Hasbro Children’s Hospital
In conjunction with
University Surgical Associates, Inc.

Pediatric Trauma Symposium
“Changing Trends in Trauma Care”

November 13, 2014

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Objectives

• Describe the imaging modalities available to image the pediatric trauma patient.
• Describe the ALARA principle and the risks of CT in pediatric patients.
• Identify appropriate imaging algorithm for imaging pediatric cervical spine trauma.
Take Home Points

• Every imaging modality has advantages and disadvantages.
• Plain radiography and CT are the modalities of choice for the pediatric trauma patient.
• Potential benefits of appropriate imaging in pediatric trauma patient exceed the risks of radiation.
• Pedi C-spine: radiographs first, not CT.
• When in doubt, talk to your radiologist.
Trauma

• 600,000 trauma-related pediatric hospital admissions annually in the U.S.
• Traumatic injuries can be difficult to diagnose by physical exam alone.
• Prompt and appropriate imaging can prevent significant morbidity and mortality of pediatric trauma patients.
Imaging Menu

- Radiography
- Ultrasound
- Fluoroscopy
- Computed Tomography
- Magnetic Resonance Imaging
Radiography

• Advantages;
  – Highest spatial resolution.
  – Excellent evaluation of osseous structures.
  – Fast.
  – Portable.
  – Inexpensive.
Radiography

• Disadvantages;
  – Limited soft tissue contrast.
  – Ionizing radiation.
Ultrasonography

Two types in setting of trauma:

1. Diagnostic US

2. F.A.S.T.= Focused Abdominal Sonogram for Trauma

- Assessment for intraperitoneal fluid.
- Replaced peritoneal lavage.
Ultrasonography

• Advantages
  – Portable
  – No ionizing radiation
  – Less expensive than CT or MRI
Ultrasonography

• Problems
  – Availability
  – Time
  – Low sensitivity and specificity for detecting visceral injuries and hemoperitoneum.
  – US does not adequately evaluate osseous structures, retroperitoneum, gas containing structures (bowel and lung) and mediastinum.
  – Operator Dependent
Ultrasonography

- Low sensitivity and specificity for detecting visceral injuries and hemoperitoneum.
- Missed 12/32 splenic injuries.
- 1/3 of visceral injuries do not have hemoperitoneum

- Presently, US is not recommended to exclude traumatic injury.*

* Minimal controversy and there is ongoing research esp. contrast enhanced US.
Fluoroscopy

- Real time “continuous” evaluation with x-rays.
- Usually following ingestion or injection of contrast medium into an orifice or blood vessel.
- Rarely used in trauma patients.
- Mentioned only for completeness.
Computed Tomography (CT)

• Advantages;
  – Excellent soft tissue contrast resolution.
  – Readily available.
  – Fast.
  – High sensitivity and specificity.
  – Multiplanar reformats.
  – Excellent evaluation of all tissues except spinal cord and ligament/tendon trauma.
Computed Tomography

• *Its advantages render it the imaging modality of choice to assess traumatic injury of the head, face, neck, abdomen and pelvis.*

• *** Could be on the “test”.*
• One of the keys to a successful chest or abdomen/pelvis trauma CT is infusion rate of IV contrast.
• This is dramatically influenced by the caliber of the IV in place. The ideal IV line for CT is an 18g in the right antecubital fossa.

• Please place larger catheters whenever possible. *(Bernoulli’s Principle)*
Magnetic Resonance Imaging (MRI)

- Uses non-ionizing radiation.
- No known deleterious effects.
- Some studies suggest it is equivalent to CT for evaluation of traumatic injuries.
- Excellent soft tissue contrast.
- Imaging modality of choice for spinal cord injury.
MRI

Disadvantages

- Longer image acquisition time
- Sedation (< 7 years, developmental delay, agitation)
- High magnetic field limits supportive equipment and ability to monitor and resuscitate patients
- Limited availability
- Expensive
- Limited evaluation of cortical bone/fractures
Ionizing Radiation

- X-rays from plain radiography, CT, and fluoroscopy are a form of ionizing radiation.
- X-rays can have deleterious effects.
  - Burns
  - Cancer
  - Alopecia
  - Birth defects

ALARA = As Low As Reasonably Achievable
• Children are more sensitive to radiation exposure than adults.
  – Inherently more radiosensitive. (esp. thyroid, breast tissue, gonads)
  – Longer life expectancy over which to express the radiation induced damage to genes.
  – Girls are slightly more sensitive than boys.
• US, MRI and the decision not to obtain imaging expose the child to the same amount of ionizing radiation: None.
• Radiography exposes children to relatively low doses of ionizing radiation.
• CT exposes children to the greatest amount of ionizing radiation in medical imaging.
• The possibility of a deleterious effect from medical radiation is very small.

ALARA = As Low As Reasonably Achievable
• One year of natural background radiation exposure is similar dose as 30 chest radiographs.

• Transcontinental flight on a commercial airliner exposes child to same dose of radiation as 2 chest radiographs.

• On our Hasbro CT scanner (iterative reconstruction algorithm), CT of the chest is the same radiation dose as 6 chest radiographs.

ALARA = As Low As Reasonably Achievable
Important Principles

- ALARA
- Risk vs. Benefit
- The Bottom Line

$ALARA = \text{As Low As Reasonably Achievable}$
• **As Low As Reasonably Achievable**
  – American College of Radiology tenet on radiation dose/exposure.
  – All medical professionals must strive toward this goal when caring for all patients, but especially children.

*** Could be on the “test”. **
How do we keep radiation exposure ALARA?

**Clinicians**
- Request imaging only when necessary.*
  - **Area of ongoing research**
- Request the appropriate exam.
- *Communicate with your pediatric radiologist.*

**Radiologists**
- Ensure imaging is necessary.
- Ensure that the appropriate exam is requested.
- Suggest appropriate alternative modalities (ex. MRI for C-spine).
- *Communicate with the requesting clinician.*
- Adjust imaging parameters to keep radiation exposure low, but maintain diagnostic image quality.

ALARA = As Low As Reasonably Achievable
The Transferred Patient

• Many children with traumatic injuries arrive at Hasbro Children’s Hospital for treatment having already received diagnostic imaging at an outside institution.

• The CD’s or films that accompany them are crucially important. If these get lost, it can result in repeated diagnostic imaging, unnecessary radiation exposure and delayed diagnosis.

• Please help prevent misplacement of these exams.
Risk vs. Benefit

While x-rays (plain radiography and CT) increase the risk of deleterious effects such as cancer, the potential benefit from the clinically necessary imaging study dramatically outweighs this risk.

ALARA = As Low As Reasonably Achievable
The possibility for traumatic injury must dictate the need for radiation-based medical imaging as the risk from exposure to ionizing radiation associated with radiological examinations is low. Nevertheless, it is still advisable to avoid such exposure where possible.
Resources


• ImageGently.com
Cervical Spine Imaging

• Controversial Topic.

• No accepted consensus.
Another problem

• Cervical spine trauma can involve osseous, ligamentous, capsular, vascular and neural structures.

• No one imaging modality can evaluate injury to all these tissues.
  – Radiographs and/or CT for osseous structures.
  – MRI for ligamentous, capsular and neural structures.
  – CTA/MRA for vascular injury.
Cervical Spine Imaging in Pediatric Trauma Patients

• Imaging algorithm varies by age, institution, superstition, etc.
• Guidelines for imaging exist, but they vary by institution, association, etc.
• Literature on pediatric cervical spine imaging remains sparse.
Pediatric Cervical Spine Imaging

- Controversy in pediatric imaging is secondary to desire to exclude/identify cervical spine trauma versus maintaining radiation exposure (and cost) As Low As Reasonably Achievable (ALARA).
- Most recommendations are based on adults.
- Given the controversy and variability, we’ll review what the American College of Radiology recommends and what I think.
What do I propose?

Cervical Spine Injury Suspected

Plain radiographs first

Tailored cervical spine CT and/or cervical spine MRI as needed

?????: If abnormality present or questioned abnormality.

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References

• American College of Radiology Appropriateness Criteria
• Children’s Hospital Boston Clinical Practice Guidelines
• Keenan et al. “Using CT of the cervical spine for early evaluation of pediatric patients with head trauma.” *AJR* 2001; 177: 1405-1409.
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