

Yield of Skeletal Survey by Age in Children Referred to Abuse Specialists

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Objective To determine rates of skeletal survey completion and injury identification as a function of age among children who underwent subspecialty evaluation for concerns of physical abuse.

Study design This was a retrospective secondary analysis of an observational study of 2609 children <60 months of age who underwent evaluation for possible physical abuse. We measured rates of skeletal survey completion and fracture identification for children separated by age into 6-month cohorts.

Results Among 2609 subjects, 2036 (78%) had skeletal survey and 458 (18%) had at least one new fracture identified. For all age groups up to 36 months, skeletal survey was obtained in >50% of subjects, but rates decreased to less than 35% for subjects >36 months. New fracture identification rates for skeletal survey were similar between children 24-36 months of age (10.3%, 95% CI 7.2-14.2) and children 12-24 months of age (12.0%, 95% CI 9.2-15.3)

Conclusions Skeletal surveys identify new fractures in an important fraction of children referred for subspecialty consultation with concerns of physical abuse. These data support guidelines that consider skeletal survey mandatory for all such children <24 months of age and support a low threshold to obtain skeletal survey in children as old as 36 months. (*J Pediatr* 2014;164:1268-73).

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Estimates identify more than 119 000 cases of physical abuse, 600 fatalities, and \$124 billion in total costs in the US each year.¹⁻³ In the absence of a “gold-standard” diagnostic test for most children who are suspected of being abused, such a diagnosis is likely to be hotly contested.⁴ With respect to a diagnosis of abuse, errors of over- or underdiagnosis carry substantial risk for morbidity and mortality.⁵⁻⁷ In determining whether a given history can plausibly explain a child’s injuries, clinicians frequently use several diagnostic tests to identify other, occult injuries that can substantially affect the perceived likelihood of abuse.⁸⁻¹³ Children who are suspected of being abused often are referred to child abuse pediatricians for subspecialty evaluation to determine which occult injury testing should be undertaken.¹⁴ To date, there are few data to evaluate the yield of tests ordered by subspecialists, and some data suggest that there is substantial variability in test use, even among leading pediatric centers.¹⁵

The radiographic skeletal survey is the most widely used and well-researched test for occult abusive injuries.¹⁶⁻²⁰ The American Academy of Pediatrics’ (AAP) current policy states that the skeletal survey “is mandatory in all cases of suspected physical abuse in children younger than 2 years; its utility diminishes thereafter. The screening skeletal survey or bone scan has little value in children older than 5 years.”²¹ Similarly, the American College of Radiology (ACR) Appropriateness Criteria state that for children older than 24 months, skeletal survey may be appropriate but that “value of survey is less as age rises. Radiographs should usually be tailored to the area(s) of suspected injury.”²² Although younger children are at greatest risk, in previous studies authors have analyzed children 24-60 months of age as a single cohort despite the important developmental milestones that may impact the utility of skeletal survey.^{18,19,23}

Our objective was to determine rates of skeletal survey completion and injury identification in different age ranges for children <60 months in a large, multi-center cohort of children who underwent subspecialty evaluation for concerns of child physical abuse.

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Supported by the Health Resources and Services Administration/Maternal and Child Health Bureau, Emergency Medical Services for Children Program (H34MC19346-01-02). D.L. and N.H. have provided paid expert testimony for prosecution and defense in cases of alleged child physical abuse. The other authors declare no conflicts of interest.

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<http://dx.doi.org/10.1016/j.jpeds.2014.01.068>

AAP	American Academy of Pediatrics
ACR	American College of Radiology
CAP	Child abuse physician
CML	Classic metaphyseal lesion
ExSTRA	Examining Siblings To Recognize Abuse

Methods

This was a retrospectively planned secondary analysis of data from the Examining Siblings To Recognize Abuse (ExSTRA) research network, the methods of which have been described previously.²⁴ In brief, the ExSTRA research network was a prospective, observational study of 20 US child abuse teams that included all children <120 months (10 years) of age who underwent subspecialty evaluation by a child abuse physician (CAP) for concerns of physical abuse between January 15th, 2010 and April 30th, 2011. For this secondary analysis, we analyzed data for all subjects younger than 60 months of age. Each center and the data coordinating center obtained local institutional review board approval of the parent study and exemption from review for secondary analysis of previously collected data that had been purged of all identifiers.

Each participating center enrolled more than 90% of eligible patients based on independent monthly audits. At the time of disposition, (sign off, discharge, or death) the responsible CAP recorded the presenting symptoms of the child, findings on physical examination, all testing that was undertaken to screen for abuse, and any injuries identified. Even though the primary analysis of the ExSTRA network involved household contacts such as siblings and children who shared a daycare with the index child, this secondary analysis includes data only from index children.

All centers conducted skeletal surveys according to the guidelines published by the AAP and ACR.^{21,25} Each participating center had a dedicated child protection team, including at least one member of The Ray E. Helfer Society, an honorary society of CAPs. All imaging was interpreted in the usual course of clinical care by experienced attending radiologists at each participating center. Investigators coded whether each skeletal survey identified a “new injury” defined as an injury that was not definitively known prior to the skeletal survey. Although a single diagnostic study might identify several injuries, each injury could only be newly identified by a single diagnostic study or physical examination. The ultimate determination of whether any fracture or other injury was identified (as when different radiologists disagreed) was made by the responsible CAP after review of any available testing, clinical information, and specialty consultation using the criterion of whether they would testify to the presence of an injury in court or in the medical record.

A single investigator (D.L.), who was blinded to the age of subjects, reviewed each chart in which a new fracture was identified by skeletal survey to determine the presence of 3 factors (altered mental status, radiographic identification of a non-skull fracture before skeletal survey, or clinical signs and symptoms related to all fractures identified by skeletal survey) that may have prompted a skeletal survey. A subset of 20% of charts was reviewed by a second investigator (M.R.) to determine interrater reliability. Symptoms and signs that were considered possibly related to fractures included bruising, deformity, limp or decreased use of ex-

tremity, bony crepitus, and swelling or tenderness in the same region as the fracture (same extremity for extremity fractures, face or head for skull fracture, chest or back for rib fractures). Symptoms and signs were considered to be present if they were reported by caregivers or noted by clinicians before the skeletal survey was obtained. Altered mental status was not considered as a sign of skull or other fractures but was analyzed separately. Respiratory distress was not considered to be a sign of rib fracture, and burns were not counted as a sign of fracture.^{26,27}

Subjects were divided according to age into 6-month cohorts and descriptive statistics were used to describe the percentage of subjects who had skeletal survey, and the percentage with new fractures identified. Age was measured with precision so that a child who was 6 months and 1 day past his or her birthday was included in the 6- to 12-month age group, and a child who was 5 months and 29 days was included in the 0- to 6-month age group. The Cohen kappa was used to describe interrater reliability. Retrospective power calculation was performed for a 2-sided comparison with alpha = 0.05. Statistical analysis was performed with SAS JMP Pro Version 10.0.0 (SAS Institute, Cary, North Carolina).

Results

The ExSTRA research network enrolled 2609 index subjects less than 60 months of age, and 2036 (78.0%) underwent a skeletal survey.⁹ Skeletal survey was performed in 1750 subjects (88.6%) <24 months and 286 subjects (45.1%) 24-60 months. Among 466 in whom the skeletal survey was coded as identifying a new injury, 5 (1.1%) subjects were excluded because the skeletal survey identified injuries that were not fractures (eg, soft-tissue swelling, bony deformity, and periostitis) and 3 (0.6%) were excluded because follow-up skeletal survey raised questions about all fractures that were identified on the initial skeletal survey. This left 458 subjects with new fractures identified by skeletal survey. The types of fractures identified in each age group are shown in **Table I**. Multiple fractures were identified by skeletal survey in 263 (57.4%) subjects. Although fractures of long bones were found in all age cohorts, skull fractures and classic metaphyseal lesions (CMLs) were almost entirely restricted to infants.

Rates of skeletal survey performance for each age cohort are shown in the **Figure**. Even though AAP and ACR guidelines would predict an important difference in skeletal survey use in children older and younger than 24 months, the biggest decrease in skeletal survey use actually occurred at 36 months. Skeletal survey was undertaken in more than 60% of subjects in all cohorts younger than 36 months, but the rates of skeletal survey were less than 35% for each cohort older than 36 months. The percentage of all subjects (counting those subjects without skeletal survey as having no fracture) with new fractures identified by skeletal survey was similar for subjects who were 12-24 months (12.0%,

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