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Case Studies in Pediatric Trauma

Injury patterns, presentations, and surgical indications for trauma vary significantly with age. Because there are fewer injured children than adults, it can be difficult to acquire experience in managing severely injured children. This course uses pediatric trauma cases to illustrate the presentation and management of common injuries in children.

- Describe the management of splenic injuries in children and how it differs from that in adults.
- Discuss the diagnosis and management of small bowel injury in children.
- Review the difference between the head-injured child and adult.

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FACULTY

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COURSE DESCRIPTION:
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OBJECTIVES:
1. Describe the management of splenic injuries in children and how it differs from that in adults.
2. Discuss the diagnosis and management of small bowel injury in children.
3. Review the difference bewteen the head-injured child and adult.

CASE SCENARIOS:

Case 1: 5 year old male struck by a car while crossing the street. Patient was thrown approximately 15 feet from the vehicle. Paramedics find patient unconscious and lying in the middle of the street.

Case 2: 6 month old brought in by paramedics when mother noted child lethargic 3 hours after returning from shopping. The mother's boyfriend had been babysitting and stated the child had seemed "sleepy" to him as well.

Case 3: 10 year old female, belted, backseat passenger BIB paramedics after automobile involved in head on collision with another automobile. Moderate front-end damage to the vehicles as reported by the paramedics

OVERVIEW:
- Leading cause of death in children (ages 1-44 years); 64% of all deaths in children
- 1.5 million injuries each year; 250,000 hospitalizations
- 100,000 permanently disabled /year
- Over 30,000 children and adolescents die each year in the US from injury
- Below is listed causes of death by age:

0-4 years	5-9 years	10-14 years	15-19 years
Homicide	MV occupant	MV occupant	MV occupant
Fires/burns	MV pedestrian	Homicide	Homicide
Drowning	Fires/burns	Suicide	Suicide
MV occupant	Drowning	MV pedestrian	MV other
MV pedestrian	Homicide	Drowning	Drowning

- Years of potential life lost= 2,232,939
- Lifetime productivity lost= $40,067,703,896
- Cost of motor vehicle= $2,599,557,288
- Childhood death from injury is described as the "tip of the iceberg"
  - For every death their are 34 admissions and 1500 children disabled

Mechanism

The majority of pediatric trauma is blunt, however with the availability of firearms (up to 50% of households), penetrating trauma is an increasing cause of pediatric morbidity and mortality.

- 87% blunt, 10% penetrating, 3% other (mainly drowning)
- Motor vehicle crashes (MVC) account for 40% of blunt trauma injuries
- Falls are second most common mechanism

Anatomy and Pathophysiology

- No other emergency creates as much anxiety in the health care worker as a critically injured child
- Physiologic differences in response to trauma in children versus adults; along with varying drug doses with age; overall lack of experience for many clinicians in caring for pediatric trauma; all increase the anxiety in the person caring for the injured child.

Anatomical Differences

Anatomical differences in the child vs the adult trauma victim may result in different patterns of injury in the pediatric patient.

- child's body size allows for a greater distribution of traumatic injuries, therefore multiple trauma is common
- greater relative body surface area also causes greater heat loss

Anatomical differences cont...

- internal organs more susceptible to injury based on more anterior placement of liver and spleen and less protective musculature and subcutaneous tissue mass
- kidney also less well protected and more mobile making it very susceptible to deceleration injury
  - 15% of patients presenting with hematuria after trauma have underlying congenital abnormality
- growth plates are not yet closed leading to Salter type fractures with possible limb length abnormalities with healing
- head to body ratio is greater, brain less myelinated, cranial bones thinner, resulting in more head injury

<u>Pediatric airway differences in anatomy</u>

- relatively larger tongue which can obstruct the airway
  - most common cause of airway obstruction in children
  - may necessitate better head positioning or use of airway adjunct (oropharyngeal (OP) or nasopharyngeal (NP) airway)
- larger mass of adenoidal tissues may make nasotracheal intubation more difficult
  - NP airways may also be more difficult to pass in infants < 1 year of age
- epiglottis is floppy and more U-shaped
  - necessitates use of a straight blade in children up to 8 years of age
- larynx more cephalad and anterior
  - more difficult to visualize the cords; may need to get lower than the patient and look up at 45°angle or greater while intubating
- cricoid ring is the narrowest portion of the airway
  - allows for use of uncuffed tubes in children up to size 6.0 mm or about 8 years of age
- narrow tracheal diameter and distance between the rings, making tracheostomy more difficult
  - American Heart Association recommends a needle cricothyrotomy for the difficult airway versus a surgical cricothyrotomy for the same reason
- shorter tracheal length (4-5 cm in newborn an 7-8 cm in 18 month old)
  - leading to intubation of right mainstem or dislodgement of the ET tube
- large airways more narrow
  - leads to greater airway resistance ($R \propto 1/\text{radius}^4$)

<u>Pediatric cervical spine</u>

- relatively larger head size, resulting in greater flexion, extension injuries
- smaller neck muscle mass - ligamentous injuries more common than fractures
- increased flexibility of interspinous ligaments
- flatter facet joints with a more horizontal orientation
- incomplete ossification making interpretation of bony alignment difficult
  - basilar odontoid synchondrosis fuses @ 3-7 yrs of age
  - apical odontoid epiphyses fuses @ 5-7 yrs of age
  - posterior arch of C_1 fuses @ 4 yrs of age

- anterior arch fuses @ 7-10 yrs of age
- epiphyses of spinous process tips may mimic fractures

- increased preodontoid space - up to 4-5 mm (3 mm in an adult)
- pseudo subluxation of C_2 on C_3 seen in 40% of children
- prevertebral space size may change due to variations with respiration

Physiologic Response to Trauma

The most important physiologic response to injury in the pediatric trauma patient is the response to acute hemorrhage. The pediatric patient will maintain his/her blood pressure with up to 25 - 30% of blood volume loss acutely. Therefore, blood pressure is not always a helpful sign of blood loss in children. Children may be in shock with a normal, increased or decreased blood pressure. In addition children are better able to tolerate increases in heart rate and are more effective in increasing their systemic vascular resistance.

Approach to Trauma Management

- The key to the management of any emergency is organization. An organized team approach to pediatric trauma emphasizing assessment followed by intervention and reassessment is imperative.
- Early recognition of signs of shock is important both in the field, so that transport is swift and so that there will be an appropriate team available when the patient arrives; and in the Emergency Department (ED), so that adequate therapy can be initiated and appropriate diagnostic procedures performed.
- In the overall management of trauma the components of the medical personnel response can be divided into five phases:
  1) Prewarning and Triage
  2) Preparation
  3) Report and Resuscitation
  4) Reassessment
  5) Disposition

Prewarning and Triage - field criteria used to identify potentially seriously injured patients and the ED warned of impending arrival

Pediatric Trauma Score (PTS)

- A score of -1 to +2 are given for each of 6 variables. The range of scores are -6 to 12; a score <=8 indicates potentially serious trauma; A PTS > 8 has been associated with 0% mortality; a PTS < 0 has a 100% mortality
- A PTS ≤8 in some emergency medical services (EMS) systems serves as a triage criterion for immediate transport to a trauma center

Weight (kg)	>20	10-20	<10
Airway Patency	Normal	Maintain	Unmaintain
Systolic BP	>90	50-90	<50
Neurologic Status	Awake	Obtunded	Comatose
Open Wound	None	Minor	Major
Skeletal Trauma	None	Closed	Open

Revised Trauma Score

- A score of 0-4 is given for each of three variables. The range of scores are from 0 to 12; a score of ≤11 indicates potentially serious trauma
- Each Emergency Medical Services (EMS) system has derived its own set of trauma triage criteria based on the above scoring systems, mechanism of trauma, some physiologic measurements or a combination of all three.

Preparation - ED response includes preparation for the arrival of the patient by ED, surgical staff and ancillary personnel; may include the preparation of equipment and or blood products

- Some EMS systems have regionalized trauma care for children to pediatric ready trauma centers or pediatric critical care centers

Report and resuscitation - ED personnel obtain **vital** information from the prehospital personnel and begin the ED assessment and resuscitation phase

The evaluation of the trauma patient in ED begins with the primary survey

- The primary survey - assess and treat life and limb threatening injury - as in the prehospital setting, the flow of assessment and care is A-B-C-D-E

Revised Trauma Score (RTS)	GCS	Systolic BP	Respiratory Rate
4	13-15	>89	10-29
3	9-12	76-89	>29
2	6-8	50-75	6-9
1	4-5	1-49	1-5
0	3	0	0

A - Airway

1. Open airway - Jaw thrust is the recommended method of opening the airway in trauma if a cervical spine (C spine) injury is suspected. Chin lift and/or the sniffing position can be used if C spine injury is not suspected. Note that the airway may need suctioning to keep clear.

2. Rarely use surgical airways in children - can use a needle cricothyrotomy in child <8 years of age in cases of inability to intubate or in cases of airway obstruction when all other maneuvers fail

3. Esophageal airway (do not use in children < 16 years)

4. Endotracheal intubation (often using rapid sequence induction) for decompensated shock, respiratory failure (hypoventilation or hypoxemia), neurologic resuscitation (GCS ≤ 9) - controlled hyperventilation (PCO_2 = 30-35 mmHg), and airway protection

Chest Trauma Facts

- Chest trauma is less common in children than adults
- Multiple rib fractures are rare in children, but if present are associated with high mortality (42% in one study; Eichelberger)
- 15 - 22% of thoracic injuries requires thoracotomy.

- ED indications for thoracotomy include: penetrating trauma with signs of life in the field and blunt trauma in which patient deteriorates despite maximal resuscitative efforts in the ED and it is believed that immediate cross clamping of the thoracic aorta may save the patient

B - Breathing

1. Look for symmetrical chest rise, listen for the breath sounds and observe tidal volume
2. Check for foreign bodies, vomitus, blood (suction airway - reposition - reassess)
3. Ventilation may need to be assisted using a bag and mask technique or endotracheal intubation. Always reassess, looking for adequate chest rise after each maneuver - remember "squeeze, release, release" to ensure adequate ventilation.
4. Nasogastric tube placement should be considered in critically injured patients to empty the stomach of air and its contents and to check for bleeding in the stomach.
5. Chest tube indications are the same for adults and pediatric patients:
   - Chest tube size:
     1) insert the largest tube as possible, especially if hemothorax is suspected; newborns (8 - 12 Fr), infants (14 - 20 Fr), children (20 - 28 Fr), adolescents (28 - 36 Fr)
     2) use the following formula - 4X ET tube size
     3) use the length-based resuscitation tape

C - Circulation

- Early restoration of circulatory volume with either crystalloid or blood products decreases the morbidity and mortality in pediatric trauma patients
- Shock - Shock may be defined as "an acute syndrome of cardiovascular failure resulting in inadequate tissue perfusion and oxygenation leading to vital organ malnutrition"
- Bottom line is the most common cause of shock in children suffering trauma is hypovolemic shock!

Class	Causes
Hypovolemia	Hemorrhage
	Burns
	Peritonitis
	Vomiting and Diarrhea
	Sepsis
Cardiogenic	Cardiomyopathy
	Myocardial Contusion
	Dysrhythmia
	Valvular Disease
Obstructive	Hemo/Pneumothorax
	Cardiac tamponade
	Flail Chest
	Pulmonary Embolus (Fat embolus)
Distributive	Spinal Cord injury
	Anaphylaxis
	Sepsis

Classfication of Shock

Management priorities:

1. Assess adequacy of airway and breathing frequently in initial resuscitation.
2. Assess perfusion by pulse rate and quality; central versus peripheral pulses; skin signs and mental status
   - Signs of shock include:
     - tachycardia
     - decreased mentation
     - cool and clammy skin
     - poor capillary refill (> 2 sec)
     - narrowed pulse pressure
     - decrease in urine output (< 1-2 ml/kg/hr)
     - hypotension (late)
       - hypotension may be defined as a systolic BP < 60mmHg (< 1 month of age) or < 70 mmHg (1 month to 1 year of age) or for patients greater than 1 year of age (70 + (2 x age yrs))

The key to correct shock management is to recognize it and treat it before the patient is severely compromised, ie; hypotensive.

3. Field: Stop external bleeding sites with elevation and/or pressure and volume replacement (20 cc/kg) as needed with Normal Saline. Remember that when signs of shock are present, the child may have lost greater than 25% of his/her circulating blood volume.

    - MAST Use of the MAST has never been shown to benefit any subset of trauma patients and may cause compartment syndromes and local thrombosis after prolonged use. The MAST is contraindicated in patients with penetrating chest trauma, pulmonary edema and relatively contraindicated in pregnancy. Rescues may not carry the appropriate size MAST for pediatric patients. The increase in intraabdominal pressure may effect diaphragmatic excursion in children.

4. ED: Continue volume replacement with crystalloid @20cc/kg, consider packed red blood cells (PRBC) -10cc/kg if the patient is unresponsive to the initial 40cc/kg of crystalloid infused. Type O or type specific blood should be used. Type specific blood has no increased risk of transfusion reactions over typed and crossed blood and it can be available quickly (<5 minutes in most centers).
    - If a peripheral IV line cannot be established after 2-3 attempts a central line in the femoral vein or a venous cutdown or (as a temporary measure) an IO needle can be placed
        - IO lines - extremities with fractures should be avoided. Note: may obtain values for sodium, potassium, bicarbonate, glucose, pH, PCO_2, and base excess from marrow fluid

    - Labs and radiographs should be ordered based on the severity of the patients injury or possible injury. The following should be ordered on all critically injured trauma patients:
        - CBC, SMA7, PT, PTT, type and cross (or screen), consider ETOH level and amylase
        - UA - if dipstick negative no need to send urine; if dipstick + then send urine for microscopic analysis as dipstick value does not correlate with the number of red cells
        - Chest radiograph, AP pelvis, cervical spine films (include odontoid > 7 years of age) and other radiographs may be need including extremity films, facial films and CT scan of the head or abdomen

DPL vs CT scan

- The use of diagnostic peritoneal lavage (DPL) in children is controversial.

- Even if a DPL is grossly positive (immediate free flow of gross blood), the patient may be stabilized with supportive care; ie crystalloid or blood transfusion; also because of differences in the treatment of splenic trauma in children vs. adults, splenic salvage is attempted in children and operative treatment is rare
- A series from Denver in which all multiply injured children had a DPL, showed that if the DPL was grossly positive and the patient underwent an exploratory laparotomy, 18% of patients had a negative laparotomy. That is 18% of the laparotomies could have been avoided - in most of these cases the injury found at laparotomy were Grade 1 or 2 spleen or liver lacerations.
  - Indications: (1) patient has an altered level of consciousness and/or an adequate abdominal exam cannot be performed and the abdomen is one of multiple possible sources of blood loss and patient undergoing surgery for life threatening intracranial or axial skeleton injury; (2) there are multiple victims and they need to be triaged rapidly. Caution however in wasting too much time before taking the patient to the operating room.
  - Procedure: The volume of Ringers Lactate that is infused is 15 cc/kg and is considered positive if the peritoneal fluid removed has greater than 100,000 RBC/mm^3 (intraperitoneal bleeding) or presence of stool, greater than 500 WBC/mm^3, elevated amylase > 175 IU/L or elevated alkaline phosphatase > 6 IU/L is present (bowel injury).
- CT scan of the abdomen is the diagnostic test of choice for patients with renal injury, or to evaluate the abdomen and pelvis in a stable multiple trauma patient.
  - CT may miss hollow visceral injury (small bowel and large bowel injury), diaphragmatic injury and interpretation of the scan is dependent upon the skill of the reader
  - CT (+) does not correlate with need for operative management (splenic salvage)
- The use of both CT and DPL in the pediatric trauma patient are undergoing continuous change and is dependent upon local facility and personnel capabilities.

5. **Patients with unstable vital signs, unresponsive to fluid and or blood product resuscitation should be treated intraoperatively**

6. Shock unresponsive to fluid management also consider tension pneumothorax or cardiac tamponade
   - Tension pneumothorax- needle thoracostomy or tube thoracostomy
   - Cardiac tamponade - needle aspiration of pericardial sac or immediate

thoracotomy
- Consider thoracotomy for patients of penetrating trauma that cannot be stabilized with maximal resuscitative efforts or for full arrest victims with penetrating trauma when signs of life were present in the field

7. Foley catheters should not be placed until the pelvis is noted to be stable, the urethra is checked for blood and a rectal exam shows the prostate to be normal
8. Significant hematuria > 20 RBCs /hpf
   - Renal injury common followed by bladder injured; urethral and ureteral injury extremely rare

D - Disability (Neurologic Assessment)

- Attention must be paid to the entire spinal column, especially the cervical spine when moving the patient or when performing therapeutic interventions
- Consider cervical spine injury with any of the following conditions
  1. Evidence of injuries involving the head, neck or face
  2. Neck pain or patient with neurologic findings including flaccid extremities
  3. Any trauma patient with altered level of consciousness
  4. Any child with distracting injuries
- SCIWORA (spinal cord injury without radiographic abnormality)
  - 2-21% of patients < 8 years of age with spinal injuries may occur without evidence of fracture; most neurologic symptoms are immediate; ? if neurologic symptoms may be delayed for days
- Pseudosubluxation C_2 on C_3: common in children up to teens (>40%); can distinguish between true subluxation by the posterior cervical line or spinolaminar line. If the spinolaminar line is normal then it is pseudosubluxation.
  - Tape and towel rolls, with or without a rigid collar is an effective method of cervical spine stabilization
  - Note may use a board with a recess for the head to accommodate the prominent occiput
  - If there is any question of possible injury, immobilize the cervical spine - remember that ligamentous injuries can be equally as devastating

Chance Fractures - seat belt injury caused by forward flexion of body over a lap belt; may show "lapbelt" ecchymoses

- Lumbar spine fractures usually L1- L4 (lamina fracture and anterior body compression)
- 50% with associated intraabdominal pathology
    - Plain radiographs AP and lateral are preferred to CT scan

Neurologic Trauma Facts

- 80% of pediatric trauma deaths are associated with neurologic injury
- Children are less likely (30%) to develop mass lesions compared to adults (40-50%)
- Children with head injury are more likely to develop ↑ICP (80%) than adults (30-40%)

Cerebral Hyperemia

The pediatric brain may lose its autoregulatory ability and become susceptible to fluctuations in systemic pressure resulting in ischemia or hyperemia - "malignant brain edema" or cerebral hyperemia results when increase in blood flow not water content occurs

Shaken Infant Syndrome

Usually in infants < 6 months of age; often with no outside signs of trauma. Constellation of findings include retinal hemorrhages; subdural and or subarachnoid hemorrhage.

Neurologic Assessment

A number of methods can be used to assess the neurologic status of the child. AVPU and Modified Glasgow Coma Scale (GCS) may be used

- AVPU: A - alert; V - verbally responsive; P - responds to painful stimuli; and U –unresponsive
- Level of consciousness, symmetrical movement of extremities, pupillary response should be evaluated and documented before and after all interventions where the patient is moved

	Child	Infant	Score
EYE	opens spontaneously		4
	opens to speech		3
	opens to pain		2
	nil		1
MOTOR	obeys commands	spontaneous movements	6
	localizes	withdraws to touch	5
	withdraws	withdraws to pain	4
	flexion	flexion	3
	extension	extension	2
	nil	nil	1
VERBAL	oriented	coos & babbles	5
	confused	irritable cry	4
	inappropriate cries	to pain	3
	incomprehensible	moans to pain	2
	nil	nil	1
		Total =	3-15

Neurologic Resuscitation:

- Hyperventilation, resulting in cerebral vasoconstriction is an effective, simple and quick method for lowering intracerebral pressure in the emergency setting, but must be done with restraint - ***more is not better!***
- Too much hyperventilation can cause secondary brain injury from too much cerebral vasoconstriction. Try to keep PCO_2 between 30-35 mmHg
- Mannitol (0.25-1g/kg, IVP) can be used but is controversial because of the risk of cerebral hyperemia
- Steroids are no longer recommended for severe head injury but is used in patients with spinal cord injury
- Maintaining adequate circulating blood volume and therefore cerebral perfusion pressure is key to the neurological resuscitation of the pediatric trauma patient - CPP = MAP-ICP.

Studies addressing CT scanning in minor head trauma:

Davis RL, Mullen N, Makela M, Taylor JA, Cohen W, Rivara FP. Cranial computed tomography scans in children after minimal head injury with loss of consciousness. *Ann Emerg Med* 1994;24:4:640-645.

- retrospective case series of 185 children (2-17 years) seen in ED after loss of consciousness from head injury; initial Glasgow =15
- 185 children: 17 excluded (skull fx, VP shunt)

  ↓

  168 children: 140 with NL neuro exam 49 with isolated head

  ↓ ↓ ↓

  28 ABNL neuro exam ↓ **0 pt with ICB**

  ↓ 91 with multiple trauma

  5 patients with ICB ↓

  7 patients with ICB

- 50% of patients with ICB had LOC 1-15 minutes
- Patients were considered to have an abnormal neurologic exam if they were drowsy, lethargic, disoriented or excessively agitated
- 14 patients had ICB (7 subdural; 3 epidural; 3 subarachnoid; 1 with subarachnoid and subdural
- No child required surgical intervention

Dietrich AM, Bowman MJ, Ginn-Pease ME, Kosnik E, King DR. Pediatric head injuries: Can clinical factors reliably predict an abnormality on computed tomography? *Ann Emerg Med* 1993;22:10:1535-1540.

- prospective cohort of 324 head CT scans performed on 322 pediatric trauma patients (10 days to 20.6 years)
- 324 scans: 250 (77%) scans reported as normal

  ↓

  74 abnormal scans: 35 with isolated skull fx

  ↓

  39 with intracranial pathology: 37 pts admitted (0-75 days); 1 died in ED; 1 D/C'd

  ↓

  5 epidural; 5 subdural; 11 contusion; 8 cerebral edema; 5 intraventricular hemorrhage; 5 pneumocephaly
- 11 pts (28%) with intracranial pathology had Glasgow Coma score of 15
- + predictive value of HA (10%); abnormal neurologic exam (48%); vomiting (12%); seizures (29%); amnesia of event (31%); loss of consciousness (28%)
- no single variable or combinations of variables were predictive of all patients with intracranial pathology

Penetrating injury Blunt injury: History of loss of consciousness Amnesia for the event Posttraumatic seizure (not impact seizure) Persistent vomiting Severe headache Abnormal neurologic exam Glasgow coma score <15 Depressed skull fracture Basilar skull fracture Underlying coagulopathy or blood dyscrasia

Indications for CT Scan of the Head

E - Exposure

- A complete and quick check of the body for signs of serious injury. All the patients clothes should be removed. After the body check, the patient should be covered with a sheet or blanket to avoid hypothermia and to protect the patient's modesty.

Child Abuse

- Child abuse should be considered in any trauma in which:
  - The history is not consistent with the physical findings
  - Injuries of different ages are noted on the exam; injuries of the trunk or buttock
  - A history is obtained from the child or other source that abuse has taken place
  - A pattern injury/burn is noted
  - Burns of hands, feet or perineum
  - Bruises of different ages
  - Bite, belt marks, cord marks or other pattern on the skin
  - Metaphyseal fractures of the tibia (bucket handle)
  - Fractures of the skull, ribs, humerus (all children with nonsupracondylar fractures < 3 years of age)

- A skeletal survey (x-rays) should be done on all children < 3 years if physical abuse is suspected by history or physical examination
  - A study by Thomas, et al, Pediatrics, 1991:
    - 60% of femur fractures in children < 1 year of age were due to abuse; older children 30% were due to abuse
    - femur fractures are often accidental and can be due to trips and falls
    - 100% of non-supracondylar fractures in children < 3 years of age were due to abuse

F - Family

Psychosocial Issues

Children who suffer physical trauma also suffer psychological trauma.

- Fear of strange faces
- Separation anxiety
- Poor understanding of their injuries
- Relationship with their parent may change (parents always feel guilty)
- Loss of function
- Pain

Tips for Caring for Children

- Be honest
- Be direct, firm and in control
- Explain process of care in terms the child will understand
- Don't be condescending
- Explain procedure immediately before it is done
- Allow child some control, if possible, in the process of care

Reassessment and Consultation - after initial ED resuscitation, an ongoing reassessment process should take place – this process may include the need to call other consultants or to obtain other diagnostic studies

Secondary Survey

- The secondary survey is a head-to-toe assessment of traumatic injuries along with the taking of a history from the patient, paramedics/EMTs, patient's family or bystanders.
- A secondary survey is performed only if the patient has been stabilized as outlined above, or the patient on initial assessment has noncritical injuries.
- 4.3% of injuries are missed on initial evaluated (during first 12 hrs of care)
- The information that should be obtained in the history can be remembered by the mnemonic -A M P L E: A - Allergies; M - Medications (including date of last tetanus); P - Past medical history; L - Last meal; and E - Events leading to the accident

Disposition - OR, ICU, ward, transfer or death

Transfer Policies

- Some areas may not tertiary care facilities available - it is clear that moderately to severely injured children do better in a pediatric specific ICU versus an adult ICU; thus transfer guidelines should be established within EMS systems
- Thorough documentation and appropriate communication of heath care professionals (nurses and physicians) may improve care and outcome in injured children transferred from one facility to another

Overview of Management

- See algorthim below
- Draw appropriate labs and obtain radiographs
- Nasogastric tube and urinary catheter placement if critically injured
- Obtain consultation early
- Appropriate fluid resuscitation
- PICU care for all critically injured children
- Keep the patient and the family informed

Algorithm for Management

Pediatric Assessment Triangle
Primary Survey
↓
Signs of shock
↓
ABCs and fluid management
crystalloid @ 20 cc/kg
↓
Reassess
crystalloid @ 20 cc/kg
↓
Signs of shock
external bleeding
sources of blood loss (chest, abdomen, pelvis, retroperitoneum)
consider PRBCs @ 10 cc/kg
consider mechanism: pneumothorax, pericardial tamponade
↓
consider OR
if stable, consider CT scan
consider DPL
↓
PICU

♦ **CASE STUDIES:**

Case 1: 5 year old male struck by a car while crossing the street. Patient was thrown approximately 15 feet from the vehicle. Paramedics find patient unconscious and lying in the middle of the street.

Prehospital Phase

- Pediatric Assessment Triangle
  - Appearance: unconscious, not responsive to surroundings
  - Work of Breathing: tachypneic, no retractions
  - Circulation: color - pale and diaphoretic

- Paramedics stabilize the cervical spine, administer 100% oxygen by face mask and attempt IV access enroute to the hospital - IV is placed in right antecubital fossa and 100 cc of NS infused prior to arrival in ED.

Report and Resuscitation

On arrival in the ED, the patient continues to be unconscious, tachypneic, diaphoretic and pale.

- Patient information:
  - Airway - airway open, increased secretions noted, trachea is midline
  - Breathing - symmetric chest wall motion, poor tidal volume, no retractions noted, breath sounds equal,
  - Circulation - color pale, skin signs show diaphoresis, no jugular venous distension and capillary refill of 4 seconds, HR = 160, thready peripheral pulse quality and BP = 75/p, note that abdominal exam shows abdomen distended and tense on palpation, pelvis stable, rectal normal - occult blood negative
  - Disability - unconscious, no spontaneous eye opening, responds to painful stimuli with flexor posturing, pupils midposition and 4mm bilaterally sluggish reaction to light
  - Exposure - contusion forehead, abrasion left arm with swelling at the level of the elbow, abrasion left flank and deformity left femur
    - Note Waddell triad = closed head injury, intraabdominal injury and midshaft femur fracture

What is the physiologic status of this child?

- Hypovolemic shock - decompensated

What are your initial management priorities?

- Contact surgeon (nurse or clerk to call with critical information based on primary survey)
- Suction airway
- Begin rapid sequence induction and endotracheal intubation (indications decompensated shock and need for neurologic resuscitation)
  - Etomidate, lidocaine, succinyl choline or rocuronium, followed by lorazepam for continued sedation
- Obtain vascular access in at least two sites (prefer antecubital fossa)
- Fluid resuscitation with O- blood and saline

- Obtain blood for type and cross (priority) if able then send hemoglobin, electrolytes, renal and liver function tests, amylase, glucose, PT and PTT
  - Initial hemoglobin 10 gm/dL drops to 7 gm/dL after initial resuscitation and up to 9 gm/dL after 400 mL of PRBCs
  - Amylase slightly elevated at 150 IU/L
  - LFTs also elevated - alanine aminotransferase (ALT) 100 IU/L and aspartate aminotransferase (AST) 80 IU/L
- Perform trauma exam
- Place Foley catheter - urine 2 +blood, microscopic evaluation with 50 RBCs per hpf
- Nasogastric tube placed - drains gastric contents and air, no blood noted
- Reassessment shows HR decreased to 130 and patient more responsive
- Family informed of patient's condition
- Radiography:
  - Chest: Normal
  - AP Pelvis: Normal
  - CT head: normal
  - CT abdomen: liver and spleen lacerations (grade II); moderate blood in the peritoneal cavity; renal contusion but bilaterally functioning kidneys
- After 3 units of PRBCs and 800 mL of saline; HR=120; patient somewhat agitated

Does this patient meet an indication for surgery?

- Although the patient presented in decompensated shock - initial resuscitation stabilized the patient - could make an argument to transfer child immediately to operating room
- Indications for surgery are listed below"
  - Hemodynamic instability despite maximal resuscitative efforts
  - Requires transfusion of greater than 50% of total blood volume
  - Radiographic evidence of pneumperitoneum, intraperitoneal bladder rupture, Grade V renovascular injury, gunshot wound to the abdomen, evisceration of intraperitoneal or stomach contents
  - Signs of peritonitis
  - Evidence of fecal or bowel contamination on DPL

What are your management priorities now?

- Secondary survey
- Obtain radiographs of cervical spine, right elbow and right femur
- Continue sedation
- Transfer patient to PICU

Pearls:

1. Pediatric patients subjected to whole body force, such as a pedestrian struck by a car or a fall - the force is distributed widely in children and therefore multiple traumatic injury versus single sytem injury is likely to result
2. Understanding the differences in anatomy and physiology between adults and children is imperative to appropriate trauma management

Case 2: 6 month old brought in by paramedics when mother noted child lethargic 3 hours after returning from shopping. The mother's boyfriend had been babysitting and stated the child had seemed "sleepy" to him as well.

Prehospital Phase

- Pediatric Assessment Triangle
  - Appearance: unconscious, not responsive to surroundings
  - Work of Breathing: bradypneic, no retractions
  - Circulation: color - pale
- Paramedics stabilize the cervical spine, begin bag-valve-mask ventilation and attempt IV access enroute to the hospital - IV placement is unsuccessful.

Report and Resuscitation

On arrival in the ED, the patient continues to be unconscious, bradypneic, and pale.

- Patient information:
  - Airway - airway open, trachea is midline
  - Breathing - shallow tidal volume and slow rate without bag-valve-mask ventilation, no retractions noted, breath sounds equal with good chest rise with bag-valve mask ventilation, pulse oximetry shows O_2 100% with ventilation
  - Circulation - color pale at first but improves with ventilation and capillary refill time of 2 seconds, HR = initially 40 in the field improves to 160 with ventilation by paramedics and ED staff, peripheral pulse quality good and BP = 75/p
  - Disability - unconscious, no spontaneous eye opening, responds to painful stimuli with flexor posturing, no verbal response, pupils show left 4 mm with sluggish reaction to light and right 2 mm with brisk response to light; modified GCS = 6
  - Exposure - no obvious trauma - other physical findings + retinal hemorrhages, abdominal exam slight distension otherwise soft nontender

What is the physiologic status of this child?

- Respiratory failure - probable occult head injury
  - History from caretakers very vague and caretakers delayed seeking care even in the face of obvious change in mental status of the infant
  - Infants under one year of age in which the history given is vague and infant presents with marked changes in mental status - consider Shaken Infant Syndrome as a potential cause

What are your initial management priorities?

- Begin rapid sequence induction and endotracheal intubation (indications respiratory failure and need for neurologic resuscitation)
  - Etomidate, lidocaine, atropine, succinyl choline or rocuronium, followed by lorazepam for continued sedation

- Begin mild hyperventilation and observe for change in pupillary status - reassess with ABG (target PCO_2 30-35 mmHg)
- Place nasogastric tube to decompress the stomach
- Obtain vascular access in at least two sites (prefer antecubital fossa)
- Obtain blood for hemoglobin and bedside glucose - Hgb 14.1 gm/dL, glucose = 160
- Give mannitol 0.25 g/kg - controversial
- Obtain CT scan of the head - shows subarachnoid hemorrhage, frontal subdural and diffuse cerebral edema
- Contact neurosurgeon
- Obtain blood for electrolytes, renal and liver function tests, amylase, glucose, PT, PTT, osmolality
  - repeat hemoglobin 13.9 gm/dL
  - all laboratories within normal limits
- Perform complete trauma exam
- Place Foley catheter - urine negative for blood
- Nasogastric tube placed - drains gastric contents and air, no blood noted
- Reassessment shows HR decreased to 120 and patient more responsive
- Family informed of patient's condition
- Radiography:
  - Chest: Normal
  - Cervical spine series: Normal

What are your management priorities now?

- Secondary survey
- Obtain skeletal survey - no other fractures noted
- Contact law enforcement and Department of Children's Services with your report of suspected child abuse
- Continue sedation
- Transfer patient to PICU

Pearls:

1. Suspect child physical abuse in patients with vague histories or histories inconsistent with level of physical findings as in this case.
2. Hyperventilation utilized acutely to avert herniation and then used with caution as too much hyperventilation can lead to secondary brain injury.

Case 3: 10 year old female, belted, backseat passenger BIB paramedics after automobile involved in head on collision with another automobile. Moderate front-end damage to the vehicles as reported by the paramedics.

Prehospital Phase

- Pediatric Assessment Triangle
  - Appearance: alert and appropriate
  - Work of Breathing: slight tachypnea, no retractions
  - Circulation: color - normal and skin appears dry

- Paramedics stabilize the cervical spine, administer 100% oxygen by face mask and attempt IV access enroute to the hospital - IV is placed in right antecubital fossa and 200 cc of NS infused prior to arrival in ED.

Report and Resuscitation

On arrival in the ED, the patient continues to be alert and appropriate, tachypneic and normal skin color.

- Patient information:
  - Airway - airway open, trachea is midline
  - Breathing - symmetric chest wall motion, decreased tidal volume, no retractions noted, breath sounds equal
  - Circulation - color - normal, skin signs show dry, warm skin, no jugular venous distension and capillary refill of 2 seconds, HR = 120, normal peripheral pulse quality and BP = 100/p, note that abdominal exam shows abdomen slightly distended and "seatbelt" ecchymosis across midabdomen, abdomen mildly tender on palpation, pelvis stable, rectal normal - occult blood negative
  - Disability - alert, fully oriented, although does not remember the accident and states had loss of consciousness at scene for unknown period of time, spontaneous eye opening, responds to commands, pupils 2 mm equal and reactive, patient with complaint of back pain but moving all four extremities on command, lower back with tenderness in lumbar region
  - Exposure - abrasion on forehead, ecchymosis on abdomen as described above, otherwise exam without evidence of injury

What is the physiologic status of this child?

- Hypovolemic shock - compensated

What are your initial management priorities?

- Contact surgeon (nurse or clerk to call with critical information based on primary survey)
- Obtain vascular access in at least two sites (prefer antecubital fossa)
- Fluid resuscitation with Normal Saline - weight determined from length based resuscitation tape to be 30 kg - 600 cc NS infused
- Obtain blood for type and cross (priority) if able then send hemoglobin, electrolytes, renal and liver function tests, amylase, glucose, PT and PTT

  - Initial hemoglobin 14 gm/dL drops to 12 gm/dL after initial resuscitation
  - Amylase slightly elevated at 150 IU/L
- Perform trauma exam - pelvis stable, rectal normal - occult blood negative
- Place Foley catheter - urine trace blood, microscopic evaluation with 10 RBCs per hpf
- Nasogastric tube placed - drains gastric contents and air, no blood noted
- Reassessment shows HR decreased to 100 beats per minute
- Family informed of patient's condition
- Radiography:
  - Chest: Normal
  - AP Pelvis: Normal
  - Cervical spine series (3 views): Normal
  - CT head: Normal
  - CT abdomen: Normal - bilaterally functioning kidneys

Does this patient meet an indication for surgery?

- No. Not at this time. This patient presented with some signs of compensated shock - tachycardia - otherwise stable and easily treated with crystalloid resuscitation.

What are your management priorities now?

- Secondary survey
- Obtain radiographs of lumbar spine - note fracture of L_3 consistent with Chance fracture
  - Chance fractures may occur with sudden forceful flexion of the lumbar spine as occurred in this patient
    - 50% of these patients will have associated intraabdominal injury
    - Lumbar spine fractures usually L_1- L_4 (lamina fracture and anterior body compression)
    - Plain radiographs AP and lateral are preferred to CT scan

  - Note: This patient developed increase in abdominal pain over the next two days plus increasing abdominal tenderness noted on serial abdominal exams. Patient taken to the operating room where small bowel injury noted with fecal contamination. Patient did well post-operatively and was discharged home in one week.

- Small bowel injury
    - Not a common injury - found in 1-5% of patients with abdominal trauma
        - "Blowout" injuries are the most common - as occurred in this patient
    - Recognition of bowel injury is often delayed - CT of the abdomen is not sensitive for hollow visceral injury, DPL is sensitive but often is not performed - serial exams remain the mainstay for evaluation
    - Signs of bowel contamination (peritoneal irritation) ususally present within the first 24-48 hours from the time of injury and may be seen as early as 6-12 hours from the time of injury
- Transfer patient to PICU

Pearls:

1. Pediatric patients involved in vehicular trauma restrained with lap belts only are at risk for intrabdominal and spinal injury.
2. Patients with lap belt ecchymoses are at risk for these injuries and they should be admitted for observation.

CONCLUSIONS:

- The health care professional must approach the pediatric trauma patient with the knowledge that the pediatric patient has anatomic and physiologic differences from the adult patient that change the pediatric patient's pattern of injury and physiologic response to hemorrhage.
- Early definitive care (remember the "Golden Hour"): transport with resuscitation in route, surgeons notified early, prepare OR and secondary transport as needed.

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