Assessing the Pediatric Trauma Patient – What imaging is enough

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Objectives

- Describe the appropriate imaging of the pediatric trauma patient
- Evaluate the risks of certain imaging modalities and establish criteria for imaging decision making
- Discuss the likelihood of pediatric spine injuries and the need for imaging
- List different modalities for abdominal evaluation of the pediatric trauma patient
Case #1

- 11 YO female who was trying to go from one fort to another via a zip line and her hand slipped and she fell 18 feet to the ground.
- She landed on her feet and crumpled to the ground.
- She denies hitting her head, denies loss of consciousness. Remembers the entire accident.
- Her only complaint is left ankle pain.
Case #1

- She was evaluated at outside institution and had
  - CT of head – negative
  - CT of C-spine – negative
  - CT of T-spine – negative
  - CT of L-spine – negative
  - CT of abdomen – negative
- No plain films obtained
- What are the consequences of all of these studies?
## Radiation Exposure in X-rays

<table>
<thead>
<tr>
<th>Study Ordered</th>
<th>Equivalent dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT head</td>
<td>20 CXR</td>
</tr>
<tr>
<td>CT C-Spine</td>
<td>60 CXR</td>
</tr>
<tr>
<td>CT Chest</td>
<td>70 CXR</td>
</tr>
<tr>
<td>CT Abdomen/Pelvis</td>
<td>100 CXR</td>
</tr>
<tr>
<td>C-Spine Series</td>
<td>15 CXR</td>
</tr>
</tbody>
</table>
## Background Radiation

<table>
<thead>
<tr>
<th>Study</th>
<th>Background radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CXR</td>
<td>10 days</td>
</tr>
<tr>
<td>CT Head</td>
<td>8 months</td>
</tr>
<tr>
<td>CT C-Spine</td>
<td>2 years</td>
</tr>
<tr>
<td>CT Chest</td>
<td>2 years</td>
</tr>
<tr>
<td>CT Abdomen/Pelvis</td>
<td>3 years</td>
</tr>
<tr>
<td>C-Spine series</td>
<td>6 months</td>
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</tbody>
</table>
Exposure to this Child

- Equivalent of 300 CXR’s in one day
- Equivalent to 8 years and 8 months of background radiation exposure
- In a child with no complaints of injury.
Case #2

- 2 YO Male who fell through a register approximately 9 to 10 feet on to a hard wood floor.
- Cried immediately, complained of headache
- Became a little somnolent and ended up intubated
- Prior to transfer CT scans obtained
Case #2

- Following studies obtained
  - CT of head – left occipital skull fracture
  - CT of C-spine – negative
  - CT chest – negative
  - CT abdomen and pelvis – negative

- No plain films obtained

- CT chest, abdomen and pelvis obtained without contrast
Radiation exposure

- Equivalent to 250 CXR’s in a 2 YO child that is highly sensitive
- CT of chest abdomen and pelvis obtained without contrast so they are truly useless.
- Do not have anyone available that can respond to data so why delay transfer to get it
- Let the referring physician decide what studies they need
CT – An Increasing Source of Radiation Exposure

- Since 1970’s CT use had increased to about 62 million CT’s a year
- 4 million CT’s in children
- Major growth has been driven by decrease time for CT
- CT contributes disproportionately to radiation dose to population
- 4% of test = 40% of radiation
Radiation Exposure

- Pediatrics represents small fraction of tests
- But fraction is increasing
- Combination of higher radiation dose and larger lifetime risk results in a significantly higher lifetime cancer mortality risk.
- Lifetime risk attributable to single dose is larger in children
Lifetime Radiation-Induced Risk of Cancer

![Graph showing lifetime attributable risk of death from cancer per million patients exposed to 10 mGy by age at exposure](image-url)
**Radiation Risks**

- Calculated risk based on atomic bomb radiation patients
- Extrapolated data to determine organ exposure based on age at exposure
- On basis of number of scans done and age distribution, the lifetime mortality risks are calculated
Radiation Risks

- Predicted total numbers of deaths attributable to 1 year of CT exams in the US are:
  - 700 for head CT
  - 1800 for CT abdomen and pelvis

- Children account for:
  - 170 for head CT
  - 310 for CT abdomen and pelvis
Radiation Risks

- Childhood CT examinations contribute significantly to overall estimate.
- Pediatric CT exams make up only 4% of total test but contribute 20% of total deaths.
- Lifetime cancer risk of a 1 year old from one CT of abdomen and pelvis is 1 in 550.
- 1 in 1500 for head CT.
Radiation Risk

- If you take 600,000 as average number of CT’s done in children under 15
- 500 children will ultimately die from the CT scan they received
- Weigh the risk benefit ration
- Use alternatives when possible
Part of the problem

- Physicians view CT studies in same light as other X-rays
- Recent survey of radiologist and ER physicians 75% underestimated radiation dose from CT
- 53% of radiologist and 91% of ER physicians did not believe CT increased lifetime risk of cancer
3 Ways to reduce exposure

- Reduce the CT dose – We are lucky to have the first CT scanner with software to reduce radiation exposure by 45%
- Replace CT when possible – Ultrasound is a very good viable alternative for trauma evaluation in children
- Simply decrease the number of CT’s ordered
Do you really need that CT?

- Despite the fact that most CT scans are associated with favorable ratios of benefit to risk, there is strong evidence that too many are being done.
- CT evaluation for blunt trauma
- Practice of defensive medicine
- Repeat CT’s (head injuries, solid organ injuries)
- Repeat because of lack of communication
Impact of CT on patient management in blunt trauma

- Recent study evaluated 1500 consecutive children with blunt abdominal trauma.
- CT findings and decision for operative or non-operative management were recorded.
- 388 (26%) of CT scans had abnormal findings:
  - 286 solid organ
  - 103 other
    - 30 hollow viscous injury
Impact of CT on patient management in blunt trauma

- 20 of the 286 (7%) of solid organ injury and 25 of 30 (83%) of hollow viscous injury children underwent surgery.
- Injury was confirmed in all children with solid organ injury and 24 of 25 children with hollow viscous injury.
- Decision for surgery was based on CT findings in 25% of solid organ injury and 68% of hollow viscous injury.
- But, 74% of children had negative CT’s.
**Alternatives**

- Focused assessment of sonography for trauma (FAST) – Evaluates free fluid around the heart and three areas of the abdominal-pelvic cavity
  - RUQ – Between liver and kidney (Morrison’s pouch)
  - LUQ – Between spleen and kidney
  - Subxiphoid area – pericardial sac
  - Suprapubic areas – behind bladder in males, uterus in females
Alternatives

- Extended version of FAST (E-FAST) involves evaluating anterior chest for pneumothorax.
- Can determine if there is free fluid in abdomen or pericardium in unstable patient to direct intervention.
- Does have limitations. Does not evaluate retroperitoneum or hollow viscous.
- Convenient, portable.
Alternatives

- Use well documented in adults. Less clear in pediatrics
- Very specific to detect hemoperitoneum but less sensitive to define “positive” study
- However, negative ultrasound and negative exam virtually excludes injury.
- Can use FAST to guide need for CT
Evaluation of the pediatric spine

- NEXUS criteria have been out for many years but have not been consistently used in pediatric patients
- Consist of deciding if patients need X-rays if they show the following
  - Midline cervical tenderness
  - Focal neurologic deficits
  - Altered mental status
  - Evidence of intoxication
  - Painful distracting injury
Evaluation of the pediatric spine

- NEXUS has been validated multiple times and compared to several other methods with good results
  - Sensitivity 99%
  - Specificity 99%
- Is the NEXUS criteria valid in children?
Evaluation of the pediatric spine

- Prospective multicenter study done in pediatric blunt trauma patients (<18 YO)
- Patient had NEXUS criteria applied during evaluation
- Decision to do films was at MD’s discretion and not driven by NEXUS but NEXUS criteria were documented
- Presence or absence of injury based on final interpretation of X-rays
Evaluation of the pediatric spine

- 3065 patients evaluated
- 30 patients (0.98%) had injury documented
- Study included
  - 88 children under 2
  - 817 between 2 and 8
  - 2160 between 8 and 17
Evaluation of the pediatric spine

- 45.9% of injuries were of the lower cervical spine
- No cases of SCIWORA
- Only 4 of 30 injured children were younger than 9
- None under 2
- Most common finding were tenderness and distracting injury
Evaluation of the pediatric spine

- NEXUS correctly identified all pediatric patients with injury
  - Sensitivity 100%
- Correctly designated 603 patients as low risk
  - Negative predictive value 100%
Evaluation of the pediatric spine

Conclusions

- Lower cervical spine most common site of injury
- Injury very rare in children under 8
- NEXUS performed well and its use could reduce 20% of c-spine films
- No single case in literature of occult injury in child classified as low risk by NEXUS
- All patients with injury report pain, have neurologic findings, or have altered mental status and get studies
CT versus plain films

- Study to determine value of CT of spine in children under 5
- 606 patients having cervical spine evaluation in the ER
- Documented age and sex as well as exam findings and presence of injury on plain films and CT
**CT versus plain films**

- Of the 606 patients studied
  - 459 (75.7%) were cleared by combination of exam, and plain films
  - 147 (24.3%) went on to CT imaging for clearing of the cervical spine
- Of the 147 who had CT
  - 143 (97.3%) were negative
  - 4 (2.7%) were positive. All of these patients had positive findings on plain films
CT versus plain films

- The yield of CT of the spine in children under 5 was very low and all patients had the same finding of plain films.
- CT of the spine is equal to 60 CXR and 4 C-spine series
- Is it worth the risk?
CT versus plain films

- A study to evaluate the radiation exposure of children who had CT of the c-spine was done in Atlanta.
- Retrospective review of all children who had CT of the spine in the ER after trauma
- 992 children were evaluated
- Only 181 (18%) had prior C-spine series
CT versus plain films

- Divided the study into three groups
  - 0-4 YO
  - 5-8 YO
  - >8 YO

- They used anthropomorphic dosimetry phantoms for group 1 and 2
CT versus plain films

- Evaluated exposure for C-spine series
  - Series 1 – lateral
  - Series 2 – Four views
  - Series 3 - Seven views

- Evaluated exposure for CT
  - CT head
  - CT C-spine
CT versus plain films

- They calculated radiation exposure of the phantoms and then retrospectively calculated the radiation exposure of the children in the study.
- They then calculated a relative risk of thyroid cancer based on comparison of previous study of children exposed to radiation in the 50’s for treatment of tinea capitis.
**CT versus plain films**

- Results showed
  - 992 patients
    - 435 had C-spine x-rays only
    - 181 had C-spine and CT
    - 376 had CT only

- Radiation dose for CT of the C-spine
  - Group 1 – 200X more than from C-spine series
  - Group 2 – 90X more than from C-spine series
**CT versus plain films**

- **Relative risk for developing thyroid cancer**
  - Group 1 – none from conventional C-spine series
  - Group 1 – relative risk from CT head was 0.03 but relative risk of 2 for CT of C-spine
  - Group 2 – no increase from C-spine series
  - Group 2 – relative risk from CT head 0.02 but increased to 0.07 for CT C-spine
What alternatives do we have

- Evaluate the patient and determine if there is need for radiologic studies
- Do not get studies because of a knee jerk decision of what is done on all trauma patients
- Evaluation of children can be very difficult. If you think the child has significant injuries and you are unable to get a good exam or feel uncomfortable, send them to someone with experience
What alternatives do we have

- Get baseline studies first
- Do not scan head to toe, rarely ever needed
- Use alternative studies when you can
- Never delay transfer to another institution to get scans. The accepting docs will determine what they need. Stabilize and send
- If you do get CT, please use contrast so we can actually use data
Figure 10. Algorithm for Abdominal Imaging in Pediatric Trauma

Key: VS – vital signs; UA – urinalysis; HCT – hematocrit; LFT – liver function test; PE – physical exam
What about C-spine

- Evaluate patient and determine NEXUS criteria
- Calm the child down and do a physical exam
- Obtain plain films first
- If you feel you need a CT by all means get it, but do not get it because it is a child and you feel uncomfortable with the exam.
- You still need an exam before clearing the spine anyway. A negative CT does not clear the spine
Clinical Pathway For Evaluation Of The Pediatric Cervical Spine

Awake and alert child with possible CSI

Is child ≥ 3 years old, AND cooperative, AND with no developmental delay AND with no high risk mechanism?  

YES  

Does child meet NEXUS criteria?  

NO  

Order AP and lateral c-spine. Order odontoid if child is ≥ 9 years of age.  
If odontoid is insufficient, order CT of occiput to C2.  
Are test abnormal or is there pain on exam?  

YES  

Cervical spine is cleared.  

NO  

Are you ordering a head CT?  

YES  

Is child ≥ 9 years of age?  

YES  

Order CT of cervical spine.  
Is CT abnormal or is there pain on exam?  

YES  

Order expert consultation.  

NO  

Order AP and lateral c-spine and CT occiput to C2.  
Patient is normal AND meets NEXUS criteria.  

NO  

Is child < 3 years of age, OR uncooperative, OR developmentally delayed, OR with high risk mechanism?  

NO  

YES  

Are you ordering a head CT?
Imaging of the pediatric trauma patient

- Hope this data has made you think about how many children we are exposing to risky doses of radiation
- This also applies to evaluation of the pediatric patient for abdominal pain
Questions