SPECIAL ARTICLE

Summary of evidence-based guideline update: Evaluation and management of concussion in sports

Report of the Guideline Development Subcommittee of the American Academy of Neurology

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ABSTRACT

Objective: To update the 1997 American Academy of Neurology (AAN) practice parameter regarding sports concussion, focusing on 4 questions: 1) What factors increase/decrease concussion risk? 2) What diagnostic tools identify those with concussion and those at increased risk for severe/prolonged early impairments, neurologic catastrophe, or chronic neurobehavioral impairment? 3) What clinical factors identify those at increased risk for severe/prolonged early postconcussion impairments, neurologic catastrophe, recurrent concussions, or chronic neurobehavioral impairment? 4) What interventions enhance recovery, reduce recurrent concussion risk, or diminish long-term sequelae? The complete guideline on which this summary is based is available as an online data supplement to this article.

Methods: We systematically reviewed the literature from 1955 to June 2012 for pertinent evidence. We assessed evidence for quality and synthesized into conclusions using a modified Grading of Recommendations Assessment, Development and Evaluation process. We used a modified Delphi process to develop recommendations.

Results: Specific risk factors can increase or decrease concussion risk. Diagnostic tools to help identify individuals with concussion include graded symptom checklists, the Standardized Assessment of Concussion, neuropsychological assessments, and the Balance Error Scoring System. Ongoing clinical symptoms, concussion history, and younger age identify those at risk for postconcussion impairments. Risk factors for recurrent concussion include history of multiple concussions, particularly within 10 days after initial concussion. Risk factors for chronic neurobehavioral impairment include concussion exposure and *APOE* ε4 genotype. Data are insufficient to show that any intervention enhances recovery or diminishes long-term sequelae postconcussion. Practice recommendations are presented for preparticipation counseling, management of suspected concussion, and management of diagnosed concussion. *Neurology*® 2013;80:2250–2257

GLOSSARY

AAN = American Academy of Neurology; **BESS** = Balance Error Scoring System; **CR** = concussion rate; **GSC** = Graded Symptom Checklist; **LHCP** = licensed health care provider; **LOC** = loss of consciousness; **mTBI** = mild traumatic brain injury; **PCSS** = Post-Concussion Symptom Scale; **RTP** = return to play; **SAC** = Standardized Assessment of Concussion; **SRC** = sport-related concussion; **SOT** = Sensory Organization Test; **TBI** = traumatic brain injury.

Concussion is recognized as a clinical syndrome of biomechanically induced alteration of brain function, typically affecting memory and orientation, which may involve loss of consciousness (LOC). Estimates of sports-related mild traumatic brain injury (mTBI) range from 1.6 to 3.8 million affected individuals annually in the United States, many of whom do not obtain immediate medical attention.[1] The table summarizes the currently available data for the overall concussion rate (CR) and the CRs for 5

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commonly played high school and collegiate sports in males and females. Variability in care provider experience and training, coupled with an explosion of published reports related to sports concussion and mTBI, has led to some uncertainty and inconsistency in the management of these injuries.

This evidence-based guideline replaces the 1997 American Academy of Neurology (AAN) practice parameter on the management of sports concussion.[2] It reviews the evidence published since 1955 regarding the evaluation and management of sports concussion in children, adolescents, and adults. This document summarizes extensive information provided in the complete guideline, available as a data supplement on the *Neurology*® Web site at www.neurology.org. References e1–e68, cited in this summary, are available at www.neurology.org.

This guideline addresses the following clinical questions:

1. For athletes, what factors increase or decrease concussion risk?

2a. For athletes suspected of having sustained concussion, what diagnostic tools are useful in identifying those with concussion?

2b. For athletes suspected of having sustained concussion, what diagnostic tools are useful in identifying those at increased risk for severe or prolonged early impairments, neurologic catastrophe, or chronic neurobehavioral impairment?

3. For athletes with concussion, what clinical factors are useful in identifying those at increased risk for severe or prolonged early postconcussion impairments, neurologic catastrophe, recurrent concussions, or chronic neurobehavioral impairment?

4. For athletes with concussion, what interventions enhance recovery, reduce the risk of recurrent concussion, or diminish long-term sequelae?

Table Concussion incidence in high school and collegiate competitions among commonly played sports

	Rate/1,000 games	
Sport	**Males**	**Females**
Football[6]		
High school	1.55	—
College	3.02	—
Ice hockey[14]		
High school	—	—
College	1.96	—
Soccer[6]		
High school	0.59	0.97
College	1.38	1.80
Basketball[6]		
High school	0.11	0.60
College	0.45	0.85
Baseball/softball[6,a]		
High school	0.08	0.04
College	0.23	0.37
Summary of 9 sports[6,b]		
High school	0.61	0.42
College	1.26	0.74

[a] Assumes that competitive high school and collegiate baseball players were mainly male and softball players were mainly female.
[b] Sports include football, boys' and girls' soccer, volleyball, boys' and girls' basketball, wrestling, baseball, and softball.

DESCRIPTION OF THE ANALYTIC PROCESS This guideline was developed according to the processes described in the 2004 and 2011 AAN guideline development process manuals.[3,4] After review of conflict of interest statements, the AAN selected a multidisciplinary panel of experts. A medical research librarian assisted the panel in performing a comprehensive literature search. Articles were selected for inclusion and rated for quality independently by 2 authors. Evidence was synthesized using a modified form of the Grading of Recommendations Assessment, Development and Evaluation process.[5] The panel formulated recommendations on the basis of the evidence systematically reviewed, from stipulated axiomatic principles of care, and, when evidence directly related to sports concussion was unavailable, from strong evidence derived from non–sports-related mTBI. The clinician level of obligation of recommendations was assigned using a modified Delphi process.

ANALYSIS OF EVIDENCE The definitions for concussion/mTBI used in the identified studies were not identical but were judged by the panel to be sufficiently similar to allow for review.

For athletes, what factors increase or decrease concussion risk? Some athletes may be at greater risk of sport-related concussion (SRC) associated with different factors (e.g., age, sex, sport played, level of sport played, equipment used).

Age/level of competition. Based on Class I studies,[6–9] there is insufficient evidence to determine whether age or level of competition affects concussion risk overall, as findings are not consistent across all studies or in all sports examined.

Sex. Because of the greater number of male participants in sports studied, the total number of concussions is greater for males than females for all sports combined. However, the relationship of concussion risk and sex varies among sports. Based on Class I and Class II studies,[6,10–13] it is highly probable that concussion risk is greater for female athletes participating in soccer or basketball.

Type of sport. It is highly likely that there is a greater concussion risk with American football and

Australian rugby than with other sports.[6,11,14–16] It is highly likely that the risk is lowest for baseball, softball, volleyball, and gymnastics. For female athletes, it is highly likely that soccer is the sport with the greatest concussion risk (multiple Class I studies).[13,17]

Equipment. It is highly probable that headgear use has a protective effect on concussion incidence in rugby (2 Class I studies).[18,19] There is no compelling evidence that mouth guards protect athletes from concussion (3 Class I studies).[18–20] Data are insufficient to support or refute the efficacy of protective soccer headgear. Data are insufficient to support or refute the superiority of one type of football helmet in preventing concussions.

Position. Data are insufficient to characterize concussion risk by position in most major team sports. In collegiate football, concussion risk is probably greater among linebackers, offensive linemen, and defensive backs as compared with receivers (Class I and Class II studies).[21,22]

Body checking in ice hockey. Body checking is likely to increase the risk of SRC in ice hockey (1 Class I study).[23]

Athlete-related factors. Athlete-specific characteristics such as body mass index greater than 27 kg/m^2 and training time less than 3 hours weekly likely increase the risk of concussion (1 Class I study).[24]

For athletes suspected of having sustained concussion, what diagnostic tools are useful in identifying those with concussion? The reference standard by which these tools were compared was a clinician-diagnosed concussion (by physician or certified athletic trainer). None of these tools is intended to "rule out" concussion or to be a substitute for more thorough medical, neurologic, or neuropsychological evaluations.

Post-Concussion Symptom Scale or Graded Symptom Checklist. The Post-Concussion Symptom Scale (PCSS) and Graded Symptom Checklist (GSC) consist of simple checklists of symptoms. They may be administered by trained personnel, psychologists, nurses, or physicians, or be self-reported. Evidence indicates it is likely that a GSC or PCSS will accurately identify concussion in athletes involved in an event during which biomechanical forces were imparted to the head (sensitivity 64%–89%, specificity 91%–100%) (multiple Class III studies).[25–33]

Standardized Assessment of Concussion. The Standardized Assessment of Concussion (SAC) is an instrument designed for 6-minute administration to assess 4 neurocognitive domains—orientation, immediate memory, concentration, and delayed recall—for use by nonphysicians on the sidelines of an athletic event. The SAC is likely to identify the presence of concussion in the early stages postinjury (sensitivity 80%–94%, specificity 76%–91%) (multiple Class III studies).[8,25,26,34–37]

Neuropsychological testing. Instruments for neuropsychological testing are divided into 2 types on the basis of their method of administration: paper-and-pencil and computer. Both types generally require a neuropsychologist for accurate interpretation, although they may be administered by a non-neuropsychologist. It is likely that neuropsychological testing of memory performance, reaction time, and speed of cognitive processing, regardless of whether administered by paper-and-pencil or computerized method, is useful in identifying the presence of concussion (sensitivity 71%–88% of athletes with concussion) (1 Class II study,[38] multiple Class III studies[25,26,39,40,e1–e6]). There is insufficient evidence to support conclusions about the use of neuropsychological testing in identifying concussion in preadolescent age groups.

Balance Error Scoring System. The Balance Error Scoring System (BESS) is a clinical balance assessment for assessing postural stability that can be completed in about 5 minutes. The BESS assessment tool is likely to identify concussion with low to moderate diagnostic accuracy (sensitivity 34%–64%, specificity 91%) (multiple Class III studies[25,26,e7,e8]).

Sensory Organization Test. The Sensory Organization Test (SOT) uses a force plate to measure a subject's ability to maintain equilibrium while it systematically alters orientation information available to the somatosensory or visual inputs (or both). The SOT assessment tool is likely to identify concussion with low to moderate diagnostic accuracy (sensitivity 48%–61%, specificity 85%–90%) (multiple Class III studies[e1,e7–e9]).

Diagnostic measures used in combination. A combination of diagnostic tests as compared with individual tests is likely to improve diagnostic accuracy of concussion (multiple Class III studies[25,26,30,31]). Currently, however, there is insufficient evidence to determine the best combination of specific measures to improve identification of concussion.

For athletes suspected of having sustained concussion, what diagnostic tools are useful in identifying those at increased risk for severe or prolonged early impairments, neurologic catastrophe, or chronic neurobehavioral impairment? In addition to use for confirmation of the presence of concussion, diagnostic tools may potentially be used to identify athletes with concussion-related early impairments, sports-related neurologic catastrophes (e.g., subdural hematoma), or chronic neurobehavioral impairments. No studies were found relevant to prediction of sports-related neurologic catastrophe or chronic neurobehavioral impairment.

Studies relevant to the prediction of early postconcussion impairments provided moderate to strong evidence that elevated postconcussive symptoms (1 Class I[40] study, multiple Class II and Class III studies[28–30,33,e10]), lower SAC scores (2 Class I studies[25,26]), neuropsychological testing score reductions (3 Class I[e4,e11,e12] and 3 Class II[28,e13,e14] studies), and deficits on BESS (1 Class I study[26]) and SOT (1 Class I study,[32] 1 Class II study[e9]) are likely to be associated with more severe or prolonged early postconcussive cognitive impairments. It is possible that gait stability dual-tasking testing identifies athletes with early postconcussion impairments (1 small Class I study,[e5] 1 Class III study[e15]).

For athletes with concussion, what clinical factors are useful in identifying those at increased risk for severe or prolonged early postconcussion impairments, neurologic catastrophe, recurrent concussions, or chronic neurobehavioral impairment? ***Predictors of severe or prolonged early postconcussion impairments.*** It is highly probable that ongoing clinical symptoms are associated with persistent neurocognitive impairments demonstrated on objective testing (1 Class I study,[40] 2 Class II studies[28,e10]). There is also a high likelihood that history of concussion (3 Class I studies,[21,23,e16] 2 Class III studies[e15,e17]) is associated with more severe/longer duration of symptoms and cognitive deficits. Probable risk factors for persistent neurocognitive problems or prolonged return to play (RTP) include early posttraumatic headache (1 Class I study,[e16] 5 Class II studies[28,e10,e18–e20]); fatigue/fogginess (1 Class I study,[e16] 2 Class II studies[e18,e21]); and early amnesia, alteration in mental status, or disorientation (1 Class I study,[e16] 1 Class II study,[e10] 2 Class III studies[29,e22]). It is also probable that younger age/level of play (2 Class I studies[e11,e23]) is a risk factor for prolonged recovery. In peewee hockey, body checking is likely to be a risk factor for more severe concussions as measured by prolonged RTP (1 Class I study[23]). Possible risk factors for persistent neurocognitive problems include prior history of headaches (1 Class II study[e19]). Possible risk factors for more prolonged RTP include having symptoms of dizziness (1 Class III study[e24]), playing the quarterback position in football (1 Class III study[e25]), and wearing a half-face shield in hockey (relative to wearing full-face shields, 1 Class III study[e26]). In football, playing on artificial turf is possibly a risk factor for more severe concussions (1 Class I study, but small numbers of repeat concussions[7]). There is conflicting evidence as to whether female or male sex is a risk factor for more postconcussive symptoms, so no conclusion could be drawn.

Predictors of neurologic catastrophe. Data are insufficient to identify specific risk factors for catastrophic outcome after SRCs.

Predictors of recurrent concussions. A history of concussion is a highly probable risk factor for recurrent concussion (6 Class I studies,[7,18,21–23,e27] 1 Class II study[e28]). It is also highly likely that there is an increased risk for repeat concussion in the first 10 days after an initial concussion (2 Class I studies[21,e29]), an observation supported by pathophysiologic studies. Probable risk factors for recurrent concussion include longer length of participation (1 Class I study[e3]) and quarterback position played in football (1 Class I study,[e3] 1 Class III study[e25]).

Predictors of chronic neurobehavioral impairment. Prior concussion exposure is highly likely to be a risk factor for chronic neurobehavioral impairment across a broad range of professional sports, and there appears to be a relationship with increasing exposure (2 Class I studies,[e30,e31] 6 Class II studies,[e32–e37] 1 Class III study[e38]) in football, soccer, boxing, and horse racing. One Class II study in soccer found no such relationship.[e39] Evidence is insufficient to determine whether there is a relationship between chronic cognitive impairment and heading in professional soccer (inconsistent Class II studies[e36,e37,e39]).

Data are insufficient to determine whether prior concussion exposure is associated with chronic cognitive impairment in amateur athletes (9 Class I studies,[e3,e31,e40–e46] 9 Class II studies,[e13,e47–e54] 3 Class III studies[e55–e57]). Likewise, data are insufficient to determine whether the number of heading incidents is associated with neurobehavioral impairments in amateur soccer. *APOE* ε4 genotype is likely to be associated with chronic cognitive impairment after concussion exposure (2 Class II studies[e32,e35]), and preexisting learning disability may be a risk factor (1 Class I study[e3]). Data are insufficient to conclude whether sex and age are risk factors for chronic postconcussive problems.

For athletes with concussion, what interventions enhance recovery, reduce the risk of recurrent concussion, or diminish long-term sequelae? Each of several studies addressed a different aspect of postconcussion intervention, providing evidence that was graded as very low to low.[e29,e58–e60] On the basis of the available evidence, no conclusions can be drawn regarding the effect of postconcussive activity level on the recovery from SRC or the likelihood of developing chronic postconcussion complications.

PRACTICE RECOMMENDATIONS For this guideline, recommendations have each been categorized as 1 of 3 types: 1) preparticipation counseling recommendations; 2) recommendations related to assessment, diagnosis, and management of suspected concussion; and 3) recommendations for management of diagnosed concussion (including acute management, RTP, and retirement). In this section, the term experienced *licensed health care provider* (LHCP) refers to an individual who has acquired knowledge and skills relevant to evaluation and management of sports concussions and is practicing within the scope of his or her training and experience. The role of the LHCP can generally be characterized in 1 of 2 ways: sideline (at the sporting event) or clinical (at an outpatient clinic or emergency room).

Preparticipation counseling.

1. School-based professionals should be educated by experienced LHCPs designated by their organization/institution to understand the risks of experiencing a concussion so that they may provide accurate information to parents and athletes (Level B).

2. To foster informed decision-making, LHCPs should inform athletes (and where appropriate, the athletes' families) of evidence concerning the concussion risk factors. Accurate information regarding concussion risks also should be disseminated to school systems and sports authorities (Level B).

Suspected concussion. ***Use of checklists and screening tools.***

1. Inexperienced LHCPs should be instructed in the proper administration of standardized validated sideline assessment tools. This instruction should emphasize that these tools are only an adjunct to the evaluation of the athlete with suspected concussion and cannot be used alone to diagnose concussion (Level B). These providers should be instructed by experienced individuals (LHCPs) who themselves are licensed, knowledgeable about sports concussion, and practicing within the scope of their training and experience, designated by their organization/institution in the proper administration of the standardized validated sideline assessment tools (Level B).
2. In individuals with suspected concussion, these tools should be utilized by sideline LHCPs and the results made available to clinical LHCPs who will be evaluating the injured athlete (Level B).
3. LHCPs caring for athletes might utilize individual baseline scores on concussion assessment tools, especially in younger athletes, those with prior concussions, or those with preexisting learning disabilities/attention-deficit/hyperactivity disorder, as doing so fosters better interpretation of postinjury scores (Level C).
4. Team personnel (e.g., coaching, athletic training staff, sideline LHCPs) should immediately remove from play any athlete suspected of having sustained a concussion, in order to minimize the risk of further injury (Level B).
5. Team personnel should not permit the athlete to return to play until the athlete has been assessed by an experienced LHCP with training both in the diagnosis and management of concussion and in the recognition of more severe traumatic brain injury (TBI) (Level B).

Neuroimaging. CT imaging should not be used to diagnose SRC but might be obtained to rule out more serious TBI such as an intracranial hemorrhage in athletes with a suspected concussion who have LOC, posttraumatic amnesia, persistently altered mental status (Glasgow Coma Scale <15), focal neurologic deficit, evidence of skull fracture on examination, or signs of clinical deterioration (Level C).

Management of diagnosed concussion. ***RTP: Risk of recurrent concussion.***

1. In order to diminish the risk of recurrent injury, individuals supervising athletes should prohibit an athlete with concussion from returning to play/practice (contact-risk activity) until an LHCP has judged that the concussion has resolved (Level B).
2. In order to diminish the risk of recurrent injury, individuals supervising athletes should prohibit an athlete with concussion from returning to play/practice (contact-risk activity) until the athlete is asymptomatic off medication (Level B).

RTP: Age effects.

1. Individuals supervising athletes of high school age or younger with diagnosed concussion should manage them more conservatively regarding RTP than they manage older athletes (Level B).
2. Individuals using concussion assessment tools for the evaluation of athletes of preteen age or younger should ensure that these tools demonstrate appropriate psychometric properties of reliability and validity (Level B).

RTP: Concussion resolution. Clinical LHCPs might use supplemental information, such as neurocognitive testing or other tools, to assist in determining concussion resolution. This may include but is not limited to resolution of symptoms as determined by standardized checklists and return to age-matched normative values or an individual's preinjury baseline performance on validated neurocognitive testing (Level C).

RTP: Graded physical activity. LHCPs might develop individualized graded plans for return to physical and cognitive activity, guided by a carefully monitored, clinically based approach to minimize exacerbation of early postconcussive impairments (Level C).

Cognitive restructuring. Cognitive restructuring is a form of brief psychological counseling that consists of education, reassurance, and reattribution of symptoms. Whereas there are no specific studies using cognitive restructuring specifically in sports concussions, multiple studies[e61–e68] using this intervention for mTBI have shown benefit in decreasing the proportion of individuals who develop chronic postconcussion syndrome.

Therefore, LHCPs might provide cognitive restructuring counseling to all athletes with concussion to shorten the duration of subjective symptoms and diminish the likelihood of development of chronic postconcussion syndrome (Level C).

Retirement from play after multiple concussions: Assessment.

1. LHCPs might refer professional athletes with a history of multiple concussions and subjective persistent neurobehavioral impairments for neurologic and neuropsychological assessment (Level C).
2. LCHPs caring for amateur athletes with a history of multiple concussions and subjective persistent neurobehavioral impairments might use formal

neurologic/cognitive assessment to help guide retirement-from-play decisions (Level C).

Retirement from play: Counseling.

1. LHCPs should counsel athletes with a history of multiple concussions and subjective persistent neurobehavioral impairment about the risk factors for developing permanent or lasting neurobehavioral or cognitive impairments (Level B).
2. LHCPs caring for professional contact sport athletes who show objective evidence for chronic/persistent neurologic/cognitive deficits (such as seen on formal neuropsychological testing) should recommend retirement from the contact sport to minimize risk for and severity of chronic neurobehavioral impairments (Level B).

AUTHOR CONTRIBUTIONS

C. Giza: drafting/revising the manuscript, study concept or design, analysis or interpretation of data, acquisition of data, study supervision. J. Kutcher: drafting/revising the manuscript, study concept or design, analysis or interpretation of data. S. Ashwal: drafting/revising the manuscript, acquisition of data. J. Barth: drafting/revising the manuscript. T. Getchius: drafting/revising the manuscript, study concept or design, study supervision. G. Gioia: drafting/revising the manuscript, analysis or interpretation of data. G. Gronseth: drafting/revising the manuscript, study concept or design, analysis or interpretation of data. K. Guskiewicz: drafting/revising the manuscript, study concept or design, acquisition of data. S. Mandel: drafting/revising the manuscript, study concept or design, analysis or interpretation of data, contribution of vital reagents/tools/patients, acquisition of data, statistical analysis, study supervision. G. Manley: drafting/revising the manuscript. D. McKeag: drafting/revising the manuscript, analysis or interpretation of data, contribution of vital reagents/tools/patients, acquisition of data, study supervision. D. Thurman: drafting/revising the manuscript, study concept or design, analysis or interpretation of data. R. Zafonte: drafting/revising the manuscript, analysis or interpretation of data, acquisition of data.

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DISCLOSURE

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DISCLAIMER

This statement is provided as an educational service of the American Academy of Neurology. It is based on an assessment of current scientific and clinical information. It is not intended to include all possible proper methods of care for a particular neurologic problem or all legitimate criteria for choosing to use a specific procedure. Neither is it intended to exclude any reasonable alternative methodologies. The AAN recognizes that specific patient care decisions are the prerogative of the patient and the physician caring for the patient, based on all of the circumstances involved. The clinical context section is made available in order to place the evidence-based guideline(s) into perspective with current practice habits and challenges. Formal practice recommendations are not intended to replace clinical judgment.

CONFLICT OF INTEREST

The American Academy of Neurology is committed to producing independent, critical and truthful clinical practice guidelines (CPGs). Significant efforts are made to minimize the potential for conflicts of interest to influence the recommendations of this CPG. To the extent possible, the AAN keeps separate those who have a financial stake in the success or failure of the products appraised in the CPGs and the developers of the guidelines. Conflict of interest forms were obtained from all authors and reviewed by an oversight committee prior to project initiation. AAN limits the participation of authors with substantial conflicts of interest. The AAN forbids commercial participation in, or funding of, guideline projects. Drafts of the guideline have been reviewed by at least 3 AAN committees, a network of neurologists, *Neurology*® peer reviewers, and representatives from related fields. The AAN Guideline Author Conflict of Interest Policy can be viewed at www.aan.com.

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The guideline is endorsed by the National Football League Players Association, the Child Neurology Society, the National Association of Emergency Medical Service Physicians, the National Association of School Psychologists, the National Athletic Trainers Association, and the Neurocritical Care Society.

This Week's *Neurology*® Podcast

Summary of evidence-based guideline update: Evaluation and management of concussion in sports **(See p. 2250)**

This podcast begins and closes with Dr. Robert Gross, Editor-in-Chief, briefly discussing highlighted articles from the June 11, 2013, issue of *Neurology*. In the second segment, Dr. Howard Goodkin talks with Dr. Christopher Giza about the guideline update on evaluation and management of concussion in sports. Dr. Adam Numis then reads the e-Pearl of the week about anti–MuSK antibody myasthenia gravis. In the next part of the podcast, Dr. Alberto Espay focuses his interview with Dr. Merit Cudkowicz on her plenary session on ALS pathways to treatments. Disclosures can be found at www.neurology.org.

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Summary of evidence-based guideline update: Evaluation and management of concussion in sports: Report of the Guideline Development Subcommittee of the American Academy of Neurology

Christopher C. Giza, Jeffrey S. Kutcher, Stephen Ashwal, et al.

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