Evidence-based Emergency Department Evaluation of Pediatric Blunt Abdominal Trauma

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Disclosure

• No financial relationships or conflict of interests
Objectives

• Epidemiology of pediatric abdominal trauma
• Clinical evaluation for intra-abdominal injury (IAI)
  – History and physical examination
  – Laboratory testing
• Indications for abdominal CT
  – Prior evidence
  – UC Davis Pilot Study
  – PECARN multicenter study
Case Presentation

• 10 y.o. female slipped off 6 foot fence, landed on right wrist and shoulder
• Difficulty breathing, R wrist and shoulder pain
• Denies LOC, neck, chest, abd, back pain
• Physical Examination
  – Crying but consolable, BP 100/60, HR 90, RR 20
  – Head/neck/chest/back: atraumatic
  – Abdomen: unclear if TTP, but distracted
  – Extremity: right wrist deformity
  – Neuro: GCS 15
Epidemiology of Pediatric Trauma

• Leading cause of death in children > 1 year
  – 70% : Traumatic brain injury
  – 25%: Abdominal and thoracic

• Preventable traumatic deaths/morbidity due to unrecognized and under-treated IAI

• More than 600,000 children with abdominal trauma evaluated in EDs each year
Epidemiology of Pediatric IAI

• Most common mechanisms of injury:
  – MVC, auto vs. pedestrian, falls

• Frequency of injured organs
  – Spleen: 40%
  – Liver: 40%
  – Kidney: 30%
  – Bowel: 15%

• Compared to adults:
  – Larger organs, less abdominal wall protection
  – Pliable chest wall: energy transferred to organs
Epidemiology of Pediatric IAI

• Evaluation particularly difficult in children
  – 20-30% with IAIs have normal abdominal exam
  – Much controversy remains over evaluation

• Limited evidence for clinical decision-making
  – 15-25% of children with abd. trauma undergo CT
  – Fewer than 10% of abdominal CTs demonstrate IAI
  – Few patients with IAI require specific therapy
Controversies in Pediatric IAI

• Reliability of the physical examination
• Role of laboratory tests
• Bedside ultrasound: Utility in children?
• Indications for abdominal CT
  – Abdominal CT is reference standard, but has risks
  – Varying acceptance between specialists in restricting CT for identification of small findings

Sokolove/Kuppermann/Holmes 2012
Patient History and IAI

• Mechanism of injury
• Chest injury and costal margin tenderness associated with missed IAI
• Helpful mechanistic injury patterns
  – MVC with lap belt: bowel and mesenteric injuries
  – Handlebar injury: pancreas and duodenum
  – Abuse: liver and spleen

• Be cognizant of mechanism and ribs!
Handlebar Injury
Abdominal Examination and IAI

• Abdominal tenderness
  – Increased risk of IAI after adjusting for other findings
  – Adjusted odds ratio = 5.8 (95% CI 3.2, 10.4)
  – Approximately 80% of alert trauma patients with IAI present with abdominal tenderness

• Low GCS complicates examination

• **Seat belt injury pattern**: hollow viscus, solid organ, lumbar spine

Seat Belt Sign
Seat Belt Injury

- Injury pattern seen in children > adults
- Flexion over lap belt (even w/shoulder harness)
- GI injuries in particular; lumbar spine fracture
- Prospective study after MVC
  - 46/390 with “Seat Belt Sign”
  - 30% (18-46%) with IAI

Sokolove/Kuppermann/Holmes 2005
Mental Status and IAI

• Decreased level of consciousness
  – Impaired ability to perceive abdominal pain
  – Physical examination unreliable in these patients

• Mental status in patients with IAI
  – GCS < 15 in ~ 45%
  – GCS < 14 in ~ 30%

Laboratory Testing and IAI

• Multiple laboratory tests have been used to screen children for possible IAI
  – AST, ALT, hematocrit, lipase, amylase, HCO3, UA

• Prior studies: conflicting results, limited in design (sample size, retrospective)

• Fundamental question...what is the marginal benefit over physical examination?
Hematuria

• Gross hematuria: 50% with IAI → obtain CT!
• Microscopic hematuria
  – Present in 30-40% of children with IAIs
  – IAI present in ~25% with microscopic hematuria

• Does microscopic hematuria add marginal benefit to examination as a predictor of IAI?
  – Physical exam + > 5 rbc/hpf = Sensitivity of 98.6%
  – Many suggested cutoffs for microscopic hematuria
  – Controversy remains owing to conflicting results

Hematocrit

- *Obtaining hematocrit is routine, but is it useful?*
  - Delay between significant blood loss and hematocrit drop (~2 hrs)
- Hematocrit < 30% significant predictor of IAI
  - Large retrospective study
  - Prospective studies
- Dropping hematocrit levels associated with IAI
  - Unclear if serial hematocrit levels are useful screen for otherwise unsuspected IAI

*Ebert 1941, Taylor 1994, Holmes/Kupfermann 2002*
Transaminases

• Several studies show correlation between elevated AST and ALT and hepatic injuries
• Degree of elevation does not correlate with grade of liver injury
• AST >200 or ALT >125 best predictor of IAI
• ALT > AST in face of liver injury suggests injury > 12 hours old

Holmes/Kuppermann 2002,9; Baxter 2007
Amylase and Lipase

• Used to identify pancreatic/bowel injuries

• Elevated amylase often salivary

• In pancreatic injury, enzymes increase 24 – 48 hours after the injury

• Not a useful predictor of IAI in pediatric trauma patients

Radiologic Imaging in Pediatric Blunt Abdominal Trauma
Abdominal Ultrasound (FAST)
Abdominal Ultrasound in Pediatric Trauma

• Rapid evaluation at patient bedside
  – Hemoperitoneum (FAST examination)
  – Solid organ injury and hemoperitoneum

• Frequently used in evaluation of adult trauma

• Less frequently performed in pediatric trauma
  – <15% in recent PECARN observational study
Abdominal Ultrasound in Pediatric Trauma

• Not as sensitive as CT for IAI

• Meta-analysis of pediatric trauma studies
  – Sensitivity for hemoperitoneum: 80% (76-84%)
  – Sensitivity for all IAI: 66% (56-75%)
  – LR (+): 14.5 and LR (-): 0.36

• Clinical utility unclear in pediatric trauma (RCT currently ongoing...)

Holmes 2007
Abdominal Ultrasound in Pediatric Trauma

• May allow risk stratification for CT scan
  – Best performance in hypotensive children
  – Negative FAST exam *may* decrease abdominal CT in children at low risk (<10%) for IAI

• Clinical implications unclear in children at substantial risk for IAI
  – Ultrasound (+) → Abdominal CT
  – Ultrasound (-) → Abdominal CT

*Menaker/Kuppermann/Holmes, 2001, 2012*
Abdominal Ultrasound in Pediatric Trauma

*Ultrasound should not replace CT, and may or may not confer benefit in initial evaluation*

**Arguments against:**
- Insufficient sensitivity
- Most IAlS managed non-operatively
- False sense of security
- “Over-triage” to the OR

**Arguments for:**
- Sensitive in unstable pts
- Bedside availability
- May decrease CT use in low risk patients
- “Risk stratification”/CT prioritization
CT for Pediatric Trauma

• Gold standard for diagnosis of IAI
  – Excellent sensitivity for solid organ injuries
  – IV contrast needed, but not oral contrast

• Drawbacks and Risks
  – Pharmacological sedation
  – Transfer outside the ED
  – Costs
  – Radiation exposure (500x that of CXR)
What’s the current evidence in children?

• No single-center study has identified criteria that identify all IAIs with great confidence
• Most pediatric studies small, retrospective, not adjusted for all important variables
• More recent data starting to clarify best approach... *multicenter data was needed!*
Indications for Abdominal CT

• Prospective observational study of 1,095 children to derive a clinical prediction rule
  – 107 with IAI
• Explicit entry criteria, age <16 years
• 664 with definitive diagnostic tests and remainder with clinical (telephone) follow-up
• Performance of decision instrument:
  – Sensitivity: 98% (95% 93, 100%)
  – NPV: 99.6% (95% 99, 100%)
Indications for Abdominal CT

• Variables in the Clinical Prediction Rule:
  – Low systolic blood pressure
  – Abdominal tenderness
  – Femur fracture
  – Elevated liver enzymes:
    • AST > 200 U/L or ALT > 125 U/L
  – Urinalysis > 5 rbc/hpf
  – Initial hematocrit < 30%
Validation of Clinical Prediction Rule

• Prospective, observational study of 1324 children to validate the prediction rule
• Children < 18 years, all imaged with CT
• ED physician documented patient history and physical examination before CT scan
• 157 (14%) with IAI

Holmes/Kuppermann 2009
Validation of Clinical Prediction Rule

- Sensitivity: 95% (95% CI 90, 98%)
- Specificity: 37% (95% CI 34, 40%)
- PPV: 20% (95% CI 17, 23%)
- NPV: 98% (95% CI 96, 99%)
- 8 missed pts; 1 non-therapeutic laparotomy (serosal tear and mesenteric hematoma)

The prediction rule requires further refinement/validation in multicenter setting...

Holmes/Kuppermann 2009
PECARN Clinical Prediction Rule

• Prospective multicenter study 2007 - 2010
  – < 18 years with blunt abdominal trauma
  – Clinical data recorded before abd CT (if done)
  – Follow-up obtained on all patients:
    • Discharged patient: Telephone follow-up
    • Admitted patients: medical record review

• Primary outcome: IAI requiring therapy (IAI\text{AI})
  – Recursive partitioning analysis
  – 761 (6.3%) with IAI and 203 (1.7%) with IAI\text{AI}
Prediction Rule for IAI\textsuperscript{Al} (n=12,044)

Abdominal wall trauma
  No
  Abdomen tender
    No
    Thoracic trauma
      No
      Abdominal pain
        No
        ↓ Breath sounds
          No
          Emesis
            No
            1,963 patients
              112 (5.7%) IAI\textsuperscript{Al}
            826 patients
              38 (4.6%) IAI\textsuperscript{Al}
            2,532 patients
              36 (1.4%) IAI\textsuperscript{Al}
            955 patients
              6 (0.6%) IAI\textsuperscript{Al}
          305 patients
            2 (0.7%) IAI\textsuperscript{Al}
          34 patients
            1 (2.9%) IAI\textsuperscript{Al}
          395 patients
            2 (0.5%) IAI\textsuperscript{Al}
      5,034 patients
        6 (0.1%) IAI\textsuperscript{Al}
  1,234 CT scans (25%)
### PECARN Prediction Rule for IAI<sup>AI</sup>

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>%, (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>197 / 203</td>
<td>97.0% (93.7, 98.9%)</td>
</tr>
<tr>
<td>Specificity</td>
<td>5,028 / 11,841</td>
<td>42.5% (41.6, 43.4%)</td>
</tr>
<tr>
<td>NPV</td>
<td>5,028 / 5,034</td>
<td>99.9% (99.7, 100%)</td>
</tr>
<tr>
<td>PPV</td>
<td>197 / 7,010</td>
<td>2.8% (2.4, 3.2%)</td>
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<tr>
<td>LR (-)</td>
<td>0.07</td>
<td>(0.03, 0.15)</td>
</tr>
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## IAI<sup>AI</sup> Not Identified by the Rule

<table>
<thead>
<tr>
<th>Age</th>
<th>Mech</th>
<th>Clinical</th>
<th>Injury</th>
<th>Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td>2yr</td>
<td>Auto-Ped</td>
<td>Hematuria</td>
<td>Renal</td>
<td>Blood Rx</td>
</tr>
<tr>
<td>2yr</td>
<td>Fall</td>
<td>↑ LFTs</td>
<td>Liver, GI</td>
<td>IV fluid</td>
</tr>
<tr>
<td>16yr</td>
<td>MCA†</td>
<td>Femur Fx, hematuria</td>
<td>Spleen, GI</td>
<td>Angio</td>
</tr>
<tr>
<td>17yr</td>
<td>MVC</td>
<td>ETOH, hematuria</td>
<td>Spleen, Renal</td>
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<td>Angio</td>
</tr>
<tr>
<td>17yr</td>
<td>MVC</td>
<td>ETOH, thorax tenderness</td>
<td>Spleen</td>
<td>Angio</td>
</tr>
</tbody>
</table>
Back to our Case...

• 10 y.o. female slipped off 6 foot fence, landed on right wrist and shoulder
• Difficulty breathing, R wrist and shoulder pain
• Physical Examination
  – Crying but consolable, BP 100/60, HR 90, RR 20
  – Head/neck/chest/back: atraumatic
  – Abdomen: unclear if TTP, but distracted
  – Extremity: right wrist deformity
  – Neuro: GCS 15
Labs and Radiology

- Hematocrit: 34%
- Urinalysis: no hematuria
- ALT: 250 U/L
- CXR: normal
- Right shoulder: normal
- Right wrist: angulated ulna/radius fracture
Summary

• High risk physical examination findings for IAI
  – Low GCS: unable to evaluate if at risk for IAI
  – Abdominal wall trauma: contusion/abrasion/seat belt sign
  – Abdominal tenderness

• High risk laboratory findings for IAI
  – Elevated AST/ALT
  – Hematuria: especially gross hematuria
  – Low hematocrit: <30%
Summary

• Exact role of abdominal ultrasound (FAST) unclear in children
  – Use if hypotensive to direct management
  – May risk stratify children for CT scan
  – May obviate CT scan in low risk children

• Abdominal CT is reference standard for IAI
  – Use in children with high risk findings
  – Use in evidence-based fashion for all others, and be cognizant of radiation risks