Penetrating Trauma in Pediatric Patients

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Introduction

- Trauma is the leading cause of death between ages of 1-18 years

- Penetrating injury accounts for 10% -20% of all trauma in pediatric patients

- Firearms account for the majority of penetrating wounds

- Penetrating wounds are more lethal than blunt trauma
Introduction

- Mortality is even higher for younger children (compared to adolescents)

- Major physiologic consequence of penetrating trauma outside of the brain = Hemorrhage
Gun Shot Wounds

• Lethality related to:
  • Projectile dispersion
  • Higher kinetic injury
  • Impulse
  • Yaw
  • Deformation
  • Fragmentation

• Shot-gun wounds
  • Multiple pellet incursions
  • Spread out over a large area
Ballistics

* Yaw – rotation of the nose of the bullet away from the line of its flight
Ammunition

- Complete cartridges containing the projectile of a firearm aka "the bullet"
- The bullet = actual projectile = primarily lead with a rounded or pointed tip; various sizes and calibers
- Caliber = width of the bullet in proportion of an inch or millimeter
- Range of designs that affect their energy transference:
  - Pointed tips        Full metal jackets
  - Round tips          Partial metal jackets
  - Hollow points       Scored bullets
Bullets

* Expanding:
  - Designed to maximize tissue damage

* Nonexpanding:
  - Greater penetration
  - Pointed tip
  - Coated with a thin metal covering/jacket of copper
    - Limits lead residue (dangerous mechanical malfunctions)
  - Bullet maintains its shape
Ammunition

* Birdshot
  - Spherical
  - Small, soft lead or similar metal

* Buckshot
  - Spherical
  - Shells contain only a few tightly packed balls – larger diameter
  - Lead or steel
Ammunition

☆ Slugs

• Single, large solid projectile
• May or may not have rifling built into the lead – gives it a spiral path which increase accuracy
• Low velocity, limited range
Damage Caused by Bullets

- Lacerate or crush tissue or bone
- Fluid-filled organs (heart, lungs, bowel) can burst by the pressure
- Fragments of bone shards can further cause damage
- Cavitation
  - Temporary
    - Formed by continuous acceleration of the medium (air or tissue)
  - Permanent
    - Caused by the pathway
Zones of Injury of Ballistic Wounding

- Primary wound tract
  - Permanent cavity, dead crushed tissue
- Contusion zone
  - Tissue adjacent to primary wound tract
  - Inflammatory with cellular debris
- Concussion zone
  - Temporary cavity
  - Tissue damage by stretching, shearing and compression
  - Inelastic tissue (bone, brain, liver, spleen) susceptible

Bruner, 2011
Air-Rifle Injuries

More fatal if:

- Suicide attempt
- Close range
- Projectile entered the cranium through the orbit or cranium
- 30% mortality
Non-firearm Related Injuries

* More difficult to predict which wounds would be fatal
Head

- 3 times more likely to die

- GCS < 8, unilateral dilated pupil, transventricular or bi-hemispheric trajectories = High mortality!

Thorax

- Most common non-intracranial lethal wound
- Most likely noted in adolescent males
- Anterior mediastinum penetration: tamponade
- Lung = Pneumothorax
- Hemothorax
- Major vascular structures
- Fatal immediately if object removed by victim or bystander
Penetrating Chest Wound
Tension Pneumothorax
Needle Decompression
Thorax

- Each hemithorax can hold up to hold of a patient’s total blood volume
- Lung tissue is low density and high elasticity
- Children have:
  - diminished functional residual capacity
  - Higher oxygen consumption
  - Prone to rapid evolution of hypoxia
  - Remain compensated with blood loss up to 40%
Thorax

- **Low-velocity GSWs**
  - Limited minimal chest trauma to the bullet entry and exit sites
  - Minimal injuries, lacerations and contusions to the lungs

- **High-velocity GSWs**
  - More extensive damage at the exit of the bullet
  - Severe tissue damage beyond the initial tract of penetration
  - More intense cavitation, laceration and contusion
Thorax

- Dyspnea
- Anxiety
- Tachycardia
- Pleural pain
- Asymmetric chest wall expansion
- Decreased breath sounds
Spinal Injuries

- Direct path and concussive effects of the missile contribute to the destruction of both spine and cord
- GSW to spine have potential for instability if missile fractures pedicles and facets as it traverses the spinal canal
- Incomplete injury or partial motor function should remain immobilized – children have the greatest likelihood of regaining ambulatory function

Cotton, 2004
Neck Injuries

- Uncommon in children
- Protected by:
  - spine posteriorly
  - Mandible anteriorly and superiorly
  - Large head
  - Short neck
- ~ 25 % will require urgent intubation
- Vascular injury is the most common complication
Neck Injuries

- Multiple structures within the neck and cervical spine are at risk
- Identify and manage injuries
- Prevent progression of injuries
- Injuries to blood vessels can be dramatic or subtle
- Cervical injuries and physical findings may not be straightforward
Neck Trauma

https://aneskey.com/neck-trauma/
Neck Trauma

- Rapidly expanding neck hematoma
- Laryngotracheal injury
- Pulsatile bleeding
- Bruit
- Lateralizing neurological signs
- Hoarseness
- Hemoptysis
Rapid First Impression

* Gather much information by quickly assessing:
  * Position found
  * Obvious injuries
  * Breathing effort
  * Skin color
  * Mental status
Abdominal Injuries

- Distension from hemorrhage or hollow visceral injury – free air
- Tenderness – secondary to
  - peritoneal irritation – blood and/or enteric content
  - Local tissue destruction
### Frequency of Intraabdominal Organs Injury

<table>
<thead>
<tr>
<th>Organ</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrointestinal tract</td>
<td>70</td>
</tr>
<tr>
<td>Stomach</td>
<td>13</td>
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<tr>
<td>Duodenum</td>
<td>4</td>
</tr>
<tr>
<td>Jejunum/ileum</td>
<td>24</td>
</tr>
<tr>
<td>Colon/rectum</td>
<td>27</td>
</tr>
<tr>
<td>Liver</td>
<td>27</td>
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<tr>
<td>Major vessel</td>
<td>19</td>
</tr>
<tr>
<td>Kidney</td>
<td>10</td>
</tr>
<tr>
<td>Spleen</td>
<td>9</td>
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<tr>
<td>Genitourinary tract</td>
<td>8</td>
</tr>
<tr>
<td>Pancreas</td>
<td>6</td>
</tr>
</tbody>
</table>

Cotton, 2012
Extremity Injuries

- Bony defects
- Joint involvement
- Peripheral nerve damage
- Vascular injuries
THANK YOU

EMS
Everyday Heroes
References