Skeletal Surveys in Children With Burns Caused by Child Abuse

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Objective: To determine the frequency of occult fractures in children with suspicious burns compared with children with other types of physical abuse.

Methods: Child abuse outpatient clinic reports and inpatient consultations from a midwest urban children's hospital for 1989 to 2000 were reviewed. Demographic and clinical data were abstracted for patients seen because of suspected physical abuse. Patients were classified based on reason seen (burns vs other physical injuries), whether they were diagnosed as abused, and whether they had at least 1 skeletal survey. Positive skeletal surveys were defined as having a fracture that was unexplained, highly specific for abuse, or with a perpetrator confession.

Results: Of 335 patients evaluated, the mean age (±SD) was 1.5 ± 1.9 years, 63% were boys, 64% were white, and 80% had skeletal surveys performed. Reasons for evaluation included 69 (21%) for burns and 266 (79%) for other injuries. After excluding patients without a final diagnosis of abuse and those presenting with obvious fractures, 5 (14%) of 36 burn patients had positive skeletal surveys compared with 45 (34%) of 133 with nonburn injuries ($P = 0.02$). Burn patients were older compared with those with nonburn injuries (mean ages, 1.8 ± 1.5 vs. 1.1 ± 1.6 years; $P = 0.03$) and were more likely to be nonwhite (69% vs. 32%; $P < 0.001$).

Conclusions: Although young children with abusive burns have fewer occult fractures compared with those with other abusive injuries, the frequency of occult fractures is still high enough to warrant the consideration of skeletal surveys in these cases.

Key Words: child abuse, burns, occult fractures, skeletal surveys

Skeletal surveys are recommended in children younger than 2 years with unexplained or suspicious injuries, because of the known high frequency of occult fractures identified.[1] In children with burns caused by abuse, however, the prevalence of occult fractures is reported to be very low. In a retrospective review during a 30-month period, Belfer et al[2] reported that only 1% of patients with nonaccidental burns had an occult fracture. In that study, however, a skeletal survey was performed in only 20% of patients with nonaccidental burns, and patient age was not reported. If there was a significant number of children younger than 2 years with nonaccidental burns and who did not have a skeletal survey performed, it is possible that the prevalence of occult fractures in this population was underestimated.

The objective of this retrospective study was to determine the frequency of occult fractures in children with suspicious burns and to compare this frequency with that observed in association with other types of physical abuse.

METHODS

Medical records for patients seen in the outpatient child abuse clinic and for inpatient child abuse consultations at a midwest urban children's hospital during 1989 to 2000 were reviewed. Demographic and clinical data for patients seen because of suspected physical abuse were abstracted. The data reviewed and abstracted included patient's age, sex, and race, reason seen, date examined, initial history, physical findings, laboratory results, radiographic findings, social work evaluation, identity of the alleged perpetrator (if known), information from involved child protective services and law enforcement agencies, and clinical outcome.

Patients were classified based on the primary reason for consultation (burns vs. other physical injuries) and whether physical abuse was present. The method for diagnosis of physical abuse was adapted from previously described criteria.[3,4] These include 7 diagnostic categories: definite abuse, likely abuse, questionable abuse, unknown cause, questionable accident, likely accident, and definite accident. Definite abuse was diagnosed, for example, if any of the following was present: perpetrator confession, eye-witness, positive skeletal survey, other types of injury suggestive of abuse (eg, pattern skin injuries, internal injuries), or a suspicious injury later followed by definite abuse. Likely abuse was diagnosed if the patient's presenting injury was considered suspicious for abuse by the treating physicians *and* the history offered was inconsistent (ie, implausible or no history, changing history, or delay in seeking care). Questionable abuse was diagnosed when an injury was not considered suspicious or was of uncertain cause *and* the history offered was inconsistent. For this study, the diagnosis of physical abuse was made for patients who were classified in either the definite abuse or likely abuse categories.

Patients were further classified based on whether they had at least 1 skeletal survey. Positive skeletal surveys were

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TABLE 1. Characteristics of the Patients With Abusive Injuries

Variable	All Patients (n = 285)	Burns (n = 54)	Nonburn Injuries (n = 231)	*P* (Burns vs Nonburn Injuries)
Age (mean ± SD), yrs	1.5 ± 2.0	2.1 ± 1.6	1.4 ± 2.1	0.01
Age category, yrs				
<2.0	211 (74)	32 (59)	179 (78)	0.01
≥2.0	74 (26)	22 (41)	52 (22)	
Sex				
Male	178 (62)	35 (65)	143 (62)	0.69
Female	107 (38)	19 (35)	88 (38)	
Race				
White	180 (63)	20 (37)	160 (69)	<0.001
Black/other	105 (37)	34 (63)	71 (31)	
Skeletal survey				
Positive	104 (37)	5 (9)	99 (43)	<0.001
Negative	132 (46)	31 (57)	101 (44)	
Not done	49 (17)	18 (33)	31 (13)	

Values for categorical variables represent number of patients (%). Percentages may not total 100 because of rounding off.

defined as having a fracture that was unexplained, highly specific for abuse, or associated with a perpetrator confession. Fractures considered highly specific for abuse were classic metaphyseal lesions, posterior rib fractures, scapular fractures, spinous process fractures, and sternal fractures.[5]

Comparisons between patients with abusive burns versus nonburn abusive injuries, and, within the abusive burns group, between contact versus scald burns were made with χ^2 or Fisher exact tests for proportions and 2-sample *t* tests for means. *P* values of less than 0.05 were considered statistically significant. All statistical analyses were performed with SPSS Version 10.0 for Windows (SPSS Inc, Chicago, Ill).

The research protocol was approved by the institutional review boards of The Children's Medical Center of Dayton and Wright State University.

RESULTS

A total of 335 patients were evaluated for suspected physical abuse. Mean age ± SD was 1.5 ± 1.9 years, 63% were boys, and 64% were white. Reasons for evaluation included 69 (21%) for burns and 266 (79%) for other injuries.

As is usual in clinical practice, skeletal surveys were performed before the final diagnosis of abuse. Of the 335 patients evaluated for suspected physical abuse, 267 (80%) had at least 1 skeletal survey performed. Skeletal surveys were obtained more frequently in patients with nonburn injuries (227/266, 85%) than in patients with burns (40/69, 58%) ($P < 0.001$). However, among all 335 subjects, those with burns were older than those with nonburn injuries (mean ages, 2.2 ± 1.6 years vs. 1.3 ± 2.0 years; $P = 0.001$). Forty percent (106/267) of patients evaluated for suspected physical abuse and who had at least 1 skeletal survey had a positive skeletal survey: 5 (12%) of 40 burn patients compared with 101 (44%) of 227 with other injuries ($P < 0.001$).

Of the 335 patients, 285 were diagnosed with physical abuse (255 [76%], classified as definite abuse, and 30 [9%], classified as likely abuse). The 255 patients classified as definite abuse included 47 with burns and 208 with nonburn injuries. The 30 patients classified as likely abuse included 7 with burns and 23 with nonburn injuries. As noted previously, not all had skeletal surveys performed.

Characteristics of the 285 patients diagnosed with physical abuse are shown in Table 1. Patients with abusive

TABLE 2. Types of Burns in the 54 Patients With Abusive Burns

Type of Burn and Agent/Mechanism	No. (%) All Burns
Contact	15 (27.8)
Curling iron	2 (3.7)
Flame	2 (3.7)
Iron	2 (3.7)
Blow dryer	1 (1.9)
Chemical	1 (1.9)
Flame and cigarette	1 (1.9)
Light bulb	1 (1.9)
Melted plastic	1 (1.9)
Stove	1 (1.9)
Unknown	3 (5.6)
Scald	38 (70.4)
Immersion	20 (37.0)
Splash/grease	5 (9.3)
Unknown	13 (24.1)
Unknown	1 (1.9)

Percentages may not total 100 because of rounding off.

burns were older and more likely to be nonwhite. With respect to race, all 34 minority patients with abusive burns were black, whereas 61 of 71 minority patients with other types of physical abuse were black. A higher proportion of patients with nonburn abusive injuries had skeletal surveys (87% vs. 67% of patients with abusive burns; $P < 0.001$). However, when only patients younger than 2 years were considered (n = 211), there was no difference in the proportions having skeletal surveys (84% of 32 burn patients vs. 93% of 179 nonburn patients; $P = 0.15$).

Of the 69 patients who presented with burns, 54 (78%) were classified as definite or likely abuse, whereas 231 (87%) of 266 patients with other physical injuries were classified as definite or likely abuse. The difference in proportions was not statistically significant ($P = 0.08$). Table 2 summarizes the types and agents/mechanisms of burns in the 54 patients with burns caused by abuse. Scald burns were most common (70.4% of all burns), and the most common type of scald burn was an immersion burn (20/38). Contact burns accounted for 27.8% of all abusive burns; the mechanism was identified in 12 of 15 and involved 9 different agents. Locations of burns by burn type are shown in Table 3. Because there were 23 combinations of burn location patterns, they were collapsed into the groupings listed in the table. Also because of the multiple combinations of patterns and the small numbers present within many of the groups, meaningful statistical analysis could not be done.

TABLE 3. Locations of Burns in the Patients With Abusive Burns*

Burn Locations	Contact Burns No. Patients (n = 15)	Scald Burns No. Patients (n = 38)
Single location	n = 8	n = 16
Head† only	0	1
Trunk‡ only	2	2
Upper extremities§ only	3	1
Lower extremities‖ only	3	11
Buttocks/genitalia/ perineum only	0	1
Multiple locations	n = 7	n = 22
Head and other	4	6
Trunk and other	2	12
Upper extremities and other	5	9
Lower extremities and other	3	20
Buttocks/genitalia/ perineum and other	1	10

The 29 patients with more than 1 burn location are counted in all of the applicable burn locations listed under ''multiple locations.''

*The 54 abusive burn patients included 1 patient in whom it was unknown whether the burn was contact or scald. The burn location for this patient was ''lower extremities only.''

†Head includes face.

‡Trunk includes chest, back, axillae.

§Upper extremities include one or both.

‖Lower extremities include one or both.

TABLE 4. Comparisons Between Patients With Abusive Contact and Abusive Scald Burns

Variable	Contact Burns (n = 15)	Scald Burns (n = 38)	*P* (Contact vs Scald Burns)
Age (mean ± SD), yrs	2.9 ± 2.2	1.9 ± 1.3	0.11
Age category, yrs			
<2.0	7 (47)	24 (63)	0.27
≥2.0	8 (53)	14 (37)	
Sex			
Male	11 (73)	23 (61)	0.38
Female	4 (27)	15 (39)	
Race			
White	4 (27)	16 (42)	0.30
Black/other	11 (73)	22 (58)	
Skeletal survey*			
Positive	0 (0)	5 (13)	0.12
Negative	7 (47)	23 (61)	
Not done	8 (53)	10 (26)	
Maximal burn depth			
Partial thickness	12 (80)	35 (92)	0.33
Full thickness	3 (20)	3 (8)	
Burn body surface area, %			
0–10	14 (93)	27 (71)	0.24
11–15	1 (7)	5 (13)	
>15	0 (0)	6 (16)	

Values for categorical variables represent number of patients (%). Percentages may not total 100 because of rounding off.

*For the patient in which it was unknown whether the burn was contact or scald, a skeletal survey was performed and was negative.

Scald burns, however, were noted to be more common than contact burns on the lower extremities, trunk, and buttocks/genitalia/perineum. Table 4 compares demographic variables, skeletal survey results, and burn severity among patients with abusive contact and scald burns. There were no significant differences between groups for any variable; however, sample sizes were small.

To assess the frequency of occult fractures among patients diagnosed with definite and/or likely abuse, patients who did not have a skeletal survey performed and those in whom a fracture was obvious or suspected on initial examination were excluded (Fig. 1). Therefore, 169 patients remained who were diagnosed with definite or likely abuse, had a skeletal survey performed, and presented without an obvious fracture. These 169 patients included 36 of the 40 who presented with burns and had at least 1 skeletal survey and 133 with nonburn injuries. Five (14%) of 36 burn patients had a positive skeletal survey compared with 45 (34%) of 133 with nonburn injuries ($P = 0.02$). For these subgroups, burn patients were also older compared with those with nonburn injuries (mean ages, 1.8 ± 1.5 vs. 1.1 ± 1.6 years; $P = 0.03$) and more likely nonwhite (69% vs. 32%; $P < 0.001$).

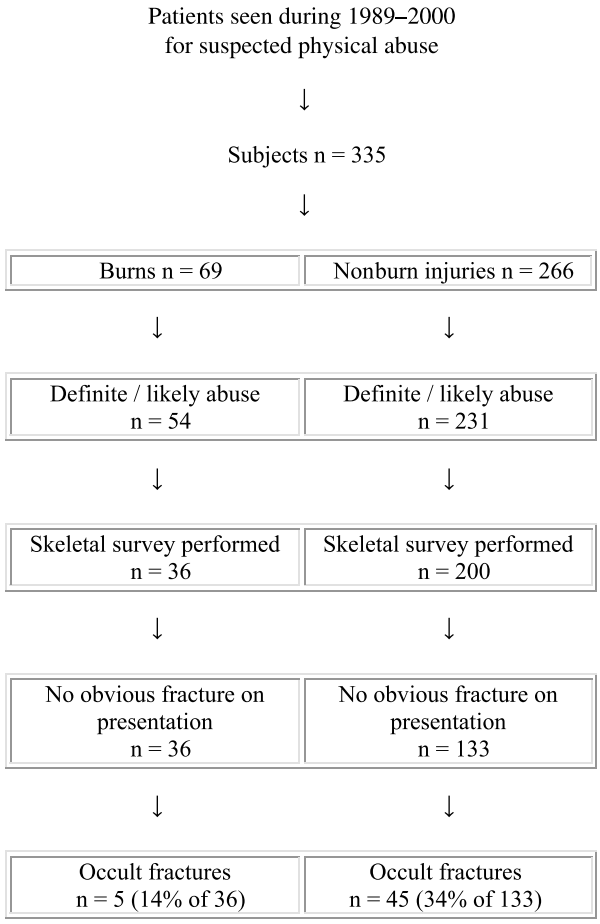

FIGURE 1. Occult fractures in patients with abusive injuries.

Fifty-seven (21%) of the 267 patients who had skeletal surveys performed also had follow-up skeletal surveys, generally done 2 weeks after having obtained the initial radiographs. Of the patients who had follow-up skeletal surveys, 55 presented with nonburn injuries and 2 with burns. Of the 55 patients with nonburn injuries who had follow-up skeletal surveys performed, 5 had fractures identified on the follow-up survey considered indicative of or suspicious for abuse. There were 9 total fractures involving the ribs (6), femur, tibia, and skull. All of these fractures were felt to have been present at the time of the patients' initial presentations because they were healing at the time of the follow-up survey, the findings were questionable but not definitive on the initial skeletal survey, or after being recognized on the follow-up survey, the findings were noted in retrospect upon re-reviewing the initial survey. The follow-up skeletal surveys performed in both patients who presented with burns were negative for occult fractures.

A total of 285 occult fractures were identified among 50 patients with abusive injuries (Table 5). Five patients with abusive burns had a total of 44 occult fractures (mean, 8.8 occult fractures per patient) compared with 45 patients with nonburn abusive injuries who had 241 occult fractures (mean, 5.4 occult fractures per patient). More than half of the occult fractures in each group were rib fractures, and more than half of the patients in each group had occult rib fractures. The next most frequent occult fracture involved the femur, accounting for 18% of occult fractures in the burn patients and 8% of occult fractures in nonburn patients. Both groups had occult fractures involving the ribs, clavicles, humeri, femora, and tibias. Occult fractures involving the skull bones, radii, ulnas, hand bones, and fibulae were observed only in the nonburn group.

TABLE 5. Occult Fractures by Location Among Patients With Abusive Burns and Nonburn Abusive Injuries

	Patients With Abusive Burns (n = 5)		Patients With Nonburn Abusive Injuries (n = 45)	
Location and Bone*	**No. Fractures (% of Total)**	**No. Patients**	**No. Fractures (% of Total)**	**No. Patients**
Skull	0 (0)	0	35 (14)	12
Trunk				
Rib	25 (57)	4	152 (63)	26
Clavicle	4 (9)	2	2 (1)	2
Upper extremity				
Humerus	3 (7)	1	4 (2)	3
Radius	0 (0)	0	5 (2)	5
Ulna	0 (0)	0	4 (2)	4
Hand	0 (0)	0	2 (1)	1
Lower extremity				
Femur	8 (18)	3	20 (8)	10
Tibia	4 (9)	2	16 (7)	13
Fibula	0 (0)	0	1 (<1)	1
Total	44 (100)		241 (100)	

*No spine, scapula, pelvis, or foot fractures were identified.

DISCUSSION

In this series, young children with abusive burns were found to have fewer occult fractures compared with those with other abusive injuries. However, the frequency of occult fractures in patients with abusive burns (14%) is still high enough to be considered clinically significant.

In the previously cited study, Belfer et al[2] reported only 1 of 75 patients with nonaccidental burns to have an occult fracture. However, only 15 (20%) of the patients with nonaccidental burns actually had a skeletal survey performed, and their age breakdown was not specified. Therefore, it is possible that the prevalence of occult fractures in such patients may have been underestimated. To fairly compare our results with those of Belfer et al[2], if all 54 patients diagnosed with abusive burns in the present study were considered (not just the 36 who received skeletal surveys), the frequency of occult fractures would decrease from 14% to 9% (5/54). On the other hand, if all 18 patients who did not have skeletal surveys actually had an occult fracture, then the frequency could be as high as 42% (23/54).

In the present study, considering patients of all ages, a skeletal survey was obtained in only 58% of patients with burns compared with 85% of patients with nonburn injuries. Therefore, the frequency of occult fractures among burn patients may have been underestimated. Still, the proportion of burn patients who had skeletal surveys performed compares favorably with 20% in the only other published study referenced above.[2] Current recommendations for skeletal surveys in children with suspicious injuries include performing one in all such children younger than 2 years.[1] In our study, 84% of patients with suspicious burns who were younger than 2 years had a skeletal survey performed.

Compared with patients with other forms of physical abuse, our patients with abusive burns were older. Their mean age of 2.1 years is similar though to other reports of children with burns caused by abuse.[6–8] Also of note in our study is the higher proportion of black children with abusive burns compared with patients with nonburn abusive injuries. Among our subjects with abusive burns classified by type (contact or scald), there was no significant difference by race. However, the sample sizes were small. Previous studies have documented an increased burn rate among black children or a higher percentage of black children with abusive burns compared with white children.[7,9,10] In these studies, the reason for this higher frequency among blacks is neither identified nor explained. The authors are not aware of any other published data to suggest a reason why burns are more frequent among black children. It is possible that coexisting confounding variables may have been present. For example, could the families in which children had burns have more children or increased social isolation? Such factors could not be assessed in this retrospective study. Another possibility could be a relationship to public housing, where tenants usually have little or no control over the thermostat settings on their hot water heaters.

In this study, patients with abusive burns who had occult fractures averaged more fractures per patient compared with patients with nonburn abusive injuries. The most common bone injuries in both groups were rib fractures, followed by femur fractures. This pattern is similar to that described by Belfer et al.[2] Other studies evaluating the utility of skeletal surveys in children seen for possible maltreatment have shown skull fractures to be the most common bone injury, followed by rib and long bone injuries.[11,12] Merten et al[11] reported 161 fractures among 494 abused children who had complete skeletal surveys. Physical abuse was not differentiated by type, so the number of patients with burns was not identified. Skull fractures were the most frequent (34%), followed by rib and epiphyseal/metaphyseal fractures (19% each). However, only 43% of these fractures were occult, and occult fractures were not reported by site. Ellerstein and Norris[12] described 8 patients with 11 occult fractures, among 331 children who had skeletal surveys as part of their evaluation for possible abuse. None of the 8 patients with occult fractures had burns; however, the proportion of total subjects with burns was not identified. The most common fractures involved the skull in 3 patients, femur in 2 patients, and rib in 2 patients. Interestingly, in the present study, there were no skull fractures noted in the children with abusive burns.

The value of follow-up skeletal surveys in cases of suspected physical abuse was first reported in 1996 by Kleinman et al.[13] Since the present study began in 1989, during the first several years, follow-up skeletal surveys were not routinely considered. Five additional patients who presented with nonburn injuries were found on follow-up skeletal surveys to have occult fractures felt to be indicative of or suspicious for abuse. If these patients had not had follow-up skeletal surveys, then the proportion in the nonburn injury group with occult fractures would have been lower (40/133 [30%] rather than 45/133 [34%]) and thus closer to that in the burn group. On the other hand, if follow-up skeletal surveys had been performed more systematically, both the frequency of occult fractures and difference between groups could have changed in either direction. We do not know if the difference between groups would have changed and in what direction.

There are several limitations to this study. The generalizability of the study is limited because it involved 1 urban children's hospital using a single physician examiner. In addition, a potential for misclassification of child abuse exists; however, we used a previously studied classification of abuse to limit this potential concern.[3,4] Another potential limitation relates to how the diagnosis of abuse is made and the possibility of circular reasoning. For example, of the 69 patients in this study who presented with burns, 40 had a skeletal survey performed. Of those 40 patients, 36 were diagnosed with definite or likely abuse. The question may be asked whether a negative skeletal survey had any influence on ruling out the diagnosis of abuse in 4 children, or was the diagnosis made independent of the skeletal survey results? Excluding such patients would decrease the denominator and therefore increase the incidence of abuse. For example, if we had required that the diagnosis of abuse be made independent of the skeletal survey results, and the 4 patients mentioned above were diagnosed as abused, then the proportion of patients with abusive burns who had occult fractures would

have been 5 (12.5%) of 40, rather than 5 (13.8%) of 36. It is unlikely that this represents a limitation though for the following reasons. In clinical practice, using the information from a skeletal survey does influence the physician's index of suspicion regarding whether abuse is present. This practice, however, should influence the results in both groups of patients (burn injuries and nonburn injuries) similarly. Furthermore, in comparing the proportions mentioned above, one realizes that there is little difference between 12.5% and 13.8%.

The results of this study show that, although the frequency of occult fractures was lower among young children with abusive burns than other abusive injuries, it is still quite high and clinically significant. Skeletal surveys should therefore always be considered to be part of the evaluation of any infant and young child with suspicious burns.

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