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Considerations for neurosurgeons: recommendations from the CDC Pediatric Mild Traumatic Brain Injury Guideline

Shelly D. Timmons, MD, PhD[1], **Dana Waltzman, PhD**[2], **Ann-Christine Duhaime, MD**[3], **Theodore J. Spinks, MD**[4], **Kelly Sarmiento, MPH**[2]

[1]Penn State University, Milton S. Hershey Medical Center, Penn State Health, Department of Neurosurgery, Hershey, Pennsylvania

[2]Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia

[3]Massachusetts General Hospital, Harvard University, Department of Neurosurgery, Boston, Massachusetts

[4]St. Joseph's Children's Hospital, Department of Pediatric Neurosurgery, Tampa, Florida

THE Centers for Disease Control and Prevention (CDC) published the "Centers for Disease Control and Prevention Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children" in September 2018. This evidence-based guideline was developed by a rigorous scientific process using modified GRADE (Grading of Recommendations Assessment, Development and Evaluations) methodology. A systematic review of the scientific literature published over a 25-year period for all causes of pediatric mild traumatic brain injury (mTBI) formed the basis of the CDC Pediatric mTBI Guideline. Neurosurgeons are frequently called upon to distinguish which pediatric patients presenting with a suspected traumatic brain injury (TBI) are at risk for intracranial injury and may need surgical intervention from those who are not. This commentary provides key takeaways for neurosurgeons and other healthcare providers outlined in the Guideline recommendations. These key points focus on risk factors for intracranial injury, neuroimaging, neuropsychological tools, and patient and family education. Neurosurgeons play an integral part in the implementation of evidence-based practices to ensure positive health outcomes among children with TBI, and they will benefit from familiarity with the CDC Pediatric mTBI Guideline.

TBI can lead to devastating effects and contributes to almost a third of all injury-related deaths in the US each year.[10] Thanks in part to advancements in research, motor vehicle safety, and clinical care (including the use of evidence-based guidelines for severe TBI among pediatric patients), deaths from TBI among children decreased dramatically between

Correspondence Shelly D. Timmons: stimmons@mac.com.

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1999 and 2010.[17] Still, the CDC estimates that there are more than 23,000 TBI-related hospitalizations (31.4 per 100,000) and 2500 TBI-related deaths (3.4 per 100,000) among children age 17 and under each year.[30] The most common principal mechanisms of injury for TBI-related hospitalizations and deaths are falls and motor vehicle crashes, respectively.[30] Among patients who are hospitalized and survive, some live with long-term problems that affect them cognitively, physically, and psychologically.[7,18,20]

Children commonly present with higher Glasgow Coma Scale (GCS) scores, placing them in the so-called “mild” TBI category. Clearly, a subset of these children harbor intracranial mass lesions and/or are at risk for deterioration and neurosurgical intervention. It is therefore critical to study this particular population and to develop an evidence basis for determining prognostication, radiographic study indications, and treatment options. Furthermore, even those children who do not deteriorate or require surgical intervention often encounter posttraumatic symptoms that require follow-up and treatment. These patients comprise a significant part of neurosurgical practice. Because early identification and immediate action can significantly reduce the risk for adverse health outcomes for patients with TBI, neurosurgeons are relied upon to provide care and will thus benefit from familiarity with the latest clinical recommendations on diagnosis and management of mTBI.

Recommendations From the CDC Pediatric mTBI Guideline

Last year, the CDC published the first-ever US evidence-based guideline on pediatric mTBI, inclusive of all mechanisms of injury.[22] The CDC Pediatric mTBI Guideline was developed based on a systematic review that spanned 25 years of research.[23] As definitions of mTBI vary among studies and disciplines, authors used “classic” definitions of mTBI. This helped to ensure broad capture of mTBI studies. Specifically, in the CDC Pediatric mTBI Guideline, mTBI was defined as patients presenting with a GCS score of 13–15, with or without loss of consciousness or amnesia, and with or without imaging findings.

Authors of the Guideline completed a rigorous process using a modified GRADE methodology developed by the American Academy of Neurology. This methodology is consistent with the National Academy of Sciences guidance on the development of evidence-based recommendations.[12] More details on the methodology used to develop the CDC Pediatric mTBI Guideline and Systematic Review are described by Lumba-Brown et al.[22,23]

While the CDC Guideline focuses on mTBI, it includes important considerations for neurosurgeons regarding risk factors for intracranial injury, the role of neuroimaging and neuropsychological tools, and patient and family education (Table 1). In addition, neurosurgeons often are called upon to serve as community educators and leaders regarding health and safety (in both sports and nonsports environments). As such, it is helpful for all neurosurgeons to be knowledgeable of the latest recommendations on proper identification and treatment of mTBI. Below is a summary of key topics in the CDC Pediatric mTBI Guideline for review.

Risk Factors for Intracranial Injury

Fortunately, the number of children presenting with GCS scores of 13–15 who have serious intracranial injury or positive findings on imaging is low, especially for intracranial findings (as opposed to scalp and skull findings). Only 0.8% of children in this category of injury require surgery.[23] Importantly, though, the CDC review identified a variety of risk factors associated with increased risk for intracranial injury. These risk factors include age < 2 years old; vomiting; loss of consciousness; severe mechanism of injury; severe or worsening headache; amnesia; nonfrontal scalp hematoma; GCS score <15; and clinical suspicion for skull fracture.[22] A GCS score < 15 at presentation was the most significant predictor, as it was found to be highly likely to predict intracranial injury. Skull fracture and vomiting were determined to be associated with moderate to high and small to moderate increased risk for intracranial injury, respectively.[14,19,28,29,34] All of the other risk factors examined were associated with a small increased risk for intracranial injury.[23] As such, the CDC Pediatric mTBI Systematic Review states, “Aside from GCS score and the presence of skull fracture, these risk factors in relation to association with important intracranial injury suggests that they are not clinically meaningful predictors when considered in isolation (i.e., not confounded with other risk factors).”[23]

Healthcare providers should take into consideration that signs of intracranial injury may have different clinical presentations in children of different ages. This is especially true among preverbal children or children not in school. For example, a toddler may manifest signs through irritability, clinginess, and poor appetite because he or she cannot express what is wrong. Likewise, it may take additional probing to detect an inability to focus in a child not yet in school.

Neuroimaging

To better understand the role of neuroimaging, the CDC Pediatric mTBI Systematic Review explores the effectiveness of cranial imaging in the identification of intracranial injury (utilizing searches for isolated skull fracture, intracranial injury with or without skull fracture, and intracranial injury or skull fracture). The Systematic Review synthesized evidence from 25 peer-reviewed studies. Based on this review, the CDC Pediatric mTBI Guideline states that healthcare providers should not routinely image all pediatric patients with suspected mTBI for diagnostic purposes. This includes the use of CT, MRI, SPECT, and skull radiography. Instead, healthcare providers should use validated clinical decision rules, such as the Pediatric Emergency Care Applied Research Network (PECARN) decision rules,[19] to determine if imaging is warranted. Existing validated decision rules work well and combine a variety of factors that might indicate a higher risk of intracranial injury, such as those outlined in the previous section.

As part of the decision-making process, the CDC Pediatric mTBI Guideline also recommends that healthcare providers discuss the risks of pediatric imaging in the context of risk of intracranial injury with the patients and their families. Additionally, 1) children with suspected intentional trauma, 2) other intracranial abnormalities, 3) specific genetic,

metabolic, or endocrine issues, and 4) bleeding disorders may be at higher risk for injury and should be evaluated on a case-by-case basis.

Neuropsychological Tools

The results of the review, in summary, call for the use of various tools in conjunction with clinical expertise to make the diagnosis of concussion, and provide the relative evidentiary basis for the use of each. Neuropsychological testing provides valuable information in diagnosing an mTBI, but should not be used *in isolation.* The CDC Pediatric mTBI Guideline recommends that age-appropriate, validated symptom rating scales[11,13,15,21,32] *should be* used in the acute period as a component of the diagnostic evaluation in children with mTBI, while computerized cognitive testing[3,21,26,32] *may be* used. The Standardized Assessment of Concussion should not be used to exclusively diagnose an mTBI in children.[15]

Most children with mTBI do not have persistent deficits or symptoms past the first few months of injury,[1,2,35] and of those who do, many have premorbid learning or behavioral risk factors.[24,27,31] Neuropsychological testing can also help determine recovery from an mTBI. Healthcare providers should use a combination of tools to assess recovery.[4,6,9] Specifically, symptom scales and cognitive testing have demonstrated the strongest evidence in assessing recovery,[5] while balance testing has shown utility in older adolescent patients.[16]

Neuropsychological testing can be a helpful tool in diagnosing and managing mTBI.[25] Neurocognitive recovery is inferred when the patient's performance either returns to baseline levels (if baseline testing was performed) or is consistent with preinjury estimates of functioning while remaining symptom free.[25] The CDC Pediatric mTBI Guideline concluded that the evidence is *insufficient* to determine whether baseline ratings in children better identify concussion as compared to postinjury scores alone.[8,33]

Patient and Family Education

For patients who do not need hospitalization or medical intervention and can be discharged from the emergency department, the CDC Pediatric mTBI Guideline recommends that healthcare providers counsel patients and their families about warning signs that may signal more serious injury. This includes a check for signs of deteriorating neurological function. Healthcare providers should discuss the expected recovery trajectory if management recommendations are followed. This may include refraining from activities with a high risk of fall or other activities that place a child at risk for head or brain injury. Healthcare providers 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 within a few days of those regular, nonsports activities that do not exacerbate symptoms.

Providing verbal and written education, giving reassurance about the likelihood of recovery, and helping patients to understand the importance of postinjury care and behavioral modification will better position pediatric patients to have positive health outcomes. One of the main findings in the CDC Pediatric mTBI Systematic Review was that most children with mTBI have a good recovery.[23] There is insufficient evidence to suggest that early return

to noncontact physical and mental activities is deleterious to outcomes.[22] This may provide some reassurance to healthcare providers, as well as to patients and their families.

Discussion

Neurosurgeons play a significant role throughout the mTBI care process and can help ensure that children with an mTBI have a good recovery. First, they act as critical decision-makers in the emergency department and hospital setting regarding observation, neuroimaging, and need for admission. Second, neurosurgeons commonly treat these patients in the office setting and can provide guidance to patients and families on neuropsychological and other testing and recovery. Finally, neurosurgeons serve in important community roles, such as team physicians, educators, and community leaders. Through all of these mechanisms, neurosurgeons can help to ensure children achieve an optimal recovery after sustaining an mTBI.

To assist neurosurgeons in integrating the Guideline recommendations into practice, the CDC created free and publicly available implementation tools. These tools include online training with continuing education credits, a checklist for providers, diagnostic tools, discharge instructions, and handouts for patients and families with symptom-based recovery tips. To access the CDC Pediatric mTBI Guideline and implementation tools, visit www.cdc.gov/HEADSUP.

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TABLE 1.

Overview of clinical recommendations most applicable to neurosurgeons contained in the CDE Pediatric mTBI Guidelilne*

Risk Factors for Intracranial Injury
• Neurosurgeons should assess risk factors associated with increased risk for intracranial injury, such as: Age < 2 years old; Recurrent vomiting; Loss of consciousness; Severe injury mechanism; Severe or worsening headaches; Amnesia; Non-frontal scalp hematoma; GSC score < 15; or Clinical suspicion for skull fracture. • Neurosurgeons should take into consideration that signs of intracranial injury may look different in children of different ages.
Neuroimaging
• Neurosurgeons should not routinely image a pediatric patient with suspected mTBI for diagnostic purposes but instead should use validated clinical decision rules that assess a combination of risk factors. • Mild TBI is a clinical diagnosis and is not dependent on head CT imaging, MRI, SPECT, or skull radiographs. Additionally, skull radiographs should not be used as a screening tool for intracranial injury. • In cases of acutely worsening symptoms of headache, especially In the setting of other risk factors, consider emergent neuroimaging to assess for more severe intracranial injuries.
Neuropsychological Tools
• Age-appropriate, validated symptom-rating scales should be used as a component of diagnostic evaluation. • Age-appropriate, validated computerized cognitive testing may be used as a component of diagnostic evaluation. • The Standardized Assessment of Concussion should not be used exclusively to diagnose mTBI in children. • Healthcare providers should use a combination of tools to assess recovery, such as symptom scales and cognitive testing (including measures of reaction time). Additionally, balance testing has shown utility in older adolescent patients.
Patient and Family Education
• To optimize outcomes, neurosurgeons should communicate clearly and provide patient/family education about mTBI, such as: Warning signs of more serious injury, such as deteriorating neurological function;

Expected course of symptoms and recovery (including the role of cognitive and physical rest);

Instructions regarding return to activity (sports, recreation, and school); and Clear clinician follow-up discharge instructions.

[*] Based on Lumba-Brown A, Yeates KO, Sarmiento K, Braiding MJ, Haegerich TM, Gioia GA, et al: Centers for Disease Control and Prevention guideline on the diagnosis and management of mild traumatic brain injury among children.