REVIEW

CDC's guideline on pediatric mild traumatic brain injury

Recommendations for neurologists

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Abstract

Purpose of review

In September 2018, the Centers for Disease Control and Prevention (CDC) published an evidence-based guideline on the diagnosis and management of mild traumatic brain injury (mTBI) among children.

Recent findings

Based on a systematic review of the evidence that covers research published over a 25-year span (1990–2015), the CDC Pediatric mTBI Guideline strives to optimize the care of pediatric patients with mTBI. The guideline was developed using a rigorous methodology developed by the American Academy of Neurology.

Summary

Clinical practice recommendations in the CDC Pediatric mTBI Guideline can help guide neurologists with critical diagnostic and management decisions and to implement evidence-based strategies for the recovery of their young patients with this injury.

In its recently published Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury (mTBI) Among Children, the Centers for Disease Control and Prevention (CDC) defines mTBI to be inclusive of patients, with "Glasgow Coma Scale scores of 13–15 with or without the complication of intracranial injury (ICI) on neuroimaging, and regardless of potentially requiring a hospital admission and/or neurosurgical intervention".[1] Caused by a force or impact to the head or body that causes the brain to accelerate and decelerate with translational, rotational, and/or angular forces, an mTBI is associated with a complex cascade of ionic, metabolic, and physiologic events[2–6] (figure 1).

An individual with mTBI generally presents with clinical symptoms that fall into 4 categories: somatic, cognitive, affective, and sleep (table 1).[7] Most pediatric patients with mTBI will no longer experience symptoms within a couple of weeks[8,9]; 70%–80% return to baseline within 3 months.[10–12] The factors associated with a prolonged recovery include the following: Hispanic ethnicity, age (particularly adolescents), neurologic or mental health disorders, learning difficulties, and family and social stressors.[1] For pediatric patients whose symptoms are ongoing, an mTBI can affect their ability to participate in school and other activities of daily living, such as social activities with friends and physical exercise.

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Figure 1 Mechanism of mild traumatic brain injury (mTBI)

mTBI results from an impact to the head or body, which leads to a complex cascade of ionic, metabolic, and physiologic events. Source: Used with permission from the Centers for Disease Control and Prevention, cdc.gov/HEADSUP.

To help optimize the care and support the recovery of pediatric patients with mTBI, CDC's Pediatric mTBI Guideline includes 19 sets of clinical practice recommendations. These recommendations cover diagnosis, prognosis, and management/treatment. This review provides an overview of the process used by CDC to develop the guideline, as well as the practice recommendations most relevant to neurologists, such as those that support diagnostic and management decisions for this injury.

Development of the CDC pediatric mTBI guideline

Consistent with other guidelines developed using the American Academy of Neurology (AAN) methodology, the CDC Pediatric mTBI Guideline is based on a comprehensive review and analysis of peer-reviewed literature, public comment, and feedback from experts in the field. The authors of the guideline developed it by independently nominating pertinent clinical questions for consideration, according to an analytic framework utilizing the Patient-Intervention-Comparator-Outcome format.[13] Collated questions were presented to the authors for ranking using a modified Delphi process over 3 rounds of voting. Through this process, the authors ultimately selected 6 clinical questions for evaluation via systematic review (table 2).

An extensive literature search, spanning 1990–2015, was conducted to identify evidence for each question. Data from each selected full-text article were extracted by at least 2 authors working independently of each other using a standardized form. Disagreement regarding the extracted elements, classification of evidence, or assessment of effect size was resolved by a discussion to reach consensus among the authors.

Table 1 Four categories of mTBI symptoms

Somatic	Cognitive	Affective	Sleep
Headache	Confusion	Emotional lability	Trouble falling asleep
Dizziness	Anterograde amnesia	Irritability	Sleeping more than usual
Balance disruption	Retrograde amnesia	Fatigue	Excessive drowsiness
Nausea/Vomiting	Loss of consciousness	Anxiety	Sleeping less than usual
Visual disturbances (photophobia, blurry/double vision)	Disorientation	Sadness	
Phonophobia	Feeling mentally "foggy"		
	Vacant stare		
	Inability to focus		
	Delayed verbal and motor responses		
	Slurred/incoherent speech		

Abbreviation: mTBI = mild traumatic brain injury.
Source: Used with permission from the Centers for Disease Control and Prevention, cdc.gov/HEADSUP.

Table 2 Clinical questions for the CDC pediatric mTBI guideline

1. For children (18 y of age and younger) with suspected mTBI, do specific tools, as compared with a reference standard, assist in accurately diagnosing mTBI?
2. For children (18 y of age and younger) presenting to the emergency department (or other acute care setting) with mTBI, how often does routine head imaging identify ICI?
3. For children (18 y of age and younger) presenting to the emergency department (or other acute care setting) with mTBI, which features identify patients at risk for important ICI?
4. For children (18 y of age and younger) with mTBI, what factors identify patients at increased risk for ongoing impairment, more severe symptoms, or delayed recovery (<1 y postinjury)?
5. For children (18 y of age and younger) with mTBI, which factors identify patients at increased risk of long-term (≥1 y) sequelae?
6. For children (18 y of age and younger) with mTBI (with ongoing symptoms), which treatments improve mTBI-related outcomes?

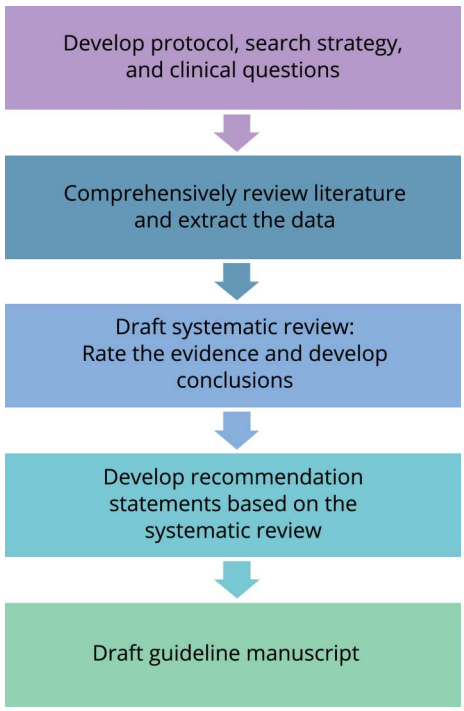
Abbreviations: CDC = Centers for Disease Control and Prevention; ICI = intracranial injury; mTBI = mild traumatic brain injury.
Source: Lumba-Brown A, Yeates KO, Sarmiento K, et al. Centers for Disease Control and Prevention guideline on the diagnosis and management of mild traumatic brain injury among children. *JAMA Pediatrics*. 2018;172:e182853.

Findings from the literature review and data abstraction were compiled into evidence tables. To judge overall confidence in the evidence, the authors used a modified Grading of Recommendations, Assessment, Development and Evaluations methodology. This process explicitly considered the risk of bias in individual studies (class of evidence), consistency between studies, precision, directness, and magnitude of effect relative to the risk of bias, presence of an expected dose-response relationship, and the direction of bias.[14] This method has been designed to be compliant with the 2010 National Academy of Science standards. A summary of the guideline development process is shown in figure 2.

CDC pediatric mTBI guideline clinical practice recommendations

In 2013, AAN published the "Summary of evidence-based guideline update: Evaluation and management of concussion in sport" in the journal *Neurology*®.[15] Expanding from this effort, the CDC Pediatric mTBI Guideline is inclusive of all causes of mTBI and focuses solely on children age 18 and under. The CDC Pediatric mTBI Guideline provides practice recommendations relevant to neurologists and other healthcare providers that are consistent with the AAN Concussion in Sports guideline. Below is a snapshot of recommendations contained in the CDC Pediatric mTBI Guideline most relevant for neurologists related to imaging, assessment, posttraumatic headache management/treatment, return to activity, and patient and family education (table 3).

Figure 2 Centers for Disease Control and Prevention pediatric mild traumatic brain injury guideline development process



Imaging

Head CT plays a critical role in distinguishing patients presenting with a suspected traumatic brain injury who are at risk for ICI. However, head CT should not be routinely used to diagnose patients with mTBI.[1] The CDC Pediatric mTBI Guideline recommends that, neurologists and other healthcare providers, "use validated clinical decision rules to identify children with mTBI at low risk for ICI, in whom head CT is not indicated, as well as children who may be at higher risk for clinically important ICI."[1] The use of validated tools, such as the Pediatric Emergency Care Applied Research Network (PECARN) decision rules,[16] serves to avoid unnecessary pediatric patient's exposure to radiation, while also ensuring that children at risk for clinically important ICI receive the needed imaging and interventions. For children found to have a risk of ICI, but not at the level to justify an immediate imaging study, healthcare providers should counsel their parents and provide information regarding monitoring children for any changes that indicate a more severe injury.

PECARN conducted the largest prospective dedicated pediatric trial for mTBI, which included more than 40,000 children, in 2009.[16] The initial PECARN study investigated both children <2 years of age and those 2–17 years of age and identified clinical criteria to stratify those with very low, intermediate, and relatively high risk for significant ICI in the setting of minor head trauma (table 4). This algorithm determined children at very low risk for clinically significant ICI with a 99.9% negative predictive value (NPV) and a 96.8% sensitivity in those ≥2 years of age and a 100% NPV and sensitivity in those <2 years of age. Of note, decisions to image by healthcare providers are also dependent on other clinical factors including multiple vs isolated findings, worsening symptoms or signs over time, age younger than 3 months, and parental preference. In addition, subsequent studies have independently validated the PECARN algorithm, one of which is a large prospective trial in Australia and New Zealand which demonstrated the PECARN criteria for very low risk of clinically significant brain injury to have a 100% NPV and 99% sensitivity in children ≥2 years of age and a 100% NPV and sensitivity in children <2 years of age.[17] While the PECARN decision rules are well known by most healthcare providers, the implementation of these rules when evaluating children with mTBI is not universal. Challenges and barriers to the implementation of these rules should be explored and addressed. In addition, while the PECARN decision rules are valuable, the final decision regarding the need for brain imaging rests with the clinical judgment of the healthcare provider treating the patient.

Assessment

Neurologists should perform a thorough neurologic history and examination on all children presenting with an mTBI. As

Table 3 Examples of clinical practice recommendations on the diagnosis and management of mTBI

CDC pediatric mTBI guideline recommendations relevant for neurologists	Level of evidence[a]	Available resources to support implementation	Consistency with AAN concussion in sports guideline
Imaging	B	PECARN decision rules[16]	Yes
Head CT			
Healthcare providers should use validated clinical decision rules to identify children with mTBI at low risk for ICI, in whom head CT is not indicated, as well as children who may be at higher risk for clinically important ICI, and therefore may warrant a head CT. Existing decision rules, such as PECARN decision rules, combine a variety of factors that together may improve the acute assessment of risk for more serious ICI.			
In children younger than 2 y, the following risk factors included			
GCS < 15			
Abnormal mental status			
Scalp hematoma except frontal			
LOC or LOC for more than 5 s			
Severe injury mechanism			
Palpable skull fracture			
Not acting normally according to the parents			
For children aged 2 y and older			
GCS < 15			
Abnormal mental status			
LOC			
Vomiting			
Severe injury mechanism			
Signs of basilar skull fracture			
Severe headache			
Other risk factors not mentioned above include			
Amnesia			
Severe or worsening headache			
Assessment	B	Examples of validated assessment scales:	Yes

Continued

Table 3 Examples of clinical practice recommendations on the diagnosis and management of mTBI *(continued)*

CDC pediatric mTBI guideline recommendations relevant for neurologists	Level of evidence[a]	Available resources to support implementation	Consistency with AAN concussion in sports guideline
Symptom Scales	C	Post-Concussion Symptom Inventory[18]	
Healthcare providers should use an age-appropriate, validated symptom rating scales as a component of the diagnostic evaluation in children presenting with acute mTBI.	B	Health and Behavior Inventory[19]	
Computerized Cognitive testing		Post-Concussion Symptom Inventory[20]	
Healthcare providers may use validated, age-appropriate computerized cognitive testing in the acute period of injury as a component of the diagnosis of mTBI.		Acute Concussion Evaluation[21]	
SAC			
The Standardized Assessment of Concussion should not be exclusively used to diagnose mTBI in children age 6–18 y.			
Posttraumatic Headache Management/Treatment	B	PECARN decision rules[16]	N/A
Healthcare professionals in the emergency department should clinically observe and consider obtaining a head CT in children seen with severe headache, especially when associated with other risk factors and worsening headache after mTBI, to evaluate for ICI requiring further management in accord with validated clinical decision making rules.	B	CDC HEADS UP handouts[7]:	Recommendations on posttraumatic headache are not covered in the AAN Concussion in Sports guideline.
Children undergoing observation periods for headache with acutely worsening symptoms should undergo emergent neuroimaging.	B	"Caring for Your Child's Concussion"	
Healthcare professionals and caregivers should offer nonopioid analgesia (i.e., ibuprofen or acetaminophen) to children with painful headache after acute mTBI but also provide counseling to the family regarding the risks of analgesic overuse, including rebound headache.	R	"How Can I Help My Child recover after a Concussion"	
Healthcare professionals should not administer 3% hypertonic saline to children with mTBI for treatment of acute headache outside of a research setting at this time.	B		
Chronic headache after mTBI is likely to be multifactorial; therefore, healthcare professionals should refer children with chronic headache after mTBI for multidisciplinary evaluation and treatment, with consideration of analgesic overuse as a contributory factor.			
Return to activity	B	CDC HEADS UP handouts[7] "Caring for Your Child's Concussion"	Yes
Following the first several d, healthcare providers should counsel patients and families to resume a gradual schedule of activity that does not exacerbate symptoms, with close monitoring of symptom expression (number, severity).		"How Can I Help My Child recover after a Concussion"	
		5th international Conference on Concussion in Sport (Berlin)[25]	
Patient and family education	A	CDC HEADS UP handouts[7]:	Yes
In providing education and assurance to the family, the healthcare providers should include the following instructions:		"Caring for Your Child's Concussion"	

Continued

Table 3 Examples of clinical practice recommendations on the diagnosis and management of mTBI *(continued)*

CDC pediatric mTBI guideline recommendations relevant for neurologists	Level of evidence[a]	Available resources to support implementation	Consistency with AAN concussion in sports guideline
Warning signs indicating a more serious injury		"How Can I Help My Child recover after a Concussion"	
Expected course of symptoms and recovery			
Instructions on monitoring post-concussive symptoms			
Prevention of further injury			
Management of cognitive and physical activity, or rest			
Instructions regarding return to school and return to play or recreation			
Clear healthcare provider follow-up instructions			

Abbreviations: CDC = Centers for Disease Control and Prevention; GCS = Glasgow Coma Scale; ICI = intracranial injury; LOC = loss of consciousness; mTBI = mild traumatic brain injury; SAS = Standardized Assessment of Concussion.
[a] Through the modified GRADE process, CDC assigned one of the action levels to each recommendation: level A: (must do) almost all patients in almost all circumstances would want the recommendation followed; level B: (should do) most patients in most circumstances would want the recommendation followed; level C: (may do) some patients in some circumstances would want the recommendation followed; level R: do only in a research setting.

Table 4 PECARN clinical criteria for mTBI

	Child ≥ 2 y	Child < 2 y of age
Very low risk/no CT required	GCS = 15 with none of the following: signs of basilar skull fracture, any LOC, vomiting, severe injury mechanism, severe headache, or other signs of altered mental status[a]	GCS = 15 with none of the following: palpable skull fracture, nonfrontal scalp hematoma, LOC of 5 s or more, severe mechanism of injury, not acting normally per parents, or other signs of altered mental status[a]
Intermediate risk/ observation versus CT	GCS = 15 with any of the following: history of any LOC, vomiting, severe mechanism of injury, or severe headache. No altered mental status or signs of basilar skull fracture.	GCS = 15 with any of the following: nonfrontal scalp hematoma, LOC of 5 s or more, severe mechanism of injury, not acting normally per parents. No other signs of altered mental status or palpable skull fracture.
High risk/ obtain CT	GCS = 14 or with other signs of altered mental status[a], or signs of basilar skull fracture.	GCS = 14 or with other signs of altered mental status[a], or signs of basilar skull fracture.

Abbreviations: GCS = Glasgow Coma Scale; LOC = loss of consciousness; mTBI = mild traumatic brain injury.
[a] Other signs of mental status include agitation, somnolence, repetitive questioning, or slow response to verbal communication.

part of this evaluation, CDC recommends the use of "an age-appropriate, validated symptom rating scale."[1] Examples of validated scales include, but are not limited to, the following: Post-Concussion Symptom Inventory,[18] Health and Behavior Inventory,[19] Post-Concussion Symptom Scale,[20] and Acute Concussion Evaluation.[21] Based on the available evidence, the guideline concluded that computerized cognitive testing may also be used as a component of assessment for mTBI.[1] However, computerized tools, as well as symptom scales, should not be used in isolation.

Several paper-and-pencil diagnostic/neurocognitive tools exist for older teens and young adults, including the Standardized Assessment of Concussion (SAC) as part of the Sport Concussion Assessment Tool (SCAT). At the time of this paper, there was no good validation of the Child-SCAT; however, more recently several studies have explored baseline normative values of the Child-SCAT in pre-teens and younger children.[22,23] These include values for cognitive (SAC-Child) and balance testing (Balance Error Scoring System). Further validation of these tools holds promise for healthcare providers without access to computerized testing.

Posttraumatic headache management/ treatment

Early treatment for headache should focus on nonopioid analgesics. However, neurologists are often called on to care for patients with chronic headaches. Because chronic headaches may have multiple contributing factors, neurologists

Neurologists should review management of cognitive and physical activity and levels of rest with the patient and their families.

should consider a multidisciplinary evaluation and treatment plan. For patients who present with severe or worsening acute headache, neurologists should consider the use of head CT to assess for more serious injury.

Return to activity

Neurologists should discuss the expected recovery trajectory for their patients with mTBI if management recommendations are followed. This may include counseling patients to refrain from activities with a high risk of fall or other activities that place a child at risk for head or brain injury. Neurologists should review management of cognitive and physical activity and levels of rest with the patient and their families. For most patients, this will entail a gradual resumption of a patient's regular, nonsports activities within a few days at intensity levels that do not exacerbate symptoms.

Healthcare providers should assist children with mTBI to progress through a graduated return to activity plan (figure 3). According to the CDC Pediatric mTBI Guideline, "Following the first several days, healthcare providers should counsel patients and families to resume a gradual schedule of activity that does not exacerbate symptoms, with close monitoring of symptom expression (number, severity)."[1] Prior guideline recommendations were relatively regimented regarding return to regular, nonsports activity advice.[24] To provide more clarity to healthcare providers, CDC Pediatric mTBI Guideline emphasizes that return to regular, nonsports activity should be individualized approach—recognizing that each concussion and each patient is unique. Certain patients have risk factors that may prolong symptoms and may affect the return to regular, nonsports activity. These factors include a premorbid history of mTBI, lower cognitive ability, presence of intracranial lesion, neurologic or psychiatric disorder, learning difficulties, increased preinjury symptoms, and family and/or social stressors. Most children can return to school within 2–3 days after

Figure 3 Return to non-sports activity plan for children following mild traumatic brain injury

Source: Used with permission from the Centers for Disease Control and Prevention, cdc.gov/HEADSUP.

Children with mTBI have distinct epidemiology, assessment, management, and recovery trajectories compared with adults.

the injury. However, the return to contact sports process (which includes a separate stepwise process outlined in the AAN Concussion in Sports guideline[15]) should only be initiated once the child is returning to their regular activities.

Patient and family education

Patient and family education about mTBI, symptom monitoring, graded return to activity, and modified school activities are associated with improved health outcomes for patients with mTBI.[1] The CDC Pediatric mTBI Guideline recommends that healthcare providers provide assurance and instructions to the family that is inclusive of warning signs for more serve injury, symptom monitoring tips, the return to activity (such as return to school and play) process, and when to follow up for additional care. Both verbal and written instructions may be beneficial.

Conclusion

This commentary provides a snapshot of the clinical practice recommendations contained in the CDC Pediatric mTBI Guideline that are most relevant to neurologists. To review the full CDC Pediatric mTBI Guideline, Systematic Review, and all 19 recommendation sets, visit: cdc.gov/HEADSUP. There, you can also download educational tools developed by CDC to help support implementation of these evidence-based recommendations.

Our understanding of pediatric-specific differences in injury response, including treatment and recovery from mTBI, is expanding rapidly. Children with mTBI have distinct epidemiology, assessment, management, and recovery trajectories compared with adults. The areas covered in the CDC Pediatric mTBI Guideline are evolving. The development of the CDC Pediatric mTBI Guideline was constrained by the lack of data and quality studies available on pediatric mTBI. Contributions to mTBI research are needed that provide further information on age-appropriate assessments, objective markers, well-controlled management and outcome studies, and optimal management for recovery. It is increasingly recognized that children with mTBI may initially encounter a wide range of healthcare providers and that those with complicated recoveries may benefit from a multidisciplinary approach.

Study funding

No targeted funding reported.

TAKE-HOME POINTS

The CDC Pediatric mTBI Guideline outlines 5 key recommendations for neurologists and other healthcare providers:

- → Do not routinely image pediatric patients to diagnose mTBI.
- → Use validated, age-appropriate symptom scales to diagnose mTBI.
- → Assess for risk factors for prolonged recovery, including history of mTBI or other brain injury, severe symptom presentation immediately after the injury, and personal characteristics and family history (such as learning difficulties and family and social stressors).
- → Provide patients with instructions on returning to activity customized to their symptoms.
- → Counsel patients to return gradually to nonsports activities after no more than a 2–3 days of rest.

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Gary Gronseth, MD	University of Kansas Medical Center, Kansas City	Author	Revised the manuscript for intellectual content
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