Radiographic Imaging in the Evaluation of Child Abuse: Refining Practice Patterns

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Objectives

- Review what constitutes a skeletal survey
- Examine the current guidelines for when to order
  - Skeletal survey
  - Head CT
- Consider several recent advances in radiologic imaging
  - As Low As Reasonably Achievable (ALARA)
  - “Image Gently”
  - Fast MRI
What Is a Skeletal Survey?

Appendicular Skeleton
- Humeri (AP)
- Forearms (AP)
- Hands (PA)
- Femurs (AP)
- Lower legs (AP)
- Feet (AP)

Axial Skeleton
- Thorax (AP, lateral and L/R obliques)
- Pelvis (AP)
- Lumbosacral spine (lateral)
- Cervical spine (lateral)
- Skull (frontal and lateral)

A series of X-rays that encompasses the entire skeleton

Individual X-rays vs. Babygram

- Order individual X-rays.

- Do not order a babygram, which is a single image of the whole baby.

Indications for Skeletal Survey

- Suspected
  - Physical abuse in infants and young children
  - Skeletal dysplasia, syndrome and metabolic disorders
  - Neoplasia
Aged Based Recommendations for Skeletal Surveys

- Infants
- Young children
  - Current AAP recommendation <24 months
  - May be expanded to <36 month

American Academy of Pediatrics, 2012

Why Are Guidelines for When to Order a Skeletal Survey Important?

- **Overutilization**
  - Radiation
  - Potential discomfort for child and/or caregiver
  - Time
  - Costly to healthcare system

- **Underutilization**
  - Missed cases of abuse

Missed Cases of Abuse

- A child who has been abused is more likely to be abused again compared to a child who has not.
- Some studies indicate that 10% of children who were not identified as being victims of abuse die from injuries that occur after being returned home.

Ravichandiran, et al., 2010
Yield of Skeletal Survey by Age

- Study design
  - Retrospective secondary analysis of an observational study
  - Measured rates of skeletal survey completion and fracture identification for children 0-60 months
    - Separated by 6-month cohorts

Lindberg DM, et al., 2014

Results of the Study

- 78% of the children had skeletal surveys performed.
- 18% had at least 1 new fracture identified.
- New fracture identification rates were similar between children 12-24 months of age and 24-36 months of age.
  - 12-24 months: 12%
  - 24-36 months: 10.3%
  - 36-48 and 48-60 months: <5%

Lindberg DM, et al., 2014

Conclusions

- Skeletal surveys identify new fractures in a significant percentage of children being evaluated by child abuse specialists.
- Data support
  - <24 months: skeletal survey is mandatory
  - 24-35 months: low threshold to obtain skeletal survey
  - 36-60 months: case by case

Lindberg DM, et al., 2014
Exceptions to the “Rules”

- Children with developmental delays
- May not be able to communicate about their abuse (e.g., what hurts, when the abuse occurred, etc.)
- Demineralization of bones due to disuse
  - Motor delays or intellectual disabilities
- Future studies should document development in addition to chronological age.

X-rays for Children > 36 months

Order specific views based on the child’s history and/or physical exam findings.

Follow-up Skeletal Surveys

- Recommended 10-14 days after the injury occurred.
- Some fractures, particularly rib fractures, are only visible as they start to heal/form a callus.
The Utility of Follow-up Skeletal Surveys in Child Abuse

- Secondary analysis of data obtained by the Examining Siblings to Recognize Abuse (ExSTRA) research network
- Children < 10 years of age
- 20 US child abuse teams
- 2049/2890 (71%) of enrolled children had skeletal survey.
- 796/2049 (39%) had a follow-up skeletal survey.

Harper, et al., 2013

New Information Is Identified by a Follow-up Skeletal Survey

- 174/796 (21.5%) had new information identified.
  - 124/796 (15.6%) had at least 1 new fracture.
  - 55/796 (6.9%) had reassuring findings.
  - A new fracture affected the perceived likelihood of abuse.

Harper, et al., 2013

New Fractures Affect the Perceived Likelihood of Abuse

- Estimated likelihood increased in 41 (33%) cases.
- Estimated likelihood remained at the maximum likelihood of abuse in 51 (41%) cases.
- Perceived likelihood of abuse impacts the child’s disposition.

Harper, et al., 2013
Physical Abuse Is Common in Young Children With Fractures

- Diagnosis of physical abuse is made in
  - 20-25% of children < 12 months with a fracture
  - 6-7% of children 12-23 months with a fracture
- Concrete recommendations on which fracture scenarios should prompt ordering a skeletal survey do not exist.

Leventhal, et al., 2008

Guidelines for Skeletal Survey in Young Children with Fractures

- Multispecialty panel of experts was assembled.
- Panelists were provided a literature review on fractures in child abuse.
- Asked to use this information and their experiences to rate the appropriateness of performing skeletal surveys in 240 scenarios.
- Also asked to assess which scenarios indicated that a skeletal survey was necessary.

Wood, et al., 2014

Skeletal Survey Is Necessary in Children 0-23 Months Old if:

- History of confessed abuse
- History of injury occurring during domestic violence
- History of impact from toy/object causing fracture
- Delay in seeking care >24 hours in a child
- Additional injuries on PE unrelated to fracture
- No history of trauma to explain fracture
  - Except for the following fractures in an ambulatory child:
    - Distal buckle fracture of the radius/ulna
    - Distal spiral or buckle fracture of the tibia/fibula

Wood, et al., 2014
Skeletal Survey Is Necessary in All Infants with Any Type of Fractures

- **Except** in the following cases if there are no additional concerns:
  - Distal radial/ulna buckle fracture or toddler fracture of the tibia/fibula in a cruising child > 9 months with a history of a fall
  - Linear, unilateral skull fracture in a child > 6 months with a history of a significant fall
  - Clavicle fracture likely attributable to birth

Wood, et al., 2014

Skeletal Survey Is Necessary in Children 12-23 Months Old

With any of the following types of fractures:
- Rib fracture
- Classic metaphyseal lesion
- Complex skull fracture
- Humeral fracture with epiphyseal separation attributed to a short fall
- Femur diaphyseal fracture attributed to a fall from any height

The Guidelines Only Apply to Children

- Who do NOT have:
  - A verifiable mechanism of accidental trauma
  - Underlying bone fragility
  - A clear history of birth trauma
Neuroimaging in Suspected Child Abuse

- Head CT should be ordered for all infants < 6 months.
- Most order it for patients < 12 months.

Utility of Head CT in Children with a Single Extremity Fracture

- Retrospective chart review of children < 2 years of age who had a skeletal survey in the ED
- Searched for clinically and/or forensically significant head injury
- Determined rate of head CT relative to patient age and location of fracture
  - Proximal vs. distal
  - Upper vs. lower extremity

Wilson, et al., 2014

Conclusions of Wilson, et al.

- Clinicians should consider obtaining a head CT if:
  - Child < 12 months of age
  - Proximal extremity fractures
  - Previous evaluations for non-accidental trauma

Wilson, et al., 2014
Risks Related to Overutilization of Head CT Scans

- Risk of sedation
- Risk of identifying "incidentalomas"
- Increased risk of intracranial malignancy
  - Cumulative absolute risk is small, but real.

Pearce, et al., 2012

As Low As Reasonably Achievable

- Make every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical.
- Takes into account:
  - State of technology
  - Economics of improvements of the state of technology
  - Societal and socioeconomic considerations

U.S. Nuclear Regulatory Committee, 2015

“Image Gently” Campaign

- The Alliance for Radiation Safety in Pediatric Imaging began as a committee of the Society for Pediatric Radiology, but subsequently engaged:
  - American College of Radiologists
  - American Society for Radiologic Technologists
  - American Association of Physicists in Medicine

Don, et al., 2013
“Image Gently”

- Goal is to change practice by raising awareness of opportunities to lower radiation dose.
- Website contains information about:
  - What you can do dependent on your role in the team
  - Procedures and protocols for various types of imaging
  - Current events
  - Educational materials

Radiation Exposure

- Skeletal survey: 0.15-0.45 mSv (9 kg patient)
- In the US:
  - Inhalation of air: 2.28 mSv/year
  - Ingestion of food and water: 0.29 mSv/year
  - Consumer items: 0.13 mSv/year

Drobach, et al., 2010

Natural Background Radiation Dose

Skeletal survey is equal to 3-10 weeks of natural background radiation.
FAST MRI
- Reduces the time it takes to scan the brain.
- Provides more dynamic images of the brain.
- Will likely impact the approach to imaging suspected victims of child abuse once it is widely available.

Feinberg and Setsompop, 2013

Summary
- Skeletal surveys consist of 19-22 individual images.
- Data support guidelines to consider skeletal survey mandatory in children <24 months and support a low threshold to obtain in children as old as 36 month.
- Follow-up skeletal surveys identify new information in about 20% of cases, which increases the estimated likelihood of abuse and, potentially, the disposition of the child.

Summary
- Recommendations on which fracture scenarios should prompt ordering a skeletal survey now exist.
- Routinely order neuroimaging for suspected victims <12 months old. (Some limit this to <6 months.)
  - Proximal extremity fractures and a previous evaluation for NAT should lower the threshold to order this.
- Recent advances in radiologic imaging:
  - ALARA
  - “Image Gently”
  - Fast MRI
References


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