BEST-EVIDENCE APPROACH TO IMAGING PEDIATRIC BLUNT ABDOMINAL TRAUMA

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Objectives

• At the completion of this discussion, the participants will:

1. Recognize and describe the common mechanisms of pediatric trauma and the associated injuries
2. Identify the utility of plain radiography in the assessment of pediatric patients with blunt abdominal trauma (BAT)
3. Recognize the role of FAST ultrasound in the management of BAT in the pediatric population
4. Evaluate the role of CT in the assessment and management of BAT in the pediatric population
Pediatric Trauma

• “If a disease were killing our children in the proportions that injuries are, people would be outraged and demand that this killer be stopped”

- C. Everett Koop
  Former Surgeon General of United States
Pediatric Trauma

- Injury accounts for more pediatric deaths each year than all other causes combined in children ages 18 and younger
- Annual cost of pediatric trauma estimated $130 billion, with $25 billion due to direct medical cost
- 16% of unintentional injuries result in permanent disability
- Leading overall cause of death → Transportation-related

Duchossois et al. Injury Prevention, Pediatric Surgery, 7th
Pediatric Trauma

• Patterns of Blunt Injury

1. Thoracic – injury to thoracic structures occur in 25% of children presenting to Level I centers
   • Most commonly high-energy blunt trauma (86%)
   • Highly variable injury pattern (minor to severe)
     • Rib/sternum fracture (26%), pneumothorax/hemothorax (26%), lung (44%), other (4%)

2. Abdominal – 30% more common than thoracic injury, but 40% less likely to be fatal.
   • 25% of injured children require operative intervention
   • Injury pattern – liver/spleen (60%), duodenum/pancreas (< 10%), stomach/SB/Colon (2 – 10%)

Stylianos et al. Abdominal Trauma, In Pediatric Surgery, 7th Ed.
Triaging Pediatric Trauma Imaging

• The devil is in the details...or more importantly the trauma history and physical findings
  • Mechanism of injury, age, clinical status, physical findings should dictate selection of imaging modalities in the evaluation of the acutely injured child.

• We should be influenced less by protocol, and more by common sense
  • Selecting appropriate imaging should fulfill 4 criteria:
    1. Will it identify the injury?
    2. Will it help exclude an injury?
    3. Is it necessary for anticipated therapy?
    4. Will it delay appropriate therapy?

  Tepas et al. Pediatric Trauma, 2004
Pediatric Trauma

Buckle Up
Next Million Miles
Blunt Trauma
Blunt Trauma
Triaging Pediatric Imaging

• What imaging modalities are available?
  1. Plain x-ray chest, abdomen and pelvis
  2. FAST ultrasound
  3. Computer Tomography

• What considerations are there to imaging?
  • Available
  • Appropriate
  • Expertise/Experience
  • Necessary
Plain Radiography

• BAT
  • Readily accessible
  • Rapid
    • Can be done coincident with primary survey without interrupting resuscitation
    • Directs priority of subsequent imaging/therapy
  • Minimal risk – does not require excessive manipulation/transport of patient
  • Radiation risk - negligible
    • CXR = 0.06 mSv
    • Abdomen = 0.7 mSv
    • Pelvis = 0.7 mSv

American College of Radiologist, 2014.
CXR

- Easy decision making
  - Needs very little additional investigation
- Needs:
  - Complete primary + secondary assessment – avoid trauma frenzy
  - Blood products
  - Broad spectrum Abx
  - CT Abd/Pelvis (stable)
    - Depends on mechanism
    - Evaluate vascular structures, retroperitoneal, solid organs.
- OR!
AXR
AXR

- Critical Findings:
  - Abdominal wall contusion (seatbelt sign)
  - Chance fracture

- Patients with findings are 232 times more likely to have significant intra-abdominal injury than those without bruise
  - If present, great consideration should be given to follow-up CT
The role of focused abdominal sonography for trauma (FAST) in pediatric trauma evaluation

Eric R. Scaife a,*, Michael D. Rollins a, Douglas C. Barnhart a, Earl C. Downey a, Richard E. Black a, Rebecka L. Meyers a, Mark H. Stevens a, Sasha Gordon b, Jeffrey S. Prince b, Deborah Battaglia c, Stephen J. Fenton a, Jennifer Plumb d, Ryan R. Metzger a

- 183 Children with BAT
  - 128 underwent FAST
  - Completely reported in 88 cases
  - 48% (42/88 cases) surgeon decided to cancel CT
    - 1 of 42 (2.3%) cases had a positive FAST
      - Patient was hypotensive in the ED, underwent resuscitation followed by CT, then OR
      - Utility of FAST given clinical findings?
    - 41 of 42 (97.6%) cases FAST was negative
      - Surgeon cancelled CT in 13 patients based upon history, physical and FAST
      - Of the remaining 27 cases, where CT would have been cancelled, FAST had a 15% false-negative.

Scaife et al. JPS, 2013
Critical Points

• Three characteristics separated cases where CT would have been cancelled from those where it was not cancelled

• CT would have been erroneously cancelled:
  1. Younger
  2. Lower ISS
  3. Lower Abdominal Injury severity scores

• Can FAST help identify injuries of significance (ie: need laparotomy or transfusion)
  • Of 88 patients, 8 (9%) had significant injury, all received transfusion, 3 had surgery (all had positive FAST)
    • Of remaining 5 with significant injury, 4 had NEGATIVE FAST

Conclusions: True positive FAST exams are uncommon and would rarely direct management. While the negative FAST would have potentially reduced CT use due to practitioner reassurance, this reassurance may be unwarranted given the test’s sensitivity.

Scaife et al. JPS, 2013
Computer Tomography

- Tremendous attention has been devoted to quantify the risk of CT scanning in children based upon radiation exposure.

- Problem in Pediatrics:
  - Dosing is not organ specific
  - Dosing is not individual specific, rather provides a relative radiation dose
  - There are no gender or age scaling factors for effective dose determination
    - Reason why the rule of thumb for cancer risk of 5% per Sievert for whole body radiation does not apply to children
      - Adjustments are neither available nor applied.
    - Doses are often higher in younger children
      - Abdomen/Pelvis = 6 – 10 mSv
      - 64-slice scanner (maximized) of abdo/pelvis can exceed 110 mSv in a 5-year old

Frush. Pediatric Radiology, 2011; 41(2)
CT in Pediatric Trauma

• Epidemiological data suggests that 10 – 50 mSv for an acute exposure is sufficient to increase the risk of cancer
  • This exposure represents an excess of 0.29% over the total number of patients who eventually die from cancer in their lifetime.
  • If one assumes a 5% per Sievert risk of cancer, then 10 mSv would result in a 0.05% risk of cancer
    • Note – NOT adjusted for pediatric population
    • “No consistent association has been observed for diagnostic radiation exposure and risk of childhood lymphoma, osteosarcoma, Ewing sarcoma, or neuroblastoma”

CT in Pediatric Trauma

• Bottom Line:
  • Given the available data, we should not withhold appropriate CT imaging in pediatric BAT

• What is appropriate?
Blunt Abdominal Trauma
CONCLUSION: Use of a prediction model based on high-risk variables for IAI may decrease cost and radiation exposure by reducing the number of abdominal CT scans in children being evaluated for blunt abdominal trauma. (J Trauma Acute Care Surg. 2012;73:371–376. Copyright © 2012 by Lippincott Williams & Wilkins)
Diagnostic accuracy of a step-up imaging strategy in pediatric patients with blunt abdominal trauma

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\textit{Conclusion:} The step-up imaging strategy that is applied in our academic level 1 trauma centre has a high sensitivity and a high negative predictive value. No clinically relevant injuries were missed without doing unnecessary harm, e.g. radiation or an intervention.

European J Radiology, 2014. 83: 204
Study Findings

• Results:
  • 122 patients included
    • 48 (39%) patients diagnosed with abdominal injuries
      • Spleen (22%), liver (17%), kidney (14%)
  • All patients underwent FAST
    • 69% of HD stable patients had free fluid
      • CT demonstrated injury in 89%
        • 20% additional burden of injury pick up with CT scan
      • 4% had negative FAST, but followed up with CT scan
        • 50% had major injury on CT
  • Not clear from paper in HD population why deviation from FAST protocol to CT
  • Given prior literature, decision to CT still based on clinical criteria
  • 20% deviation from protocol, where CT performed despite FAST findings
    • 73% of violations demonstrated significant findings in CT (perforation, free-fluid, organ laceration).
      • Interestingly, HD unstable patient (n=1) also violation.
        • Despite positive FAST, and need for ongoing resuscitation, patient had CT
Paediatric blunt abdominal trauma – are we doing too many computed tomography scans?

M Arnold, S W Moore

Table 1. Imaging modalities employed to evaluate abdominal injuries in paediatric patients with MVA/PVA-related BAT

<table>
<thead>
<tr>
<th>Time periods and imaging modalities</th>
<th>Pre-trauma unit CT (group 1), N=66</th>
<th>Post-introduction trauma unit CT (group 2), N=37</th>
<th>Prior paediatric surgical review for CT (group 3), N=14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal imaging, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AXR</td>
<td>3 (4.5)</td>
<td>0 (0)</td>
<td>2 (14.3)</td>
</tr>
<tr>
<td>US abdomen</td>
<td>22 (33.3)</td>
<td>1 (2.7)</td>
<td>1 (7.1)</td>
</tr>
<tr>
<td>US only</td>
<td>9/22 (40.9)</td>
<td>1 (2.7)</td>
<td>1 (7.1)</td>
</tr>
<tr>
<td>CT abdomen</td>
<td>48 (72.7)</td>
<td>36 (97.3)</td>
<td>13 (92.9)</td>
</tr>
<tr>
<td>US &amp; CT abdomen</td>
<td>11/22 (50.0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>CT brain</td>
<td>16 (24.2)</td>
<td>6 (16.2)</td>
<td>11 (78.6%)</td>
</tr>
</tbody>
</table>

MVA = motor vehicle accident; PVA = pedestrian-vehicle accident; BAT = blunt abdominal trauma; CT = computed tomography; AXR = abdominal radiograph; US = ultrasound.

Results. There were 66 patients in group 1 and 37 in group 2. An apparent increase in CT use with increased availability was accompanied by a marked increase in negative CT scans (38.9% compared with 6.2%; p<0.006). Despite a slightly higher prevalence of associated injuries in group 2, as well as a slightly longer length of hospital stay, there was a similar prevalence of intra-abdominal injuries detected in positive scans in the two groups. In addition, rates of small-bowel perforation in the two groups were similar. The rate of negative scans in group 3 was 46.2% (6/13), but all except one of these patients had a severe brain injury preventing adequate clinical evaluation of intra-abdominal injury.

Conclusion. CT scanning for blunt abdominal trauma in children is essential in the presence of appropriate clinical indications. Ease of access probably increases availability, but the rate of negative scans may increase. Management guidelines should be in place to direct CT scanning to cases in which clinical examination and/or other modalities indicate a likelihood of intra-abdominal injury. The principle of ‘as low (radiation) dose as reasonably achievable’ (ALARA) should be adhered to because of the increased radiation exposure risks in children.
Study Summary

- The availability of CT drives utilization
  - Rate of negative CT scans increased with introduction of CT
    - 38.9% vs. 6.2%
    - Higher incidence of injuries observed after intro of CT
    - Abdominal CT underlies the success of selective non-operative management, with negative predictive value exceeding 99%
    - Decisions regarding emergency surgical intervention are based primarily on clinical grounds, not radiological findings
**Indications to consider primary abdominal CT**

- Significant abdominal tenderness as evidenced by verbal report, facial expression, pulse rate response, etc. N.B.: Repeat examination as necessary for confirmation where equivocal due to other painful injuries or in young, frightened children

- Hypotensive on admission with sustained stabilisation after fluid resuscitation

- Abdominal distension (re-evaluate after insertion of nasogastric tube and urinary catheter)

- Abdominal tenderness with significant ecchymosis and abrasions, e.g. seatbelt sign

- Abdominal signs and suspicion of non-accidental injury (important to document for medicolegal reasons)

- Abdominal signs with known bleeding dyscrasia, splenomegaly (high risk for splenic rupture)

- Macroscopic haematuria

- Polytrauma including significant trauma above and below abdomen, Chance fracture, head or spinal injury, etc. precluding reliable examination of abdomen and increasing risk of associated intra-abdominal injury
Conclusion
Although we strongly support the use of CT scanning in children with BAT where clinically indicated, we feel that it should be limited to patients with agreed clinical indications.

Secondly, in order to decrease radiation exposure to children with BAT, CT should not be relied on as the first-line imaging modality exclusively, but should rather be used for greater anatomical accuracy where clinical examination and/or other modalities indicate likely intra-abdominal pathology.

Thirdly, when CT is required, the machine settings should be adjusted to allow ‘as low (radiation dose) as reasonably achievable’ (ALARA) to minimise radiation risks.
Summary

• Plain x-rays:
  • available, quick, do not interfere with resuscitation, are safe (very low radiation), may direct subsequent therapy
  • Good first-line screen

• FAST:
  • Rapid, demands expertise, volume is everything, reasonable in HD stable
  • MUST recognize limitations, should not replace good clinical judgment and the value of repeated clinical examination
  • Current evidence does not support routine use in pediatric BAT

• CT:
  • Availability drives utilization, not without risk (radiation), patient vulnerable while in scan, may miss injuries
  • Should never replace sound clinical assessment and judgment
THANK YOU

Questions?