Update on Child Abuse Imaging

Jeannette M. Perez-Rossello, MD
Department of Radiology
Boston Children’s Hospital
Harvard Medical School
Overview

• Multimodality Imaging
  – Skeletal Survey
  – Bone Scintigraphy F-18 PET
  – CT and 3-D models
  – MRI and Whole Body MRI

• Uncommon Fractures
  – Hands and Feet
  – Scapula
  – Spine
  – Pelvis

• Can we decrease the number of images in the skeletal survey?
Skeletal Survey - ACR Standards

- Cone to anatomic region
- Injuries viewed in at least two planes
- Adequate spatial resolution
- High signal to noise, sufficient mAs (dose)
- Low kVp 50-70 for high contrast
- Oblique views of the chest (2011)

Follow-Up Skeletal Survey

Adds information in 15-60% cases
Role of Bone Scan

- Screening child 2-5 years of age or in SPICA cast
- High suspicion of abuse but the SS is equivocal or normal
- Suspect poor compliance with F/U-SS

F-18 NaF PET

- Higher resolution
- Multiplanar imaging
- Rapid scanning after agent administration
- Dose comparable to $^{99m}Tc$ MDP
  - Effective dose 3 mSv for 10 kg patient
- Dose 10x higher than skeletal survey
- Requires sedation

F-18 has better sensitivity than skeletal survey for all fractures and chest/posterior rib fractures (SS:152 vs F-18:200)

Role of CT

• Better visualization of rib fractures
• Characterize complex fractures
• Evaluation of solid organ injury

Role of MRI

- Soft tissue injury
  - Joint effusions
  - Intramuscular hematomas
  - Subcutaneous edema
  - Solid organ injury
- Salter II/Epiphyseal separation
- Vertebral body fractures

Whole Body MRI

- WB-MRI insensitive to the high specificity indicators of abuse, namely CMLs and rib fractures, and currently cannot replace the skeletal survey

Perez-Rossello. AJR 2010;195:744-750
Can We Decrease the Number of Images in the Skeletal Survey?
The Prevalence of Uncommon Fractures on Skeletal Surveys Performed to Evaluate for Suspected Abuse in 930 Children: Should Practice Guidelines Change?

Boaz Karmazyn1,2
Max E. Lewis3
S. Gregory Jennings2
Roberta A. Hibbard4
Ralph A. Hicks4

OBJECTIVE. The objective of our study was to evaluate the prevalence and site of fractures detected on skeletal surveys performed for suspected child abuse at a tertiary children’s hospital and to determine whether any survey images may be eliminated without affecting clinical care or the ability to make a diagnosis.

MATERIALS AND METHODS. We identified all skeletal surveys performed for suspected abuse from 2003 to 2009 of children younger than 2 years. Repeated studies were excluded, as were studies not performed to evaluate for suspected abuse. From the reports, we documented the sites of all the fractures.

RESULTS. Nine hundred thirty children (515 boys and 415 girls) with a median age of 6 months met the entry criteria for the study. Fractures were detected in 317 children (34%), of whom 166 (18%) had multiple fractures. The most common sites for fractures were the long bones (21%), ribs (10%), skull (7%), and clavicle (2%). Ten children (1%) had fractures in the spine (n = 3), pelvis (n = 1), hands (n = 6), and feet (n = 2). All 10 children had other signs of physical abuse.

CONCLUSION. In skeletal surveys performed for suspected child abuse, fractures limited to sites other than the long bones, ribs, skull, and clavicles are rare. The additional radiation exposure and cost of obtaining radiographs of the spine, pelvis, hands, and feet may outweigh their potential benefit. Given the rarity of fractures of the spine, pelvis, hands, and feet, consideration may be given to eliminating those views from routine skeletal surveys performed to evaluate for suspected child abuse.
Prevalence of Uncommon Fractures

• Among positive skeletal surveys
  – Lindberg (1): 10% hands, feet, spine, pelvis
  – Kleinman (2): 10% hands, feet, spine

<table>
<thead>
<tr>
<th>Body Region</th>
<th>All Initial Skeletal Surveys (n=365)</th>
<th>Positive Skeletal Surveys (n=225)</th>
<th>Skeletal Surveys With &gt; 1 Fracture (n=98)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spine</td>
<td>2.7 (10)</td>
<td>4.4 (10)</td>
<td>10.2 (10)</td>
</tr>
<tr>
<td>Hands</td>
<td>1.4 (5)</td>
<td>2.2 (5)</td>
<td>5.1 (5)</td>
</tr>
<tr>
<td>Feet</td>
<td>1.6 (6)</td>
<td>2.7 (6)</td>
<td>6.1 (6)</td>
</tr>
</tbody>
</table>

• Pelvic fractures are rare (1,3)

1. Lindberg. Pediatr Emer Care (2013);29:26-9
2. Kleinman. AJR (2013);200:641-644
Vertebral Fractures

Spinal fractures carry significantly greater risk of intracranial injury

- Children with spinal fractures = 71% AHT
- Positive SS and no spinal fractures = 33% AHT
- $p<0.05$, OR 5.5; 95% (CI 1.6-18.8)

Barber Martinez de la Torre. Ped Rad (2013); in press
Hands and Feet

- Radiation less than 5% of the skeletal survey radiation exposure
- Acquisition time minimal, cost of SS unaffected
- Potentially no effect on medical diagnosis; may affect legal outcome

Pelvis

- In the initial skeletal survey it provides a view of the abdomen, frontal view of the lumbosacral spine, additional views of the lower ribs and the proximal femurs
Follow-up skeletal surveys for nonaccidental trauma: can a more limited survey be performed?

Susan R. Harlan • G. William Nixon • Kristine A. Campbell • Karen Hansen • Jeffrey S. Prince

Routine Protocol

- Initial: 21 views
- Follow-up: 17 views
- New information in 37%

Limited 15-Views

1. AP bilateral oblique chest
2. AP humeri
3. AP forearms
4. AP hands
5. AP femurs
6. AP tib/fib
7. AP feet

No pelvis or lateral spine

Harper. Pediatrics (2013);131:e672-8
Take Home Points

• Multimodality imaging
  – High detail skeletal survey/ACR
  – Bone scintigraphy with F-18 PET
  – MR and CT for problematic cases.
  – Don’t forget US!

• Medical diagnosis does not insure medico-legal diagnosis/outcome
  – All injuries should be documented
  – Hands, feet and spine fractures are not ‘uncommon’ among patients with positive skeletal surveys
  – Vertebral body fractures carry a significant risk of intracranial injury
  – Fracture of the hands and feet may carry a special significance in court

• Multicenter studies are needed to determine if the initial and follow-up skeletal surveys can be performed with less images
  – Possibly eliminate AP pelvis and lateral views of the spine in the follow-up skeletal survey