Evaluation and Management of Concussion in Young Athletes

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Learning about concussion diagnosis and management is important for all individuals who will be taking care of young athletes. There are about 1.7 million reported concussions per year, and, of these, about 20% are sports related. There are risks in all sports, but the highest rates of concussions are from football, rugby, and hockey, with soccer being the highest cause for girls. An on-field assessment includes evaluating airway, breathing, and circulation, followed by cervical spine assessment. Then, concussion evaluation tools can be used to aid in making the diagnosis. While concussion symptoms for the majority of youth resolve within a few weeks, some individuals may have persistence of symptoms for 3 months or more, referred to as postconcussive syndrome. Providers should consider ongoing symptoms in assessing when an athlete may safely return to sports and to learning. A major concern that has become more apparent in recent years is the possibility that concussions may have a longitudinal effect on health, such as in the development of chronic traumatic encephalopathy. Research has shown that there is an increase in the number of patients presenting to their primary care physician with concussions. Knowing how best to prevent, diagnose, and manage concussions will help to minimize risks to young athletes.

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Introduction

There are reported to be approximately 300,000 cases per year of mild traumatic brain injury (mTBI), or brain concussion, from contact sports in the United States.[1] Even before having the name "concussion", this was a known entity in athletes who had taken repeated blows to the head. A 1928 article published in the Journal of the American Medical Association describes what was previously known as being "punch drunk" in boxers. Fans described these fighters as " 'cuckoo', 'goofy', 'cutting paper dolls', or 'slug nutty'." The article went on to mention that a sports writer had consulted top neurologists who said that the condition did not exist and that the description of being "punch drunk" was an exaggeration.[2] Clearly, much more is now known about concussions and the symptoms and sequelae that come with them. Learning about concussion diagnosis and management is important for all individuals who will be taking care of youth involved in sports.

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Definition

The Concussion in Sport Group has met at an International Conference on Concussion in Sport five times since 2001, the most recent meeting being in October 2016.[3] At these meetings, the attendees discuss epidemiology, basic and clinical science, grading systems, cognitive assessment, research methods, protective equipment, management, prevention, and long-term outcomes of concussions. The consensus statement from the Fifth International Conference in 2016 presents the definition of concussion as:

> *"Sport related concussion [SRC] is a traumatic brain injury induced by biomechanical forces. Several common features that may be utilized in clinically defining the nature of a concussive head injury include:*

- *SRC may be caused either by a direct blow to the head, face, neck, or elsewhere on the body with an impulsive force transmitted to the head.*
- *SRC typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, signs and symptoms evolve over a number of minutes to hours.*
- *SRC may result in neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury, and as such, no abnormality is seen on standard structural neuroimaging studies.*

- *SRC results in a range of clinical signs and symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive features typically follows a sequential course. However, in some cases symptoms may be prolonged.*

  The clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc.) or other comorbidities (e.g., psychological factors or coexisting medical conditions)." [3]

Pathophysiology

A concussion occurs due to acceleration−deceleration and rotational forces. The pathophysiology of a concussion, which has been studied in animal models, consists of a disruption of the neuronal membrane, resulting in potassium efflux to the extracellular space, leading to release of glutamate. Glutamate then causes further potassium efflux, leading to depolarization and suppression of neuronal activity. There then follows an increase in activity of the sodium−potassium pump, which results in excessive adenosine triphosphate consumption and glucose utilization. Lactate then accumulates and cerebral blood flow decreases. Calcium also builds up in cells, which may interfere with oxidative metabolism.[4] There is acute axonal and astroglial damage.

There have been many studies looking at diagnostic and prognostic uses of biomarkers in those who have had a concussion. A systematic review revealed that 99 different biomarkers have been assessed in over 49 different human studies.[5] However, the clinical use of any of these is still being investigated. A study by Shahim et al from 2014 discusses blood biomarkers that may be used both to diagnose concussions as well as to determine when athletes are ready for return to play.[6] Total tau (T-tau) is one marker of axonal injury that was studied in a population of ice hockey players. T-tau was found to be increased in players that had suffered a concussion. The highest concentration was right after the injury, followed by a decline in the first twelve hours, which was then followed by a second peak between twelve and thirty-six hours. The concentration of T-tau one hour after concussion predicted the number of days of recovery, and the study reported that by the time the players had returned to unrestricted activity, the T-tau levels had normalized.[6] As it may not always be feasible to measure the biomarkers one hour after concussion, there was also an evaluation at 144 h post-concussion. This evaluation found T-tau significantly elevated in the players that had post-concussion symptoms at the six day point versus those that had post-concussion symptoms lasting less than six days, as well as versus T-tau levels after a friendly game in which no head injuries had occured.[6] Another study looked at the glial and neuronal blood biomarkers of glial fibrillary acidic protein (GFAP) and ubiquitin C-terminal hydrolase L1 (UCH-L1) and their use in diagnosing mild to moderate traumatic brain injury.[7] It was previously known that both of these are elevated in the serum one hour after a mild traumatic brain injury. This study further examined the time course of the elevations and found that GFAP reached a peak at 20 h after injury, decreased over the next 72 h, and was still found in the blood at 7 days. UCH-L1 peaked at 8 h and then decreased quickly over the next 48 h.[7] However, while studies of biomarkers show promise for future management of concussions, most biomarker measurements are not yet routinely available in clinical practice and remain generally limited to research studies.

Epidemiology

Concussions in youth sports are often underreported due to fear of not being able to play or for lack of recognition of concussion symptoms.[8] The Centers for Disease Control and Prevention (CDC) says that 20% of the 1.7 million (reported) concussions per year are sports-related.[8] The majority of these are in children and adolescents because of the large numbers of individuals in these age groups involved in school and community sports. It is reported that 8.9% of sports-related injuries in high school athletes and 5.8% in college athletes are concussions.[4,8] Girls are affected more than boys. This may possibly be attributed to differences in anatomy, in that girls have weaker neck muscles and a smaller head mass, or it may be due to boys being more hesitant to report symptoms in order to avoid being removed from play. Football, rugby, and hockey have the highest number of reported concussions. For girls, soccer is the sport with the highest reported rate of concussions.[4,8]