Concussion in Sports: Minimizing the Risk for Complications

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Mild traumatic brain injury, or concussion, is a common consequence of collisions, falls and other forms of contact in sports. Concussion may be defined as an acute trauma-induced alteration of mental function lasting fewer than 24 hours, with or without preceding loss of consciousness. The physician's responsibilities in assessing an athlete with concussion include determining the need for emergency intervention and offering guidance about the athlete's ability to return to play. Concussion may be complicated by cerebral edema related to the second impact syndrome, cumulative neuropsychologic deficits, intracranial bleeding or the postconcussion syndrome. The risk of complications is increased in athletes who prematurely return to play and in those with prolonged loss of consciousness or post-traumatic amnesia. An athlete with prolonged loss of consciousness or signs and symptoms that worsen or persist after a concussion should be evaluated in the emergency department. An athlete should not be allowed to resume sports participation until all symptoms of a concussion have resolved. (Am Fam Physician 2001;64:1007-14.)

See editorial on page 938.

Participation in contact sports, including football, ice hockey, soccer, boxing, lacrosse, wrestling and basketball, carries a risk of mild traumatic brain injury, or concussion. The risk of concussion is also increased in other sports and activities, such as gymnastics, skiing, sledding, ice skating, rollerblading and horseback riding. In football alone, an estimated 10 percent of college players and 20 percent of high school players sustain brain injuries each season.[1]

Concussion in an athlete may go untreated because few symptoms are visible to casual observers. In addition, an athlete may experience considerable emotional pressure to resume sports participation. This pressure can come from spectators, coaches and the sports media, as well as the athlete's own desire to take part in the sport.

Multiple concussions over months or years may result in cumulative neuropsychologic deficits.[2] Repeated concussions over a short period may lead to the second impact syndrome. In this syndrome, a concussion sustained while an athlete is still symptomatic from an earlier concussion results in progressive cerebral edema.[3,4]

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Increased awareness of the potential for complications, including cumulative neuropsychologic effects and the second impact syndrome, in athletes with concussion has resulted in the development of guidelines for the assessment and management of mild traumatic brain injury in sports.[5-7] If physicians are aware of the symptoms and potential complications of concussion, as well as the recommendations for management and prevention of this injury, they can do much to limit disabling problems in athletes at all levels of play.

Definitions and Diagnosis

The usual sign of traumatic brain injury in sports is an acute alteration in mental status that may or may not involve loss of consciousness after the traumatic event. The severity of the injury is determined according to measures that include the presence and duration of both loss of consciousness and post-traumatic amnesia *(Table 1)*.[5-7] Conventionally, brain injuries are classified as mild,

TABLE 1
Concussion Grading Scales

	Concussion grades and definitions		
Guideline	*1*	*2*	*3*
Cantu[5]	No loss of consciousness Post-traumatic amnesia for fewer than 30 minutes	Loss of consciousness for fewer than 5 minutes Post-traumatic amnesia for more than 30 minutes	Loss of consciousness for more than 5 minutes Post-traumatic amnesia for more than 24 hours
Colorado Medical Society[6]	No loss of consciousness No post-traumatic amnesia Confusion	No loss of consciousness Post-traumatic amnesia Confusion	Loss of consciousness of any duration
American Academy of Neurology[7]	No loss of consciousness Concussion symptoms for fewer than 15 minutes	No loss of consciousness Concussion symptoms for more than 15 minutes	Loss of consciousness of any duration

Information from references 5, 6 and 7.

moderate or severe, based on these measures. Assessment of the severity of the brain injury facilitates determination of the prognosis for recovery, as well as management of the injury.

Mild traumatic brain injury has been defined as head trauma with loss of consciousness, if any, lasting fewer than 30 minutes and post-traumatic amnesia lasting fewer than 24 hours.[8] The term "concussion" is often used in the medical literature as a synonym for a mild traumatic brain injury. If a concussion is managed appropriately, the prognosis for complete recovery is good.[9]

The hallmarks of concussion are confusion and amnesia, often without preceding loss of consciousness.[7] The amnesia generally involves loss of memory for the traumatic event but frequently includes loss of recall for events immediately before or after the head trauma. An athlete with amnesia may be unable to recall details about recent plays in the game or details of well-known current events in the news. Amnesia also may be evidenced by an athlete repeatedly asking a question that has already been answered.

Signs and symptoms of a concussion may immediately follow the head trauma or evolve gradually over several minutes to hours.[10] Early symptoms may include headache, dizziness, nausea or vomiting, slurred or incoherent speech, and imbalance or incoordination. Signs of confusion may include a vacant stare, disorientation, delayed ability to follow instructions or answer questions, and poor concentration or attention. Signs of disorientation include a loss of sense of time or place. For example, signs would be evident in a dazed-appearing athlete walking in the wrong direction on the playing field.

Early symptoms of concussion may include headache, dizziness, nausea or vomiting, slurred or incoherent speech, and imbalance or incoordination.

Occasionally, associated transient cortical neurologic deficits, such as global amnesia or cortical blindness, can occur. These deficits are thought to be secondary to vascular hyperreactivity and may be trauma-induced, migraine-equivalent phenomena.[11-13]

Pathologic Features

Axonal shear injury is the primary pathologic feature of traumatic brain injury in all levels of severity.[14] The extent of axonal injury is suggested by the duration of loss of consciousness and post-traumatic amnesia.[9]

With uncomplicated brain concussion, limited structural axonal injury may be present but not evident on diagnostic computed tomographic (CT) scanning or magnetic resonance imaging (MRI). However, concussion can be complicated by coexistent cortical contusions and the development of intracranial hemorrhage.

Brain contusions are areas of bruising with associated localized ischemia, edema and mass effect.[15] They result from direct external con-

TABLE 2
Management of First Concussion Based on Grade

	*Concussion grades and management recommendations**		
Guideline	*1*	*2*	*3*
Cantu[5]	Athlete may return to play if asymptomatic for one week (if athlete is totally asymptomatic, return to play on same day may be considered).	Athlete may return to play if asymptomatic for one week.	Athlete may not return to play for at least one month; athlete may then return to play if asymptomatic for one week.
Colorado Medical Society[6]	Athlete may return to play if asymptomatic for 20 minutes.	Athlete may return to play if asymptomatic for one week.	Athlete should be transported to a hospital emergency department; athlete may return to play one month after injury if asymptomatic for two weeks.
American Academy of Neurology[7]	Athlete may return to play if asymptomatic for 15 minutes.	Athlete may return to play if asymptomatic for one week.	Athlete should be transported to a hospital emergency department; if athlete had brief loss of consciousness (i.e., seconds), may return to play when asymptomatic for one week; if athlete had prolonged loss of consciousness (i.e., minutes), may return to play when asymptomatic for two weeks.

**—In each guideline, "asymptomatic" means that the athlete with a concussion has no somatic, behavioral or cognitive symptoms at rest or with exertion.*

Information from references 5, 6 and 7.

tact forces or from the brain being slapped against intracranial surfaces with acceleration/deceleration trauma. Signs of cortical contusions vary based on their location within the brain but may include weakness, numbness or incoordination relating to the extremities, and difficulties with speech, memory, thought processes and behavioral or emotional control. Brain contusions may delay recovery from a concussion.

Intracranial hemorrhage is another possible complication of concussion. Neurologic deterioration subsequent to a concussion is highly suggestive of an evolving intracranial hematoma. Signs include worsening headache, confusion and lethargy, which may progress to loss of consciousness or even death. It is estimated that before neurologic deterioration, 20 to 50 percent of persons with epidural hemorrhage have a "lucid interval" following a brief loss of consciousness or period of confusion.[16] Epidural hemorrhage presents acutely or subacutely, and usually occurs secondary to the tearing of a middle meningeal artery.

Subdural hemorrhage occurs when trauma results in the tearing of bridging veins or dura. The presentation may be acute, subacute or chronic. Chronic subdural hematomas can present months or even years after seemingly trivial head injury.[16] Subarachnoid hemorrhage results from bleeding into the cerebrospinal fluid cisterns from torn small blood vessels.

In addition to brain concussion, head trauma may result in injuries to other parts of the head or neck, including skull or facial bone fractures, spine or spinal cord injuries, eye injuries, and damage to major blood vessels within the neck. A skull fracture may be accompanied by underlying pathologic findings, including brain contusions, dural tears and vascular trauma.[17]

Guidelines on Management

Many guidelines have been published to assist physicians in determining the readiness of athletes to return to play after a concussion. Three of the most popular guidelines are summarized in *Tables 1, 2 and 3*.[5-7] The Cantu guidelines (1986)[5] have been adopted by the American College of Sports Medicine, and the Colorado Medical Society guidelines (1991)[6] have been adopted by the National Collegiate Athletic Association. Most recently (1997), the American Academy of Neurology published guidelines[7] for the grading and management of concussion in athletes.

Essentially, these guidelines divide concussion into three grades of severity and provide recommendations regarding return to play based on the grade and number of concus-

TABLE 3
Management of Multiple Concussions Based on Grade

		Concussion grades and management recommendations		
Guideline	*Frequency**	*1*	*2*	*3*
Cantu[5]	Second concussion	Athlete may return to play in two weeks if asymptomatic for one week.	Athlete may not return to play for at least one month; athlete may then return to play if asymptomatic for one week.	Terminate season.
	Third concussion	Terminate season.	Terminate season.	
Colorado Medical Society[6]	Second concussion	Athlete may return to play if asymptomatic for one week.	Athlete may return to play if asymptomatic for one month.	Terminate season.
	Third concussion	Terminate season.	Terminate season.	
American Academy of Neurology[7]	Second concussion	Athlete may return to play if asymptomatic for one week.	Athlete may return to play if asymptomatic for two weeks.	Athlete may return to play if asymptomatic for one month or longer.
	Third concussion	No recommendation	No recommendation	No recommendation

**—Number of concussions occurring in the same season.*

Information from references 5, 6 and 7.

sions in a season. All three guidelines remain controversial, but they do promote the use of uniform terminology. Furthermore, they all agree that athletes suspected of having a concussion should be removed from sports participation immediately, and that athletes should not return to play while signs or symptoms of concussion are present at rest or with exercise.

The guidelines also agree that athletes who have symptoms of concussion lasting more than 15 minutes or who have post-traumatic amnesia should not be permitted to resume sports participation for at least one week. In addition, athletes who suffer loss of consciousness should not be allowed to return to play until they have been asymptomatic at rest or with exertion for a minimum of one week. The more current guidelines recommend an emergency department evaluation for any athlete who suffers loss of consciousness.[6,7]

The guidelines differ regarding the management of a second or third concussion of the same grade in an athlete. Finally, none of the guidelines offers recommendations on return to play for athletes who have sustained serial concussions of various grades.

The physician must carefully assess and reassess every athlete with a concussion. No athlete should be permitted to return to play while signs or symptoms of a concussion are present. The final decision regarding return to play should be based on the clinical judgment of the treating physician. The similarities in management recommendations given in the available guidelines may assist the physician in making this decision.

Acute Evaluation of Concussion

In 1999, the American Academy of Pediatrics (AAP) and the American Academy of Family Physicians (AAFP) developed a practice parameter for the evaluation and management of acute minor closed head injury in children and adolescents (two to 20 years of age).[18] The AAP/AAFP algorithm *(Figure 1)*[18] also pertains to the evaluation of concussion in athletes.

The AAP/AAFP practice parameter[18] defines patients with minor closed head injury as those who were previously neurologically healthy and have normal mental status on presentation, no abnormal or focal findings on neurologic examination and no physical

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Athletes who suffer loss of consciousness should not be allowed to return to play until they have been asymptomatic at rest or with exertion for a minimum of one week.

evidence of a skull fracture. Thus, the initial assessment of a closed head injury should include mental status testing, a thorough neurologic examination (including funduscopy) and an evaluation for physical signs of a skull fracture (e.g., hematotympanum, Battle's sign or palpable depression).

In addition, the AAP/AAFP practice parameter[18] addresses the evaluation and management of children and adolescents who meet criteria for a minor closed head injury at the time of initial evaluation but who also may have experienced observed loss of consciousness for less than one minute or a seizure at the time of injury, and those who may have exhibited signs and symptoms (e.g., headache, lethargy or vomiting) before evaluation.

The following paragraphs discuss the AAP/AAFP algorithm for the evaluation and management of children and adolescents with minor closed head injury, as well as the workup of those who fall outside the AAP/AAFP definition but have signs and symptoms consistent with the clinical spectrum of concussion.

The risk of subsequent neurologic deterioration is low in previously healthy children and adolescents who appear neurologically normal after a closed head injury with loss of consciousness, if any, lasting less than one minute. In these instances, the AAP/AAFP practice parameter[18] recommends a period of observation by a competent observer in the home, clinic, office or emergency department.

Children and adolescents with nonspecific signs such as headache, vomiting or lethargy, as well as those who may have experienced loss of consciousness or an impact seizure, may be more likely to have intracranial injury than those without such signs.[18] CT scanning of the brain, along with observation, is another management option in patients with minor closed head injury and brief loss of consciousness (less than one minute). The assessment should include a brain CT scan if a patient has more than "brief" loss of consciousness or has persistent confusion, lethargy, amnesia or focal neurologic signs.[19]

Brain CT scanning is the imaging modality of choice for the assessment of acute head trauma to determine the presence of intracranial injury or bleeding that may warrant neurosurgical intervention.[18] Skull radiography may assist the physician only in defining the risk for intracranial injury: skull fracture may be detected in the absence of intracranial injury, and intracranial injury may be present in the absence of skull fracture.

Neurologically normal patients with a normal CT scan are at low risk for subsequent neurologic deterioration.[18,19] In these instances, the AAP/AAFP practice parameter[18] suggests that a patient may be discharged from the hospital if a reliable observer is available to monitor the patient's clinical condition in the home over an appropriate period of time. If the brain CT scan reveals abnormalities, proper disposition of the patient depends on a thorough consideration of the abnormalities and, if warranted, consultation with a neurologist or neurosurgeon.

Intracranial bleeding or evolving cerebral edema associated with brain contusions may account for progressive deterioration of neurologic function from the time the patient with head trauma is first evaluated by paramedics or a physician. If a patient's condition deteriorates during observation, a thorough neurologic examination should be performed, and immediate brain CT scanning should be performed once the patient's condition has been stabilized.[18] If a repeat brain CT scan indicates new intracranial pathologic findings, consultation with appropriate subspecialists should be obtained.

A brain CT scan is also useful in evaluating patients who are having seizures after head trauma. Seizures at the scene of the traumatic event or in the emergency department can be related to physiologic or structural brain injury. The incidence of immediate post-traumatic seizures is greatest in the pediatric population,[20] but the overall lifetime risk of developing epilepsy after a concussion is low.[21] Seizures that occur within the first week after

FIGURE 1.

FIGURE 1 *(continued)*

**—The AAP/AAFP practice parameter focuses on the management of previously neurologically healthy children and adolescents with minor closed head injury who present with normal mental status, have no abnormal or focal findings on neurologic examination (including funduscopy) and no evidence of skull fracture (e.g., hematotympanum, Battle's sign or palpable skull depression).*

†—Observation under the care of a competent observer, conducted in the home, clinic, office or emergency department, is recommended for children and adolescents with minor closed head injury and no loss of consciousness.

‡—Observation under the care of a competent observer, conducted in the home, clinic, office or emergency department, may be used to manage children and adolescents with minor closed head injury and loss of consciousness.

§—Brain CT scanning, along with observation, also may be used in the initial evaluation and management of children and adolescents with minor closed head injury and brief loss of consciousness.

‖—If imaging is desired by the physician, brain CT is the modality of choice. If CT scanning is not readily available, skull radiographs may help define the risk for intracranial injury.

¶—Although some studies have found magnetic resonance imaging (MRI) to be more sensitive than CT scanning in diagnosing certain intracranial lesions, the consensus of the AAP/AAFP subcommittee is that brain CT scans offer advantages over MRI studies (i.e., reduced cost, quicker and easier performance, no significant difference in findings) in the acute care of children and adolescents with minor closed head injury.

#—If the postinjury brain CT scan is normal, the patient may be discharged from the hospital for observation by a reliable observer. A decision for home observation should consider the time for return to the hospital and the reliability of the observer(s). Otherwise, depending on physician and patient preferences, observation may take place in the office, clinic, emergency department or hospital.

***—If brain CT scanning reveals abnormalities, proper disposition depends on thorough consideration of the CT findings and, when warranted, consultation with appropriate subspecialists.*

††—If the patient's neurologic condition worsens during observation, a thorough neurologic examination is performed, along with immediate brain CT scanning once the patient's condition has been stabilized. If the brain CT scan shows new intracranial abnormalities, consultation with an appropriate subspecialist is warranted.

trauma, intracerebral hematoma, brain contusions and depressed skull fractures may all increase the risk for post-traumatic epilepsy.[16]

Patients with normal brain CT scans but clinical abnormalities on neurologic examination or significant symptomatic complaints may have abnormalities on MRI of the brain. Compared with CT scanning, MRI is more sensitive in showing small areas of contusion or axonal shear injury, and it may be most sensitive if performed shortly after trauma.[22] Lesions found on MRI scans may resolve by three months after a concussion.[22]

Criteria for Hospital Admission

Hospital admission for further observation or treatment is indicated when an athlete has persistent confusion, lethargy, focal neurologic signs or abnormal findings on the brain CT scan, or when the clinical picture is confounded because of seizures.[17,19] Admission should also be considered if no responsible person is available at home to monitor the patient for progression of symptoms.

Observation

Observation is recommended for at least 24 hours after a concussion.[18,23] Factors such as the time and distance to reach appropriate care and the competency of the observer may influence where observation occurs. Home observation may be permitted for the patient whose neurologic condition is unlikely to deteriorate.[18,23] The observer should be given explicit and understandable instructions on patient monitoring, and on how and when to seek medical help *(Table 4)*.[23] The patient should be awakened from sleep every two hours and avoid should strenuous activity for at least 24 hours.

The Postconcussion Syndrome

Athletes may experience somatic, affective or cognitive symptoms that gradually taper in severity over days, weeks or even months after a concussion. The most common symptoms are headache and dizziness.[9] Other symptoms include blurred vision, neck pain, fatigue, problems sleeping, emotional or cognitive dis-

TABLE 4
Warning Signs to Seek Immediate Medical Help for a Patient with Concussion

Inability to awaken the patient	Vomiting, fever or stiff neck
Severe or worsening headaches	Urinary or bowel incontinence
Somnolence or confusion	Weakness or numbness involving any part of the body
Restlessness, unsteadiness or seizures	
Difficulties with vision	

Adapted with permission from Lawler KA, Terregino CA. Guidelines for evaluation and education of adult patients with mild traumatic brain injuries in an acute care hospital setting. J Head Trauma Rehabil 1996;11:18-28.

TABLE 5
Selected Web Sites for Information on Concussion and Its Prevention

American Academy of Neurology, http://www.aan.com
Brain Injury Association, Inc., http://www.biausa.org
Think First Foundation, http://www.thinkfirst.org
National Safe Kids Campaign, http://www.safekids.org

turbances, tinnitus, problems with balance or coordination, and loss of hearing, taste or smell. Postconcussion symptoms may result from brain injury or from trauma involving head and neck structures.[9]

Athletes with unilateral or multifocal brain lesions on CT or MRI scan may be more likely to have neuropsychologic symptoms after trauma.[15,22] Referral to a psychologist for neuropsychologic testing and treatment is indicated when an athlete is suspected of having neuropsychologic symptoms after a concussion.[24]

Brain imaging, if not previously performed, is indicated in the athlete with chronic headaches after a concussion. The athlete who is experiencing dizziness may be evaluated with audiologic testing, electronystagmography, a fistula test and/or posturography. These tests are used to help localize the source of dizziness to specific regions of the central or peripheral nervous system.[25]

Diagnosis of factors responsible for postconcussion symptoms is essential to appropriate management of an athlete who has sustained a concussion. Premature return to play by a symptomatic athlete places that athlete at greater risk for subsequent concussion and cumulative brain injury.[2,10,24]

Internet sources for additional information on concussion and its prevention are listed in *Table 5.*

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