Imaging Visceral Trauma in Abuse

Katherine Nimkin, MD
Division of Pediatric Imaging
Massachusetts General Hospital
Assistant Professor of Radiology
Harvard Medical School Boston, MA
Objectives

• Summary of recent retrospective reviews
• Imaging of specific injuries of the neck, chest and abdomen in abused children
• Imaging strategies
• Conclusions
Disclosures

• No relevant financial disclosures
# Retrospective Reviews

## Abdominal Trauma Presentation: Accidental vs Abusive

<table>
<thead>
<tr>
<th>Study</th>
<th>Percentage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>DiScala et al (2000)</td>
<td>10% blunt trauma due to abuse in children &lt;5 years</td>
<td>The abused children were younger and had a worse outcome compared to accidentally injured children.</td>
</tr>
<tr>
<td>Trokel et al (2004)</td>
<td>16% blunt trauma due to abuse in children &lt;5 years</td>
<td>Abuse was most common cause of injury in children less than 2 years and abused children had higher mortality.</td>
</tr>
<tr>
<td>Wood et al (2005)</td>
<td>11% abdominal injuries due to abuse</td>
<td>Abused children were younger, more severely injured, had more bowel injuries and had delay in seeking care. Solid organ injury predominated in all groups.</td>
</tr>
</tbody>
</table>
# Retrospective Reviews

## Abused Children Presentation: Prevalence of Abdominal Injuries

<table>
<thead>
<tr>
<th>Study</th>
<th>Percentage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sivit et al (1989)</td>
<td>First larger review using CT. 14/69 (20%) abused children had visceral injuries.</td>
<td>10 were stable enough for CT; liver injury most common in this group. 4 were too unstable for CT; intestinal/mesenteric injuries were most common.</td>
</tr>
<tr>
<td>Roaten et al (2005)</td>
<td>24/265 (9%) abused children had visceral injuries.</td>
<td>Abused children with visceral injuries had more severe injuries and were more likely to need surgery.</td>
</tr>
<tr>
<td>Hilmes et al (2010)</td>
<td>35/84 (42%) abused children ≤5 years had abdominal injuries on CT.</td>
<td>60% had significant abdominal clinical findings. Liver and bowel were most commonly injured. 9 required surgery; 9 died (all from head injury).</td>
</tr>
<tr>
<td>Trout et al (2011)</td>
<td>11/68 (16%) children &gt;3 years old with suspected abuse had positive findings on abdominal CT.</td>
<td>Multiple abnormal physical and laboratory abnormalities were associated with positive CT.</td>
</tr>
</tbody>
</table>
Visceral Injury in Abuse

- Visceral injury in abused children is uncommon
- 2.33 cases/million children/year in children <5 years (Barnes 2005)
- Increased prevalence in children with clinical or laboratory findings suggesting abdominal injury
- True prevalence is likely underestimated
- Up to 16% abdominal injuries in young children are due to abuse
- Second most common cause of death from abuse after brain injury
Visceral Injury in Abuse

• Usually younger than 3 years
• Delay in seeking care
• Multiple and severe injuries
• Due to direct blow to the abdomen and shearing forces
• Mortality rate up to 53%, likely partly due to delay
• Average age of fatal injury around 2 years
Visceral Injury in Abuse

- Solid organ injuries (liver) most common
- Hollow viscus injuries/pancreatic injuries have strongest association with abuse and more often require surgery
- Clinical presentation similar to that seen with accidental trauma-distension, pain, vomiting
- Bruising often absent
LIVER

• Most commonly injured organ with inflicted abdominal injury

• Elevated transaminases have high specificity and sensitivity for hepatic injury

• Hepatic transaminases rise rapidly after uncomplicated blunt liver injury and fall predictably

• ALT > AST indicates subacute injury
LIVER

- Injuries to left lobe in abuse-compressed against spine
- US and CT
- Periportal tracking, laceration, hematoma
- Portal venous gas, vascular injury, avulsion of bile duct
Pneumatosis (white arrows) and portal venous gas (black arrows) in abused 2 year old with duodenal and colonic hematoma.

8 month old with bruising and elevated transaminases. T12-L4 compression fractures and left liver laceration (arrow).
5 month old with head and skeletal injuries. Left liver laceration (arrow) on CT and MRI (cor STIR).
7 month old with grade IV liver laceration and left 12th posterior rib fracture.
Hollow Viscus Injury

- Injury to mesentery, bowel perforation or bowel hematoma
- Usually duodenum and jejunum
- These injuries are more common with abuse than accidental injury
- Shearing forces generated by a direct blow or sudden deceleration lead to intestinal-mesenteric injuries
Hollow Viscus Injury

- CT findings: free air or contrast, bowel wall thickening or defect, pneumatosis, mesenteric stranding, free fluid
- May overlap with hypoperfusion complex
- Fractures of lower anterior ribs associated with bowel injury
- Intestinal strictures may develop later
Hollow Viscus Injury

Perforation

- MVA less likely to cause perforation
- Falls on stairs rarely cause bowel perforation
- Perforation-usually near ligament of Treitz: jejunum > duodenum > ileum
- Gastric perforation rare
- Free air seen in only one third of perforations
- Most frequent CT findings with bowel rupture is unexplained free fluid
36 month old abused boy with jejunal perforation. Free air (black arrows) small bowel wall thickening (white arrow) and free fluid.

Hollow Viscus Injury

Hematoma

- Partial thickness tear and subserosal bleeding
- Duodenal hematoma is the most common bowel injury in abuse
- Ultrasound may detect the bowel hematoma- echogenic or hypoechogenic
- UGI series to confirm or follow duodenal hematoma- "coiled spring" appearance, intramural mass or focal mural thickening
- CT- hyper or hypodense mass
Duodenal and jejunal hematomas in a 2 1/2-year-old abused infant with multiple bruises and no history of trauma.

3 year old abused child with chylosus ascites and duodenal hematoma.

2 year old abused infant, elevated transaminases and pancreatic enzymes
Vomiting, diarrhea, bruises on face and abdomen
Duodenal hematoma (arrows)
Edema pancreatic head
21 month old with vomiting and elevated transaminases
Duodenal hematoma
Most common cause of pancreatitis in children is trauma

8.6% of abusive abdominal injuries (Trokel 2006)

Elevated amylase/lipase not reliable indicators of injury and do not correlate with grade of injury

Edema, laceration, hematoma
PANCREAS

- Thin section CT for subtle injuries
- CT findings: pancreatic enlargement, peri-pancreatic fluid, linear or rounded hypodensity in gland, fluid between splenic vein and pancreas, pseudocyst
- Osseous changes due to fat necrosis-lytic bone lesions, lower extremities
24 month old girl with lethargy, abdominal distension and pain. Contrast-opacified loops of bowel (arrow) are interposed between the head and tail of the pancreas (arrowheads). Pancreatic transection

3 year old boy without a history of trauma exhibits a thick wall pseudocyst (c), transection through the pancreatic body (t) and blurring of the peripancreatic fat (arrowheads).

Permeative changes due to pancreatitis
Pancreatic enzymes cause medullary fat necrosis and osteolysis

• Less commonly injured than liver with inflicted injury

• Massive bleeding may cause hypoperfusion complex
ADRENAL

- Adrenal hemorrhage is a marker of significant blunt trauma to the abdomen
- Seen with inflicted injury associated with other visceral injuries
- More common on right
3 month old bruising and elevated transaminases. Right adrenal hematoma, bilateral rib fractures, right liver laceration and periportal tracking.
Right adrenal hemorrhage in 4 month old abused infant

Hyperdense on CT

URINARY TRACT

- Renal injuries less common in abuse
- Use of microscopic hematuria as a screening tool for renal injury is controversial
- Bone scans may detect renal injuries
- Bladder injuries rarely occur - blunt trauma when bladder is full - perforation at dome of bladder
- CT of bladder perforation - unexplained ascites
3 year old abused by babysitter
Large right renal laceration with development of urinomas

Follow-up images

Bone scan- Abnormal tracer accumulation right kidney
4 year old abused child with intraperitoneal bladder rupture. Air-fluid level in bladder and free fluid with no solid organ injury. Stepmother confessed to forcibly pulling child into her knee.

• Rhabdomyolysis from soft tissue injuries can lead to myoglobinuria and acute renal failure
• Dark urine with positive dipstick for blood without significant RBCs
• IV contrast is contraindicated
4 hour delayed film from IVP
Renal failure due to probable myoglobinuria in an abused child

ANOGENITAL INJURIES

- May mimic injuries seen with accidental injury
- Trauma due to foreign bodies and sexual abuse
- Scrotal bruising and hematoma
Forced insertion of battery into vagina of 3 year old girl
Tear in hymen and acid burn on cervix and upper vagina

Courtesy of Dr. Alice Newton
2 month old boy with distal bowel obstruction. Mass in the distal colon (arrows) initially felt to represent stool. At laparotomy, a carrot was found in the descending colon, presumably forcibly inserted into the rectum.

CHYLOUS ASCITES

- May be seen with abuse
- Traumatic disruption of lymphatic drainage
- May be associated with chylothorax, skeletal and other abdominal injuries
Transection neck of pancreas (white arrow) with chylous ascites. Pancreatic duct (black arrow).

CHEST

- Thoracic injuries 3x more common with abuse than accidental injury
- Pulmonary contusion, pneumothorax, hemothorax, rib fractures, chylothorax
- Rib fractures may be absent with significant chest injury due to pliable rib cage in young children
Pulmonary contusion most common injury in children with chest trauma

Non-cardiogenic pulmonary edema due to upper airway obstruction (suffocation) or neurogenic cause (head trauma)

Flail chest in neonate

Foreign bodies forced into airway and aspirated

Vascular injuries rare
3 month old baby-PCP noted crepitus over chest. Multiple bilateral rib fractures and moderate right hemothorax.
CARDIOVASCULAR

- Intracardiac needle
- Traumatic VSD, LV aneurysm
- Commotio cordis (cardiac concussion)-blow to the chest causes dysrhythmia and cardiac arrest
- Vascular injuries rare in abuse
- False aneurysm left gastric artery-mimicked liver mass
- Abdominal aortic transection-one case associated with L2-3 fracture-dislocation
NECK

- Pharyngeal, hypopharyngeal and esophageal perforations-forced insertion of objects, sexual abuse, blunt or penetrating external trauma
- Usually seen in infancy- stridor, respiratory problems
- Subcutaneous emphysema, pneumomediastinum, retropharyngeal abscess
- Foreign body may migrate into mediastinum
3 week old with inflicted hypopharyngeal perforation

2 month old abused infant with extensive cervical and mediastinal emphysema and hypopharyngeal perforation.

Kleinman PK (1998) editor. Diagnostic imaging of child abuse. 2nd ed. Mosby, St. Louis
7 month old
Marble in soft tissues of neck
Perforated esophagus with migration into neck
Forced in mouth by mother
Who Should Be Imaged?

- Significant clinical findings suggesting blunt abdominal trauma- especially young children with abdominal bruising and distension
- Elevated transaminases, gross hematuria, elevated amylase/lipase, and falling hematocrit in the setting of suspected abuse
Who Should Be Imaged?

Screening Tests

- Coant (1992)-49 abused kids without clinical signs of abdominal trauma, 4 had elevated transaminases, 3/4 had liver laceration on CT

- Lindberg et al (2009)-suggest imaging abused children when AST/ALT>80 IU/L or when bruising, distention or tenderness

- Lane et al (2009)-findings support screening with liver and pancreatic enzymes for physically abused children
Who Should Be Imaged?

Selective imaging

- Trout et al (2011) - found CT abdomen positive in only 16% of cases of suspected abuse
- They recommend CT with absent/hypoactive bowel sounds, LFTs greater than twice normal and ≥2 abnormal labs or physical exam findings
- Should CT be performed in children with lower anterior rib fractures?
- Should forensic value be considered?
**Visceral Imaging Approach**

**Abdominal Injury**

- Supine and upright radiographs of the abdomen
- Ultrasound to assess for free abdominal fluid but not adequate to evaluate for visceral injury - may detect duodenal hematoma
- Abdominal CT with IV contrast with delayed images of the bladder (oral contrast optional)
- Pediatric CT protocols should utilize all available dose reduction techniques
Visceral Imaging Approach

Abdominal Injury

- UGI series and/or ultrasound to follow or diagnose suspected duodenal hematoma
- Consider repeat abdominal CT with oral and IV contrast if bowel injury suspected and not seen on prior exam
- Chest CT in selected cases only
- Contrast enhanced ultrasound and whole body MRI may show future promise
Visceral Imaging Approach

*Neck and Chest*

- Neck and chest radiographs
- Non-ionic contrast swallowing study in suspected pharyngeal perforation and/or CT neck with contrast
Conclusions

• Visceral injuries in abused children are relatively uncommon but second only to head trauma as a cause of death with abuse

• When present, visceral injuries are usually multiple and severe

• A delay in seeking care and no history of trauma are typical
Conclusions

- Hepatic injury is the most common visceral injury with abuse; bowel and pancreatic injuries are strongly associated with abuse.
- Imaging should be performed when clinical and/or laboratory findings are suggestive of inflicted visceral injury.
- Documentation of clinically insignificant visceral injury made have significant medico-legal implications.
References


References


