

AUTHORS

Akhila Pamula, MD,

Resident Physician, Stanford/Kaiser
Emergency Medicine Residency,
Department of Emergency Medicine,
Stanford School of Medicine,
Stanford, CA

Calvin E. Hwang, MD,

Kaiser Permanente Santa Clara
Medical Center, Santa Clara, CA

N. Ewen Wang, MD,

Professor of Emergency Medicine,
Associate Director of Pediatric
Emergency Medicine, Stanford
School of Medicine, Stanford, CA

PEER REVIEWER

Samuel H.F. Lam, MD,

RDMS, Clinical Associate Professor
of Emergency Medicine, University of
Illinois at Chicago

STATEMENT OF FINANCIAL DISCLOSURE

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Diagnosis and Management of Pediatric Concussions in the ED

Head trauma is a common pediatric presentation in emergency departments (EDs). While traumatic brain injury can be a major cause of death and disability, most children have mild, non-life-threatening events. In recent years, there has been increased public awareness of mild traumatic brain injury, or “concussion,” and its sequelae in children. Children with a possible concussion frequently first present in the ED. Thus, its diagnosis, management, and aftercare are significant issues in the pediatric ED.

— Ann M. Dietrich, MD, FAAP

Definition

A wide variation exists in definitions for pediatric head injuries. For the purpose of this article, pediatric head trauma will be divided into three categories: mild head trauma, mild traumatic brain injury, and clinically important traumatic brain injury.¹ Definitions for these three distinct entities can be found in Table 1. Diagnostic criteria for mild traumatic brain injury are listed in Table 2. The term concussion has been used interchangeably with mild traumatic brain injury, although a universally accepted definition still remains elusive. The current international definition of concussion, as determined by the Fourth International Conference on Concussion in Sport, has multiple components; it is defined as a brain injury induced by biomechanical forces resulting in short-lived impairment of neurologic function that resolves spontaneously. According to the definition, the acute clinical symptoms of concussion reflect a functional disturbance as opposed to a structural injury; therefore, no abnormality is seen on standard structural neuroimaging studies.² Acute symptomatology is thought to be related to transient axonal injury, alteration in cerebral blood flow, metabolic derangement, and microstructural change.

Epidemiology

More than 600,000 cases of pediatric head trauma present to EDs annually.³ Males in early adolescence are at the highest risk for concussion. Falls are the most common cause in children younger than 10 years of age. Sports-related concussions are the most common cause in children ages 10 years and older.⁴

Clinical Manifestations

Concussions cause a constellation of functional symptoms in the absence of structural damage. Symptoms can begin with the trauma or in the subsequent 24–48 hours and may evolve slowly over days to weeks. (See Table

EXECUTIVE SUMMARY

- Headache is the most commonly reported symptom of concussion, with immediate loss of consciousness occurring in < 10% of cases. Early symptoms of concussion may also include dizziness, amnesia to the event, confusion, nausea, and vomiting.
- Short-term predictors of prolonged symptoms include increased number of initial symptoms, older age (adolescent vs child), loss of consciousness and amnesia, and premorbid conditions including previous concussion, learning difficulties, and psychiatric illness.
- Regardless of age group, PECARN recommends a CT scan in any child who presents with a Glasgow Coma Scale < 15, altered mental status, signs of palpable or basilar skull fracture.
- In children older than 2 years of age, symptoms in which shared decision-making should be employed regarding CT imaging vs observation (either at home or in the ED) include history of vomiting, loss of consciousness, severe headache, or severe mechanism of injury.
- In children younger than 2 years of age, risk factors in which imaging should be considered include a nonfrontal scalp hematoma, abnormal activity according to the parents, or a severe mechanism of injury.

3.) Headache is the most commonly reported symptom. Immediate loss of consciousness occurs in < 10% of cases. Early symptoms of concussion may also include dizziness, amnesia to the event, confusion, nausea, and vomiting. The incidence of post-traumatic dizziness or vertigo, thought to be caused by direct injury to the cochlear, labyrinthine, or vestibular structures, has not been well-characterized in the literature.⁵

Over the next hours to days, patients may develop mood or cognitive disturbance, light and noise sensitivity, and sleep disturbance. Occasionally, there may be transient cortical neurologic deficits, including cortical blindness, global amnesia, and slurred or incoherent speech, thought to be due to vascular hyperreactivity, a migraine-equivalent phenomenon.³ A surprisingly large percentage of patients can have continued symptoms for months, which can result in a phenomenon known as post-concussive syndrome described later in this article.

Short-term predictors of prolonged symptoms vary across studies but appear to include increased number of initial symptoms, older age (adolescent vs child), loss of consciousness and amnesia, and premorbid conditions including previous concussion, learning difficulties, and psychiatric illness.⁶ Interestingly, family history of headaches or migraines is not a predictor identified in the literature.

ED Evaluation

In the ED, all patients with head

trauma should have a full medical assessment with a thorough history from both the patient and witnesses to the event. This includes number of previous concussions or head injuries and the dates they occurred. The physical exam should pay special attention to the head, neck, and neurologic exam, including mental status, gait, balance, and evidence of associated extracranial injury. Management of serious brain injury, cervical spine injuries, and major trauma are outside the scope of this article.

Diagnosis — Ruling Out Clinically Important Brain Injury

The differential diagnosis for a concussion includes intracranial injuries such as a contusion, hemorrhage, or edema. Ultimately, the diagnosis of a concussion can be made only after the exclusion of these more serious, structural brain injuries. Thus, a common diagnostic dilemma in children with head trauma is the decision to obtain computed tomography (CT) imaging, an imaging modality both highly sensitive and specific for the detection of epidural and subdural bleeds, and subarachnoid hemorrhages. However, as practitioners and families have become increasingly aware of the possible long-term sequelae of ionizing radiation, researchers have developed algorithms to help guide practitioners in imaging children with head trauma.⁷

The Pediatric Emergency Care Applied Research Network (PECARN)

consortium produced the largest study to date that derived and validated a clinical prediction rule to identify children with very low risk for clinically important traumatic brain injury who, therefore, do not require CT imaging.⁸ The study population included a combined 42,412 children in the derivation and validation populations. Of note, 10,718 children were younger than 2 years of age. Clinically important traumatic brain injury was defined as brain injury resulting in any of the following: death from traumatic brain injury, brain injury requiring neurosurgical intervention, intubation for more than 24 hours for the brain injury, and/or hospital admission of at least 2 days. Figure 1 describes the PECARN algorithm. Children are divided into two categories: those between the ages of 2 and 18 years and those younger than 2 years of age. Regardless of age group, a CT scan is recommended in any child who presents with a Glasgow Coma Scale (GCS) < 15 (see Table 4), altered mental status, or signs of palpable or basilar skull fracture. Severe mechanism of injury is defined as a fall greater than the child's height (typically < 3 feet for children younger than 2 years of age and > 5 feet for children older than 2 years of age); a motor vehicle collision with ejection, rollover, or fatality; a bike/pedestrian vs vehicle accident in which the patient was not wearing a helmet; or being struck by a high-impact object.

In children older than 2 years of age, symptoms in which shared decision-making should be employed regarding CT imaging vs observation (either at

Table 1. Definition of Pediatric Head Trauma

	Mild Head Trauma	Mild Traumatic Brain Injury	Clinically Important Traumatic Brain Injury
Glasgow Coma Scale	15	14-15	Usually < 14
Definition	Age < 2 years: either a history or physical signs of blunt trauma to the skull or scalp in an infant or child who is alert or awakens to voice or light touch. Age > 2 years: head trauma resulting in a normal neurologic exam and no physical evidence of skull fracture	Head trauma associated with disorientation, vomiting, or brief loss of consciousness	Head trauma associated with the presence of intracranial injury on CT imaging that warrants surgical intervention, intubation for management, hospitalization for > 48 hours, or death

Adapted from: Schutzman S. Minor head trauma in infants and children: Management. In: Post TW, ed. *UpToDate*. Waltham, MA: UpToDate. Available at: <http://www.uptodate.com/contents/minor-head-trauma-in-infants-and-children-evaluation>. Accessed Aug. 8, 2015.

home or in the ED) include history of vomiting, loss of consciousness, severe headache, or severe mechanism of injury. Recent studies have demonstrated that isolated brief loss of consciousness and minimal vomiting are rarely associated with clinically important traumatic brain injury.⁹

In children younger than 2 years of age, risk factors in which imaging should be considered include a non-frontal scalp hematoma, abnormal activity according to the parents, or a severe mechanism of injury (*see definition above*). CT imaging should be more strongly considered in infants younger than 3 months of age, as the absence of clinical signs of brain injury is not as reliable. A summary of decision rules for avoiding CT in children with head trauma is presented in Table 5.

Two other studies have developed clinical guidelines regarding when to image children with head trauma. The children's head injury algorithm for the prediction of important clinical events (CHALICE) study identified 14 high-risk criteria for clinically important traumatic brain injury that indicate the need for further imaging. Criteria included witnessed loss of consciousness > 5 minutes, > 5 minutes of amnesia, abnormal drowsiness, more than three episodes of emesis, suspicion of non-accidental injury, seizure, GCS < 14, signs of basilar or depressed skull fracture, focal neurologic exam, or high-risk mechanism. Using these criteria, the group

Table 2. Diagnostic Criteria for Mild Traumatic Brain Injury

A patient with mild traumatic brain injury has had a traumatically induced physiologic disruption of brain function, as manifested by 1 or more of:

- any loss of consciousness up to 30 minutes;
- any loss of memory for events immediately before or after the collision, but not lasting longer than 24 hours;
- any alteration of mental state at the time of the collision (e.g., feeling dazed, disoriented, or confused); or
- focal neurologic deficits that might or might not be transient, but where the severity of the injury does not exceed the following:
 - loss of consciousness exceeding 30 minutes,
 - post-traumatic amnesia longer than 24 hours, or
 - Glasgow Coma Scale score falling below 13 after 30 minutes.

Adapted from the Mild Traumatic Brain Injury Committee of the American Congress of Rehabilitation Medicine

achieved a sensitivity of 98.6% and a specificity of 86.9%.¹⁰ Similarly, the Canadian Assessment of Tomography for Childhood (CATCH) study identified four high-risk factors and three medium-risk factors for clinically significant head injury in children. (*See Table 6.*) The high-risk features include a GCS < 15 at 2 hours after injury, suspected open or depressed skull fracture, worsening headache, or irritability. The medium-risk factors include signs of basal skull fracture, large boggy scalp hematoma, and mechanism of injury (motor vehicle collision, fall from elevation ≥ 3 ft or five stairs, fall from bicycle with no helmet). The high-risk features were 100% sensitive and 70.2% specific in

detecting clinically important traumatic brain injury, while the medium-risk features were 98.1% sensitive and 50.1% specific.¹¹ However it is important to note that these rules have not been as well validated as the PECARN rule.¹²

Diagnosis of Concussion

Once the diagnosis of structural brain injury has been excluded (with or without imaging), concussion can still be difficult to identify, as there is currently no objective measure with which to make the diagnosis. Given that the majority of concussions do not result in dramatic symptoms such as loss of consciousness, a concussion can go unrecognized by both

Table 3. Concussion Symptom Checklist

Physical	Cognitive	Emotional	Sleep
<ul style="list-style-type: none"> • Headache • Nausea • Vomiting • Balance problems • Dizziness • Blurry vision • Fatigue • Photophobia • Phonophobia • Numbness/tingling 	<ul style="list-style-type: none"> • Feeling mentally foggy • Feeling slowed down • Difficulty with concentration • Difficulty with memory 	<ul style="list-style-type: none"> • Irritability • Sadness • Emotional lability • Nervousness 	<ul style="list-style-type: none"> • Drowsiness • Sleeping either more or less than usual • Trouble falling asleep

Adapted from: Centers for Disease Control and Prevention. Acute Concussion Evaluation (ACE). Available at: http://www.cdc.gov/headsup/pdfs/providers/ace_ed-a.pdf. Accessed July 30, 2015.

Table 4. Glasgow Coma Scale (Infant GCS in Italics)

	Eyes	Verbal	Motor
1	No response	No response	No response
2	Open to pain	Incomprehensible sounds <i>Moans to pain</i>	Extension posturing (decerebrate)
3	Open to speech	Inappropriate words <i>Cries to pain</i>	Flexion posturing (decorticate)
4	Spontaneously open	Confused <i>Irritable</i>	Withdraws to pain
5		Oriented <i>Coos, babbles, smiles, interacts</i>	Localizes to pain <i>Withdraws to touch</i>
6			Spontaneous movement

the patient and medical providers. Thus, a number of cognitive diagnostic tools have been developed to aid in the identification of a concussion. The Standardized Assessment of Concussion (SAC) and the Sport Concussion Assessment Tool 3 (SCAT3) are the most commonly used cognitive screens. The SAC, which was part of the predecessor for the SCAT3, was developed for the sideline evaluation of athletes who sustained head trauma, and includes measures of orientation, immediate memory, delayed recall, concentration, neurologic testing, and exertional maneuvers, with lower scores associated with concussion. It is important to note that while the scores were found to be slightly lower in children with concussion, it only reached statistical significance in the age group of 12-14 years.

Furthermore, it should not be used in isolation to determine return to play.¹³

Endorsed by the Consensus Statement on Concussion in Sport in 2014, SCAT3 increasingly has been used. It assesses subjective symptoms, includes the SAC cognitive assessment, and evaluates coordination and balance. It differs from SCAT2 in that it includes a neck exam. For children younger than age 12 years, a Child SCAT3 has been developed.² Checklists for the SCAT3, Child SCAT3, and SAC assessments can be found online: (SAC/SCAT3: <http://bjsm.bmj.com/content/47/5/259.full.pdf>, accessed Sept. 2015; Child SCAT3: <http://bjsm.bmj.com/content/47/5/263.full.pdf>, accessed Sept. 2015).

SCAT3 can be time-consuming and ideally it is used as a tool for repeat

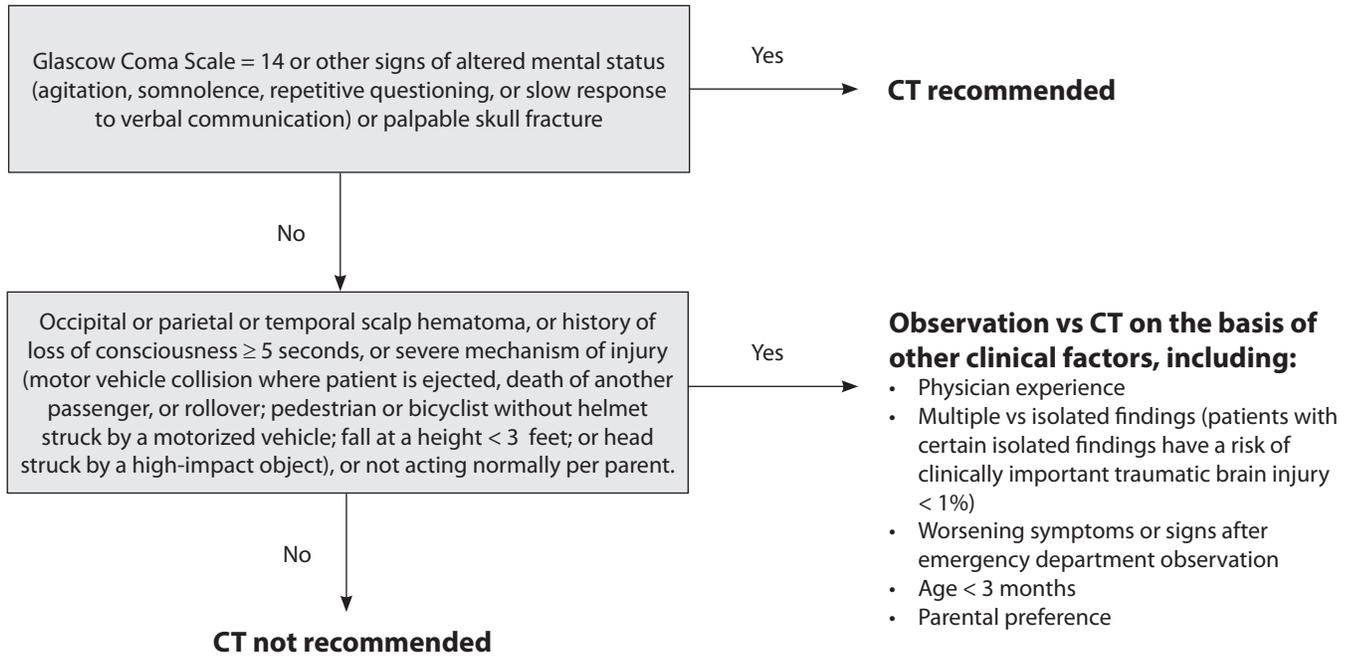
assessment; therefore, it is not an ideal test to perform in the ED. However, there is general consensus that balance testing is the most specific finding for concussion.

Disposition

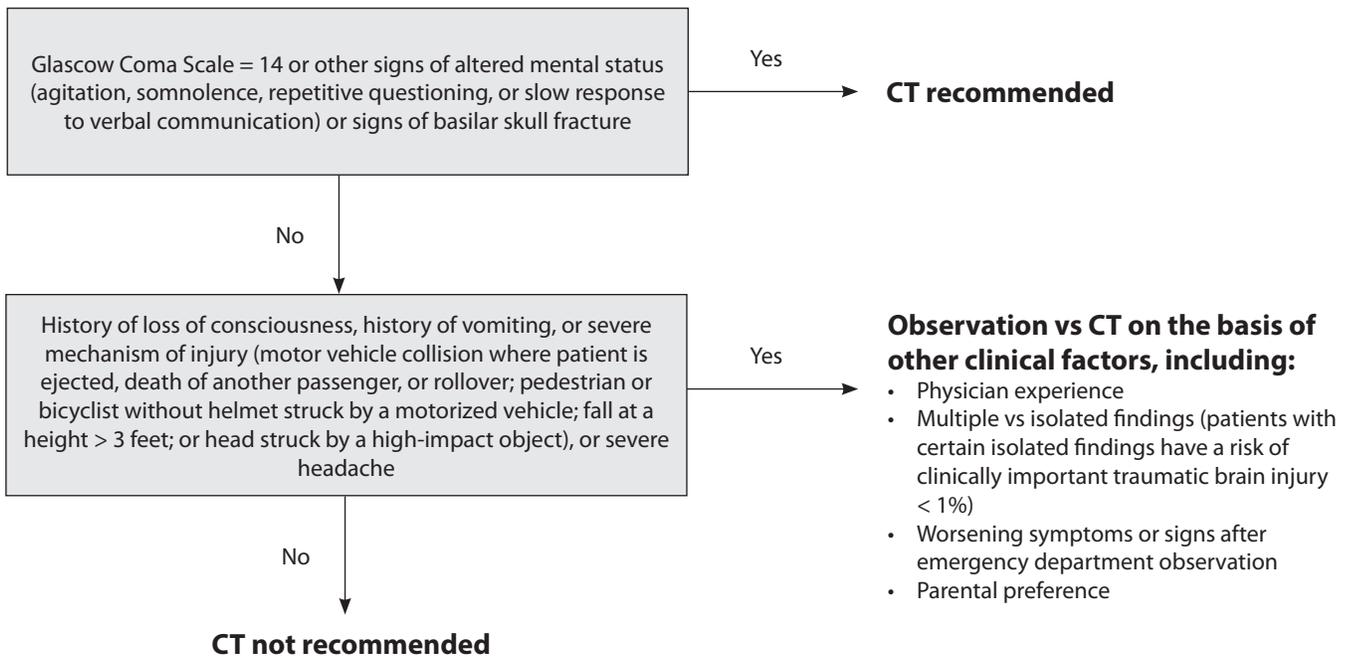
Patients can be discharged safely from the ED if the following criteria are met: a return to baseline level of function with a GCS of 15, tolerance of oral intake without significant nausea or vomiting, no other injuries warranting admission, and reliable caretakers. Discharge instructions should outline strict return precautions, including inability to awaken the child, seizure, vomiting that begins 4-6 hours after the injury or continued vomiting, a change in mental status, or new unsteady gait or clumsiness/incoordination. Although there is still

Figure 1. PECARN Algorithm for Imaging Children with Head Trauma

Suggested Algorithm for Children Younger than Age 2 Years



Suggested Algorithm for Children Older than Age 2 Years



Adapted from: Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically important brain injuries after head trauma: A prospective cohort study. *Lancet* 2009;374:1160-1170.

debate about periodically waking up the child from sleep during the night, providers now feel that there may be more benefit from uninterrupted sleep, and frequent awakenings may exacerbate symptoms.¹⁴ Follow-up with a physician or an athletic trainer should be arranged within 48 hours for symptom re-evaluation and initiation of progression to return to activity if appropriate.¹⁵

Typically, if a child has not been imaged and continues to be symptomatic or returns with increased symptoms, he or she should be imaged. If the child has been imaged, it is important to note that delayed clinically important traumatic brain injury after a normal CT scan is extremely rare. A retrospective cohort study of more than 17,000 children in Canada with a normal CT or asymptomatic 6-hour observation period identified delayed clinically important traumatic brain injury in 0.03% of patients.¹⁶ Magnetic resonance imaging (MRI) can detect cerebral contusion, petechial hemorrhage, and white matter injury at a superior level to CT; however, its use in a child with a negative CT and without severe or focal symptoms is not recommended in the ED setting, as the management of the patient likely would not change based on the results. Rather, further imaging is best coordinated, if indicated, through the care of an outpatient physician evaluating the child.¹⁴ Care and reimaging should be managed in conjunction with parents and considering the entire clinical picture. It is not unreasonable to admit a patient with a negative head CT for observation, hydration, and management of symptoms.

Headache is a frequent complaint after blunt head trauma, and is of particular concern to parents, patients, and practitioners when it is persistent or worsening over time. However, if mild-to-moderate headache is the only symptom, even if the patient was not imaged initially (in accordance with PECARN guidelines), imaging studies are not generally indicated, as the risk of a clinically important traumatic brain injury is low. A recent prospective multicenter cohort of

Table 5. Decision Rules for Avoiding CT in Children with Head Trauma

< 2 years of age	> 2 years of age
Normal mental status	Normal mental status
No scalp hematoma except frontal	No loss of consciousness
Loss of consciousness < 5 seconds	No vomiting
Non-severe injury mechanism*	Non-severe injury mechanism*
No palpable skull fracture	No signs of basilar skull fracture
Normal behavior	No severe headache

*Severe mechanism defined as motor vehicle collision with patient ejection, death of a passenger, rollover; pedestrian or cyclist without helmet struck by motorized vehicle; fall > 1.5 m for children (> 2 years), struck by motorized vehicle; fall > 1.5 m for children (> 2 years), fall > 0.9 m for < 2 years; or head struck by high-impact object

Table 6. Canadian Assessment of Tomography for Childhood Head Injury: The CATCH Rule

CT of the head is required for children with a minor head injury* plus any one of the following findings:
<p>High risk (need for neurological intervention)</p> <ul style="list-style-type: none"> • Glasgow Coma Scale score < 15 at 2 hours after injury • Suspected open or depressed skull fracture • History of worsening headache • Irritability on examination
<p>Medium risk (brain injury on CT scan)</p> <ul style="list-style-type: none"> • Any sign of basal skull fracture (e.g., hemotympanum, raccoon eyes, otorrhea or rhinorrhea of cerebrospinal fluid, Battle's sign) • Large, boggy hematoma of the scalp • Dangerous mechanism of injury (e.g., motor vehicle collision, fall from a height ≥ 3 feet [≥ 91 cm] or down five stairs, falling from a bicycle without a helmet)
<p>*Minor head injury is defined as an injury sustained within the past 24 hours associated with witnessed loss of consciousness, definite amnesia, witnessed disorientation, persistent vomiting (more than one episode), or persistent irritability (in a child younger than 2 years of age) in a patient with a Glasgow Coma Scale score of 13 to 15.</p> <p>CT = computed tomography</p>

approximately 28,000 verbal children with minor head trauma found that there was no associated clinically important traumatic brain injury when headache was an isolated symptom.¹⁷

Generally, acetaminophen is the recommended medication for treatment of post-concussion headache. Nonsteroidal anti-inflammatory drugs (NSAIDs) should be avoided for at

least the first 48-72 hours after a head injury. It is generally recommended to also avoid narcotics to prevent changes in mental status or neurologic exam. A retrospective study in adolescent patients with concussion demonstrated that overuse of analgesics may exacerbate concussion-related headaches or prolong their duration.¹⁸ Nausea is also a common problem associated

Table 7. Graduated Return to Play Protocol

Rehabilitation Stage (usually a minimum of 24 hours per stage)	Functional Exercise at Stage	Objective of Stage
No activity	Symptom limited physical and cognitive rest	Recovery
Light aerobic exercise	Walking, swimming, stationary bike, keeping intensity < 70% maximum permitted heart rate	Increase heart rate
Sport-specific exercise	No head impact activities	Add movement
Noncontact training drills	<ul style="list-style-type: none"> • More complex training drills • May start progressive resistance training 	Exercise, coordination, and cognitive load
Full contact practice	Participation in normal training activities	Assess functional skills by coaching staff
Return to play	Normal game play	

Adapted from: McCrory P, Meeuwisse W, Aubry M, et al. Consensus statement on concussion in sport: The 4th International Conference on Concussion in Sport, held in Zurich, November 2012. *Clin J Sport Med* 2013;23:89-117.

with concussion, so using non-sedating antiemetics, such as ondansetron, can be helpful in both the immediate and outpatient setting. Vertiginous symptoms post trauma can be treated with meclizine. Patients with ongoing and/or severe symptoms may require vestibular rehabilitation for their vertigo, although this determination will need to be done as an outpatient by a primary care physician or a provider specializing in concussion.¹⁹

Some patients may be asymptomatic initially and develop symptoms hours after the head trauma. A 2014 study by Eisenberg et al showed that fatigue, sleep disturbance, forgetfulness, and frustration often developed within 1 week of the initial head trauma.²⁰ Thus, in the ED, it is important to set expectations for possible occurrence and follow-up of the above-mentioned delayed symptoms. For the majority of patients, symptoms resolve within 2 weeks of injury. However, during this recovery period, symptoms can be debilitating, with more than two-thirds of patients reporting continued headaches 1 week after the injury, and the majority complaining of dizziness, fatigue, and slower thinking.²⁰

During counseling, it is important to discuss potential complications and provide thorough instructions regarding physical and cognitive rest. Pediatric patients have a higher risk of prolonged post-concussive symptoms and recurrent concussion when there

is premature return to cognitive and physical activity. Furthermore, there is evidence that pediatric patients take longer to recover from mild traumatic brain injury compared to adults.^{21,22}

Patients diagnosed with concussion should be told to avoid any resistance and aerobic activities, including returning to sports, for a minimum of 48 hours or until evaluated by a medical provider, particularly when concussion symptoms are ongoing. Recent evidence has suggested that light cardiovascular activity, initiated 48 hours after head injury, may shorten duration of symptoms.²³ Although children should be told to see their primary physician prior to return to play, emergency practitioners should be aware of the general recommendations of Return to Play protocols (*see Table 7*). Once athletes are asymptomatic and their SCAT3 scores are at baseline (if one is available), they may begin the Return to Play protocol and should spend a minimum of 24 hours at each step of the pathway. If symptoms recur at any step, the patient should return to the previous asymptomatic step and should only attempt to progress after remaining asymptomatic for 24 hours. The Return to Play protocol was developed for high school and college-aged athletes; in younger children, a more prolonged progression through the protocol should be considered.²⁴

Cognitive rest is a more controversial topic. Strict cognitive rest,

including the absence from school and avoidance of screen time, social activities, video games, loud music, and reading, has been part of the primary treatment for pediatric concussion. However, a recent study demonstrated that strict cognitive rest was associated with more daily reported post-concussive symptoms during the 10 days of follow-up, with no differences in neurocognitive function.²³ Therefore, a more individualized approach to cognitive rest — in which patients are instructed to avoid mental activities that worsen symptoms, with close follow-up by their outpatient provider — may be prudent. Patients who continue to have symptoms beyond 2 weeks may warrant neuropsychological testing, further follow-up with a concussion specialist, and potentially further imaging (e.g., MRI) at the discretion of that provider.

Complications

The long-term effects of concussions in the pediatric population are not well understood given the lack of long-term prospective studies. Studies have shown that 3 months after concussion, 35% of children between the ages of 8 and 16 years complained of difficulty with concentration and memory.²⁵ Another study indicated that > 60% of pediatric patients reported a decline in grades for that term.²⁶

Post-concussion Syndrome. While

there is no universally accepted definition for post-concussion syndrome, the DSM-IV defines it as 3 months duration of three or more of the following symptoms: fatigue, dizziness/vertigo, headache, personality or behavioral changes, anxiety or depression, or apathy. There is often a decline in school performance and difficulty in memory or attention.²⁷ (See Tables 8 and 9.) Post-concussion syndrome is a common sequelae of mild traumatic brain injury, with studies citing anywhere from 29–43% of patients experiencing symptoms including headaches, dizziness, neuropsychiatric symptoms, and cognitive impairment.^{25,28} Risk factors for developing persistent post-concussive symptoms include older age, headache as the initial symptom, high initial level of symptomology, post-traumatic amnesia, loss of consciousness, and premorbid conditions including previous concussions, learning difficulties, and underlying psychiatric difficulties.^{29,30} Children with presumptive post-concussion syndrome should be referred to a concussion specialist for further management, which may include neuropsychiatric testing.

Second Impact Syndrome.

Second-impact syndrome is a rare condition in which the brain undergoes rapid and severe swelling. It occurs when a second head injury occurs before the symptoms associated with the initial injury have resolved. The pathophysiology is poorly understood, but it is thought to result from a loss of autoregulation, causing cerebral vascular congestion that can progress to severe cerebral edema.³¹ Interestingly, all reported cases have been in athletes younger than 20 years of age, leading to the conclusion that pediatric and adolescent athletes are at higher risk for this complication.

Summary

Concussion is a common presentation in the pediatric population. Patients and parents should be made aware that symptoms can persist for some time and that recovery time can vary. After ruling out clinically important traumatic brain injury, the

Table 8. Diagnostic Criteria for Post-concussive Disorder

A history of head trauma that has caused considerable cerebral concussion
Evidence from neuropsychological testing or quantified cognitive assessment of difficulty in attention (concentrating, shifting focus of attention, performing simultaneous cognitive tasks) or memory (learning or recall of information)
Three (or more) of the following occurring shortly after the trauma and lasting at least 3 months: <ul style="list-style-type: none"> • becoming fatigued easily; • disordered sleep; • headache; • vertigo or dizziness; • irritability or aggression on little or no provocation; • anxiety, depression, or affective instability; • changes in personality (e.g., social or sexual inappropriateness); or • apathy or lack of spontaneity
The symptoms in bullets 2 and 3 have their onset following head trauma or represent a substantial worsening of pre-existing symptoms.
The disturbance causes considerable impairment in social or occupational functioning and represents a considerable decline from a previous level of functioning. In school-age children, the impairment might manifest as a substantial worsening in school or academic performance dating from the trauma.
The symptoms do not meet criteria for dementia due to head trauma and are not better accounted for by another mental disorder (e.g., amnesic disorder due to head trauma, personality change due to head trauma).
No single test score can be the basis of a concussion diagnosis. Moderate evidence that standardized symptom checklists (Post-Concussion Symptom Scale/ Graded Symptom Checklist [GSC]) and the Standardized Assessment of Concussion (SAC) when administered early after a suspected concussion have moderate to high sensitivity and specificity in identifying sports concussions relative to those of the reference standard of a clinician-diagnosed concussion. Low-moderate evidence that the Balance Error Scoring System (BESS) has low to moderate sensitivity and moderate to high specificity in identifying sports concussions. Those affected may have exacerbation of symptoms with mental or physical exertion. Adapted from: <i>Diagnostic and Statistical Manual of Mental Disorders</i> , 4th edition.

Table 9. Diagnostic Criteria for Post-Concussion Syndrome (ICD-10)

A. History of head trauma with loss of consciousness preceding symptom onset by a maximum of 4 weeks.
B. Symptoms in 3 or more of the following symptom categories: <ul style="list-style-type: none"> • Headache, dizziness, malaise, fatigue, noise tolerance • Irritability, depression, anxiety, emotional lability • Subjective concentration, memory, or intellectual difficulties without neuropsychological evidence of marked impairment • Insomnia • Reduced alcohol tolerance • Preoccupation with above symptoms and fear of brain damage with hypochondriacal concern and adoption of sick role
World Health Organization. ICD-10 Version:2016. F07.2 Postconcussional syndrome Available at: http://apps.who.int/classifications/icd10/browse/2016/en#/F07.2 . Accessed Jan. 7, 2016.

emergency physician should treat symptoms, counsel patients about the need for close follow-up, and provide discharge instructions to not resume exacerbating cognitive or physical activities until evaluated by their outpatient provider.

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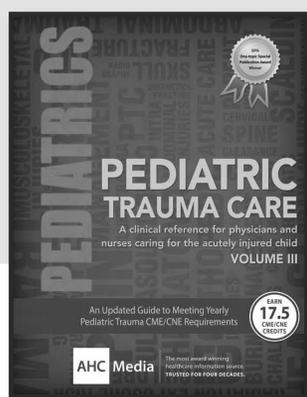
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PEDIATRIC TRAUMA CARE III

Earn
17.5
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A Clinical Reference for Physicians and Nurses Caring for the Acutely Injured Child

Children have unique patterns of injury and require special care to prevent mortality and minimize morbidity. *Pediatric Trauma Care III* covers the latest scientific information on caring for children who present with traumatic injuries. The peer-reviewed, evidence-based articles will help readers recognize and manage pediatric injuries in a timely manner to decrease risk, to quickly stabilize patients, and improve outcomes.



BENEFITS:

- ✓ Comprehensive review on the latest information on treating children with traumatic injuries;
 - ✓ Describes modalities to identify various traumatic conditions;
 - ✓ Cites methods to quickly stabilize and manage pediatric patients;
 - ✓ Identifies complications that may occur with traumatic injuries in children.
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CME/CE Questions

1. What is the most common cause of concussion in children younger than 10 years of age?
 - A. Falls
 - B. Motor vehicle collision
 - C. Non-accidental trauma
 - D. Sports-related injury
2. Which of the following statements about concussion is *true*?
 - A. Concussion results in a constellation of symptoms in the absence of structural damage.
 - B. Nausea and vomiting are the most commonly reported symptoms.
 - C. Loss of consciousness occurs in more than 20% of concussions.
 - D. Young age at time of concussion is a predictor of prolonged symptoms.
 - E. Symptoms are maximal at onset and rarely evolve.
3. According to the PECARN algorithm, which of the following symptoms or characteristics does not necessarily require a CT scan?
 - A. Glasgow Coma Scale 13
 - B. Altered mental status
 - C. Signs of basilar skull fracture
 - D. Head trauma secondary to a motor vehicle accident with fatality
 - E. Nausea

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4. Which of the following is true about the Return to Play protocol?
 - A. Athletes should spend a minimum of 72 hours at each step of the pathway.
 - B. If symptoms recur at any step, the patient should return to the beginning of the protocol for 24 hours.
 - C. The Return to Play protocol was developed in high school athletes and cannot be used for younger children.
 - D. Recent evidence has suggested that light cardio activity, initiated 48 hours after head injury may shorten duration of symptoms.
 - E. Patients can start the protocol even if they are symptomatic as long as it has been 72 hours since the initial injury.
5. Which of the following is *not* thought to be a risk factor for post-concussion syndrome?
 - A. Younger age
 - B. Post-traumatic amnesia
 - C. Headache as the presenting symptom
 - D. History of concussions
 - E. Learning difficulties

For the questions 6–8, please refer to the following scenario:

A 17-year-old male presents to the emergency department for headache after sustaining a hit in football practice the previous day. He reports limited memory for the events occurring immediately after the impact but denies loss of consciousness. He also describes feeling worse now than he did immediately after the impact. He has no visible head injury and did not lose consciousness, but does report sensitivity to light and sound.

6. According to the PECARN algorithm, there is an exceedingly low risk of clinically important traumatic brain injury, therefore a CT scan is not recommended.
 - A. True
 - B. False

7. If the patient is found to have hemotympanum on exam, there is no need for a CT scan given that he has no other symptoms over 24 hours after the injury.
 - A. True
 - B. False
8. The patient is at low risk for second-impact syndrome given that his only symptom of concussion is a headache.
 - A. True
 - B. False

For questions 9–10, please refer to the following vignette:

A 1-year-old female is brought into the emergency department after falling from the couch (approximately 2 feet) onto the hardwood floor 2 hours ago. She cried immediately and did not appear to lose consciousness. She has a large frontal hematoma and has been more agitated since the fall, but her mother can't tell if it is because she is in pain or if it is because she missed her nap. Patient is fussy and crying in her mother's arms.

9. According to the PECARN algorithm, there is an exceedingly low risk of clinically important traumatic brain injury, therefore a CT scan is not recommended.
 - A. True
 - B. False
10. The lack of a non-frontal hematoma makes a clinically important traumatic brain injury less likely.
 - A. True
 - B. False

PEDIATRIC EMERGENCY MEDICINE REPORTS

CME/CE Objectives

Upon completion of this educational activity, participants should be able to:

- recognize specific conditions in pediatric patients presenting to the emergency department;
- describe the epidemiology, etiology, pathophysiology, historical and examination findings associated with conditions in pediatric patients presenting to the emergency department;
- formulate a differential diagnosis and perform necessary diagnostic tests;
- apply up-to-date therapeutic techniques to address conditions discussed in the publication;
- discuss any discharge or follow-up instructions with patients.

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Bronx, NY

NURSE REVIEWER

Lee Ann Wurster, MS, RN, CPNP
Trauma Coordinator
Nationwide Children's Hospital
Columbus, OH

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Practical, Evidence-Based Reviews in Pediatric Emergency Care

Diagnosis and Management of Pediatric Concussions

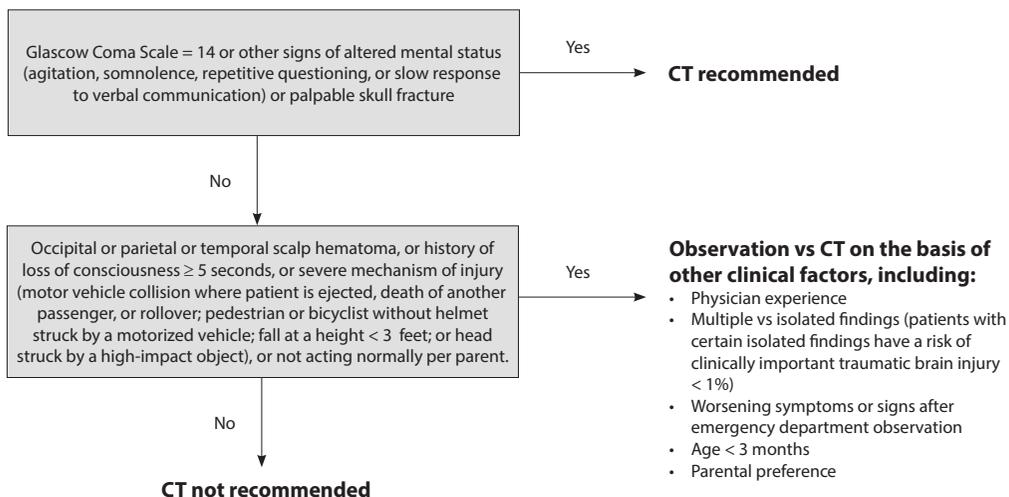
Definition of Pediatric Head Trauma

	Mild Head Trauma	Mild Traumatic Brain Injury	Clinically Important Traumatic Brain Injury
Glasgow Coma Scale	15	14-15	Usually < 14
Definition	<p>Age < 2 years: either a history or physical signs of blunt trauma to the skull or scalp in an infant or child who is alert or awakens to voice or light touch.</p> <p>Age > 2 years: head trauma resulting in a normal neurologic exam and no physical evidence of skull fracture</p>	Head trauma associated with disorientation, vomiting, or brief loss of consciousness	Head trauma associated with the presence of intracranial injury on CT imaging that warrants surgical intervention, intubation for management, hospitalization for > 48 hours, or death

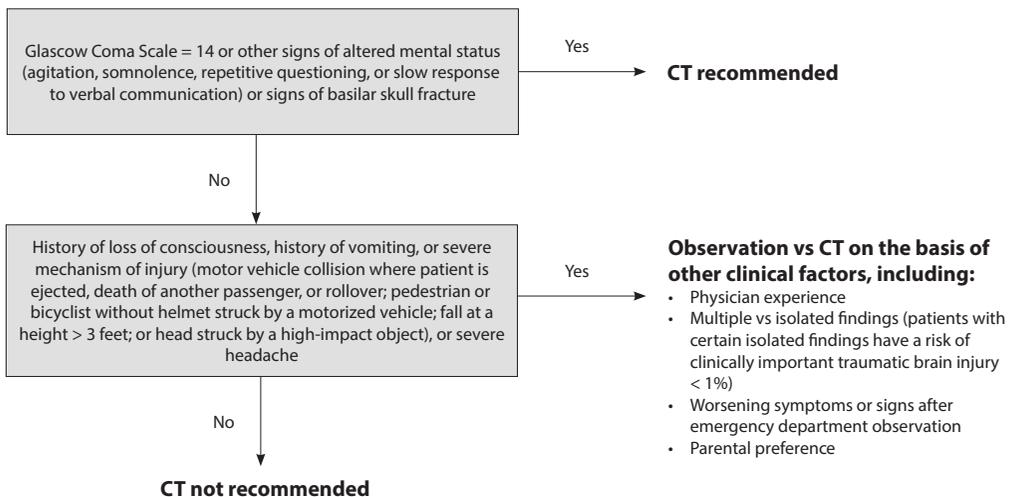
Adapted from: Schutzman S. Minor head trauma in infants and children: Management. In: Post TW, ed. *UpToDate*. Waltham, MA: UpToDate. Available at: <http://www.uptodate.com/contents/minor-head-trauma-in-infants-and-children-evaluation>. Accessed Aug. 8, 2015.

PECARN Algorithm for Imaging Children with Head Trauma

Suggested Algorithm for Children Younger than Age 2 Years



Suggested Algorithm for Children Older than Age 2 Years



Adapted from: Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically important brain injuries after head trauma: A prospective cohort study. *Lancet* 2009;374:1160-1170.

Concussion Symptom Checklist

Physical	Cognitive	Emotional	Sleep
<ul style="list-style-type: none"> • Headache • Nausea • Vomiting • Balance problems • Dizziness • Blurry vision • Fatigue • Photophobia • Phonophobia • Numbness/tingling 	<ul style="list-style-type: none"> • Feeling mentally foggy • Feeling slowed down • Difficulty with concentration • Difficulty with memory 	<ul style="list-style-type: none"> • Irritability • Sadness • Emotional lability • Nervousness 	<ul style="list-style-type: none"> • Drowsiness • Sleeping either more or less than usual • Trouble falling asleep

Adapted from: Centers for Disease Control and Prevention. Acute Concussion Evaluation (ACE). Available at: http://www.cdc.gov/headsup/pdfs/providers/ace_ed-a.pdf. Accessed July 30, 2015.

Graduated Return to Play Protocol

Rehabilitation Stage (usually a minimum of 24 hours per stage)	Functional Exercise at Stage	Objective of Stage
No activity	Symptom limited physical and cognitive rest	Recovery
Light aerobic exercise	Walking, swimming, stationary bike, keeping intensity < 70% maximum permitted heart rate	Increase heart rate
Sport-specific exercise	No head impact activities	Add movement
Noncontact training drills	<ul style="list-style-type: none"> • More complex training drills • May start progressive resistance training 	Exercise, coordination, and cognitive load
Full contact practice	Participation in normal training activities	Assess functional skills by coaching staff
Return to play	Normal game play	

Adapted from: McCrory P, Meeuwisse W, Aubry M, et al. Consensus statement on concussion in sport: The 4th International Conference on Concussion in Sport, held in Zurich, November 2012. *Clin J Sport Med* 2013;23:89-117.

Diagnostic Criteria for Mild Traumatic Brain Injury

A patient with mild traumatic brain injury has had a traumatically induced physiologic disruption of brain function, as manifested by 1 or more of:

- any loss of consciousness up to 30 minutes;
- any loss of memory for events immediately before or after the collision, but not lasting longer than 24 hours;
- any alteration of mental state at the time of the collision (e.g., feeling dazed, disoriented, or confused); or
- focal neurologic deficits that might or might not be transient, but where the severity of the injury does not exceed the following:
 - loss of consciousness exceeding 30 minutes,
 - post-traumatic amnesia longer than 24 hours, or
 - Glasgow Coma Scale score falling below 13 after 30 minutes.

Adapted from the Mild Traumatic Brain Injury Committee of the American Congress of Rehabilitation Medicine

Diagnostic Criteria for Post-concussive Disorder

A history of head trauma that has caused considerable cerebral concussion

Evidence from neuropsychological testing or quantified cognitive assessment of difficulty in attention (concentrating, shifting focus of attention, performing simultaneous cognitive tasks) or memory (learning or recall of information)

Three (or more) of the following occurring shortly after the trauma and lasting at least 3 months:

- becoming fatigued easily;
- disordered sleep;
- headache;
- vertigo or dizziness;
- irritability or aggression on little or no provocation;
- anxiety, depression, or affective instability;
- changes in personality (e.g., social or sexual inappropriateness); or
- apathy or lack of spontaneity

The symptoms in bullets 2 and 3 have their onset following head trauma or represent a substantial worsening of pre-existing symptoms.

The disturbance causes considerable impairment in social or occupational functioning and represents a considerable decline from a previous level of functioning. In school-age children, the impairment might manifest as a substantial worsening in school or academic performance dating from the trauma.

The symptoms do not meet criteria for dementia due to head trauma and are not better accounted for by another mental disorder (e.g., amnesic disorder due to head trauma, personality change due to head trauma).

No single test score can be the basis of a concussion diagnosis.

Moderate evidence that standardized symptom checklists (Post-Concussion Symptom Scale/ Graded Symptom Checklist [GSC]) and the Standardized Assessment of Concussion (SAC) when administered early after a suspected concussion have moderate to high sensitivity and specificity in identifying sports concussions relative to those of the reference standard of a clinician-diagnosed concussion. Low-moderate evidence that the Balance Error Scoring System (BESS) has low to moderate sensitivity and moderate to high specificity in identifying sports concussions. Those affected may have exacerbation of symptoms with mental or physical exertion.

Adapted from: *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition.

Supplement to *Pediatric Emergency Medicine Reports*, February 2016: "Diagnosis and Management of Pediatric Concussions in the ED." Authors: Akhila Pamula, MD, Resident Physician, Stanford/Kaiser Emergency Medicine Residency, Department of Emergency Medicine, Stanford School of Medicine, Stanford, CA; Calvin E. Hwang, MD, Kaiser Permanente Santa Clara Medical Center, Santa Clara, CA; and N. Ewen Wang, MD, Professor of Emergency Medicine, Associate Director of Pediatric Emergency M.

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