Medical Emergencies in the Pediatric Population B

Cathleen M. Tichy-Dreher, RN CNNP CPNP
Pediatric Critical Care Medicine
The Children’s Hospital
Cleveland Clinic Foundation

Status Epilepticus

© Cleveland Clinic 2012
**Objectives**

- Discuss etiology and management of status epilepticus
- Recognition and treatment of febrile seizures

**Seizures**

- A time-limited alteration in
  - Behavior, motor activity, autonomic function, consciousness, or sensation, accompanied by an abnormal electrical discharge in the brain
  - Sudden
  - Involuntary
Status Epilepticus

• Definition

  – “OLD” continuous convulsion lasting longer than 30 minutes, or
    the occurrence of serial convulsions between which there is no
    return of consciousness

  – “NEW” a seizure persists for a sufficient length of time or is
    repeated frequently enough to produce a fixed and enduring
    epileptic condition

Types of Status Epilepticus

• Generalized
  – Tonic-clonic, absence type

• Partial
  – Simple, complex, or with secondary generalization

• Non-convulsive status epilepticus
Case Presentation: Status Epilepticus

• 5 y/o brought in to ED by EMS with generalized clonic/tonic movements
  – Upon arrival to patients home, brief history revealed no previous seizures
  – Mom said child was well until this AM when she noted the child to be playing then suddenly drop to floor, shaking all over and incontinent of urine
  – EMS states movements have continued now for over 30 minutes

What to do?

• ABCs!
• High flow O₂, 100%
• Connect to cardio/resp monitor and pulse-oximetry
• IV access - OI if necessary
• Obtain labs
  – VBG
  – Electrolytes (Na, Ca, Mg, PO₄, and glucose)
  – CMP
  – Toxicology screen
  – CBC
  – Blood cultures
  – Anticonvulsant levels, if patient is already on anticonvulsant medications
• Repeated reassessment
Treatment

• Administer medications to stop seizures
  
  – Lorazepam: 0.1mg/kg (max 4mg)
    – Repeat at same dose if seizure not stopped after 5 minutes
  
  – If no IV or IO access, may give IV form rectally (administer with butterfly catheter tubing with needle portion removed) or Diazepam PR (0.5mg/kg)
    – Repeat same dose if seizure > 5 minutes
  
  – Monitor for respiratory depression

Treatment

• Lorazepam has longer anticonvulsant effect and less respiratory depression than diazepam

• Administer long-acting anticonvulsant
  
  – Fosphenytoin or phenytoin 20mg/kg IV
  – Keppra 20mg/kg IV
  – May also use Phenobarbital 10-20mg/kg IV
    – Again may cause respiratory depression, especially in the neonate
    – Have intubation equipment ready
Treatment

• When ABCs are controlled and seizures are fairly controlled, obtain imaging-CT scan, quick and safe. (MRI if prolonged)

• Lumbar Puncture
  – Defer in unstable patient, but never delay antibiotic/antiviral meds when indicated
  – Obtain opening pressure

Etiology

• Acute CNS insult
• Metabolic disorder
• Underlying chronic seizure disorder
• Non-Compliance with home medication
• Idiopathic
• Precipitating factors
  – Fever
  – Sudden discontinuation of anticonvulsant medications
**Etiology**

- Severe anoxic encephalopathy
- Encephalitis, meningitis
- Malformations of brain
- Inborn error of metabolism
- Electrolyte abnormalities
- Drug intoxication
- Malignancy

**Pathophysiology**

- Failure of mechanisms that prevent seizures
- Excitatory neurotransmitters-glutamate, aspartate, and acetylcholine
- Inhibitory neurotransmitter - GABA
- Neuronal inhibitory mechanism-blockage of NMDA channels, calcium dependent potassium ion current
CNS Events During Status Epilepticus

- Increased cerebral blood flow
- Increased metabolic demand
- Increased intracranial pressure
- Alteration of blood brain barrier
- Cerebral edema

Systemic Events During Status Epilepticus

- Hypoxia with impaired ventilation, secretions, increased O\(_2\) consumption
- Metabolic (lactic) and respiratory acidosis
- Hyperpyrexia, hyperkalemia
- Rhabdomyolysis, myoglobinuria and renal failure
Management

• Obtain a thorough history including:
  – Any previous seizures
  – Chronic and recent medication (medications of others in the household)
  – Inter-current illness
  – Head trauma
  – Details regarding onset of the seizure

• Obtain primary exam, ABCs and a thorough secondary exam

• Maintain adequate vital functions with prevention of systemic complications

Management

• Control seizure activity safely and quickly while minimizing treatment-related morbidity

• Evaluate and treat underlying cause

• If non-accidental trauma is suspected, immediate notification to social worker and county, especially when other children may be present in the household
Conclusion

- Status Epilepticus is a medical emergency-ABCs
- Prompt and appropriate intervention
- Maintenance of adequate vital functions
- Admission to a hospital for a child in Status Epilepticus and who may be unresponsive and post-ictal
- Supporting the family

Febrile Seizures

- Seizures that occur in association with fever but without evidence of intracranial infection or other definable cause.
  - Excludes seizures with fever in children with h/o non-febrile seizures
  - Must be distinguished from epilepsy, which is characterized by recurrent non-febrile seizures
  - Disease of childhood, typically 3 months to 5 years of age
Case Presentation: Febrile Seizure

• 18 month old brought into ED by EMS
  – C/o whole body shaking
  – Was at babysitters playing
  – Had possible fever earlier in day, no temp taken
  – No h/o URI, vomiting or diarrhea

• Patient presently alert, playful, interactive with mom

• VS: T-37, HR-80s, RR-20s, B/P-90/50s

• Neurologic exam intact

What to do?

• A thorough history and physical to determine it to be a febrile seizure
Epidemiology

• Most common seizure disorder in children
  – Effects 2-5% between 6 mos – 5 yrs.

• May occur with variable degrees of fever
  – 75% with T>39c, higher risk of recurrence
  – With lower temperatures
  – Risk factors
    – Family h/o febrile seizure
    – Peak temp
    – Rate of rise

Pathophysiology

• Mechanism unclear, possibly related to rate of rise of fever, actual peak temperature

• Possible cytokine and temp effect on neuronal tissue
Clinical Manifestations

• Most occur within 2-4 hours of fever onset
  
  – Simple
    – Generalized tonic/clonic
    – Last <15 minutes
    – Do not recur within 24 hours
  
  – Complex
    – Less common and focal
    – Prolonged to >15 minutes
    – Recur within 24 hours
    – More common in children with neuro-developmental abnormalities

Treatment

• Most febrile seizures do not require intervention and end within < 10 minutes

• Rectal diazepam can be used in outpatient setting to stop complex febrile seizure

• Long-term anticonvulsant not recommended for simple febrile seizures

• Antipyretics have not shown to decrease risk of recurrence of simple febrile seizures
  – May use with recurrent complex febrile seizures
Septic Hip / Arthritis

• Definition: Pyogenic or septic arthritis refers to a bacterial infection of the joint space

  – Most commonly affects young children and infants, but can occur at any age

  – Constitutes a clinical emergency because complications of untreated infection include
    – Dissolution of articular cartilage
    – Necrosis of the underlying epiphysis
    – Destruction of the adjacent growth plate
    – Dislocation of the joint itself
Etiology

- Hematogenous spread into the synovium. Blood vessel that connects the metaphysis and epiphysis serve as a conduit by which bony infection reaches joint space.

- Proteolytic enzymes released by inflammatory cells damage joint cartilage.

- Inflammatory mediators, bacteria and pus increase pressure within the joint, compress intra-articular vessels and impair blood supply to the cartilage and adjacent bone.

Common Pathogens

- Most common across all ages is Staph Aureus.

- Neonates
  - Gram-negative organisms, coag-neg staph, and GBS

- Older infants and young children
  - H. flu was common prior to the vaccine. Staph aureus, MRSA

- Older children
  - Staph Aureus and Group A Streptococcus
Case Presentation: Septic Hip

- 6 month old brought into ED
- C/o developing fever this AM
- Mom states child holds his hip rigidly in a flexion, abduction and external rotation position
- She also states that when she changes the baby’s diaper, he screams in pain

“Pediatric Septic Arthritis Surgery”
Schwentker et al, WebMD, January 21, 2009

Evaluation

- Prompt evaluation is needed
  - Degradation of articular cartilage occurs within 8 hours, causing ischemic necrosis of the femoral head

- Recent illness with fever, malaise, poor appetite, irritability and localized symptoms

- Exam reveals swelling, tenderness and redness over the joint, not always seen in hips with it a deep joint

- Most characteristic is pain with motion.
Management

A single (or, less often, two or three) acutely, hot, swollen joint(s)

History:
- Prior similar episode
- Typical rash, endocarditis area
- Trauma, joint injury

Consider
- Crystal induced arthritis
- Lyme arthritis
- Monoarthritis

Bacterial arthritis unlikely, but

Joint aspiration

Purulent joint fluid

Crystals, blood

Gram stain

Aerobic culture

Negative

Positive

Alternative diagnosis

Dry tap

Non-inflammatory synovial fluid

CT guided or joint aspiration

Culture

Negative

Positive

Antibiotics, joint drainage

Alternative diagnosis

ESR (sed rate)
- Typically elevated, although normal in early course

CRP
- Elevated and more sensitive in the initial illness

Blood culture
- Majority of septic arthritis are of hematogenous origin
- + in at least 40% cases

Joint fluid aspiration
- Sent for gram stain and culture and cell count
- Pyogenic >50,000 cells/mcL and PMNs
**Imaging**

- **Plain films**
  - Bone changes unlikely early in course but should be done for baseline and exclude other bone abnormalities

- **Ultrasound**
  - Useful in detecting the capsular distention that accompanies septic hip; also used for guiding when tapping the effusion for diagnosis

- **MRI**
  - Sensitivity 97%, specificity 92%, but should not delay treatment when waiting for this study

- **Bone scan**
  - Large amount of radiation, in infants < 6 months negative studies in up to 60% of cases

---

**Treatment**

- **Prompt decompression of the joint by an orthopedic surgeon**
  - Open drainage may be necessary if failure to aspirate pus due to the thickness of material

- **After aspiration of joint, which is sent for culture, antibiotics appropriate for the pathogen should be started.**
  - Consider Vancomycin with higher incidence of MRSA
Treatment

• Parenteral antibiotics until acute signs of infection have resolved, then may switch to oral antibiotics to complete the course

• ESR and CRP should be normalizing prior to switching to oral antibiotics

• Antibiotics are continued for at least 3-4 weeks, a more permanent IV access, PIC line, should be considered

• Treatment longer if concurrent osteomyelitis is present

Complications

• Develop complications in 10-25%, including abnormal bone growth, unstable joint, decreased range of motion, and a limp

• If osteomyelitis develops, will develop loss of bone structure, abnormal growth, recurrent osteomyelitis, DVTs, and reactive arthritis
Conclusion

- Septic arthritis/hip is an urgent situation and requires immediate evaluation and treatment by PCP, orthopedic surgeon and infectious disease specialist.
Objectives

- Discuss identification and management of sports injuries
- Discuss identification and management of heat injury
- Discuss identification and management of concussion, return to play

Sports Injuries

- Result from acute trauma or repetitive stress associated with athletic activities
- The most common cause of injury in children
- Most can be treated effectively, making return to physical activity a reality
- Most can be prevented if proper precautions are taken
Sports Injuries

Two thirds of all sports injuries can be reduced by:
- Improvements in conditioning
- Equipment
- Compliance with rules
- Coaching and supervision
- Rehab of existing injuries
- Efforts to prevent injury

Common Types of Sports Injuries

• Muscle Sprain
  - A stretch or tear of a ligament, the band of connective tissue that joins the end of one bone with another.
  - Caused by a fall or a blow to the body knocking a joint out of position

• Muscle Strain
  - A twist, pull, or tear of a muscle or tendon, a cord of tissue connecting muscle to bone.
  - An acute, noncontact injury that results from overstretching and over-contracting
Common Types of Sports Injuries

• Tears of four major ligaments supporting the knees:
  – ACL  Anterior Cruciate Ligament
  – PCL  Posterior Cruciate Ligament
  – MCL  Medial Collateral Ligament
  – LCL  Lateral Collateral Ligament

• Tears of the tendons that support joints

  • Achilles tendon injury:
    – Tear of the tendon that connects the calf muscle to the back of the heel
    – Occur in quick acceleration and jumping sports, i.e. -football and basketball
Common Types of Sports Injuries

• Dislocated joints
  – When two bones that come together to form a joint become separated
  – Contact sports, i.e. football and basketball, and high impact sports with excessive stretching and falling cause a majority of dislocations

• Dislocated joints are an emergency situation that require medical treatment

Common Types of Sports Injuries

• Fractures
  – A break in the bone that can occur from either a quick one-time injury (acute fracture), or from repeated stress to the bone over time (stress fracture)
Treatment of Sports Injuries

• Seek medical treatment when
  – The injury causes severe pain, swelling, or numbness
  – Can’t tolerate any weight on the area
  – The pain or dull ache of an old injury is accompanied by increased swelling or joint abnormality or instability

Treatment of Sports Injuries

• Home therapy
  – Use RICE method to relieve pain and inflammation and expedite healing

  — **REST**: no sports activities for 24 to 72 hours
  — **ICE**: apply ice pack to the injured area for 20 minutes at a time, 4 to 8 times/day
  — **COMPRESSION**: may reduce swelling
  — **ELEVATION**: keep injured area above the level of the heart to help decrease swelling
Heat Injury

• Divided into 3 syndromes
  – Heat cramps
  – Heat exhaustion
  – Heatstroke

Heat Cramps

• They are symptoms of dehydration and heat stress rather than muscle problems.
  – Involve the arms, abdomen or legs
  – Cramps are from profuse sweating

• Treatment consists of:
  – Rest in a cool environment
  – Stretching
  – Fluids
Heat Exhaustion

- A more severe syndrome and is probably caused by ineffective cardiovascular and autonomic responses to heat
  - Symptoms of weakness, feeling faint, dizzy and nauseous
  - May sweat profusely, or severely dehydrated skin is warm to touch and dry

- Treatment consists of
  - Providing cool fluids and placing the athlete in a cool environment
  - If unable to tolerate oral fluids, IV fluids should be considered

Heatstroke

- A medical emergency in which mechanisms of the body for cooling are overwhelmed.
  - Rectal temp is high
  - Skin is hot and dry
  - Patients will show CNS dysfunction with irritability, combativeness and disorientation and can lead to obtunded
  - Tachycardia and hypotension are present

- Second most common cause of death in football players
**Heatstroke**

- Treatment consists of:
  - Ice water-soaked towels
  - Sheets with a fan should be applied

- Should be taken to ED emergently

- Most common when the temperature > 95°F and the humidity > 50%

---

**Concussion**

- Each year, >300,000 sports-related, mild to moderate, traumatic brain injuries occur in the United States

- Among the highest incidents of concussion
  - Football and ice hockey
  - Followed by soccer, wrestling, basketball, field hockey, baseball, softball and volleyball
  - Lacrosse is up and coming
Definition

- A clinical syndrome of neurological impairment that results from traumatic, biochemical forces transmitted to the brain, either directly or indirectly

- Concussion reflects a disturbance of brain function rather than a structural injury

Pathophysiology

- Changes after concussion include:
  - Abrupt neuronal depolarization
  - Release of excitatory neurotransmitters
  - Ionic shifts
  - Altered glucose metabolism and cerebral flow
  - Impaired axonal function
Case Presentation: Concussion

- 16 y/o male playing football, punched in the head during a game. Initially no symptoms, but within 10 minutes c/o feeling foggy with poor concentration; amnestic to the event and dizzy. Taken to OSH-ED with c/o amnestic to event, headache, irritability, sensitivity to light and noise.

Signs and Symptoms

- Typically are temporary and resolve spontaneously and uneventfully within 10-14 days of injury

- Recovery varies from person to person and injury to injury

- Consensus is that premature return to play and a subsequent injury before recovery predisposes the player to a poorer outcome, the injury is known as "Second Impact Syndrome"
Signs and Symptoms

“Second Impact Syndrome”

- A diffuse cerebral swelling with delayed catastrophic deterioration; a known complication of brain trauma postulated to occur after repeated concussive brain injury in sports

- Athlete who has sustained an initial, mild brain injury followed by a second mild brain injury before the symptoms of the first injury have fully cleared

Signs and Symptoms

“Second Impact Syndrome”

- Death usually follows rapidly, 2-5 minutes, due to brainstem herniation

- Disordered cerebral autoregulation of cereblood flow → vascular engorgement → increased ICP → brainstem herniation

- Mortality = 50-100%
Signs and Symptoms

• Signs and symptoms of a sports-related concussion can range from:
  – Change in playing ability
  – Vacant stare, fogginess, confusion
  – Slowing
  – Memory disturbance
  – Loss of consciousness
  – Increased emotionality
  – Lack of coordination
  – Headache
  – Dizziness and vomiting

Signs and Symptoms

• Can lead to post-concussive symptom:
  – SOMATIC
    – Headache, fatigue and low energy, sleep disturbances, nausea, vision changes, tinnitus, dizziness, balance problems, sensitive to light and noise
  – EMOTIONAL / BEHAVIORAL
    – Low frustration tolerance, irritability, emotional, depression, anxiety, clinginess, personality changes
  – COGNITIVE
    – Slow thinking or response, fogginess, poor concentration, distractibility, trouble with learning and memory, disorganized problem-solving difficulties
Making the Diagnosis

- Sport Concussion Assessment Tool 2 (SCAT2)
  - A graded symptom checklist to be used at the sidelines
  - Developed in Zurich, November 2008 at Third International Conference on Concussion in Sport
  - Provided guidelines for understanding and best practice management in treating concussion
  - Establish individual baseline, critical to proper concussion management
  - Baseline scores vary by gender and concussion history
  - Females scored significantly better (e.g. had higher total scores on the SCAT2) compared to males
  - Prior history scored significantly lower on the SCAT2
    - 88.7% with positive concussion history vs 79.5% with no history

Making the Diagnosis SCAT2

- SCAT2 total score
  - Sum each component score
  - Maximum 100 points
- 22 item graded symptom scale
  - 22 points
- 2 item sign score determining loss of consciousness and balance difficulties
  - 2 points
- Glasgow Coma Scale (GCS) evaluating eye response, verbal response, and motor response
  - 15 points
- Standard Assessment of Concussion (SAC) for orientation, immediate memory, concentration, and delayed recall
  - 30 points
- Modified Balance Error Scoring System (BESS)
  - 30 points
- Coordination examination
  - 1 point
- Maddocks’ questions for sideline assessment
  - Does the athlete know where they are
  - What half/period it is
  - Who scored last
  - What team they played last
  - Did their team win
  - Not included in SCAT2 summary score, used for sideline diagnosis of concussion only
Management

• Most athletes recover within the first hours, days or weeks after a concussion

• Symptoms that persist beyond 10-14 days may be indicative of structural head injury

• Suspicion of structural injury or any focal findings warrants a CT scan, possible X-ray or MRI
Management

• Early rest, a period of cognitive and physical rest to facilitate recovery

• Monitoring recovery (SCAT) of post-concussion signs and symptoms

• Neuro-physiological tests to estimate recovery of cognitive function

• A graduated return to activity with monitoring for recurrence of symptoms

Return to Play

• “It is not appropriate for a child or adolescent student-athlete with concussion to RTP on the same day as the injury.”

• Stages to RTP
  1. Rest until asymptomatic (physical and mental rest)
  2. Light aerobic exercise, e.g. stationary cycle
  3. Sport-specific exercise
  4. Non-contact training drills
  5. Full contact training after medical clearance
  6. Return to competition (game play)
Conclusion

- Concussion in sports is a functional disturbance, not a structural injury to the brain. The majority of athletes recover…

Childhood Trauma
(Multi-system)
Objectives

• Management of pediatric trauma
  – Primary survey
  – Secondary survey

• Recognition and management of the different types of traumatic injuries in children

Epidemiology

• Leading cause of death in children > 1 yr

• < 5 yr highest risk; boys > girls

• Blunt > penetrating
  – Pediatric 80-90% blunt trauma, 10-20% penetrating trauma
  – Adult 50% blunt, 50% penetrating
  – MVA > MPA > falls > abuse > drown > burns
  – Head injury is most common (80%) cause of fatalities
Types of injuries

• In children, most serious injuries involve blunt trauma to the head

• Head injuries lead to significant morbidity and mortality

• 1 in 10 children with head injury suffers moderate to severe neurological impairment

• Head injuries are likely to result in problems affecting airway and breathing due to LOC

High-Risk Mechanism of Injury

• Motor vehicle crashes
  – Unrestrained passenger (includes ATV: All Terrain Vehicles)
  – Pedestrian

• Moderate falls (5-15 feet) and high falls (> 15 feet)

• Diving injuries

• Bicycle crashes, not wearing a helmet
Low Risk Mechanism of Injury

• Motor vehicle crashes
  – Restrained passenger

• Low falls (2 - 4 feet)

• Bicycles crashes with helmet

Trauma

• General principles for patients are the same no matter what age

• Rapid recognition of life threatening conditions, with coincidental initiation of therapeutic interventions, to decrease morbidity and mortality

• The ABCDE approach begins at the scene of the accident

• Without appropriate evaluation and intervention at the scene, good outcome is less likely
Principles of Resuscitation

• Scene survey: rapid assessment of safety at the scene

• General impression “looks good vs looks bad”

• Primary Survey: rapid evaluation and stabilization of the ABCDEs

• Secondary evaluation: focused history and detailed physical examination (complete head-to-toe).

Anatomical and Physiological Differences In Children vs. Adults

• Airway and shock management paramount

• Children die from hypoxia and respiratory arrest

• Impact over small area → multi-system injury

• Head injury: ↑ morbidity & mortality

• Little, or no, external injury

• ↑ heat loss

• Glucose

• Fluid requirements
ATLS Primary and Secondary Surveys

• Primary Survey
  – Life-threatening injuries are rapidly evaluated and corrected
  – Secondary Survey
    – Head-to-toe examination
    – Laboratory and imaging examinations exclude or confirm clinical diagnoses

Primary Survey

• **Airway**
  – Assess ability to maintain airway without support, while maintaining cervical spine stabilization

• **Breathing**
  – Assess oxygenation and ventilation, monitor for hemothorax/ pneumothorax

• **Circulatory**
  – Control obvious bleeding; obtain adequate vascular access for rapid fluid/ blood product resuscitation

• **Disability**
  – Evaluate neurological status

• **Exposure and Environment**
  – Expose all of the patient’s skin to look for hidden injuries; take measures to prevent cold stress and hypothermia
**Airway**

- Airway control involves use of the jaw thrust with cervical spine stabilization. The typical head tilt/chin lift is contraindicated until the neck is cleared.

- In the field immobilization of the neck should be maintained from extrication to delivery to the ED. The jaw thrust may assist in opening the airway when needed.

---

**Airway**

- If the airway cannot be maintained with positioning and suctioning, then oral intubation with spine stabilization is indicated.

- Nasal intubation contraindicated
  - Increased likelihood of c-spine movement
  - Any skull fracture which may lead to insertion of the tube intracranially
Airway

- Respiratory failure = primary cause of arrest
- ET tube size determined by equation \((16 + \text{age}) / 4\)
- Insert to \(3 \times \text{diameter at lip}\)

Anatomical Airway Issues

- Big tongue, soft tissue \(\rightarrow\) obstruction
- Anterior larynx
- Short trachea
- Narrowest at subglottis
- Nose breathers < 6 months
- Big occiput
- Big epiglottis \(\rightarrow\) straight blade
Rapid Sequence Intubation

- Pre-oxygenate without PPV
- Pre-treat atropine 0.02 mg/kg all < 6 years (min 0.1mg)
- Induction:
  - ketamine 1-2 mg/kg (not with head injury)
  - midazolam 0.2-0.3 mg/kg
  - propofol 2 mg/kg
  - thiopental 3-7 mg/kg
- Neuromuscular blocking (NMB) agent
  - Rocuronium 1.2 mg/kg, avoid succinylcholine
- Cricoid pressure

Breathing

- Provide breathing support when needed
- BVM for short transports
- Do not hyperventilate or hypoventilate
- Chest walls more compliant; may have major internal thoracic injuries without signs of external trauma or rib fractures
- If intubate, don’t forget gastric decompression
- OG not NG with any possible facial trauma
Circulation

- Early signs of shock:
  - Altered LOC
  - Tachypnea
  - Tachycardia
  - Mottled, cool extremities, ↓ pulses, cap refill < 2 - 3 sec
- Scalp laceration may cause shock
- Low BP very late sign
  - Children compensate well ≥ 25% loss of blood volume
  - Minimum acceptable systolic BP: 80 mm Hg + (2 x age in yrs)
- Assume internal bleeding with abnormal VS until proven otherwise

Circulation

- IV’s:
  - Size: short, fat
  - Location: antecubital, femoral, external jugular
  - Attempt <90 sec, then intraosseous
- Fluids: crystalloid 20cc/kg x 2, then 10cc/kg PRBCs
- Hypertonic saline
Intraosseous placement

- Age limit?
- Landmarks?

Disability

- Evaluate neurologic response, and maintain spinal immobilization
Exposure & Environment

• Prevent hypothermia

• High ratio of body surface to body mass in children
  – Increases heat exchange with the environment
  – Directly affects the child’s ability to regulate core temperature
  – Thin skin and lack of subcutaneous tissue contribute to increased evaporative heat loss and caloric expenditure

Secondary Survey

• A trauma specific history- use the AMPLE mnemonic to recall the components of focused history
  – Allergies
  – Medications
  – Past medical history
  – Last meal
  – Events leading up to current injury

• A detailed head-to-toe examination for injuries

• Log roll child from side-to-side to examine the back for injuries and deformation when caring for patients with potential spinal injuries.
Secondary Survey

• Laboratory studies
  – HCT
  – Electrolytes
  – Renal functions (e.g. Creatinine)
  – Coagulation studies
  – Type and crossmatch

• Radiographic evaluation
  – Cervical spine
  – Chest
  – Pelvis, in most cases
  – Ultrasound/CT studies, if clinically indicated

Head Injury

• Leading cause of death in pediatric trauma (80%)

• 90 % initially reported as “minor”

• Falls > MVA > MPA > bicycle > assault

• Few require surgery: 0.4 -1.5%

• No evidence in pediatrics for early surgery

• 4-6% with normal exam have ICH on CT scan
Head Injury: Anatomic Differences

Protective

• Fontanels
• Open sutures
• Plasticity

Susceptible

• Big head, weak neck → torque
• Soft cranium → injury w/o fracture
• Less myelin → more shearing forces
• Prone to reactive hyperemia

Head Injury: Types of injury

• Contusions, diffuse axonal injury, sub-arachnoid hemorrhage, parenchymal

• Epidural: uncommon in young children; subtle presentation, minor trauma

“Epidural hematoma”, Azmoun et al, November 14, 1995

• Subdural: common in infants; poor outcome
  – Shaken Baby Syndrome: LOC, seizure, retinal hemorrhages, inconsistent history, brain swelling out of proportion to bleeding

“Subdural Hematoma”, Abramson & Hsu, November 29, 1994
Head Injury: Assessment

• Pediatric GCS: not predictive in infants

<table>
<thead>
<tr>
<th>Eye Opening Response</th>
<th>Verbal Response</th>
<th>Motor Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 = Spontaneous</td>
<td>5 = Oriented</td>
<td>6 = Obey commands</td>
</tr>
<tr>
<td>3 = To verbal stimuli</td>
<td>4 = Confused</td>
<td>5 = Localizes pain</td>
</tr>
<tr>
<td>2 = To pain</td>
<td>3 = Inappropriate words</td>
<td>4 = Withdraws from pain</td>
</tr>
<tr>
<td>1 = None</td>
<td>2 = Incoherent</td>
<td>3 = Flexion to pain or</td>
</tr>
<tr>
<td></td>
<td>1 = None</td>
<td>decorticating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = Extension to pain or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>decerebrate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = None</td>
</tr>
</tbody>
</table>

• Signs of ↑ ICP in infants:
  - Full, tense fontanel, split sutures, altered mental status, irritable, persistent emesis, "setting sun" sign

Skull Fracture

• Linear > depressed > basilar
• X-rays not sensitive nor specific
• 90% linear fractures have overlying hematoma
• “Growing skull fractures” → dural tear → meninges herniate, prevents closure
• Depressed fractures: may miss on CT scan
Management

- MAP > 70 teen, 60 child, 45 infant
- Hyperventilation: not in first 24 hrs
- Mannitol: no studies
- HTS: small studies
- Euglycemia: ↑glucose worse neuro outcome
- Prophylactic anticonvulsants: consider in moderate/severe HI, >1 seizure or prolonged
- Prophylactic Antibiotics for basil skull fracture: no role
- Normothermia: temp > 38.5 worse neuro outcome

C-Spine Injuries

- Less common in kids, higher mortality
- Associated with CHI
- Falls > MVA > sports (trampolines)
- < 8 yr: 2/3 above C3
SCIWORA – Spinal Cord Injury Without Radiological Abnormality

- The vertebrae can slide across each other and pinch, or bruise, the spinal nerves without any bones breaking.
- 16-50% of all SCI
- < 9 years
- Transient neuro symptoms (paresthesias)
- Recur up to 4 days later
- **Bottom line:**
  - CT / MRI if abnormal neck / neuro exam, distracting injuries, altered LOC, high risk mechanism DESPITE normal 3-views

Chest Trauma

- 2nd leading cause of pediatric trauma death
- Compliant chest wall: rib fractures uncommon
  - significant injuries w/o external signs
  - if fractures present, severe injury
- Treat conservatively:
  - 15% require more than chest tube
- Pulmonary contusion most common, aortic injury rare

"Blunt Traumatic Tracheal Laceration", Komanapali et al, CTSNet, August 16, 2005
Chest Trauma

• Soft, pliable chest wall = transmission of forces, resulting in injury to the pulmonary parenchyma; rib fractures uncommon.

• Compliant chest wall = high frequency of pulmonary contusion

• Mobility of mediastinal structures makes a child more sensitive to tension pneumothorax and flail segments.

• Treatment:
  – Chest tube as needed
  – Ventilation
  – High PEEP
  – Elevate head

Abdominal Trauma

• 3rd leading cause of trauma death
  – often occult fatal injury

• Blunt: MVA, bikes, sports, assault
Abdominal Trauma: Anatomic Issues

• Larger solid organs, less musculature, compact torso, elastic ribcage, liver & spleen anterior
  – ↑ potential internal injury
  – Most solid organ
  – Spleen > liver > kidney > pancreas > intestine

• Bladder intra-abdominal
  – 10% have GU injury

Abdominal Trauma: Assessment

• Low BP late sign of shock
• Clinical findings unreliable
• Shoulder tip pain, flank / lap ecchymosis
• U/A, NG
• Reassess, reassess, reassess
• Mechanism
  – handlebars, lap belt
Abdominal Trauma: Management

• Spleen and liver:
  – 90% conservative: admit, observe, Hct
  – More fatal hemorrhage with liver injuries
  – Exploratory lap if unstable after resuscitation

• Hematuria:
  – Gross or >20 RBC + unstable → IVP in OR
  – >10 RBC + stable → CT cystogram

Bottom Lines in Pediatric Trauma

• Severely injured do better at trauma center
• Metabolic requirements differ
• Multi-system injury is RULE
• Occult injuries are common
• Head injuries: high mortality, associated injuries
• Use of imaging unclear: low threshold
• Be aware of potential abuse
1. A 3-year-old child, unrestrained back-seat passenger low-speed car crash. Hits her head on the interior of the car. The child is awake and crying at the scene. She has an obvious scalp laceration, bilateral periorbital hematomas, and bleeding from the right nares. Which of the following actions is most appropriate and in correct order of priority?

a) Perform immediate tracheal intubation because of the mechanism of injury and manually immobilize the cervical spine

b) Assess airway patency, breathing, circulation, and neurologic function; then immobilize the child on a spine board while applying manual traction to the cervical spine

c) Assess airway patency while manually immobilizing the cervical spine; assess and support breathing, circulation, and neurologic function; and apply pressure to sites of obvious bleeding

d) Apply direct pressure to the nose and scalp; place the child in a recovery position; and assess airway, breathing, and circulation

The correct answer is C. The first priority of assessment and stabilization is airway assessment and support with cervical spine immobilization.

• Answer A
  — Incorrect because immediate tracheal intubation is not always necessary. Providers should base the decision for advanced airway support on the findings of the ABCDE assessment, not solely on the mechanism of injury.

• Answer B
  — Incorrect because you should not routinely apply traction to the cervical spine.

• Answer D
  — Incorrect because it omits spinal immobilization, which is part of the primary survey (initial assessment). You should not delay spinal immobilization to complete the primary survey.
2. A 3-year-old child, unrestrained back-seat passenger low-speed car crash. Hits her head on the interior of the car. The child is awake and crying at the scene. She has an obvious scalp laceration, bilateral periorbital hematomas, and bleeding from the right nares. Which of the following actions is most appropriate and in correct order of priority?

- You arrive on the scene the child has labored breathing and a “tire tattoo” extending across the right chest.
- You stabilize the cervical spine; the airway is patent.
- While the child is receiving 100% oxygen by non-rebreathing face mask, his oxygen saturation by pulse oximetry is 100%.
- The child has significant respiratory distress with a respiratory rate of 40 breaths/min, grunting respirations, and a heart rate of 150 bpm.
- Heart sounds are present but localized more laterally to the left than normal.
- The child has crepitus of the right chest wall, no breath sounds over the right chest, but no tracheal deviation or neck vein distention. There are no obvious rib fractures.
- Which of the following interventions should you perform first?

a) Immediate tracheal intubation without sedation or paralysis

b) Immediate needle decompression of the right chest, with preparation for tracheal intubation if necessary

c) Immediate chest x-ray to determine if a tension pneumothorax is present with preparation for needle decompression of the chest and tracheal intubation if necessary

d) Immediate pericardiocentesis for presumed cardiac tamponade
The correct answer is B. The mechanism of injury places the child at risk for chest injury, and rapid cardiopulmonary assessment reveals respiratory failure and signs consistent with right tension pneumothorax.

•Answer A  
  Incorrect because providers should not delay needle decompression to obtain chest x-ray. The child’s mechanism of injury and clinical signs are consistent with a tension pneumothorax. Tracheal deviation and neck vein distention are not always present in children with tension pneumothorax.

•Answer C  
  Incorrect because providers should not delay needle decompression to obtain chest x-ray. The child’s mechanism of injury and clinical signs are consistent with a tension pneumothorax. Tracheal deviation and neck vein distention are not always present in children with tension pneumothorax.

•Answer D  
  Incorrect because although cardiac tamponade is a life-threatening potential complication of blunt chest trauma, the patient’s symptoms are most consistent with a tension pneumothorax. Providers should not delay decompression.

3. An unrestrained 6-year-old child is riding in the back of a pickup truck. The truck collides head on with another vehicle. The child is ejected from the truck. He briefly loses consciousness, but he later begins to walk at the scene. When EMS arrives, the child is complaining of severe abdominal pain. Which of the following is the first step you should take during your initial assessment and stabilization?

a) If the child requires airway support, you should use a jaw thrust
b) Ask the child to lie down on a backboard, perform a head tilt-chin lift to open the airway, assess airway patency, and then immediately immobilize the cervical spine.

c) Determine the child’s Glasgow Coma Scale score and check pupil size and reactivity

d) Perform a careful abdominal examination because the child reports pain in his abdomen
The correct answer is A. The mechanism of injury suggests a risk of cervical spine injury. You should immobilize the cervical spine. If the child requires airway support, you should perform the jaw thrust if needed and immobilize the cervical spine.

Answer B is incorrect. If the patient needs airway support, a jaw thrust is preferable to the head tilt-chin lift in injured children.

Answer C is incorrect. Although it is appropriate to apply the Glasgow Coma Scale and to evaluate pupil size and reactivity, these assessments should follow assessment and support of airway, breathing, and circulation with cervical spine immobilization. Rapid neurologic assessment is step D (Disability) of the ABCDE Approach.

Answer D is incorrect. Providers should assess the abdomen after they perform the primary survey to detect and treat life-threatening injuries.
Cleveland Clinic

Every life deserves world class care.