Infants With Isolated Skull Fracture: What Are Their Clinical Characteristics, and Do They Require Hospitalization?

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Data from 34 of our study subjects were presented in abstract form at the Ambulatory Pediatric Association Annual Meeting, May 1995.

Study objective: We sought to identify the historical factors and physical examination findings typical of infants who have sustained isolated skull fracture (ISF)—in the absence of associated intracranial injury—after head trauma. We also assessed the risk of clinical deterioration (and therefore the need for inpatient observation) in infants with ISF.

Methods: We conducted a retrospective analysis of all patients younger than 2 years admitted to a tertiary care pediatric hospital with a diagnosis of ISF over a 3-year period.

Results: During the study period, 101 infants with radiographically proven ISF were admitted to the hospital. Falls were the most common reported mechanism of injury (n=90 [89%]). Many falls involved short distances: 18 patients (18%) fell less than 3 feet. Nonaccidental trauma was suspected in only 10 patients (10%). Seventy-two patients (71%; 95% confidence interval [CI], 61%, 79%) had at least one of the clinical signs considered potential indicators of serious head injury: initial loss of consciousness, seizures, vomiting, lethargy, irritability, depressed mental status, and focal neurologic findings. In 97 patients (96%;95% CI, 89%, 98%), local findings of head injury (palpable fracture, soft-tissue swelling, or signs of basilar skull fracture) were noted on physical examination. None of the patients (0%; 95% CI, 0%, 3%) demonstrated clinical decline during hospitalization. All were neurologically normal on discharge.

Conclusion: A diagnosis of ISF should be considered even in infants with minor mechanisms of head injury who appear well. However, infants with ISF rarely present without local signs of head injury on physical examination. If no other specific clinical concerns necessitate hospital admission, infants with ISF who have reliable caretakers may be considered for discharge home.

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INTRODUCTION

Historically, screening for skull fractures has been performed in head-injured patients as a means of identifying patients at risk for intracranial injury.[1,2] Older guidelines called for hospitalization and observation of any patient with skull fracture resulting from head trauma.[1,2] As computed tomography (CT) has become widely available as a more definitive measure of intracranial injury, the significance of skull fractures in older children and adults has been called into question. Most authors consider the presence of an isolated skull fracture (ISF), in the absence of intracranial abnormalities on CT, to have little effect on treatment or expected outcome for older children or adults.[3-5]

For several reasons, however, infants with ISF should be considered separately from older children and adults. First, many investigators have found infants younger than 2 years to be at especially high risk for skull fractures and intracranial injuries even in cases of minor head trauma.[1,6-10] Second, concern is increasing with regard to recognition of skull fracture in infants, both because of the possibility that the diagnosis may lead to the recognition of child abuse and because of concerns about monitoring the infant with skull fracture for complications such as leptomeningeal cyst ("growing fracture").[6,11-14] Third, the authors of studies of outcome in patients with ISF have generally either explicitly excluded infants or have included only a few infants in the study population. As a result, few data on the clinical course of infants with ISF have been reported.[3,15,16] Because of the paucity of data about the clinical course of such patients, many EDs—among them our own—routinely admit infants with ISF to the hospital for observation.

We undertook our study with these issues in mind. Specifically, our goals were (1) to identify historical factors or physical examination findings typical of infants who have sustained ISF as a result of head trauma and (2) to determine the risk of clinical deterioration (and therefore the need for inpatient observation) in infants with ISF.

MATERIALS AND METHODS

The setting for the study was Boston Children's Hospital, a 300-bed tertiary care pediatric hospital that serves as a Level I pediatric trauma center and has an annual ED volume of 50,000.

We conducted a retrospective analysis of all children admitted to Children's Hospital between January 1, 1992, and December 31, 1994, who met the following criteria: (1) 24 months or younger, (2) no underlying condition that would make fracture more likely (eg, osteogenesis imperfecta), (3) diagnosis of skull fracture confirmed with radiography or CT, and (4) CT showing no acute intracranial injury.

Subjects were identified by a search of the hospital's medical records database for all admissions coded with a discharge diagnosis related to head trauma. Of 180 infants younger than 24 months admitted for head trauma during the study period, a diagnosis of ISF was made in 105 (58%). In four of these subjects head CT was not performed, and therefore intracranial injury could not be definitively ruled out. These subjects were excluded from further analysis, yielding a study group of 101 infants with radiographically proven ISF.

We also reviewed the charts of the other 75 infants with head injury to be certain that none had initially presented with ISF and then later exhibited signs of intracranial injury.

Historical information, physical findings, hospital course, and follow-up information were abstracted from the chart. When historical features (eg, vomiting or seizures) were not documented in the chart, they were presumed not to have occurred. For patients who were referred from other institutions, copies of the records from the referring institutions (included in the patients' charts at our hospital) were also reviewed.

For those patients with histories of falls, if the height of the fall was not noted in the chart, standard height estimates were assigned (falls from beds were assigned a height of 2 feet, falls from couches a height of 1.5 feet, falls from tables a height of 2.5 feet, and falls from an adult's arms a height of 4 feet). Falls down stairs were recorded separately.

Patients for whom any evaluation for incidental injury was undertaken (including any of the following: filing with the state's department of social services, a consultation with the hospital's child-protection team, a skeletal survey, an ophthalmologic consultation to evaluate for retinal hemorrhages, or a nuclear scintigraphy bone scan) were recorded as "possible nonaccidental injury." Patients in whom nonaccidental injury was considered the likely or definitive diagnosis on discharge (as indicated by clinicians' notes in the chart) were noted as "likely nonaccidental injury."

Level of consciousness was recorded as alert, responsive to verbal stimuli, responsive to painful stimuli, or unresponsive on the basis of physicians' and nurses' notes. Patients were noted to be lethargic if there was no mention of depressed level of consciousness but the child was described as lethargic, tired, listless, or having decreased activity. Patients were noted to be irritable if they were described as irritable or crying inconsolably.

Results from head CT and skull radiographs were recorded on the basis of the attending radiologist's reports.

All therapies performed or initiated in the ED were noted. The hospital course of every patient was also examined. Any change in clinical status requiring further diagnostic evaluation (eg, repeat CT) or new therapeutic maneuvers was recorded. The condition on discharge (normal neurologic status, abnormal neurologic status, or death) was recorded.

We analyzed data with the SPSS 6.1.1 program for the Macintosh computer. Results are reported as mean±SD. Frequency data are presented with 95% confidence intervals (CIs), calculated with standard formulas.

RESULTS

One hundred one infants younger than 2 years were admitted to Children's Hospital with radiographically proven ISF during the study period. The mean age of these patients was 7.3±5.1 months (range, 2 weeks to 23 months). Ninety-one of the patients (90%) were younger than 1 year.

Thirty-nine of the patients (39%) were girls, 62 (61%) boys. Twenty-nine of the patients (29%) were evaluated first in our ED, and 72 (71%) were referred from another institution after the skull fracture was diagnosed. In 7 of the 101 subjects, the time from injury to initial evaluation was unknown. For the other 94 subjects, the median time from injury to initial evaluation was 1 hour. Eight of these 94 subjects (8%) presented more than 12 hours after the injury (range, 14 hours to 10 days).

None of the 75 infants with head trauma who had discharge diagnoses other than ISF was initially admitted with a diagnosis of ISF.

Overall, 90 of the subjects (89%) sustained ISF in a fall. The specific mechanisms of injury sustained by the subjects with ISF are summarized in the Table.

Sixty subjects sustained falls that did not involve stairs. For these subjects, the mean fall distance was 3.3±1.8 feet (median, 3 feet; range, 1 to 14 feet). Many of these falls involved short distances: 18 of the 60 patients (30%) fell from heights of less than 3 feet. Fifty-five (92%) fell from heights of less than 5 feet.

Evaluation for possible nonaccidental injury was initiated in 30 patients (30%). Nonaccidental trauma was considered likely in 10 patients (10%) at the time of discharge, including 5 who were reported to have fallen and 5 with no clear mechanism of injury.

Seventeen of 18 subjects with reported falls from heights of less than 3 feet were younger than 1 year; only one of them was suspected of having been the victim of nonaccidental trauma. In the single subject older than 1 year with a reported fall of less than 3 feet, nonaccidental trauma was suspected.

The Figure summarizes the historical features and physical examination findings of the 101 subjects with ISF.

In all, 72 subjects (71%; 95% CI, 61% to 79%) met at least one of the clinical criteria generally considered suggestive of an increased risk of complications from head trauma: initial loss of consciousness, vomiting, seizures, focal neurologic findings, depressed level of consciousness, lethargy, and irritability. Twenty-nine of the subjects (29%) met none of these criteria.

As shown in the Figure, 97 subjects (96%; 95% CI, 89% to 98%) had local findings on physical examination of the head overlying the site of the skull fracture. Four patients (4%) demonstrated no abnormalities on physical examination of the head.

In 99 of the 101 subjects (98%), injuries were isolated to the head. Of the remaining two subjects, one was a 2-month-old who had fallen from a height of 3 feet and had a clavicle fracture and the other was a 15-month-old with suspected nonaccidental trauma who had sustained a duodenal hematoma.

Fractures were noted in 89 patients (88%) on CT of the head; in 74 (73%), fractures were diagnosed by means of skull radiography.

Skull radiography and CT of the head were performed in 77 patients (76%). Fractures were visualized on radiography but not CT in 12 of these patients (15%; 95% CI, 8% to 25%).

Conversely, fractures were seen on CT but not radiography in three patients (4%; 95% CI, 1% to 12%). Two of the three patients had "questionable" fractures of the occipital bone; in the third, no fracture line was identified but find-

Table.
Mechanism of injury in subjects with ISF.

Mechanisms of Injury	No. (%)
Free falls	60 (60)
Adult's arms	19 (19)
Table	14 (14)
Bed	8 (8)
Banister	2 (2)
Bathtub	2 (2)
Couch	2 (2)
Crib	2 (2)
Other	11 (10)
Stair falls	30 (30)
Carried by adult	4 (4)
In a walker	19 (19)
Other	7 (7)
Direct blow to head	2 (2)
Unclear	9 (9)
Total	**101 (100)**

ings suggestive of a basilar skull fracture (pneumocephaly and fluid in the mastoid air cells) were detected.

Seventy-one of the subjects had fractures involving the parietal bone, 16 (16%) had fractures involving the occipital bone, 10 (10%) had fractures involving the temporal bones, 8 (8%) had fractures involving the frontal bone, and 1(1%) had a fracture of the basilar skull.

Ninety-two of the subjects (91%) had single skull fractures; multiple fractures were detected in 9 (9%). Of the nine patients with multiple fractures, eight had sustained falls and in one the mechanism of injury was unclear. Nonaccidental trauma was considered likely in two of the subjects with multiple fractures (22%). In three of the other subjects with multiple fractures, relatively unimpressive mechanisms of injury were reported. One of these subjects was an 8-month-old who fell 2 feet, one was a 19-month-old who fell down three stairs, and another was a 2-month-old who fell down two stairs.

Seventy-eight of the subjects (77%) had linear fractures and 22 (22%) had depressed fractures. In one (1%) no fracture line was seen, but CT of the head showed pneumocephaly and blood in the mastoid air cells, and the patient was presumed to have a basilar skull fracture. Of the 22 subjects with depressed skull fractures, only one required surgical elevation. This subject had an obvious skull deformity on physical examination. Six of the subjects with depressed skull fractures were among the 12 children who fell less than 3 feet and had no evaluation for nonaccidental trauma.

Two of the 101 patients with ISF (2%) required medical or surgical therapy related to the head injury. Both of these patients had physical findings indicating the need for intervention at the time of initial evaluation. One had an infected subgaleal hematoma that required drainage and antibiotics, and the other had a depressed skull fracture that required surgical elevation.

None of the patients (0%; 95% CI, 0% to 3%) demonstrated clinical decline or required any new therapy related to head injury after being admitted to the hospital. The median hospital stay was 1 day; 89 subjects (88%) stayed 2 days or fewer. Of the 12 subjects hospitalized longer than 2 days, 2 stayed for postoperative treatment and 10 stayed for more extensive social service intervention. All subjects were discharged with normal neurologic status.

DISCUSSION

The data from our series help clarify several issues about infants with ISF. Specifically, our study has been able to demonstrate that (1) infants may sustain ISF—even depressed or multiple fractures—as a result of what, by history, are minor mechanisms of injury; (2) although infants with ISF may appear generally well, the vast majority have some local findings on head examination; and (3) infants with ISF have a very low risk of clinical deterioration.

We have found ISF to be a common reason for hospital admission of head-injured infants, accounting for 58% of all admissions to our institution for head injury in children

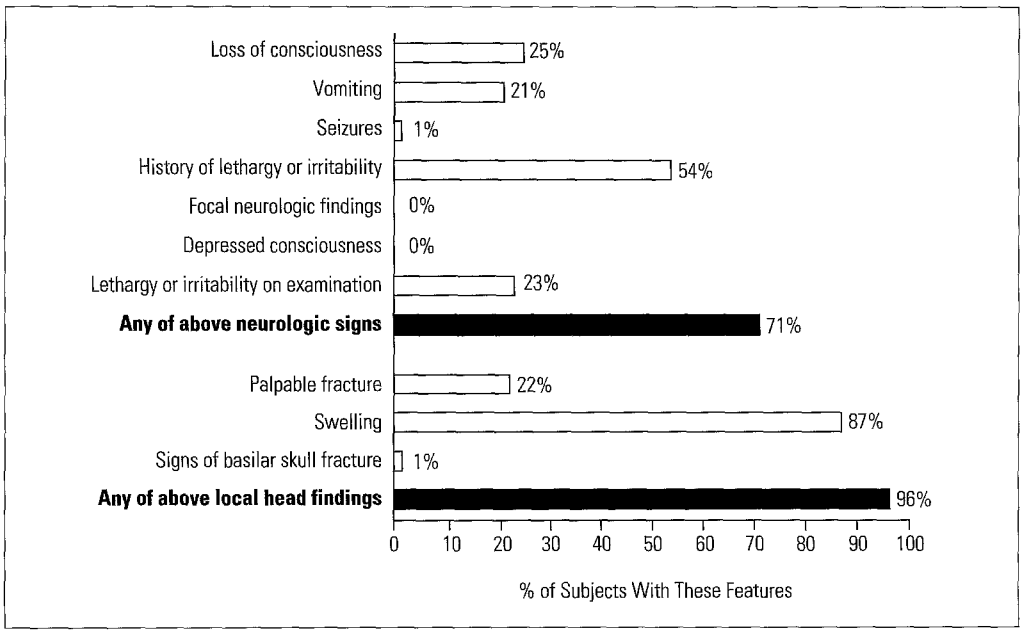

Figure.
Frequency of historical features and physical findings on ED presentation.

younger than 2 years. This finding is in keeping with data from other investigators, who have found infants younger than 2 years to be prone to skull fracture.[1,7] Our data suggest, however, that infants younger than 1 year are at particularly high risk for ISF. Ninety percent of the subjects in our series were younger than 12 months.

In our series, many infants sustained ISF, including depressed and multiple fractures, as a result of minor mechanisms of injury. Approximately one fifth of all cases of ISF resulted from falls of less than 3 feet. Other investigators have found that short-distance falls may result in ISF. Duhaime et al[6] found that in infants younger than 2 years, linear skull fractures were as likely to result from falls of less than 4 feet as they were to result from falls of greater than 4 feet. Ros and Cetta[9] found that 3 of 35 infants who demonstrated no symptoms after minor head trauma had ISF and that all 3 of these infants had fallen less than 3 feet.

However, our findings differ from those of Duhaime et al;[6] in their series, none of the patients with depressed fractures had sustained a short fall. In our series, 6 of the 22 subjects with depressed fracture reportedly had fallen from heights of less than 3 feet. The different findings in the two studies may reflect the fact that Duhaime et al collected data prospectively, specifically to evaluate for the possibility of child abuse, and may therefore have been more sensitive in detecting subtle evidence of child abuse in those cases in which low-impact mechanisms were reported. Alternatively, the difference between the two studies may reflect the fact that our series includes a larger number of patients with depressed fractures (22, versus 8 in the study by Duhaime et al) and therefore that we were more likely to find the rarer cases in which low-impact mechanisms led to depressed skull fracture.

Given the understanding that infants may sustain skull fracture even in minor falls, the clinician is faced with the question of which clinical parameters indicate a high risk for skull fracture. Ros and Cetta[9] suggested that all infants presenting for evaluation after minor head trauma should undergo radiography. Data from our series may help narrow this recommendation. Our findings suggest that ISF is unlikely when no local physical findings are indicative of head trauma; such findings were seen in 96% of infants with ISF. In most of these subjects, soft-tissue swelling was the only local sign of injury; only 22% of the subjects had a palpable fracture. These findings are consistent with those of Kleinman and Spevak,[17] who found that soft-tissue swelling (diagnosed by means of CT) was ubiquitous in patients who had sustained acute skull fracture.

Other clinical signs or symptoms of head injury were insensitive as indicators of risk for ISF. About one third of the patients with ISF in our series had no history of loss of consciousness and no lethargy or irritability (by history or physical examination), vomiting, or neurologic abnormalities.

CT has become the imaging study of choice in patients who may have intracranial injury resulting from head trauma. Our data indicate that CT misses some cases of ISF that can be diagnosed by the use of radiography. This finding probably reflects the fact that some skull fractures run between and parallel to the planes of adjacent CT "cuts" and therefore do not appear on any of the CT images. With this understanding in mind, clinicians might consider radiography as an adjunct to CT when ISF is suspected but CT findings are negative.

Recommendations for the management of the infant with radiographically proven ISF are unclear. Although Masters et al[10] suggested that well-appearing adults with linear skull fracture may be safely discharged home, they argued that not enough data about children under 2 years of age had been reported for them to be included in that recommendation. Because of the paucity of data about infants with ISF, other authors such as Duhaime et al[6] have adopted a strategy of inpatient observation for these patients.

Our data suggest that infants with ISF are at low risk for clinical decline. Nonetheless, with only 101 subjects in our sample, we must interpret our data with some caution, recognizing that our CIs are consistent with actual risk of clinical decline, the incidence of which may be as great as 3%.

The fear of potential late clinical decline in these subjects derives from several reports of patients with late posttraumatic intracranial hemorrhage hours to weeks after the initial head injury.[18-23] In these cases, however, virtually all of the patients had abnormal neurologic or CT findings on presentation. Domenucci et al[21] found reports of only three patients in the world literature who demonstrated delayed epidural hematoma after presenting initially with normal neurologic and CT findings.

A few studies from the literature indicate that children with normal CT findings after head trauma have a very low risk of clinical decline. Schunk et al[24] reported only one late intracranial complication in a group of 300 children with initially negative CT findings after head trauma. That patient had a small contusion that required no specific therapy. Similarly, Ros and Ros[25] described no late complications among 73 well-appearing children with normal CT findings after head trauma.

Although these studies do not include children with skull fracture, their data are consistent with our observation that head-injured infants without evidence of intracranial injury on CT generally have a benign clinical course. We believe

that if nonaccidental trauma is not suspected, the diagnosis of ISF does not in itself necessitate inpatient observation.

In our series, had hospital admission been pursued only for those patients with ISF who needed specific therapy or who were suspected to have sustained nonaccidental trauma, 69 of all admissions of infants with ISF (68%) could have been eliminated. This practice would have resulted in a 38% reduction in the total number of infants admitted to our institution with head trauma over the 3-year study period.

Some limitations of our data must be noted. First, several potential sources of selection bias may have affected our study population. For example, our institution has no uniform protocol for determining which patients should undergo radiography after head trauma. Clinicians may be more likely to request radiographic studies in patients who are younger or in patients with local head findings on physical examination. This bias may make young age and local head findings appear to be more sensitive indicators of ISF than they truly are. Furthermore, because 71% of our subjects were referred from other institutions, we must recognize possible variations in the way head-injured infants are evaluated at other institutions, as well as differences between the patients who were referred to us and those who were managed at outside institutions without referral.

Another limitation of our study is that we restricted our analysis to admitted patients and therefore may have missed some subjects with ISF who were discharged home from our ED. It is standard practice in our institution, however, for infants with ISF to be admitted for observation. We therefore believe that our sample is an accurate representation of the population of infants found to have ISF in our ED.

Finally, our study is limited by the fact that we have limited certainty in determining which patients may have sustained nonaccidental trauma. Evaluation for nonaccidental trauma was initiated only in those cases in which clinicians or social workers considered nonaccidental trauma possible. The diagnosis of child abuse may have been missed in some cases in which skull fracture was attributed to low-impact mechanisms of injury. Nonetheless, it is important to recognize that ISF was frequently seen in cases in which a low-impact mechanism of injury was reported and in which clinicians and social workers did not suspect abuse.

We have found that infants younger than 2 years, particularly those younger than 1 year, are at risk for ISF even after minor mechanisms of injury. Although ISF is often a result of nonaccidental trauma (especially in cases in which no clear mechanism of injury is reported), most cases result from accidental injury. Neurologic symptoms and signs of head injury—including loss of consciousness, vomiting, lethargy, irritability, focal neurologic abnormalities, and seizures—are insensitive predictors of ISF. The vast majority of infants with ISF do, however, have some local signs of injury overlying the fracture site on physical examination.

Infants with ISF generally have a benign clinical course. If no other specific clinical concerns necessitate hospital admission, infants with ISF who have reliable caretakers may be considered for discharge home.

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