Seminars in
SPINE
SURGERY

Sports-Related Cervical Spine Injuries: On-Field Assessment and Management

Usman Zahir, MD, and Steven C. Ludwig, MD

A wide range of cervical spine injury patterns are related to sports activities. The clinical presentation of the injuries, a pertinent focused physical examination, and proper on-field management are paramount in the successful treatment of an injured athlete. Preexisting conditions (both acquired and congenital) affecting the spine must be determined. All these factors contribute to the challenges faced by health-care professionals in making accurate diagnoses, developing treatment plans, and deciding whether and when the athletes can return to play. A thorough understanding of the injury patterns assists in early recognition and subsequent management. In addition, clinical guidelines are available to assist health-care professionals in stratifying athletes into risk categories and subsequently decide when it is safe to allow them to return to play. Most important to the successful management of the injured athletes is their on-field management.
Semin Spine Surg 22:173-180 © 2010 Published by Elsevier Inc.

KEYWORDS sports related cervical spine injuries, on field management

According to the National Spinal Cord Injury Statistical Center, approximately 12,000 new cases of spinal cord injuries occur each year, with sports-related events causing approximately 7.6% of the injuries.[1] Fortunately, severe catastrophic cervical spine injuries are rare in athletes, and the most common injuries involve sprains and peripheral nerve injuries. Historically, much attention has been placed on football as a high-risk sport, but during the past decade, ice hockey, diving, and other sports have drawn their share of attention. Overall, the number of catastrophic cervical spine injuries resulting from contact sports has been decreasing since the latter part of the 1970s, primarily because of modifications in playing habits and adoption of rules to decrease the potential for injury.[2,3]

Although the incidence of catastrophic cervical spine injuries is lower in association with football compared with gymnastics and ice hockey, football is still associated with the largest number of overall catastrophic cervical spine injuries because of the large numbers of participating athletes. Approximately 1,500,000 high school and middle school football players and more than 75,000 college football players participate each year.

Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, MD.

Address reprint requests to Steven C. Ludwig, MD, Department of Orthopaedics, University of Maryland School of Medicine, 22 S. Greene Street, Suite S11B, Baltimore, MD 21201. E-mail: sludwig@umoa.umm.edu

From a historical perspective, between 1945 and 1994, nearly 85% of all football-related fatalities resulted from head and cervical spine injuries. The greatest numbers of those injuries occurred between 1965 and 1974, with a dramatic decrease during the next 2 decades.[4]

Since the 1970s, nonfatal cervical spine injuries have also been decreasing, largely because of laws prohibiting unsafe defensive plays, such as spearing (ie, use of the vertex of the helmet as a point of contact in tackling), which was outlawed in 1976.[5] With the adoption of this rule, the occurrence of cervical quadriplegia in football decreased from 34 cases in 1976 to only 5 in the 1984 season.[6]

Despite that overall trend, some variability in the data has been noted. Data from the National Center for Catastrophic Injury Research, Annual Report reveals that during the 2008 football season (includes high school, college, and professional football), 13 cases of incomplete cervical spine injuries occurred. This number is the greatest reported since 2004, when 13 cases also occurred. These data are in contrast to the single digits noted during much of the 1990s.[5] It is unclear whether the increases were noted because of improved reporting mechanisms or whether they represent a change in trends.

Although football-related spine injuries seem to be more highly publicized in the North American press, Canadian ice hockey is associated with a greater incidence of cervical spine injuries compared with American football. Most ice hockey injuries result from checking (striking an opponent from be-

1040-7383/$-see front matter © 2010 Published by Elsevier Inc.
doi:10.1053/j.semss.2010.06.012

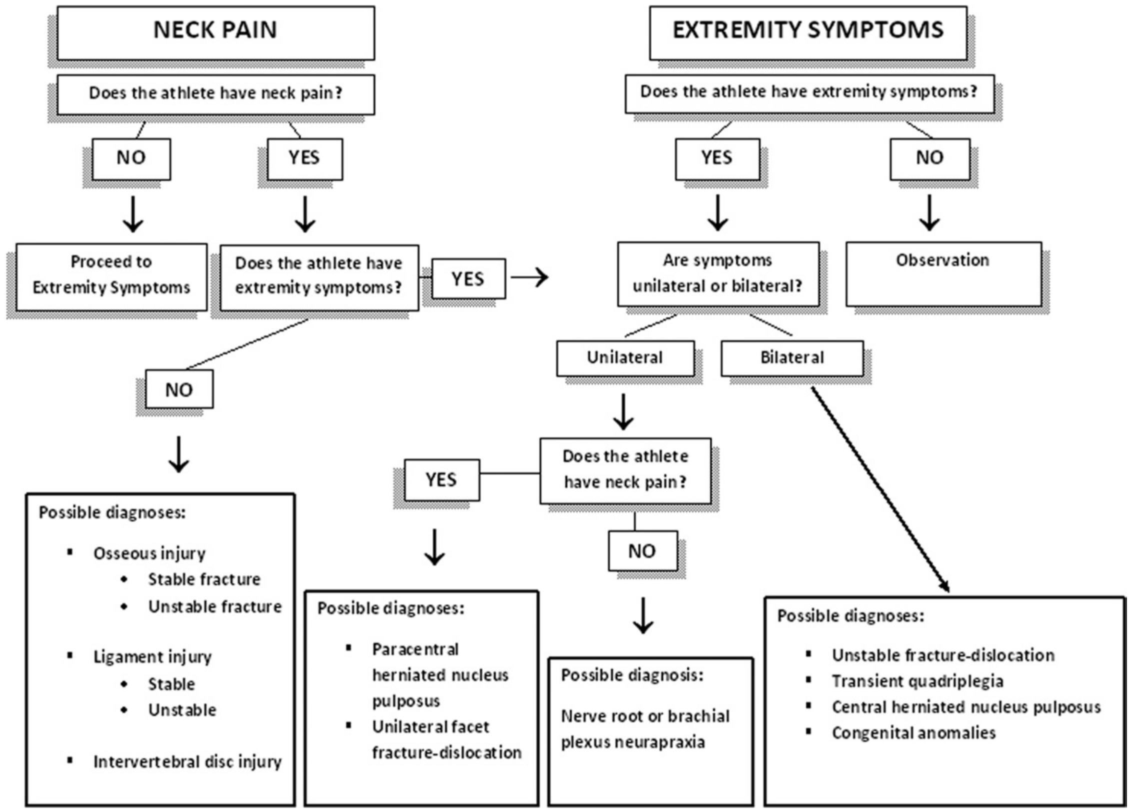

Figure 1 On-field assessment clinical algorithm.

hind), which can result in the attacked player sliding and striking his or her head against the surrounding ice rink.[5] At the international level, rules put into place during the mid-1990s require a penalty for pushing or checking players from behind. The rules were noted to have an effect in decreasing the incidence of severe spinal cord injuries.[7] Current National Hockey League rules allow for face-to-face body checking, but shoves or body checks behind a player are prohibited.[8]

Initial Evaluation

On-Field Assessment

Although the vast majority of sports-related cervical spine injuries are sprains, every patient with a suspected injury requires a complete physical examination of the cervical spine (Fig. 1). Every athlete should be assessed as though an unstable cervical spine injury is present. The head and spine should be immobilized immediately, and a standard sequence for treating all trauma patients should begin with an assessment of airway, breathing, circulation, disability, and neurological status. Careful attention should be directed to any signs of head trauma, complaints of headaches, or changes in mental status, and the Glasgow Coma Scale should be used. Cranial nerve abnormalities (abnormal pupillary responses, extraocular movements), bilateral neurological complaints, midline spinal pain and tenderness, and any signs of spinal deformity should alert the examiner to potential central nervous system injury. Careful physical examination of the extremities should be performed next to assess for any obvious deformities, areas of swelling, and points of tenderness along the spine. Careful motor and sensory examinations should then be performed.

Assessing cervical spine injuries in the sports setting requires not only careful physical examination but familiarity with the most common clinical presentations and subsequent on-field management. Banerjee et al,[9] discussed 3 potential clinical scenarios for patients presenting with cervical spine injuries:

1. Altered mental status with cardiorespiratory compromise.
2. Altered mental status without cardiorespiratory compromise.
3. Normal mental status without cardiorespiratory compromise.

The first scenario, although rare, is serious and must be quickly recognized. The presence of respiratory depression can result from direct injury to the airway or indirectly from an associated upper cervical cord injury (C3-C4) affecting the muscles of respiration. The primary objective in such a situation is to ensure a patent airway and adequate ventilatory support without additional neurological injury. The first step in ensuring a patent airway is to remove any oral protective devices (mouth pieces in football players) while stabilizing the neck. Patients in the prone position at the time of evaluation should be log-rolled with proper cervical spine precautions into the supine position. The face mask can then be removed, followed by opening of the airway via the jaw-thrust or placement of an oral airway. These interventions can safely be performed without the need to remove the helmet or shoulder pads on the field. Alternatively, those patients presenting with signs suggestive of cardiac shock after an injury should have the shoulder pads opened to allow for cardiac resuscitation.

Although hemorrhage and hypovolemia are rare in the setting of a sports-related spinal injury, patients with severe cervical spine injuries are at risk for neurogenic shock, which is characterized by disruption of the sympathetic outflow with resulting hypotension and associated bradycardia. Hypotension should be managed aggressively with intravenously administered fluids. Patients with spinal cord injuries should have mean arterial pressures maintained at >85 mm Hg mitigating ongoing spinal cord ischemia.[10] Vasopressors might be required in cases of persistent hypotension.

Most patients with sports-related cervical spine injuries are hemodynamically stable. They can, however, have varying degrees of consciousness related to the injury. Patients who present in an unconscious state should have the face mask removed immediately. In an alert, awake, and cooperative patient, with the absence of neck pain, the examination can include assessment of active range of motion of the cervical spine (passive range of motion of the cervical spine should not be performed in a symptomatic patient). Strength testing of the extremities and assessment of sensation and reflexes are conducted next. Serial examinations are also necessary if any deficits are noted to see if a resolution of the deficit becomes apparent. Considering that the vast majority of patients are conscious, assessment should focus on the presence of spinal tenderness, restricted range of motion, and any neurological deficits before the athletes are sent to the sidelines. Athletes with any of the aforementioned symptoms should be immobilized on a backboard and transferred to a hospital with protective gear (helmets and shoulder pads) in place for further evaluation.

Cervical Immobilization and Patient Transfer

Athletes with neck tenderness, limitations in cervical motion, or evidence of neurological symptoms should have the cervical spine immobilized in a neutral alignment with spine precautions. For airway management, the jaw-thrust maneuver is recommended. Head tilting is not recommended, and if difficulties arise with airway management, a laryngoscope can be used in cases requiring intubation.

Cervical spine immobilization in the supine patient should be performed carefully, avoiding any traction and distraction. While the physician cups the occiput with his or her hands, the mastoid processes should be held bilaterally by use of the fingertips, with gradual alignment of the cervical spine into a neutral position.[11] The reasons for maintaining a neutral alignment have been evaluated indirectly by anatomic and biomechanical studies of cervical spine fractures.[11,12] When placed in a neutral position, the cervical spinal canal has less risk of canal occlusion compared with positions in extension.[12] Although the goal is to keep the spine in a neutral position, manual adjustments should not be performed if the patient reports increasing pain and/or spasms or if a change in the neurological examination findings is noted during attempts at placing the cervical spine in neutral position.[13] A 2-piece cervical collar should then be applied. These patients can be stabilized in a position of comfort until transfer to the nearest hospital. Patients should be immobilized on a long spine board during the transfer process.

When transferring a patient to a board, one should avoid log rolling should the patient is in the prone position. Although thoracolumbar spine injuries are rare in contact sports, log-rolling has been shown to cause excessive motion in unstable thoracolumbar fracture sites.[14] This portion of the on-field management of spinal cord injury patients should proceed carefully with multiple assistants. For athletes in the prone position, the primary survey should begin before moving the patient. If the patient is helmeted, one person should stabilize the cervical spine by placing one hand on each side of the helmet while another examines the patient. Log-rolling to the supine position is the next step and requires a minimum of 4 assistants, each stabilizing the cervical spine, torso, hips, and legs. The athlete's arms should be crossed across their chest, allowing synchronous motion at the time of turning. The turning is initiated by the person stabilizing the cervical spine. If a spine board is present, the patient can be directly rolled into the supine position onto the board allowing for transportation.[9]

For the athlete who is initially assessed in the supine position, a lift-and-slide maneuver is generally recommended because it causes less motion of the spine.[15-17] Although a cervical collar should be in place before transfer to a board, application of the collar is difficult with athletes who have protective equipment in place. To assist with immobilization in such cases, sandbags or foam blocks can be taped to the side of the helmet and board or a cervical vacuum immobilizer can be used. The vacuum immobilizer can be placed under and around the cervical region. During deflation, it becomes a rigid support.[18]

Management of Protective Equipment

For any patient with suspected cervical spine injury, maintaining cervical spine immobilization is of central importance. The recommended protocol for football-related injury includes removal of the face mask and maintenance of the helmet and shoulder pads until the player is in the hospital setting. Once stabilized, the patient should be transferred to the nearest hospital for further diagnostic studies and care. The helmet should remain in place because of the risk of hyperextension of the cervical spine with independent removal. A cadaveric study showed that removal of the helmet and shoulder pads causes variable degrees in motion of the unstable cervical spine, potentially causing harm.[19] The helmet and shoulder pads should be removed carefully and simultaneously with the help of assisting staff in a monitored setting.

Several methods have been described for removal of helmets and shoulder pads.[20] The flat torso method involves the physician removing the helmet while maintaining in-line spinal stabilization precautions. The front shoulder pads are cut and removed first, and the back pads are then slid from under the patient.[20] The elevated torso technique uses an extra assistant to lift the shoulders approximately 30 degrees while maintaining spine precautions, theoretically minimizing any disturbances during shoulder pad removal. Horodyski et al,[20] by using a cadaveric model, compared the elevated torso and flat torso techniques in intact and unstable cervical spines with tracking sensors. The elevated torso method was noted to be superior in the 6 motion parameters that were studied, with decreases noted in flexion, extension, axial rotation, lateral bending, medial-lateral translation, axial translation, and anteroposterior translation. However, the method is associated with risk of causing injury if a concomitant thoracolumbar spine injury is present. It is therefore not recommended for nonisolated cervical spine injuries.

Hospital and Trauma Center Evaluation

Medical personnel and their assistants on the field should be available at the time of transfer to the emergency department. Their availability will assist in continuity of care and communication regarding the injury and initial neurological examination. After the helmet and shoulder pads have been removed, trauma and/or emergency department staff need to proceed with a comprehensive examination, with special notice given to any changes in neurological status.

A standard diagnostic evaluation of the cervical spine consists of anteroposterior, lateral, and odontoid view radiographs of the entire cervical spine. Adequate radiographs should include the occiput C1 and C7-T1 junctions. Obtaining adequate radiographs in the trauma setting continues to be a challenge, and the role of computed tomography (CT) of the cervical spine therefore continues to expand. CT provides the best bony detail compared with all other imaging studies and allows a clear assessment of areas that often are obscured on plain radiographs. CT has traditionally been viewed as an adjunctive tool in the diagnosis of cervical spine injuries. A prospective study[21] directly compared the use of CT of the cervical spine versus standard plain radiography. CT was noted to have a higher sensitivity, specificity, positive predictive value, and negative predictive value compared with radiography ($P = 0.001$). Interestingly, even in cases for which adequate plain radiographs were obtained, a large number of cervical spine injuries were still missed by radiography but revealed by CT.[21-23] At many centers, CT is now the initial diagnostic study of choice for patients presenting with cervical spine trauma.

Use of flexion-extension cervical spine films in the acute trauma setting is not recommended. The presence of pain and neck spasms can preclude an accurate assessment of stability.[24] In cases of suspected ligamentous injury, disk herniation, or other soft-tissue injury, obtaining magnetic resonance imaging (MRI) studies is warranted.

More often, patients present to their treating physicians on an outpatient basis. Patients should be asked specific questions relating to the mechanism of the event, the nature of the injury, and any history of previous episodes. The severity of the injury can be assessed by asking the patient whether he or she was able to complete the athletic event or was unable secondary to pain. Routine clinical assessment and detailed physical examination should then be performed.

Common Injury Patterns

The cervical spine is most stable in the lordotic position. Biomechanically, the lordotic position allows for forces to be effectively distributed through the paraspinal neck musculature and ligaments. In the contact sports setting, the cervical spine is at risk when the head is in a flexed forward position at the time of direct impact. When the protective lordosis of the cervical spine is eliminated, a straightened or slightly kyphotic position places the cervical spine at increased risk for injury. In addition to axial compression, other mechanisms of injury include rotational forces, hyperflexion, hyperextension, and lateral bending. Also, the role of chronic repetitive noncatastrophic cervical spine injuries cannot be underemphasized. Chronic injuries can hasten the onset of degenerative changes in the cervical spine and result in long-term morbidity.

The spear tackler's spine is a condition that often occurs in athletes involved in collision sports in which the head is used as a point of contact. The condition is classically associated with North American football. When diagnosed, it is considered an absolute contraindication to participation in contact sports. Characteristics of this condition include (1) cervical spine stenosis, (2) straightening of the cervical spine and loss of normal physiological lordosis (diagnosed on upright lateral view radiographs), (3) posttraumatic radiographic abnormalities, and (4) documented history of using spear tackling techniques. Loss of lordosis of the cervical spine places patients at increased risk for permanent neurological injuries because of recurrent axial loading injuries.[25] Recognition of the radiographic entity is imperative because the condition precludes return to play in a contact sport.

Transient Quadriplegia and Spinal Cord Neurapraxia

Transient quadriplegia and spinal cord neurapraxia refer to a spectrum of injury presentations ranging from momentary and self-limiting paralysis to weakness resulting from a collision. Patients with these injuries present without evidence of radiographic abnormalities. Neurapraxia of the cervical cord with transient quadriplegia was described in 1986 by Torg et al[26] as involving dysesthesias, tingling, and sensory deficits in the setting of motor weakness or paralysis. Within football, the prevalence of cervical cord neurapraxia is approximately seven in 10,000 players.[27]

Mechanisms

Narrowing of the canal has been associated with folding of the ligamentum flavum during hyperextension, resulting in transient compression between the subjacent vertebral lamina and the inferior portion of the superior vertebral body. A variety of theories attempt to explain the transient nature of the symptoms of transient quadriplegia and spinal cord neurapraxia. Pathophysiologically, the temporary motor and sensory deficits associated with the conditions have been attributed to conduction delays secondary to focal segmental demyelination within axons, resulting in prolonged refractory periods in conduction.[28] Researchers have also theorized neuronal damage to occur from increased levels of intracellular calcium. In an axonal injury model, by Torg et al[29] examined the properties of squid axons under mechanical deformation. The degree of nerve injury was directly related to the proportion of intracellular calcium concentrations in the axon. The proportion of intracellular calcium was in turn directly proportional to the amount of tension applied to the axon. The authors therefore concluded that nerve dysfunction was related to the degree of local nerve anoxia and subsequent rise in intracellular calcium levels. No evidence of permanent cord injury resulting from this mechanism has been reported. The transient mechanism, with complete resolution of symptoms, often is referred to as spinal cord concussion. It can be differentiated from spinal cord contusion based on lack of edema within the spinal cord, as shown by MRI.

Patients with transient quadriplegia and spinal cord neurapraxia may have sensory disturbances with varying degrees of motor involvement ranging from mild weakness to complete paralysis. Symptoms usually resolve within 10 to 15 minutes, whereas more severe cases can take up to 48 hours. Neck pain usually is not present. Hallmarks of the diagnosis include the absence of radiographic evidence of spinal cord or osseous injury and the self-limiting nature of the injury.

Expectant management and observation usually are sufficient for transient quadriplegia and spinal cord neurapraxia. Short-term immobilization, nonsteroidal antiinflammatories, and muscle relaxants commonly are used for symptomatic care. For more severe symptoms, a short course of oral steroids can be helpful. As symptoms resolve, mobilization of the cervical spine and physical therapy can be initiated.

Stingers

Stingers, also known as burners, are unilateral transient injuries affecting the brachial plexus or cervical nerve roots. They are among the most common cervical spine injuries in athletes. More than half of all college football players experience stingers each year.[30,31] Although a single isolated stinger is a benign injury, multiple recurrent episodes can cause morbidity over the long term.

Mechanisms

Several mechanisms explain the injury pattern of stingers. An abrupt extension and lateral head bending motion can result in compression of an ipsilateral nerve root (C5, C6, and C7 are most common).[31] Another mechanism involves direct traction injury to the brachial plexus; for instance, direct impact that causes shoulder depression places the brachial plexus under tension.

Several studies[31-33] suggest that some athletes may have an anatomic predisposition to sustaining stingers. One study[32] correlated an increased frequency of stingers in patients with cervical canal stenosis (low Torg ratios 0.8). Levitz et al,[31] in an observational study of 55 athletes with histories of stingers, noted that Spurling test findings were positive in 70% of the athletes, narrowed cervical canals were present in 53%, and 87% had evidence of disk disease shown by advanced imaging studies. In addition, 93% had disk disease or narrowing of the intervertebral foramina secondary to degenerative disk changes. The stinger phenomenon, however, is thought to occur at the cervical root and brachial plexus level and not at the cord level.

Nevertheless, Kelly et al,[33] in a similar study, used a control group for comparison. Lateral view radiographs of the cervical spine were reviewed for athletes who had sustained stingers. In addition to Pavlov ratios, another radiographic measurement was studied. The foramen: vertebral body ratio (foraminal height: height of the subjacent vertebral body) was studied because it was thought to better correlate with cervical root involvement. The study showed notable differences between the stinger group and the control group in mean minimum Pavlov ratios (0.875 for the stinger group and 0.94 for the control group) and in foramen: vertebral body ratios (0.65 for the stinger group and 0.72 for the control group). The results were statistically significant, suggesting that athletes sustaining stingers had increased risk for cervical canal and foraminal stenosis.

Patients incurring stingers most often report dysesthesias and numbness in the affected extremity. Associated weakness may also be present. Important characteristics of the injury are that it involves only one extremity at a time and symptoms are transient. Stingers can take from a few seconds to several hours to resolve. Neck pain is not a hallmark finding, and patients usually have full painless range of motion of the neck.

Stingers usually are self-limiting, and treatment involves conservative care (nonsteroidal antiinflammatories and short-term immobilization) and close monitoring of symptoms. Once radicular symptoms and weakness resolve, players can return to play without restriction. If symptoms persist or if neck stiffness, limitations in neck motion, neck pain, or bilateral symptoms are present, the patient should be reexamined.[34] Any symptoms lasting longer than a day warrant further evaluation with additional diagnostic studies. MRI can be performed in such persistent cases to rule out disk herniation, which often presents with overlapping symptoms.

Although viewed as a benign injury, repetitive stingers can cause permanent deficits. Electromyography is a useful adjunctive test; the presence of moderate sharp waves or fibrillation potentials with abnormal findings of a neurological examination is a contraindication to further contract sports until symptoms resolve. Classification systems are not frequently used when describing stingers. Clancy et al,[30] in 1977, proposed a classification system based on the duration of symptoms (Table 1).

Disk Herniation

Cervical spine disk herniation is caused by tearing of the annulus fibrosis with subsequent extrusion of the nucleus

Table 1 Classification System Based on Duration of Symptoms[31]

Grade	Duration of Symptoms
Grade I	2 weeks
Grade II	2 weeks-1 year
Grade III	1 year

pulposus. The herniation results in varying degrees of neurological involvement depending on the extent and location of the herniation. Compression of the associated nerve root causes symptoms in the affected dermatomes. Patients usually present with acute onset of posterior neck pain and spasms with associated radiculopathy, paresthesia, weakness, and numbness. The most common levels of involvement include C6 and C7. One cannot exclude disk herniation based on the absence of radicular symptoms. Patients may have nonspecific shoulder or trapezial pain without radiation into the arm. All patients should be evaluated for potential upper motor neuron signs (Hoffmann sign, inverted brachioradialis reflex, clonus, hyper-reflexia, and gait abnormalities). The findings should be correlated to MRI findings.

Initial treatment is the same as for all cervical spine injuries. Patients should be adequately immobilized. Short-term immobilization for rest may be helpful for acute symptoms. Surgical indications include the following: (1) protracted symptoms for longer than 6 weeks without evidence of improvement, (2) devastating neurological loss (C5 palsy), and (3) progressive neurological deficit. Surgical management can be performed using an anterior approach (diskectomy with or without fusion) or a posterior laminoforaminotomy (with or without diskectomy), depending on the location of the herniation.

Fractures and Unstable Ligamentous Injuries

The cervical spine can incur a wide variety of fracture patterns depending on the position of the spine at the time of impact (Table 2). Concomitant ligamentous injuries account for the vast majority of catastrophic cervical spine injuries and most often occur in the subaxial spine.

Depending on the forces involved, the hyperflexion mechanism may result in bilateral facet dislocation, as often occurs with severe diving injuries. Any rotational component will cause a unilateral facet dislocation. Bilateral facet dislocations have the highest incidence of spinal cord injury (50%). Neurological involvements vary. Patients may present neurologically intact or may have incomplete or complete spinal cord injury patterns.

Patients with cord injuries are at risk for neurogenic shock and should be carefully evaluated. The presence of complete or incomplete cord injury is assessed with an examination of sacral function, especially in the acute setting when spinal shock is present. Resolution of spinal shock is marked by return of sacral reflexes.

Specific Cord Injury Patterns

The diagnosis of specific incomplete cord injuries can assist clinicians in determining overall prognosis.[35] The patterns are summarized in Table 3. In the acute setting, the goals of managing cervical spine injuries include reduction of any associated fractures or dislocations and subsequent stabilization. Cervical traction can safely be used for closed reduction of fractures and dislocations in any awake, alert, and cooperative patient regardless of the initial neurological deficit. Further use of traction should be aborted if the neurological examination shows any sign of deterioration. In unconscious patients and in cases in which it is difficult to obtain consistent examination findings, MRI should be performed to rule out concomitant disk herniation, which can cause compression of the spinal cord during reduction. Furthermore, all patients who undergo closed reduction should also undergo MRI after the reduction is completed. The presence of significant disk herniation necessitates surgical treatment. Anterior diskectomy decompression usually is performed before any posterior stabilization procedure. Unilateral facet dislocations and bilateral facet dislocations necessitate surgical treatment through a posterior, anterior, or combined approach.

Patients with cervical spinal cord injury should be adequately resuscitated, with special attention given to maintaining mean arterial blood pressures 85 mm Hg to assist with cord perfusion. Officially, the National Acute Spinal Cord Injury Study III Trial recommended the use of intravenously administered methylprednisolone for patients with acute spinal cord injury, but a fair amount of controversy exists regarding the clinical benefits of steroid use versus the associated complications.[36,37] Currently, it is up to the practitioner to weigh the pros and cons of intravenously administered methylprednisolone and determine whether its use is indicated.

Return-to-Play Criteria

The decision to allow an athlete to return to playing contact sports often is challenging and variable. It is dependent on

Table 2 Cervical Spine Fracture Patterns

Compression	Anterior and posterior columns undergo direct vertical pressure, resulting in failure; burst fracture occurs, with displacement of osseous structures into canal
Compression-flexion	Axial load applied to vertex of skull at position of flexion; compressive forces are along anterior column, and tensile stresses are on posterior ligamentous structures
Flexion	Rapid deceleration or direct impact to posterior skull; primary mechanism involves severe tensile stresses to posterior ligamentous structures

Table 3 Incomplete Spinal Cord Injury Syndromes

Syndromes	Mechanism and Cord Involvement	Neurological Loss	Prognosis
Central cord	Hyperextension (usually with preexisting stenosis); central portion of cord	Upper-extremity motor worse than lower, and distal worse than proximal; variable sensation	Favorable
Anterior cord	Anterior two-thirds of cord; anterior columns	Paraplegia or quadriplegia + loss of pain and temperature sensitivity	Poor, if no recovery within 24 hours
Posterior cord	Posterior one-third of cord; posterior columns	Loss of motor and proprioception	Rare
Brown–Séquard	Penetrating trauma; hemisection	Ipsilateral loss of motor, vibratory, and proprioception; contralateral loss of pain and temperature sensitivity	Best

the context of the injury, the number of previous injuries, and any known risk factors. Furthermore, pressures from players, coaching staff, and family add another dimension to the decision-making process. Although published guidelines do exist, it is unclear how often or to what degree they are used. One study used a questionnaire to assess physicians' return-to-play decision-making processes after cervical spine injury.[38] The study evaluated the use of published guidelines, type of sport, number of years in practice, subspecialty interest, and sports participation of the physician in return-to-play decision making. The study showed that even though 49% of the surgeons reported using guidelines in their decision-making process, the use of guidelines was statistically significant in one case. A statistically significant correlation was shown between the number of years a physician was in practice and the type of return to play that was selected by the physician. More senior physicians were noted to recommend a "lower level of play." Physicians with spine subspecialties were found to recommend higher levels of play compared with other specialties. Overall, the study concluded that no consensus was reached regarding postinjury management of patients with cervical spine injuries.

Return-to-Play Guidelines

Return-to-play decisions on the field after an acute injury can be challenging and should be made taking into account the injury, the physical examination findings, and the history of injuries for that particular athlete. Physicians should resist pressure from coaches, fans, and family members in the decision-making process. A patient who sustains a first-time isolated stinger can return to play in the same game when neck motion is painless, paresthesia is resolved, and no motor weakness is present. Any patient who presents with bilateral upper extremity symptoms suggestive of transient quadriplegia, a history of multiple stingers (>3), unilateral and sustained symptoms that do not resolve (such as paresthesia and/or weakness), or limitations in neck range of motion should be taken out of the game, immobilized, and carefully evaluated as an outpatient with further testing as needed. Most return-to-play decisions are made in the outpatient setting.

Conclusions

Cervical spine injuries present diagnostic and subsequent on-field management challenges. Immediate return-to-play decisions on the field depend on accurate diagnoses and use of clinical guidelines that can assist in the decision-making process. For each injured athlete, assess the mechanism of injury, clinical symptoms, known preexisting structural abnormalities, history of insults, and nature of the sport involved. The successful management of a patient with a suspected cervical spine injury is dependent on careful on-field management of these potentially devastating injuries.

Acknowledgments

The authors thank senior editor and writer Dori Kelly, MA, University of Maryland School of Medicine, for expert assistance with the manuscript.

References

1. Spinal Cord Injury Information Network: Facts and figures at a glance: April 2009. Available at: http://www.spinalcord.uab.edu/show.asp?durki=119513&site=4716&return=19775. Accessed October 22, 2009
2. Tator CH: Recognition and management of spinal cord injuries in sports and recreation. Neurol Clin 26:7988:viii, 2008
3. Torg JS, Vegso JJ, O'Neill MJ, et al: The epidemiologic, pathologic, biomechanical, and cinematographic analysis of football-induced cervical spine trauma. Am J Sports Med 18:50-57, 1990
4. Mueller FO: Fatalities from head and cervical spine injuries occurring in tackle football: 50 years' experience. Clin Sports Med 17:169-182, 1998
5. Mueller FO, Cantu RC: Annual Survey of Catastrophic Football Injuries. Available at: http://www.unc.edu/depts/nccsi/FootballCatastrophic.pdf. Accessed October 29, 2009
6. Torg JS, Vegso JJ, Sennett B, et al: The National Football Head and Neck Injury Registry: 14-year report on cervical quadriplegia, 1971 through 1984. JAMA 254:3439-3443, 1985
7. Biasca N, Wirth S, Tegner Y: The avoidability of head and neck injuries in ice hockey: an historical review. Br J Sports Med 36:410-427, 2002
8. National Hockey League: Official Rules: rule 44: checking from behind. Available at: http://www.nhl.com/ice/page.htm?id=26333. Accessed October 22, 2009
9. Banerjee R, Palumbo MA, Fadale PD: Catastrophic cervical spine injuries in the collision sport athlete. Part 2: principles of emergency care. Am J Sports Med 32:1760-1764, and Appendix 1 and 2, 2004
10. Vale FL, Burns J, Jackson AB, et al: Combined medical and surgical treatment after acute spinal cord injury: results of a prospective pilot

study to assess the merits of aggressive medical resuscitation and blood pressure management. J Neurosurg 87:239-246, 1997
11. Lennarson PJ, Smith DW, Sawin PD, et al: Cervical spine motion during intubation: efficacy of stabilization maneuvers in the setting of complete segmental instability. J Neurosurg 94:265-270, 2001 (suppl 2)
12. Ching RP, Watson NA, Carter JW, et al: The effect of post-injury spinal position on canal occlusion in a cervical spine burst fracture model. Spine 22:1710-1715, 1997
13. De Lorenzo RA: A review of spinal immobilization techniques. J Emerg Med 14:603-613, 1996
14. McGuire RA, Neville S, Green BA, et al: Spinal instability and the log-rolling maneuver. J Trauma 27:525-531, 1987
15. Del Rossi G, Horodyski MH, Conrad BP, et al: The 6-plus-person lift transfer technique compared with other methods of spine boarding. J Athl Train 43:613, 2008
16. Del Rossi G, Horodyski M, Conrad BP, et al: Transferring patients with thoracolumbar spinal instability: are there alternatives to the log roll maneuver? Spine 33:1611-1615, 2008
17. Del Rossi G, Heffernan TP, Horodyski M, et al: The effectiveness of extrication collars tested during the execution of spine-board transfer techniques. Spine J 4:619-623, 2004
18. Ransone J, Kersey R, Walsh K: The efficacy of the rapid form cervical vacuum immobilizer in cervical spine immobilization of the equipped football player. J Athl Train 35:65-69, 2000
19. Donaldson WF III, Lauerman WC, Heil B, et al: Helmet and shoulder pad removal from a player with suspected cervical spine injury: a cadaveric model. Spine 23:1729-1732, 1998
20. Horodyski M, DiPaola CP, DiPaola MJ, et al: Comparison of the flat torso versus the elevated torso shoulder pad removal techniques in a cadaveric cervical spine instability model. Spine 34:687-691, 2009
21. McCulloch PT, France J, Jones DL, et al: Helical computed tomography alone compared with plain radiographs with adjunct computed tomography to evaluate the cervical spine after high-energy trauma. J Bone Joint Surg 87:2388-2394, 2005
22. Hanson JA, Blackmore CC, Mann FA, et al: Cervical spine injury: a clinical decision rule to identify high-risk patients for helical CT screening. AJR Am J Roentgenol 174:713-717, 2000
23. Li AE, Fishman EK: Cervical spine trauma: evaluation by multidetector CT and three-dimensional volume rendering. Emerg Radiol 10:34-39, 2003
24. Wang JC, Hatch JD, Sandhu HS, et al: Cervical flexion and extension radiographs in acutely injured patients. Clin Orthop Relat Res 365:111-116, 1999
25. Torg JS, Sennett B, Pavlov H, et al: Spear tackler's spine: an entity precluding participation in tackle football and collision activities that expose the cervical spine to axial energy inputs. Am J Sports Med 21:640-649, 1993
26. Torg JS, Pavlov H, Genuario SE, et al: Neurapraxia of the cervical spinal cord with transient quadriplegia. J Bone Joint Surg 68:1354-1370, 1986
27. Torg JS, Guille JT, Jaffe S: Injuries to the cervical spine in American football players. J Bone Joint Surg 84:112-122, 2002
28. Zwimpfer TJ, Bernstein M: Spinal cord concussion. J Neuosurg 72:894-900, 1990
29. Torg JS, Thibault L, Sennett B, et al: The Nicolas Andry award: the pathomechanics and pathophysiology of cervical spinal cord injury. Clin Orthop Relat Res 321:259-269, 1995
30. Clancy WG Jr, Brand RL, Bergfield JA: Upper trunk brachial plexus injuries in contact sports. Am J Sports Med 5:209-216, 1977
31. Levitz CL, Reilly PJ, Torg JS: The pathomechanics of chronic, recurrent cervical nerve root neurapraxia: the chronic burner syndrome. Am J Sports Med 25:73-76, 1997
32. Meyer SA, Schulte KR, Callaghan JJ, et al: Cervical spinal stenosis and stingers in collegiate football players. Am J Sports Med 22:158-166, 1994
33. Kelly JD IV, Aliquo D, Sitler MR, et al: Association of burners with cervical canal and foraminal stenosis. Am J Sports Med 28:214-217, 2000
34. Vaccaro AR, Watkins B, Albert TJ, et al: Cervical spine injuries in athletes: current return-to-play criteria. Orthopedics 24:699-703, 2001
35. Merriam WF, Taylor TK, Ruff SJ, et al: A reappraisal of acute traumatic central cord syndrome. J Bone Joint Surg 68:708-713, 1986
36. Bracken MB, Shepard MJ, Holford TR, et al: Administration of methylprednisolone for 24 or 48 hours or tirilazad mesylate for 48 hours in the treatment of acute spinal cord injury: results of the third national Acute Spinal Cord Injury Randomized Controlled Trial: national acute spinal cord Injury Study. JAMA 277:1597-1604, 1997
37. Hurlbert RJ: The role of steroids in acute in acute spinal cord injury: an evidence-based analysis. Spine 26:S39-46, 2001 (suppl 24)
38. Morganti C, Sweeney CA, Albanese SA, et al: Return to play after cervical spine injury. Spine 26:1131-1136, 2001