Chapter 08
Trauma and Burns

Objectives
- Identify common mechanisms and types of injury in infants and children.
- Explain the difference between primary and secondary brain injury.
- Compare and contrast an epidural hematoma and subdural hematoma.
- Explain the initial management of the patient with a head injury.

Objectives
- Explain mechanisms of injury that indicate spinal stabilization may be required.
- Differentiate the clinical presentation of neurogenic shock from hypovolemic shock.
- Explain the pathophysiology and initial management of a flail chest, open pneumothorax, tension pneumothorax, pulmonary contusion, and traumatic asphyxia.
Objectives

- State the immediately life-threatening and potentially life-threatening thoracic injuries.
- Predict abdominal injuries based on blunt and penetrating mechanisms of injury.
- Discuss mechanisms of burn injuries.
- Identify and describe the depth classifications of burn injuries.

Objectives

- Describe how to determine the body surface area percentage of a burn injury by using the "rule of nines" and the "rule of palms."
- Describe the initial management of a thermal burn injury.

Penetrating Trauma

- Penetrating trauma
  - Any mechanism of injury that causes a cut or piercing of the skin
    - Typically results from a gunshot, stab wound, or blast injury
    - May also result from a child's toy or foreign body
Penetrating Trauma

- Usually affects organs and tissues in the direct path of the wounding object
- Severity of a knife wound depends on:
  - Length of the blade
  - Angle of penetration
  - Area of the body pierced with the knife
  - Motion applied to the blade

Penetrating Trauma

- Severity of a firearm injury is related to:
  - The size or caliber of the bullet
  - Alteration in the trajectory of the bullet within the body
  - The bullet’s velocity
  - The distance of the victim from the weapon

Blunt Trauma

- Blunt trauma
  - Any mechanism of injury that occurs without actual penetration of the body
  - Motor vehicle crashes
  - Falls
  - Sports injuries
  - Assaults with a blunt object
Blunt Trauma

- Produces injury first to the body surface and then to the body’s contents
  - Results in compression and/or stretching of the tissue beneath the skin
- Amount of injury depends on:
  - Length of time of compression
  - Force of compression
  - Area compressed

Motor Vehicle Crashes

- Three separate impacts occur as kinetic energy is transferred:
  1. The vehicle strikes an object
  2. The occupant collides with the interior of the vehicle
     - Includes a seatbelt, airbag, or the dashboard
  3. Internal organs collide with other organs, muscle, bone, or other supporting structures inside the body
     - Lungs, brain, liver, and spleen are particularly vulnerable to this trauma
  4. A fourth impact may occur if loose objects in the vehicle become projectiles

Motor Vehicle Crashes

- Resulting injuries depend on the:
  - Type of collision
  - Position of the occupant inside the vehicle
  - Use or nonuse of active or passive restraint systems
Peds Pearl

- An unrestrained child involved in a front-end crash at 30 miles per hour hits the dashboard with the same force as in a three-story fall.

Child Safety Seats

- An improperly worn restraint:
  - May not protect against injury in the event of a crash
    - May even cause injury

Child Safety Seats

- Predictable injuries that may occur even with proper use of a child safety seat include:
  - Blunt abdominal trauma
  - Change of speed injuries from deceleration forces
  - Neck and spinal injury
Motor Vehicle/Pedestrian Crashes

- Most pedestrian injuries occur during the day, peaking in the after-school period
- Approximately 30% of pedestrian injuries occur while the child is in a marked crosswalk

Motor Vehicle/Pedestrian Crashes

- Pedestrian injuries are the most important cause of traumatic coma in children
  - Frequent cause of serious lower extremity fractures, particularly in the school-aged child
Motor Vehicle/Pedestrian Crashes

- Adults will typically turn away if they are about to be struck by an oncoming vehicle, resulting in lateral or posterior injuries.
- In contrast, a child will usually face an oncoming vehicle, resulting in anterior injuries.

Factors affecting the severity of injury include:
- The speed of the vehicle
- The point of initial impact
- Additional points of impact
- The height and weight of the child
- The surface on which the child lands

Initial impact:
- Because a child is usually shorter, initial impact occurs higher on the body than in an adult.
- Bumper strikes child’s pelvis or legs (above knees)
- Fender strikes abdomen
- Predictable injuries include injuries to the chest, abdomen, pelvis, or femur.
Motor Vehicle/Pedestrian Crashes

Second impact
- Occurs as front of vehicle's hood continues forward and strikes child's thorax
- Child is thrown backward; head and neck flex forward
- Child's head and face may strike front or top of vehicle's hood
- Predictable injuries include facial, abdominopelvic, and thoracic trauma, and head and neck injury

Motor Vehicle/Pedestrian Crashes

Third impact occurs as the child is thrown to the ground
- The child may:
  - Fall under vehicle and be trapped and dragged for some distance
  - Fall to side of vehicle; child's lower limbs run over by a front wheel
  - Fall backward and end up completely under the vehicle

Motor Vehicle/Pedestrian Crashes

Waddell's triad
- The injury pattern experienced by a child involved in a pedestrian injury
  1. Extremity trauma
  2. Thoracic and abdominal trauma
  3. Head trauma
Falls

- Falls are the single most common cause of injury in children

- Factors to consider in a fall are:
  - The height from which the child fell
    - Greater height = greater injury
  - The mass of the child
  - The surface the child landed on
    - Harder surface = greater injury
  - The part of the child’s body that struck first

- Infants
  - Fall from changing tables, high chairs, countertops, and beds

- Preschool children
  - Usually fall from windows

- Older boys
  - Fall from dangerous play areas, such as rooftops and fire escapes
Falls

- Fatalities occur primarily when:
  - A child falls from a height of more than two stories or 22 feet
    - Fall from a roof, window, or balcony
  - The head of a child hits a hard surface (e.g., concrete)

Bicycle Injuries

- Most severe and fatal bicycle injuries involve head trauma

- Associated injuries
  - Facial and extremity trauma
  - Abdominal injuries (from striking the handle bars)
Bicycle Injuries

- Helmet use can reduce the risk of head injury
  - Helmets reduce the risk of head injury by 85% and serious brain injury by 88%

Assessment of the Pediatric Trauma Patient

Pediatric Assessment Triangle

- Evaluate scene safety
- Form your general impression of the patient

<table>
<thead>
<tr>
<th>Appearance</th>
<th>Breathing</th>
<th>Circulation</th>
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<td>Body position</td>
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<td>Muscle tone</td>
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<td>Body position</td>
<td>Work of breathing (ventilatory rate/effort)</td>
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Primary Survey

- Immediately life-threatening injuries that must be identified and managed in the primary survey include the following:
  - Airway obstruction
  - Open pneumothorax
  - Tension pneumothorax
  - Massive hemothorax
  - Flail chest
  - Cardiac tamponade

Primary Survey

Airway and cervical spine protection
- Assume spinal injury:
  - If the child has experienced blunt trauma above the nipple line
  - Has a significant mechanism of injury
  - Complains of neck or back pain
  - Complains of numbness or tingling
  - Experiences loss of movement or weakness
  - Has multiple injuries of any cause

Primary Survey

Cervical spine
- If c-spine injury is suspected:
  - Manually stabilize the head and neck in a neutral in-line position
  - Maintain spinal stabilization if already completed
Primary Survey

- If an attempt to move the head and neck into a neutral in-line position results in any of the following, STOP any movement and stabilize the head in that position:
  - Compromise of the airway or ventilation
  - Neck muscle spasm
  - Increased pain
  - Onset or increase of a neurologic deficit
    * Numbness, tingling, loss of motor ability

- To maintain the c-spine in a neutral position, it is often necessary to place padding under the torso of an infant or young child.

- Padding should be of appropriate thickness so that the child’s shoulders are in horizontal alignment with the ear canal.

Primary Survey

- Open pneumothorax
  - Cover the wound with a sterile occlusive dressing taped on three sides

- Tension pneumothorax
  - Needle decompression
Primary Survey

• Signs particularly helpful in detecting shock:
  ➢ Heart rate
  ➢ Capillary refill
  ➢ Children younger than 6 years
  ➢ Mental status

Primary Survey

• If signs of shock are present:
  ➢ Establish vascular access
  ➢ If decompensated shock:
    ➢ Establish access in two sites using large-bore catheters
    ➢ Give 20 mL/kg of NS or LR

  ➢ Suspect internal bleeding if signs of shock but no evidence of external volume loss

Primary Survey

• Pediatric Glasgow Coma Scale (GCS)
Head Trauma

A child is vulnerable to head injury because:

- The skull of an infant and child is thin and pliable
- Large size and weight of the head
- Underdeveloped cervical ligaments
- Relatively weak neck muscles

Cerebral Perfusion

- Cerebral perfusion pressure is the difference between mean arterial blood pressure (MAP) and ICP
- Maintenance of an adequate blood volume and BP is critical for brain perfusion
  - If BP is reduced, so is cerebral perfusion pressure
Intracranial Pressure

- The brain can compensate for changes in intracranial pressure by manipulating one of three major components of the skull
- A decrease in any one of these will lower ICP:
  - Brain tissue (occupies 78% of the skull)
  - Blood volume (occupies 12%)
  - Cerebrospinal fluid (occupies 10%)

General Categories of Head Injury

- Coup injuries
  - Injury directly below point of impact
- Contrecoup injuries
  - Injury at another site, usually opposite the impact

Diffuse axonal injury (DAI)

- Shearing, tearing, stretching force of nerve fibers with axonal damage

Focal injury

- An identifiable site of injury limited to a particular area or region of the brain
Mild Diffuse Axonal Injury

- Concussion (mild DAI)
  - Transient impairment of consciousness followed by rapid recovery to baseline neurologic activity
  - Most common result of blunt trauma to the head
  - Infrequently associated with structural brain injury
  - Rarely leads to significant long-term sequelae

Moderate Diffuse Axonal Injury

- Shearing, stretching, or tearing results in minute petechial bruising of brain tissue
- Brainstem and reticular activating system may be involved leading to unresponsiveness
- Commonly associated with basilar skull fracture
  - Most survive but neurologic impairment common

Severe Diffuse Axonal Injury

- Severe mechanical disruption of many axons in both cerebral hemispheres and extending to the brainstem
- Assessment
  - Unresponsiveness for prolonged period
  - Posturing common
  - Other signs of increased ICP occur depending on various degrees of damage
Posturing

- Decorticate posturing
  - Legs extended
  - Arms flexed

- Decerebrate posturing
  - All extremities extended and rotated inward

Linear Skull Fracture

- Line crack in the skull

- Most common type of skull fracture
  - Approximately 60% to 90% of skull fractures in children

- Most have an overlying hematoma or soft tissue swelling

Bilateral black eyes are seen in this 12-day-old
Linear Skull Fracture

- This infant's soft palate was shredded by repeated stabs with a sharp object. He presented with a report of spitting up blood and no history of trauma.
- Linear skull fracture found in the same infant.

Depressed Skull Fracture

- Pieces of bone are pushed inward pressing on, and sometimes causing tearing, of brain tissue
- Most commonly seen in parietal area
  - Higher likelihood of intracranial hemorrhage
- Open (compound) or comminuted fracture requires neurosurgical evaluation

Depressed Skull Fracture

- Neurologic signs and symptoms evident
- Cover depressed area with a sterile dressing moistened with sterile saline
- Monitor closely for signs of increased ICP
Basilar Skull Fracture

- Extension of linear fracture to floor of skull
- May not be seen on radiograph/CT
- Often involves temporal bone with bleeding into middle ear
- May cause a dural tear
  - Can lead to CSF leak
  - Exposure to microorganisms of upper airway
- CSF/blood from ear(s) or nose
- Bilateral black eyes—raccoon’s eyes
- Bruising behind ear(s)
  - Battle’s sign
- Hemotympanum
- Hearing loss occurs in up to ½ of patients
- Possible seizures due to irritation of blood on brain tissue
- Most heal spontaneously within 7 to 10 days

Open Skull Fracture

- Severe force involved, brain tissue may be exposed
- Neurologic signs and symptoms evident
**Cerebral Contusion**

- A focal brain injury in which brain tissue is bruised and damaged in a local area
  - May occur at both the area of direct impact (coup) and/or on side opposite the impact (contrecoup)

- Airway patency and breathing adequacy a priority
- Alteration in level of responsiveness
- Confusion or unusual behavior common
- May complain of progressive headache and/or photophobia
- May be unable to lay down memory; repetitive phrases common
- Assess for signs and symptoms of increased ICP

**Epidural Hematoma**

- An epidural hematoma is a rapidly accumulating hematoma between the dura and the cranium
- 85% are associated with an overlying skull fracture
  - Most serious lacerate middle meningeal artery
  - Occasionally, may be result of venous bleeding
- Loss of consciousness followed by a lucid, awake interval
Epidural Hematoma

- Hallmark sign
  - Dilated and fixed pupil on same side as the impact

- Other signs and symptoms
  - Headache, vomiting
  - Altered mental status
  - Early dilation of ipsilateral pupil
  - Contralateral hemiparesis

Subdural Hematoma

- Usually results from tearing of the bridging veins between the cerebral cortex and dura
  - Blood fills space between dura and arachnoid

Subdural Hematoma

- Pupillary changes
- Hemiparesis
- Restlessness
- Focal neurologic signs
- Altered mental status
**Head Injury—Assessment**

- May be impossible to tell which type of hematoma is present
  - More important to recognize the presence of brain injury
- Assess Glasgow Coma Scale score
- History is important
  - What was the child doing? What happened?
  - What is wrong now?
  - What doesn’t seem right?

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**Signs/Symptoms of Increasing ICP**

- Headache that becomes increasingly severe
- Vomiting
- Lethargy
- Confusion
- Changes in consciousness
- Pupil changes
- Pulse slows or becomes irregular
- Respirations become irregular
- Posturing
- Seizures
- Coma

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**Signs of Brain Irritation**

- Change in personality
- Irritability
- Lethargy
- Confusion
- Repeating words or phrases
- Changes in consciousness
- Paralysis of one side of the body
- Seizures
General Management of Head/Brain Injuries

- Suspect cervical spine injury; cervical spine precautions
- Maintain airway and adequate ventilation
  - Hypoxia must be prevented
  - Tracheal intubation often necessary for severely head-injured child
  - Consider RSI and use of lidocaine before procedure to reduce ICP
  - Ensure the availability of suction
  - Consider placement of an orogastric tube

- Elevate head of stretcher or backboard 30 degrees
- Establish vascular access
  - Start IV of isotonic fluid (NS or LR) and titrate to BP
  - Prevent hypotension to preserve CPP
  - If hypotension present, look for internal bleeding
  - Stop external bleeding

- Pharmacologic treatment
  - Possible use of diuretics
  - Paralytics/sedation
  - Avoid glucose unless hypoglycemia confirmed
General Management of Head/Brain Injuries

- Treat seizures if present

- Perform serial neurologic checks
  - Every 15 to 30 minutes until the child is alert
  - Then every 1 to 2 hours for 12 hours
  - Then every 2 to 4 hours thereafter

- Use Glasgow Coma Scale for serial comparisons
  - GCS score that falls two points suggests significant deterioration
  - Urgent patient reassessment is required

Spinal Trauma

- Children can have spinal nerve injury without damage to the vertebrae
  - Spinal Cord Injury Without Radiographic Abnormality (SCIWORA)
Spinal Trauma

- Can have spinal column injury (i.e., bony injury) with or without spinal cord injury
- Can have spinal cord injury with or without spinal column injury

Causes of Spinal Trauma

- Direct trauma
- Excessive movement—acceleration, deceleration, deformation
- Directions of force
  - Flexion or hyperflexion
  - Extension or hyperextension
  - Rotational
  - Lateral bending
  - Vertical compression
  - Distraction

Types of Spinal Cord Injuries

Primary injury
- Occurs at time of impact/injury
- Causes
  - Cord compression
  - Direct cord injury
    - Sharp or unstable bony structures
    - Interruption in the cord’s blood supply
Types of Spinal Cord Injuries

Secondary injury
- Occurs after initial injury
- Causes
  - Swelling
  - Ischemia
  - Movement of bony fragments
- Cord concussion
  - Results from temporary disruption of cord-mediated functions

Complete Cord Transection
- All tracts of spinal cord completely disrupted
- Cord-mediated functions below transection are permanently lost
- Results in:
  - Quadriplegia
    - Injury at the cervical level
    - Loss of all function below injury site
  - Paraplegia
    - Injury at the thoracic or lumbar level
    - Loss of lower trunk only

Incomplete Cord Transection
- Some tracts of the spinal cord remain intact
- Some cord-mediated functions intact
- Potential for recovery
  - Function may only be temporarily lost
- Types
  - Anterior cord syndrome
  - Central cord syndrome
  - Brown-Séquard syndrome
Incomplete Cord Transection

- Anterior cord syndrome
  - Caused by bony fragments or pressure on spinal arteries
  - Symptoms include loss of motor function and pain, temperature, and light touch sensations
  - Some light touch, motion, position, and vibration sensations are spared

- Central cord syndrome
  - Usually occurs with hyperextension of cervical region
  - Symptoms include weakness or paresthesia in upper extremities but normal strength in lower extremities
  - May have varying degrees of bladder dysfunction

- Brown-Séquard syndrome
  - Caused by penetrating injury and involves hemi transection of cord involving only one side of cord
  - Symptoms include complete cord damage and loss of function on affected side with loss of pain and temperature sensation on side opposite the injury
Signs and Symptoms of Spinal Trauma

- Pain to the neck or back
- Pain on movement of the neck or back
- Pain on palpation of posterior neck or midline of back
- Deformity of the spinal column
- Guarding or splinting of the muscles of the neck or back
- Priapism (males)
- Signs and symptoms of neurogenic shock (peripheral vasodilation, bradycardia, and hypotension)
- Paralysis, paresis, numbness, or tingling in the arms or legs at any time after the incident
- Diaphragmatic breathing

Neurogenic Shock

- Occurs secondary to spinal cord injury
- Injury disrupts the body’s sympathetic compensatory mechanism
  - Loss of sympathetic tone to the vessels
    - Arteries and arterioles dilate, enlarging the size of the vascular container and producing a relative hypovolemia
    - Skin will be warm and dry due to cutaneous vasodilation
  - Relative hypotension
  - Relative bradycardia

- Shock presentation is usually the result of hidden volume loss (e.g., chest injuries, abdominal injuries)
- Treatment focus primarily on volume replacement
- Differentiate neurogenic shock (↓ blood pressure, ↓ heart rate) from hypovolemic shock (↓ blood pressure, ↑ heart rate)
General Management of Spinal Injuries

- Use and effectiveness of steroids in spinal cord injury is controversial
- Primary goal is to prevent further injury
- Treat the spine as a long bone with a joint at either end
  - Stabilize the joint above (head) and the joint below (pelvis) the injury

Spinal Stabilization
Helmeted Patients

- Special assessment needs for patients wearing helmets
  - Airway and breathing
  - Fit of helmet and movement within the helmet
  - Ability to gain access to airway and breathing
Indications for Leaving a Helmet in Place

- Good fit with little or no head movement within helmet
- No impending airway or breathing problems
- Removal may cause further injury
- Proper spinal stabilization could be performed with helmet in place
- No interference with ability to assess and reassess airway

Indications for Helmet Removal

- Inability to assess or reassess airway and breathing
- Restriction of adequate management of the airway or breathing
- Improperly fitted helmet with excessive head movement within helmet
- Proper spinal stabilization cannot be performed with helmet in place
- Cardiac arrest

Thoracic Trauma
Thoracic Trauma

- Thoracic trauma associated with a high mortality rate
- Greater elasticity and resilience of the chest wall
  - Rib and sternum fractures less common than in adults
  - But, force is more easily transmitted to the underlying lung tissues

Rib Fractures

- Most frequently caused by blunt trauma
- May be associated with injury to the underlying lung (pulmonary contusion) or the heart (myocardial contusion)
- Seriousness of the injury increases with:
  - Age
  - Number of fractures
  - Location of the fractures

Rib Fractures

- Localized pain at the fracture site
- Pain on inspiration
- Shallow breathing
- Tenderness on palpation
- Deformity of chest wall
- Crepitus
- Swelling and/or bruising at the fracture site
- Possible subcutaneous emphysema
Rib Fractures

- Airway and ventilation
  - Oxygen therapy
  - Positive pressure ventilation if needed
  - Encourage coughing and deep breathing
- Pharmacological—analgesics
- Non-pharmacological
  - Splint, but avoid circumferential splinting
  - Do not apply tape or straps to ribs or chest wall

Flail Chest

- Results when two or more adjacent ribs are fractured at two points, allowing a freely moving segment of the chest wall to move in paradoxic motion
- Life-threatening injury
- Most commonly occurs because of a vehicle crash
- May also occur because of:
  - Falls from a height
  - Assault
  - Birth trauma
- Uncommon in children

Flail Chest

- Most commonly occurs because of:
  - Falls from a height
  - Assault
  - Birth trauma
- Uncommon in children
Flail Chest

- Chest wall contusion
- Respiratory distress
- Paradoxical chest wall movement
- Pleuritic chest pain
- Crepitus
- Pain and splinting of affected side
- Tachypnea
- Tachycardia

Flail Chest

- Supplemental oxygen
- Positive pressure ventilation may be needed
- Evaluate the need for tracheal intubation
- Positive end expiratory pressure (PEEP)
- Pharmacologic—analgesics
- Non-pharmacologic
  - Positioning
  - Tracheal intubation
  - Positive pressure ventilation
Pulmonary Contusion

- One of the most common chest injuries in children
- Potentially life-threatening injury
- Frequently missed due to presence of other associated injuries

Pulmonary Contusion

- Pathophysiology
  - Alveoli fill with blood and fluid because of bruising of the lung tissue
  - Area of lung available for gas exchange is decreased
  - Severity of signs and symptoms depends on amount of lung tissue injured

Pulmonary Contusion

- Evidence of blunt chest trauma
- Apprehension
- Anxiety
- Tachypnea
- Tachycardia
- Cough
- Hemoptysis
- Dyspnea
- Wheezes, crackles
- Decreased breath sounds
- SC emphysema may or may not be present
- ABG changes precede clinical symptoms
  - Increased PaCO₂
  - Decreased PaO₂
Pulmonary Contusion

- Mild contusion
  - Observation and supportive care

- More severe contusion
  - Tracheal intubation
  - Mechanical ventilation with positive end-expiratory pressure (PEEP)

- Maintain normal blood volume

Simple Pneumothorax

- May occur as a result of blunt or penetrating chest trauma
  - Rib fractures
  - Central line placement

- If child is sitting or standing, air will accumulate in apices
  - Check there first for diminished breath sounds

- If child is supine, air will accumulate in anterior chest
Simple Pneumothorax

- Tachypnea
- Tachycardia
- Respiratory distress
- Absent or decreased breath sounds on affected side
- Decreased chest wall movement
- Dyspnea
- Slight pleuritic chest pain

Simple Pneumothorax

- Small pneumothorax may not require treatment other than observation
- Positive pressure ventilation if necessary
- Monitor for development of tension pneumothorax

Open Pneumothorax

- Open defect in chest wall
  - Allows communication between pleural space and atmosphere
  - Prevents development of negative intrapleural pressure
  - Collapse of ipsilateral lung
  - Inability to ventilate affected lung
  - Ventilation/perfusion mismatch
Open Pneumothorax

- Severity depends on size of wound
  - If chest wound diameter is more than 2/3 diameter of patient's trachea, air will enter chest wound rather than through trachea with each breath
  - Sucking/gurgling sound

- If chest wall flap closes during expiration, air will become trapped inside pleural space
  - Possible tension pneumothorax
  - Direct lung injury may be present

Open Pneumothorax

- Defect in chest wall
- Penetrating injury to chest that does not seal itself
- Sucking sound on inhalation
- Tachycardia
- Tachypnea
- Respiratory distress
- Subcutaneous emphysema
- Decreased breath sounds on affected side
Open Pneumothorax

- Positive pressure ventilation if necessary
- Monitor for development of tension pneumothorax
- Promptly close chest wall defect with occlusive dressing
  - Tape dressing on three sides
- Tube thoracostomy
  - In-hospital management

Tension Pneumothorax

- Common in children
- Life-threatening chest injury
- Can occur because of:
  - Blunt or penetrating trauma
  - Complication of treatment of an open pneumothorax

Tension Pneumothorax

- May result from:
  - An opening through the chest wall and parietal pleura (open pneumothorax)
  - A tear in the lung tissue and visceral pleura (closed pneumothorax)
Tension Pneumothorax

- Air enters pleura during inspiration
  - Progressively accumulates under pressure
- Flap of injured lung acts as one-way valve
  - Air enters pleural space during inspiration
  - Trapped during expiration
- Injured lung collapses
- Pressure rises
- Trachea, heart, and major vessels pushed toward opposite side

Tension Pneumothorax

- Cool, clammy skin
- Increased pulse rate
- Cyanosis (late sign)
- JVD
  - May not be prominent if hypovolemia present
- Hypotension
- Severe respiratory distress
- Agitation, restlessness, anxiety
- Bulging of intercostal muscles on affected side
- Decreased or absent breath sounds on affected side
- Tracheal deviation toward unaffected side (late sign)
- Possible SubQ emphysema in face, neck, or chest wall

Tension Pneumothorax

- Positive pressure ventilation if necessary
- Relieve tension pneumothorax to improve cardiac output
  - If patient has an open chest wound with signs of a tension pneumothorax:
    - Remove dressing over wound for a few seconds
    - Reseal wound with occlusive dressing once pressure released
    - If this does not relieve signs of tension pneumothorax, needle decompression
  - Tube thoracostomy
    - In-hospital management
Hemothorax

- Life-threatening injury
- Frequently requires urgent chest tube and/or surgery
- Requires a minimum of 10 mL/kg of blood to be visualized on chest radiograph

Hemothorax

- Occurs as a result of blunt or penetrating trauma
- Blood accumulates in pleural space and compresses lung
- Massive hemothorax indicates great vessel or cardiac injury
  - Rare in children
  - Produces both respiratory failure and circulatory collapse

Hemothorax

- Tachypnea
- Tachycardia
- Respiratory distress
- Hypotension
- Narrowed pulse pressure
- Flat neck veins
- Pleuritic chest pain
- Pale, cool, moist skin
- Dyspnea
- Decreased breath sounds on affected side with or without obvious respiratory distress
- Dullness to percussion on affected side
Hemothorax

- Tracheal intubation if necessary
- Treat hypovolemia and shock with IV fluids
  - Blood administration as indicated
- Tube thoracostomy
  - In-hospital management
  - Ensure IV fluid resuscitation is initiated before procedure

Traumatic Asphyxia

- Sudden compression force to the chest or upper abdomen
  - Lungs full of air and glottis closed
  - Causes sudden increase in intrapleural and intra-abdominal pressure
  - Blood in veins of thorax and neck forced into chest, lungs, neck, head, and brain

Traumatic Asphyxia

- Increased venous pressure causes capillary rupture
- Results in:
  - Violet color of skin in head and neck area
  - Bilateral subconjunctival hemorrhages
  - Facial edema
Traumatic Asphyxia

- Cyanosis of the face and upper neck
- JVD
- Swelling or hemorrhage of the conjunctiva
- Skin below area remains pink
- Tachypnea
- Disorientation
- Hemoptysis
- Epistaxis
- Signs of respiratory insufficiency

Traumatic Asphyxia

- Manage associated injuries (e.g., pulmonary contusion)
- Supportive care

Pericardial Tamponade

- Rapid accumulation of fluid in pericardial sac
  - Compresses heart
  - Decreases cardiac output due to restricted diastolic expansion and filling
  - Hampers venous return
Pericardial Tamponade

- Tachycardia
- Respiratory distress
- Pulsus paradoxus
- Beck’s triad
  - Narrowing pulse pressure
  - Neck vein distention
  - Muffled heart tones
- Cyanosis of head, neck, upper extremities
- Dysrhythmias
  - Bradycardia
  - Pulseless electrical activity
  - Asystole
- Cyanosis of head, neck, upper extremities
- Dysrhythmias
  - Bradycardia
  - Pulseless electrical activity
  - Asystole

Beck’s triad is not often evident in the pediatric patient.

- If profound hypovolemia is present, JVD will be absent.
- If bradycardia occurs, the patient is about to arrest.

Airway and ventilation

IV fluid challenge
  - May transiently increase cardiac output by increasing filling pressure of the heart

Pericardiocentesis
  - In-hospital management
  - Prepare for possible Emergency Department thoracotomy, operative intervention
Commotio cordis

- Disorder described in the pediatric population
- Results from sudden impact to the anterior chest wall (e.g., baseball injury) that causes cessation of normal cardiac function

Abdominal and Pelvic Trauma

Abdominal Trauma

- Third leading cause of traumatic death, after head and thoracic injuries
- Most common cause of unrecognized fatal injury in children
Abdominal Trauma

- Abdominal wall is thin
  - Organs are closer to surface of abdomen
- Proportionally larger solid organs, less subcutaneous fat and less protective abdominal musculature than adult
- Liver and spleen of small child lower in abdomen
  - Less protected by the rib cage

Blunt Abdominal Trauma

- Blunt mechanisms (85% of cases)
- In children, primarily caused by:
  - Motor vehicle collisions
    - Causes >50% of abdominal injuries in children
    - Most lethal cause of abdominal injury in children
  - Motorcycle collisions
  - Falls
  - Sports-related injuries
  - Pedestrian crashes
  - Child abuse

Abdominal Trauma

- Effects of bicycle injuries may not be seen on initial presentation
  - Mean elapsed time to onset of symptoms is nearly 24 hours
Penetrating Abdominal Trauma

- Penetrating mechanisms (15% of cases)
  - Energy imparted to the body
  - Low velocity
    - Knife, ice pick, scissors
  - Medium velocity
    - Gunshot wounds
    - Shotgun wounds
  - High velocity
    - High power hunting rifles
    - Military weapons

Splenic Injuries

- Most frequently injured abdominal organ during blunt trauma
  - Motor vehicle collisions
  - Sudden deceleration injuries
  - Contact sports-related injuries

- May present with LUQ abdominal pain radiating to left shoulder
  - Kehr’s sign
  - Result of diaphragm irritation

Splenic Injuries

- Patient presentation may range from stable to persistent hypotension to cardiovascular collapse
  - Stable patients
    - CT scan or bedside ultrasound

- Bleeding from a minor splenic injury often stops spontaneously
  - However, spontaneous splenic rupture 3 to 5 days after the injury has been described
Liver Injuries

- Liver vulnerable to injury
  - Large size
  - Fragile
- Second most commonly injured solid organ in the pediatric patient with blunt abdominal trauma
  - Most common cause of lethal hemorrhage

Liver Injuries

- Injuries may be the result of blunt or penetrating trauma
  - Firm blow to RUQ or right-sided rib fractures may cause liver injury
- Absence of localized bruises or abrasions does not rule out possibility of serious laceration or rupture

Kidney Injuries

- Children are more susceptible to renal injuries because:
  - Kidneys are large in proportion to abdomen
  - Lower ribs do not shield kidneys from injury
  - Underdevelopment of abdominal wall muscles and a lack of extensive perirenal fat provides less protection for kidneys
  - Their kidneys are mobile
Kidney Injuries
- Usually caused by blunt trauma
  - Deceleration forces
- Rarely caused by penetrating trauma
- Often present with hematuria, back pain
- Most injuries are minor and can be managed without surgical intervention

Pancreatic Injuries
- Contusion most common type of injury to pancreas
- Common mechanisms of injury:
  - Falling from a bicycle with injury caused by handlebars
  - Pedestrian traffic collisions
  - Motor vehicle collisions
  - Child abuse

Pancreatic Injuries
- Lacerations cause hemorrhage and release of enzymatic contents toxic to surrounding tissues
- Penetrating trauma requires surgical evaluation
Hollow Organ Injuries

- Small and large intestines
  - Most often injured as a result of penetrating injuries
  - Can occur with deceleration injuries

- Stomach
  - Most often injured as a result of blunt trauma
  - Full stomach before incident increases risk of injury

Hollow Organ Injuries

- Duodenum
  - Most often injured as a result of blunt trauma
  - Recognition often delayed

Hollow Organ Injuries

- Bladder
  - Most often injured as a result of blunt trauma due to automobile or auto-pedestrian collisions
  - Full bladder before incident or inappropriate use of lapbelts may increase risk of bladder injury
  - Penetrating injuries may be caused by guns, knives, or fractured pelvic bones
Chance Fracture
- Also called a seatbelt fracture
- Horizontal fracture of thoracic or lumbar spine caused by a hyperflexion injury with little or no compression of vertebral body
- Typically occurs when a lap belt is worn with no shoulder harness during a motor vehicle collision

Correct (left image) and incorrect (right image) positions for lap belts on children.

Evisceration
- Do not touch or try to replace the exposed organ
- Carefully remove clothing from around the wound
- Cover exposed organs and wound
  - Apply a large sterile dressing, moistened with sterile water or saline, over organs and wound
  - Secure dressing in place with a large bandage

Pelvic Fractures
- Fractures of the pelvis in children are uncommon
  - Associated soft tissue injuries may be severe
- Many pelvic fractures occur in children struck by moving vehicles
**Pelvic Fractures**

- Treatment of a pelvic fracture depends on type of fracture
- Follow local protocol

**Extremity Trauma**

- Fractures are among the most frequently missed injuries in children with multiple trauma
Extremity Trauma

- Be alert for evidence of possible child abuse:
  - Fractures of differing ages
  - Discrepancy between history and injury
  - Prolonged and/or unexplained delay in treatment
  - Different stories at different times
  - Poor health and hygiene

Extremity Stabilization

- Stabilize joint above and below the fracture site
- Assess and document pulses, motor function, and sensation in the affected extremity before and after stabilization

Amputated Part

- Apply a sterile dressing soaked in NS to stump, then splint it
  - If profuse bleeding is present, apply direct pressure with a soft dressing
  - Immobilize limb to prevent further injury
- Gently rinse dirt and debris from amputated part with NS or LR solution
  - Do not scrub
  - Clean water is an acceptable alternative if sterile isotonic solution is not available
Amputated Part

- Put the part in a plastic bag or waterproof container
- Place the plastic bag or waterproof container in water with a few cubes of ice
- Transport the amputated part with the patient

Amputated Part

- Do not use dry ice
- Do not allow the part to freeze
  - Freezing renders tissues non-replantable
- Do not place amputated part directly on ice or in water
- Do not complete partial amputations

Thermal Burns
Depth Classification of a Burn Injury

- It is often days before depth can be determined accurately

Thermal Burns

- Superficial burn (first-degree)
  - Example: sunburn
  - Only epidermis involved
  - Dry, no blisters
  - Minimal or no edema
  - Painful and erythematous
  - Heal in 2 to 5 days with no scarring

Thermal Burns

- Partial-thickness burn (second-degree)
  - Often caused by scalds
  - Epidermis and dermis involved, but dermal appendages spared
  - Superficial second-degree burns are blistered and painful
  - Deep second-degree burns may be white and painless
Superficial Partial-Thickness
Second-Degree Burn

Thermal Burns
Partial-thickness burn (second-degree)

- Healing
  - Superficial: 5 to 21 days with no grafting
  - Deep partial: 21 to 35 days with no infection
  - If infected, converts to full thickness

Full-thickness burn (third-degree)
- Typically result from flame or contact injuries
- Epidermis and dermis involved; may include fat, subcutaneous tissue, fascia, muscle, and bone
- Color may vary from yellow or pallid to black and charred, with a dry, waxy, or leathery appearance
- Often insensate to pinprick because nerve endings have been destroyed
- Large areas require grafting
- Small areas may heal from the edges after weeks
Rule of Nines

- Adult body is divided into anatomic regions that have surface area percentages that are multiples of 9%
- Less accurate for children who tend to have proportionally larger heads and smaller legs
  - Pediatric version developed
- Calculations with the rule of nines tend to overestimate burn size

Rule of Palms

- May be used to estimate burns encompassing 5% total BSA or less
- The surface area of the patient's palm is estimated to be 1% of the patient's total BSA
Lund and Browder Chart

- Adult and pediatric versions are widely used in burn care

Thermal Burns—Initial Treatment Guidelines

- Remove all clothing and jewelry
- Assess for associated injuries or shock
  - Assess posterior surface of patient for burn injury
- Keep burned extremities elevated above level of heart
- Keep the burned patient warm
- Monitor vital signs at least every 15 to 30 minutes

Thermal Burns—Initial Treatment Guidelines

- Establish vascular access with LR solution

- Two commonly used burn resuscitation formulas:
  1. Parkland burn formula
     - 4 mL/kg divided by the percentage of total BSA burned
  2. Consensus formula
     - 2 to 4 mL/kg divided by the percentage of total BSA burned
Thermal Burns—Initial Treatment Guidelines

- Urinary catheter insertion for fluid resuscitation or as indicated
- Keep patient NPO
- Insert nasogastric tube for all air transports, burns affecting more than 20% total BSA, or those who are intoxicated, intubated, or as indicated
- Give IM tetanus toxoid if patient has not been immunized in preceding 5 years

Thermal Burns—Initial Treatment Guidelines

- Pain management
  - IV analgesia is often necessary to treat pain
    - Consider narcotic therapy for pain management
  - Give pain medication IV in small increments, titrated to level of comfort
- Provide emotional support to patient and family

Questions?