Advances in Pediatrics 61 (2014) 271–286

ADVANCES IN PEDIATRICS

Management of Pediatric Mild Traumatic Brain Injury

Robert C. Caskey, MD, MSc[a], Michael L. Nance, MD[b,*]

[a]Department of Surgery, University of Pennsylvania School of Medicine, 3400 Spruce Street, Philadelphia, PA 19104, USA; [b]Department of Surgery, Children's Hospital of Pennsylvania, 34th and Civic Center Boulevard, Philadelphia, PA 19104, USA

Keywords

• Mild traumatic brain injury • Concussion • Second impact syndrome
• Neuropsychological testing • Return to play protocol • Return to learn protocol

Key points

- Mild traumatic brain injury (mTBI), which includes both concussive and subconcussive injuries, is very common and underdiagnosed in the pediatric population.
- In mTBI, the primary injury results from acceleration-deceleration and/or rotational forces on the brain (not necessarily a blow to the head). The hallmark is a metabolic mismatch which, if not treated appropriately, may result in a delay in recovery or further injury to the brain.
- mTBI is a clinical diagnosis. Imaging studies are used to rule out the presence of a more significant traumatic brain injury (TBI) (eg, intracranial hemorrhage) only when suspected.
- The treatment of mTBI is centered on the prevention of secondary brain injury through both cognitive and physical rest.
- Sports-related injuries remain a significant and underdiagnosed cause of pediatric mTBI.
- There have been many important advances in mTBI since the previous article on this topic, most notably:
  - Consensus Statements of the Third and Fourth International Conferences on Concussion in Sport (2008 and 2012).
  - Validated prediction rules for cranial computed tomography following pediatric TBI.
  - Pediatric-specific (ages 5–12 years) neuropsychological testing is now available, but has yet to be thoroughly researched.
  - Adoption of Return to Learn and Return to Play algorithms.

*Corresponding author. *E-mail address*: nance@email.chop.edu

0065-3101/14/$ – see front matter
http://dx.doi.org/10.1016/j.yapd.2014.03.006

INTRODUCTION

Head injuries remain the leading cause of both morbidity and mortality in children. With more than 700,000 reported pediatric head injuries occurring annually, and many more unreported, this represents a major pediatric health problem [1,2]. Fortunately, most head injuries in children are classified as mild traumatic brain injury (mTBI). Although there is no uniformly accepted definition in the literature, mTBIs essentially encompass both concussions and subconcussive injuries. Most children (approximately 85%) recover from these injuries uneventfully when treated appropriately. However, in some patients mTBIs can be associated with significant morbidity, including developmental and psychosocial delays in addition to long-term disability. Though very rare, death has been reported with mTBIs (second impact syndrome).

As with all injuries, prevention is the most powerful tool for combating mTBI. Once a mTBI occurs, however, management is centered on the prevention of secondary damage to the brain. Several important advances in the management of mTBI have occurred in the past 10 years, perhaps most notably a heightened awareness of these injuries and the importance of appropriate care and recovery. To this end, mTBI treatment strategies currently focus on cognitive and physical rest, exemplified by the Return to Learn and Return to Play protocols. Combined with improvements in the ability to identify pediatric mTBI, these strategies should lead to a significant decrease in the morbidity associated with this prevalent pediatric disease.

PATHOPHYSIOLOGY OF TRAUMATIC BRAIN INJURIES

Traumatic brain injury (TBI) can occur any time that acceleration-deceleration and/or rotational forces are applied to the head. These forces can be applied through direct impact, such as occurs in sports-related injuries, or without direct impact, such as when rotational forces are applied to the head during a motor vehicle crash. Because of their anatomy, pediatric patients are particularly susceptible to TBI [3]. Children's heads are disproportionately larger and heavier than those of adults, and their skulls are more compliant. Children also have weaker neck muscles and, most importantly, their neurons are less myelinated. Therefore, the pediatric brain is not only more likely to sustain greater shearing forces when a force is applied but also, because of the decreased myelination, is more prone to axonal damage [3,4].

The mechanism of injury is a key factor in determining the severity of the TBI. In pediatric patients, the most common mechanism responsible for TBI occurs in an age-dependent manner. Within the age group 0 to 4 years old falls are the most common mechanism, whereas motor vehicle crashes are the most common cause of TBI in the 14- to 19-year-old group [1]. Sports-related head injuries, another common mechanism, increase with age as the child becomes old enough to participate in sports, especially contact sports, and are reported to peak in the 10- to 14-year age group. However, this may represent underreporting in athletes of high school age [4]. Finally, in any child presenting with a