Penetrating Trauma
“The Violent Side of Pediatrics”

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Disclosure

I have no conflicts of interest or financial relationships for this presentation.
Objectives

Describe common penetrating injuries in the pediatric population

Discuss the importance of effective communication in the trauma bay
Which of the following is an indication for laproscopic or laparotomy exploration in a pediatric patient with penetrating abdominal trauma?

- A. Violation of the fascia
- B. GSW or other high velocity projectile
- C. Hemodynamically unstable patient
- D. All of the above
What is Penetrating Trauma?

- Penetrating trauma is an injury that occurs when an object pierces the skin and enters a tissue of the body, creating an open wound.

- May include
  - Firearms
  - Knives and swords
  - Animal related injuries
  - Tools and lawnmowers
  - Impalements
Epidemiology

- Despite widespread publicity penetrating trauma relatively less common
- Recent study 154,045 patients treated in 125 US trauma centers – 6.4% volume (GSW), 1.5% (SW)
- Some studies show GSW 20% of the volume, but accounts for 50% of the mortality rate
Less “well known”
Even less known
Nokia’s Version
In a moment’s notice…

You must be ready for *ANYTHING!!*
Pediatric Differences

- More cartilaginous chest wall
- Less soft tissue protection
- Greater risk for hypoxia
  - Pliable ribs
  - Poorly developed intercostals
  - Fewer & smaller alveoli
- Mediastinal structures
- Compensatory mechanisms
- Increased body surface area
Mechanisms of Injury in Penetrating Trauma

- **Low velocity injuries**
  - Stab wounds
  - Disrupt only the structures penetrated

- **Medium velocity injuries**
  - Handguns and pellet guns
  - Shotguns
  - Secondary cavitation

- **High Velocity Injuries**
  - Military weapons and rifles
  - Secondary cavitation
Penetrating Trauma

- Approximately 8% at CMH
- 8-12% of pediatric abdominal trauma admissions (nationally)
- GSWs most common cause of penetrating trauma in pediatrics
- GSWs leading cause of death in black males 15-24 y/o
Wound types by range
Penetrating Abdominal Trauma

- Abdomen extends from the nipples to the groin crease anteriorly, and the tips of the scapulae to the gluteal skin crease inferiorly.
## Organs most often injured

<table>
<thead>
<tr>
<th>Frequency of Organ Injury</th>
<th>Blunt</th>
<th>Penetrating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>15%</td>
<td>22%</td>
</tr>
<tr>
<td>Spleen</td>
<td>27%</td>
<td>9%</td>
</tr>
<tr>
<td>Pancreas</td>
<td>2%</td>
<td>6%</td>
</tr>
<tr>
<td>Kidney</td>
<td>27%</td>
<td>9%</td>
</tr>
<tr>
<td>Stomach</td>
<td>1%</td>
<td>10%</td>
</tr>
<tr>
<td>Duodenum</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>Small Bowel</td>
<td>6%</td>
<td>18%</td>
</tr>
<tr>
<td>Colon</td>
<td>2%</td>
<td>16%</td>
</tr>
<tr>
<td>Other</td>
<td>17%</td>
<td>6%</td>
</tr>
</tbody>
</table>

Saxena, et al, Medscape Reference, May 9, 2011
Evaluation

- **ABC’s**
  - Airway – with cervical spine control
  - Breathing
  - Circulation – with hemorrhage control
  - Disability
  - Expose/Environment – with temp control

- **Good exam**
  - Avoid multiple repeated exams if findings positive
    - Peritonitis
    - Pelvic instability
Any injured child who is cool and tachycardic is in shock until proven otherwise...
Pearl #2....

Every child deserves a Sherlock Holmes
Stable Patients

- Evaluate for injury – “Tubes & fingers in every orifice” Still true?
  - Chest Xray
  - Other plain films- mark entrances and exits
  - NG Tube
  - Urinary Catheter
  - Rectal Exam/Vaginal Exam
  - Other imaging modalities

- OR?
Unstable Patients

- Need to go to OR
- Decide which cavity to open first
  - Obvious penetrating injury to abdomen requires laparotomy/laparoscopy
  - Questions may arise if multiple area penetrating trauma, massive hemothorax, evidence of tamponade, “grey zone areas” such as thoracoabdominal junction, buttock wound
- Sometimes need diagnostic testing
  - Diagnostic Peritoneal Lavage (?)
  - FAST Scan (user dependent)
  - CT (?)
Indications for OR (per ATLS)

- Any patient with hemodynamic abnormalities
- Gunshot wounds
- Signs of peritoneal irritation
- Signs of fascial penetration
Evisceration
Evisceration?
Non-operative GSWs?

- 11 year retrospective study
- Level 1 trauma center
- Excluded tangential injuries, deaths and transfers
- 125 patients
- 38(30%) managed nonoperatively initially
  - Serial exams and CTs
- 7 ended up with operation
- 10 patients had nontherapeutic laparotomies - 3 developed complications
Non-Operative Penetrating Wounds in Children

- Cigdem, et al
- Turkish chart review
- 90 children, mean age 9.9 years
- 2/3 stab wounds, 1/3 GSW
- Most common injury- bowel
- 56.6% (51 patients) treated nonoperatively
Non-Operative Penetrating Wounds in Children

- Non-operative group: (n=51)
  - 41 stab, 10 GSW
  - All had detailed ultrasounds
  - 2 went to OR
  - One ileum perforation (OR at 20 hours)
  - One with signs of peritonitis at 24 hours (no injury found in OR)
Focused Assessment Sonography in Trauma (FAST)

- Rapid, noninvasive, inexpensive
- Accurate (if experienced user)
- Indications- same as DPL
- Limitations:
  - Limited in detecting <250 cc intraperitoneal fluid
  - Particularly poor at detecting bowel and mesentery damage (44% sensitivity)
  - Difficult to assess retroperitoneum
  - Small spaces / relatively larger organs / etc.
- Easy to reproduce
- Utility may be compromised if:
  - Obesity
  - Subcutaneous air
  - Previous abdominal surgeries
diaphragm

liver

free fluid
Abdominal CT

- Requires transport
- Requires contrast
- Time consuming - Only use if hemodynamically stable
- Relatively specific
- Good for retroperitoneal injuries
- May miss gastrointestinal, diaphragmatic and pancreatic injuries
Abdominal CT

Features of Penetrating Trauma CT’s

- Signs of peritoneal violation
  - Free intra-peritoneal air
  - Free intra-peritoneal fluid
- Wound track extending through peritoneum
- Bowel wall defect/thickening
- Intraluminal contrast leak
- Diaphragmatic defect
CT Before OR?

- Neal, et al.
  - Pittsburgh- retrospective study
  - National Trauma Data Bank Review
  - Patients >14 y/o
  - Came from scene
  - Hypotensive upon arrival
  - Abbreviated Injury Score >3
  - Underwent laparotomy within 90 min
CT Before OR?

- 3218 patients
- Abdominal CT group-
  - More likely penetrating (49% vs 43%)
  - More intubations before leaving ED
  - More commonly undergoing head injury eval as well
  - Higher mortality (70% higher risk)
  - Significant delay in getting to OR if abdominal CT
    - Head CT didn’t impact OR time
Interpreting CT

- 2008 study
- Compared surgical residents’ interpretation to radiologist
- 84 injuries in 31 patients
- Residents correctly identified:
  - 96% (25/26) of head injuries – vs 89% radiologists
  - 67% (28/42) of chest injuries – vs 90% radiologists
  - 94% (15/16) of abdomen/pelvis injuries – vs 88% radiologists
- None of missed injuries were life threatening or required immediate attention
Local Wound Exploration

- Extend wound and follow the tract
- Penetration of the anterior abdominal fascia is considered positive and patient gets laparotomy/laparoscopy
- 25% of anterior abdominal stab wounds do not penetrate
- Only 50% of stab wounds that do penetrate actually require surgical intervention
Laparoscopy??

- Less invasive
- Adult literature
  - Laparotomy with 5% associated mortality
  - Relatively high incidence adhesions and obstruction later
  - Limited literature suggests utility of laparoscopy
Laparoscopy

- Adult literature – Yecul, et al
- Prospective study
- Stab wounds
- Hemodynamically stable without abdominal tenderness
- 36 patients all had exploratory laparoscopy
- 36.1% had diaphragmatic injury
- 53% of those had associated abdominal injury
- Laparotomy required in only one case
Laparoscopy?? Pediatric

- Marwan, et al, University of Alabama
- Retrospective review 1997-2009
- Blunt and penetrating trauma
- 71 laparotomies, 21 laparoscopies
- All acute laparoscopies (19/21) were diagnostically successful
  - Not as successful in delayed cases (2)
- 5 had therapeutic laparoscopies as well
- Laparotomy avoided in 13/21 patients and 10/10 penetrating trauma patients
- Laparoscopy not done if peritoneal violation
Case #1- 2 year old fell off bed

- 2 Days prior, fell off bed onto carpet
- Landed on abdomen
- Family noted tiny drop of blood midline upper abdomen
- Seen at outside hospital next day, discharged
- Seen at CMHK for continued tenderness next day
Case #1

2 year old fell off bed
Case 2
Penetrating Trauma

- 14 year old boy
- Fell from second story window
- Landed on a pipe sticking out of the ground
- Presents to ED triage
Case 2
Penetrating Trauma
Case 2
Penetrating Trauma
Case 3

“Pen”etrating trauma

- 9 year old boy with wound to abdomen
- Fell on a gel pen
- Tip broke off
- Mild pain at entrance
- Ink oozes from entrance site if pressure applied.
- Minimal abdominal pain
“Pen”etrating Trauma
“Pen”etrating Trauma
Case Study #4

- 12y/o M – 45KG
  - Shot in chest with BB gun
    - Single 3mm wound L midline
    - 3rd intercostal space
    - Minimal bleeding
  - Found sitting on couch obtunded
  - Radial pulse absent
    - Heart tones normal
Case Study #4

- **Vital Signs**
  - 67/47, 140, 22, GCS 8, RTS 8

- **Treatment**
  - Full Spinal Immobilization
  - ECG
  - O2 @ 12LPM via NRB
  - NS Bolus – 900ml (f/u 49/28, 120, 20)
So what should we expect?

- Tube thoracostomy
- Needle thoracostomy
- Pericardiocentesis
- Thoracotony
- IVF Bolus
- Vasopressors
- Intubation
- I don’t wanna be here anymore!
Case Study #4

- **ED Arrival**
  - 1800 Pelvis X-Ray
  - 1802 Muffled heart tones
  - 1812 NS @ 999ml/hr (warmed)
  - 1817 Abd FAST (-), + Pericardial fluid
  - 1819 GCS <10 – Intubation
  - 1820 Pericardiocentesis – drain placed
  - 1820 Ketamine/Roc/Versed/Fent
  - 1827 CR <2sec, 2+ distal pulses
So what should we expect now?

- Tube thoracostomy
- Needle thoracostomy
- Pericardiocentesis
- Thoracotomy
- IVF Bolus
- Vasopressors
- Intubation
- I don’t wanna be here anymore!
Case 5

- 10 year old tornado victim
- Sustained right thoracic trauma
  - Right flail chest
- Intubated at scene for distress
Primary Survey

- A – Direct laryngoscopy?
- B – ↓ BS on the right
  - Intervention?
  - Right tube thoracostomy
- C – Aggressive fluid resuscitation?
  - "Pop the clot”
  - Contribute to coagulopathy
  - 1:1:1
- D – Moving all 4 extremities at scene
- E – Metal rod right back/shoulder (TEMP!)
- CXR +/- Pelvis
Secondary Survey

- Gen - Intubated & sedated
- HEENT - Orally intubated
- Spine - C-collar
- Chest - Increased BS on right
- CV - Tachycardic, BP WNL
- Abd - soft, non-distended
What Now?

- OR?
- ED Thoracotomy?
- Imaging?
  - CT
  - Angiography

1. Clinical Condition
2. Chest Tube Output
Management

- OR

- Removal of bar, debridement and drainage of open right humerus fracture

- Thoracotomy, evacuation of hemothorax and control of bleeding
Indications for Thoracotomy

- Initial CT output > 15 ml/kg
- CT output of 2-3ml/kg/hr x 3 hours
- Cardiac tamponade
- Trans-mediastinal injury with HD instability
- Massive air leak
Chest or Abdomen??
Thoracoabdominal Injuries

- Any penetrating injury that traverses the diaphragm
- Suspect between nipples and umbilicus
- Always get chest xray!
- Most require exploration to rule out diaphragmatic injury
Remember the diaphragm

- Diaphragm can rise as high as the 4th thoracic vertebrae
- Diaphragmatic injury occurs in
  - 45% of thoracoabdominal GSWs
  - 15% of thoracoabdominal stab wounds
- Injuries are more common on the left
Miscellaneous

- Consider all penetrating injuries to be contaminated
- Tetanus prophylaxis
- 15% with thoraco-abdominal penetrating injuries will have other injuries
- Gluteal injuries - up to 50% with intrabdominal injuries
- For penetrating rectal injuries, consider triple contrast CT
Social Considerations

- History often inaccurate
- Reportable to PD
  - All pediatric GSW and stab wounds should be reported
- Consider hotline to child protective services
The End(s)...

Thank You!!
References

- American College of Surgeons, ATLS Student Course Manual, 8th edition.