Current Concepts in Concussion: Evaluation and Management

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Concussion is a disturbance in brain function caused by direct or indirect force to the head. It is a functional rather than structural injury that results from shear stress to brain tissue caused by rotational or angular forces—direct impact to the head is not required. Initial evaluation involves eliminating cervical spine injury and serious traumatic brain injury. Headache is the most common symptom of concussion, although a variety of clinical domains (e.g., somatic, cognitive, affective) can be affected. Signs and symptoms are nonspecific; therefore, a temporal relationship between an appropriate mechanism of injury and symptoms must be determined. There are numerous assessment tools to aid diagnosis, including symptom checklists, neuropsychological tests, postural stability tests, and sideline assessment tools. These tools are also used to monitor recovery. Cognitive and physical rest are the cornerstones of initial management. There are no specific treatments for concussion; therefore, focus is on managing symptoms and return to play. Because concussion recovery is variable, rigid classification systems have mostly been abandoned in favor of an individualized approach. A graded return-to-play protocol can be implemented once a patient has recovered in all affected domains. Children, adolescents, and those with a history of concussions may require a longer recovery period. There is limited research on the management of concussions in children and adolescents, but concern for potential consequences of injury to the developing brain suggests that a more conservative approach to management is appropriate in these patients. (*Am Fam Physician*. 2012;85(2):123-132. Copyright © 2012 American Academy of Family Physicians.)

ILLUSTRATION BY SCOTT BODELL

▶ **Patient information:** A handout on concussion, written by the authors of this article, is provided on page 137.

See related editorial on page 100.

Concussion is a disturbance in brain function caused by direct or indirect force to the head.[1] Terms such as concussion and mild traumatic brain injury are often used interchangeably.[2] Although there is no universal definition for concussion, the most recently proposed definition is provided in *Table 1*.[1]

Concussion is a common injury that has emerged as a major health care concern in the United States.[2-6] Emergency departments report more than 1 million visits annually for traumatic brain injuries, most of which are concussions.[2] However, this is likely underreported because many persons do not seek medical care for head injuries.[6-10] The incidence of sports-related concussions is estimated to be 1.6 to 3.8 million annually.[5,6,11-14] The danger associated with premature return to play and emerging evidence of long-term consequences of concussions have prompted state and national legislation for youth athletics.[15] The legislation has led to new guidelines, expansion of neuropsychological testing, and rule changes for sporting events. Consequently, management of concussions has changed significantly.

Concussion can be difficult to recognize, complicated by the lack of a universal definition. Additionally, there are no direct objective measures for diagnosis or recovery, no treatments with well-documented effectiveness,[14,16] and limited empiric prospective data to guide return-to-play decisions.[17-19] Clinical judgment, expert guidelines, and

SORT: KEY RECOMMENDATIONS FOR PRACTICE

Clinical recommendation	*Evidence rating*	*References*
Evaluation of a possible concussion should include a physical examination in addition to use of available concussion assessment tools.	C	1, 5, 8, 18
Imaging studies are sometimes used to rule out serious injuries, but are not indicated in the evaluation of uncomplicated concussion.	C	1, 2, 5, 8, 10, 12, 16, 21, 32
Complete cognitive and physical rest are key components in the initial management of concussion.	C	1, 9, 10, 12, 18, 20
After concussion symptoms resolve, postural stability testing should be performed to ensure complete recovery.	C	1, 5, 8, 10
Concussion should be managed based on the individual patient, with a graded return-to-play protocol.	C	1, 5, 8-10
After sustaining a concussion, athletes should not return to play until they have completely recovered.	C	1, 5, 8-10, 12, 18, 20
Medical treatment of concussion focuses on symptom management, including the same medications appropriate in patients without a concussion.	C	1, 5
Athletes should not return to play on the same day of sustaining a concussion.	C	1, 8, 10, 18
A more conservative approach, including a longer asymptomatic period before return to play, should be considered for the management of concussion in children.	C	1, 9, 18, 20
Protective gear has not been shown to reduce the incidence of concussion, but should be used to prevent other injuries.	C	1, 8, 10, 12, 33

A = consistent, good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to http://www.aafp.org/afpsort.xml.

Table 1. Definition of Concussion from the Third International Conference on Concussion in Sport

- A complex pathophysiologic process affecting the brain, induced by traumatic biomechanical forces
- Several common features that incorporate clinical, pathologic, and biomechanical injury constructs that may be used in defining the nature of a concussive head injury include the following:
  - Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head
  - Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously
  - Concussion may result in neuropathologic changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury
  - 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, postconcussive symptoms may be prolonged
  - No abnormality on standard structural neuroimaging studies is seen in concussion

Adapted with permission from McCrory P, Meeuwisse W, Johnston K, et al. Consensus statement on concussion in sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. J Athl Train. *2009;44(4):435.*

available assessment tools must be integrated to establish diagnosis and estimate recovery.[14]

Presentation

Concussion is a functional rather than structural injury that can affect somatic, cognitive, and affective domains.[1,8,10,20] Sleep disturbances are also common.[10,21] If any of these domains are impaired, concussion should be considered[1]; however, other conditions cause similar symptoms (e.g., heat illness, exertional migraines, sleep disorders).[9,10,16] To diagnose a concussion, a temporal relationship between an appropriate mechanism of injury and onset or worsening of symptoms must be established.[10]

Headache is the most common symptom of concussion.[9,14,22,23] Other common symptoms include dizziness, balance disturbances, and disorientation.[14,16,22-24] Loss of consciousness, once considered a hallmark of concussion, occurs in less than 10 percent of patients.[9,12,16,22] Selected symptoms of concussion are listed in *Table 2*.[5,8-10,12,16,19-21,23,25]

Classification

There is no consensus regarding classification of concussions.[2,9] Although numerous severity scales exist, none are validated scientifically.[12,26] Previous classification systems (e.g., Cantu, American Academy of Neurology) focused on loss of consciousness and amnesia; however, research has demonstrated that such markers do not

Table 2. Selected Symptoms of Concussion

Affective/emotional	**Sleep†**
Anxiety/nervousness*†	Decreased sleep
Clinginess	Difficulty initiating sleep
Depression†	Drowsiness*§
Emotional lability	Increased sleep*
Irritability*†	**Somatic/physical**
Personality changes	Blurred vision*§
Sadness	Convulsions
Cognitive	Dizziness/poor balance*‡§
Amnesia	Fatigue*†§
Confusion‡	Headache*†‡§
Delayed verbal and other responses	Light-headedness†
Difficulty concentrating*†§	Light sensitivity*†§
Difficulty remembering*†§	Nausea*‡§
Disorientation*†	Noise sensitivity*§
Feeling foggy*§	Numbness/tingling
Feeling slowed down*§	Tinnitus†
Feeling stunned	Vomiting‡
Inability to focus	
Loss of consciousness	
Slurred speech	
Vacant stare	

**—Common in self-report symptom checklists.*

†—American Academy of Neurology defines as a late symptom, lasting days to weeks.[21]

‡—American Academy of Neurology defines as an early symptom, lasting minutes to hours.[21]

§—Part of the 12-item Concussion Symptom Inventory, the only empirically derived symptom checklist.[19]

Information from references 5, 8 through 10, 12, 16, 19 through 21, 23, and 25.

accurately reflect concussion severity or recovery.[8-10,12,14,20] The International Conference on Concussion in Sport proposed classification based on simple versus complex presentations; however, this was applied retrospectively and therefore was not an acceptable guide to treatment.[1]

An ideal classification system would determine severity at the time of injury, provide prognostic information, and help guide return-to-play decisions. Because such a system does not exist, an individualized approach of monitoring symptoms to resolution is recommended, followed by a graded return-to-play strategy.[1,5,8,20]

Pathophysiology

Previously, most reported concussions were a result of falls or motor vehicle collisions.[2] Recent studies of younger populations suggest most concussions occur during sporting events,[4,26] with greatest risk during competitions.[3,9,20] Although there are no definitive data on whether males or females are at greater risk of concussions, different mechanisms of injury have been suggested. Males seem prone to concussion through player-to-player contact, whereas concussions in females tend to be caused by contact with the playing surface or equipment.[27]

Concussion is caused by rotational and angular forces to the brain, and direct impact to the head is not required.[9,10,12,20] Shear forces disrupt neural membranes, allowing potassium efflux into extracellular space. Resultant increases of calcium and excitatory amino acids are followed by further potassium efflux, leading to suppression of neuron activity.[8-10,12,20] As sodium-potassium pumps restore balance, there is increased energy requirement, yet a paradoxical decrease in cerebral blood flow. Disruptions of autonomic regulation can persist for several weeks, and the brain may be vulnerable to additional injury.[12,28]

Natural History

Symptoms of concussion typically present immediately after injury, but may be delayed several hours.[10,16,21] Concussion symptoms usually last less than 72 hours,[16] and most concussions resolve spontaneously within seven to 10 days.[1] Recovery may be prolonged in children, adolescents,[1,3,9,12,17] and those with previous concussions.[23,29]

Assessment of symptoms has traditionally been used to monitor recovery; however, the role of cognitive dysfunction has received significant attention. Although described inconsistently in the literature,[14] cognitive function likely recovers independently of symptoms. This raises concern for increased risk of additional injury even after symptoms have resolved.

Factors predictive of recovery are poorly defined. Traditional markers (i.e., loss of consciousness, amnesia, convulsions) were extrapolated from data of more severe traumatic brain injuries. Studies have demonstrated that brief loss of consciousness is not associated with prolonged recovery,[1,8,26] and that convulsions immediately after injury are benign.[26] The significance of amnesia is less clear. Recent findings suggest that prolonged headache (more than 60 hours), fatigue, tiredness, fogginess, or presence of more than three symptoms at presentation may be associated with prolonged recovery.[14]

The incidence of sports-related concussions is estimated to be 1.6 to 3.8 million annually.

Assessment Tools

Most concussions lead to subtle changes; therefore, evaluation can be challenging.[9,30] Numerous assessment tools exist to aid diagnosis and management

Table 3. Assessment Tools for Concussion Diagnosis and Management

Type	*Examples*	*Comments*
Symptom checklists	Postconcussion Symptom Scale Graded Symptom Checklist Head Injury Scale McGill Abbreviated Concussion Evaluation (ACE) postconcussion symptom scale HeadMinder Concussion Symptom Inventory	The most commonly used type of concussion assessment tool Quick, easy, cost-effective tool with good sensitivity; allows athletes to self-report symptoms Cautions: symptoms may be delayed, may not be reported, or were already present at baseline Most checklists developed using clinical judgment; the Concussion Symptom Inventory is the only empirically derived symptom checklist
Neuropsychological tests	Written Trail Making Test Digit Symbol Substitution Test Controlled Oral Word Association Test Hopkins Verbal Learning Test Stroop Color and Word Test Computer-based HeadMinder CogSport ImPACT Automated Neuropsychological Assessment Metrics	Designed to identify subtle cognitive deficits Written tests are labor intensive and must be interpreted, whereas computer-based tests can be administered rapidly and to multiple patients simultaneously Results best interpreted when compared with baseline data; affected by psychiatric disorders, physical symptoms, cultural factors, and motivation/effort These tests are not validated, and no data demonstrate that they affect outcomes when used to guide return to play There are limited baseline data in children younger than 12 years; child-specific computerized tests are under development
Postural stability testing	BESS (and modified version) SOT	Very sensitive for concussion diagnosis, but there are limited data regarding its use in monitoring recovery SOT is the preferred test, but it is not portable; BESS is inexpensive and easy to administer on the sideline of a sporting event Instability usually lasts three to five days after a concussion occurs
Sideline assessment tools	SAC SCAT SCAT2	A single, simple tool to assess a variety of domains in the initial concussion assessment Often used to monitor the recovery process SAC can be used immediately after injury to evaluate orientation, memory, concentration, and delayed recall; validated as a sideline tool for athletes junior high school–aged and older; emergency department version is validated in adults SCAT2 combines multiple assessment tools (symptom checklist, concentration and memory tasks [Maddock's questions], SAC, BESS, and Glasgow Coma Scale); it is not validated but is widely used and the most sophisticated sideline tool available

BESS = Balance Error Scoring System; SAC = Standardized Assessment of Concussion; SCAT = Sport Concussion Assessment Tool; SOT = Sensory Organization Test.

Information from references 1, 5, 16, 18, 19, 30, and 31.

(Table 3).[1,5,16,18,19,30,31] Although none are exclusively effective,[8] combining tools increases sensitivity and specificity.[1,16,31] Assessment tools are most beneficial when baseline measurements are available for comparison.[8]

SYMPTOM CHECKLISTS

Most guidelines primarily recommend checklists that allow for patients to self-report their concussion symptoms[16,19]; however, symptoms may be delayed, may not be reported, or were already present at baseline.[1,16] Most checklists have been developed through clinical experience and have significant similarities, yet none are considered superior.[19,24]

NEUROPSYCHOLOGICAL TESTING

Neuropsychological tests are designed to identify subtle cognitive deficits. Written tests are labor-intensive and require trained administrators, whereas computer-

based tests allow for rapid administration to multiple patients simultaneously.[16] There is no consensus on which tests are most effective.[5,9,10,19,20,25] A meta-analysis found no statistically significant difference in sensitivity 14 days after injury among written tests, computer-based tests, and the Standardized Assessment of Concussion (SAC; a sideline assessment tool).[30] Neuropsychological testing is often considered the cornerstone of concussion evaluation; however, there is no evidence that it affects outcomes.[5,9,10,12,19,20] There is also disagreement on the degree of recovery necessary for safe return to play.[25]

POSTURAL STABILITY TESTING

Concussion leads to impaired balance, which typically lasts three to five days.[1,5,16,26,31] Postural stability testing is an integral part of evaluation[1]; however, there is insufficient evidence on its use.[31] Some balance testing requires sophisticated equipment; however, the Balance Error Scoring System requires only a foam block and can be performed on the sideline of an athletic event.

SIDELINE ASSESSMENT TOOLS

Common sideline tools include the SAC and Sport Concussion Assessment Tool 2 (SCAT2). These tools assess several domains to diagnose concussion and monitor recovery. The SAC has been validated in athletes who are junior high school–aged and older. Emergency department versions are validated in adults, although they are not optimal for use in children.[29] The SCAT2 has not been validated; however, it is widely used and the most sophisticated sideline assessment tool available.[18] The SCAT2 includes a symptom checklist, concentration and memory tasks (Maddock's questions), the SAC, the Balance Error Scoring System, and the Glasgow Coma Scale. The SCAT2 is available for download in the online version of this article or at http://www.cces.ca/en/files-116.

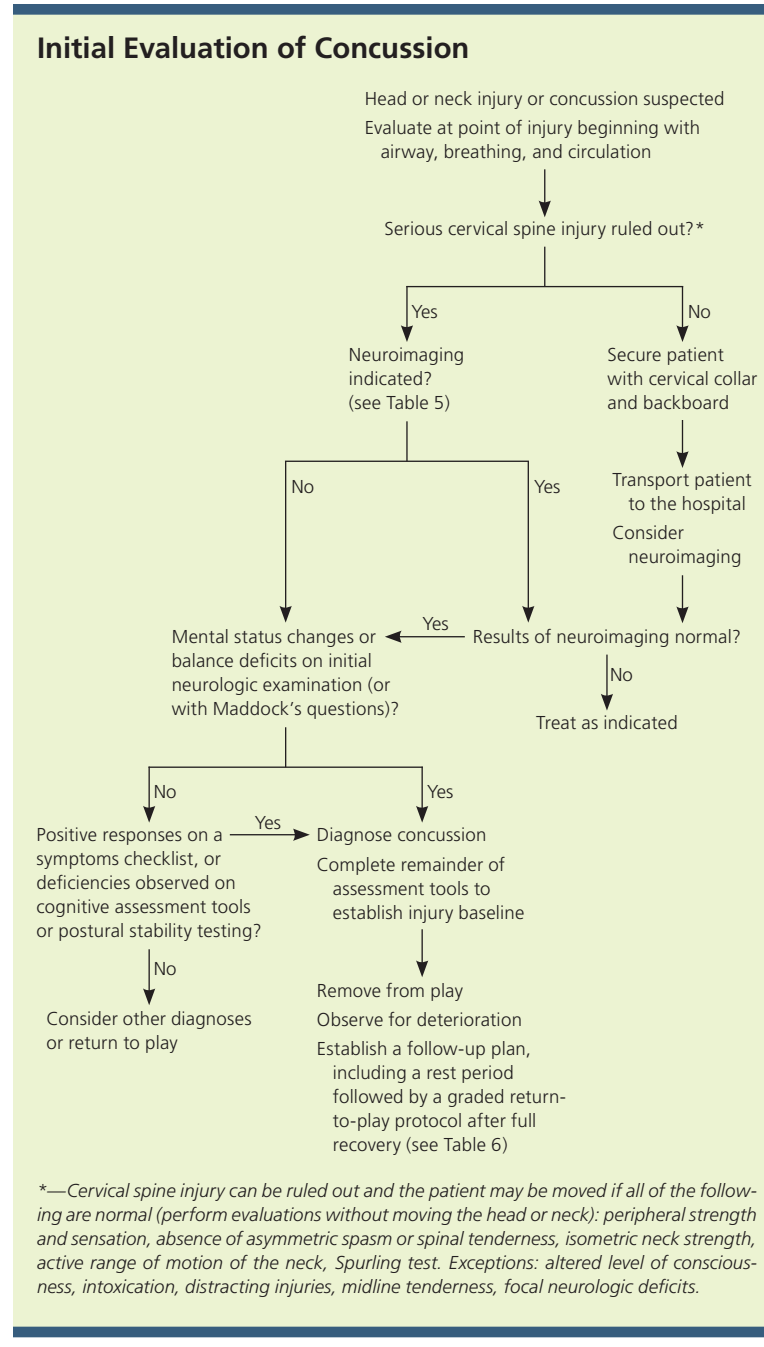

Figure 1. Suggested algorithm for the evaluation of concussion.

Information from references 1, 2, 5, 8, 9, 12, 16, 18, 21, 31, and 32.

Initial Evaluation

Figure 1 is a suggested algorithm for the evaluation of concussion.[1,2,5,8,9,12,16,18,21,31,32] For obvious head and neck injuries, assessment begins at the site of injury[1,8,9,12,20] and focuses on evaluating the cervical spine.[8] In unconscious persons, cervical spine injury must be assumed.[9,12,25] *Table 4* includes neurologic examination findings that may indicate more significant traumatic brain injury and the need for hospital evaluation.[1,5,10]

SIDELINE EVALUATION

Further evaluation can occur on the sideline or in the training room. With concussion, neurologic findings are normal other than mental status and balance

Table 4. Neurologic Examination Findings Suggesting Severe Injury in Patients with Suspected Concussion

*Type of assessment**	*Findings*
Balance†	Romberg sign, postural instability, unsteadiness
Cranial nerves	Vision problems; unequal or fixed, dilated pupils; abnormal extraocular movements; or other abnormal cranial nerve findings may be suggestive of brainstem lesion
Deep tendon reflexes	Hyperreflexia or Babinski reflex suggests upper motor neuron lesion
Finger-to-nose test	Abnormal findings suggest coordination deficit
Gait	Ataxic gait may suggest cerebellar dysfunction
Mental status‡	Prolonged loss of consciousness (more than 60 seconds); somnolence or confusion; disorientation; deficit in language, speech, or long-term memory
Muscular strength	Weakness or unequal strength, decreased tone; involuntary movements may indicate basal ganglia or cerebellar injury
Sensory assessment of dermatomes§	Numbness or abnormal sensation can be traced to spinal nerve root

**—Evidence is lacking as to what a focused neurologic examination should include. Most patients with a concussion have cognitive and memory deficits; therefore, any focal neurologic deficit should prompt immediate evaluation for possible intracranial lesion.*

†—Standard balance examinations are not sensitive to subtle changes caused by a concussion. Postural stability tests are sensitive enough for diagnosis (see Table 3 for examples).

‡—Standard orientation questions are not sensitive to subtle changes caused by concussion. Maddock's questions are sensitive and effective for sideline assessment.

§—Sensory examination is subjective and may be difficult to perform on uncooperative patients or those with cognitive deficits.

Information from references 1, 5, and 10.

deficits; however, subtle changes from a concussion are not identifiable through standard orientation questions or traditional balance testing.[1,9,12,20,25] Assessment of a patient with possible concussion should include a physical examination in addition to use of available concussion assessment tools.[1,5,8,18] Monitoring for deterioration over several hours is essential.[1,8] The athlete should not return to play unless evaluation provides confidence that the patient does not have a concussion.[1]

HOSPITAL EVALUATION AND IMAGING

Evaluation in the hospital is identical to that on the sideline, but involves a more detailed history and neurologic examination.[1] The greatest challenge is determining who requires advanced neuroimaging.[1,2] Imaging is often overused and contributes little to management of concussion, other than ruling out more serious traumatic brain injuries, skull fractures, and cervical spine injuries.[1,2,5,8,10,12,16,21,32] If it is determined that imaging is warranted *(Table 5*[2,32]*)*, computed tomography is the initial modality of choice because of availability and sensitivity for diagnosing intracranial hemorrhage.[2,8,21,32] Magnetic resonance imaging is acceptable acutely, but is more appropriate for evaluation of prolonged deficits.[12] Plain radiography of the head has no role in the evaluation of possible concussion.[2,32] Newer imaging modalities (e.g., functional magnetic resonance imaging) are under investigation; however, evidence is limited, few are readily available, and none have fully established clinical application.[1,5,6,10,12,16,33]

If the patient has no significant cervical spine or intracranial injury, home care with observation is appropriate provided there is a responsible caretaker and sufficient ability to seek medical care if needed; the patient and caretaker should receive written instructions on when to seek medical attention.[2,12,32] Follow-up is necessary because return-to-play decisions cannot be made acutely.[4,8] Periodic wakening is controversial; although this practice may allow for detection of progressive neurologic decline, sleep deprivation may exacerbate concussion symptoms.[12]

Management

Management of concussion is summarized in *Table 6*.[1,9,10,12,18,20] Essential elements include rest followed by a graded return-to-play strategy. For most patients, the SCAT2 can be used alone to monitor recovery and guide return-to-play decisions.

Complete cognitive and physical rest are cornerstones of initial management[1,9,10,12,18,20] because activity may exacerbate concussion symptoms and delay recovery.[1] After resolution of symptoms, postural and cognitive testing (within the SCAT2) can confirm that the patient has recovered completely. A graded return-to-play protocol may then be implemented. Athletes should not return to play until they are completely recovered from the concussion and free of medications that may mask the symptoms of the concussion.[1,5,8-10,12,18,20] In those at risk of prolonged recovery, formal neuropsychological testing and referral to a health care professional experienced in concussion management may be considered. Reevaluation several months after recovery is prudent to screen for depressive symptoms.

Table 5. Indications for Neuroimaging

Guidelines from the American College of Emergency Physicians[2]*
Imaging is indicated in patients with a loss of consciousness or amnesia if at least one of the following is present: headache (diffuse), vomiting, age older than 60 years, intoxication, deficits in short-term memory, evidence of trauma above the clavicle, seizures, GCS score of less than 15, focal neurologic deficits, coagulopathy
Imaging is indicated in patients with no loss of consciousness or amnesia if at least one of the following is present: focal neurologic deficit, vomiting, severe headache, age older than 65 years, signs of basilar skull fracture, GCS score of less than 15, coagulopathy, significant mechanism of injury (e.g., ejection from vehicle, pedestrian struck by vehicle, fall from a height greater than 3 ft or five stairs)
Guidelines from the American Academy of Pediatrics and the American Academy of Family Physicians[32]†
Perform imaging in patients with loss of consciousness of greater than 60 seconds, evidence of skull fracture, or focal neurologic findings
Consider imaging or observation if patient has brief loss of consciousness
Note that nonspecific signs (e.g., immediate seizures, headache, vomiting, lethargy) increase the likelihood of intracranial injury, but have very limited predictive value

NOTE: *Both guidelines are extremely sensitive to structural intracranial injury, but at the expense of specificity. Such guidelines result in excessive use of neuroimaging.*

GCS = Glasgow Coma Scale.

**—Applies to patients older than 16 years who present to the emergency department within 24 hours of a nonpenetrating head injury and have a GCS score of 14 or 15.*

†*—Applies to patients two to 20 years of age who present to the emergency department within 24 hours of an isolated closed head injury.*

Information from references 2 and 32.

Evidence regarding pharmacologic therapy is limited. Treatment focuses on symptom management, including the same medications appropriate in patients without a concussion.[1,5] Medications that may mask worsening symptoms or confuse changes in mental status should be avoided. Medications that may worsen the potential for intracranial bleeding (e.g., nonsteroidal anti-inflammatory drugs) should be used with caution.

Special Considerations

SAME-DAY RETURN TO PLAY

Athletes should not return to play the same day of sustaining a concussion,[1,8,10,18] and most athletic organizations and state laws prohibit it. However, limited data have prompted some to suggest exceptions for professional athletes if sufficient sideline resources exist to assess the athlete and if the athlete demonstrates complete recovery.[1,28] This exception does not apply to younger athletes.[1,10,12,18]

CHILDREN AND ADOLESCENTS

Managing concussion in the developing brain is a unique challenge,[12] and the approach must be different than that for adults.[11,20] Most research on concussion management applies to persons who are high school–aged or older. Little is known about concussions in children; therefore, conservative management is appropriate (e.g., a longer asymptomatic period before return to play).[1,9,11,18,20] Special considerations and recommendations for managing concussions in children are included in *Table 7*.[1,7,9-12,17,18,20]

MULTIPLE CONCUSSIONS

Epidemiologic studies suggest long-term cognitive deficits with multiple concussions; however, medical research is conflicting.[7,9,10,23,25,26] Those with previous concussions have increased risk of recurrent injury[9,10,20,23,25] and have longer recovery periods.[7,9,20,23,25,29] There are no guidelines regarding athletic disqualification or retirement; however, it may be prudent to disqualify athletes who sustain concussions with increasing frequency or in response to decreased impact.

SECOND IMPACT SYNDROME

Second impact syndrome can occur if an athlete returns to play before full resolution of a concussion.[28] After a concussion, the brain may be susceptible to extremes of blood pressure.[17,28] A catecholamine surge from a second impact to the head or body may cause vascular congestion, cerebral edema, increased intracranial pressure, and ultimately coma or death.[8,10,12,20,25,28] There are few documented cases,[19,25] but all have occurred in persons younger than 20 years.[8,12] Although the existence of second impact syndrome is controversial,[10,28] it is universally accepted that no athlete should return to play after a concussion while symptomatic.[9,10]

Prevention, Education, and Legislation

There is no evidence that protective gear prevents concussions.[1,8-10,12,33] Helmets and mouth guards reduce risk of skull and dental fractures, but neither has been demonstrated to reduce the incidence of concussion.[8,12,33] Rule changes to eliminate dangerous behaviors in sports may have a more protective effect.

Education may reduce violence in sports and allow early recognition of concussion symptoms to prevent further injury.[8] The Centers for Disease Control and Prevention has instituted the Heads Up campaign to promote concussion education. Educational and clinical management tools are available at http://cdc.gov/concussion/headsup.

Table 6. Elements of Concussion Management

Element	*Recommendations*	*Comments*
Cognitive rest	Avoid text messaging or video games Limit television and computer use Decrease schoolwork	Avoid activities that require attention or concentration
Physical rest	Avoid any physical activity that exacerbates symptoms (e.g., aerobic exercise, lifting weights, household chores, sexual activity)	Severe or worsening headache, persistent vomiting, or seizures may suggest a need for neuroimaging
Medications/ interventions	Wear sunglasses for photophobia Wear earplugs or noise canceling headphones for phonophobia Take medications to alleviate specific symptoms (e.g., nonsteroidal anti-inflammatory drugs, acetaminophen, or amitriptyline for persistent headaches; sleep aids, anxiolytics, selective serotonin reuptake inhibitors for depressive symptoms) Be aware that some medications may mask postconcussive symptoms Avoid acute use of nonsteroidal anti-inflammatory drugs if there is potential for intracranial bleeding	There is poor evidence for use of medications for postconcussive symptoms; therefore, medication choices are the same for those without concussion
Transition back to school	Alert school personnel to injury, and initiate slow reintegration Consider the following: forgiveness of missed assignments and more time to complete tests and schoolwork, standard breaks and rest periods as needed, decreased schoolwork, distraction-free work areas, note taker Avoid standardized testing during recovery Monitor carefully for two to three months after concussion for scholastic difficulties	Usually can be accomplished informally, but formal interventions may be required (e.g., IEP, 504 plan)
Graded return to play	After rest and resolution of symptoms, athletes may progress through a return-to-play protocol; each of the following steps should take 24 hours: Nonimpact aerobic exercise Sport-specific exercise (nonimpact drills) Noncontact training drills Full contact practice Return to normal play	Patient must be symptom-free and medication-free before starting return-to-play protocol If any symptoms develop, activity should be stopped immediately; 24 hours after symptoms resolve, protocol may resume at the last step for which the athlete was asymptomatic
Higher-risk patients	Factors that may suggest prolonged recovery or caution for return to play: More than three symptoms at presentation Specific symptoms (i.e., fatigue, tiredness, or fogginess) Headache lasting more than 60 hours Loss of consciousness for more than 60 seconds Amnesia History of concussion Age younger than 18 years Comorbid conditions Medication use (psychotropic drugs, anticoagulants) Dangerous style of athletic play High-risk sport (contact, collision)	Consider multidisciplinary approach (e.g., referral to health care professional experienced in concussion management, formal neuropsychological testing, communication with coach and training staff)

IEP = individualized education program.

Information from references 1, 9, 10, 12, 18, and 20.

Table 7. Selected Special Considerations for Managing Concussions in Children and Adolescents

Special considerations	*Recommendations*
Developmental	
Grade school children may have different symptoms than adults, may not comprehend symptom checklist items, or may not have the ability to describe symptoms	Use additional information from caretakers, educators, and coaches
Patients in early adolescence use concrete thinking, may not comprehend injury significance	Educate with simple, concrete language; involve caretakers in management
Patients in midadolescence are easily influenced (e.g., peers, media), have a growing sense of independence and often a sense of invulnerability, and may have difficulty accepting activity restrictions	Educate on the significance of the injury; involve caretakers, coaches, and trainers in ensuring compliance; observe for depression or other reactions to restrictions
Patients in late adolescence have increased ability for abstract thinking and future planning	Educate on potential consequences of noncompliance with activity restrictions
Children and adolescents constantly acquire new skills	Because a return to baseline on neuropsychological testing may not indicate full recovery, use the other assessment tools in conjunction
Contextual	
Children and adolescents lack personal independence	Educate caretakers, who have significant impact on school, home, and extracurricular activities
Children may look outwardly well upon return to school, despite incomplete recovery	Requires significant communication with educators; consider that informal plans are sufficient for most children, but formal education interventions (e.g., IEP, 504 plan) may be necessary
Assessment	
No guideline focuses exclusively on children	Consider more conservative approach with children
The Sport Concussion Assessment Tool 2 applies only to patients older than 10 years	Rely on clinical judgment and other assessment tools (symptom checklists in those older than six years); identified as a key area of research
The Standardized Assessment of Concussion tool has not been validated in grade school children	Do not necessarily discount this tool, but be aware of its potential age limitations
No significant data exist for the use of symptom checklists in children six years and younger	Recognize that symptoms are often different in children than in adults; suspect concussion if mechanism of injury is consistent with diagnosis
There are very limited baseline neuropsychological data for children younger than 12 years	Cognitive testing should be related to appropriate developmental stage and interpreted by a trained neuropsychologist
Postural stability testing requires mature/developed balance mechanisms	Consider baseline assessments; observe gait and coordination if unable to assess postural stability
Recovery	
Most children and adolescents with concussions recover fully, but data suggest longer recovery periods than in adults (typically seven to 10 additional days)	Consider a more conservative approach to management, plan for extended follow-up periods, evaluate for persistent symptoms and school performance or behavioral changes
Increased concern for second impact syndrome in younger patients (all cases of the condition have occurred in persons younger than 20 years)	Never allow same-day return to play; consider longer asymptomatic rest periods before initiating graded return-to-play protocol

IEP = individualized education program.

Information from references 1, 7, 9 through 12, 17, 18, and 20.

In 2009, Washington State enacted the Zackery Lystedt Law requiring concussion education for coaches, athletes, and parents.[15] The law also mandates removal of athletes from activity if there is any suspicion of concussion, and return to play must be cleared by a licensed health care professional. Other states have since enacted similar legislation.[34]

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the U.S. Army Medical Department or the U.S. Army Service at large.

Data Sources: A PubMed search was completed in Clinical Queries using the key terms concussion, traumatic brain injury, and brain injury, with additional searches narrowed by the terms epidemiology, assessment, evaluation, management, treatment, and imaging. The search included meta-analyses, randomized controlled trials, clinical trials, and

reviews. Also searched were the Cochrane database, Clinical Evidence, National Guideline Clearinghouse, Agency for Healthcare Research and Quality Evidence Reports, and UpToDate. Search dates: September 30, 2010, and October 31, 2010.

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