A Review of Pediatric Trauma
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Trauma

- Most common cause of pediatric morbidity and mortality.
- Leading cause of death in children >1 yr
- More than 500,000 pediatric trauma admissions per year
- Over 20,000 pediatric deaths each year due to trauma

Trauma

- Age and gender: most important factors in determining patterns of injury
- Male children in all age groups have higher injury and mortality rates
- Infants: Abuse
- Toddlers: Falls
- School-age children: Bike accidents + motor vehicle accidents (pedestrian injuries)
- Adolescents: Motor vehicle accidents +/- ETOH use
Trauma

- 80-90% of pediatric trauma due to blunt forces.
- Penetrating trauma has a much higher mortality rate.
- Rates of penetrating trauma increasing in children, especially in urban areas.

Trauma

- Trauma management is very systematic
- Begins with the primary survey with simultaneous initial resuscitation
- Followed by the secondary survey after patient is stabilized.

Trauma

- Primary Survey
  1. Airway with cervical spine stabilization
  2. Breathing and ventilation
  3. Circulation and hemorrhage control
  4. Disability (neuro screen)
  5. Exposure

If serious alterations are encountered, resuscitative care is performed prior to moving onto the next system.
**Trauma**

- Secondary Survey: A focused evaluation of each body area, proceeding from head to toe.
- Should only be completed after major physiological instabilities are recognized and treated during the primary survey stage.

**Questions**

- 3 year old boy brought to ED by EMS after being struck by a car. A large occipital hematoma noted. He was intubated by EMS secondary to being unresponsive with dilated pupils. You are managing the airway.

**Questions**

- What is the optimal end-tidal CO2 for this patient?
  - A. 10 mm Hg
  - B. 20 mm Hg
  - C. 30 mm Hg
  - D. 40 mm Hg
  - E. 50 mm Hg
Head Trauma

- Head trauma is the leading cause of morbidity and mortality in children.
- 80% of children who die from trauma have significant head injuries.
- Falls are the most common cause of head injury, followed by motor vehicle accidents, bike accidents and assaults.

Brain injury classified as primary or secondary.
- **Primary Injury**: Occurs at time of impact. Rarely influenced by interventions.
- **Secondary Injury**: Occurs after the impact. Refers to neuron death resulting from hypoxia, ischemia or increased ICP.
- The goal in the management of head injury is to limit secondary brain injury.

Final common pathway leading to secondary injury is increased ICP and decreased CPP.
- CPP = MAP - ICP
- Goal of management of head injured patient is to maintain CPP within normal range with interventions focusing on the MAP and ICP.
**Head Trauma**

**PRIMARY INJURY ➔ BRAIN DAMAGE**
- Fracture, Intracranial hemorrhage  
- Concussion, Axonal shearing  

**CNS-REACTIVE LESIONS ➔ SECONDARY INJURY**
- Cerebral hypotension
- Vascular autoregulation
- Cerebral edema

- Mechanical distortion
- Ischemia
- Hypoxemia

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**Head Trauma**

- Intracranial volume (fixed) = CSF volume + Blood volume + Brain volume
- Exception: infants with open fontanelle
- Once compliance of IC volume is exceeded, small changes in any component ➔ huge increases in ICP
- Early Sx of increased ICP = headache, vomiting, altered MS, abnormal posturing

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**Head Trauma**

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Head Trauma

- Management of Intracranial Hypertension
  1. Avoid secondary injury: correct hypoxia, hypoglycemia, hyperthermia, seizures
  2. MILD Hyperventilation: end-tidal CO2 30-35 mm Hg (vasoconstriction)
  3. Sedation: lowers ICP, prevent Sz, decrease cerebral metabolism
  4. Diuresis: Mannitol or furosemide. Increasing use of hypertonic saline.

Questions

- 3 year old male presents to your office after falling and hitting his forehead on furniture at home. He cried immediately. Has had no vomiting. He seems quieter than usual per mother, but fell asleep in the care. On exam, he is active and has a 2 cm hematoma over his mid-forehead. He is able to perform simple tasks. Remainder of exam is unremarkable.

Questions

- The next step in the management plan is:
  A. Skull x-rays
  B. Discharge home with instructions
  C. Admit to the hospital for observation
  D. MRI of brain
  E. Head CT
Head Trauma

- Head CT is initial imaging study
- MRI not during the initial diagnostic phase.
- Role of skull films: Use much lower given the information provided by CT. May be indicated in evaluation of suspected depressed skull fractures, suspected basilar skull fractures, skeletal survey for child abuse, and in patients with prior craniotomies or shunts.

Head Trauma

Absolute Indications for Head CT:
1. Penetrating injury
2. GCS<15
3. Focal neurologic deficit
4. Post-traumatic seizures
5. Extensive facial injury
6. Signs of basilar skull fracture

Head Trauma

Relative Indications for Head CT
1. History of a change in LOC
2. Alcohol or drug intoxication
3. Suspected child maltreatment
4. Unreliable/inadequate history
5. Age<2
6. Post-concussive amnesia or severe HA
Head Trauma

- Criteria for discharge from ED:
  1. Brief of no LOC
  2. History compatible with only minor injury
  3. Asymptomatic with GCS=15
  4. Normal radiographic findings
  5. Reliable caregivers
  6. Easy access to hospital if deteriorate

Head Trauma

- Homegoing instructions: Return to ED for any of the following in 72 hours:
  1. Disorientation/unusual behavior
  2. Unusual drowsiness and sleepiness
  3. Inability to wake child from sleep
  4. Increasing headache
  5. Seizure activity/abnormal gait/weakness
  6. Vomiting more than 2 times

Questions

- 5 year boy is injured while wrestling with his older brother at home, hitting his head against the fireplace mantle. No loss of consciousness, but confused for several minutes. Played outside for a few hours, but came inside complaining of a headache, then began to vomit. Lump on side of head noted by mother. By the time he arrived to the ED he is difficult to arouse.
Questions

- The most likely cause of his clinical findings is:
  A. Parenchymal contusion
  B. Subdural hematoma
  C. Basilar skull fracture
  D. Epidural hematoma
  E. Concussion

Head Trauma

- **Skull Fractures**:
  1. Linear: most common, usually no Sx except for focal swelling, f/u with serial CT/xrays for resolution
  2. Depressed: large force to small area (e.g. hammer), can be assoc. with underlying brain injury. Mandatory neurosurgical evaluation

Head Trauma

- **Skull Fractures**
  3. Basilar: Thru the basal portion of the skull. Characterized by periorbital hematomas (raccoon eyes), CSF rhinorrhea, hemotympanum, otorrhea (glucose present), CN palsies, or periauricular hematomas (Battle's sign). Neurosurg eval. 95% heal with bed rest and elevating head of bed.
Head Trauma

- **Epidural Hematoma:**
  - Classically from tearing of a meningeal artery (usually middle meningeal artery).
  - Head injury → AMS/LOC → *Lucid interval* → Deterioration
  - In children, from high fall onto hard surface or motor vehicle accident
  - CT: Hyperdense lenticular collection of blood
  - Mandatory neurosurgical consultation

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Epidural Hematoma

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Head Trauma

- **Subdural Hematoma:**
  - 5-10x more common than epidurals
  - Usually occur in infants more often than older children
  - Tearing of bridging veins
  - CT: hyperdense blood in crescent shape
  - Nonspecific symptoms (esp infants): irritability, vomiting, seizures
Subdural Hematoma

Head Trauma

- **Diffuse Axonal Injury:**
  - Occurs during abrupt deceleration b/c white and grey matter have different densities and different rates of deceleration: tearing of bridging veins, shearing of myelin, hemorrhage of white and grey matter
  - Assoc. with child abuse in children < 1yr

Diffuse Axonal Injury
**Torso Trauma**

- Blunt trauma is most common cause of chest and abdominal trauma: falls, motor vehicle accidents and sports
- Children more at risk because of less overlying subcutaneous fat, more exposed organs, and more compliant chest wall (allows energy transfer without external evidence of trauma)

**Chest Trauma**

- Symptoms of intrathoracic trauma:
  1. Chest pain
  2. Noisy or rapid breathing
  3. Respiratory distress or failure
  4. Bloody sputum

Examples: pulmonary contusion, pneumothorax, cardiac contusion

Relatively rare, but increased risk for multisystem trauma

**Questions**

- 11 year old boy presents with abdominal pain after being tackled while playing football at home. His VS are normal. He has left upper and lower quadrant tenderness on exam. He also states his left shoulder is hurting.
Questions

- The most likely cause of his symptoms is:
  A. Pancreatic injury
  B. Duodenal hematoma
  C. Renal contusion
  D. Bladder rupture
  E. Splenic laceration

Abdominal Trauma

- Signs and symptoms of abdominal trauma:
  1. Abdominal pain/tenderness
  2. Abdominal distention
  3. Abdominal wall contusions
  4. Vomiting

CT is imaging modality of choice

Splenic and hepatic injuries are relatively common in children, but mgmt is usually conservative. Only a few need operative care.

Liver Laceration
Abdominal Trauma

- **Sports related abdominal trauma**: usually isolated organ injury due to a direct blow to abdomen
- **Handlebar injuries**: May have delayed symptoms. Traumatic pancreatitis most common, followed by spleen or liver injuries, and duodenal hematoma
- **Lap belt complex**: bursting injury of solid or hollow visera and disruption of diaphragm or lumbar spine

Burns

- >90,000 children/yr injured due to burns
- Scald injuries more common in young children. May be accidental or intentional
- Flame related injuries more common in older children, e.g. playing with matches, putting flammable liquids on fires

Questions

- 14 month female is brought to the ED after grabbing and spilling her mother’s coffee cup onto her one hour ago. On exam, she has edema, erythema and blistering over her right neck and upper chest, tapering towards her abdomen. The burn is very tender to palpation.
Questions

The appropriate management plan would include the following EXCEPT:
A. Referral to Burn Center or Plastic Surgery
B. Systemic antibiotics
C. Debridement of open lesions
D. Topical antibiotics
E. Application of sterile dressing.

BURNS

- Burns classified according to depth of the burn
- Common classification system: 1st, 2nd, 3rd and 4th degree burns
- Newer classification: superficial, superficial partial thickness, full thickness and deep full thickness (subdermal)

Burns

- **Superficial burns (1st degree):**
  - Affects only the epidermis
  - Erythema without blisters, e.g. sunburn
  - Painful
  - Heals within 1 week
  - Tx: Oral analgesics, topical moisturizers
Superficial Burn

- Through the epidermis and into dermis
- Erythema with blister formation
- Nerve endings exposed→Pain

→ Surgical debridement to remove blisters may be needed. Topical antibiotics, 2-3 weeks to heal.

Burns

- **Superficial Partial Thickness Burns (2nd degree):**

Superficial Partial Thickness (2nd degree)
Burns

- **Deep Partial Thickness Burns (3rd degree):**
  - Through the epidermis and deeper into the dermis
  - White yellow appearance with blisters
  - Decreasing pain because increasing nerve endings destroyed
  - Tx: Surgical debridement, topical antibiotics, possible skin grafts

- **Full Thickness Burns (4th degree):**
  - Through the entire depth of dermis and possibly into muscle and bone
  - Skin is white, yellow, brown or black. Hard inelastic eschar formation
  - NO blisters
  - Minimal pain
  - Tx: excision of eschar, skin grafts
Burns

Burn Management
1. Stabilize ABCs, obtain IV access and begin fluids, as needed
2. Assess extent and depth of burns
3. Irrigate with sterile saline
4. Remove devitalized tissue
5. Topical antibiotics to partial thickness burns
6. Cover burns with sterile dressings
7. Tetanus prophylaxis, as needed

Burns

- Indications for treatment at regional burn center:
  1. Burns accompanied by respiratory injuries or major trauma
  2. Major chemical or electrical burns
  3. Partial thickness burns > 20% BSA
  4. Full thickness burns >2% BSA
  5. Full thickness burns of face, hands, feet or perineum
Questions

- 16 month old girl brought to the ED after she was found chewing on an electrical cord. She presents with burns to the left corner of her mouth.

Questions

The most serious complication from this injury is:

- A. Arrhythmias, including asystole or V-fib
- B. Wound infection
- C. Permanent facial nerve damage
- D. Delayed labial artery bleeding
- E. None of the above
Burns

1. Common electrical injury occurs to lips and mouth of toddler who suck on plugs/electrical cords. May cause deep burns to labial commissure.
2. Requires special care to prevent scarring and contracture
3. Bleeding from labial artery 1-2 weeks after injury, when eschar separates. Risk for large amount of blood loss.

Questions

- 2 year old female presents to the ED with complaints of a rash on the buttocks. Mother states she noted redness to the area after the child’s bath that evening. On exam, her VS are normal. She has second degree burns over the upper posterior thighs, and perineum, sparing the buttocks and anterior surface of the thighs. Otherwise unremarkable exam.
Questions

- The most important step in the management of this patient would be:
  A. Tetanus immunoglobulin
  B. IV antibiotics
  C. Plastic surgery consultation
  D. Child abuse evaluation
  E. NS bolus

Burns

- Patterns of burns associated with child abuse:
  1. Immersion burns: when a body part is dipped in a hot-liquid.
  2. Contact burns on dorsum of hands
  3. Markings consistent with an object
Burns

Child Abuse

- Over 3 million cases reported annually
- For each case reported, 1-2 cases go unrecognized
- Over 1000 deaths a year
- Most vulnerable to abuse are infants, children with disabilities or chronic disease
Child Abuse

- Factors that increase risk of physical abuse:
  1. Social isolation
  2. Lack of support system
  3. Chemical dependency
  4. Domestic violence
  5. Poverty

*Abuse crosses cultural lines and all socio-economic levels

Child Abuse

- Historical features suggestive of abuse:
  1. Inconsistent history
  2. Delay in seeking medical care
  3. History of mechanism inconsistent with developmental age or severity of injury
  4. History of multiple traumatic injuries treated in different EDs

Questions

- The following fractures are pathognomonic for abuse EXCEPT:
  A. Scapula fractures
  B. Posterior rib fractures
  C. Single bone transverse fractures
  D. Metaphyseal chip fractures
  E. Complex skull fractures
Child Abuse

- Fractures associated with high rate of abuse: rib fractures, metaphyseal chip fractures, spine and scapula fractures, and complex skull fractures
- Fractures with lower rate of abuse: linear skull fractures, clavicle fractures, single bone transverse fractures, spiral fractures of the tibia

Questions

- For which of the patients would a skeletal survey be indicated:
  A. 20 month old who fell while running with a spiral tibial fracture
  B. 7 month old who rolled off the bed with a clavicle fracture
  C. 3 day old infant, delivered vaginally, with a fracture clavicle
  D. A 2 month who rolled off the couch with a spiral humerus fracture
  E. A 3 year old who fell off the swing with a supracondylar fracture
Child Abuse

- Any child under the age of 2 years with a fracture suspicious of abuse should have a COMPLETE SKELETAL SURVEY to detect occult or healing fractures.
- Bruises and fractures in children who have not yet learned to ambulate should be considered a sign of abuse.

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Child Abuse

Classic findings of Shaken Baby Syndrome:
1. Intracranial hemorrhage: Subdural+/or subarachnoid hemorrhage
2. Cerebral edema. Loss of gray-white matter differentiation
3. Retinal hemorrhages
Eye Injuries

History in patients with an injured eye:
1. Mechanism of injury
2. Change in visual acuity
3. Change in appearance of eyes
4. Pain, discomfort or photophobia
5. Use of corrective lenses
6. Medications
7. Systemic disease
Eye Injuries

- Physical Exam
  1. Visual Acuity
  2. Extraocular muscles
  3. Pupillary reactions
  4. Direct ophthalmoscopy
  5. Periorbital tissue and eyelids

Questions

- A 15 year old girl presents with severe eye pain. She states she was punched in the eye yesterday during a fight. On exam, she has a difficult time cooperating because of pain. Her conjunctiva on the affected side is diffusely injected and her affected pupil is round, but more constricted than that of the uninjured eye.

Questions

- This patient’s most likely diagnosis is:
  A. Ruptured globe
  B. Blowout fracture
  C. Hyphema
  D. Traumatic iritis
  E. Corneal Abrasion
Questions

- 10 year old boy struck by a baseball in the right eye. Brought to ED with complaints of pain, periorbital swelling and ecchymosis. On exam, he has a round, reactive pupil, conjunctival hemorrhage and a large amount of blood in the anterior chamber.

Questions

- Within the next week, the most serious complication from this injury is:
  - A. Orbital cellulitis
  - B. Permanent loss of vision
  - C. Glaucoma
  - D. Persistent periorbital edema
  - E. Rebleeding

Corneal Abrasion

1. FB sensation, pain, photophobia.
2. Tetracaine 0.5%; relief of pain, facilitate exam.
4. Treat with antibiotic ointment/suspension. Patching eye does not speed healing or decrease Sx.
5. Ophtho F/U if still with Sx in 48 hrs
Corneal Abrasion

Post-Traumatic Iritis

1. Inflammation w/in anterior chamber of eye after blunt trauma to eye.
2. Eye pain, redness, photophobia, occas. visual loss. Sx don’t present until 24-72 hrs after injury.

Post-traumatic Iritis
Hyphema

1. Blood in anterior chamber. May be completely filled or may have only small clots.
2. Best detected on slit lamp exam.
3. Size of hyphema directly proportional to incidence of secondary glaucoma.
4. Most vulnerable to rebleeding in 1st 5 days after injury. Hemoglobinopathies most at risk.
5. Mandatory Ophtho consult. Eye shield, bed rest, elevate HOB, daily F/U.

Ruptured Globe

1. Results from laceration or puncture of cornea or sclera.
2. At cornea-scleroid junction, iris comes forward to plug wound. Causes pupil to take on teardrop shape. Hyphema often present too.
3. Emergent Ophtho consultation.
4. Eye shield (not patch), no drops in eye, pain mgmt, antiemetics if needed. (Do not increase intraocular pressure). Tetanus, antibiotics.
3 year old boy presents after a fall. His front incisor was knocked out. The parent found his tooth and has it with him. The injury occurred about 20 minutes ago. He has FROM of his jaw. No intra-oral bleeding noted.
**Questions**

- The management plan for this patient is:
  A. Saline rinses and follow up as needed
  B. Placement of the tooth in milk
  C. Immediate Panorex films
  D. Placement of the tooth in the socket
  E. Prophylactic antibiotic treatment

**Dental Trauma**

- Types of peridontal injuries
  1. **Concussion**: Trauma to the tooth with no displacement or mobility
  2. **Subluxation**: Trauma to tooth with minor mobility, but no displacement in socket
  3. **Intrusion**: Tooth impacted into socket
  4. **Extrusion**: Tooth dislodged from socket
  5. **Avulsion**: Complete displacement of tooth from socket

**Dental Intrusion**
**Dental Avulsion**

Management of Primary Tooth Avulsion
1. Saline rinses and outpatient follow up with dentistry
2. Evaluate for other potential oral injuries
   **Primary teeth should NOT be re-implanted. Increased risk of ankylosis (bony fusion of tooth with alveolar bone). May interfere with eruption of permanent tooth.**

**Dental Trauma**

Management of Secondary Tooth Avulsion
1. Find the avulsed tooth. 30 minutes is critical!!
2. Rinse tooth gently. No scrubbing.
3. Place in milk/Lugor’s solution
4. Insert tooth in socket
   90% chance of tooth survival if re-implanted within 30 minutes. Survival declines by 1% for each minute beyond the initial 30 minutes
**Lacerations**

1. Lacerations account for 30-40% of all injuries seen in Pediatric EDs
2. Various mechanisms. More than 40% of wounds involve a fall
3. 2/3 occur during warm weather
4. Deaths rare from laceration, but complications can be up to 10%
5. Common complications include infection, hypertrophic scarring, poor cosmetic results

**Wound Healing**

1. Normal skin under tension. Amount varies by location and position of body part
2. Lacs running parallel to joints and skinfolds heal more quickly with better results.
3. All wounds deeper than dermis have potential for scar formation
4. Collagen synthesis begins within 48 hrs, peaks w/in 1st week. Factors delay healing include infection, tissue edema, poor nutrition

**Wound Care**

- Factors contributing to wound infection:
  1. Wound age
  2. Presence of foreign material
  3. Amount of devitalized tissue
  4. Presence of bacterial contamination
  5. Advanced patient age
  6. Ability of patient to mount adequate immune response
Wound care

1. Most wounds may be closed primarily to speed healing and improve result. “Golden period” is within 6 hrs. May increase to 12-24 hrs for those with low risk of infection.
2. Allow certain types of wounds to heal by secondary intention: those for increased risk of infection after golden period, many animal bites (except face), human bites over MCP joints. Delayed closure after risk decreases.

Questions

- In which wound can lidocaine with epinephrine be used for local anesthesia?
  - A. Laceration to the pinna of the ear
  - B. Laceration to the temporal scalp
  - C. Laceration to the glans of the penis
  - D. Laceration to the distal fingertip
  - E. Laceration to the tip of the nose

Wound Care

- Types of anesthesia
  - 1. EMLA: Topical, intact skin, onset 45 min
  - 2. LET: Topical, can be placed on lacerations, avoid mucous membranes, onset 20 min.
  - 3. Lidocaine: Injectable, avoid areas of terminal circulation (pinna, fingers, toes, nose, penis), onset 10 min.
Wound Care

- Wound closure techniques:
  1. Sutures: Greatest tensile strength, meticulous. Requires removal, anesthesia required
  2. Staples: Fast, cheap. Less meticulous
  3. Tissue adhesive: Fast, comfort, no removal. Lower strength, dehiscence over high tension areas, avoid applying over unintended area.