Emergency Medicine: Open Access

Demirkol D, Emergency Med 2014, 4:6
DOI: 10.4172/2165-7548.1000222

Review Article Open Access

Minor Pediatric Head Trauma in the Emergency Unit

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Received date: August 22, 2014, **Accepted date:** October 13, 2014, **Published date:** October 20, 2014

Introduction

Traumatic brain injury (TBI) is a significant health care problem, leading to 0.5% of all emergency unit visits and 37,000 to 50,000 pediatric hospitalizations each year [1-3]. The CDC observed a 14% increase in TBI-related emergency department (ED) visits from 2002 to 2006 and Marin et al showed 29.1% increase in TBI-related ED visits between 2006 and 2010 [3,4].

The management of children with minor TBI and radiographic findings of intracranial injury on CT is not clearly defined. Most head trauma in children is minor and not associated with brain injury or long-term sequel. A small number of children who appear to be at low risk after minor head trauma may have clinically important traumatic (ciTBI) brain injury. Children with clinically significant intracranial injuries require urgent identification to prevent further damage to the brain. This cause to use of head computed tomography (CT) in the evaluation of pediatric TBI. The rate of cranial CT use in children increased fivefold between 1995 and 2006 [5]. However, there is an increasing evidence of the risk associated with CT. As many as 1 in 1,200 children scanned will die secondary to malignancy caused by radiation exposure from diagnostic imaging [6,7]. Children may require sedation to allow imaging with consequent sedation associated risks [8]. They also have resource implication for EDs and health system [9].

The purpose of the current review is to discuss the epidemiology of head trauma in infants and children, clinical features of head injured children with and without ciTBI, and the evaluation of infants and children with mild head trauma.

Definitions

One approach to categorizing head injuries is to group them according to the patient`s Glasgow Coma Scale (GCS) score. However the clinical assessment is difficult and intracranial injuries are frequently asymptomatic in children younger than two years of age and this group is generally defined separately. Minor head trauma in children younger than two years can be defined as a history or physical signs of blunt trauma to the scalp, skull, or brain in an infant or child who is alert or awakens to voice or light touch [10]. In children two years and older with minor head trauma have GCS ≥ 13, no abnormal or focal findings on neurologic examination and no physical evidence of skull fracture. Patients with mild TBI usually have GCS scores 13 to 15 and is generally associated with symptoms, such as a brief loss of consciousness, disorientation, or vomiting. Patients with moderate TBI have GCS scores between 9 and 12 and those with severe injuries have a score of 8 or less.

Epidemiology

Traumatic brain injury is most frequent among children under the age of 1 and more frequent in males in every age group. The age distributions are also fundamentally different among the sexes, with males having a bimodal distribution (peak at 0-1 and 14-15) and females a positively skewed distribution (peak at 0-1 and long right-sided tail) [1,2,11].

The majority of TBI are related to unintentional injuries (72%), and additional are related to assault (9%). The percentage of intentional injuries is higher among males than females (7-10%). Falling is the leading mechanism of injury for both females and males. Among females, motor vehicle traffic-related crashes are the second-leading mechanism of injury, followed by being struck. Among males, being struck is the second-leading mechanism of injury, followed by motor vehicle traffic-related crashes.

In children younger than two years with minor head trauma and a normal neurologic examination, approximately 3 to 10 percent have a TBI on CT, 1 percent has ciTBI, and 0.2 percent requires surgical intervention [12]. In children two years of age and older with minor head trauma and a normal neurologic examination, 3 to 7 percent may have a TBI on CT.

Timely descriptive national data about the incidence and circumstances of TBIs should be known for prevention local TBIs. Further national research should be done about the TBI epidemiology.

Symptoms

Loss of consciousness

Loss of consciousness (LOC) occurs in approximately 5 percent of children <2 years of age with minor head trauma [12]. In one study it was shown that, up to 13% of children ≥ 2 years of age had some degree of LOC [12]. Documented LOC, particularly for longer than a few seconds can be associated with ciTBI in children who have other findings associated with ciTBI. However the association between duration of LOC and risk of cTBI is not clear and should be clarified.

Headache

Studies report a prevalence of headache of 10% to 45% after injury and lasting weeks and months in some of them [13,14].

Vomiting

Vomiting may occur independently as a result of the severity of the head injury. At least one episode of vomiting is reported in approximately 13% of patients following minor head trauma [12]. There are not clear definitions for identifying the patients with ciTBI according the number of vomiting episodes and the timing of these episodes. Vomiting two or more times after head trauma was found associated 37 percent increase in TBI in one study [15].

Seizures

Posttraumatic seizures occur in as many 5% to 10% of all-injured children. The timing of the seizure is classified as immediate, early and late. Immediate post traumatic seizures occur at the time of injury, and are thought to be due to instant depolarization of the cortex in response to the injury. The impact seizures occurred in ≤ 0.6% (16). This type of seizure generally does not recur. These "impact seizures", are not predictive of clinically significant intracranial injuries, nor do they require any specific treatment or imaging. In contrast, early seizures occur after the impact, but within 24 hours of the injury. Early seizures are more likely to be manifestations of an intracranial injury and therefore warrant imaging. Late seizures occur greater than 1 week after injury and are a result of scarring and mechanical irritation of the brain. The routine use of prophylactic antiepileptic medications after minor head trauma is not necessary.

Scalp injuries

Although it is a highly vascular structure that bleeds profusely when injured, the scalp is underestimated in its contribution to head injury morbidity. In young infants, scalp injuries, with or without an opening in the skin, can cause deterioration from hemorrhagic shock [16]. In particular, a subgaleal hematoma in an infant may be significant source of hypovolemia from scalp hemorrhage without any signs external bleeding.

Skull fractures

Skull fractures occur up to 10% of children younger than two years of age following minor head trauma [17]. Linear skull fractures are the most common type of fracture seen in pediatrics, comprising approximately 75% to 90% of all fractures [18]. Among children with linear fractures, 15 to 30% have associated intracranial injuries [19,20]. In infants younger than one year of age, large scalp hematoma, younger age and/or nonfrontal location suggest a higher incidence of skull fracture. Other findings of skull fracture include palpable skull defect, rhinorrhea or otorrhea, Batlle's sign, hemotympanum and Raccoon eyes.

Transient cortical blindness and trauma triggered migraine

Transient cortical blindness has been reported as a complication of head trauma. Traumatic cortical blindness is typically seen in children and young adults who have sustained minor head injury, brief or no loss of consciousness, blindness occurring within hours of the head injury, normal pupils and fundi, and a normal CT scan of the head [21]. There appears to be some overlap with transient cortical blindness and what has been called "trauma triggered migraine". In these cases, a child sustains a blow to the head and then has a clinical presentation like that of classic migraine. These deficits are thought to be secondary to vascular hyper reactivity.

Unfortunately the studies that describe clinical features following minor head trauma only included children who underwent head CT. Observational more studies should be done about the clinical features associated with minor head trauma.

Evaluation

The priority for the evaluation of children with apparently minor head trauma is to identify those patients with TBI who may require immediate intervention, admission for monitoring or close follow up, while limiting unnecessary neuroimaging.

The historical features that may suggest an increased risk of clinically important TBI should be recorded:

Younger than two years of age and not acting normally

Seizure, confusion, or LOC

Vomiting

Severe injury mechanism

Underlying disease that place the child at risk for intracranial hemorrhage

During physical examination the presence of the following specific findings should alert the physician:

Scalp abnormalities, such as larger hematoma, tenderness, or depression

In infants, bulging anterior fontanel

Abnormal mental status

Focal neurologic abnormality

Signs of basilar skull fracture, hemotypanum, otorrhea or CSF rhinorrhea

In children with minor head trauma the combination of history and clinical findings can help stratify a patient's risk of ciTBI and decide to perform neuroimaging.

Algorithms for Cranial CT in the Emergency Department

In mild head injuries, prevalence of abnormal CT is very low and increases substantially with decreasing GCS. However, up to 40% of children with mild head trauma underwent neuroimaging, despite the fact that more than 90% of the CR results were negative. This increase is likely due to combination of easier access to CT scanners and more efficient technology and concern amongst physicians of being unable to reliably identify intracranial injury based solely on a child`s clinical condition. One way increasing clinical sensitivity and specificity is to develop and use clinical decision rules (CDRs).

Immediate CT is indicated in any child with GCS less than 13 on initial examination, a GCS less than 15 at 2 hours after the injury, suspected open or depressed skull fracture, any sign of basilar skull fracture, seizure, coagulopathy, or more than 3 episodes of vomiting [22]. The National Emergency X-ray Utilization Phase II (NEXUS II; n=1600 children) recommends that a CT be made if any of the following factors are present: significant altered mental status, skull fracture, neurologic deficit, persistent vomiting, scalp hematoma, abnormal behavior, or coagulopathy [23]. For minor head trauma The NEXUS II sensitivity is 98.6% and even 100% in infants younger than 3 years. The Children`s Head Injury Algorithm for the Prediction of Important Clinical Events (CHALICE) from UK (n=2772) was derived for children with head injuries of all severities, presenting at any point after the injury. CHALICE uses more parameters and is thus complex to perform but its sensitivity is 98%, although it also misses some patients with significant intracranial injury because its negative predictive value is 99.97 [15]. The Canadian Assessment of Tomography for Childhood Head Injury (CATCH) (n=2772) was derived to manage children with minor head injuries presenting within 24 hours. CATCH proposes 4 high risk factors (GCS<15 at 2 hours after injury, open or depressed skull fracture, worsening headache, irritability) and 3 medium-risk factors (basal skull fracture, hematoma of the scalp, dangerous mechanism of injury). Given one of these factors, the need for neurosurgical intervention was predicted with a sensitivity of 100% for the high risk factors and 98.1% for the medium-risk factors [15]. Kuppermann et al. [12] described the highest risk for ciTBI as altered mental status and palpable unclear skull fracture in those younger than 2 years or signs of basilar skull fracture in those older than 2 years. All of the mentioned CDRs aim to identify children likely to have significant intracranial injury who warrant a cranial CT scan.

The Pediatric Emergency Care Applied Research Network (PECARN) algorithm from USA developed prediction rule for the identification of children at very low risk of ciTBI [12]. PECARN rule focuses on children with minor head injuries presenting within a 24-hour period and aims to identify patients unlikely to have a ciTBI who can be safely discharged without a CT scan. The group formulated two aged-based algorithms for children with GCS scores of 14-15 after head trauma, which stratified patients into high, intermediate and low risk based on predictors that were identified during the derivation portion of the study. For children aged below 2 years, the predictors:

GCS=14 or other sign of altered mental status

Presence of a palpable skull fracture

Occipital, parietal or temporal scalp hematoma

History of LOC for at least 5 s

Not acting normally per parent

The predictors for children aged at least 2 years with GCS scores of 14-15 after head trauma

GCS=14 or other signs of altered mental status

Signs of basilar fracture

History of LOC

History of vomiting

Severe headache

In prospective validation for PECARN, high sensitivities for the detection of ciTBI (100% for children <2 years and 97% for children ≥ 2 years) and high negative predictive values (100% for children <2 years and 99.95 % for children ≥ 2 years) were achieved.

In a prospective, single center observational study of physician judgment and CDRs in which PECARN, CHALICE and CATCH decision rules were all applied to 1009 children with minor head injury, only physician practice and the PECARN rule identified all ciTBI, including four patients requiring neurosurgical intervention [25]. However, the performance accuracy and positive predictive value of each CDR in identifying ciTBI should be compared. Furthermore, CDRs are not intended to replace clinical judgment.

The injury mechanism and neuroimaging

The association between injury mechanism and ciTBI is not clearly known. A severe injury mechanism can be defined as a motor vehicle collision with patient ejection, death of another passenger, or rollover; a pedestrian or bicyclist without helmet struck by motorized vehicle; falls (at a height of >1 m for children aged <2 years and >1.5 m for children >2 years); or the head struck with a high impact object. Nigrovic et al. [26] recently investigated the prevalence of ciTBI in children with severe injury mechanism but with no other PECARN risk factors. They found the risk of ciTBI 0.9% in children with isolated severe injury of mechanism. The authors concluded that children who had head trauma with isolated severe injury mechanism might not require cranial CT.

Management after initial assessment

Although there is not uniformity regarding risk factors derived from the large, multicenter observational studies, there are many consistencies. This approach is largely consistent with guidelines evaluation and management of minor head trauma in children previously proposed by expert consensus [10].

Most infants and children who have isolated minor head trauma can be safely discharged following evaluation. In patients with normal cranial CT, hospitalization for neurologic observation is not necessary. Asymptomatic patients may be discharged home to the care of reliable parents or guardians [27]. Written instructions describing signs to watch for, who to contact in such a case and when to return for follow-up, should be provided. There is no cure for mild head injury, but treatment can help. Recommended therapy is rest, enough fluids, and sufficient analgesia in the form of paracetamol and antiemetics such as ondansetron. Because of the potential risk of bleeding, nonsteroidal anti-inflammatory drugs or aspirin should be avoided, unless there is a very small risk of ciTBI.

If after initial evaluation there is headache or repeated vomiting, or there is a history of LOC at the time of trauma, a period of clinical observation, with reassessment, is indicated. If there is improvement in symptoms and the GCS is 15, the patient may be discharged home with parental instructions as above. If there is no improvement, the patient should be admitted to hospital with evaluation of vital signs and level of consciousness every 2 h to 4 h. Intravenous rehydration should be provided for patients with persistent vomiting. Persistent symptoms after 18 h to 24 h of hospitalization may indicate a head CT scan, if not already performed. A CT scan with positive findings should be discussed with a neurosurgeon, and consulting a clinician experienced in the management of head trauma may be appropriate for patients with negative CT scans but experiencing persistent symptoms.

In the child younger than two years of age, and particularly in children younger than 12 months of age, greater caution is advised. The challenges of their clinical assessment and the importance of identifying abusive trauma should lead clinicians to observe these patients for a longer period, with frequent reassessments. Trivial head trauma in an asymptomatic, ambulatory toddler is compatible with discharge from the ED; this may not be the case for an infant or baby. The presence of a widened or diastatic skull fracture (>4 mm) increases the risk of developing a leptomeningeal cyst, and follow-up of these patients should be arranged [28].

Hospital Admission

For children older than 2 years a UK guideline recommends hospital admission for LOC lasting more than 5 minutes, amnesia, headache, vomiting, or lethargy [22]. The patients should also admitted if there is suspicion of inflicted injury, if age is <3 months, do not aroused with light touch with a normal neurologic examination, do not return to baseline level of function during observation, do not tolerated oral intake of fluids because of vomiting, have extracranial injuries warranting admission and caretakers do not capable reliably observe the child.

Discharge

Infants and children with minor head trauma who have undergone a complete evaluation and are found to be low risk for ciTBI based upon clinical findings or according to a clinical decision rule should discharged home. Infants or children who are at intermediate risk for ciTBI and who are observed without neuroimaging should discharged home rather than undergo hospital admission if they show improvement in initial symptoms during an observation period lasting up to four to six hours post-injury. Infants and children with minor head trauma who are initially not at low risk for ciTBI but have normal neuroimaging, a normal level of consciousness, and meet all discharge criteria should undergo home.

Observation is still important even in discharged patients because signs and symptoms of TBI may arise and prompt return to the ED for reevaluation. Caretakers should be instructed to call right away or seek emergency treatment for the following indications:

Persistent or worsening headaches

Vomiting after the initial injury

Change in mental status or behavior

Unsteady gait or clumsiness/incoordination

Bloody or clear rhinorrhea or otorrhea

Development of focal weakness or numbness

Irritability

Difficulty staying awake or being aroused

Conclusions

Minor TBI is the most common presentation of the head-injured child to the ED. The best way to manage children with minor TBI is still matter of debate. The radiation risk posed by CT scanning in children must be balanced by the benefits. The application of CDRs can aid the clinician in identifying children at low risk for ciTBI and minimize unnecessary radiation exposure. However further research is needed for determine the rate of ciTBI, the rate of neurosurgical intervention, number of missed ciTBI, characteristics of missed ciTBI, sensitivity, specificity, negative and positive predictive value of CDRs, diagnostic accuracy of each of CDRs and outcome of minor head injury.

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