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Cervical Spine Injury in Athletes

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As humanity pushes forward in its relentless drive to expand its physical capabilities and surpass traditional human limits, the stresses the body endures would be expected to yield to a higher incidence of mechanical failure. The cervical spine, its eloquent contents, and its precarious interposition between a 60 kilogram body mass and a 10 kilogram head mass make it exquisitely susceptible to such mechanical failure. Unfortunately, this can lead to catastrophic neurologic injury. Athletes are bigger, stronger, and faster than ever before. What is common place today was considered extreme 10 years ago. What is considered extreme today was considered ridiculously inconceivable 10 years ago. Yet, in professional athletics, the incidence of cervical spinal cord injury is actually decreasing. Neuroepidemiologic, and biomechanical studies combined with improved understanding of kinesthetic physiology, have protected athletes from succumbing to the injuries associated with the ever-increasing demands we place on the human body. An understanding of these sciences and the athletic activities themselves, allows those that train, coach, parent, or otherwise care for athletes to contribute to the overall success of an athlete while minimizing the risks of spinal cord injury.

Introduction. Athletic competition contributes bountifully to the degree of satisfaction we experience in our lives. It gives us a sense of accomplishment, a sense of fulfillment, and a sense of pride. The accomplished athlete holds special esteem in our culture. External forces motivate us to push ourselves towards this end, but with these activities comes certain risks. There is little doubt that the positive attributes of athletic competitive participation far outweigh the risks of serious injury, nonetheless accidents do happen. Athletes, physicians, trainers, and coaches who possess a basic understanding of the biomechanics involved with various sports, cervical anatomy, and physiology can recognize the specific risks, and identify those who

References

1. Torg JS, Vegso JJ, Sennett B. The National Football Head and Neck Injury Registry: 14-year report on cervical quadriplegia (1971-1984). *Clin Sports Med.* 1987;6:61-72.

2. Feuer H. History, examination, and acute management of spinal injury. In: Nicholas JA, Hershman EB, eds. *The lower extremity and spine in sports medicine.*St. Louis, MO. Mosby. 1995.

3. Green BA, Eismont FJ, O'Heir JT. Pre-hospital management of spinal cord injuries. *Paraplegia*. 1987;25:229-238.

4. Green BA, Eismont FJ. Acute spinal cord injury: a systems approach. *Cent Nerv Syst Trauma.* 1984;1

may be at risk. This advance knowledge allows the implementation of appropriate safety equipment, training and counseling in the fight to minimize risk.

Knowledge of current treatment modalities will minimize extension of an injury and provide enhanced opportunity for recovery potential. For those with resolved injuries, analysis of potentially rectifiable etiologies of injury needs to be accomplished prior to return to play. Anatomic variances, equipment inadequacies, technique, strength, or conditioning deficiencies are some of the factors that may be analyzed.

An understanding of cervical biomechanical anatomy, various risk categories, and an ability to identify those at risk is paramount in undertaking a risk prevention analysis. Such analysis rewards athletes with a playing environment with the lowest possible injury risk. The backbone of a comprehensive risk reduction plan is “The doctrine of shared responsibility.” This doctrine states that the athlete, parents, trainers, coaches, medical personnel, and other involved persons all share in the responsibility to minimize risk.

Neuroepidemiology. Neuroepidemiology is the scientific foundation upon which factors are determined that influence injury rates in athletics. It is the basis by which changes in technique, equipment, training, conditioning, and other factors are recommended. It does not take into account the financial or economic cost of recommended changes.

In general, the economic costs associated with caring for a spinal cord injured athlete are quite high. Thus it substantiates higher financial costs associated with injury prevention. For this reason, the NFL and other professional athletic organizations have spent hundreds of millions of dollars in studying spinal cord injury and prevention strategies. The results have paid off. Despite athletes being bigger, stronger, and faster than ever before, the incidence of spinal cord injury has dropped significantly since the late 1970’s. In professional sports the incidence of spinal cord injury has dropped by 50% to 75%.1 The incidence in amateur sports has not dropped as significantly. There are several reasons for this.

Differences in professional and amateur injury rates. The difference between professional and amateur injury rates is due to a multitude of factors. Money, age, size, and education all play a roll. An

(2):173-195.

5. Bracken MB, Shepard M, Holford TR, et al. Administration of methylpednisolone for 24 or 48 hours or trilizaed mesylate for 48 hours in the treatment of acute spinal cord. *JAMA*. 1997;277:1597-1604.

6. Bracken MB, Shepard MJ, Collins WF, et al. A randomized, controlled trial of methylprednisolone or naloxone in the treatment of acute spinal cord injury. Result of the second National Acute Spinal Cord Injury Study. *N England J Med.* 1990;322:1405-1411.

7. Wada K, Alonso OF, Busto R. Early treatment with a novel inhibitor of lipid peroxidation (LY341122) improves histopathological outcome after moderate fluid percussion brain injury in rats. *Neurosurgery*. 1999;45:601-608.

8. Berthea JR, Nagashima H, Acosta MC, et al. Systemically administered Interleukin-10 reduces tumor necrosis factor-

injured professional athlete is economically more expensive than an amateur athlete. Therefore, the protection of the professional athlete at a higher financial cost is acceptable. Their protective equipment is custom fit and state of the art. Age also plays a roll. The younger athlete has different external motivators, and biomechanical tissue properties. Younger athletes function against peer pressure and do not consider consequences of their actions as readily as older individuals. The younger athlete has increased ligamentous laxity allowing for greater range of bony motion. This predisposes younger athletes to a special kind of cervical spinal cord injury called spinal cord injury without radiographic abnormality (SCIWORA). In the teenage years, size is an important factor as maturity rates vary greatly during this time. It is not uncommon for a 90 pound 15-year-old to share a team name with a 190-pound counterpart. Lastly, in general, professional athletes are educated as to the warning signs of potential problems so that they can be addressed before disaster strikes. These factors and the fact that safety measures applied to professional athletes “trickle” down to amateur athletes at a slow pace account for the discrepancy in injury rates between professional and amateur athletes.

Cervical spine biomechanical anatomy. From a biomechanical standpoint, the anatomy of the cervical spine makes no sense. It seems paradoxical that the most delicate structure in the human body has the least protection here. This is the cost for the extensive range of motion the cervical spine provides. In simplistic terms, it is analogous to a 15-pound bowling ball whipping around on a stick. To compensate for this biomechanical weakness, there are 4 layers of protection; the cervical lordosis, the musculature, the ligaments, and the bony anatomy. The first line of defense is the normal cervical lordosis. In the neutral position this is generally 20 to 30 degrees. This acts as a shock absorber for axial loading. When the athlete straightens his cervical spine as in the ill fated “spear tackle”, he loses this protective lordosis and places himself at increased risk for axial loading injuries. In 1976 the National Collegiate Athletic Association (NCAA) passed “Rule 9-1-2-n” which prohibited spear tackling and the incidence of spinal cord injury dropped precipitously. The second line of defense is the cervical musculature. It is designed not only to provide strength and to resist gravity but also to resist excessive range of motion. When the cervical musculature fails, the third line of defense are the ligaments. Ligaments exist to resist excessive ranges of motion in every axis of motion. In adults they are less elastic and will generally fail before bone. In children they are more elastic and are less likely to fail before bone. When ligaments, either because of failure or

alpha production and significantly improves functional recovery following traumatic spinal cord injury in rats. *J Neurotrauma.* 1999;16:851-863.

9. Wieder B, Yu CG, Jimenez O, et al. Beneficial effects of modest systemic hypothermia on locomotor outcome and histophathological damage following contusion spinal cord injury in rats. *J Neurosurg*. 2000. In press.

10. Torg IS, Pavlov H, Genuario SE, et al. Neuropraxia of the cervical spinal cord with transient quadriplegia. *J Bone Joint Surg Am.* 1986;68:1354-1370.

11. Cantu RC. Cervical spine stenosis: Challenging an established detection method. *Physician Sports Med.* 1993;21 (9):57-63.

12. Cantu RV, Cantu RC. Guidelines for return to contact sports after transient quadriplegia. *J Neurosurg.* 1994;80:592-594.

13. Torg JS, Glasgow SG. Criteria for return

elasticity, allow excesses in bony range of motion, the bony housing of the spinal cord is the last line of defense. If its alignment or structure is lost, spinal cord injury is eminent.

to contact activity following cervical spine injury. *Clin J Sport Med.* 1991;1:12-26.

There are several biomechanical and anatomic differences in younger athletes that deserve special attention. Prior to puberty, the ratio of head size and weight to body weight is greater, thus placing an increased burden on the cervical spine. To magnify this dilemma, younger athletes are less likely to be able to resist excessive forces as a consequence of their usually less significant muscular development. Furthermore, the presence of growth plates creates weak areas in the spine. And as previously mentioned, there is increased ligamentous laxity. This laxity allows for excessive range of motion prior to ligamentous failure. This can lead to hyperextension and hyperflexion injuries without radiographic evidence of injury or so called SCIWORA.

Occasionally, safety equipment can actually magnify the anatomic and biomechanical differences of the younger athlete and actually increase the risk of injury. A good example of this is the helmet. When you strap on a heavy helmet to a child that is already less muscularly developed and has an increased head to body mass ratio you further increase the biomechanical stresses on the cervical spine. It is particularly important to strengthen the cervical musculature in those young athletes required to wear helmets.

Who can play? Every effort is made to allow all who are capable to participate in athletics. The benefits far outweigh the risks. There does however need to be a cost-effective way of identifying those at risk. Summary radiographs for all athletes clearly is not the answer. Often, school physical exams are done in mass and are meant to screen out common general medical ailments. They are rarely sensitive enough to identify the salient features of someone at risk for spinal cord injury. Several questions should be asked.

“Is there a history of exertional headaches?” These are headaches that are only caused by activity. Fully, 30 % of such athletes are found to have anatomic explanations for the headache and associated risks for spinal cord injury. Secondly ask, “Is there is a history of tingling or numbness in one or both upper extremities with any activity in the past?” Commonly called “stingers,” children often experience these very transient symptoms while “horsing around.” They are self-limited and last seconds to minutes. If unilateral, they are rarely a concern and do not need to be pursued unless they are recurrent. If they are bilateral, this may be the only heralding symptom of congenital or acquired cervical stenosis and should be evaluated thoroughly prior to allowing participation.

On physical exam, any evidence of myelopathy, ie, hyper-reflexia, or spasticity, should be evaluated thoroughly prior to play. Neurological referral and appropriate radiographic evaluation is recommended prior to participation.

There are several unique circumstances that deserve special attention. Athletes with Down's syndrome, achondroplasia, or seizure disorders, are like any other athlete in that they greatly benefit from athletic activity and should not necessarily be limited from participation. However, they do have special risk considerations.

Athletes with Down's syndrome have a 10% to 40% percent incidence of occipito-cervical and atlanto-axial instability due to extreme ligamentous laxity. This places them at a theoretical increased risk of cervical spinal cord injury. In the literature however, the incidence of spinal cord injury in such athletes has not necessarily been increased over the normal age matched population. Nonetheless, we recommend screening with flexion and extension dynamic images of the cervical spine and, if subluxation exists, we follow the recommendation of the Special Olympics Committee and recommend restriction from activities such as diving, gymnastics, high jump, butterfly stroke, alpine skiing, soccer, and power lifting. They can usually be counseled to allow them to excel in another athletic activity.

Athletes with achondroplasia generally suffer from multiple levels of cervical and spinal stenosis. Often there is tight stenosis at the cervico-medullary junction at the foramen magnum. It has been found that achondroplasts are at quite high risk of spinal cord injury with hyperflexion and hyperextension. We routinely obtain MRI of the cervical spine without contrast and plain x-ray radiographs to assess the degree of stenosis prior to participation in any athletic activity. We recommend restriction of any high velocity activity or those activities with a propensity for cervical hyper-extension or hyper-flexion if stenosis exists. In this group, an option exists for cervical decompression to allow participation in athletics with a greater degree of safety. The Center of Skeletal Dysplasia currently recommends prophylactic decompressive surgery in such instances.

Athletes with seizure disorders present an interesting problem in that they may be a danger to themselves or to those around them. Interestingly, seizure activity during athletic competition has been shown to decrease. Epileptics are actually less likely to have a seizure during competition. The risk of spinal cord injury is not necessarily higher. However, if a seizure does occur, the result of a race car driver or hang glider having a seizure is very much different than if a baseball player or football player has a seizure. Furthermore, since seizure activity is related to hyperexcitable neural networks within the brain, those activities that may predispose the athlete to unusual risk of close head trauma should be avoided. Athletes with seizure disorders that continue to have seizures during athletic competition should be evaluated by a neurologist and have an MRI with and without gadolinium. Optimization of medications and or a more thorough search for the epileptic etiology may be necessary as increased seizure activity during athletics is uncommon.

Every effort should be made to minimize the risks of spinal cord injury in the handicapped so that they may be allowed to participate. The benefits usually outweigh the risks and they experience a greater joy, happiness, pride, and quality of life than those who are precluded from participation.

Radiographic Screening. In those athletes that are identified for further evaluation prior to play, appropriate imaging is necessary. Static plain films are often ordered but rarely are useful alone. Plain static radiographs show only bony anatomy and it is difficult to assess the spinal cord in relationship to the bony anatomy since the standard magnification factor is rarely standard. Furthermore, it gives only indirect information about the soft tissue component of the cervical spine and its relationship to the spinal cord. Dynamic or flexion and extension images show the vertebral motion segment anatomy as it relates to adjacent levels during motion. These images are helpful in athletes that complain of exertional headaches or are at increased risk of ligamentous laxity or have had previous injuries. Once again it gives only indirect information about the soft tissues. MRI of the cervical spine allows an assessment of the neural element’s relationship to the adjacent bony and soft tissue elements. It is essential in those that have had a previous neural injury and those at risk for spinal stenosis.

The injured athlete. All athletic activities have a stereotypic force pattern with respect to cervical spine injuries. The physician who cares for athletes should be familiar with the cervical stress profiles of the various sports. An understanding of the force that caused an injury is the first step towards appropriate treatment.

The forces that cause cervical spine injury include axial compression, distraction, hyperflexion, hyperextension, shearing, and rotation. More often than not the injury is due to a combination of these forces. These forces cause readily identifiable injury patterns and may take the form of fractures, sprains, disc disruptions, SCIWORA, strains, stretch neuropraxias, cord injury, accelerated degenerative disease, etc.**2**

Neurologic injury occurs in 3 stages, the acute injury, the sub-acute injury, and the chronic injury. The acute injury is the actual physical injury that occurs at that time of impact. There is very little that currently can be done to salvage this acutely injured spinal cord. The sub-acute injury is the injury that occurs to the tissue in proximity to the acute injury site and is often called the penumbra zone. This is the region of the spinal cord that undergoes secondary injury due to local swelling, inadequate perfusion pressure and chemical mediated cytotoxicity. This is the region of the spinal cord injury that the current acute treatment strategies are meant to protect. The chronic injury refers to the post-traumatic leukomalacia, myelocystic changes, and tethering that occurs following spinal cord injury. Appropriate acute treatment can minimize the chronic sequelae of spinal cord injury. Furthermore, as treatments become available for application to the chronic stages of injury, those patients that had the best treatment in the acute stage will be more suitable candidates for any future treatments that may be available. Late stage management of spinal cord injury is beyond the scope of this topic treatment.

In the acute management of spinal cord injury, assume the worst! The spine is immobilized and, if concomitant head injury exists, forceful immobilization may be required if the athlete is confused. Airway is established, ventilation is assured, and adequate circulation is maintained. This provides for adequate spinal cord perfusion pressure and tissue oxygenation. Face masks are cut off to allow access to the airway, but padding and helmets are left in place to be removed in the emergency room. Initial neurologic assessment begins on the field.**3**

In the emergency room, treatment follows a sequence of neuroprotective strategies.**4** Currently, the standard of care is for administration of Solumedrol. This will be followed by spinal cord decompression, either with traction or surgery. If necessary, this is followed by stabilization, which usually requires fusion and instrumentation to maintain stability of the bony anatomy until adequate fusion occurs.

Acute non-surgical neuroprotective strategies are interestingly controversial. Solumedrol has been found to help only minimally, if at all.**5** Nonetheless, it is the standard of care.**6** Therefore, other potentially better neuroprotective agents can not be trialed clinically without giving Solumedrol concomitantly. Several agents including NBQX, a highly selective antagonist to the non-N-methyl-D-aspartate excititory amino acid receptor, oxygen radical scavengers such as LY341122,**7** modulators of the anti-apoptotic gene Bcl-2, and the anti-inflammatory cytokine IL-10 **8** have shown clinical promise as neuroprotective agents. Hypothermia is also known to be valuable in neuroprotection.**9** These treatment strategies may be more useful than Solumedrol in the acute injury phase. Unfortunately some of these agents can not be used in conjunction with Solumedrol and are therefore yet to be studied in humans.

Significance of transient paralysis, and "stingers". A stinger injury is a transient neurologic phenomenon. It may include electrical sensations, numbness, and complete but transient paralysis of one or more limbs. They are quite common in athletic activities that expose the athlete to axial injuries, such as diving and football. With cervical axial loading the ligaments are shortened like a relaxed rubber band. The intervertebral discs are compressed leading to annular bulging. These factors decrease the spinal canal diameter and lead to transient stenosis. In athletes with congenital or acquired stenosis this may lead to transient spinal cord compression. Likewise the neuroforaminal height is decreased leading to transient neuroforaminal stenosis. This may lead to transient nerve root compression. This may lead to unilateral or bilateral "stingers."

Unilateral stingers are usually the result of root irritation due to foraminal compression. They are usually self-limited and are not a serious concern unless the athlete is having more than an expected number of these types of injuries or if they consistently occur in the same arm or distribution. In this case playing technique needs to be evaluated along with level of conditioning. Appropriate radiographic evaluation is undertaken to ensure that there is no existing foraminal stenosis that is predisposing the athlete to repetitive injuries. Oblique cervical spine films and an MRI is recommended before play is continued.

Bilateral stingers are also usually the result of nerve root irritation and are usually self-limited, but some of these may be in fact transient spinal cord compression and therefore this pattern of stinger should be taken very seriously. A single bilateral stinger may be the only heralding sign of potentially catastrophic spinal cord injury.**10** This author believes all such injuries should be evaluated with MRI even after a single incident.

Players should be counseled as to the significance of "stinger" injuries and not taught to just "shake it out." The coach, trainers, and possibly the physician should be notified and keep records of the patterns of such injuries.

Return to play. An injured athlete will fall into one of 3 categories; those with persistent neurologic deficits, those with resolved deficits and abnormal radiographs, and those with resolved deficits and normal radiographs. Those with persistent deficits are counseled not to return to play. There are numerous reports of neurologic disasters with return to play.**11**

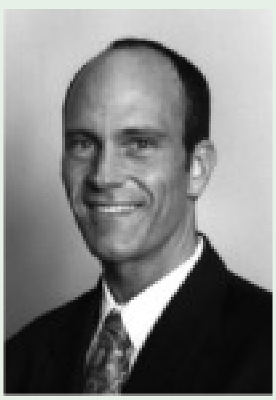
The issue of athletes with resolved deficits returning to play is a more complex question. Those with abnormal x-rays either due to congenital or acquired abnormalities need special counseling. This is a relative contraindication to return to play. There may be a surgical treatment for the abnormality that would allow the player to return to play. Alternatives would be to counsel the athlete concerning the risks of return to play and helping the athlete find an acceptable, less risky, alternate activity.**12**

Those that have appropriate normal radiographic studies are allowed to return to play and are not at increased risk of further injury.**13** However, prior to return to activity, both groups should be extensively evaluated, with video tape of the injury if available, to assess for flaws in athletic technique, faulty safety equipment or inadequate conditioning or strength factors that might have predisposed the athlete to injury.

Conclusion. Athletic competition contributes meaningfully to quality of life. Every effort should be made to allow participation. Recognition of those potentially at risk of spinal cord injury allows for cost effective screening. Identified risk factors can be minimized with surgical treatment, counseling towards less risky activities, improved customization of safety equipment, appropriate activity specific conditioning, and strengthening programs and education.

If injury does occur, appropriate acute management may minimize subacute and chronic injury. As future treatments for spinal cord injury become available, appropriately treated patients have the highest likelihood of benefiting from such treatments.

In those with resolved deficits, return to play can be accomplished after risk assessment analysis and appropriate neurologic and imaging evaluation has ruled out radiographic abnormalities. If abnormalities do exist, counseling and possible surgical correction of the abnormality may be recommended.



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