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REVIEW ARTICLE

Cervical Spine Injuries in Sports

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ABSTRACT

Injuries to the cervical spine in athletes are rare but potentially devastating outcomes resulting from involvement in sports activities. New rules and regulations implemented by national sports organizations have helped to decrease the rate of cervical spine and spinal cord injuries sustained by athletes. A basic understanding of cervical spine anatomy, physical examination and spine precautions is necessary for any physician evaluating athletes on the field to determine if transfer to higher level of care is needed. It is particularly important to know the systematic protocol for spine immobilization, neurologic exam and helmet removal in a patient with a suspected cervical spine injury. While cervical strain is the most common cervical spine injury, physicians should be familiar with the presentation for other injuries, such as Burner's syndrome (Stinger), cervical disk herniation, transient quadriplegia and cervical spine fractures or dislocations. Special consideration is needed when evaluating patients with Down syndrome as they are at higher risk for atlantoaxial instability. Determination of when an athlete can return to play is patient-specific with early return to play allowed only in a completely asymptomatic patient.

Keywords: Athlete, Cervical, Cervical spine, Sports, Sports injury, Management.

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INTRODUCTION

Athletic injuries account for approximately 10% of all cervical spine injuries in the United States.[1] Cervical spine injury has been reported in football, soccer, wrestling, basketball, trampoline, sledding, baseball, hockey, water sports, diving and rugby with the majority occurring in collision sports.[2,3] Injuries range from transient radiculopathies to permanent, complete spinal cord injury. Here, we review the incidence and management of a variety of cervical spine injuries that can be seen among athletes.

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INCIDENCE

The sports associated with the highest rates of spine injuries include football, ice hockey, wrestling, driving, skiing, snowboarding, rugby, cheerleading and baseball.[4] The majority of these spine injuries involve axial forced applied to the head with the head in slight flexion. Football has been associated with the highest number of spine injuries; however, the actual rate of spine injuries in higher in gymnastics and hockey.

Rates of devastating spine injuries in contact sports, particularly football, have decreased dramatically due to improved equipment, medical care, rule changes, and coaching. In 1976, the National Collegiate Athletic Association (NCAA) banned the intentional striking of an opponent with the crown of the helmet (spearing) in football. In 1978, the National Operating Committee of Safety of Athletic Equipment (NOCSAE) implemented the football helmet standard for collegiate football which was subsequently implemented at the high school level 2 years later. As of 1976, the rate of quadriplegia was 2.24/100,000 players in high school and 10.66/100,000 in college.[5] From 1989 to 2002, the overall incidence of quadriplegia dropped to 0.82/100,000 at the college level and 0.5/100,000 at the high school level. While not completely understood, the discrepancy in quadriplegia incidence is likely due to bigger, faster and stronger players at the college level. Despite the rule changes, spear-tackling continues to be the most common cause of quadriplegia with defensive players being at the greatest risk for this injury. There is a continued focused effort in player education on proper tackling technique to further reduce incidence in cervical quadriplegia.[6]

Ice hockey has one of the highest rates of cervical spine injuries. The majority injuries occur at the C5-7 levels and result from body-checking when the head is tilted downward.[4] During the 1980s, the incidence of spine injuries in ice hockey significantly increased as checking became a more accepted part of the game. In 1994, the International Ice Hockey Federation established that checking or pushing from behind qualifies as a penalty. This rule change has led to lower spine injury rates. Further, changes including padded boards are being assessed to help further decrease the rate of spine injury among ice hockey players.

Wrestling has the highest rate of catastrophic injuries to cervical spine.[4] The rate of catastrophic injury is around

1 per 100,000 high school and collegiate wrestlers, most commonly occurring with a takedown of an opponent. Injury prevention is currently focused on education by coaches and referees on safe rolling techniques and discouragement from 'slams,' or takedowns with excessive force.

Though there remains potential for improvement in equipment in many other sports, the primary focus of cervical spine injury prevention remains legislation of new rules or amendments to current rules and education on proper playing technique.

ANATOMY AND MECHANICS

The cervical spine consists of seven cervical vertebrae. The occiput, atlas and axis comprise the 'upper cervical spine'. The atlanto-occipital articulation accounts for 50% of cervical flexion-extension motion. The atlanto-axial articulation accounts for 50% of cervical rotation motion. The 'lower cervical spine' includes C3 through C7. Progressing down the spinal column, the diameter of the bony canal gradually narrows as the diameter of the spinal cord widens, thus reducing the space available for the cord in the inferior cervical spine.

Cervical stenosis is defined as a canal diameter that is less than 13 mm or a Pavlov ratio (cervical canal diameter/vertebral body width) less than 0.8 on a lateral radiograph.[2] In neutral position, the overall alignment of the cervical spine is lordotic. When engaging in collision sports, the majority of force is dissipated by the paravertebral musculature. If the neck is flexed, however, lordosis is reduced and the cervical sagittal alignment becomes straight. If a tackle is made in this position (spear tackling), the axial load is absorbed by the spine causing compression of the cervical spine, which can result in catastrophic spine injury.[6] The majority of cervical spine injuries sustained by athlete results from an axial force when the spine is in a flexed position.

Particularly at the high school level, special consideration should be given to the pediatric cervical spine. Children have more horizontally oriented facets, increased capsular and ligamentous laxity, and their paracervical musculature is not fully developed, all of which leads to a relative hypermobility. However, children tend to recover faster and sustain less disabling injuries than adults.[7]

Physical Examination including Provocative Maneuvers

The examination of an awake and alert patient with neck pain after an injury should begin with palpation of the spinous processes and paracervical musculature. Active range of motion is evaluated in flexion, extension, lateral flexion (both directions) and rotation. A complete sensorimotor evaluation of the extremities is performed with attention toward any sensory deficits that occur in dermatomal distributions. Biceps, brachioradialis and triceps deep tendon reflexes should be tested. Spurling's maneuver should be assessed. This is tested by applying axial load to spine with patient's head turned toward side of interest. This maneuver narrows the vertebral foramen, reproducing radicular symptoms. Controlled separation of the head and shoulder can be used to reproduce symptoms of a traction injury to the brachial plexus.

Cervical Spine Injuries

Cervical Strain

Paraspinal muscle strain and cervical ligament sprain are the most common cervical spine injuries in athletes. Direct blows or rapid eccentric muscle contraction can cause strains of the muscle. Forced flexion of the head and neck can cause ligamentous sprains or capsular injures of the facets. Patients will present with localized pain without radiation or neurologic deficit and range of motion may be limited secondary to pain. When an athlete complains of acute pain after a contact injury, a cervical collar should be prophylactically placed as further work-up is initiated. Anteroposterior, lateral and odontoid radiographs should be obtained initially and lateral flexion/extension radiographs can be used to assess for instability. The mainstay of treatment is immobilization and anti-inflammatories until pain resolves. The collar can be discontinued and the patient can return to play once full, painless range of motion is demonstrated.

Burners Syndrome (Stinger)

Burners syndrome is condition marked by temporary burning and weakness in a single upper extremity, most commonly occurring at the C5 and C6 distribution. The mechanism is due to a traction injury to the brachial plexus in younger athletes and compression of the upper cervical roots in adult athletes. The cervical foramina are narrowed transiently when the cervical spine is forced into hyperextension alone or in combination with lateral flexion or shoulder elevation to the affected side resulting in transient radiculopathy. Athletes complain of a transient paralysis with a burning sensation that radiates from the shoulder to the fingertips. Full recovery normally returns within 10 minutes. The athlete can be allowed to return to play once symptoms resolve and they are assessed to have a normal cervical spine and upper extremity sensorimotor exam. Athletes should be

restricted from play if they have had more than three episodes, cervical stiffness and tenderness, persistent weakness or both upper extremities are involved. These athletes should undergo formal imaging and examination to rule-out potential anatomical variations or pathology that pose an increased potential for permanent injury. Once these entities are ruled out, the athlete should undergo a period of rest and upper extremity strength rehabilitation.[7]

Intervertebral Disk Herniation

Acute disk herniations result from an axial load that rapidly increases intradiscal pressure. The nucleus pulposus is extruded through the annulus fibrosus into the spinal canal or neuroforamen, compromising the space available for the spinal cord or nerve roots. The resulting cord injury can be either transient or permanent. The athlete may present with paralysis of all four extremities, loss of pain and temperature sensation, posterior neck pain and/or paraspinal spasm.[2] Patients may also present with anterior cord syndrome. Magnetic resonance imaging (MRI) is the gold-standard for diagnosis of a herniated disk.

Transient Quadriplegia

Neurapraxia of the cervical cord can result in transient quadriplegia. Hyperextension can cause infolding or bunching of the ligamentum flavum creating a dynamic narrowing of the canal. Hyperflexion can cause a pincer effect between the lamina of the cranial vertebra and the endplate of the caudal vertebra. Brief compression of the cord creates a 'postconcussive' effect on the cord.[2] Athletes with cervical stenosis may be predisposed to transient quadriplegia. A Pavlov/Torg ratio of less than 0.8 was found in 93% of football players with transient quadriplegia. The recurrence rate in football players has been reported as high as 56%.[8]

Athletes present with pain, burning and tingling bilaterally that is thought to be due to local compression or contusion of the cord. Symptoms can be in the upper extremities, lower extremities or both with variable penetration of motor deficits. The symptoms are temporary with complete recovery usually occurring within 15 minutes, but in some recovery may take up to 48 hours.

Congenital Anomalies and Down Syndrome

Congenital anomalies change the structural integrity of the cervical spine, predisposing an athlete to catastrophic injury. Klippel-Feil syndrome is a failure of segmentation characterized by fusion of two or more vertebrae. With an increasing number of fused segments, fewer motion segments can dissipate applied loads, inherently increasing the risk of injury at the remaining mobile segments. Odontoid hypoplasia can result in atlantoaxial instability placing the athlete at risk of spinal cord injury from a variety of mechanisms.

Athletes with Down syndrome have hypermobile occipitocervical and atlantoaxial articulations. Atlantoaxial instability is defined as an atlantodens interval (ADI) of 5 mm or more and is seen in 10 to 30% of Down syndrome patients.[9] Some athletic organizations, including the special olympics, require lateral flexion-extension radiographs to screen athletes with Down syndrome prior to participation in high-risk sports, such as gymnastics and contact sports. An athlete with an atlantodens interval greater than 5 mm, but less than 10 mm, is restricted from high-risk sports. Patients with progressive instability, myelopathy or an ADI greater than or equal to 10 mm warrant evaluation for surgical stabilization.[7]

Unstable Fractures and Dislocations

Upper cervical spine fractures or dislocations rarely cause spinal cord injury due to greater space available cord in the cervical spine. Most fractures and dislocations occur in the lower cervical spine. In a compressive-flexion injury, axial force and a bending moment result in shortening of the anterior column. This is often referred to as a 'teardrop' injury and is frequently associated with spinal cord injury. When the injury is purely compressive, an axial load causes failure of the endplate resulting in a burst fracture. Retropulsion of bony fragments often results in spinal cord compromise. Flexion-distraction injury results in facet dislocation.

A range of neurologic deficits are possible in athletes with unstable fractures, dislocations or both. However, athletic spinal cord injuries are most often incomplete. Central cord syndrome, where upper extremity weakness is more pronounced than lower extremity weakness, is the most common pattern.[10] A variant of this, 'burning hands' syndrome, is a condition whereupon dysesthesias occur both hands without sensorimotor loss.[11]

Permanent Neurologic Deficits

Permanent deficits occur most commonly with fractures and dislocations. Increased risk for permanent neurologic damage is associated with 'spear tackler's spine.' Torg described this entity as follows:

- Narrowed cervical canal (a Pavlov/Torg ratio of <0.8 at 1 or more levels).
- Persistent reversal of the normal cervical lordosis.
- Concomitant pre-existing post-traumatic radiographic abnormalities of the cervical spine.

Permanent neurologic injury occurred in 4 of 15 cases identified with spear tackler's spine. Athletes with

a diagnosis of 'spear tackler's spine' are restricted from collision sports.[6]

On-field Management of a Player with a Suspected Neck Injury

Immobilization

When a spine injury is suspected, the athlete should be removed from play after manual cervical spine stabilization or placement of a cervical collar with the spine in neutral position. If the spine is not in a neutral position, it should be realigned to neutral for optimal airway management. Contraindications' placement of the spine in a neutral position include increased pain from movement, neurologic symptoms, muscle spasm or airway compromise, any difficulty repositioning the spine, resistance encountered or patient apprehension.[12] The facemask should be removed prior to transport.[13] It is important to know whether a wire cutter, screwdriver or both are needed to remove the facemask. Both tools need to be a part of the sideline medical supplies at football games. Before the athlete is moved, airway, breathing and circulation should be assessed. Once these are stabilized, the athlete is transferred onto a spine board taking care to move the head and trunk as a unit in logroll fashion. Taping or strapping the helmet to the backboard for transportation effectively immobilizes the athlete's head.

Helmet Removal

The helmet and shoulder pads should remain in place during the initial clinical and radiographic assessment. According to NCAA guidelines,[12] the helmet should not be removed on the field when there is the potential of a head or neck injury unless there are specific circumstances, such as respiratory distress coupled with an inability to access the airway or one of the following:

- The helmet does not adequately immobilize the head.
- Airway cannot be controlled due to design of the helmet.
- The facemask cannot be removed after a reasonable amount of time.
- The helmet prevents immobilization in an appropriate position.

X-rays should be obtained with the helmet and shoulder pads in place. If plastic or metal prevents adequate visualization of the cervical spine, the helmet and shoulder pads may be removed, although some recommend bypassing triage and proceeding directly to CT scan.[14] Follow the 'all or none' policy in both youth and adults where both the helmet and shoulder pads are left on or removed at the same time.[15]

Removal of the helmet and shoulder pads should be performed with two people, with one person immobilizing the head and neck at all times.[16] The second person begins with removal of the facemask followed by the chin strap. The cheek/jaw pads are removed next by using scissors under the pads and twisting to loosen them. The exception is with the Riddel Revolution helmet where the pads must be deflated with an 18 gm needle prior to removal. Next, the air inflation system is deflated using one of the external ports with an 18 gm needle or air pump needle. The assistants switch places with the second person assuming head immobilization using one hand to hold the mandible and the other hand underneath the occiput. The first person places a thumb in each earhole of the helmet and curls their fingers underneath the helmet edges, removing the helmet by gently rotating it off the head taking care not to pull laterally. This should be performed simultaneously with pad removal to avoid the head from falling into hyperextension. If unable to perform simultaneously, the head must be immobilized at all times for staged removal of the helmet and shoulder pads. A cervical collar should be placed following removal of equipment.[16]

Return to Play

The majority of the studies regarding return to play after sustaining a cervical spine injury are class III evidence. Most recommendations are made on an individual basis and based on clinical judgment.[16] In general, patients who are completely pain free with full range of motion and strength may be eligible for return to play if no other injuries are present. However, potential cervical spine injuries should be handled on a case-by-case basis and involve thorough evaluation by a trained physician to make the determination.

SUMMARY

Cervical spine injuries can be potentially devastating injuries to athletes and should be treated systematically and using every precaution necessary. Thorough evaluation should be performed of all suspected injuries maintained cervical spine immobilization, return to play should be based determined on an individual basis with only completely asymptomatic patients cleared for early return.

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