The information provided in this reference sheet is not evidence based. The updated guideline (in press) may present evidence that contradicts the information presented here.

Concussion is a brain injury caused by biomechanical forces and generally characterized by the rapid onset of a set of neurologic symptoms or cognitive impairment. The injury is typically self-limited and resolves spontaneously. Concussion commonly arises from sports injuries, which account for between 1.6 and 3.8 million concussions annually in the United States. Nearly nine percent of all US high school sports injuries involve concussions. A small percentage of concussions can be serious, leading to prolonged symptom course, significant morbidity, or even death. For more information on sports concussion and traumatic brain injury, refer to the December 2010 issue of *Continuum: Lifelong Learning in Neurology*.

Increasing media coverage and government regulation of concussion management have boosted public awareness of this prevalent and potentially serious condition. Clinicians thus are advised to learn about their states' laws concerning concussion management. Visit www.aan.com/go/about/sections/sports for information on concussion laws by state.

### Current Clinical Trends

The 1997 guideline provides a grading system for acute concussion symptoms. However, subsequent research suggests that this grading system does not predict long-term symptom occurrence or outcomes. Rather, it is important to treat concussion on a case-by-case basis, taking into account the unique circumstances of the affected individual and the injury event. Thus, clinicians should consider their clinical experience to be more valuable than a written protocol in their decision making. A multidisciplinary panel is currently updating the 1997 guideline and examining the best available evidence for concussion management.

The assessment of concussion is a complex process. However, assessing concussion in athletes poses particular challenges. Because many sports involve physical impact, the source of head injury in athletes is not always clear. In addition, accuracy of reporting varies from athlete to athlete. In the general population, patients typically report concussion accurately or overstate symptoms. However, athletes (or their coaches, teammates, or families) tend to underreport concussion symptoms. Sometimes concussion symptoms are downplayed so that the injured athlete may return to the game quickly. In other cases, the athlete is not aware of being concussed because signs and symptoms can be delayed for up to several days.

### Clinical Presentation

The signs and symptoms of concussion often begin immediately after or within minutes of the injury. These may worsen over minutes and even hours. In some cases, symptoms may not appear until the affected person undergoes significant physical or mental exertion. See Table 1 for common signs and symptoms of concussion.
clinician should advise general supportive care such as maintaining oral intake and sleeping liberally. Psychological counseling with the aim of cognitive restructuring also is encouraged. This may involve educating the athlete and family about the nature of the injury. It also may include reassuring them about both the prognosis and one of the few interventions proven to reduce the likelihood of developing chronic post-concussion syndrome.

Return-to-Play Decision Making

Before returning the athlete to participation, it is essential that the clinician be reasonably certain that the physiologic effects of the injury have subsided. Any preinjury objective data, if available, should be examined. Several tools are available as aids. In addition to a comprehensive neurologic history and examination, assessment tools to consider include the Sport Concussion Assessment Tool 2, Balance Error Scoring System, standardized symptom checklists, reaction time testing, and neuropsychological testing. Regardless of the tools used, it is important to remember that no tool be used as the sole determinant in decision making. Rather, tools optimally should be used in the context of a comprehensive concussion management program.

The clinician should ensure the following before returning the athlete to play:

- Performance on objective testing is normal
- Symptoms are absent even without medication use
- Examination is normal; patient is asymptomatic at rest and on exertion

The return to physical activity should occur in a gradual, well-defined manner, with activity levels escalated in a stepwise fashion. The final level should mimic game conditions as much as possible without risk of further head injury. It also is suggested that return-to-play guidelines be more conservative in younger athletes with concussion.

See Table 2 for a graduated return-to-play protocol.

<table>
<thead>
<tr>
<th>Rehabilitation Stage</th>
<th>Functional Exercise at Each Stage of Rehabilitation</th>
<th>Objective of Each Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) No activity</td>
<td>Complete physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>(2) Light aerobic exercise</td>
<td>Walking, swimming, stationary bike</td>
<td>Increase heart rate</td>
</tr>
<tr>
<td>(3) Sport-specific exercise</td>
<td>Running drills in soccer, skating drills in hockey, etc.</td>
<td>Add movement</td>
</tr>
<tr>
<td>(4) Noncontact drills</td>
<td>More complex training drills, may start resistance training</td>
<td>Coordination and cognitive load</td>
</tr>
<tr>
<td>(5) Full-contact practice</td>
<td>With medical clearance, participate in normal training activities</td>
<td>Restore confidence and assess functional skills by coaching staff</td>
</tr>
<tr>
<td>(6) Return to play</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
</table>


Neuroimaging

Traditional neuroimaging modalities typically do not reveal abnormalities from concussion caused by mild traumatic brain injury. However, emergent head CT is indicated in situations involving more serious signs and symptoms. Red flags include loss of consciousness, persistent or worsening alteration in mental status, severe or worsening headache, seizure, focal weakness/paralysis, and repeated vomiting. Although currently experimental, various imaging techniques such as diffusion tensor imaging and magnetic resonance spectroscopy play an increasing role in answering long-term questions.

Rare Complications and Long-term Effects

A very rare form of injury seen following critical concussion is malignant cerebral edema. This manifests as a significant first injury or a reinjury from a second impact. The latter type, known as second-impact syndrome (SIS), is a form of reinjury that happens before the previous concussion has completely resolved. The reinjury, often seemingly minor, can lead to devastating injury or death. Almost all suspected SIS cases to date have occurred in athletes under age 20, most of whom were 18 years or younger.

Contrary to conventional wisdom, the chronic cumulative effects of concussion can be many and serious in a subset of patients. Of particular concern is that repetitive concussion might be a risk factor for persistent cumulative cognitive problems or early-onset dementia.

Deciding When to Retire from Contact Sports

Given that each athlete is an individual with unique risks and concussions are heterogeneous injuries, any decision about when to retire from contact sports needs to be approached carefully, with consideration of the complete medical history. Certainly, any athlete who appears to be getting injured more easily; has a prolonged, complicated, or severe symptom course; or has any notable change in baseline cognitive function should be counseled to avoid further contact sport risk.

Table 2. Graduated Return-to-Play Protocol

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