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ORIGINAL PAPER

Children presenting in delayed fashion after minor head trauma with scalp swelling: do they require further workup?

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Abstract
Purpose It is common to evaluate children who have sustained minor head trauma with computed tomography (CT) of the head. Scalp swelling, in particular, has been associated with intracranial injury. A subset of patients, however, present in delayed fashion, often days after the head trauma, as soft tissue edema progresses and their caregiver notices scalp swelling. We explore the value of further workup in this setting.
Methods We conducted a retrospective review of a prospectively collected cohort of children ≤24 months of age presenting to the Texas Children's Hospital with scalp swelling more than 24 h following a head trauma. Cases were collected over a 2-year study period from June 1, 2014 to May 31, 2016.
Results Seventy-six patients comprising 78 patient encounters were included in our study. The mean age at presentation was 8.8 months (range 3 days–24 months). All patients had noncontrast CT of the head as part of their evaluation by emergency medicine, as well as screening for nonaccidental trauma (NAT) by the Child Protection Team. The most common finding on CT head was a linear/nondisplaced skull fracture (SF) with associated extra-axial hemorrhage (epidural or subdural hematoma), which was found in 31/78 patient encounters (40%). Of all 78 patient encounters, 43 patients (55%) were discharged from the emergency room (ER), 17 patients (22%) were admitted for neurologic monitoring, and 18 patients (23%) were admitted solely to allow further NAT evaluation. Of those patients admitted, none experienced a neurologic decline and all had nonfocal neurologic exams on discharge. No patient returned to the ER in delayed fashion for a neurologic decline. Of all the patient encounters, no patient required surgery.
Conclusions Pediatric patients ≤24 months of age presenting to the ER in delayed fashion with scalp swelling after minor head trauma—who were otherwise nonfocal on examination—did not require surgical intervention and did not experience any neurologic decline. Further radiographic investigation did not alter neurosurgical management in these patients; however, it should be noted that workup for child abuse and social care may have been influenced by CT findings, suggesting the need for the future development of a clinical decision-making tool to help safely avoid CT imaging in this setting.

Keywords Minor pediatric head trauma · Scalp swelling · Delayed presentation

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Introduction

Head trauma is a common childhood injury, which accounts for approximately 600,000 emergency room (ER) visits annually, with hospital care costs alone exceeding one billion dollars per year [1–3].

In adult trauma populations, the neurologic examination is often used to guide patient evaluation and treatment. However, it has been noted that both the neurologic exam

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and plain skull radiographs in infants and children can be unreliable in predicting intracranial injury and that even pediatric patients with normal neurologic exams may have significant findings on cranial imaging [4–12].

Scalp swelling, which may amount to no more than a "bump" or "knot" on the head following a trauma, might seem a fairly innocuous clinical sign, particularly in the absence of symptoms. Such swelling, however, has been linked to findings of skull fracture or intracranial injury (ICI) on cranial imaging, even in asymptomatic patients [13–16].

Guidelines published by Schutzman et al. for management of minor head trauma in young children (<2 years old) categorize patients presenting with scalp hematomas as falling in an "Intermediate Risk Group" for whom computed tomography (CT) imaging or a 4–6 h observation period is indicated [17].

These guidelines, however, acknowledge the following:

"Occasionally, children are brought for evaluation > 24 hours after the traumatic event when a large scalp swelling is noted, and are diagnosed with a SF. If asymptomatic, these patients have passed the test of time for acute complication, so the risk of a clinically important ICI is likely lower than for patients with acute SFs. However, data are not available for the incidence of ICI in asymptomatic and well-appearing children with nonacute SF."

The current study seeks to address this familiar vignette and evaluate this very question, to describe treatment and outcomes for children ≤24 months of age presenting in delayed fashion with scalp swelling after minor head trauma.

Materials and methods

A retrospective review of a prospectively collected cohort of children ≤24 months of age presenting to the Texas Children's Hospital (TCH) was undertaken from June 1, 2014 to May 31, 2016. Inclusion criteria were any patient presenting to TCH with scalp swelling more than 24 h following a head trauma. Patients were excluded if they did not have a confirmed head trauma or if they presented within 24 h of said head trauma. Inclusion in the study was performed via answers to a small electronic questionnaire required when adding patients to the neurosurgery service census, which is administered electronically.

Children ultimately diagnosed as physical abuse victims also presented with trauma histories greater than 24 h prior to assessment. There is a difficult dynamic involved in the assessment of abusive injuries, because determining what portion of the history is truth and which is misdirection is a challenge; however, since the history of present illness fell within the inclusion criteria and delay in seeking care for injuries is a common factor in cases of physical abuse, these children were also included for analysis.

Patients with other complaints in addition to scalp swelling were included and no patients were excluded for a focal finding on the neurologic exam. All data were collected via electronic medical record (EMR). This review was approved by the Baylor College of Medicine Institutional Review Board.

Demographic data (age, sex, date of birth, and time to presentation) were collected for all the patients. Radiographic data were collected for all the patients, including incidence of repeat imaging, and CT or magnetic resonance imaging (MRI) findings were determined by a radiologist's report.

Primary outcomes assessed via the EMR were need for surgery, neurologic decline if admitted, and return to the ER at any point for neurologic decline. Secondary outcomes included neurologic exam on follow-up in the TCH multidisciplinary Head Injury Clinic, as well as Health-Related Quality of Life (HRQoL) indices assessed in the Head Injury Clinic. Specifically, patients followed in the Head Injury Clinic were assessed using the Pediatric Quality of Life Inventory™ (PedsQL) [18].

Additional outcomes assessed included cost of hospital encounter and results of nonaccidental trauma (NAT) workup. All patients received screening for NAT by the Child Protection Team (CPT). Patients' CPT assessments were reviewed retrospectively and each patient was assigned a number on the Lindberg scale (1–7) [19]. The Lindberg scale was then collapsed into three categories, where a Lindberg scale score of 1–3 was considered to be a low concern for abuse, a score of 4 was deemed to be indeterminate, and a score of 5–7 was thought to represent a significant concern for abuse.

Statistical analysis

Clinical, operative, and radiographic parameters were collected. Frequency distributions and summary statistics were calculated for these data.

The mean PedsQL score from our cohort was compared to the mean PedsQL score of patients ≤24 months old collected over the same 2-year study period from the general traumatic brain injury (TBI) population at our institution using an unpaired two-tailed *t* test. Similarly, the mean hospital charge for patients discharged from the ER was compared to the mean hospital charge for those admitted. A probability value (*p* value) of ≤0.05 was considered statistically significant. Graphpad QuickCalc software was used.

Results

Seventy-six patients comprising 78 patient encounters were included in our study. For comparison, the pediatric neurosurgical service at the Texas Children's Hospital evaluated 436 overall TBI patients over the same 13-month study period.

Demographics

The mean age at presentation was 8.8 months (range 3 days–24 months). Our patient population included 48 males and 28 females.

Clinical and radiographic data

In 5 of 78 patient encounters (6.4%), though the chief complaint was scalp swelling, patients had additional clinical complaints, including reduced oral intake, headache/irritability, and lethargy. No patients had focal neurologic deficits on examination. When the specific date of head trauma was recorded (70/78 patients encounters, 90%), the median time passed since head trauma was 3 days (range, minimum 1–60 days). Documentation reporting a confirmed head trauma "over the weekend" or "last week" did not allow for a more precise calculation of "time from head trauma."

All patients were imaged with noncontrast CT of the head. The most common findings on CT head were isolated linear/nondisplaced skull fractures, which was found in 33/78 patient encounters (42%). Other findings, in a descending order of frequency, were linear/nondisplaced skull fractures with associated extra-axial hemorrhage (epidural or subdural hematoma) (32/78, 41%), a normal CT head save for scalp hematoma (4/78, 5.1%), linear/nondisplaced skull fracture and chronic subdural hemorrhage or hygroma (3/78, 3.8%), and depressed skull fracture with associated extra-axial hemorrhage (epidural or subdural hematoma) (3/78, 3.8%). Additional findings in single patients included an isolated depressed skull fracture, as well as a mildly depressed skull fracture with associated cortical contusion.

Of all the 78 patient encounters, 43 patients (55%) were discharged from the ER, 17 patients (22%) were admitted for neurologic monitoring as decided by the neurosurgery attending on call, and 18 patients (23%) were admitted solely to allow further NAT evaluation.

Repeat imaging

Thirteen of 78 patient encounters (17%) involved repeat cranial imaging at some point in time. Only 4/78 patient encounters (5%) involved repeat imaging within the first 24 h of admission. Three of these instances involved repeat "interval" CT head imaging to monitor the size of an extra-axial hemorrhage and were not prompted by clinical deterioration. One of these instances involved an expedited MRI of the brain obtained for the evaluation and workup of NAT and was not prompted by clinical deterioration.

Nine of 78 patient encounters (12%) involved repeat imaging in delayed fashion. The median time to repeat imaging was 3 days (range 2–240 days). Five of these instances occurred during the same admission (5/9, 56%), while four instances occurred on an outpatient basis (4/9, 44%).

Of delayed scans obtained during the same admission, in three instances, a brain MRI was obtained for the evaluation and workup of NAT. In one instance, repeat CT imaging was obtained after an initial radiology read at an outside ER missed an extra-axial hemorrhage prior to the patient's presentation. In one instance, repeat CT imaging was obtained for anemia and an enlarging cephalohematoma. None of these scans were prompted by a neurologic decline.

Of delayed scans obtained on an outpatient basis, one scan was obtained 17 days later through the head injury clinic evaluate resolution of an epidural hematoma, another 45 days later to reevaluate an incidentally discovered arachnoid cyst, yet another 90 days later to evaluate delayed onset of seizures, and, finally, another obtained 240 days later for evaluation of macrocephaly.

No instances of repeat cranial imaging, acute or delayed, inpatient or outpatient, were prompted by an acute neurologic decline and none prompted neurosurgical interventions. Repeat imaging, however, when obtained for medical reasons distinct from a neurologic decline (anemia, delayed onset seizure, macrocephaly) or as part of a NAT workup, did influence clinical decision-making in a meaningful way. "Interval" scans, however, did not change management.

Outcome

Of those patient encounters leading to admission, the median length of stay was 1 day (range 1–14 days).

Of those patients admitted, no patients experienced a neurologic decline and all had nonfocal neurologic exams on discharge. Of all the patient encounters, including admissions and ER discharges, three patients returned to the ER in delayed fashion, but none had experienced a neurologic decline.

One patient who returned to the ER did so 4 days after discharge out of concern for persistent scalp swelling in the absence of any neurologic decline and was discharged. The second patient who returned to the ER did so after caregivers suspected an unwitnessed ground-level fall that did not result in any symptoms or scalp swelling 14 days after the initial evaluation—this patient also had no evidence of a neurologic decline and was discharged. The third patient returned to the ER 7 days after initial evaluation due to altered sleep patterns that concerned her caregiver—this patient also had no evidence of neurologic deficit and was discharged from the ER.

Of all the patient encounters collected over the 2-year study period, no patient required surgery at any point in time.

Follow-up

Sixty-three out of the 76 patients (83%) in this cohort had institutional follow-up at TCH, which revealed no instance

of interim neurosurgical interventions or admissions at outside institutions. Median institutional follow-up was 2 months (range 5 days–11 months).

Follow-up in a multidisciplinary Head Injury Clinic was available in 45 of 76 patients (59%). Median follow-up for those evaluated in this setting, specifically, was 2 months (range 4 days–12 months).

Of those patients followed in the Head Injury Clinic, none had focal neurologic deficits.

HRQoL and NAT outcomes

PedsQL data were available for 35/76 patients (46%) who followed up in the Head Injury Clinic. The mean PedsQL score was 2.43 (range 0–24). PedsQL data collected over the same 2-year study period in patients ≤24 months old from the general TBI population was also reviewed. PedsQL data were available for 131 patients from the general TBI population, with a mean PedsQL score of 4.18 (range 0–44). The difference between mean PedsQL scores in the delayed scalp swelling cohort and the TBI population in general was not statistically significant ($p = 0.24$).

NAT

All patients underwent screening for NAT. Of all the patient encounters, there were 64 instances (64/78, 82%) where NAT was thought to be unlikely (Lindberg scale score, 1–3), eight instances (8/78, 10%) where the NAT evaluation was indeterminate (Lindberg scale score, 4), and six instances (6/78, 8%) where NAT evaluation revealed a high concern for abuse (Lindberg scale score, 5–7).

Cost

Hospital charges were stratified by ER discharge or admission. The mean hospital charge for inpatient admission was twice the mean hospital charge of a patient discharged from the ER. Mean hospital charges were statistically significantly lower for patients discharged from the ER compared to those admitted to the hospital ($p = 0.001$).

Discussion

Scalp swelling, in particular, has been linked to significant radiographic findings such as skull fractures or intracranial hemorrhage [13–16].

In a prospective cohort study of 422 asymptomatic infants (<2 years old) status post minor head injury, Greenes et al. found that parietal and temporal scalp hematomas, though not frontal hematomas, were found to be significantly associated with skull fractures, while large scalp hematomas and parietal hematomas were associated with ICI, which was defined as acute intracranial hematoma, cerebral contusion, or evidence of cerebral edema [13]. Only one patient in this cohort (1/422, 0.2%) required surgical intervention. An earlier study of the same cohort by Greenes et al. found that scalp hematomas had a significant odds ratio of 2.78 for association with ICI [9].

Similarly, a retrospective case series of 278 infants (<2 years old) evaluated for head injury by Gruskin et al. found that scalp abnormalities were significantly associated with skull fractures or ICI, similarly defined as an intracranial hemorrhage, contusion, or signs of cerebral edema [16]. One patient in this series required placement of an intracranial pressure monitor (1/278, 0.3%).

These studies observed that skull fractures or ICIs are often seen in entirely asymptomatic patients and concluded that the presence of a scalp hematoma should prompt further radiographic evaluation, even in otherwise neurologically intact infants.

None of these studies, however, evaluated the significance of time to presentation following an inciting head trauma. In particular, no distinction is made between patients presenting acutely (within 24 h of injury) or in delayed fashion (greater than 24 h after injury). Patients who present in delayed fashion, as acknowledged by the guidelines proposed by Schutzman et al. [17], have already undergone a period of self-imposed observation, so to speak.

Our study examined this question: Were these patients to have presented acutely, and were they found to have intracranial injury, though asymptomatic, they would likely have been admitted for a period of observation and, remaining asymptomatic, been discharged in less than 24 h. In our study population, this period of observation has already taken place. Even acknowledging the association of a scalp hematoma with skull fractures or intracranial injury, obtaining neurosurgical consultation in this subset of patients appears to be of little value, as it is unlikely to change medical management. Our results support this conclusion.

In our series, collected over a 2-year period, not one patient had a focal neurologic deficit on presentation, none experienced a clinical decline (if admitted), none returned to the ER for neurologic decline, and none required surgery. These results stand out despite the fact that over half of the patient encounters (40/78, 51%) revealed an ICI of some kind that, in an acute presentation, almost certainly would have resulted in admission for observation. It may be that referral to an outpatient multidisciplinary head injury clinic to monitor long-term outcomes may be all that is required from a neurosurgical perspective.

It must be noted, however, that a small but significant minority of patients in our series were thought very likely to be the victims of NAT (6/76, 8%). Thus, presentation to an ER or walk-in clinic for the evaluation of delayed scalp swelling, if only for the purpose of a thorough NAT screening, remains

vital and, while delayed scalp swelling may not necessitate admission or neurosurgical consultation, it is significant in raising questions about the safety of a child's caretaker environment. The question remains, however, if the liberal use of CT head can be refined.

Perhaps prior to more intensive workup in the ER with advanced imaging, such as CT, patients who present with delayed scalp swelling should undergo social and clinical screenings for NAT guided by the child's expected and reported developmental milestones, as well as for red flags in the home environment—signs of diminished resources, such as a single-parent family structure, familial history of substance abuse or domestic violence, recent separation or divorce, and adolescent parent(s). Our patients with suspected abusive head injury were typically those who were nonambulatory and therefore were unable to create circumstances for accidental injury independently. Children with "red flags" in clinical or psychosocial parameters, such as those who demonstrate facial, neck or trunk bruises, intraoral injury, traumatic alopecia, burns, genital injuries, or whose injuries have an absent or changing trauma history or a history of prior child protective services (CPS) involvement, should undergo a further abuse workup [20–22]. Future directions of our research may include the refinement of a clinical decision rule [20] to identify young children with skull fracture and ICI, presenting with delayed scalp swelling.

From the health finance standpoint, avoiding unwarranted hospital stays, consultations, and imaging tests may result in lower cost without compromising patient care and safety. In certain settings where the concern for abuse is low, avoiding a referral to the ER altogether may be feasible if proper follow-up can be ensured.

To this point, Arrey et al. recently reviewed a large series of 326 patients between 0 and 16 years old presenting to a single institution with linear nondisplaced skull fractures ("NDSFs") [23]. In this series, no patients required a neurosurgical intervention, leading the authors to conclude that even a 23-h observation for NDSFs was costly and, perhaps, unnecessary. While the findings of this series are valuable, our study differed in meaningful ways. Most importantly, we examined patients ≤24 months of age who presented with scalp swelling in delayed fashion, specifically, and included all such patients regardless of their radiographic findings, including those with ICI—a group of patients that were excluded in the study by Arrey et al. We reported that these patients, too, required no neurosurgical intervention, a finding that is distinct from but complementary to those reported by Arrey et al.

Limitations

There are several limitations to this study. Most importantly, this is a retrospective chart review, though the patient cohort was collected prospectively. It is subject to all the shortcomings associated with this type of analysis, including documentation omissions, missed relevant cases, and selection bias. Additionally, not all patients followed up in our multidisciplinary Head Injury Clinic for proper evaluation and neurologic testing. It is possible that these patients suffered from some form of neurologic decline or even required surgical intervention at an outside institution and that these events were missed by our review; seven patients were lost to follow-up during our study period.

Additionally, the study population remains small in comparison to some other larger series investigating the significance of scalp swelling or NDSFs. It must be emphasized, however, that our study examined a specific subset of patients that comprise a minority of pediatric head injury patients—at our own institution, patients meeting the inclusion criteria represented only 17% (76/436) of the patients presenting with head trauma. Considering this incidence, our cohort of 76 patients is considerable, certainly the largest reported in the literature.

Lastly, data on imaging results were based on a review of radiology reports, not on new and independent retrospective review of the imaging by a third party.

Conclusions

Infants and toddlers presenting to the ER primarily because of delayed scalp swelling 24 h or more after trauma, who are otherwise nonfocal on examination and are at an ambulatory developmental level, have an excellent prognosis; this subset of patients may not require further acute radiographic investigation, neurosurgical consultation, or admission for neurologic surveillance. Thorough physical exam and psychosocial evaluation for NAT, however, remain vital, and there may be a need to admit these patients with further radiographic evaluation in the setting of suspected abuse.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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