Concussion: A Primer for the Physician

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Concussions have garnered much attention in recent years and are recognized as having far reaching and potentially permanent consequences. They often cause significant and sustained neuropsychological impairments in information-processing speed, problem solving, planning, and memory, and these impairments are worse with multiple concussions.[1] This is best demonstrated in athletes, a population of patients at greatest risk for repeated head injuries. In fact, concussions are the most common head injury sustained by athletes; 8.9% of all high school sports injuries reported are concussions and account for 19% of all non-fatal injuries in football.[2] The incidence of concussion among American teen athletes has grown from 300,000 incidents annually 10 years ago to upward of three million cases now. The increase is likely due to the increased awareness by the sports community, leading to greater recognition and reporting. It is unclear if changes in rules and protective equipment has changed incidence.

Nonetheless, these figures underestimate the frequency of concussions, as those with minor head injuries are often unlikely to seek care. In a survey by the Associated Press in 2009,[3] it was found that at the professional level, nearly one-fifth of 160 NFL players had hidden or downplayed the effects of their concussions. Athletes fear being removed from play and letting teammates down. Coaches, sideline personnel, and athletes themselves often do not recognize their own symptoms as a concussion. According to a McGill University study, 70.4% of athletes surveyed retrospectively reported experiencing the symptoms of a concussion during the past year, but only 23.4% realized that they had sustained a concussion in real time.[4] The study also found that 84.6% of athletes with a concussion had actually experienced more than one concussion. Part of the dilemma in diagnosing concussions is that the definition itself has been evolving. At this time, the most accepted definition of concussion is a clinical one, introduced in 2001.[5]

> Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury constructs that may be utilized in defining the nature of a concussive head injury include:
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> 1. Concussion 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.
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> 2. Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously.
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> 3. Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.
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> 4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however, it is important to note that, in a small percentage of cases, post-concussive symptoms may be prolonged.
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> 5. No abnormality on standard structural neuroimaging studies is seen in concussion.

Contrary to popular belief, loss of consciousness is not required for the diagnosis of a concussion. In fact fewer than 10% of concussions include a loss of consciousness.

Post-concussive syndrome, a constellation of symptoms seen after a head injury, is defined by the World Health Organization as starting at 3 months after the injury. Until this time, symptoms reported by the athlete are referred to as "concussive symptoms."[6]

SEQUELAE

The most feared complication of a concussion is second impact syndrome. This rare condition occurs when a second impact is sustained before the brain has recovered from the first concussion. This has only been reported in children and can be catastrophic. Those who survive are often left permanently disabled. By 2003, 21 deaths had been attributed to second impact syndrome.[7]

Psychiatric sequelae of mild traumatic brain injury include dementia, depression, and early onset of Alzheimer's and other memory-related diseases.[8] A 2005 UNC Chapel Hill survey of 2,550 retired professional football players found that 61% had experienced at least one concussion during their career, with 24% experiencing at least 3 concussions, and that this population had a significantly earlier onset of Alzheimer's disease than the general male population.[8] Another survey of 1,063 retired NFL players found that 6.1% of players age 50 and older had been diagnosed with a dementia-related condition, while age matched controls had a rate of 1.2%. They also found that younger players (30 to 49 years) had a rate of 1.9%, 19 times the age matched control rate of 0.1%.[9]

The neuropsychological effects of sports-related concussion have been extensively documented.[6] A study comparing cognitive function and post-concussive symptoms between 183 college athletes with concussions and age-matched control subjects found impaired performance and increased headaches, concentration difficulties, and behavioral problems in the injured group. Furthermore, in a study of boxers, 100% of those studied were found to have impaired concentration, attention, and memory. The degree of cognitive dysfunction was proportional to the boxer's sparring exposure, a finding that supports the concept that multiple concussions have a cumulative adverse effect on cognitive function.[10] Athletes who suffered multiple concussions were found to perform more poorly on neuropsychological tests and were more likely to have prolonged learning difficulties than those with a single or no history of concussion.

Another postulated long-term consequence of mild traumatic brain injury is Chronic Traumatic Encephalopathy (CTE), a disease that develops as a result of multiple concussions and subconcussive blows to the head. It is associated with personality changes, memory impairment, parkinsonism, and speech and gait abnormalities. First described in 1928, it was believed to be a disease that affected only boxers but is now believed to affect a much larger population of contact athletes, military personnel, and others who sustain multiple minor brain traumas.[11]

The result of concussions is cumulative. The forces required to sustain a subsequent concussion need not be as great as those that result in an initial concussion, a finding that persists even after complete recovery. Extrapolating these long-term consequences from the NFL to the college, high school, and Pop Warner athlete is cause for concern. Early identification and proper treatment can help reduce the numbers of some of these complications and educates the athlete on the risks of head injury while playing sports.

PATHOPHYSIOLOGY

Concussions have been recognized to result from a confluence of head acceleration, sheer force, and rotational deformity.[6] The signs and symptoms of concussion are related to a metabolic dysfunction in the inferior parietal, prefrontal, and cingulate cortex. Decreased cerebral blood flow, hypermetabolic state with increases in glycolysis, glutamate-induced excitotoxicity, and abnormal cellular ionic fluxes occurring after a concussion all contribute to the dysfunction.[12] Because a concussion is a functional disturbance rather than a structural one, there are no gross changes on CT and MRI.

DIAGNOSIS AND MANAGEMENT

Acutely, a thorough neurologic exam should be done either on the sideline, in the Emergency Department, or in the primary care office. The history should probe the presence and severity of symptoms commonly seen in concussion, as well as eliciting a brief history of prior head injuries. Symptoms of a concussion usually fall in one or more of six categories: cognitive, physical, emotional, balance and vestibular, visual, and sleep.[6]

The cohort of patients that requires urgent neurologic imaging is not well defined. From the sideline, patients with a concerning physical exam or deteriorating neurologic status should be emergently transported to the Emergency Department. The goal of imaging is not to diagnose a concussion, but rather to exclude more life-threatening brain injuries, including skull fractures, intracranial hemorrhage and parenchymal contusion. The American College of Emergency Physicians has published guidelines to help identify those patients who require imaging after sustaining a blunt head injury. (http://www.acep.org/Clinical---Practice-Management/Revised-Clinical-Policy--Neuroimaging-and-Decisionmaking-in-Adult-Mild-TBI-in-Acute-Settings/)

The management of concussions continues to evolve. To date, there are over 70 definitions and grading scales for concussion, all of which have fallen out of favor. Nevertheless, the initial goal of concussion management is to protect the brain and reduce brain vulnerability. To that end, any athlete who sustains a concussion should not be allowed back on the field the same day. Based on their symptom score and threshold, instructions should recommend individualized programs of physical and cognitive rest, as well as reduced visual stimulation to hasten recovery. Given the natural pathophysiology of concussions, symptoms can worsen within the first 24-48 hours; therefore, the athlete should not be allowed to return to the field and should be observed during this time.[6]

Balance testing (such as Balanced Error Scoring System testing) and computerized neurocognitive testing have been found to be helpful adjuncts in managing the patient with a concussion.[13] For both, baseline testing plays an important role in offering a personalized point of comparison, similar to a baseline EKG. In general, computerized neuropsychological assessment employs a 30-minute online module that includes a symptom checklist and tests of memory, speed and processing time. When a baseline test is available, it can be used as a tool to guide the clinician in deciding when it is safe for a patient to return to activity. However, the computerized testing cannot serve as a substitute for a medical evaluation and is not a stand-alone assessment program.

Once the athlete is asymptomatic and clinical examination, balance and neurocognitive test scores normalize, he or she may be considered for physical reintegration. This involves a graded return to play as described in the Prague/Zurich guidelines.[14] The student athlete represents a special population that also requires cognitive reintegration. No guidelines exist regarding cognitive reintegration and often this is done in collaboration with the athlete, the parents, and the school.

THE LAW

Inspired by Zackery Lystedt, in 2011, Rhode Island, along with all of the other states, enacted a youth sports concussion-related law. While the details vary slightly from state to state, the goal of the law is to treat our high school athletes as formally and aggressively as we do our professional athletes. Patients who will be putting themselves at risk for another head injury, i.e. athletes, require documentation stating that they have recovered from their concussion. Optimally, evaluation and return to learn and play decisions should be managed by an individual with experience in managing sports-related concussions.

In June 2014, the law was expanded requiring school nurses to obtain education regarding the signs and symptoms of a concussion. Because cognitive activity can exacerbate the symptoms of a concussion, school nurses are poised to identify those who have a delayed presentation of their concussion.

For further information, visit the Heads Up program website, an online resource developed by the CDC to help educate medical professionals, coaches and parents about concussions: http://www.cdc.gov/concussion/HeadsUp/youth.html.

FUTURE DIRECTION

The area of concussion research has exploded in Rhode Island and nationally. Please refer to the May 2014 RIMJ to find out about projects being conducted in Rhode Island, available at: http://www.rimed.org/rimedicaljournal/2014/05/2014-05.pdf

Graded return to play protocol: from "Consensus statement on concussion in sport: the 3rd International Conference on Concussion in Sport."[14]

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity	Complete physical and cognitive rest.	Recovery
2.Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity < 70% MPHR No resistance training.	Increase HR
3.Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities.	Add movement
4.Non-contact training drills	Progression to more complex training drills e,g. passing drills in football and ice hockey. May start load progressive resistance training)	Exercise, coordination, and cognitive
5.Full contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6.Return to play	Normal game play	

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