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.)

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. 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.
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. 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.

The hallmarks of concussion are confusion and amnesia, often without preceding loss of consciousness. 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. Early symptoms may include headache, dizziness, nausea or vomiting, slurred or incoherent speech, and imbalance or incoordination.

Pathologic Features

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

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. They result from direct external con-
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-
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 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 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 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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### TABLE 3

**Management of Multiple Concussions Based on Grade**

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Frequency*</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cantu5</td>
<td>Second concussion</td>
<td>Athlete may return to play in two weeks if asymptomatic for one week.</td>
<td>Athlete may not return to play for at least one month; athlete may then return to play if asymptomatic for one week.</td>
<td>Terminate season.</td>
</tr>
<tr>
<td></td>
<td>Third concussion</td>
<td>Terminate season.</td>
<td>Terminate season.</td>
<td></td>
</tr>
<tr>
<td>Colorado Medical Society6</td>
<td>Second concussion</td>
<td>Athlete may return to play if asymptomatic for one week.</td>
<td>Athlete may return to play if asymptomatic for one month.</td>
<td>Terminate season.</td>
</tr>
<tr>
<td></td>
<td>Third concussion</td>
<td>Terminate season.</td>
<td>Terminate season.</td>
<td></td>
</tr>
<tr>
<td>American Academy of Neurology7</td>
<td>Second concussion</td>
<td>Athlete may return to play if asymptomatic for one week.</td>
<td>Athlete may return to play if asymptomatic for two weeks.</td>
<td>Athlete may return to play if asymptomatic for one month or longer.</td>
</tr>
<tr>
<td></td>
<td>Third concussion</td>
<td>No recommendation</td>
<td>No recommendation</td>
<td>No recommendation</td>
</tr>
</tbody>
</table>

*—Number of concussions occurring in the same season.

Information from references 5, 6 and 7.
Evidence of a skull fracture. Thus, the initial assessment of a closed head injury should include mental status testing, a thorough neurologic examination (including funduscop) 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 parameter18 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, 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 work-up 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 parameter18 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.18

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 parameter18 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
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trauma, intracerebral hematoma, brain contusions and depressed skull fractures may all increase the risk for post-traumatic epilepsy.\textsuperscript{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.\textsuperscript{22} 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.\textsuperscript{22} Lesions found on MRI scans may resolve by three months after a concussion.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{18,23} The observer should be given explicit and understandable instructions on patient monitoring, and on how and when to seek medical help (\textbf{Table 4}).\textsuperscript{23} The patient should be awakened from sleep every two hours and avoid 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.\textsuperscript{9} Other symptoms include blurred vision, neck pain, fatigue, problems sleeping, emotional or cognitive dis-

\begin{table}
\centering
\caption{Warning Signs to Seek Immediate Medical Help for a Patient with Concussion}
\begin{tabular}{ll}
\hline
\textbf{Inability to awaken the patient} & Vomiting, fever or stiff neck \\
\textbf{Severe or worsening headaches} & Urinary or bowel incontinence \\
\textbf{Somnolence or confusion} & Weakness or numbness involving any part of the body \\
\textbf{Restlessness, unsteadiness or seizures} & \\
\textbf{Difficulties with vision} & \\
\hline
\end{tabular}
\end{table}

\textsuperscript{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.}
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 post-concussion 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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REFERENCES