Does an Isolated History of Loss of Consciousness or Amnesia Predict Brain Injuries in Children After Blunt Head Trauma?

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ABSTRACT. *Background.* A history of loss of consciousness (LOC) is frequently used as an indication for cranial computed tomography (CT) in the emergency department (ED) evaluation of children with blunt head trauma.

Objective. We sought to determine whether an isolated LOC and/or amnesia is predictive of traumatic brain injury (TBI) in children with blunt head trauma.

Methods. We prospectively enrolled children <18 years old presenting to a level I trauma center ED between July 1998 and September 2001 with blunt head trauma. We evaluated the association of LOC and/or amnesia with 1) TBI identified on CT and 2) TBI requiring acute intervention. We defined the latter by a neurosurgical procedure, antiepileptic medication for >1 week, persistent neurologic deficits, or hospitalization for ≥2 nights. We then investigated the association of LOC and/or amnesia with TBI in those patients without other symptoms or signs of TBI ("isolated" LOC and/or amnesia).

Results. Of eligible children, 2043 (77%) were enrolled, 1271 (62%) of whom underwent CT; 1159 (91%) of these 1271 had their LOC and/or amnesia status known. A total of 801 (39%) of the 2043 enrolled children had a documented history of LOC and/or amnesia. Of the 745 with documented LOC and/or amnesia who underwent CT, 70 (9.4%; 95% confidence interval [CI]: 7.4%, 11.7%) had TBI identified on CT versus 11 of 414 (2.7%; 95% CI: 1.3%, 4.7%) without LOC and/or amnesia (difference: 6.7%; 95% CI: 4.1%, 9.3%). Of the 801 children known to have had LOC and/or amnesia (regardless of whether they underwent CT), 77 (9.6%; 95% CI: 7.7%, 11.9%) had TBI requiring acute intervention versus 11 of 1115 (1%; 95% CI: 0.5%, 1.8%) of those without LOC and/or amnesia (difference: 8.6%; 95% CI: 6.5%, 10.7%). For those with an isolated LOC and/or amnesia without other signs or symptoms of TBI, however, 0 of 142 (95% CI: 0%, 2.1%) had TBI identified on CT, and 0 of 164 (95% CI: 0%,1.8%) had TBI requiring acute intervention.

Conclusions. Isolated LOC and/or amnesia, defined by the absence of other clinical findings suggestive of TBI, are not predictive of either TBI on CT or TBI requiring acute intervention. Elimination of an isolated LOC and/or amnesia as an indication for CT may decrease unnecessary CT use in those patients without an appreciable risk of TBI. *Pediatrics* 2004;113:e507–e513. URL: http://www.pediatrics.org/cgi/content/full/113/6/e507; *traumatic brain injury, loss of consciousness and/or amnesia, CT, cranial tomography, emergency department evaluation, children.*

ABBREVIATIONS. TBI, traumatic brain injury; ED, emergency department; CT, computed tomography; LOC, loss of consciousness; GCS, Glasgow Coma Score; CI, confidence interval.

Traumatic brain injury (TBI) is the leading cause of death due to trauma in children,[1–5] resulting in ~3000 deaths as well as 50 000 hospitalizations and 650 000 emergency department (ED) visits per year in the United States.[1–3] Cranial computed tomography (CT) is the diagnostic test of choice for evaluating children with blunt head trauma in the ED. Less than 10% of these CT scans, however, are diagnostic of TBI.[6–13] Furthermore, cranial CT has associated drawbacks and risks including the requirement for transport of the child away from the direct supervision of ED physicians, increased time for completing ED evaluation, exposure to ionizing radiation, with its potential long-term risk for malignancy,[14–16] the occasional requirement for pharmacological sedation,[17–19] and additional health care costs.[20,21] Therefore, cranial CT scans should ideally be selectively used.

A history of loss of consciousness (LOC) is frequently suggested as an indication for CT in the ED evaluation of children with head trauma,[13,22–26] although clinicians' practice patterns regarding patients with this history vary.[27–29] Many investigators in this area of research acknowledge the limitations of available data regarding the relationship between a history of LOC and TBI and highlight the need for larger, prospective studies on this topic.[12,24–26,30,31]

Several investigators have evaluated the association between clinical signs and symptoms and TBI identified on CT in children who have sustained blunt head trauma.[6–13,22,23,32–36] However, there are

limited data regarding the association of TBI with a history of LOC and/or amnesia in the absence of other signs or symptoms suggestive of TBI ("isolated" LOC and/or amnesia).[36] Furthermore, to our knowledge there have been no prior studies of children with blunt head trauma that have explored the relationship between a history of LOC and/or amnesia and a clinical TBI outcome variable such as TBI requiring acute intervention.[6]

In this study, we sought to evaluate the association between an isolated LOC and/or amnesia and TBI in children with blunt head trauma. We hypothesized that an isolated LOC and/or amnesia is not predictive of TBI.

MATERIALS AND METHODS

Study Design and Setting

We conducted a prospective observational cohort study in the pediatric ED of a level I trauma center. The study site's Human Subjects Research Committee approved the study with a wavier of informed consent. The methods have been published[6] and will be summarized briefly here.

Study Population

From July 1998 to September 2001, we enrolled children <18 years old presenting to the pediatric ED after a history of blunt head trauma with historical or physical examination findings consistent with head trauma. These findings included a history of LOC, amnesia, seizures, vomiting, current headache, dizziness, nausea, or vision change; or physical examination findings of abnormal mental status, focal neurologic deficits, clinical signs of skull fracture, or scalp trauma. This patient population included children with head injuries of all severities. We excluded children with head trauma resulting from ground-level falls or from walking or running into stationary objects if the only abnormal finding was a scalp laceration or abrasion. We also excluded children transferred to the study facility if CT scans were obtained before transfer.

Study Protocol

All patients were examined by faculty emergency physicians. The clinical findings listed above were recorded onto a standardized data sheet before CT scan (if CT was obtained). Two faculty emergency physicians independently evaluated a convenience sample of 5% of patients to assess interobserver agreement. The convenience sample consisted of eligible patients who arrived in the ED when 2 faculty physicians were available.

A study research assistant reviewed the medical records for patients in whom predictor data fields were incomplete and abstracted the information from the medical record. Abstracted information was used on an average of <1% of all data fields, with a range of 0% to 3% for each variable studied. In a small number of patients, information regarding specific predictor variables was missing despite review of the medical record to abstract these missing data. These patients, however, were included in the analysis, with those predictors coded as missing.

CT scans were obtained at the discretion of the treating faculty physicians. Institutional recommendations for obtaining CT scans in head-injured children, however, included a history of LOC, amnesia, seizure, vomiting, or headache, physical examination findings of abnormal mental status, neurologic deficit, skull fracture, or deep or multiple scalp lacerations, children <2 years old with scalp hematomas, children with multiple trauma, or children for whom shaken-infant syndrome was a concern. Because clinicians' practice patterns vary and not all children with head trauma routinely undergo CT at the study institution, we could not ethically mandate obtaining CT scans on all enrolled patients.[37] CT scans were performed with a GE high-speed CT/I (GE Medical Systems, Waukesha, WI), or Toshiba 900 scanner (Toshiba America Medical Systems, Tustin, CA), with 5-mm cuts from the foramen magnum to the vertex of the skull.

We reviewed the charts of hospitalized patients to determine interventions and outcomes. All patients discharged from the ED were telephoned ~1 week after ED evaluation. In this telephone survey, 3 questions were asked: 1) Is your child back to normal? 2) Do you have any concerns about your child's health related to the recent head injury? and 3) Has your child needed to be seen by another doctor for concerns related to the head injury since the ED visit? We recorded symptoms of head injury, the need for reevaluation by a physician, or a missed diagnosis of TBI. We mailed a survey with these same 3 questions to those unavailable by telephone. Children discharged from the ED who did not have a TBI demonstrated by subsequent brain imaging and did not require subsequent hospitalization were considered not to have TBIs. At study completion, we reviewed the county morgue records and hospital trauma registry for the names of patients who were unavailable by telephone or mail follow-up to ensure that they were not subsequently diagnosed with a TBI. The trauma registry tracks all trauma victims admitted to the trauma surgery service and the pediatric surgery service of the participating institution.

Variable Definitions

Because the Glasgow Coma Score (GCS) alone is an insensitive way of characterizing the heterogeneous group of pediatric patients with minor head injury,[32,38–40] we created the clinical variable "abnormal mental status." We considered abnormal mental status to be present if the patient had a GCS or pediatric GCS[41] of <15 or if the patient was confused, somnolent, repetitive, or slow to respond to verbal communication. Clinical signs of skull fractures were defined as a palpable skull fracture, retro-auricular bruising, periorbital bruising, hemotympanum, or cerebrospinal fluid otorrhea or rhinorrhea.

We defined LOC as a report by the patient or witness of LOC of any duration. We considered an isolated LOC as a history of LOC in the absence of findings suggestive of TBI, specifically a history of vomiting, seizure or current headache, or physical examination findings of altered mental status or clinical signs of skull fracture, focal neurologic deficits, or scalp hematomas. We defined LOC and/or amnesia as a report by the patient or witness of LOC and/or a report by the patient of amnesia to the complete events of the injury. We defined an isolated LOC and/or amnesia as LOC and/or amnesia in the absence of other findings suggestive of TBI as described above.

Outcome Measures

We evaluated 2 outcome variables: 1) TBI identified on CT (an imaging-defined variable) and 2) TBI requiring acute intervention (a clinically defined variable). These 2 outcome variables have an overlapping but nonhierarchical relationship.

TBI identified on CT was defined by the presence of intracranial hemorrhage, hematoma, or cerebral edema based on the faculty radiologists' interpretations of the initial CT scans obtained during the ED evaluation. CT scans with equivocal readings were given to a faculty pediatric radiologist (masked to clinical information) for definitive interpretation. Isolated skull fractures (ie, without visible TBI) were not considered TBIs, because children with isolated skull fractures do not routinely require hospitalization.[42,43]

We defined TBI requiring acute intervention by ≥1 of the following: the requirement for a neurosurgical procedure, ongoing antiepileptic pharmacotherapy beyond 7 days, the presence of a neurologic deficit that persisted until discharge from the hospital, or ≥2 nights of hospitalization for treatment of the head injury. This definition therefore includes those children with an isolated depressed skull fracture if they required neurologic surgery intervention. This definition, however, excludes those children routinely admitted for overnight observation because of a small TBI identified on CT scan, children who are given an empirical prophylactic 1-week course of antiepileptic medication after head trauma as well as children hospitalized for social or other reasons not directly related to medical care of the head trauma. In constructing the definition of TBI requiring acute intervention, we sought to define an outcome that was meaningful to clinical decision-making, independent of the sensitivity of neuroimaging technology[44,45] and independent of physician accuracy in recognition of subtle TBIs on imaging studies.[46,47]

Data Analysis

We conducted 2 separate analyses (using LOC alone and LOC and/or amnesia), because many would consider that traumatic

amnesia likely reflects a history of LOC at the time of the traumatic event. We performed descriptive and bivariable analyses using Fisher's exact test for categorical data and Student's t test for continuous data using Stata 7.0 (Stata Corporation, College Station, TX) statistical software. Statistical significance was determined by using 95% confidence intervals (CIs). We measured differences in categorical data by calculating the differences in proportions and the corresponding 95% CI. Interobserver agreement was calculated by using the κ coefficient.[48]

We determined the bivariable associations between LOC with the 2 outcome variables: TBI identified on CT and TBI requiring acute intervention. In a separate analysis, we also determined the association between LOC and/or amnesia and the same 2 outcome variables. We then determined the associations between an isolated LOC, as well as an isolated LOC and/or amnesia, and the 2 outcome variables. We calculated 95% CIs for the rates of occurrence of the TBI outcome variables. Only those children with a documented presence or absence of LOC and/or amnesia and who underwent cranial CT scans were included in the analyses for TBI identified on CT. All children with a documented presence or absence of LOC and/or amnesia, regardless of whether they underwent cranial CT, were included in the analysis for TBI requiring acute intervention.

Sample-Size Determination

The study sample-size goal was 300 children with an isolated LOC and/or amnesia, which was based on the premise that none of these patients would have a TBI, and the subsequent upper limit of the 95% CI for TBI in patients with this history would therefore be 1%. The study sample size, however, was primarily driven by a separate aim of the study, which was to derive a clinical decision rule for identifying children at low risk for TBI after blunt head trauma.[6] For that aim, the sample size was 90 children with TBI identified on CT to evaluate 9 variables in the multivariable analysis of that study.[49,50] Patient enrollment was halted after enrolling a sufficient number of children with TBI identified on CT.

RESULTS

Study Population

We enrolled 2043 (77.4%) of 2640 eligible children. The mean age was 8.3 years (SD: 5.3 years; range: 10 days to 17.9 years), 327 (16%) were ≤2 years old, 65% were male, and 39% had histories of LOC or amnesia. The mechanisms of injury were: fall (35%), motor vehicle crash (19%), automobile versus pedestrian (11%), assault (8%), fall off a bicycle (7%), automobile versus bicyclist (5%), child abuse (0.2%), and other (15%). Fifty-three percent of enrolled patients had isolated head trauma. The median GCS of enrolled patients was 15 (interquartile range: 15, 15), and 91% had GCSs of 14 or 15.

Of enrolled children, 1271 (62.2%) underwent CT, and TBI on CT was present in 98 (7.7%; 95% CI: 6.3%, 9.3%; Table 1). Of the 98 patients with TBI identified on CT, 23 (23.5%) did not meet the criteria for TBI requiring acute intervention. TBIs requiring acute

intervention were present in 105 (5.1%; 95% CI: 4.2%, 6.2%; Table 2) of the 2043 patients. Of these 105 patients, 12 (11.4%) expired, and 29 (27.6%) underwent neurosurgical procedures. Twenty nine (27.9%) of these 105 patients did not have TBIs identified on the initial cranial CT obtained in the ED.

LOC and LOC and/or Amnesia

Tables 3 and 4 report the frequency of LOC and LOC and/or amnesia, respectively, in the study population. The presence or absence of LOC was known in 1747 (85.5%) of those enrolled and 1012 (79.6%) of those who underwent CT. The presence or absence of LOC and/or amnesia was known in 1916 (93.8%) of those enrolled and 1159 (91.2%) of those who underwent CT.

Interobserver Agreement

Two investigators independently evaluated a convenience sample of 109 (5.3%) of the 2043 patients. Of these 109 patients, 87 (80%) had CTs performed, and TBI on CT was present in 14.9% (95% CI: 8.2%, 24.2%). The rate of TBI in need of acute intervention in these 109 patients was 12.8% (95% CI: 7.2%, 20.6%). Interobserver agreement for both a history of LOC and for amnesia was excellent, with κ scores of .86 (95% CI: .65, 1.0) and .63 (95% CI: .40, .87), respectively ($P < .001$ for both measurements). κ values for other variables used in the evaluation of these children (see variable definitions above) were between .56 and .91, representing moderate to almost perfect agreement ($P < .05$ for all measurements).[48]

Association of TBI With a History of LOC

Table 5 describes the rates of TBI identified on CT and TBI requiring acute intervention in those with and without a history of LOC regardless of the presence of other clinical variables. We found that the risk of a TBI was higher in those with a history of LOC. However, in those children with an isolated LOC (ie, LOC in the absence of other findings suggestive of TBI as described above), there were no TBIs. The prevalence of TBI identified on CT was 0 of 122 (95% CI: 0%, 2.4%), and the prevalence of TBI requiring acute intervention was 0 of 135 (95% CI: 0%, 2.2%).

Association of TBI With a History of LOC and/or Amnesia

Table 6 describes the rates of TBI identified on CT and TBI requiring acute intervention in those with and without a history of LOC and/or amnesia re-

TABLE 1. TBIs Identified on CT (Total: 98 Children)

Type of Injury	n (% of Total)
Cerebral contusion/hemorrhage	50 (51.0)
Subdural hematoma	31 (31.6)
Subarachnoid hemorrhage	24 (24.5)
Cerebral edema	17 (17.3)
Epidural hematoma	16 (16.3)

A total of 98 enrolled children had TBIs identified on CT; a combination of injuries was found in 41 of the 98. Note that an isolated skull fracture was not considered a TBI. This table was previously published[6] (copyright © 2003; reprinted with permission from American College of Emergency Physicians).

TABLE 2. Description of Children With TBI Requiring Acute Intervention (Total: 105 Children)

Criteria Met	n (% of Total)
Hospitalization ≥2 nights*	58 (55.2)
Neurosurgical procedure	29 (27.6)
Neurological deficit	14 (13.3)
Anticonvulsant medication >1 week	4 (3.8)

* Without any of the other 3 criteria. This table was previously published[6] (copyright © 2003; reprinted with permission from American College of Emergency Physicians).

TABLE 3. Prevalence of LOC in Those With LOC Status Known

	History of LOC	No History of LOC
All children (n = 1747)	633 (36.2%)	1114 (63.8%)
Children who underwent CT (n = 1012)	601 (59.4%)	411 (40.6%)

TABLE 4. Prevalence of LOC and/or Amnesia in Those With LOC and/or Amnesia Status Known

	History of LOC and/or Amnesia	No History of LOC and/or Amnesia
All children (n = 1916)	801 (41.8%)	1115 (58.2%)
Children who underwent CT (n = 1159)	745 (64.3%)	414 (35.7%)

gardless of the presence of other clinical variables. We found that the risk of a TBI was higher in those with a history of LOC and/or amnesia. However, in those children with an isolated LOC and/or amnesia (ie, LOC and/or amnesia in the absence of other findings suggestive of TBI as described above), there were no TBIs. The prevalence of TBI identified on CT was 0 of 142 (95% CI: 0%, 2.1%), and the prevalence of TBI requiring acute intervention was 0 of 164 (95% CI: 0%, 1.8%).

Implications for CT Usage

Of the 1021 children who underwent CT and whose LOC status was known, 122 (11.9%; 95% CI: 10.0%, 14.1%) had an isolated LOC, and none had TBI identified on CT (Table 5). Of the 1159 enrolled patients who underwent CT and whose LOC and/or amnesia status was known, 142 (12.3%; 95% CI: 10.4%, 14.3%) had an isolated LOC and/or amnesia, and none had TBI identified on CT (Table 6). Eliminating isolated LOC and/or amnesia as an indication for cranial CT would have reduced CT use by 12% during this study.

Follow-up

Follow-up was achieved in 88% of patients who were discharged from the ED, and none had a missed TBI. A review of county morgue records and hospital trauma registry for the remaining 12% failed to identify any patients with a missed TBI.

Patients Eligible for the Study but Not Enrolled

Of the 2640 eligible patients, 597 (22.6%) were inadvertently not enrolled ("missed") into the study. The mean age of missed children was 8.8 years (vs 8.3 years for enrolled), 64.2% were male (vs 64.9% for enrolled), and the mean GCS was 14.7 (vs 14.4 for enrolled). The rate of TBI identified on CT was similar between enrolled patients and those not enrolled (7.7% for enrolled, 5.9% for missed patients; difference: 1.8%; 95% CI: −1.3%, 4.9%).

DISCUSSION

In this study, we analyzed the relationship between TBI and both a history of LOC and of LOC and/or amnesia in children evaluated in the ED for blunt head trauma. We included both LOC and am-

nesia in this analysis, because a history of amnesia after blunt head trauma may be a surrogate marker for a history of LOC. We found that an isolated LOC and isolated LOC and/or amnesia (defined by the absence of a history of vomiting, seizure, or current headache or physical examination findings of skull fracture, altered mental status, neurologic deficits, or scalp hematomas) was not associated with either TBI identified on CT or TBI in need of acute intervention.

Head trauma is an important childhood health problem,[1–5] is commonly encountered by clinicians in the ED,[1] and has been identified as a priority area in need of additional research.[12,24,30,31] CT is commonly used in the ED assessment of children with blunt head trauma, although there is variation in clinicians' practice patterns.[27–29] Evidence-based guidelines for cranial CT usage in children sustaining blunt head trauma are few,[24–26] because the data are limited.[12]

Because the clinical presentation of TBI in children may be subtle[8,10,11,25,26,32–35,51] and the consequences of missing a TBI may be substantial,[52] some advocate liberal use of CT scans in the ED evaluation of children with blunt head trauma.[8,23,32,33,40,53] The benefits of performing CT imaging, however, must be balanced by its disadvantages, which include the transport of the child away from the direct supervision of ED physicians, increased time for completing the ED evaluation, exposure to ionizing radiation, with its associated long-term risk for development of malignancy,[14–16] the occasional requirement for pharmacological sedation,[17–19] and additional health care costs.[20,21]

Several studies have identified a history of LOC as a predictor of TBI in children who have sustained blunt head trauma,[9,12,13,22,23,28,32,54] although children may have a relatively lower physiologic threshold for LOC than adults.[55] Despite this, some previous studies have failed to demonstrate that a history of LOC[6–8,10,11,33,35,36,56] or amnesia[8,9] is predictive of TBI. Nevertheless, several current guidelines recommend considering cranial CT scans for all children with a history of LOC after blunt head trauma.[24–26]

Some studies have also evaluated the association between TBI and a history of LOC in children with blunt head trauma and a GCS of 15.[7,33,36] One retrospective study of 168 children >2 years old with documented histories of LOC or amnesia found that 0 of 49 children with an isolated head injury, who were neurologically normal, had TBI identified on CT.[7] Another retrospective study of children <16 years old found that TBI was present in 35 (16%) of 215 children who did not have a history of LOC and in 16 (10%) of 162 children with a history of LOC.[33] The authors concluded that LOC was not a sensitive clinical predictor of TBI.[33] A recent prospective study of 175 children 5 to 17 years old with a history of LOC and normal GCS score found that 0 of 41 patients with an isolated LOC had a TBI or depressed skull fracture.[36]

The current study differs from previous work on the topic in several important ways. First, we measured the associations between LOC alone as well as LOC and/or amnesia with TBI. In addition, the sam-

TABLE 5. Association of TBI and Other Clinical Characteristics With History of LOC

Variable	No LOC n = 1114	History of LOC n = 633	Difference	95% CI
Mean age	7.1 y	10.4 y	3.3 y	2.7, 3.7
Mean GCS	14.8	13.9	0.9	0.7, 1.1
TBI identified on CT	15/411 (3.7%)	58/601 (9.7%)	6.0%	3.0, 9.0
TBI requiring acute intervention	15/1114 (1.4%)	65/633 (10.3%)	8.9%	6.5, 11.4

For those with an isolated history of LOC, 0 of 122 (0%; 95% CI: 0%, 2.4%) had TBI on CT, and 0 of 135 (0%; 95% CI: 0%, 2.2%) had TBI in need of acute intervention. See "Materials and Methods" for definitions of outcome variables, TBI identified on CT, and TBI requiring acute intervention. Note that percentages were calculated only for patients who had known presence or absence of a history of LOC.

TABLE 6. Association of TBI and Other Clinical Characteristics With History of LOC and/or Amnesia

Variable	No LOC and/or Amnesia n = 1115	History of LOC and/or Amnesia n = 801	Difference	95% CI
Mean age	7.0 y	10.6 y	3.6 y	3.1, 4.0
Mean GCS	14.8	14.1	0.7	0.6, 1.0
TBI identified on CT	11/414 (2.7%)	70/745 (9.4%)	6.7%	4.1, 9.3
TBI requiring acute intervention	11/1115 (1.0%)	77/801 (9.6%)	8.6%	6.5, 10.7

For those with an isolated history of LOC and/or amnesia, 0 of 142 (0%; 95% CI: 0%, 2.1%) had TBI on CT, and 0 of 164 (0%; 95% CI: 0%, 1.8%) had TBI in need of acute intervention. See "Materials and Methods" for definitions of outcome variables, TBI identified on CT, and TBI requiring acute intervention. Note that percentages were calculated only for patients who had known presence or absence of a history of LOC and/or amnesia

ple size in the current study was relatively large, therefore allowing a more powerful analysis than that of many previous studies. Because our study was prospective, we were able to determine more accurately the presence or absence of important clinical variables than retrospective studies. Finally, we evaluated 2 outcome variables: TBI identified on CT scan and TBI requiring acute intervention. This latter clinical outcome variable is relevant to clinical decision-making, is not dependent on neuroimaging modality,[44,45] and is independent of physician accuracy in interpreting the imaging study.[46,47] Therefore, the relationship between LOC and/or amnesia and TBI requiring acute intervention presented here likely will be relevant in the foreseeable future despite advances in neuroimaging technology.

Nevertheless, our study has several potential limitations. A history of LOC may be difficult to ascertain at times because of a lack of a witness to the traumatic event as well as difficulties in ascertaining whether unconsciousness was actually present. However, there was excellent clinician interobserver agreement on the report of this variable in this study. Although this study was large, the 95% CIs for TBI given an isolated LOC and/or amnesia do not exclude the possibility of a 2% rate of TBI for patients with this history. This risk may be greater than that considered acceptable to some clinicians. In addition, there were not enough children <2 years old to perform a meaningful subanalysis in this younger, more difficult-to-evaluate age range. Child abuse may have also been underestimated because of the difficulty in ascertaining this history as a mechanism of injury at the time of emergency evaluation for head trauma. Furthermore, because of ethical concerns, faculty physicians were not required to obtain CT scans on all children with a history of LOC and/or amnesia. Most patients who were not imaged with CT, however, had telephone follow-up to identify potentially important missed injuries. Although

clinical follow-up is an acceptable endpoint when more definitive testing is not feasible or ethical,[37] some patients who were not imaged may have had clinically silent but radiographically visible TBIs. In addition, although we searched the trauma registry and morgue records for the names of patients discharged from the ED and unavailable for follow-up, it remains possible that some of these patients nevertheless may have had a TBI missed at the initial evaluation. We were able to obtain follow-up, however, on 88% of patients discharged from the ED in addition to reviewing the county morgue records and the trauma registry. We also used dichotomous categorization of predictor variables for ease of data collection, analysis, and interpretation. In so doing, however, we may have lost some important clinical discrimination. For example, with regard to a history of LOC, a child with a brief LOC was considered similarly to a child with prolonged LOC in our data analyses. Previous studies, however, lack consensus as to the relationship between duration of LOC and risk of TBI.[7,23,54,56] Finally, the results from this single-center study may not necessarily be generalized to all centers; external validation of these results using a large, diverse sample of pediatric head trauma patients is necessary.

CONCLUSIONS

We found that an isolated LOC and isolated LOC and/or amnesia, defined by the absence of other clinical findings suggestive of TBI, are not predictive of either TBI on CT or TBI requiring acute intervention. Elimination of an isolated LOC and/or amnesia as an indication for CT may decrease unnecessary CT use in those patients without an appreciable risk of TBI.

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