CNE Continuing Nursing Education
Objectives and instructions for completing the evaluation and statements of disclosure can be found on page 272.

Mild Traumatic Brain Injury in Children

Christine Narad Mason

Traumatic brain injuries (TBIs) in childhood, especially those related to participation in sports and recreation activities, are receiving increased public awareness. Research is beginning to show that even mild TBIs (mTBIs) may not be mild at all, and could have serious long-term effects on the health, behavior, and cognitive abilities of children. With the development of the Centers for Disease Control and Prevention's TBI tools for professionals, a more evidenced and systematic way is available to help recognize and manage mTBI. New research on predictor values showing that symptoms may not be the best way to assess the severity of mTBI will help to change how mTBIs are managed in the future.

Recent media attention has increased awareness of the long-term impact of concussions on athletes following the recent $765 million settlement between the National Football League (NFL) and 18,000 retired football players with long-term concussive-related injuries (ESPN, 2012). Consequently, more attention is focused on the impact of concussions for children, adolescents, and young adults. Most health care providers understand and are concerned about how traumatic brain injuries (TBIs) in children can affect school performance, behavior, and general health and well-being. Longer-term impact of repeated concussions on children – disorders, including Alzheimer's, dementia, Parkinson's, Amyotrophic Lateral Sclerosis (ALS), or psychiatric diagnoses, such as depression and anxiety – may not be an immediate concern. Mild traumatic brain injury (mTBI) is a common occurrence in pediatric patients, with consequences for short- and long-term sequelae (Rapp & Curley, 2012) and potentially significant mortality and morbidity (Centers for Disease Control and Prevention [CDC], 2013).

The National Institute of Neurological Disorders and Stroke (NINDS) defines TBI as an acquired brain injury caused by sudden trauma resulting in damage to the brain tissue. There are three categories of TBI: mild, moderate, and severe (NINDS, 2013). The focus of this article will be on the evaluation and management of traumatic brain injuries in the mild category.

Christine Narad Mason, DNP, C-PNP, *is a Children's Neurosurgery Pediatric Nurse Practitioner, Children's National Medical Center, Children's Neurosurgery, Fairfax, VA.*

Incidence and Etiology

It is estimated that approximately half a million children between the ages of birth and 14 years are admitted to emergency rooms each year in the United States for TBIs (Faul, Likang, Wald, & Coronado, 2010). Children from birth to four years of age, and those 15 to 19 years of age, are the most likely to suffer from a TBI. Gender differences exist, with males being 59% more likely to experience a TBI compared to females, especially from birth to four years of age (Faul et al., 2010).

Data from emergency room visits collected by the CDC from 2002-2006 show that over 50% of TBIs in children from birth to 14 years of age are caused from falls (Faul et al., 2010). In fact, TBIs account for over 18% of yearly emergency room visits, with a 62% increase in falls for children younger than 14 years of age compared to data before 2002. In this same age group, 25% of children were injured when they collided into a moving or stationary object. Motor vehicle accidents account for 7% of TBI incidents and for 31.8% of TBI deaths in all age groups. Almost 3% of TBIs in children from birth to 14 years of age are caused by assault (see Figure 1). All of these are significant numbers begging to answer the question, "Why are children more likely to have a TBI?"

Although the details of biomechanical and biochemical assault on the brain after injury is beyond the scope of this article, the simple answer is that the anatomy of a child's body is different than that of an adult and lends itself to brain injuries. The basic pathophysiology for TBI is that following a blow to the head, the brain undergoes an acceleration and then deceleration, causing stretching of neuronal fibers, changes in excitatory amino acid neurotransmitters, alternations in blood flow, oxygenation, and at times, anatomical injury to the brain (Giza et al., 2013; Russo Buzzini & Guskiewicz, 2006). Once the injury has occurred, the inflammatory process begins and edema ensues, sometimes resulting in the anoxic cascade.

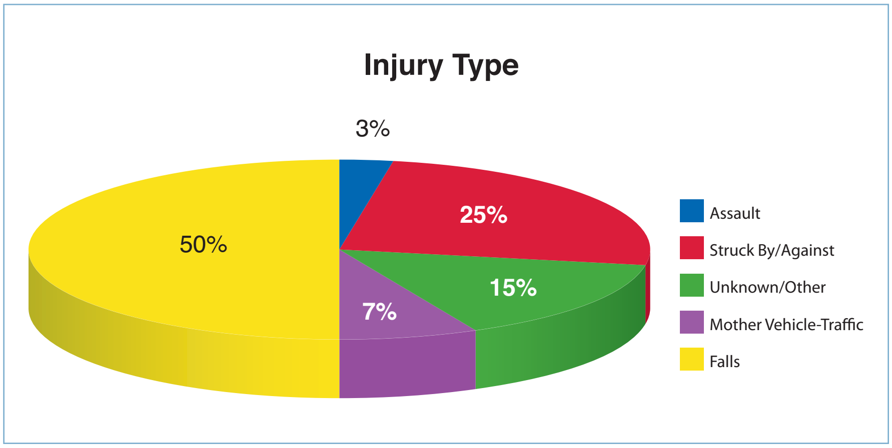
Appreciating the differences in children's anatomy and physiology makes it easier to understand why infants and young children are more susceptible to TBIs and have different symptoms than older children or adolescents. In infancy, the skull is subdivided into eight bones with sutures (separations) between the bones. Unlike the adolescent skull, these patent sutures allow the infant's skull to spread wider and grow larger if an injury occurs to the brain. Thus, the infant can sustain a significant bleed or brain swelling and quickly accommodate without an increase in the cranial pressure (Enix, Mullin, Green, & Kahn, 2007). Older children and adolescents cannot tolerate a rapid increase in intracranial pressure because the closure of skull bones renders the skull rigid and unyielding. This fusion process typically occurs by two years of age. In addition, younger children generally have fewer events with loss of consciousness when compared to older children who exhibit more classic signs of a concussion.

The term *concussion* is very broad and conjures up different connotations for people. The term concussion is used to describe a set of symptoms that happen after the brain sustains a traumatic injury and is categorized on the continuum of mild to severe. Despite the term "mild," which indicates a minor injury, mTBI can have significant detrimental effects, especially in children (Rapp & Curley 2012; Taylor, 2012).

Anatomical differences make infants and children more vulnerable to extensive injuries following head trauma. The brain of a child has wide spaces located between the skull and brain (subarachnoid spaces) containing blood vessels that can become damaged after experiencing shearing forces and movement (Barth, Freeman, Broshek, & Varney, 2001). The infant's head-to-body ratio is much larger than an adult's, and the neck is more flexible, which increases the potential for greater movement and damage from jarring forces. When a force is applied to the head or the head strikes a stationary object, the brain moves back and forth inside the skull. This causes the brain fibers to be stretched, blood vessels to bleed, and inflammation to occur. Once this happens, the child may begin to show signs of a concussion. In mild cases the child may experience a headache; however, the more severe and/or repetitive the injury, the more likely significant damage may occur, such as hemorrhage and severe brain injury.

Symptoms of mTBI (see Table 1) also occur in moderate and severe

Figure 1.
Traumatic Brain Injury by Injury Type for Children Birth to 14 Years of Age



Sources: Centers for Disease Control and Prevention, 2010.

Table 1.
Common Symptoms of Mild Traumatic Brain Injury

Symptom	Description	Comment
Dizziness/vertigo	Occurs with or without changes in position.	Often due to acceleration/deceleration of the brain.
Headache	Photophobia, throbbing, constant or increased duration or severity with increased activity, sensitivity to sound.	Chronic headaches or post-traumatic migraines may develop, requiring symptomatic treatment.
Visual disturbance	Double vision, blurred vision.	Indicates increased pressure in the brain.
Nausea/vomiting	Vomiting that occurs more than twice in one hour initially is a red flag for increased concern and may necessitate a CT scan.	Persistent vomiting can indicate an underlying hemorrhage and places the child at risk for dehydration, which can increase symptoms.
Loss of consciousness	Loss of consciousness for less than 30 minutes.	Loss of consciousness does not have to be present to have a brain injury and is less common in children.
Fatigue or difficulty sleeping	Increased sleepiness, sluggish, feeling "foggy."	Very common after TBI. Child should also be observed for depressive symptoms. Some children will have difficulty sleeping and develop insomnia. Lack of sleep will increase fatigue symptoms or sleep pattern.
Blacking out/blank spells	Trouble concentrating or frequent forgetfulness. Answers questions slowly or forgets the question.	May have no memory of the injury event. Can be worse when the child is tired. May be an indication of post-traumatic seizures, requiring additional investigation with an EEG.
Emotional disruptions Mood and personality changes	Anger and temper outburst above and beyond the child's baseline. Shorter tolerance for limit setting.	Emotional outbursts are common and will often lessen further from the event; however, a subgroup of children may go on to have long-term personality changes.
Difficulty with memory	Forgetfulness or trouble understanding or accessing new or old information, trouble concentrating, confusion.	There is often a decrease in school performance in school-age children.

Sources: Adapted from Anderson, Heitger, & Macleos, 2006; Centers for Disease Control and Prevention, 2013; Cohen, Gioia, Atabaki, & Teach, 2009, Giza et al., 2013; Russo Buzzini & Guskiewicz, 2006.

Table 2.
Red Flags Indicating Emergency Situations

Symptom	Description
Loss of consciousness	Increased difficulty staying awake. More difficulty waking up. More periods of sleepiness.
Changes in mental status	Increased confusion or agitation. Inability to recognize familiar people or places. Restlessness, aimless walking around. Bizarre or unusual behavior.
Headache	Worsening of headache; neck pain.
Changes in speech	Slurred speech.
Vomiting	Vomiting more than two times in an hour or an increase in the number of nausea and vomiting episodes.
Changes in mobility	Weakness, numbness, or tingling. Imbalance, falling.
Seizures	Development of or worsening of existing seizure condition.
Pupil changes	Change in pupil size one larger than the other or rapid changes in visual disturbances.

Source: Adapted from Anderson, Heitger, & Macleos, 2006; Centers for Disease Control and Prevention, 2013; Giza et al., 2013; Russo Buzzini & Guskiewicz, 2006.

TBIs, only to a more acute and intense degree. Common symptoms for mTBI are confusion, drowsiness, change in sleeping pattern (more or less), headache, blurred vision, ringing in the ears, balance problems, dizziness, vomiting, nausea, sensitivity to light and noise, and numbness or tingling in the extremities. Later symptoms include trouble in school, behavior problems (increased aggression and short temper), memory problems, and attention and concentration problems. Decreased levels of consciousness for less than 30 minutes place children in the mTBI category; however, the signs and symptoms of mTBI are often difficult to distinguish, and thus, determining the exact type of TBI may be difficult (Dennis, 2009).

The symptoms of mTBI can have lasting effects for days, weeks, or months post-injury (see Table 2). In cases where the child has had multiple concussions, the symptoms can occur for a longer duration, resulting in an increased length of recovery time for the child. In some cases, multiple mTBIs can cause long-term damage to the brain and lifelong cognitive and emotional problems (Langliois, Rutland-Brown, & Wald, 2006; Rapp & Curley, 2012).

Assessing MTBI: Concerns About Radiation Exposure

The use of radiological imaging for children with mTBI is controversial. Intracranial hemorrhages, a major complication of TBI that if undiagnosed can be fatal, is identified using neuroimaging. If a child has any red flag signs or symptoms, assessment should escalate from observational status to an acute evaluation that includes radiographic evaluation of the head. In this era of cost containment, not all children need to have a computed tomography (CT) scan; however, if there are any concerns about a skull fracture or an intracranial bleed, an imaging study should be obtained.

Many parents and providers are concerned about exposure to radiation from CT scans increasing the future risk of cancer. Limited long-term epidemiology studies have been performed, which makes it difficult to predict exact risk (Brenner, Hall, & Phil, 2007). Radiation exposure is a concern for all ages; however, the National Cancer Institute (NCI, 2012) cites three unique considerations in children. A child:

- Is more sensitive to radiation than an adult.
- Has a longer life expectancy than an adult, which leaves more opportunity for experiencing radiation damage.
- Might receive a higher dose of radiation than needed if scanner settings have not been adjusted for a smaller body size (NCI, 2012).

However, the estimated dose risk of cancer after exposure to radiation due to head CT scan over a lifetime is approximately 0.065 (Brenner et al., 2007). To put this in perspective, risk data from 1991-1996 estimates that 0.4% of cancer in the United States may be attributed to radiation exposure from CT scans (Brenner et al., 2007).

Clinical judgment is needed to weigh the need for a CT scan with the risk of unnecessary exposure to low-dose radiation while still assessing for potential serious acute and long-term effects of mTBI. For children suspected of having intracranial hemorrhages, the benefits of a CT scan outweigh the risks of radiation exposure, especially in the case of an epidural bleed. Technology is now so far advanced that most CT scans take approximately one second, and the dose of radiation exposure has been lowered to more acceptable limits (Brenner et al., 2007). Magnetic resonance imaging (MRI) is a technique that can be used without radiation; however, the MRI may require sedation, takes a longer period of time (usually 45 minutes to an hour) than CT, and results in a delay of treatment. An MRI can be a useful technique to obtain brain injury information for long-term management (Suskauer & Huisman, 2009).

Management

Currently, no standards exist on how to identify, evaluate, and manage children with TBIs. There are over 20 different assessment scales published to assess sports-related TBI in children (Russo Buzzini & Guskiewicz, 2006). The challenge for the pediatric health care provider is deciding if the TBI is mild, moderate, or severe because this determination has an impact on the child's care and long-term prognosis. The Acute Concussion Evaluation (ACE) developed by Gioia and Collins (2006) provides an evidence-based protocol for mTBI assessment. The ACE objectively identifies physical, cognitive, and emotional symptoms that can be tracked over a period of time, which is especially important for children who experience multiple concussions (see Figure 2). The ACE protocol also has a companion ACE Care Plan that outlines mTBI home and school management and includes guidelines for when children can resume sports practices (CDC, 2011; Cohen, Gioia, Atabaki, & Teach, 2009). In a study with parent informants of 354 patients three to 18 years of age with suspected mTBI, the ACE symptom checklist exhibited reasonably strong psychometric properties as an initial assessment tool for mTBI (Gioia, Collins, & Isquith, 2008). The ACE and ACE protocol are movements toward improved management and treatment of mTBI in children.

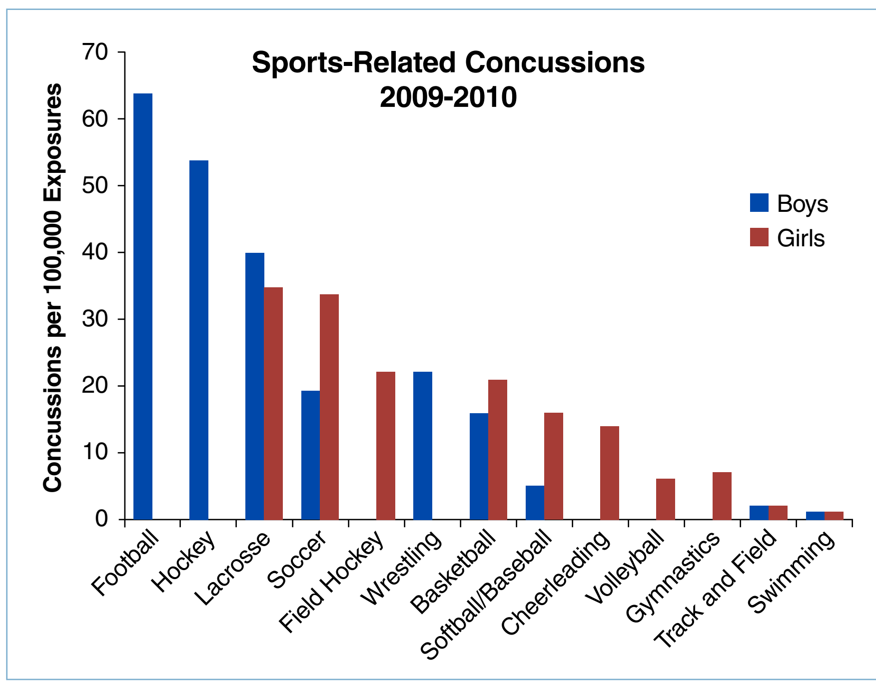
Not all children need an immediate referral to the emergency room after a blow to the head. Children who exhibit red flag symptoms (see Table 2) need more intensive evaluations. In general, children experiencing the following symptoms warrant immediate evaluation: a headache that increases in severity; seizures; focal neurologic signs (e.g., can't move an arm, twitching); difficulty staying awake or waking up; vomiting more than twice in one hour; slurred speech; inability to recognize common people, places, or objects; increasing confusion or irritability; weakness in extremities; neck pain; and/or changes in level of consciousness (Elovic, Baerga, & Cuccurullo, 2004).

Limited information is available on prognostic indicators for children with mTBI. Wiebe, Collins, and Nance (2012) performed a prospective study looking at derivation and validation of the ImPACT assessment with children 11 to 17 years of age who were seen in the emergency room and then admitted to the hospital for mTBI management. The children underwent neuropsychological testing focused on assessing two outcome measures: impairment and severe impairment. The participants were tested using a 22-item Likert ImPACT scale at initial presentation and two weeks post-discharge. The absence of neurocognitive symptoms at the initial evaluation in some cases did not correlate to being symptom-free two weeks post-discharge. This finding reinforces the need for continued neurocognitive evaluations to return to normal activities and sports play.

Figure 2.
Resources

Acute Concussion Evaluation Tool – Gerard Gioia, PhD, and Micky Collins, PhD http://www.cdc.gov/concussion/headsup/pdf/ace-a.pdf
The Latest Management Guidelines of Concussions in the Young Student-Athlete – Gerard Gioia, PhD http://www.childrensnational.org/files/PDF/ForDoctors/cnhn/ace-packet.pdf
Training Course for High School Coaches – National Association of State High School Associations (NFHS) http://nfhslearn.com/electiveDetail.aspx?courseID=38000
Heads Up Online Training Course – Centers for Disease Control and Prevention http://www.cdc.gov/concussion/headsup/online_training.html

Figure 3.
Sports-Related Concussions for High School Students



Sources: Adapted from Marar, McIlvain, Fields, & Comstock, 2012.

Sports-Related Brain Injuries

Sports injuries are the leading cause of TBI in children five to 18 years of age (CDC, 2011). Non-fatal emergency room visit data obtained through the CDC's National Electronic Injury Surveillance System – All Injury Program, United States 2001-2009, provide insight into potential risk of TBI with various sports activities (CDC, 2011). Figure 3 illustrates the rates of sports-related concussions for high school students by activity and gender (Marar, McIlvain, Fields, & Comstock, 2012).

High school sports are known risk factors for mTBI. Concussive injuries to males occur most frequently in contact football and soccer. Female youth experience mTBI most commonly from soccer and basketball injures (Giza et al., 2013). Other accidents that result in TBI in children five to 18 years of age involve bicycles, playground incidences, all-terrain vehicles, skateboards, and horseback riding (Cohen et al., 2009).

Sports injuries often occur in the school setting where lay providers are the first ones to evaluate the child. The National Association of State High School Associations (NFHS) offers training for high school coaches on the management and evaluation of concussions and other problems that can and do occur in the sports arena on a regular basis (see Figure 2). The training is robust and offers a sound grounding in principles to keep children safe.

One of the most common questions asked following mTBI is, "When can the child return to sports activities?" The answer depends upon several factors, including but not limited to the severity and mechanism of the injury and the number of previous concussions. Sarsfield, Moreley, Callahan, Grant, and Wojcik (2013) described emergency department discharge practices and found that caregivers often were not given appropriate instructions for when their children could resume activities. The "Cantu Evidence Based System and Return to Play Guidelines" is one of the more popular guides available (Russo Buzzini & Guskiewicz, 2007). Cantu (2001) developed a grading system that subdivides concussions into three categories: Grade 1 – No loss of consciousness and amnesia that lasts less than 30 minutes after the event; Grade 2 – loss of consciousness is less than five minutes and amnesia lasts 30 minutes to under 24 hours; Grade 3 – When loss of consciousness is for more than five minutes and amnesia lasts for more than 24 hours. Grade 1 concussions are considered to be mTBI; Grades 2 and Grade 3 are more severe and beyond the scope of this article.

Carrol et al. (2004) performed a meta-analysis of 428 studies looking at mTBI epidemiology, treatment, and prognosis. The researchers found consistent evidence that children who suffer mTBI recover rapidly and have few, if any, cognitive or behavioral problems. Most symptoms are completely resolved three to 12 months after injury. It is interesting to note, however, that poverty is associated with a poorer outcome (Geberding & Binder, 2003).

Exploration of research on the impact of mTBI on children and the evaluation of interventions to improve outcomes are growing. Ponsford and colleagues (2001) questioned whether providing children with information on mTBI would have an impact on their outcomes three months after injury. The researchers studied children six to 15 years of age who had a history of mTBI with loss of consciousness for less than 30 minutes. The children were randomized to intervention and non-intervention groups. In the intervention group, the 61 children were assessed at one week after injury and given an information booklet outlining what to expect after mTBI and suggested coping strategies, and assessed again at the three-month post-injury mark. The 58 children in the non-intervention group were assessed three months after injury only and did not receive the booklet. These two mTBI groups were compared to two control groups of children with minor injuries and no head trauma. The intervention group of children with mTBI seen at one week reported more symptoms than controls, but demonstrated no impairment on neuropsychological measures. Although initial symptoms had resolved for most children three months following injury, 20% of the children reported significant ongoing problems. This group of children tended to have a history of previous head injury, learning or behavioral difficulties, other neurological or psychiatric disturbance, or family stressors. These findings are consistent with those of previous researchers (Asarnow et al., 1987; Farmer, Singer, Mellitis, Hall, & Charney, 1987). Regarding the intervention, the children not seen at one week and not given the information booklet reported more symptoms overall and were more stressed three months after injury than the intervention group. Ponsford et al. (2001) concluded that providing an information booklet reduces anxiety and thereby lowers the incidence of ongoing problems.

Treatment

Guidelines on how to treat a concussion are variable depending on the source used to assess the initial injury and the child's underlying health and environmental factors. In general, it is recommended that the child athlete use a slow systematic approach to return to all activities. Athletic pursuits are often of most concern to the child who, with medical clearance, may begin with light aerobic activity (walking), followed by more sport-specific training (running) and advance to drills without contact (Kirkwood, Yeates, & Wilson, 2006). If the child's concussive symptoms return at any point in time or new symptoms arise, restrictions are reinstituted. If each phase is completed without recurrence of symptoms, the child may advance to full contact practice and then participate in the game (Kirkwood et al., 2006).

Parents are often most concerned about the child's return to school and academic performance. School personnel are an integral part of the child's life and should be told of the child's mTBI and symptoms to observe while the child is in the school setting. Working with the school to develop a transition plan is imperative. Fatigue and concentration issues can make it difficult for the child to return to a full day of school while making up missed work and participating in the new daily work expected in the classroom. Special accommodations, such as a 504 Education Plan, special education classes, or homebound tutoring, may be needed to ensure the child has adequate rest to heal the brain and to set realistic expectations concerning academic progress (Kirkwood et al., 2006). Borg et al. (2004) looked at non-surgical interventions for children with mTBI and found that education on mTBI symptoms and recovery had a positive impact on decreasing parental anxiety.

Actions

Educating children and families about risks of TBI associated with sports and childhood activities, as well as what to expect after mTBI are important nursing interventions. However, the ultimate goal is prevention of mTBI to minimize long-term complications. Neuropsychological testing provides a road map for how the brain processes information and is very helpful to gage neurocognitive deficits following mTBI. Children with mTBI may experience temporary disruption of cognitive processing, making it extremely difficult to keep up or maintain normal levels of schoolwork. Alternate schedules for school may be necessary for the child to maintain grade-appropriate work. Many schools systems are starting to make baseline neuropsychological testing a requirement for each athlete prior to any sports participation. A baseline examination is critical to be able to understand the degree of change that occurs after injury. Injured children should resume sports activities only after they return to baseline. When the brain is overstimulated after a concussion, symptoms such as headaches and confusion may get worse or attention may be more difficult to maintain over a set period of time.

Conclusion

The majority of children who suffer mTBI will do well, although current empirical evidence does not provide a means to predict which children will have long-term problems. Children who have suffered a TBI are also three to six times more likely to suffer a second or third TBI. Being familiar with the grading criteria and understanding that most children recover in three to 12 months is essential. Symptoms such as headaches, fatigue, and cognitive issues are most common following the initial head injury. Issues with depression and school problems can become long-term problems (Silver, McAllister, & Arciniegas, 2009). Rest with decreased stimulation is the most effective treatment. More research is needed in the area of post-concussive testing and factors that predict outcomes. With better understanding and proper evaluation and time to recover, the ultimate goal of preventing TBI and minimizing the potential damage and long-term consequences for the child and athlete can be achieved.

References

Anderson, T., Heitger, M., & Macleod, A.D. (2006). Concussion and mild head injury. *Practical Neurology, 6*(342), 342-357.

Asarnow, R.F., Satz, P., Light, R., Zaucha, K., Lewis, R., & McCleary, C. (1995). The UCLA study of mild closed head injury in children and adolescents. In S. Browman & M.E. Michel (Eds.), *Traumatic head injury in children* (pp. 117-146). New York, NY: Oxford University Press.

Barth, J., Freeman, J., Broshek, D., & Varney, R. (2001). Acceleration-deceleration sport-related concussion: The gravity of it all. *Journal of Athletic Training, 36*, 253-256.

Borg, J., Holm, L., Peloso, P.M., Cassidy, J.D., Carroll, J.D., von Holst, H., … Yates, D. (2004). Non-surgical intervention and cost for mild traumatic brain injury: Results of the WHO collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, Suppl. 43*, 76-83. doi:10.1080/1650 1960410023840.

Brenner, D.J., Hall, E.J., & Phil, D. (2007). Computer tomography – An increasing source of radiation exposure. *The New England Journal of Medicine, 357*, 2777-2784.

Cantu, R.C. (2001). Posttraumatic retrograde and anterograde amnesia: Pathophysiology and implications in grading and safe return to play. *Journal of Athletic Training, 36*(3), 244-248.

Carrol, L.J., Cassidy, J.D., Pelosos, P.M., Borg, J., von Holst, H., Holm, L., … Pepin, M. (2004). Prognosis for mild traumatic brain injury: Results. *Journal of Rehabilitation Medicine Supplement, 43*, 84-105. doi:10.1080/16501960410023 859

Centers for Disease Control and Prevention (CDC). (2010). *Traumatic brain injury in the United States: Emergency department visits, hospitalizations and deaths 2002-2006* (p. 19). Retrieved from http://www.cdc.gov/traumaticbraininjury/pdf/blue_book.pdf

Centers for Disease Control and Prevention (CDC). (2011). Nonfatal traumatic brain injuries related to sports and recreation activities among persons aged < 19 years – United States, 2001-2009. *Morbidity and Mortality Weekly Reports, 60*(39). Retrieved from http://www.cdc.gov/mmwr/pdf/wk/mm6039.pdf

Centers for Disease Control and Prevention (CDC). (2013). *Traumatic brain injury*. Retrieved from http://www.cdc.gov/traumaticbraininjury/

Cohen, J.S., Gioia, G., Atabaki, S., & Teach, S.J. (2009). Sports-related concussions in pediatrics. *Current Opinion in Pediatrics, 21*, 288-293. doi:10.1097/MOP.ob13e32832b1195

Dennis, K.C. (2009). Current perspectives on traumatic brain injury. *American Speech-Language-Hearing Association, 8*(4), 118. doi:10.1097/MOP.obo13e32835a279b

Elovic, E., Baerga, E., & Cuccurullo, S. (2004). Mild traumatic brain injury and postconcussive syndrome. In S. Cucurullo (Ed.), *Physical medicine and rehabilitation board review* (pp. 76-81). New York, NY: Demos Medical Publishing.

Enix, A., Mullen, J., Green, C., & Kahn, S. (2007). Traumatic brain injury. In C. Cartwright & D. Wallace (Eds.), *Nursing care of pediatric neurosurgery patients* (pp. 149-190). Berlin: Springer.

ESPN. (2012, August 29). *NFL, players reach concussion deal.* Retrieved from http://espn.go.com/nfl/story/_/id/9612138/judge-nfl-players-settle-concussion-suit

Farmer, M.Y., Singer, H.S., Mellitis, E.D., Hall, D., & Charney, E. (1987). Neurobehavioral sequelae of minor head injuries in children. *Paediatric Neuroscience, 13,* 304-308.

Faul, M., Likang, X., Wald, M.M., & Coronado, V.G (2010). *Traumatic brain injury in the United States: Emergency department visits, hospitalizations and deaths 2002-2006.* Atlanta: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control.

Gerberding, J.L., & Binder, S. (2003). *Report to Congress on mild traumatic brain injury in the United States: Steps to prevent a serious public health problem.* Atlanta: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control.

Gioia, G., & Collins, M. (2006). *Acute concussion evaluation (ACE).* Retrieved from http://www.cdc.gov/concussion/headsup/pdf/ace-a.pdf

Gioia, G., Collins, M., & Isquith, P. (2008). Improving identification and diagnosis of mild traumatic brain injury with evidence: Psychometric support for the acute concussion evaluation. *Journal of Head Trauma and Rehabilitation, 23*(4), 230-242.

Giza, C.C., Kutcher, J.S., Ashwal, S., Barth, J., Getchius, T.S.D., Gioia, G.A., … Zafonte, R. (2013). Summary of evidence-based guideline update: Evaluation and management of concussion in sport. *Neurology, 80,* 2249-2257. doi:10.1212/WNL.obo13e311828d57dd

Kirkwood, M.W., Yeates, K.O., & Wilson, P.E. (2006). Pediatric sports-related concussion: A review of the clinical management of an oft-neglected population. *Pediatrics, 117,* 1359-1371. doi:10.1542/peds.2005-0994

continued on page 282

Instructions For Continuing Nursing Education Contact Hours

Mild Traumatic Brain Injury In Children

Deadline for Submission: December 31, 2015

PED 1309

To Obtain CNE Contact Hours

1. For those wishing to obtain CNE contact hours, you must read the article and complete the evaluation through ***Pediatric Nursing*'s Web site.** Complete your evaluation online and your CNE certificate will be mailed to you. Simply go to **www.pediatricnursing.net/ce**
2. Evaluations must be completed **online December 31, 2015**. Upon completion of the evaluation, a certificate for **1.4** contact hour(s) will be mailed.

Fees – ***Subscriber:*** **Free** ***Regular:*** **$20**

Goal

To provide an overview of mild traumatic brain injury (mTBI), including its causes, treatment modalities, and how mTBIs can be managed in the future.

Objectives

1. Define mild traumatic brain injury (mTBI).
2. List the symptoms of mTBI.
3. Discuss the impact a patient's age has on recovery following a mTBI.
4. Explain the importance of proper categorical diagnosis of a patient presenting with a TBI.

Statements of Disclosure: The author reported no actual or potential conflict of interest in relation to this continuing nursing education activity.

The *Pediatric Nursing* Editorial Board members reported no actual or potential conflict of interest in relation to this continuing nursing education activity.

This independent study activity is provided by **Anthony J. Jannetti, Inc.** (AJJ).

Anthony J. Jannetti, Inc. is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.

Anthony J. Jannetti, Inc. is a provider approved by the California Board of Registered Nursing, Provider Number, CEP 5387.

Licenses in the state of California must retain this certificate for four years after the CNE activity is completed.

This article was reviewed and formatted for contact hour credit by Hazel Dennison, DNP, RN, APNc, CPHQ, CNE, Anthony J. Jannetti Education Director; and Judy A. Rollins, PhD, RN, *Pediatric Nursing* Editor.

Mild Traumatic Brain Injury in Children

continued from page 272

Langliois, J.A., Rutland-Brown, W., & Wald, M.M. (2006). The Epidemiology and impact of traumatic brain injury: A brief overview. *Journal of Head Trauma Rehabilitation, 21*(5), 375-378.

Marar, M., Mcllvain, N.M., Fields, S.K., & Comstock, R.D. (2012). Epidemiology of concussions among United States high school athletes in 20 sports. *American Journal of Sports Medicine, 40,* 747-755.

National Cancer Institute (NCI). (n.d.). *Radiation risk and pediatric computer tomography (CT): A guide for health care providers.* Retrieved from http://www.cancer.gov/cancertopics/causes/radiation/radiation-risks-pediatric-CT

National Institute of Neurological Disorders and Stroke (NINDS). (2013). *What is traumatic brain injury?* Retrieved from http:www.ninds.nigh.gov/disorders/tbi/tbi.htm

Ponsford, J., Willmontt, C., Rothwell, A., Cameron, P., Ayton, G., Nelms, R., … Ng, K. (2001). Impact of early intervention on outcome after mild traumatic brain injury in children. *Pediatrics, 108*(6), 1297-1303. doi:10.1542/peds.108.6.1297

Rapp, P.E., & Curley, K.C. (2012). Is the diagnosis of "mild traumatic brain injury" a category mistake? *Journal of Trauma and Acute Care Surgery, 73*(2 Suppl. 1), S13-S23. doi:10:1097/TA.obo13e318260604b

Russo Buzzini, S.R., & Guskiewicz, K.M. (2006). Sports-related concussion in the young athlete. *Current Opinion in Pediatrics, 18,* 376-382.

Sarsfield, M.J., Moreley, E.J., Callahan, J.M., Grant, W.D., & Wojcik, S.M. (2013). Evaluation of emergency medicine discharge instructions in pediatric head trauma. *Pediatric Emergency Care, 29*(8), 884-887.

Silver, J.M., McAllister, T.W., & Arciniegas, D.B. (2009). Depression and cognitive complaints following mild traumatic brain injury. *American Journal of Psychiatry, 166,* 653-661.

Suskauer, S.J., & Huisman, T.A. (2009). Neuroimaging in pediatric traumatic brain injury: Current and future predictors of functional outcome. *Developmental Disability Research Reviews, 15*(2), 117-1123. doi:10.1002/ddrr.62

Taylor, A.M. (2012). Neuropsychological evaluation and management of sport-related concussion. *Current Opinion in Pediatrics, 24*, 717-723.

Wiebe, D.J., Collins, M.W., & Nance, M.L. (2012). Identification and validation of prognostic criteria for persistence of mild traumatic brain injury-related impairment in the pediatric patient. *Pediatric Emergency Care, 28*(6). 498-502.

Additional Reading

Kaye, A.J., Gallagher, R., Callahan, J.M., & Nance, M.L. (2010). Mild traumatic brain injury in the pediatric population: The role of the pediatrician in routine follow-up. *The Journal of Trauma Injury, Infection and Critical Care 68*(6), 1396-1400. doi:10.1097/TA.obo13e3181cf7d1b