Prevalence of the Classic Metaphyseal Lesion in Infants at Low Versus High Risk for Abuse

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OBJECTIVE. The purpose of this article is to determine the relative likelihood of encountering a classic metaphyseal lesion in infants at low and high risk for abuse.

MATERIALS AND METHODS. This 10-year retrospective study compared the prevalence of the classic metaphyseal lesion on high-detail American College of Radiology–standardized skeletal surveys in infants at low and high risk for abuse. Low-risk infants met all of the following criteria: skull fracture without significant intracranial injury on CT, history of a fall, and no other social risk factors for abuse. High-risk infants met all of the following criteria: significant intracranial injury, retinal hemorrhages, and skeletal injuries (excluding classic metaphyseal lesions and skull fractures). Differences between the two groups were calculated using the Fisher exact test.

RESULTS. There were 42 low-risk infants (age range, 0.4–12 months; mean age, 4.4 months) and 18 high-risk infants (age range, 0.8–10.3 months; mean age, 4.6 months). At least one classic metaphyseal lesion was identified in nine infants (50%) in the high-risk category. No classic metaphyseal lesions were identified in the low-risk group. The relative prevalence of classic metaphyseal lesions in the low-risk group (0/42) versus that in the high-risk group (9/18) was statistically significant ($p < 0.0001$; 95% CI, 0–8% to 29–76%).

CONCLUSION. Classic metaphyseal lesions are commonly encountered in infants at high risk for abuse and are rare in infants with skull fractures associated with falls, but no other risk factors. The findings support the view that the classic metaphyseal lesion is a high-specificity indicator of infant abuse.

Keywords: bone, child abuse, differential diagnosis, fracture healing, fractures, infant, radiography

DOI:10.2214/AJR.11.6540

Received January 20, 2011; accepted after revision March 7, 2011.

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AJR 2011; 197:1005–1008

0361–803X/11/1974–1005

The classic metaphyseal lesion, originally detailed by Caffey in 1957 [1], is a widely accepted high-specificity indicator of infant abuse. The foundation for this view rests in extensive literature describing the classic metaphyseal lesion in association with other inflicted injuries, as well as detailed radiologic and histopathologic correlations of the distinctive fracture shape and healing characteristics [2–9]. However, rigorous research defining the prevalence of the classic metaphyseal lesion in the general population and comparing it to a cohort of abused infants has not been performed, to our knowledge [10]. Prospective studies that seek to estimate the prevalence of classic metaphyseal lesions in the general population are not feasible, but the use of a cohort of infants who have undergone a skeletal survey after a household fall may provide a surrogate for a control population [11]. The purpose of this study was to compare the relative likelihoods of encountering a classic metaphyseal lesion in infants at low and high risk for abuse.

Materials and Methods

This retrospective study was approved by the institutional review board.

Low-Risk Group

A text search was performed of radiology reports on all infants (< 1 year old) undergoing skeletal survey because of skull fractures identified on head CT between 1999 and 2009. The CT reports were reviewed for the presence of skull fractures and their characteristics as well as associated intracranial abnormalities. Medical records, including the emergency department notes, consultations, and inpatient records were reviewed. Cases were classified using categories outlined in a recent study by Wood et al. [11]. Inclusion criteria in the low-risk group are detailed in Table 1.

High-Risk Group

During the same 10-year period, a search of radiology reports and hospital child protection team (CPT) consultations was performed to identify infants at high risk for abuse. Inclusion criteria were all of the following: subdural hematoma, retinal

TABLE 1: Inclusion Criteria for Low-Risk Group

Criteria
Skull fracture noted on head CT
Skeletal survey [12]
Child protection team or emergency department social worker consultation
History of a fall
Short fall (< 3 feet)
Long fall (> 3 feet)
Other (e.g., fall with parent landing on child)
No significant intracranial injury (focal extraaxial blood underlying fracture site excluded)
No risk factors for abuse
Absent or inconsistent history of injury
Presence of other suspicious injuries
Delay in care > 72 hours
Previous child protective service involvement

hemorrhages, skeletal injuries (other than classic metaphyseal lesions and skull fractures), and determination of abuse by the CPT and state child protective services.

Characteristics of the subdural hematomas and associated parenchymal injuries, retinal hemorrhages, and fractures were noted. Although follow-up skeletal surveys were regularly performed in the high-risk infants, the findings on those examinations were not included in the analysis to maintain consistency with only a single survey in the low-risk patients.

Skeletal surveys were performed according to the protocol recommended by the American College of Radiology [12]. Anteroposterior views of the appendicular skeleton and anteroposterior and lateral views of the axial skeleton were obtained, collimated to each anatomic region. From 1999 to 2004, images were acquired with a high-detail mammographic screen-film imaging system. For the latter part of the study, images were acquired with a high-resolution dual-side-read computed radiographic system [13].

Statistical Analysis

The percentage of infants with at least one classic metaphyseal lesion was compared between low-risk and high-risk infants by Fisher exact test. The comparison was repeated with adjustment for age and sex by exact logistic regression. The distribution of classic metaphyseal lesions per patient was compared by Wilcoxon rank-sum test. SAS software (version 9.2, SAS Institute) was used for all statistical computations.

Results

Low-Risk Group

There were 42 infants in the low-risk group, with a mean age of 4.4 months (range, 0.4–12 months). A social work assessment in the emergency ward or after admission to the hospital was performed for all patients, and 39 infants also had a hospital CPT consultation. Four patients were discharged home from the emergency department, and the remaining patients were discharged after 24–48 hours of observation. All patients had normal neurologic examinations at admission and throughout the hospital stay. In all cases, the neurosurgical service was consulted; only one case required neurosurgical intervention to elevate a depressed skull fracture. Filings with the state child protective services were made in three cases; two reports were filed at an outside hospital, and the other was filed because a parent had herself been a foster child.

Thirty-one (74%) of the low-risk infants sustained their injuries during a short fall, eight (19%) had a long fall, and the remaining three (7%) were injured from a complex fall, such as a fall involving a parent who landed on the infant or a fall down stairs. Twenty-six skull fractures were complex (bilateral, multiple, depressed, or with underlying intracranial hemorrhage). Of these, four were bilateral or depressed (62%), four were bilateral fractures with associated intracranial hemorrhage, and 18 were linear with intracranial hemorrhage. In all cases with intracranial hemorrhage, the findings consisted of focal extraaxial blood underlying the fracture site. Two noncranial fractures were identified in the low-risk group, and both were consistent with clavicular birth injuries (ages 0.4 and 1.0 months). There were no classic metaphyseal lesions in the low-risk group.

High-Risk Group

There were 18 infants in the high-risk group, with a mean age of 4.6 months (range, 0.8–10.3). Subdural hematomas were bilateral in 10 infants and unilateral in eight. Cerebral hypodensities were present in seven infants. Retinal hemorrhages were severe (bilateral or multilayered) in 16 infants and mild (unilateral or unilayered) in two. Excluding classic metaphyseal lesions and skull fractures, there were 62 fractures (Table 2). There were a total of 18 classic metaphyseal lesions noted in nine infants (Table 3), with zero to three classic metaphyseal lesions per patient (Fig. 1).

The relative prevalence of classic metaphyseal lesions in the low-risk group (0/42) versus that in the high-risk group (9/18) was statistically significant ($p < 0.0001$; 95% CI, 0–8% to 29–76%). When adjusted for sex and age, the difference remained statistically significant ($p < 0.0001$). The distribution of classic metaphyseal lesions per patient also differed significantly between the groups ($p < 0.0001$).

TABLE 2: Distribution of Skeletal Injuries in High-Risk Group

Type of Injury	No. (%) of Injuries
Rib	30 (38)
Classic metaphyseal lesion	18 (22)
Vertebral compression	13 (16)
Long bone	5 (6)
Digit	5 (6)
Acromial	3 (4)
Subperiosteal new bone formation	3 (4)
Clavicle	3 (4)
Total	80 (100)

Note—There were 51 (64%) high-specificity fractures.

TABLE 3: Location and Distribution of Classic Metaphyseal Lesions in High-Risk Group

Location of Lesion	No. (%) of Infants
Femur distal	5 (27)
Tibia proximal	4 (22)
Tibia distal	2 (11)
Humerus proximal	2 (11)
Radius distal	2 (11)
Ulna distal	1 (6)
Fibula proximal	1 (6)
Fibula distal	1 (6)
Total	18 (100)

Note—Fifty-five percent of classic metaphyseal lesions were around the knee.

Discussion

When infants present to the emergency department with a possible head injury and cranial CT reveals an isolated skull fracture, additional injuries are uncommon. Wood et al. [11] studied 341 infants with non–motor vehicle–related skull fractures evident on CT and reviewed the results of skeletal surveys in 141 cases (41%). The surveys detected additional fractures in only two instances (1.4%). Both fractures were non–classic metaphyseal lesion injuries occurring in association with clinical findings that raised the suspicion of abuse. Their study included children with and without a specific history of a traumatic event, and there was no initial attempt to exclude those patients with other clinical findings that raised the suspicion of abuse. In an effort to minimize the inclusion of abused infants, and more closely approximate a control population, we excluded infants without a history of fall and those with red flags for abuse according to clinical assessment, including social worker evaluation and CPT consultation.

Although Caffey is generally credited with the description of the classic metaphyseal lesion, in particular the corner fracture and bucket handle patterns, examples of this injury can be found in articles predating his classic 1957 article [1]. Notably, his protégé Silverman illustrated several florid examples of "metaphyseal infractions" in his article published in 1953 [14]. Numerous articles and textbooks have detailed the radiologic and histopathologic features of these injuries, and conventional wisdom holds that there is a strong association between the classic metaphyseal lesion and infant abuse [2, 3, 5–8, 10, 11, 14]. A critical review published in 2008 found the literature to be lacking in a rigorous evidence base to support this widely held view [10]. Our study addresses this issue and indicates that, in otherwise normal infants, the classic metaphyseal lesion is rare and, in particular, is unlikely to occur with a fall that also results in a skull fracture. The findings support the view that the classic metaphyseal lesion is a high-specificity indicator of infant abuse.

Our study has several limitations. Our low-risk population does not represent a true control group because of the inclusion criteria of a skull fracture after a fall. However, because a fall is often alleged to explain injuries that are eventually shown to be inflicted, comparison of the skeletal survey findings in a cohort of abused infants with a cohort of infants sustaining presumed accidental injuries may have relevance to the clinical environment. With the exception of two birth-related injuries, the fact that no fractures were identified in our 42 infants with presumed accidental skull fractures supports the view that children sustaining accidental head injuries are unlikely to have associated fractures that might be confused with inflicted injury. It is interesting to note that 62% of our skull fractures were classified as complex, a fracture pattern that has been thought to have a higher specificity for abuse than a simple linear fracture [7]. Our findings echo the conclusion by Wood et al. [11] that complex fractures may, in fact, be sustained with household accidental injuries. Our retrospective method does not ensure that the assessment by the emergency department social worker and CPT were performed in a standardized fashion, and the details of the injuries in the low-risk group were often limited. Therefore, it would be impossible to exclude the possibility that the history of a fall in the low-risk group was misleading and that abuse was present. Similarly, it would be impossible to entirely exclude a natural or accidental cause for the findings in the high-risk group; however, the use of stringent criteria, including subdural hematoma, retinal hemorrhages, and fractures (excluding classic metaphyseal lesions) for diagnosis, minimized this possibility.

There are a variety of differential considerations that should be excluded when metaphyseal irregularities are encountered in infancy. These include birth injuries, several bone dysplasias, neuromuscular and metabolic disorders, and developmental variants. Most of these are readily apparent with a careful analysis of the imaging findings and routine clinical assessment [4, 9, 15, 16]. Involvement of a multidisciplinary CPT in selected cases, with the judicious use of biochemical and genetic testing as recommended by the American Academy of Pediatrics, are appropriate [4, 17]. When findings consistent with classic metaphyseal lesions are identified radiologically and this systematic approach has excluded other differential considerations, the findings are sufficient for clinical management decisions, and they should also be deemed an adequate foundation for opinions offered in medicolegal proceedings.

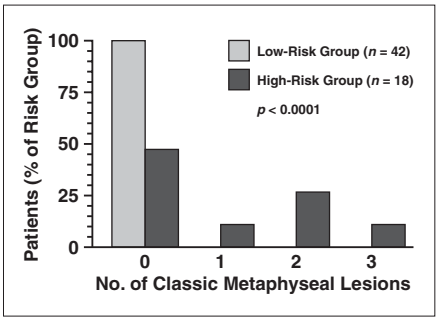

Fig. 1—Classic metaphyseal lesion frequency in low- versus high-risk infants.

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