Evaluation of Head Injury in a Pediatric Emergency Department

Pretrauma and Posttrauma System

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Objective: To determine if trauma center protocols affect the number of tests and consultations performed and the length of time spent in the emergency department or hospital.

Design: A retrospective review and comparison of treatment for children with isolated head injury admitted to the emergency department before trauma center designation (group 1, 1985), and 5 years after implementation of trauma center protocols (group 2, 1991).


Results: One hundred sixty-five children met the enrollment criteria in 1985 and 162 met the criteria in 1991. Falls were the predominant mechanism of injury (55%) for both years. For patients with moderate injury (Glasgow Coma Scale score, 9-12) or severe injury (Glasgow Coma Scale score, <9), there was no difference in radiographic or laboratory evaluation. For patients with minimal head injury (Glasgow Coma Scale score, 15, no loss of consciousness, amnesia, seizure, focal neurologic findings, or persistent symptoms) and minor head injury (Glasgow Coma Scale score, >12, and loss of consciousness or amnesia), more radiologic and laboratory studies were done in 1991 that showed no clinically significant abnormalities. Patients with minimal head injury in group 2 were 14 times more likely to have cranial computed tomographic scans performed (95% confidence interval [CI], 3.4-67); 11 times more likely to have cervical spine radiographs (95% CI, 2.2-76.6); and 23 times more likely to have hepatic enzymes obtained (95% CI, 3-491). These differences persisted when analyzed by both the age of the patient and mechanism of injury.

Conclusions: Application of trauma system protocols to isolated head injury patient evaluation results in increased use of laboratory and radiologic services. These practices have the potential to increase the cost of medical care without significantly improving outcome.


Editor’s Note: Just 4 days ago I attended a conference where managed cost administrators hailed the use of protocols as the manna of medicine. I wonder if they’d consider the protocols in this study as manna from heaven or hell.

Catherine D. DeAngelis, MD

CHILDMORTALITY has declined in recent decades, but a large proportion of these deaths still occur due to preventable injuries.1,2 Preliminary data indicate that unintentional injury accounted for 63% of childhood deaths in 1996.1 Injury is second in frequency to respiratory infections and is the third most common cause of health-related restricted activity and hospitalization. Injuries also account for approximately 7% of the time children spend in the hospital.3 Related costs of health care and morbidity due to permanent disability are estimated to be more than $10 billion annually.4,5

These pediatric injury mortality statistics have not declined in the last several years,6,7 but there have been major changes in pediatric trauma management.8-10 Protocols were developed based on the epidemiology and mechanism of adult trauma. The compelling evidence that standardized trauma center care has improved the early morbidity and mortality outcomes for adult victims of trauma has led to the same epidemiology and mechanism being applied to children.11-16 These protocols run the risk of unnecessary testing and procedures that may increase children’s trauma. The application of adult trauma protocols to all pediatric trauma victims, regardless of injury severity, may simply change care without having the desired affect on outcome.

We hypothesized that the establishment of The Children’s Hospital of Philadelphia, Philadelphia, Pa, as a trauma
MATERIALS AND METHODS

A retrospective medical record review, using historical controls, was designed to review physician management of isolated head injury for patients evaluated in the emergency department in 1985 (group 1) compared with those evaluated in 1991 (group 2). The children’s hospital became certified as a level I pediatric trauma center in 1986. Admitted patients were chosen, as they are consistently evaluated by both pediatric emergency medicine and trauma surgeon subspecialists. Patients were identified using the International Classification of Diseases, Ninth Revision diagnoses for head injury. Exclusion criteria included the following: (1) the presence of other injuries requiring cranial computed tomographic (CT) imaging or hospital admission; (2) a complicating underlying medical illness or neurologic disability; or (3) child abuse as the mechanism of injury. The medical records were reviewed for the mechanism of injury, events at the scene, the patient’s physical examination and diagnostic evaluation, details of the hospitalization, and the ultimate outcome of the patient.

Patients were divided into subgroups categorizing the severity of their head injury based on criteria from recent English-language literature.17 Patients with minimal head injury included those with a Glasgow Coma Scale (GCS) score of 15 on presentation to the emergency department and the absence of other risk factors including loss of consciousness, amnesia, history of seizure, focal neurologic examination findings, or persistent headache or vomiting. Patients categorized as having minor head injury included those with a GCS score of 13 or higher and/or a history of loss of consciousness or amnesia. Patients with moderate head injury included those with a GCS score higher than 8 but less than 13. Those with major head injury had a GCS score less than 9. The analysis focused on the patient subgroups with minimal and minor head injuries.

χ² Distribution was used for categorical data, analysis of variance was used to analyze continuous data, and the Mann-Whitney U test was used for rank order data. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated when significant differences were noted between the 2 study years. An a priori level of statistical significance was set at P<.05.

RESULTS

We identified 165 children with isolated head injuries admitted during the pretrauma center era (group 1) and 162 from the posttrauma center era (group 2). Population characteristics of the 2 groups are compared in Table 1. While small differences were noted for age, referral pattern, and the proportion of motor vehicle crash victims, groups were similar for sex, racial composition, and the most common mechanism of injury (falls). Importantly, the proportion of patients in each of the 4 injury severity categories was not different between the 2 eras. In group 2, 13% of patients with minor head injury had a GCS score of 13 or 14 compared with 21% of patients in group 1. Similarly, the study groups were comparable for almost all the injury severity variables including: GCS score, trauma score, loss of consciousness, seizure activity, focal neurologic findings, and symptoms of headache and vomiting persisting longer than 8 hours. The groups differed only in the presence of amnesia.

We noted significant differences in the medical management in the 2 eras. Most (73%) of group 1 patients were admitted to the general pediatric service; 21.2% were sent to the neurosurgical service. In contrast, in group 2, most patients (62%) were admitted to the trauma surgical service, 30% were admitted to the neurosurgical service, and 6.8% were admitted to the general pediatric service.
Comparison of the use of radiographic studies between groups is illustrated in the Figure and in Table 2. Children in group 2 with minimal or minor head injuries were more likely to have a cranial CT performed, with group 2 vs group 1 OR at 8.4 (95% CI, 2.3-30) for minimal injury and 7.0 (95% CI, 2.8-17.7) for minor injuries. Although represented by small numbers, there was no difference in the frequency of cranial CT imaging in the moderate and major injury categories. Similarly, cervical spine and chest radiograms were obtained more frequently in group 2 minor head injury patients, while group 1 patients with minor and minimal head injury usually received plain skull film studies. Cervical spine, thoracic, and abdominal radiographs for group 1 and group 2 patients with minimal or minor head injury showed no abnormalities.

As expected, the use of laboratory studies in both the minimal and minor head injury groups drastically increased in group 2 patients (Table 2). Children with isolated minimal head injury were 20 times more likely to have laboratory tests performed. A few patients had abnormal study results, but none were of any clinical significance.

Patients in group 2 also had more subspecialty consultations (Table 3). Patients in the minor head injury group had a slightly longer emergency department and hospital stay.

A separate analysis was performed on patients aged 3 years or younger to exclude the confounding effect age may have had on physical examination assessment. In group 2 patients with minimal head injury, 66% underwent cranial CT imaging (OR, 18; 95% CI, 2-463) and 57% had cervical spine films (OR, 13; 95% CI, 1-332). In group 1, 11% of patients had cranial CT scans and none had cervical spine films. Of group 2 patients with minor head injury, 47% (OR, 7; 95% CI, 2-20) had cranial CT imaging; 71% (OR, 14; 95% CI, 5-43) had cervical spine films; 53% (OR, 75; 95% CI, 10-1613) had liver func-

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**Table 2. Radiographic and Laboratory Evaluations: Differences in a Pretrauma vs Posttrauma Emergency Department**

<table>
<thead>
<tr>
<th>Modality</th>
<th>Minimal Head Injury, Percentage Patients</th>
<th>Minor Head Injury, Percentage Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>Radiographic evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skull film</td>
<td>81.0</td>
<td>63.0</td>
</tr>
<tr>
<td>Cervical spine</td>
<td>5.9</td>
<td>49.0</td>
</tr>
<tr>
<td>Chest film</td>
<td>8.8</td>
<td>12.4</td>
</tr>
<tr>
<td>Abdominal film</td>
<td>2.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Extremity film</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Laboratory evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hematocrit</td>
<td>35.0</td>
<td>60.0</td>
</tr>
<tr>
<td>Liver function test results</td>
<td>0.0</td>
<td>39.0</td>
</tr>
<tr>
<td>Amylase</td>
<td>6.0</td>
<td>41.0</td>
</tr>
<tr>
<td>PT/PTT*</td>
<td>3.0</td>
<td>39.0</td>
</tr>
</tbody>
</table>

* CI indicates confidence interval; PT/PTT, prothrombin time/partial thromboplastin time.
† Ellipses indicate no data available.

**Table 3. Consultation and Length-of-Stay Differences in a Pretrauma vs Posttrauma Emergency Department**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimal Head Injury</th>
<th>Minor Head Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>No. of consultations &gt;2, %</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Mean ± SD time spent in the emergency department, h</td>
<td>3 ± 1.3</td>
<td>3 ± 2.6</td>
</tr>
<tr>
<td>Length of stay &gt;1 d, %</td>
<td>35</td>
<td>29</td>
</tr>
</tbody>
</table>

* Odds ratio (95% confidence interval) for number of consultations in patients with a minimal head injury was 8.46 (1-1845) and in patients with a minimal head injury was 7.1 (2-27).
tion tests; and 40% (OR, 44; 95% CI, 6-936) had serum amylase tests. In group 1 patients, 13% had cranial CT imaging; 15% had cervical spine radiographs; 0% had liver function tests; and 12% had serum amylase analysis obtained.

Patients not referred to our institution were also evaluated separately, as referral may affect physician practice. The difference in the extent of diagnostic evaluation remained: group 2 patients with minor head injury were more likely to have cranial CT scans performed (OR, 5.5; 95% CI, 2-16). This difference was also present in the rate of cervical spine films (OR, 20; 95% CI, 7-56), and hematocrit (OR, 6; 95% CI, 2-14), liver function (OR, 89; 95% CI, 12-1854), and serum amylase (OR, 14; 95% CI, 5-40) tests performed.

Our outcome results are reported at the time of patient discharge from the hospital and no conclusions can be drawn from this small data set. A good outcome for minimal head injury was seen in both study years, with 100% (95% CI, 90.7-100) in group 1 and 100% (95% CI, 92.8-100) in group 2. No difference was noted in patients with minor head injury between the study years, with good outcome for 100% (95% CI, 93.6-100) in group 1 and 100% (95% CI, 93.5-100) in group 2. Intracranial examination showed no abnormalities in any patient for either study year including contusions, subarachnoid hemorrhage, and small epidural hematomas (Table 1).

Management style as guided by trauma center protocols for children with isolated minimal or minor head injury has resulted in increased use of radiographic and laboratory tests, subspecialty consultations, and time spent in the emergency department and hospital. Although this is an observational study of practice, it is arguable that change in practice for patient groups with isolated minimal or minor head injury has little effect on patient care quality or outcome, and has increased the cost of care.

We chose to compare patients in the year prior to trauma center designation, and 5 years after the designation to allow for protocols and practice to become established. This 5-year time difference between the groups may also reflect a change in practice over time that is unrelated to the trauma center designation. For patients with minor head injury, the English-language literature and practice has changed as cranial CT imaging has become more routine. Fewer skull films and more cranial CT scans may simply reflect this change in practice. For patients with minimal head trauma (GCS score of 15 and absence of all risk factors), the literature and practice has changed as cranial CT imaging practice did not change. This 5-year time difference between the study years, with good outcome for 100% (95% CI, 93.6-100) in group 1 and 100% (95% CI, 93.5-100) in group 2. Intracranial examination showed no abnormalities in any patient for either study year including contusions, subarachnoid hemorrhage, and small epidural hematomas (Table 1).

Most remarkable is the increased use of laboratory testing in the trauma center era. Although these children had isolated head injury, a blood sample was drawn to evaluate the liver and pancreas, as well as coagulation and hematocrit function. Some children in the isolated minor head injury group may have had altered states of consciousness, with GCS scores of 13 or 14, and required some laboratory evaluation. This 40- to 70-fold increase in studies persisted, even in children who were aged 3 years or older and were usually able to verbalize their complaints. When children specifically referred to the trauma center were omitted, there was an 11- to 22-fold increase in laboratory evaluation in the minimal head injury group.

Our study reflects change in practice at a tertiary care children's hospital. The children in group 1 were cared for primarily by pediatric emergency medicine physicians, who were supported by general pediatricians and pediatric subspecialists such as neurosurgeons, general surgeons, orthopedists, and radiologists. After the institution of trauma center status (group 2), primary responsibility was shifted to the trauma surgery group, both in the emergency department and the inpatient unit. The increased number of consultations may reflect the change in primary management from a pediatric generalist to a surgical subspecialist. In either period, our findings may not be applied to the management of injured children in other care settings.

The American College of Surgeons' efforts to provide universal, high-quality care to decrease injury mortality and morbidity is a laudable one. Standardized, regional trauma center care has improved the morbidity and mortality of adult trauma victims, now special attention needs to be devoted to the pediatric patient, who experiences different mechanisms of injury than the adult population. Application of adult protocols and practices to the pediatric patient may increase trauma to patients and costs to their families. Pediatric protocols and practices must be developed with the input from pediatricians and a critical review of the literature.

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REFERENCES