrease cerebral perfusion leading to cerebral hypoxia and ischemia

Cerebral perfusion pressure in children (CPP):

< 2 years ≥ 45mmHg

2-6 years ≥ 50mmHg

7-10 years ≥ 55mmHg

11 years ≥60mmHg

ICP monitor placement = Ventriculostomy catheter

-keep HOB at 30 degrees

-ICP monitor zeroed/functional

3. Prevent hypotension

Maintain normal intravascular blood volume

- Blood product administration
- Appropriate IVF
- Monitor urine output/renal perfusion
- Important lab goals: Sodium goal = 145-155
  Serum glucose goal = 120-180
  Keep hematocrit above 28

4. Support oxygenation

- Goal SpO2 > 96%
- Goal PaCO2 336-40 to maintain CPP
- Monitor MAP
- Balancing act: PaO2 and PaCO2 also stimulate intracranial blood vessels to dilate or constrict
- Prevent atelectasis

5. Empower your bedside nurses!

- Appropriate sedation/paralysis for intubated patients
- C-spine
- ICP monitoring
- HOB midline/30 degrees
- Foley in
- Neurochecks q 1 hour
- Skin care/PT/OT
- Zantac
- Labs: ABG, chem 8, urine dip, CBC
- A-line/CVP set up
- Minimize suctioning

Cerebral Edema

- inflammatory response triggered by acute injury
- fluid collects between and within neurons
- displacement of blood vessels, brain tissue = increased ICP

Interventions: Cerebral Edema

- Mannitol: Pulls water from CNS into intravascular space aka osmotic gradient, SE: hypotension and dehydration
- Mild hyperventilation
- 3% normal saline (6mg/kg over 20 minutes)

Anticipate seizures…

- Lorazepam
- Load: phosphenytoin ≥ 2 years or phenobarbital ≤ 2years
- Levetriacetam
- Transient tachycardia?
- Neurology consult
- EEG

Diffuse Axonal Injuries (DAI)

- damage to white matter tracks due to shearing mechanisms: MVC, motorcycles/dirt bikes
- can result in death or long-term disability
- typically tragic

A Play for Injury Prevention

- 15 children in the US die every day from unintentional injuries = 5600 lost lives per year.
- 80% of childhood injuries are preventable

All providers who care for children have the potential to incorporate

injury prevention principles into practice

Pearls for preventing pediatric head injuries

1. Shopping Carts
2. Stairs
3. High Chairs
4. Cribs
5. Windows
6. Cars
7. Bicycles
8. Sports

Considerations for Providers:

Accidental vs Non-accidental trauma

- infants from 3-5 months at highest risk
- previous history of abuse
- is the story consistent with the injury?
- bruising/fractures at different stages of healing
- family support and coping mechanisms
- delays in medical treatment
- injuries that are inconsistent with developmental level of child
- old or new bruises, scars, welts, or burns on the child
- inappropriate child behavior/affect can also be an indicator

Anticipatory Guidance: crying infants

- crying is how babies communicate
- expect an increase in crying from birth until approx 6 weeks
- crying is more common in the late afternoon and evening
- infants cannot learn social behaviors: they are not little adults
- infant crying is not indicative of a parental failure
- never discipline a crying infant via forcefully shaking or tossing
- stage an intervention: some parents enlist a phone-a-friend type model to have support for frustrating child care moments

Children's Hospital LOS ANGELES
We Treat Kids Better

In Review

- Many pediatric head injuries are preventable.
- Children have certain anatomical and developmental differences that contribute to risk for head injury.
- Head injuries from falls are concerning: may potentially result in long term disability or even death.
- Head injuries may include both accidental and/or non-accidental components.
- Education for fall prevention needs to start early: car seat safety checks, child proofing home/injury prevention themed home visits, family anticipatory guidance by health care providers.

REFERENCES

American College of Surgeons Committee on Trauma (2008). *Advanced trauma life support of doctors: student course manual* (8th ed). Published by the American College of Surgeons, Chicago, IL.

American College of Surgeons Committee on Trauma, *Resources for optimal care of the injured patient 2006.*(2006) American College of Surgeons: Chicago, Il.

Browne, N.T., Flanigan, L.M., McComiskey, C.A., Pieper, P. (2007). *Nursing care of the pediatric surgical patient.* (2nd ed). Jones and Bartlett Publishers Inc: Sudbury, MA.

Buttaravoli, P. (2007). *Minor emergencies: splinters to fractures.* (2nd ed). Mosby Elsevier: Philadelphia, PA.

REFERENCES

Centers for Disease Control and Prevention, *Protect the ones you love: child injuries are preventable.* www.cdc.gov/SafeChild/falls/.

Centers for Disease Control and Prevention,*CDC Childhood injury report: Patterns of unintentional injuries among 0-19 year olds in the united states, 2000-2006*. www.cdc.gov/SafeChild/images/cdc.ChildhoodInjury.pdf.

Emergency Nurses Association (2007). *Trauma nursing core course.*(8th ed). Published by the Emergency Nurses Association, Des Plaines, IL.

Glick, P.L., Pearl, R.H., Irish, M.S., Caty, M.G. (2001). *Pediatric surgery secrets*. Hanley and Belfus: Philadelphia, PA.

Halstead, M.E., Walter, K.D., and The Council on Sports Medicine and Fitness. (2010). *Sport related concussion in children and adolescents.* Pediatrics.126:567.

REFERENCES

Images obtained via google images

Reuter-Rice, K. and Bolick, B. (2012). *Pediatric acute care: a guide for interprofessional practice.* Jones and Bartlett Learning: Burlington, MA.

Ryan-Wenger, N.A. (2007). *Core curriculum for primary care pediatric nurse practitioners.* Mosby Elsevier, St. Louis, MI.

Selbst, S.M. & Cronan, K. (2008). Pediatric emergency medicine secrets. (2nd ed). Mosby Elsevier: Philadelphia, PA.

Strange, G.R., Ahrens, W.R., Lelyveld, S., & Schafermeyer, R.W. (2002). Pediatric emergency medicine: a comprehensive study guide. (2nd ed). New York: McGraw-Hill.

Upperman, J.S., Burd, R., Cox, C. Ehrlich, P., Mooney, D., Groner, J.I. (2010). Pediatric applied trauma research network: a call to action. Journal of trauma injury, infection, and critical care. v69: n5.

Zebrack, M., Dandoy, C., Hansen, K., Scaife, E., Mann, N.C., & Bratton, S.L. (2009) *Early resuscitation of children with modedrate-to-severe traumatic brain injury*. Pediatrics. 124;56-64.