Management of Minor Head Injury in Children

Case Study and Commentary, Angela K. Lumba, MD, and Simon J. Lucio, MD

ABSTRACT

• **Objective:** To review diagnosis and management of mild traumatic brain injury (mTBI) in the pediatric patient following closed head injury (CHI).
• **Methods:** Review of the literature.
• **Results:** Mild TBI may result from any degree of head injury regardless of severity and present with concussive symptoms. The differential diagnoses of concussive symptoms assist in the identification of mTBI. There are several recently published guidelines to aid in the diagnosis of mTBI. Treatment for the mTBI patient includes both supportive care as well as family education. Post-CHI return to play guidelines are important in the management and prevention of potentially devastating sequelae.
• **Conclusion:** Pediatric CHIs are common and can result in TBI. The vast majority of pediatric TBI post-CHI are classified as “mild.” Using current established guidelines, pediatric patients with mTBI can be managed supportively upon their initial diagnosis and throughout their recovery period.

The Centers for Disease Control and Prevention (CDC) have deemed TBI in children a public health problem [1]. Pediatric TBI accounts for 3000 deaths, 29,000 hospitalizations, and 473,947 emergency department (ED) visits in the United States annually in children aged 14 years and younger [1]. However, the vast majority of pediatric TBIs are classified as mild. Seventy-five percent of pediatric closed head injuries (CHIs) result in mild TBI (mTBI) [2].

The Mild Traumatic Brain Injury Committee of the American Congress of Rehabilitation Medicine defined mTBI as a “traumatically induced physiological disruption of brain function” after a head injury [3]. However, identifying the concussed child with mTBI can be challenging. Concussion is a constellation of symptoms caused by mild, moderate, or severe TBI. These symptoms may include loss of consciousness, altered mental status, nausea and vomiting, headache, amnesia, dizziness, and speech and coordination problems. Concussion in itself may be mild to severe and has not been shown to correlate with the degree of TBI sustained. Pediatric patients with moderate to severe TBI are also concomitantly diagnosed with concussions. In a prospective cohort study of 432 pediatric patients with TBI, Dematteo et al found that of the 32% of concussed pediatric patients, only 37% had Glasgow Coma Score (GCS) of 13 to 15 [4]. In the face of concussive symptoms, mTBI is a diagnosis of exclusion made after sufficient observation time or imaging studies. The decision to observe in the ED versus at home or obtain immediate imaging is multifactorial.

**CASE STUDY**

**Initial Presentation**

A 3-year-old child who fell from her father’s shoulders approximately 5 feet onto a concrete floor approximately 2 hours ago presents to the pediatrician’s office, which is closing in half an hour. The child cried immediately and did not lose consciousness but has since vomited once. The pediatrician refers her “to the ER for head CT.”

• **What is the initial approach to assessment of the pediatric patient with CHI?**

The initial approach to a pediatric patient after CHI begins with assessment of their airway, breathing, circulation, and mental status. Once it has been established that the child is breathing and oxygenating adequately, hemodynamically stable, and without neurologic deficit or other signs of intracranial injury, the clinician may proceed with a focused history and physical examination. Essential information gathered from the history

From the Rady Children’s Hospital, Department of Pediatric Emergency Medicine, San Diego, CA.
Pediatric Head Injuries

includes time and mechanism of injury, history of altered mental status or loss of consciousness, vomiting, seizure, or speech problems. Key physical examination finding include the presence of cephalohematomas, palpable cranial step irregularity suggesting a skull fracture, focal neurologic deficits, distracting injuries, altered mental status and a diminished GCS.

• **How does a clinician identify minor head injury in the pediatric population?**

The pediatric patient with head injury is brought to a clinician’s attention by a caregiver after a history of injury and/or with symptoms of concussion. Concussive symptoms are proposed to be caused by the neurobiochemical alterations induced by TBI [5]. This has been shown in animal models to include oxidative damage, decreased energy metabolism, decreased N-acetyl aspartate concentration, and increased GABA-mediated inhibition [5,6]. Such changes can occur in the brain after force to the head, be it with shaking or blunt head injury, even in the absence of intracranial hemorrhage or contusion. The remainder of our discussion will characterize mTBI by this mechanism of injury.

Mild TBI often presents with concussion symptoms including loss of consciousness, amnesia, confusion, headache, nausea and vomiting. Further evaluation for other potential etiologies must also be considered. A broad differential diagnosis of the concussed pediatric patient after head injury exists and includes:

- Mild, moderate, severe TBI including intracranial hemorrhage and cerebral edema
- Skull fracture
- Cephalohematoma
- Nonaccidental trauma
- Headache, including migraine
- Stroke
- Drug ingestion
- Seizure
- Meningitis/encephalitis
- Diabetic ketoacidosis
- Heat illness

• **Are minor head injury, concussion, and mTBI the same thing?**

Many physicians synonymously define minor head injury, concussion, and mTBI. However, these entities are not entirely inclusive of each other and their connotations have different relevancies to families, sports coaches, and health care providers. A recent study highlighted the misconception that an injury described as a concussion is less severe than one described as an mTBI and suggested that this may result in a premature return to activity [4]. In another study, parents who did not equate mTBI with a concussion regarded the latter as considerably “better” than mTBI [7].

The American Academy of Neurology describes concussion as a “trauma-induced alteration in mental status that may or may not involve a loss of consciousness” with symptoms attributable to an underlying pathology—TBI, mild to severe [8]. As stated previously, the Mild Traumatic Brain Injury Committee of the American Congress of Rehabilitation Medicine describes mTBI as a physiologic brain pathology induced after trauma with clinical manifestations of concussion [3]. The Children’s Hospital of Philadelphia practice guidelines further defines mTBI in children to include a GCS of 14 to 15 at the initial examination without focal neurologic deficits [9].

Hence, we define concussion as symptomatology after a head injury and mTBI as the intracranial pathology causing those symptoms. We do not recommend classifying head injuries as mild, moderate, or severe. Instead, it may be more appropriate to apply mild, moderate, and severe to the severity of symptoms of the concussion or pathologic brain injury. Additionally, physicians caring for pediatric patients and their families must come to consensus on terminology related to pediatric CHI.

• **What are the symptoms of mTBI?**

Symptoms of mTBI range from minimal headache to concussion and its manifestations.

The CDC classifies the symptoms of mTBI into 4 categories: physical, cognitive, emotional, and sleep (Table) [10].
**Are there historical findings that suggest mTBI?**

A thorough and complete history from the patient (if possible) and the parent can aid in determining if the symptoms of concussion are due to mTBI or from a more ominous pathology.

**Time Post Injury**

Neurologic deterioration after mTBI is very rare. Evaluation of a patient 1 hour post injury is more complex than evaluating the patient 1 day post injury. A retrospective cohort showed that 2 patients out of 18,000 children presenting to the ED with minor head injury had delayed deterioration after 6 hours [11]. A delay in seeking medical care for a head injury in a pediatric patient should alert the clinician to the possibility of nonaccidental trauma or medical neglect [12]. Additionally, history of other recent head trauma is important to elicit in order to assess for the presence of second impact syndrome [8].

**Mechanism of Injury**

Mild, moderate, and severe mechanisms of injury can result in mTBI. Severe mechanism of injury places the child at higher risk for all types of TBI. The 2009 PECARN (Pediatric Emergency Care Applied Research Network) study defined severe CHI mechanisms as motor vehicle crash with patient ejection, death of another passenger, or rollover; pedestrian or bicyclist without helmet struck by a motorized vehicle; falls of more than 3 feet in children less than 2 years old or more than 5 feet in children 2 years and older, or head struck by a high-impact object [13]. The CHALICE rules define severe injury mechanisms as high-speed accidents or projectiles and falls of more than 3 meters [14]. Ultimately, the clinician will determine the relevance of mechanism severity and decide if clinically significant TBI exists.

Conversely, mild mechanism of injury does not rule out the possibility of intracranial hemorrhage (ICH). Gruskin evaluated children younger than 2 years of age with CHIs and found that increasing the height of fall resulted in a higher incidence of ICH or skull fractures, but also noted that 7% of the children who fell less than 3 feet also had these injuries [15].

**Symptoms Upon Injury**

As a general rule, isolated symptoms after CHI are not strong predictors of TBI. However, identifying their presence in conjunction with the physical exam can aid in the clinician’s diagnosis. Common symptoms include of loss of consciousness, vomiting, and post-CHI seizures.

TBI occurs more commonly in children with a history of loss of consciousness than those without [16,17]. A history of loss of consciousness post-CHI can occur in isolation of other signs and symptoms. In a single-center study, Palchak found that none of the 142 children with CHI presenting with isolated loss of consciousness or amnesia had clinically important TBI. Conversely, 9.4% of those patients with loss of consciousness or amnesia in addition to other symptoms demonstrated evidence of injury on CT [18]. PECARN’s abstract of secondary analysis of isolated loss of consciousness following blunt head injury reported that the risk of TBI is very small: 4 of 790 children with isolated loss of consciousness had positive CT findings with only 1 requiring intervention [16].

Vomiting frequency alone is not a predictor of ICH, as described in a large meta-analysis by Dunning [14].

### Table. Symptoms of Mild TBI

<table>
<thead>
<tr>
<th>Physical</th>
<th>Cognitive</th>
<th>Emotional</th>
<th>Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>Feeling mentally “foggy”</td>
<td>Irritability</td>
<td>Drowsiness</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>Feeling slowed down</td>
<td>Sadness</td>
<td>Sleeping more than usual</td>
</tr>
<tr>
<td>Nausea or vomiting (early on)</td>
<td>Difficulty concentrating</td>
<td>More emotional</td>
<td>Sleeping less than usual</td>
</tr>
<tr>
<td>Dizziness</td>
<td>Difficulty remembering new information</td>
<td>Nervousness</td>
<td>Trouble falling asleep</td>
</tr>
<tr>
<td>Sensitivity to noise or light</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance problems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from reference 10.
analysis showed that acute repetitive vomiting was not more significant than a single emesis in predicting ICH. Preliminary data from PECARN suggested that 1.7% of children with isolated vomiting had TBI on CT, while 0.2% required intervention [18]. The risk of TBI did not increase with any increased number of vomiting episodes. In 1999, Nee found that there was an increased relative risk of skull fracture in adults and children with head injury and vomiting [19]. This study demonstrated that a single episode of vomiting was as significant as multiple episodes. These studies support the notion that identifying a history of vomiting is more important than quantifying the number of emesis episodes post-CHI.

Posttraumatic seizures can occur after minor CHI, even though they are more commonly associated with severe TBI. They occur in less than 10% of pediatric head injuries [20]. It is important to ascertain from the patient’s past medical history if the seizure may have actually precipitated the CHI.

Seizure disorders, history of syncope or stroke, possible ingestion, as well as other etiologies increase the risk of falling, leading to potential CHI. Knowledge of history of previous head injury or symptoms of concussion should heighten concern for TBI sequelae such as second impact syndrome. Patients with congenital or acquired bleeding disorders are at increased risk of ICH after minor head injuries and will likely be symptomatic if ICH is present [21]. A secondary analysis by Lee demonstrated that children with bleeding disorders sustaining head injury with subsequent ICH are generally symptomatic [22]. Similarly, anticoagulant use, with warfarin for example, increases the likelihood of ICH in mTBI [23]. A recent study in the Journal of Trauma highlighted the relationship between high INR and the likelihood of ICH in adults, suggesting a cutoff value of 2.43, holding a negative predictive value of 97% [24]. Drug ingestions such as acute alcohol intoxication and illicit drug use can potentially lead to CHIs. Medications such as clonidine may cause changes in blood pressure and can precipitate dizziness that leads to falling and possible CHI.

**Case Continued**

The ED clinician notices that the patient has a small frontal cephalohematoma with an otherwise normal examination. She is awake and alert, speaking and playing normally, but complains of a headache. Her father reports that she is an otherwise well child and not on any medications.

**Are there physical findings that suggest mTBI?**

There is no single physical finding that suggests mTBI. Any patient with a CHI should have vital signs assessment and pediatric GCS assignment as well as a complete neurologic examination. The Children’s Hospital of Philadelphia practice guidelines defines pediatric mTBI in children with a minimum GCS of 14 to 15 at the initial examination and without focal neurologic deficits [9]. Pediatric patients who sustain CHI and present with GCS < 14 have a risk of more than 20% of TBI on head CT [25]. Neurological deficits or instabilities warrant further assessment for moderate to severe TBI. It is equally important to note that a normal GCS is not a reliable indicator for the absence of TBI [26].

Cephalohematoma or skull abnormality can be present after CHI but is not necessarily suggestive of TBI. PECARN concluded that there is a low risk (0.5%) of clinically important TBI in children less than 2 years of age with isolated scalp hematomas. However, it was noted that the likelihood of CT-positive TBI was higher in children younger than 3 months and in those with large temporal-parietal cephalohematomas [27]. Skull fracture post CHI has been shown to increase the risk of ICH fourfold [28]. Because children with signs of skull fracture have a higher risk of clinically important TBI, both the PECARN’s derived clinical decision rules as well as the CHALICE rules recommend obtaining head CT in the patient's evaluation [13,14].

Clinician evaluation of other injuries may suggest nonaccidental trauma and increase concern for TBI.

**Does the pediatric patient with mTBI need a head CT?**

A pediatric patient with suspected mTBI does not need a head CT. However, if the evaluating clinician has any concern for moderate to severe TBI such as an ICH, imaging is warranted. Fifty percent of children assessed for CHI in North American EDs undergo head CT scanning because it is considered the best imaging modality to evaluate for TBI in the acute setting [29]. However, head CT imaging carries a risk of radiation and children are 10 times more radiosensitive than adults [30,31]. The risk for subsequent malignancy from head CTs has been extrapolated from Japan’s atomic bomb survivors’ data and is estimated at...
1 fatal cancer per 1000 to 5000 pediatric head CT exams [30,31]. The “ALARA” principles recommend imaging with exposures kept “as low as reasonably achievable;” an adult-protocolled head CT scan delivers twice the amount of radiation as a similar pediatric-protocolled scan [32]. The National Cancer Institute reports a single unadjusted head CT (200mAs) produces 1.8–3.8mSv of radiation while a pediatric adjusted head CT (100 mAs) produces 0.9–1.9 mSv [33]. However, not all hospitals utilize pediatric-specific protocols.

Over the past 10 years, many studies and guidelines have been published on CT imaging in pediatric CHI, including the CATCH rules of 2010, PECARN’s 2009 Lancet study, and Dunning’s CHALICE rules from 2006 [13,14,34]. Collectively, these derivation rules and guidelines recommend assessing patient injury history, symptomatology, and clinician findings in the decision to obtain head CT imaging.

The PECARN clinical prediction rules are the most recent guidelines published in evaluating the use of CT imaging in over 40,000 pediatric patients at very low risk of clinically important TBI [13]. It assessed numerous potential predictors including severity of injury mechanism, history of loss of consciousness, duration of loss of consciousness, headache, severity of headache, vomiting and number of times, acting abnormally according to parent, altered mental status, signs of basilar skull fracture, palpable skull fracture, scalp hematoma and its location. The prediction rules recommend CT for children less than 2 years of age with a GCS of 14, other signs of altered mental status, or palpable skull fracture. The decision to observe versus obtain at CT is multifactorial in children with occipital/parietal/temporal scalp hematomas, a history of loss of consciousness for 5 seconds or longer, a severe mechanism of injury, or not acting normally per parents. Determining factors can include clinician experience, multiple symptoms, worsening ED course, parental preference, and the evaluation of very young infants. If no predictors were present, the patient had a 0.02% or less risk of clinically important TBI. The prediction rules recommend CT in children 2 years and older with a GCS of 14 or other signs of altered mental status or signs of basilar skull fracture. In a child with a history of loss of consciousness, history of vomiting, severe injury mechanism, or severe headache, the decision to observe versus obtain CT imaging is multifactorial. If none of these predictors were present, the patient had a 0.05% or less risk of clinically important TBI. The prediction rules do not recommend CT in pediatric patient without any of the above findings. It is important to note that non-accidental trauma was not evaluated in this study.

Head CT imaging is not mandatory in the pediatric patient with uncertain indications if close observation is possible. Nigrovic studied 40,000 children with minor CHI and compared a subset of 5433 that were observed [35]. The rate of head CT in those observed was 31.1% as compared to 35% in those who were not observed, suggesting that clinical monitoring is a factor in the decision to obtain head CT.

The 1999 American Academy of Pediatrics recommended 24 hours of observation in hospital, ED, doctor’s office, responsible home environment, or any combination of the above for patients with suspected mTBI [36]. Depending on the facility, observation units may be utilized for monitoring after CHI [37]. Nigrovic et al reported that clinical observation in the ED was associated with a reduction of head CT ordered in children with minor head injury [35].

- **What treatments are available for the pediatric patient with mTBI?**

Symptomatic control is the main objective in mTBI when the concern for ICH or skull fracture has been effectively ruled out via imaging or clinical examination and observation.

Pain control of headache associated with direct blow, cephalohematoma, and concussion should be initiated. Acetaminophen does not have the antiplatelet effect found in ibuprofen or the sedative properties of narcotics and is a prudent first-line medication in the patient who has not had ICH effectively ruled out by imaging. There is no evidence that acetaminophen or nonsteroidal anti-inflammatory agents (NSAIDs) alleviate or shorten the duration of concussive symptoms [38]. A single animal study showed that chronic ibuprofen use post TBI worsens cognitive outcome [39]. Stronger analgesics such as opioids and opiates may alter the patient’s baseline mental status, making continued evaluation during observation difficult for clinicians and caretakers.

Nausea and vomiting are symptoms of concussion that may potentially be ameliorated by antiemetics such as metoclopramide or ondansetron. There is valid concern in administering antiemetics to concussed pediatric patients who do not receive head CTs because protracted vomiting in this population would likely warrant imaging to evaluate...
PEDIATRIC HEAD INJURIES

for ICH. Side effects of metoclopramide include extrapyramidal symptoms. Charbit reported that ondansetron use led to significant prolongation of the QTc interval [40]. The FDA warns to avoid the use of ondansetron in patients with congenital long QT syndrome because of the risk for developing torsades des pointes. The FDA also recommends ECG monitoring in patients taking ondansetron with electrolyte abnormalities, congestive heart failure, bradyarrhythmias, or in patients taking other medications that can lead to QT prolongation [41]. Due to these new FDA regulations, discharge prescriptions for ondansetron should be administered with caution to pediatric patients.

Despite pain control and antiemetics, if the patient persists with symptoms of severe concussion, admission to an inpatient ward or observational unit is warranted for further therapy including potential intravenous antiemetics, pain management, and fluid rehydration.

**Case Continued**

The patient has remained stable after her fall from father’s shoulders, now 5 hours ago. She has been observed in the ED for 3 hours and has had normal behavior per her father during this time. She initially complained of headache, which has since resolved after acetaminophen administration and she is tolerating oral liquids without further vomiting. The ED physician decides not to obtain a head CT in this patient as the risks of ionizing radiation and sedation outweigh the benefits in this well-appearing child.

**Can the patient be safely discharged home?**

The patient in our case study did not undergo imaging despite sustaining a head injury with concussive symptoms suspected to represent a mTBI. Because she has remained clinically stable for 5 hours post injury, it is unlikely that she will further decompensate. In 2010, Hamilton examined the incidence of delayed ICH in children after an uncomplicated minor CHI [11]. Out of the 17,962 children evaluated, only 2 patients had delayed symptomatic presentation of ICH at 8 and 38 hours. Extrapolation of the data resulted in an incidence of 0.57 cases of delayed deterioration per 100,000 children with minor head injuries per year.

Pediatric patients with concussion or resolved concussive symptoms and mTBI diagnoses must meet discharge criteria prior to going home with their family. Discharge criteria include:

- Hemodynamic stability with physician expectation of persisting stability
- Absence of alteration in mental status
- Absence of intolerable pain
- Ability to tolerate oral fluids
- Presence of reliable caretakers
- Primary care provider in place
- Caretaker understanding of discharge instructions including return precautions and re-evaluation prior to returning to activity.

It is important to discuss recommendations for cessation of contact activities and the need for medical clearance by a care provider prior to return to play. Families should be made aware of postconcussive syndrome and the risk for second impact syndrome. An online resource created by the CDC, *Heads UP: Concussion*, provides important information for families as well as school personnel and health care professionals on preventing, recognizing, and responding to a concussion [42].

Pediatric patients that do not meet all of these discharge criteria require admission for evaluation, further treatment, and close monitoring. Criteria for admission include: physician concern for potential change in medical stability, severe and protracted headache, or inability to tolerate fluids orally either by refusal or with frequent vomiting.

**When can the pediatric patient with mTBI return to play?**

Pediatric patients with mTBI are at risk for re-injury and prolonged recovery if they return to play prior to resolution of the symptoms. Complete resolution of the symptoms should occur both at rest and during physical exertion prior to resuming physical activities [10]. Neuropsychosocial testing may also help identify patients who are still symptomatic and not ready to resume play [43]. Many concussion authorities, including the CDC and the International Conference on Concussion in Sports, recommend a stepwise process for return to play over several days beginning with light activity and progressing to full activity if concussive symptoms do not recur [8,43].
Second impact syndrome is a serious concern for re-injury in the recently concussed pediatric patient. In fact, all reported cases of second impact syndrome have been in patients under 20 years old [44,45]. Second impact syndrome is a catastrophic subsequent brain injury occurring after an initial TBI and generally before the symptoms of concussion have resolved. Research suggests that even a mild TBI can cause complex biochemical derangements in the brain and persist through recovery as a “situation of metabolic vulnerability” [3]. Hence, a subsequent normally mild injury can present with the “biochemical equivalence of a [severe] TBI” when a compounding additional injury ensues [3]. It is hypothesized that the mechanism for injury is progressive cerebral vascular injury resulting in diffuse cerebral swelling and death [46].

• What side effects can we expect to see in children who suffered mTBI?

Most children with mTBI will recover from their concussive symptoms within 2 weeks [47]. A 2009 study of 116 children admitted with mTBI evaluated for a variety of persisting concussive symptoms found that on follow-up assessment from hospital discharge, the most common symptom was excess sleep [48]. When post CHI symptoms persist longer than 7 to 10 days, patients are considered to have postconcussive syndrome. This syndrome can manifest with any combination of headache, sleep disturbance, dizziness, nausea, fatigue, attention problems, irritability, anxiety, depression, and emotional lability [49]. Blume examined headache in concussed children and found that after 3 months, 43 out of 100 children who experienced an mTBI complained of headaches [50]. A recent study examined postconcussive symptoms in children with mTBI as compared to children with uncomplicated orthopedic injuries [51]. Acute CT scan or MRI abnormality, loss of consciousness, hospitalization, and injuries to body regions other than the head predicted a higher likelihood of postconcussive symptoms.

CONCLUSION

Pediatric CHIs are common and can result in TBI. The vast majority of pediatric TBI post CHI are classified as “mild” [1]. Research and guidelines in the management of pediatric mTBI have advanced in the last 10 years. An expert panel on pediatric mTBI has been newly formed by the CDC to establish national recommendations for this common injury. Using current guidelines, pediatric patients with mTBI can be managed from the onset of their initial diagnosis and throughout their recovery period.

Corresponding author: Angela K. Lumba, MD, Rady Children’s Hospital, Department of Pediatric Emergency Medicine, 5075 Children’s Way, San Diego, CA 92123, alumba@aol.com

Financial disclosures: None.

Author contributions: conception and design, AKL; analysis and interpretation of data, AKL, SJL; drafting of article, AKL; critical revision of the article, AKL, SJL; collection and assembly of data, AKL.

REFERENCES

Pediatric Head Injuries


41. FDA Drug Safety Communication: Abnormal heart rhythms may be associated with use of Zofran (ondansetron) Accessed 14

Copyright 2012 by Turner White Communications Inc., Wayne, PA. All rights reserved.