ARTICLE

The Presence of Bruising Associated With Fractures

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Objective: To determine the occurrence of bruising near the site of fracture in a group of children with inflicted fractures.

Design: Case series.

Setting: Two children's hospitals.

Participants: Suspected child abuse victims with fractures.

Main Outcome Measure: The presence of bruising and fracture in a single body region or appendage.

Results: The study included 192 children with inflicted fractures. No bruising was found in 111 (57.8%) of the study participants. Forty patients (20.8%) had bruising near the site of at least 1 fracture. Of these, bruising or subgaleal hematoma near the site of a skull fracture was seen most often, in 43.3% of patients. Bruising in association with extremity fractures was seen much less commonly, ranging from 3.8% (n=2) of children with tibia fracture to 16.7% (n=1) of children with fibula fracture. Rib fractures also were associated uncommonly with bruising. When skull fractures are excluded, 45 (8.1%) of 555 fractures had bruising near the fracture site, in 13 (6.8%) patients.

Conclusions: In children with inflicted skeletal trauma, the fractured bones that most frequently have associated bruising are the skull bones. The presence of bruising near the fracture site is uncommon in extremity or rib fractures.

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FRACTURES AND SOFT TISSUE injuries represent the most common presentations of child abuse in the United States.[1,2] Both bruises and fractures may be seen in the same patient. When faced with a child who has sustained a fracture, investigators, the courts, and clinicians sometimes are puzzled as to the absence of bruising over the area of fracture. In a 1998 study of normal children with no specific concern of abuse,[3] bruising was reported to be infrequent at the site of the fracture. However, some authors have suggested that the absence of bruising in patients with unexplained fractures indicates an increased likelihood of metabolic bone disorders. According to these arguments, such patients would demonstrate increased vulnerability of the bone due to metabolic disease and thus require less force to produce bony injury, leaving no cutaneous finding.[4-8] Taitz[9] reviewed records associated with court proceedings of 22 infants with fractures whose cases were being examined for child protection issues or whose caregivers were charged with abuse. In 10 infants, the absence of bruising was alleged to be evidence of metabolic bone disease. Taitz concluded that no child in his series exhibited convincing medical evidence of bone disease, and that a lack of bruising near the fracture was not a relevant clinical fact with regard to possible inflicted injury. There has been no previous report focusing on bruising in abusive fractures. In this study, we examine the presence and location of bruising in a population of infants and children with inflicted fractures.

METHODS

We retrospectively reviewed all cases of suspected child abuse evaluated by the child abuse evaluation teams at Vanderbilt University Medical Center in Nashville, Tennessee, between January 1, 1996, and August 31, 2000, and at the Children's Hospital in Denver, Colorado, between January 1, 1996, and December 31, 1999. Infants and children were eligible for inclusion if they had been admitted to the hospital with a formal consult made to the inpatient medical child abuse and neglect consultation service and subsequently were de-

Table 1. Fracture Location According to Association With Bruise[a]

Fracture Site	Total Fractures, No.	No Bruise or Bruise Not Near Fracture, No.	Bruise Near Fracture, No. (%)
Skull	71	35	32 (45.1)
Face	1	0	1 (100)
Rib	317	298	29 (9.1)
Humerus	33	30	3 (9.1)
Radius	29	26	2 (6.9)
Ulna	19	14	1 (5.3)
Femur	66	55	5 (7.6)
Tibia	64	61	2 (3.1)
Fibula	7	6	1 (14.3)
Spine	4	4	0
Pelvis	1	0	1 (100)
Clavicle	7	7	0
Acromion	2	2	0
Metacarpal	3	3	0
Metatarsal	2	2	0

[a] Patients with unknown site of bruising were not included.

Table 2. Bruising According to Area of Body[a]

Location of Bruise	Total No. of Patients With Bruises	No. (%) of Patients With Fractures	
		Total Patients With Bruises Near Fracture	Total Patients Without Bruises Near Fracture
Head	52	21 (40.4)	31 (59.6)
Chest	8	3 (37.5)	5 (62.5)
Abdomen	15	1 (6.7)	14 (93.3)
Genitals	2	0	2 (100)
Buttocks	5	2 (40)	3 (60)
Back	7	2 (28.6)	5 (71.4)
Upper extremity	7	6 (85.7)	1 (14.3)
Lower extremity	15	6 (40)	9 (60)

[a] Several children had bruising at multiple sites. Excludes patients with unknown bruising site.

termined to have been abused. Determination of the presence or absence of abuse was made by the hospital-based multidisciplinary team for each study site. All medical charts with consults for suspected abusive fractures were reviewed, and all patients with inflicted fractures were entered into the study. The presence and types of fractures were determined by radiographs ordered by the physicians caring for the child, and were read by pediatric radiologists. Fractures were classified as acute or healing; those fractures without a documented state of healing were excluded from analysis of bruising as related to healing or acute fractures. Fractures of the skull or metaphysis were excluded from this analysis due to the known difficulty in dating such fractures. All cases of suspected child abuse had been reported to Child Protective Services and/or to law enforcement. Institutional review board approval was obtained before study onset, with consent waived.

Cutaneous injuries were defined as bruises if ecchymosis, petechiae, or a visible or palpable hematoma was present on physical examination. Patients with scalp swelling noted on imaging studies alone or only notable by fluctuance were not included in the category of bruise. Other injuries such as abrasions, bite marks, and burns were not included in the category of bruise. No data on bruising were collected from autopsy results in those patients with fatal injuries. In order to be as inclusive as possible, the bruising considered to be potentially associated with a fracture was broadly defined. Bruising anywhere on the head or neck was considered to be associated with any fracture of the skull or face. Bruising of the lower extremity was considered to be associated with fractures of the femur, tibia, fibula, or metatarsals. Bruising on the upper extremity was considered to be associated with fractures of the humerus, radius, ulna, or metacarpals. Bruising of the chest, back, or trunk was considered to be associated with fractures of the rib, clavicle, or the acromion process of the scapula. Bruising on the abdomen, back, or trunk was considered to be associated with fractures of the pelvis or lumbar spine.

RESULTS

A total of 626 fractures were diagnosed in 192 patients. The patients ranged in age from 2 weeks to 120 months (mean age, 13.6 months; median age, 6 months; and mode, 2 months). Of the total number of patients, 100 were male (52.1%) and 90 were female (46.9%), with 2 children whose sex was unreported; 2 patients died. The median number of fractures per patient was 2, and the maximum number was 31. The location of fractures and associated bruises is summarized in **Table 1**.

Of 192 patients, 109 (58.2%) had no bruises noted on physical examination. A total of 32 patients (16.6%) had bruising present that was not near the site of any fracture. Bruising was observed near the site of at least 1 fracture in 40 patients (20.8%). There were 9 patients (4.6%) with reported bruising at unspecified sites. Bruising according to area of the body is summarized in **Table 2**.

A total of 76 metaphyseal fractures were found in 23.4% of all patients (n=45). Of these fractures, 18 (23.7%) occurred in the upper extremities and 58 (76.3%) in the lower extremities. More than half of the metaphyseal fractures (42 [55.3%]) had no bruise near the fracture site. One quarter of these fractures (19 [25.0%]) had bruising, but not near the site of fracture. Bruising was found near the site of fracture in 10 (13%) of the metaphyseal fractures, representing 8.6% of all metaphyseal leg fractures and 27.8% of all metaphyseal arm fractures.

On examination, subgaleal hematomas or scalp swelling was found in 10 children (5.2% of all patients). All but 1 of these also had a skull fracture (9 [90.0%]). Four of these patients also had other noted bruises. Of 60 total patients with skull fractures, 9 (15.0%) were noted to have subgaleal hematomas. The characteristics of these subgaleal hematomas were not specified. Of the 9 patients with an unspecified bruising location, 2 had subgaleal hematomas with skull fractures.

One patient with no bruising was found to have osteogenesis imperfecta by tissue biopsy. This patient was a 1-month-old male infant with acute and chronic subdural hematomas, retinal hemorrhages, adrenal hemorrhage, diaphyseal femur fracture, 2 metaphyseal fractures of the femur and tibia, and 21 acute and healing rib fractures. This patient's caregiver admitted to injuring this child and was subsequently imprisoned.

BRUISING AND OTHER INJURIES

A number of children presented with at least 1 additional nonfracture and/or nonbruise abusive injury, as summarized in **Table 3**. Of these, having 1 additional injury type was most common, in 25.5% of patients, with 21.4% having 2 additional injury types and 13.2% having 3 additional injury types. Four patients had 4 other types of injuries, and 1 child had 5 injury types. Retinal hemorrhages, which were not considered to be an additional injury type, were noted in 31 patients, all of whom had evidence of acute brain injury.

We examined separately the data of the 53 patients with diagnosed inflicted traumatic brain injury. Of these patients, 40 (75.5%) had skull fractures. Conversely, the number of patients who had a skull fracture who also had evidence of intracranial injury was only 29 (48.3%). Of all patients with inflicted head injury with or without intracranial injuries, 67.9% had either skull fracture or cutaneous evidence of head injury.

Table 3. Bruising and Other Injuries

Type of Injury	No. (%) of Patients
Head injury	53 (27.6)
Abdominal injury	17 (8.9)
Oral injury	13 (6.8)
Burns	4 (2.1)
Genital injury	3 (1.6)

AGE OF FRACTURE AND BRUISE

Fractures were classified as being acute or healing. Skull fractures and all metaphyseal fractures were excluded from classification of healing status due to the known difficulty of dating these fractures. A total of 121 acute fractures and 120 healing fractures were seen. A total of 5 acute fractures in 5 patients were seen near bruising (2 humerus, 1 radius, 1 ulna, and 1 femur). There were 26 healing fractures with bruising near the site of fracture. However, most of these were rib fractures (n=23) seen in 3 patients. The remaining 3 healing fractures with nearby bruising were of a humerus, a femur, and a vertebra.

COMMENT

Smaller studies have reported bruising to be infrequently associated with fractures. Mathew et al[3] reported associated bruising in less than one third of a group of 93 acute fractures in 88 children. The bones fractured were not specified, and no mention was made as to whether or how they were screened to exclude child abuse. In their study, 8 fractures had bruising in the area of the fracture at presentation, 13 children initially with no bruising developed it by the time of their in-hospital definitive treatment, and 4 fractures of 16 that were reexamined within the first week had developed bruising. Overall, 25 fractures (28%) had associated bruising in the first 7 days after trauma, with only 9% having bruises at the time of presentation. Mathew et al stated that they examined "for evidence of bruising around the fracture site,"[3(p1117)] but did not specify further how the determination was made as to specifically which bruises were considered to be around the fracture site, nor whether bruising was noted anywhere else on examination.

In our patient group of both acute and healing inflicted fractures, 20.8% of patients had bruising near the site of at least 1 fracture. Bruising or subgaleal hematoma was common at the site of skull fracture, seen in 43.3% of patients with skull fractures. When patients with skull fractures are not considered, only 9.3% of our patients had bruising near the site of fracture. Rib fractures were not associated frequently with nearby bruising, seen in 7.1% of all patients with rib fractures. Bruising was seen infrequently in extremity fractures, ranging from 3.8% (n=2) of children with tibia fracture to 16.7% (n=1) of children with fibula fractures. The number of children with fibula fractures (n=7) and pelvic fractures (n=1) was small. Due to the small sample size, it is uncertain if the association of bruises with fibula and pelvic fractures would be reflective of the actual occurrence in a larger population.

In our study, 58.3% of our patients had no bruise at all, and 16.5% had bruising present, but not at the site of fracture. Eastwood[10] made note of the "common knowledge among orthopaedic surgeons that there may be no external signs of bruising in association with the fracture," which is partially responsible for the "emphasis . . . on marking the limb for surgery."[10(p1096)] There are several possible reasons why bruising is typically not associated with fractures. The site of contact resulting in fracture may be far from the actual site of fracture. Common examples seen in the pediatric emergency setting include the toddler's fracture, in which a young child plants the foot and then rotates on the leg, resulting in a spiral tibia fracture, or forearm fractures, which commonly result from falling on an outstretched hand. The mechanism of twisting or jerking an extremity to produce metaphyseal fractures is also that of a force at a site distant from the fracture and is unlikely to cause bruising. More than 80% of metaphyseal fractures in our study had no associated bruising. In addition, soft tissue injury may take time to appear on the surface of the skin.[3,11-13] In our population of acute and healing fractures, bruises either may have healed by the time of observation or have been evolving and are not yet present.

Bruising of the head and neck in skull fractures has been found to be highly correlated in abused children. Schutzman et al[14] noted in 2001 that scalp swelling has a high degree of specificity for the presence of skull fracture in patients with minor accidental head trauma. Our data indicate that subgaleal hematomas are clinically important in suspected inflicted trauma as well. Subgaleal hematomas are known to be difficult to appreciate on examination, or may have a delay in the appearance of the full extent of injury.[14-18] A high degree of clinical suspicion should be used when examining the scalp of children who are suspected victims of child abuse.

Some authors have suggested that the absence of bruising or other external signs of trauma is an indicator that a bone disorder may be present. Paterson,[8] in a response

to an article by Chapman[19] regarding copper deficiency in infants and the bony findings seen in these rare patients, commented on the relative lack of trauma seen in copper-deficient patients, implying that the trauma necessary to cause fracture in these patients was less, resulting in the lack of skin findings. In his response to Paterson, Chapman[8(p213)] commented on the anecdotal clinical observation that normal children with acute trauma are noted not to have external signs of trauma. He also noted that, in abused infants, the lack of external signs of injury is not unusual, due to twisting far from the fracture site or the passage of time in occult healing fractures. Paterson asserted in a different letter to the editor[7] that transverse fractures and recent or multiple fractures with lack of bruising should serve as a "more significant pointer" to the clinician that a metabolic bone disorder might be present. Our data indicate that bruising is entirely absent in well over half of infants and children with inflicted fractures. While noninflicted etiologies also should be considered in any patient with suspected abuse, the absence of skin findings does not necessarily indicate the presence of a rare metabolic disorder.

One of our patients with healing and acute fractures, including multiple rib and classic metaphyseal lesions, was determined by tissue biopsy to have osteogenesis imperfecta. Rib fractures and classic metaphyseal lesions are rare in osteogenesis imperfecta.[20] This patient also had retinal hemorrhages, acute and chronic subdural hematomas, and adrenal hemorrhage. His caregiver admitted to abusing him and was imprisoned. This case illustrates that even children with metabolic bone disease can be abused.

There are several limitations to this study. Bruising locations were generalized to the upper extremity, lower extremity, chest, head and neck, back, genitals, abdomen, and buttocks. This generalization makes the exact association of bruising less precise, and increases the chance that a bruise will be associated with the fracture site. The less precise location of bruising therefore may inflate the percentage of children with bruises near their fractures. Our method provided the greatest opportunity for a fracture to be associated with bruising, yet most fractures in this study did not have bruising in the fracture's vicinity. In addition, we included healing fractures, in which sufficient time may have passed such that any initial bruising had faded. A possible confounding factor in examining bruising with acute and healing fractures is the possibility of a child being reinjured, resulting in new bruises that might be interpreted as being related to an older fracture. Again, this could result in an overestimation of fractures with associated bruising.

The passage of time from injury to medical presentation may have decreased the number of patients with bruising noted near the fracture site due to fading of bruises over time. Delay in seeking care is a well-recognized phenomenon in inflicted trauma. Determination of the age of bruising in delayed presentation is not possible due to the well-documented inability to accurately date bruises on examination.[12,13,21] A higher association between fractures and bruising might have been seen in patients with known acute presentation.

A large number of patients had bruising of the head as well as skull fractures. Accidental bruising commonly is seen on the head in ambulatory children, particularly over the bony prominences. Some of the head bruising seen in our patients may have been of accidental origin, thus overestimating the frequency of bruising being associated with inflicted skull fractures. Also, the number of patients with extremity bruising in our study also would seem unusually low, considering that extremity bruising in ambulatory children is encountered frequently as a normal nonabusive finding.[22-25] However, the median age of our patients is a preambulatory 6 months, suggesting such over- or underestimation would be of limited impact because the numbers of accidental extremity bruises are likely to be small. In addition, it is possible with this retrospective study that patient bruising was incompletely catalogued, particularly in locations of common accidental childhood bruising. Last, we examined a group of patients with a diagnosis of child abuse, further selecting for the presence of inflicted fractures. A larger prospective study of all acute fractures in both abused and unabused children likely would reveal additional useful information.

The absence of bruising in patients with suspected inflicted fracture is common. The absence of bruising should not eliminate the possibility of fractures. Only 20.8% of the children had bruises at the site of their fractures, with a preponderance of these being associated with skull fractures. If skull fractures are excluded, less than 10% of all other fractures had nearby bruising. The absence of bruising associated with fractures should not imply the absence of child abuse.

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