Management of accidental minor head injuries in children: a prospective outcomes study

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Object. The authors conducted a study to determine clinical, patient/family satisfaction, and financial outcomes following application of a management scheme that involves evaluation of computerized tomography (CT) scans and emergency department observation, rather than overnight admission, for children who have sustained accidental minor closed head injuries (Glasgow Coma Scale Scores 13–15) and who have met predefined clinical and radiographic criteria.

Methods. During 18 consecutive months, all children age 24 months and older who sustained accidental minor head injuries were managed prospectively according to a standard protocol. All children meeting prospectively established clinical criteria underwent immediate CT scanning and were observed in the emergency department. Those in whom there were no intracranial radiographically demonstrated abnormalities and who met established clinical criteria were discharged to home observation.

Two hundred fifteen children met the criteria for the study. Falls (53%) and motor vehicle accidents (13%) constituted the most common mechanisms of injury. Of the patients for whom information was recorded, 40% experienced a loss of consciousness and 49% had amnesia. Repeated vomiting occurred in 45%. Skull fractures were rare. No child suffered a clinical complication or neurological deterioration. Two patients (0.9%) underwent reevaluation within 48 hours for persistent symptoms; no intracranial abnormality was demonstrated in either on repeated CT scanning and both recovered uneventfully. Follow-up phone surveys in a subgroup of patients indicated universal parent satisfaction. Compared with a control group that underwent both CT scanning and were admitted to the hospital, statistically significant cost savings were realized in the cohort.

Conclusions. A management scheme that involves routine initial CT studies and a brief period of observation in the emergency department is safe and readily accepted by patients and families and can achieve significant cost savings.

KEY WORDS • trauma • head injury • concussion • skull fracture • pediatric neurosurgery

Each year in the US alone, approximately 100,000 children suffer head injuries, 90% of which are classified as “minor” (GCS Score 13–15). Although guidelines for the management of children with minimal head injuries (an LOC < 1 minute, normal mental status, and no abnormal neurological findings on initial examination, as well as no physical evidence of skull fracture) have recently been published, no consensus exists regarding the management of more seriously injured children with minor head injuries.

Despite the lack of consensus, the practical management of children sustaining accidental minor head injuries has changed during the past decade. Whereas these children were previously admitted to the hospital for a period of observation (and may or may not have undergone CT scanning), the authors of several retrospective studies have suggested that many of these children could be as safely and more efficiently managed by following a protocol that combines initial CT scanning and a brief observation period in the emergency department, followed by discharge to home under adult supervision. A prospective study of such a management protocol, however, has not been undertaken nor have family satisfaction and economic costs been fully evaluated as part of such a study. During an 18-month period, we prospectively applied a unified algorithm for the management of children (age ≥ 24 months) who had sustained accidental minor closed head injuries. Clinical outcome, family satisfaction, and management costs were evaluated, and clinical parameters and management costs were contrasted with those demonstrated in a comparable group of historical control individuals who had undergone CT scanning and were admitted to the hospital for observation.

Clinical Material and Methods

An algorithm (Table 1) was jointly developed by a team.
Minor accidental head injuries in children

**TABLE 1**
Management algorithm for accidental minor head injuries in pediatric patients*

1) child is evaluated by ED personnel & meets clinical entry criteria
(see Table 2)
2) child undergoes urgent CT scanning & meets radiographic criteria
(see Table 3)
3) neurosurgery consulted for evaluation of
   *≥2 mins LOC
   *any skull fracture
   *persistent GCS score <15 or any sustained deterioration in score
   *or clinical status
   *significant neck or back pain/tenderness
   *intracranial abnormality (eliminates patient from algorithm)
4) child is observed for at least 2 hrs in ED
5) child meets discharge criteria (see Table 4)
6) child is discharged to home under the care of a reliable caretaker

* ED = emergency department.

of pediatric emergency medicine physicians, pediatric neurosurgeons, and pediatric radiologists under the aegis of the Center for Improved Outcomes in Children's Healthcare, and it was applied prospectively to the management of all children (age ≥ 24 months) who had sustained an accidental minor closed head injury (GCS Score 13–15) presenting to the emergency department at the Children's Hospital of Buffalo during an 18-month period. Any child in whom an abuse-related head injury was suspected was excluded. To be included, all cases had to meet one of the following: 1) more than a brief (seconds) LOC; 2) significant amnesia; 3) multiple episodes of vomiting (> one); or 4) persistent lethargy. Children initially evaluated at another hospital and subsequently transferred to Children's Hospital of Buffalo were excluded from analysis to avoid referral bias as a confounding factor in the study. Children younger than 24 months were excluded from the study because of the following. 1) Inadequate verbal abilities and developmental ages potentially could render clinical evaluations more difficult. 2) Adequate serial clinical examinations would be more difficult for parents at home for similar reasons. and 3) The potential for abusive head injury is greater.

All children meeting the established clinical parameters (Table 2) underwent an immediate evaluation by the emergency department staff. All patients underwent unenhanced CT scanning (scan time 800 msec/image); because of the speed with which the scans could be obtained, sedation was not necessary for any child. Neurosurgical consultation was requested whenever the child had 1) LOC for longer than 2 minutes, 2) any skull fracture, 3) persistent GCS score of less than 15 after arrival and initial evaluation in the emergency room, 4) any deterioration in GCS score or clinical status, or 5) any significant neck tenderness or pain, or abnormality demonstrated on cervical spine radiographs.

Children in whom no visible intracranial abnormality was demonstrated on the initial CT scan and in whom prospectively determined radiographic criteria were satisfied (Table 3) underwent serial neurological examinations for a minimum of 2 additional hours in the emergency department. Children meeting predefined discharge criteria (Table 4) were discharged to home in the care of a responsible adult. Parents were given instructions to call immediately if there were any concerns or complications. The attending physician in the emergency department had the option to admit any child for observation if either the family or staff had reservations about sending the child home; the clinical outcomes for these children were also documented. Additionally, although our use of a fast CT scanner did not require sedation in any child, we would either have continued observing the patient until full recovery or admitted for observation any child who had required sedation.

Clinical information for each child was extracted from emergency department records and included the patient’s age and sex, the mechanism of injury, location of impact, presence and duration of LOC and amnesia, presence and frequency of vomiting, admission and lowest GCS scores, presence and location of skull fractures, and existence of other injuries.

The protocol included follow-up phone calls 1 day after discharge, both to follow the clinical status of the child and to determine the family’s attitude toward the management scheme. Calls were repeated on subsequent days if there was no answer on the first attempt. Unfortunately, many families could not be contacted either because the telephone numbers provided at the time of the visit were incorrect or not in service, or because the families could not be reached despite repeated attempts. Those who were contacted expressed universal satisfaction with the management scheme. The follow-up phone calls were therefore abandoned after 2 months, but parents were explicitly advised to return with their children in the event of any complications.

Finally, financial data for each case were obtained from hospital computers. For comparison purposes, 21 additional cases of minor head injuries were randomly selected from all children who would have met the study criteria but who were treated during the 6 months before the study; their clinical characteristics and hospital charges were compared with those in the study group.

All data were analyzed using the SPSS (SPSS, Inc., Chicago, IL); probability values of less than 0.05 were considered statistically significant. The study received the approval from our institution’s review board.
TABLE 3

<table>
<thead>
<tr>
<th>Radiographic parameters for inclusion in study*</th>
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<tr>
<td>no intracranial abnormalities related to the head injury</td>
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<tr>
<td>skull fractures allowed except:</td>
</tr>
<tr>
<td>those that cross the MMA (present on 1st 3 CT slices of the middle fossa b/n the sphenoid wing &amp; petrous ridge)</td>
</tr>
<tr>
<td>those that cross the dural venous sinuses (sagittal, transverse, &amp; sigmoid)</td>
</tr>
<tr>
<td>those that are depressed &gt; thickness of the adjacent skull</td>
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* MMA = middle meningeal artery.

Results

Overall 215 children (126 boys and 89 girls) met inclusion criteria during a consecutive 18-month period. Six of these children were admitted for observation despite their eligibility for the study because their families did not feel entirely comfortable with home observation, there was no home phone number for follow-up interview, or home supervision was inadequate; all six were discharged after 24 hours of hospital observation without complications. They were, however, included for purposes of analysis.

The most common mechanism of injury (in 114 cases) accounting for 53% of injuries was a fall from height. Fifty-three children (25%) collided with or were struck by an object, 28 (13%) were injured in motor vehicle accidents, 13 (6%) were victims of an assault, and one case was classified as “other.” Of those 114 who sustained a fall, 77% fell from a height of 6 ft or less, whereas 5% fell from greater than 10 ft. Similarly, for those 28 patients involved in motor vehicle accidents, 21 (75%) involved speeds of 35 mph or less, whereas three (11%) were traveling in, or were struck by, cars traveling at speeds of 50 mph or greater.

Of the 176 patients for whom information was available, 106 (60%) did not experience an LOC, and only six (3%) experienced an LOC of greater than 5 minutes. Similarly, of the 125 for whom information was available, 61 (49%) had experienced some form of amnesia (retrograde, antegrade, or both). Of the 185 patients for whom information was available, vomiting occurred in 97 (52%) and often involved multiple episodes; of those with emesis, 126 (68%) experienced three or more episodes. The admission and lowest documented GCS scores are depicted in Fig. 1. Of the 168 children in whom a GCS score was documented on arrival to the emergency department, a GCS score of 15 was present in 153. Of the 93 children with a documented follow-up GCS score, a GCS of 15 was maintained in 87 (94%) throughout their emergency department stay, and the GCS score in the remaining six improved to 15 prior to discharge.

All CT scans, by definition, demonstrated no evidence of intracranial injuries. Although children with certain types of skull fractures (Table 3) could be treated using the algorithm, only two with skull fractures, one linear and one basilar, met both the clinical and radiographic criteria for inclusion in the study.

During the follow-up period, no child suffered a medical complication or died, and no neurosurgical or other operation was subsequently required. Two children were reevaluated in the emergency department for persistent vomiting within 1 day of their initial visit. In both, no neurological deterioration had occurred, and repeated CT scanning in both demonstrated normal results. One child was admitted overnight and discharged the next day; the other child received intravenous hydration and was discharged again from the emergency department. Neither child returned subsequently. None of the six children who met the inclusion criteria but who were admitted for overnight observation experienced any complications.

Follow-up telephone calls to the 27 families who could be reached demonstrated universal satisfaction with the algorithm (Fig. 2). No family was dissatisfied with the experience, and 96% reported they were “very satisfied.” All but one family described their child’s condition as “back to normal” at the time of the follow-up survey, although 7% reported headaches and 15% vomiting after their child had been discharged from the emergency department.

When the randomly selected control group of 21 children with minor head injuries treated during the preceding 6-month period, all of whom underwent CT scanning and were admitted to the hospital for observation, were compared with the study patients, no significant differences between the two groups were found with respect to any clinical variables; however, there were significant reductions in costs (p < 0.05) for total hospital charges, patient payments, insurance payments, and total payments for the study cohort. The mean hospital costs (excluding physician fees) for the cohort was $1052, compared with $2355 for the control group, representing a mean cost savings of $1303 per case.

Discussion

To the best of our knowledge, this is the first study to document the effect of a consistent management algorithm prospectively applied to children with minor head injuries, as well as the first to include data on clinical outcomes, patient/family satisfaction, and economic measures. We found that a management scheme for children with minor head injuries that includes initial CT scanning and a brief period of observation in the emergency department, followed by discharge to home, is safe, well accepted by patients and families, and cost effective. The size of our cohort indicates that the maximum risk of an untoward outcome after following this management algorithm (using 95% confidence limits) is 0.9%. Unfortunately, one of the limitations of our study was an inability to contact the families consistently for follow-up phone surveys. This proved to be a very frustrating experience because many families had provided phone numbers that were either out of service or inaccurate, leading us eventually to
abandon the follow-up calls. Although not every patient was contacted directly following discharge, we feel confident that we did not miss any significant complications or death because of the following. 1) All families had come directly to the Children’s Hospital of Buffalo for care and had received specific written instructions to call or bring the child back with any problems or concerns. 2) There were no complications reported during the follow-up telephone surveys that were completed. 3) Children’s Hospital of Buffalo, as the preeminent regional pediatric institution, sees the overwhelming majority of traumatic brain injuries in children. 4) The Buffalo region has a relatively small number of neurosurgeons who are in frequent contact with one another, and none contacted the authors about a complication. 5) We neither heard from any other hospital nor were the recipients of any notice of legal action involving any of the children in the cohort.

There are several other caveats that should be made clear in reporting such a study. The first involves specifically defining who is included. Most authors arbitrarily define minor head injury as an LOC of less than 20 minutes and a GCS score of 13 to 15; however, some have included children with such minor injuries that no LOC, amnesia, or other symptoms occurred, and others have included children with persistent vomiting or lethargy, posttraumatic seizures, the pediatric postconcussive syndrome, or posttraumatic migraine. The inclusion of various groups of children can obviously affect the outcomes of a study, and one must therefore be exact in defining the study population. Our definition (Table 2) encompassed those children with significant enough head injuries that, previously, we would have admitted for observation, but excluded those with such minor head injuries that even previously we would have discharged from the emergency department without further workup. Although this algorithm allowed for management of children with certain types of skull fractures, we encountered only two children with skull fractures that met all other clinical and radiographic criteria; it is therefore impossible to apply our findings to this subgroup.

It is also important to be clear about which children are specifically excluded from study. We excluded children with skull fractures that crossed either the proximal middle meningeal artery (lowest three CT slices through the middle fossa) or a dural venous sinus, who might be at greater risk of developing an epidural hematoma. We (and others) have also excluded children younger than 24 months of age for three reasons. First, the results of several studies have indicated that infants may be at greater risk for both skull fractures and intracranial injuries after minor head injuries. Second, a detailed neurological examination may be more difficult in infants and they are less capable of voicing complaints. Third, there are concerns about the possibility of abuse-induced head injury, particularly in cases in which the trauma did not occur in public and/or the mechanism was not obvious.

Most children with minor head injuries fare well without intervention, but significant healthcare resources are expended to identify the rare child who harbors a potentially life-threatening intracranial injury. The critical question is how best to identify those rare cases at risk for complications without wasting precious healthcare resources. The two extremes—obtaining a CT scan and admitting every child for a period of observation on the one hand, or discharging every child to home without radiological evaluation on the other hand—are untenable options. Whether selected children should either undergo CT scanning or be admitted for observation involves weighing the relative risks of clinical deterioration in each scenario. Specifically, what is the risk of neurological deterioration in the child with a minor head injury who returns to neurologically normal status, and can we identify any clinical features that identify a child at higher risk for intracranial
injury and which might therefore prompt either a CT study or period of observation? In contrast, what is the risk of delayed intracranial hemorrhage and/or late-onset clinical deterioration in a child with a minor head injury and no identifiable intracranial abnormality on an initial screening CT scan?

The incidence of a radiographically documented intracranial abnormality in children with minor head injuries (GCS Score 13–15) is 3 to 53%.

Even among children with a GCS score of 15, the risk of intracranial injury ranges from 2.5 to 7%.

Choux and colleagues have estimated that 57% of children and 85% of infants with epidural hematomas experienced no LOC at the moment of impact and that 7% of the children in their series had no alteration in consciousness at any time after the injury. It is therefore readily apparent that clinically significant, even life-threatening, intracranial injuries can exist in children without significant initial clinical manifestations. It is also apparent that no single clinical feature or combination of features can be reliably used to identify a child at greater risk for serious intracranial injury or hematoma. Although persistent altered mental status, focal neurologic deficits, and posturing have some predictive value, children with these signs do not meet our criteria for minor head injury.

The incidence of delayed deterioration in patients with head injuries is estimated to be between 1 and 4%.

Although much has been written about this phenomenon, a detailed review of the literature suggests that, in virtually all of these reports, one of the following occurred: Insufficient data were available to allow proper evaluation of the case. Initial CT scans demonstrated abnormality or were never obtained. Patients had moderate or severe brain injuries (GCS score < 13) on the initial examination, were receiving anticoagulant agents at the time of the injury, or had been treated with osmotic diuretics. Although the so-called talk and die syndrome has received considerable attention, a detailed review of these studies indicates that most, and perhaps all, of the patients exhibited abnormal mental status or other clinical features that would have excluded them from meeting the criteria for our definition of minor head injury, or they had not undergone an initial cranial imaging study or their study demonstrated an abnormal finding.

On the other hand, a delayed epidural hematoma is extraordinarily rare if both neurological examination and CT scanning have revealed normal findings; a comprehensive review of the world literature by Domenicucci and associates identified only three such cases, of which was a child. In a series of 791 children with minor head injuries, Hahn and McLone reported only two cases (0.3%) in which deterioration occurred when an initial CT scan had demonstrated normal findings (one involving a child with a delayed epidural hematoma and the other involving diffuse brain swelling). In both children, the GCS score was 13 on admission, and it is not clear whether their GCS score increased to 15 before their deterioration; had it not, the patients would not have met our discharge criteria. The authors of several recent retrospective studies of minor head injuries in patients with GCS scores of 13 to 15 and in whom CT scans demonstrated normal findings also provided evidence that late-onset deterioration in this setting is very rare.

Evaluation of five separate retrospective pediatric studies, totaling 1241 children with minor head injuries and normal initial CT scans, suggests that these children could safely be discharged home with an approximately 0.5% return rate and no significant complications.

The authors of other retrospective studies have suggested that infants younger than 24 months of age, as well as children harboring uncomplicated skull fractures and/or basilar skull fractures, could be similarly managed. The cost savings of such an approach in these groups have been documented in other studies.

Conclusions

Our analysis of an algorithm that was designed prospectively and applied consistently to 215 consecutive children confirms and extends the findings of previous retrospective studies in suggesting that selected children with minor head injuries may indeed be managed safely in an outpatient setting without routine admission to the hospital. Our survey of a subset of patients indicates that this management scheme is well accepted by families (although with only a small subset of follow-up satisfaction surveys there is a maximum 10% chance of dissatisfaction when using 95% confidence limits). Finally, the $1200 cost savings per case is both statistically significant and considerable. Applying this algorithm to the approximately 90,000 cases of pediatric minor head injuries evaluated in physicians’ offices and hospitals each year in the US would save considerable healthcare resources. We recommend further prospective studies to confirm and extend these findings.

References


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