Understanding Bilateral Skull Fractures in Infancy
A Retrospective Multicenter Case Review

Mandy A. O'Hara, MD, MPH,*† Thomas J. Valvano, MD, JD,‡ Marisha Kashyap, MPH,§ Jennie C. Daly, MD,‖
Angela N. Bachim, MD,¶ Marguerite M. Care, MD,# Melissa K. Egge, MD,‖ Jamie S. Kondis, MD,**
Ann M. Lenane, MD,†† Alexis B.R. Maddocks, MD,‡‡ James B. Metz, MD,§§ Anne K. Nielsen, CPNP,‖‖‖
Kristen N. Reeder, MD,¶¶ Michelle T. Ruda, MD,## Rachel Segal, MD,‖‖‖‖ Jacqueline M. Sugarman, MD,***
Kerri Weeks, MD,††† and Resmiye Oral, MD‡‡‡

Background: Bilateral skull fractures in infancy often raise suspicion for abuse. Nevertheless, literature suggests that they may occur accidentally. However, empiric data are lacking.

Objective: This multicenter retrospective review aimed to characterize bilateral skull fractures in a large sample.

Participants and Setting: Medical records for infants younger than 24 months with bilateral skull fractures involving hospital consultation with a child abuse pediatrician (CAP) were reviewed from 2005 to 2020 at 13 nationally represented institutions.

Methods: Standardized data collection across institutions included historical features, fracture characteristics, and additional injuries, as well as the CAP's determination of accident versus abuse. Pooled data were analyzed for descriptive and bivariate analyses.

Results: For 235 cases, 141 were accidental, and 94 abuse. The majority occurred in young infants, and a history of a fall was common in 70% of cases. More than 80% involved both parietal bones. Bilateral simple linear fractures were more common in accidental cases, 79% versus 35%, whereas a complex fracture was more frequent in abuse cases, 55% versus 21% ($P < 0.001$). Almost two thirds of accidental cases showed approximation of the fractures at the sagittal suture, compared with one third of abuse cases ($P < 0.001$). Whereas focal intracranial hemorrhage was seen in 43% of all cases, diffuse intracranial hemorrhage was seen more in abuse cases (45%) than accidents (11%). Skin trauma was more common in abusive than accidental injury (67% vs 17%, $P < 0.001$), as were additional fractures on skeletal survey (49% vs 3%, $P < 0.001$).

Conclusions: A fall history was common in bilateral skull fractures deemed accidental by a CAP. Most accidental cases involved young infants with biparietal simple linear fractures, without skin trauma or additional fractures. A skeletal survey may aid in the determination of accidental or abusive injury for unwitnessed events resulting in bilateral skull fractures in infants.

Key Words: skull fracture, bilateral, biparietal, accident, abuse

S kull fractures in infancy are common in both accidental and inflicted injury.[1] Simple linear fractures of the parietal bone are the most common type of skull fracture in both accidents and abuse.[2,3] However, certain fracture characteristics, including multiple, bilateral, or complex skull fractures, have been shown to be associated with abuse in some studies,[4–6] although not so in a more recent study.[7] The finding of bilateral skull fractures in an infant often prompts consultation with a child abuse professional to assist with determining the likelihood of abuse. When the mechanism of injury provided on history does not seem plausible, concern for inflicted injury may lead to child protection involvement. Although often suspicious for abuse, some literature supports that complex skull fractures, including bilateral fractures, can occur accidentally,[7–9] even from a single impact event.[10–12] Literature from the field of forensic pathology describes the pliable nature of the infant skull supporting the possibility of a skull fracture resulting from direct or indirect force—with inbending of the skull at the point of impact and outbending of the adjacent site.[9,13,14] A review of bilateral skull fractures in infancy proposed 3 general mechanisms of injury, including single impact, double impact, and compression mechanisms.[15] Nevertheless, empiric data describing bilateral skull fractures are limited. In one cadaver study that included a case of a single impact fall resulting in bilateral skull fractures, the study lacked historic detail about the anatomic impact site.[9,16] Only a few in vivo case reports exist in the literature describing bilateral skull fractures, caused by falls and crush/compression. These include accidental single impact falls to the vertex or midline posterior occiput,[10–12,17] double impact including 2 separate events or stair falls,[12,15,18] dog bite crush injury,[19] compression of the head between two unyielding surfaces,[20] and confession of abusive compression of the head with hands and arms.[21] Even when a mechanism is presented on history, bilateral skull fractures may still raise suspicion for abuse because of limited understanding of these injuries leading to question of plausibility for nonwitnessed events. In a recent study of witnessed accidental cases, the series was limited to 3 cases, which included a fall from the father's arms on stairs from a height of 121 cm, a similar height fall from a sibling's arms, and a fall from a changing table.[12]

A thorough understanding of bilateral skull fractures is crucial to prevent over-calling abuse or mistaking inflicted injury as

From the *Department of Pediatrics, New York-Presbyterian Hospital, Vagelos College of Physicians and Surgeons, Columbia University Irving Medical Center, New York; NY; †Department of Pediatrics, Albert Einstein College of Medicine, Children's Hospital at Montefiore, Bronx, NY; ‡Department of Pediatrics, Oregon Health and Science University, Portland, OR; §Mailman School of Public Health, Columbia University, New York, NY; ‖Department of Pediatrics, Loma Linda University Children's Hospital, Loma Linda, CA; ¶Department of Pediatrics, Baylor College of Medicine, Texas Children's Hospital, Houston, TX; #Department of Radiology and Medical Imaging, Cincinnati Children's Medical Center, Cincinnati, OH; **Department of Pediatrics, St. Louis Children's Hospital, St. Louis, MO; ††Department of Pediatrics, University of Rochester Medical Center, Rochester, NY; ‡‡Department of Radiology, New York-Presbyterian Hospital, Vagelos College of Physicians and Surgeons, Columbia University Irving Medical Center, New York, NY; §§Department of Pediatrics, University of Vermont Children's Hospital, Burlington, VT; ‖‖Department of Pediatrics, University of Iowa Stead Family Children's Hospital, Iowa City, IA; ¶¶Department of Pediatrics, UT Southwestern Medical Center, Dallas; ##Department of Pediatrics, University of Texas Health Science Center, Houston, TX; ***Department of Pediatrics, Kentucky Children's Hospital, University of Kentucky, Lexington, KY; †††Department of Pediatrics, Wesley Children's Hospital, Wichita, KS; and ‡‡‡Department of Pediatrics, Children's Hospital at Dartmouth, Lebanon, NH.
Disclosure: The authors declare no conflict of interest.
Reprints: Mandy A. O'Hara, MD, MPH, J.E. and Z.B. Butler Center for Families and Children, Children's Hospital at Montefiore, 3314 Steuben Ave, Bronx, NY 10467 (e-mail: manohara@montefiore.org).
Copyright © 2022 Wolters Kluwer Health, Inc. All rights reserved.
ISSN: 0749-5161

accidental. Given the paucity of empiric data on bilateral skull fractures in infancy, this retrospective case review sought to describe characteristics of bilateral skull fractures in infancy for a large sample involving child abuse hospital consultation to determine accident versus abuse.

METHODS

Study Design

Based on solicitation for cases on the child abuse medical provider professional society listserv, a total of 13 nationally represented hospitals volunteered to submit cases for this study. This included performing retrospective case reviews of medical records for infants younger than 24 months with bilateral skull fractures involving child abuse pediatrics or hospital child protection consultation. Because there is no *International Classification of Diseases, Ninth Revision or Tenth Revision*, code specific for bilateral skull fractures, cases for study inclusion were obtained from each coinvestigator searching their institution's child protection consultation database. As such, the time frame for cases included in this study varied for each institution, with a range from 2005 to 2020. Bilateral skull fractures included at least 1 left-sided fracture and at least 1 right-sided fracture, such that biparietal fractures, nonparietal fractures, or more than 2 fractures on either side were included as long as at least 2 fractures were located on contralateral sides of the cranium. This was determined based on medical record review of the radiographic report of skull films and neuroimaging as available for each case. Neuroimaging consisted of computed tomography (CT) scans for 98% of cases submitted, whereby, for a small percentage of cases, bilateral skull fractures were diagnosed by plain films with head magnetic resonance imaging obtained and reviewed for additional data. When available, radiographic reports of 3-dimesional (3D) reconstruction of CT imaging were reviewed as well to determine the presence of bilateral skull fractures, and this was the case for 70% of cases submitted for this study. All participating institutions obtained institutional review board approval and submitted a data use agreement with the lead institution Columbia University, where data were stored and analyzed.

Coinvestigators were trained in utilization of a standardized codebook for data extraction into an Excel spreadsheet, based on review of the medical record. Multiple variables were coded for each case, including demographics, historical features, fracture characteristics, additional findings of trauma, and psychosocial risk. Main historical variables included whether there was a history of a fall, and if so, further details included fall description, height, and impact surface. Psychosocial risk factors were recorded as a dichotomous variable based on review of the medical documentation and included domestic violence, prior child protective services reporting, caregiver substance abuse, caregiver mental illness contributing to risk for abuse, teenage parenthood, housing instability, or other identified risk.

Fracture characteristics included fracture location, fracture type, overlying scalp hematomas, and approximation at the sagittal suture. Fracture location was defined as both fractures of the parietal bone versus 1 or both skull fractures involving a nonparietal bone. Fracture type was defined as simple linear horizontal or vertical, versus complex defined as branching, comminuted, significantly depressed, stellate, or ping-pong. Approximating at the sagittal suture was defined as both left and right fractures vertically connecting with or just adjacent to the sagittal suture, based on each coinvestigator's view of the neuroimaging if not documented in a written report. Data for scalp hematomas or scalp abrasions were assessed as overlying one, both, or neither fracture.

Additional injurious findings included intracranial hemorrhage (ICH); oral, skin, or abdominal trauma; additional fractures; or retinal hemorrhages. Intracranial hemorrhage was categorized as focal if there was a subdural, epidural, or subarachnoid hemorrhage directly underlying a fracture site and diffuse if ICH extended beyond the fracture site on either or both sides. Oral trauma was defined as frenulum tear, tongue trauma, gingival or tooth trauma, or any other intraoral injury. Traumatic skin findings were defined as any acute trauma to the skin including bruise, abrasion, laceration, contusion, petechiae, or burn. Abdominal trauma was defined as either occult trauma based on elevated pancreatic or liver (>80 U/L) enzymes or injury seen on abdominal radiographic imaging. Additional fracture on skeletal survey and data on the presence or absence of retinal hemorrhages were also collected when available. Any additional fracture identified on either the initial skeletal survey, a follow-up skeletal survey, or both was considered a positive skeletal survey.

Each coinvestigator submitted only those cases that involved consultation at the time of injury with the hospital's child abuse consultation team. Most teams included a child abuse pediatrician (CAP). Child abuse pediatricians are physicians with expertise in evaluating child abuse and use information from the medical evaluation, child protective services investigation, and any law enforcement investigation to formulate a final opinion about the cause of injury. The team's final determination of cause of injury at the time of initial consultation was recorded as definite accidental trauma, definite abusive injury, or indeterminate if a definite determination was not made. Cases with an indeterminate outcome, or that did not have a CAP's expertise at the time of consultation, were excluded for purposes of this study.

Statistical Analysis

Pooled data were exported into SPSS version 28 for statistical analysis. Descriptive and bivariate analyses were completed including Pearson χ^2 tests comparing accidental versus abusive cases. A subanalysis of the accidental cases with a reported history of a fall was performed for descriptive findings.

RESULTS

A total of 293 cases were obtained for review. Exclusion criteria included 53 cases that were indeterminate for abuse or accident and 5 cases that did not involve a CAP in consultation, resulting in a final sample size of 235 (Fig. 1). There were 94 cases determined to be from abuse and 141 cases from accidental injury in the final analysis.

As shown in Table 1, 70.6% of cases were younger than 6 months, 57% were male sex, and 45.1% were identified as minority race. There were slightly more minority infants in the abuse cases compared with those determined to be accidental (52.1% vs 40.4%, $P = 0.037$). One third of the overall sample had psychosocial risk factors documented on medical record review, more so in abuse cases than accidents (52.1% vs 21.3%, $P < 0.001$). A history of a fall was provided for 69.8% of cases overall and was more common in accidents (90.8% vs 38.3%, $P < 0.001$).

As seen in Table 2, most cases (84.3%) were bilateral parietal in location. For 61.7% of all cases, both fractures were simple linear, and for 34.5%, at least 1 of the fractures was complex. Half of the cases had fractures approximating at the sagittal suture.

Almost a third of cases did not have intracranial hemorrhage, whereas focal ICH was more common than diffuse ICH (43.0% vs 24.3%). Most cases, 92.4%, had scalp hematomas overlying 1 or both fractures. Additional findings on skeletal survey were found in 21.3%, with 7.7% of the sample missing these data. Information on the presence or absence of retinal hemorrhages was only
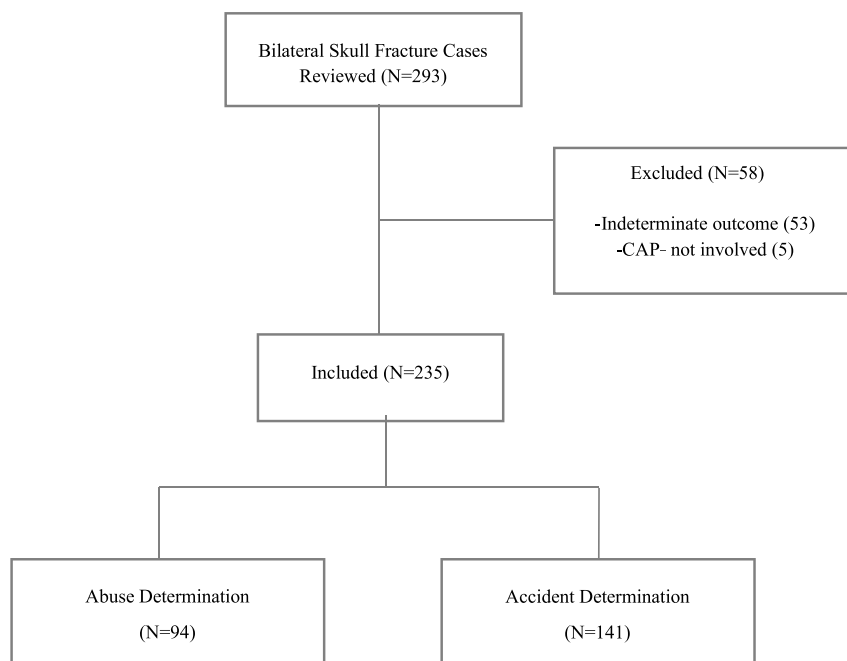
FIGURE 1. Study flow diagram of cases reviewed and included in study.

available on 71.5% of the data and was present in 8.9% of all cases. Injurious skin findings were present in 34.9% of cases. Oral trauma or abdominal trauma was infrequent, in only 6% and 12% of cases, respectively.

Regarding fracture characteristics, for both abuse and accidents, biparietal skull fractures were the majority—greater than 80%. However, the abuse cases were more likely to have at least 1 complex fracture compared with the accidental cases (55.3% vs 20.6%, $P < 0.001$). The 2 fractures approximating at the sagittal suture was observed in 58.9% of accidental cases and only 33% of abuse cases ($P < 0.001$). Overlying scalp hematomas were common in more than 90% of both cases. Although it was not uncommon

to have no ICH for either case, diffuse ICH was more common in abuse cases (44.7%), and focal ICH was more common in accidents (52.5%).

When analyzing those cases determined to be accidental, additional injurious findings were uncommon. Skeletal surveys showed additional fracture in only 2.8% of accidental cases, versus 48.9% of abuse cases ($P < 0.001$). Acute injury to the skin occurred in 17% of accidents, compared with 67.1% of cases determined to be abuse ($P < 0.001$).

A separate descriptive analysis of the 70% of cases that had a history of a fall was done (n = 164). Most of these cases, 78%, were determined to be accidental. A descriptive analysis of the subgroup of cases with a history of a fall determined to be

TABLE 1. Demographic and Historical Variables for Cases Deemed Accident Versus Abuse

	All Cases (N = 235)	Accident (n = 141 [60%])	Abuse (n = 94 [40%])	*P*
Age				0.198
<6 mo	169 (70.6%)	104 (73.8%)	62 (66%)	
≥6 mo	69 (29.4%)	37 (36.2%)	32 (34%)	
Sex				0.667
Male	134 (57.0%)	82 (58.2%)	52 (55.3%)	
Female	101 (43.0%)	59 (41.8%)	42 (44.7%)	
Race				0.037
White	111 (47.2%)	75 (53.2%)	36 (38.3%)	
Minority	106 (45.1%)	57 (40.4%)	49 (52.1%)	
Psychosocial risk factor				<0.001
Yes	79 (33.6%)	30 (21.3%)	49 (52.1%)	
No	153 (65.1%)	111 (78.7%)	42 (44.7%)	
Fall history				<0.001
Yes	164 (69.8%)	128 (90.8%)	36 (38.3%)	
No	71 (30.2%)	13 (9.2%)	58 (61.7%)	

  Sum of percentages less than 100% indicates missing data.

TABLE 2. Fracture Characteristics and Additional Findings for Cases Deemed Accident Versus Abuse

	All Cases (N = 235)	Accident (n = 141 [60%])	Abuse (n = 94 [40%])	*P*
Fracture location				0.319
Both parietal	198 (84.3%)	122 (86.5%)	76 (80.9%)	
At least one nonparietal	36 (15.3%)	19 (13.5%)	17 (18.1%)	
Fracture type				<0.001
Both simple linear	145 (61.7%)	112 (79.4%)	33 (35.1%)	
At least one complex	81 (34.5%)	29 (20.6%)	52 (55.3%)	
Approximating at the sagittal suture				<0.001
Yes	116 (49.4%)	83 (58.9%)	31 (33.0%)	
No	114 (48.5%)	57 (40.4%)	59 (62.8%)	
Intracranial hemorrhage				<0.001
Focal	101 (43.0%)	74 (52.5%)	27 (28.7%)	
Diffuse	57 (24.3%)	15 (10.6%)	42 (44.7%)	
None	75 (31.9%)	50 (35.5%)	25 (26.6%)	
Scalp hematoma				0.015
Overlying one fracture	73 (31.1%)	35 (24.8%)	38 (40.4%)	
Overlying both fractures	144 (61.3%)	97 (68.8%)	47 (50.0%)	
None	16 (6.8%)	8 (5.7%)	8 (8.5%)	
Skeletal survey finding				<0.001
Yes	50 (21.3%)	4 (2.8%)	46 (48.9%)	
No	167 (71.1%)	120 (85.1%)	47 (50.0%)	
Not done	18 (7.7%)	17 (12.1%)	1 (1.1%)	
Retinal hemorrhages				<0.001
Yes	21 (8.9%)	3 (2.1%)	18 (19.1%)	
No	147 (62.6%)	80 (56.7%)	67 (71.3%)	
Not assessed	67 (28.5)	58 (41.1%)	9 (9.6%)	
Skin finding*				<0.001
Yes	82 (34.9%)	24 (17.0%)	58 (61.7%)	
No	152 (64.7%)	117 (83.0%)	35 (37.2%)	

Sum of percentages less than 100% indicates missing data.

*Bruise, abrasion, laceration, contusion, petechiae, or burn.

accidental is shown in Table 3. Whereby 39.1% of falls were from furniture, 60.9% were falls from stairs, strollers, caregiver's arms, or other non–furniture-related falls. About half of cases were reported as short falls less than or equal to 3 ft, and the majority (86.7%) were onto hard surfaces, as opposed to carpet, rugs, or grass (9.4%). Skeletal survey was completed for 88% of accidental cases with a history of a fall and was positive for additional fracture in only 3 cases (2.3%).

DISCUSSION

The results from this study demonstrate that bilateral skull fractures in infancy are more commonly determined to be from accidental rather than abusive trauma, especially if there is a history of a fall. Although case reports of bilateral skull fractures exist in the literature,[10–12,15,17] this study is the first of its kind to describe findings for a large sample. As such, this study expands the data that can be used to inform practice.

Although most cases of bilateral skull fractures in this study were young infants younger than 6 months, age span for this study did include 4 cases between the ages of 21 and 24 months. All were biparietal fractures from falls onto hard surfaces, and 3 of them were deemed accidental. Thus, although not frequent in this study, bilateral skull fractures did occur in the older toddler.

Several scalp and fracture characteristics were explored in this study. The presence of scalp hematoma overlying 1 or both fractures was seen in more than 90% of cases, most commonly overlying both fracture sites, in 60%. In contrast to a systematic review of abusive versus nonabusive head trauma that showed scalp hematoma was associated with accidental head injury,[22] scalp hematomas in this sample were common overall in both accidental and abusive injury. A review of the literature has suggested that scalp hematomas overlying both fracture sites in bilateral skull fractures may be associated with a double impact mechanism.[15] Although mechanisms of injury were not assessed in this study, bilateral scalp hematomas may indicate focal impact or localized edema secondary to bone breakage whether or not an impact occurred at that location and may not necessarily indicate double impact.[14]

The vast majority, more than 80%, of cases of bilateral skull fractures in this study were biparietal in location for both accidental and abusive injuries. However, having at least 1 of the bilateral fractures of a complex nature in this sample was more common with a determination of abuse. Complex skull fractures have been shown to have greater association with abuse in some studies, which may be consistent with these findings.[4,23] In contrast, a recent study by Metz et al[8] found that, among children with a complex skull fracture, which included multiple or bilateral skull

TABLE 3. Descriptive Findings for Accidental Cases With a History of a Fall (n = 128)

	n (%)*
Age	
<6 mo	97 (75.8)
≥6 mo	31 (24.2)
Sex	
Male	74 (57.8)
Female	54 (42.2)
Race	
White	70 (54.7)
Minority	50 (39.1)
Psychosocial risk factor	
No	103 (80.5)
Yes	25 (19.5)
Fall type	
Furniture	50 (39.1)
Other falls†	78 (60.9)
Fall height	
Low ≤3 ft	62 (48.4)
High >3 ft	58 (45.3)
Impact surface	
Soft‡	12 (9.4)
Hard§	111 (86.7)
Fracture location	
Both parietal	113 (88.3)
At least one nonparietal	15 (11.7)
Fracture type	
Both simple linear	102 (79.7)
At least one complex	26 (20.3)
Approximating at sagittal suture	
No	50 (39.1)
Yes	77 (60.2)
Intracranial hemorrhage	
Focal	69 (53.9)
None	44 (34.4)
Diffuse	13 (10.2)
Skin finding‖	
No	109 (85.2)
Yes	19 (14.8)
Skeletal survey	
Negative	109 (85.2)
Positive	3 (2.3)

*Sum of percentages less than 100% indicates missing data.

†Other falls: stairs, caregiver arms, strollers, and other/non–furniture falls.

‡Carpet, rug, or grass.

§Hard wood floor, tile, linoleum, or concrete.

‖Bruise, abrasion, laceration, contusion, petechiae, or burn.

fractures, the positive predictive value for abuse was low at 7%. They argue that the type of skull fracture alone cannot determine abuse and that complex skull fractures including multiple fractures occur frequently from accidental injury. In this study, although bilateral skull fractures are common accidental injury, if 1 of the fractures is complex in nature, abuse was more frequent. This finding stresses the importance of identifying fractures accurately, which can be aided by routine use of 3D reconstructive cranial CT images

for infants with bilateral skull fractures as with all infants with head trauma concerning for abuse.[24] Future studies that include 3D reconstructive images for all CT scans may yield more information to aid in understanding fracture complexity for bilateral skull fractures in infancy.

Half of this study's cases showed the 2 fractures approximating at the sagittal suture. This was almost twice as frequent for cases of accidental injury. Whether an impact occurs to the vertex or other location may determine the likelihood of vertical biparietal fractures approaching or connecting with the sagittal suture.[9,10,17] A variable fracture pattern, including both vertically aligned fractures approaching the sagittal suture or horizontally aligned fractures, is possible in accidental injury, based on the recent series of 3 witnessed accidental biparietal skull fractures, where 1 had bilateral horizontal fractures and 2 had bilateral vertical fractures.[12] Future studies including analysis of witnessed mechanisms of injury and impact sites resulting in different patterns of bilateral skull fractures may increase the understanding of fracture patterns for such cases.

In this sample of infants with accidental falls and bilateral skull fractures, there was an equal proportion of cases from low-fall and high-fall heights. Most commonly, the falls were onto hard surfaces. Falls from caregiver's arms and onto stairs were more frequent mechanisms of injury than furniture falls in this study. Literature has shown that falls onto stairs and from caregiver's arms are complex mechanisms that can result in multiple fracture types and more severe injury.[25,26]

One of the key findings from this study was that having an additional fracture on skeletal survey was found in almost half of abuse cases, with the study completed for 99% of these cases. Although completed for only 88% of accidental cases, additional fracture was found in only 3% of accidental bilateral skull fractures. Whether a positive skeletal survey informs the CAP's decision making for determination of abuse or a positive skeletal survey is highly associated with abusive bilateral skull fracture injury warrants further study. It may be that additional fractures do not often occur by the accidental mechanisms that commonly cause bilateral skull fractures. This study's findings support the importance of considering obtaining a skeletal survey as part of the evaluation for an infant presenting with bilateral skull fractures.

LIMITATIONS

There are several limitations to this study. The retrospective design of this study limits the strength of the data. In addition, relying on the CAP's determination of abuse, as opposed to including investigative or legal outcomes, may have limited the accuracy of determinations for these cases. Psychosocial risk for this study was based on review of the medical record, which included risk factors identified at the time of initial consultation. This may be an underrepresentation of risk factors if they were not disclosed. In addition, there was a slightly greater proportion of minority race in the abuse cases. Altogether, race and psychosocial risk factors may raise consideration of bias contributing to an abuse determination. These data were further limited by several cases missing assessments for skeletal survey and retinal hemorrhages. As additional signs of injury are known to increase suspicion for abuse, future prospective studies that include skeletal surveys and dilated retinal examinations for all cases are needed.

CONCLUSIONS

Although bilateral skull fractures in infancy may raise suspicion for abuse, they are often accidental, especially when there is a history of a fall. Additional injurious findings were uncommon in bilateral skull fractures deemed accidental. A thorough evaluation, ideally in consultation with a CAP, should include additional

workup for abuse, including a skeletal survey and neuroimaging, with attention to presence of complex fractures and diffuse intracranial hemorrhage to aid in determining cases of abuse. Simple linear bilateral skull fractures in infancy most commonly result from accidental falls and infrequently cause additional traumatic injury.

REFERENCES

1. Leventhal JM, Martin KD, Asnes AG. Incidence of fractures attributable to abuse in young hospitalized children: results from analysis of a United States database. *Pediatrics*. 2008;122:599–604.

2. Leventhal JM, Thomas SA, Rosenfield NS, et al. Fractures in young children. Distinguishing child abuse from unintentional injuries. *Am J Dis Child*. 1993;147:87–92.

3. Kemp AM, Dunstan F, Harrison S, et al. Patterns of skeletal fractures in child abuse: systematic review. *BMJ*. 2008;337:a1518.

4. Hobbs CJ. Skull fracture and the diagnosis of abuse. *Arch Dis Child*. 1984; 59:246–252.

5. Meservy C, Towbin R, McLaurin R, et al. Radiographic characteristics of skull fractures resulting from child abuse. *Am J Roentgenol*. 1987;149:173–175.

6. Billmire ME, Myers PA. Serious head injury in infants: accident or abuse? *Pediatrics*. 1985;75:340–342.

7. Kleinman PK. *Diagnostic Imaging of Child Abuse*. 3rd ed.. (Press CU, ed). Cambridge, United Kingdon: Cambridge University Press; 2015.

8. Metz JB, Otjen JP, Perez FA, et al. Are complex skull fractures indicative of either child abuse or major trauma in the era of 3-dimensional computed tomography imaging? *Pediatr Emerg Care*. 2020;38:e200–e204.

9. Wood JN, Christian CW, Adams CM, et al. Skeletal surveys in infants with isolated skull fractures. *Pediatrics*. 2009;123:e247–e252.

10. Arnholz D, Hymel KP, Hay TC, et al. Bilateral pediatric skull fractures: accident or abuse? *J Trauma*. 1998;45:172–174.

11. Morse H, Goldthorpe G, Bradford N. When a system of child protection becomes abusive—case report: bilateral linear parietal skull fractures in an infant from accidental occipital trauma. *J S C Med Assoc*. 2013;109:94–95.

12. AlSahlawi A, Morantz G, Lacroix C, et al. Bilateral parietal skull fractures in infants attributable to accidental falls. *Pediatr Neurosurg*. 2021;56:424–431.

13. Case ME. Accidental traumatic head injury in infants and young children. *Brain Pathol*. 2008;18:583–589.

14. Baumer TG, Passalacqua NV, Powell BJ, et al. Age-dependent fracture characteristics of rigid and compliant surface impacts on the infant skull—a porcine model. *J Forensic Sci*. 2010;55:993–997.

15. O'Hara MA. The infant with bilateral skull fractures: diagnostic considerations in consultation with a child abuse pediatrician. *J Inj Violence Res*. 2019;11:15–20.

16. Weber W. Biomechanical fragility of the infant skull. *Z Rechtsmed*. 1985; 94:93–101.

17. Paddock M, Sprigg A, Offiah AC. Imaging and reporting considerations for suspected physical abuse (non-accidental injury) in infants and young children. Part 2: axial skeleton and differential diagnoses. *Clin Radiol*. 2017;72:189–201.

18. Duhaime AC, Alario AJ, Lewander WJ, et al. Head injury in very young children: mechanisms, injury types, and ophthalmologic findings in 100 hospitalized patients younger than 2 years of age. *Pediatrics*. 1992; 90(2 pt 1):179–185.

19. Cowie RA, Tsementzis SA. Bilateral compound fractures of the infant skull caused by dog bite. *Br J Clin Pract*. 1983;37:30–31.

20. Hiss J, Kahana T. The medicolegal implications of bilateral cranial fractures in infants. *J Trauma*. 1995;38:32–34.

21. Brown ECB, Donaruma-Kwoh MM, Otjen JP, et al. 3 Cases of inflicted skull crush injuries in infants. *Pediatr Emerg Care*. 2021;37:e872–e874.

22. Piteau SJ, Ward MG, Barrowman NJ, et al. Clinical and radiographic characteristics associated with abusive and nonabusive head trauma: a systematic review. *Pediatrics*. 2012;130:315–323.

23. Barber I, Perez-Rossello JM, Wilson CR, et al. The yield of high-detail radiographic skeletal surveys in suspected infant abuse. *Pediatr Radiol*. 2015;45:69–80.

24. Parisi MT, Wiester RT, Done SL, et al. Three-dimensional computed tomography skull reconstructions as an aid to child abuse evaluations. *Pediatr Emerg Care*. 2015;31:779–786.

25. Hughes J, Maguire S, Jones M, et al. Biomechanical characteristics of head injuries from falls in children younger than 48 months. *Arch Dis Child*. 2016;101:310–315.

26. Pennock AT, Gantsoudes GD, Forbes JL, et al. Stair falls: caregiver's "missed step" as a source of childhood fractures. *J Child Orthop*. 2014;8: 77–81.