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## From the Chair

Alex B. Valadka, MD



Alex B. Valadka, MD

A young man is brought to an emergency center after an automobile accident. He soon deteriorates from normal alertness to unconsciousness. The computerized tomographic scan reveals a large epidural hematoma. The emergency

physician cannot locate an on-call neurosurgeon. The patient's pupil begins to dilate.

Meanwhile, when a similar patient is brought to an emergency center in another city, an "acute care surgeon" is called. This surgeon spent three months on a neurosurgery service during postgraduate training in general trauma and emergency care. He takes the patient to surgery to evacuate the epidural hematoma, but most of the clot is left behind. The patient subsequently comes under the care of a neurosurgeon who promptly performs surgery to evacuate the residual clot. The patient remains severely debilitated.

Both of these stories are fictitious, but there have been accusations that scenarios like the first one have already occurred. Partly in response to these claims, but mostly in an attempt to breathe life into the specialty of trauma surgery, plans are underway to create a new specialty called acute care surgery. These specialists would take care of trauma patients, but they would also handle nontrauma surgical emergencies like appendicitis, bowel obstruction, vascular emergencies, etc. Some leaders have explained that the members of this proposed new specialty would act like "surgical hospitalists."

Of relevance to neurosurgeons is that the proposed training curriculum for acute care surgeons includes ventriculostomies, burr holes, placement of intracranial pressure monitors, elevation of depressed skull fractures, and ap-

plication of cervical traction. The proposed curriculum includes orthopedic procedures, and performance of "limited craniotomy" also has been suggested.

It is unrealistic to expect that a brief exposure to neurosurgery provides sufficient training to guarantee competence in these procedures. The second scenario described above was inspired by published reports from our Scandinavian colleagues, who document poor technical results and poor patient outcomes after non-neurosurgeons attempted to evacuate epidural hematomas (1,2).

I was invited to attend a meeting of the group that is working on the creation of this new specialty of acute care surgery. It soon became apparent that our differences in opinion necessitated a face-to-face meeting between the leaders of organized neurosurgery and those of general and trauma surgery. From the perspective of the Trauma Section, the interest that neurosurgery's leadership has shown in this issue has been gratifying. Important questions are at stake, including the basic ways in which neurosurgery services are structured in many hospitals in this country, as well as the ways in which patients with neurosurgical emergencies will receive care in the future.

In a recent popular action movie, the hero begins his final battle with his longtime nemesis by declaring, "It ends tonight." That's a perfect analogy for discussions about neurosurgical emergency care. High-level meetings between officers of different professional societies are important and necessary, but the real answers will be provided by each of us, one hospital at a time and one neurosurgeon at a time. The answer will be dictated by the way you respond—and the way your hospital and regional emergency

# Neurotrauma Highlights at the 2006 AANS Annual Meeting

San Francisco Convention & Visitors Bureau Photo



## Sunday, April 23, 2006

### Practical Clinics

8:00 AM–5:00 PM

#### 027 Head Trauma: Current Treatments and Controversies With Hands-On Practical Session in Brain Monitoring and Techniques

*Co-directors: Geoffrey T. Manley, MD, PhD; Shelly D. Timmons, MD, PhD*  
*Faculty: M. Ross Bullock, MD, PhD; Domenic P. Esposito, MD, FACS; Michael G. Fehlings, MD, PhD, FRC; Donald W. Marion, MD; Anthony Marmarou, PhD; Raj K. Narayan, MD; Alex B. Valadka, MD*

This clinic emphasizes case studies and covers the significant breadth of the field of neurotrauma and critical care. Also, an afternoon session offers hands-on instruction in techniques and devices for ICP monitoring, parenchymal oxygen monitoring and decompressive craniectomy.

Total Fee: \$475.00

#### 031 Management of the Craniocerebral Trauma Patient for Allied Health

AANS has applied for nursing contact hours.

*Director: Andrea L. Strayer, MSN, CNRN*

*Faculty: Kimberly A. Clark, PA-C, MS; Leo Timothy Harris, PA-C; Twiyila Lay; Peter B. Letarte, MD; Geoffrey T. Manley, MD, PhD; Christine Martin, RN, MS, CNS; Michael Patrick Steinmetz, MD*

This course will provide practical, current, didactic information on the assessment and management of the craniocerebral trauma patient. Expert advance practice nurse, physician assistant and neurosurgeon faculty will explore the challenges of caring for this complex patient population.

Total Fee: \$375.00

## Monday, April 24, 2006

### Breakfast Seminar

7:30–9:30 AM

#### 119 Cerebral Trauma State-of-the-Art Treatment

*Moderator: Alex B. Valadka, MD*

### Executive Committee Meeting

1:00–2:45 PM

### Scientific Session VI—Neurotrauma and Critical Care

2:45–5:15 PM

*Moderator: Alex B. Valadka, MD*

This session will summarize the latest basic and clinical research advances in traumatic brain injury and spinal cord injury.

646

2:45–3:00 PM

#### Treatment of Traumatic Brain Injury in Rats With a Combination Therapy of Marrow Stromal Cells and Atorvastatin

San Francisco is the site of the 74th AANS Annual Meeting, April 22–27. The meeting incorporates innovative educational and social programs that emphasize the 2006 Annual Meeting theme, Meeting the Challenges of Neurosurgery: Expanding Resources for a Growing Population, and the scientific program features the latest technological innovations and scientific advances from all areas of neurosurgery. Detailed information is available online at [www.aans.org/annual/2006/](http://www.aans.org/annual/2006/).

647

3:00–3:15 PM

#### Electrographic Seizures After Human Traumatic Brain Injury Result in a Delayed, Prolonged Increase in Intracranial Pressure

648

3:15–3:30 PM

#### The Role of Serum Magnesium Level in Severe Traumatic Brain Injury Outcome

### Invited Lecturer

3:30–4:00 PM

#### The Metabolic Response to Traumatic Brain Injury: Issues of Cellular Vulnerability and Recovery of Function

*Speaker: David A. Hovda, PhD*

649

4:00–4:15 PM

#### Response of Brain Tissue Oxygen to Oxygen Tension to an Oxygen Challenge Is Related to Lung Function in Severe TBI

650

4:15–4:30 PM

#### Hypertonic Saline (HTS) and Its Effect on Intracranial Pressure (ICP) and Brain Tissue Oxygen (PtO<sub>2</sub>)

651

4:30–4:45 PM

#### Medical Management to Maintain Cerebral Oxygenation in Patients With Traumatic Brain Injury

652

4:45–5:00 PM

#### Recombinant Activated Factor VII Treatment Reduces Hippocampal Neuronal Death After Traumatic Brain Injury in Pigs

653

5:00–5:15 PM

#### The Integration of Flexion/Extension Cervical CT Scanning in the Trauma Protocol

## Tuesday, April 25, 2006

### Breakfast Seminar

7:30–9:30 AM

#### 204 Current Options in Cerebral Neuromonitoring

*Moderator: Johannes Schramm, MD*

*Panelists: Robert L. Macdonald, MD, PhD; Donald W. Marion, MD; Gary K. Steinberg, MD, PhD*

This seminar will review the use of various cerebral neuromonitoring techniques for surgical and ICU patients.

### Poster Viewing

2:00–2:45 PM

• Neurotrauma and Critical Care

### AANS/CNS Section on Neurotrauma and Critical Care

2:45–5:30 PM

*Moderator: Jamie S. Ullman, MD*

This session will review several promising treatment strategies for spinal cord injury and will serve as a forum for the presentation of new research in neurotrauma and critical care.

### Symposium

2:45–4:00 PM

#### Evaluating the Latest Clinical Advances in Spinal Cord Injury

*Moderator: Jamie S. Ullman, MD*

**Neural Cybernetic Implants: From Science Fiction to Science Fact**  
*Arthur L. Jenkins III, MD*

2:45–3:00 PM

**Current Status of Stem Cells for Spinal Cord Injury**  
*Michael G. Fehlings, MD, PhD, FRCS*

3:00–3:15 PM

**Clinical Trials in Spinal Cord Injury: Do They Have Promise?**  
*Charles H. Tator, MD, PhD, MA*

3:15–3:30 PM

**Discussion**

3:30–3:45 PM

**Codman Neurotrauma Research Fellowship Presentation: Repopulation of Injured Brain With Human Adipo-Derived Stem Cells After Traumatic Brain Injury**

3:45–3:55 PM

*Presented by Michael G. Fehlings, MD, PhD, FRCS*  
*Recipient: David O. Okonkwo, MD, PhD*

**Announcement of 2006–2007 Codman Neurotrauma Research Fellowship Awardee**  
*Recipient, TBD*

3:55–4:00 PM

**Announcement of 2006–2007 J. Douglas Miller Traveling Fellowship Awardee**  
*Recipient, TBD*

**737 Synthes Award for Resident Research on Spinal Cord and Spinal Column Injury Presentation: Delayed Transplantation of Adult Neural Stem Cells Promotes Remyelination and Functional Neurological Recovery After Spinal Cord Injury**

4:00–4:15 PM

*Authors: Soheila Karimi-Abdolrezaee, PhD; Eftekhar Eftekharpour, PhD; Jian Wang, MD; Cindi M. Morshead, PhD; Michael G. Fehlings, MD, PhD, FRCS*

**738 Synthes Award for Resident Research on Brain and Craniofacial Injury Presentation: Contrast Ultrasound Assessment of Cerebral Perfusion in Patients Undergoing Decompressive Craniectomy for Traumatic Brain Injury**

4:15–4:30 PM

*Authors: Dilantha B. Ellegala, MD; Jason S. Weinstein, MD; Ian F. Dunn, MD; Peter A. Heppner, MD, BS, BSc; John A. Jane Sr., MD, PhD, FRCS*

**739 Novel Biomarker in Cerebrospinal Fluid of Traumatic Brain-Injured Patients**

4:30–4:45 PM

*Authors: Daniel Hirt; Thomas C. Glenn, PhD; Matthew Eliseo; Jon Berg; Paul Vespa, MD; Adrienne Matz; Neil Martin, MD*

**740 HBOC-201 Improves Resuscitation Parameters and Prevents Secondary Brain Injury in a Swine Model of Traumatic Brain Injury and Hemorrhage**

4:45–5:00 PM

*Authors: Guy Rosenthal, MD; Mitchell Coben, MD; Diane Morabito, RN; Nikita Derugin, MS; Annina Roeytenberg, MD; Scott Panter, PhD; M. Peggy Knudson, MD; Geoffrey T. Manley, MD, PhD*

**741 The Effect of Blood Transfusion on Extracellular Metabolites in Adult Traumatic Brain Injury**

5:00–5:15 PM

*Authors: Brian T. Jankowitz, MD; Ava M. Puccio, MSN, RN; Michael R. Fischer, BS; Rick Madbok, MD; Stephen R. Wisniewski, PhD; Kevin A. Walter, MD*

**742 Utility of Repeat Head Computed Tomography in Children With a Traumatic Brain Injury**

5:15–5:30 PM

*Authors: Marjorie C. Wang, MD, MPH; Monica S. Vavilala, MD; Sidhartha Choudhry, MD; Sarah Layman, RN; Saipin Muangman, MD; Jeffrey G. Jarvik, MD, MPH; William Hollingworth, PhD*

**From the Chair** *continued from front page*

medical system have decided you should respond—when the emergency room pages you tonight.

**Final Thoughts**

During the 2006 AANS Annual Meeting, I will complete my term as Trauma Section chair. It has been a great honor to serve in this role, and I am indebted to the officers and members of the section, to the staff of the AANS and the CNS, and to many other individuals who have provided help, advice, and insight.

David Adelson, MD, will be the next chair of the Trauma Section. Dave has already distinguished himself several times over as an outstanding clinician, basic and clinical researcher, and all-around academic. His advice has been invaluable to me during the past two years. The section could not be in any better hands.

It's a funny thing about these newsletters. When you're a chair-elect, you think about all sorts of things you'd like to write about. But once you're chair, you get so caught up in the flow of events that you don't have time or space to say what you had planned. A good example is the preceding discussion about the acute surgery curriculum. Spending so much time and effort on that issue is completely appropriate, but it should not eclipse the many other activities of the section.

We continue to enjoy outstanding corporate support that goes a long way towards helping us meet our section goals. The Codman research fellowship and the Synthes resident research

awards support research work that is truly of the highest caliber. Together with the Synthes resident courses, these projects have helped open residents' eyes to the challenges and possibilities of careers in neurotrauma and critical care. Integra has generously begun to support an annual lecture by an international leader in the neurotrauma field. The J. Douglas Miller Traveling Fellowship, through which an international neurosurgeon can visit several North American centers and attend an annual meeting of the AANS or CNS, is being supported by DePuy. Codman underwrote the efforts of Jamie Ullman, MD, to create and mail to all section members the CD containing a neurotrauma slide presentation. All this help from industry has made it possible for the Trauma Section to increase its impact among our residents, our domestic members, and our international colleagues.

There is no question that the educational and research arms of the Trauma Section have never been stronger and that the profile of the section has never been higher throughout the ranks of organized neurosurgery. The Trauma Section is well positioned to continue moving our field forward for years to come. ■

1. Wester K. Decompressive surgery for "pure" epidural hematomas. *Neurosurgery* 44(3):495–500, 1999.
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## Head Injury in Athletes: Advances and Initiatives in Neurological Sports Medicine

Julian E. Bailes, MD

**D**uring the previous decade, there was focus on defining, analyzing, and categorizing the athlete with head injuries in order to improve clinical management. Long-held theories concerning the benign nature of minor head injuries, such as the so-called “dinged” state in football, are now realized to be inaccurate, and the potential seriousness of these injuries may often be underestimated.

Although much public scrutiny and media attention have been paid to the professional athlete who may have a career-threatening injury, the large numbers of people who sustain minor head injuries in organized high school or recreational sports emphasize the magnitude of the problem. The Centers for Disease Control and Prevention recently announced that concussion in athletes has reached epidemic proportions in the United States.

There are many issues and characteristics that make diagnosis and treatment of athletes esoteric and difficult. A peculiar aspect of working with this patient population is that this is the only group of patients who request to be allowed to return to play, thereby increasing the likelihood that they will sustain other head impacts and, often, concussions. Although the incidence of serious or life-threatening brain injury has decreased in most sports, there is new evidence suggesting that mild traumatic brain injury, MTBI, or concussion may be more common and more serious than previously thought. The long-term consequences of repetitive blows to the head are now considered to be detrimental to the future well-being of the athlete. In addition, the possibility of a major injury or of death, despite their relative rarity, remains a constant in nearly every sport and thus must be thoroughly understood. For instance, despite excellent medical care, there were two deaths related to brain injury in professional boxing during the past year in Las Vegas.

There are many factors, including social ones, that may affect our ability to care for the recreational, student, or professional athlete with a head injury. We now have several new and accurate tools at our disposal that allow improved diagnosis and treatment of these patients. Many advances in the fields of diagnostic neuroradiology, neurobiology, neuropsychology, and sports medicine now provide the neurosurgeon with accurate means to best analyze the proper management of athletes with head injuries.

### Incidence of Sports-Related Injury

The frequency of all sports-related concussion has been estimated to be up to 300,000 occurrences annually in the United States. Equestrian sports account for approximately 46,000 hospital emergency department visits annually, with nearly 20 percent of equestrians experiencing injuries to the head or neck and 70 percent of deaths related to head injuries. Recreational and commuter bicyclists have between 1,000 and 1,300 fatalities each year, with approximately one-half being children and adolescents, and the majority dying of brain injuries. There has been an annual rate of approximately seven fatalities from skateboard activities, while roller skating and in-line skating combined cause about 100,000 injuries yearly, with few

reported deaths and a 5 percent incidence of head injury.

Serious head injuries in recreational sports occur at one of the highest rates in downhill skiing, occurring as a result of collision, often at high speed, with trees and boulders as well as other skiers. Head injury is the leading cause of fatality at most large alpine skiing resorts, causing approximately 32 deaths annually in the United States. Most of these traumatic lesions are extra-axial hematomas, often with associated parenchymal damage, cerebral edema, cranial fractures, and resultant brain herniation syndromes. Adherents of the newly popular sport of snowboarding seem to be as prone to serious and fatal brain injury or spinal injury as skiers are. Most other sports involve sporadic head injuries, with hang gliding, skydiving, mountaineering and race-car driving being important exceptions. While diving mishaps are the leading cause of spinal cord injury in sporting activities, intracranial injury is rare.

In organized athletics in the United States, football is the sport with the highest number of participants and incidence of head injuries. It has been estimated that there are nearly 1.4 million annual participants in contact football in the United States, and it has been variously estimated that 4 percent to 20 percent sustain an MTBI each season. A few will experience either cumulative MTBI or serious head injuries annually. Currently, there are approximately 4 deaths (range, 0–7 deaths) annually in the United States attributable to head injuries in organized football. The head often initiates the impact in football, and injuries occur during blocking, tackling or carrying the ball. Soccer, a sport with not only collisions but also heading the ball, also is associated with MTBI. Ice hockey experienced a significant decrease in serious head injuries and concussions after the sport implemented the use of effective helmets, but concussion has been reported to occur in as many as 7 percent of ice hockey players annually. Major brain injuries are rare in rugby, basketball, and baseball, and seasonal concussion rates are reported as 6 percent, 2 percent, and 1 percent, respectively.

### The Two Aspects of Cumulative Brain Injury

Cumulative brain injury is an important concept in the management of athletic head injury. There are two aspects to this phenomenon. First, the immediate effects of concussion seem to be most pronounced after the athlete sustains a proximal second concussion. Second, although exact data do not exist, it seems that sustaining multiple episodes of MTBI may lead to a greater chance of having a prolonged period of postconcussion symptoms or long-lasting effects. In the immediate period, this affects the return of the athlete to competition and may affect his or her personality, academic productivity, and sports performance.

Chronic traumatic brain injury represents the additive effect of multiple subconcussive and concussive head impacts and is expressed as the long-term neurological functioning of the athlete. Chronic injury in the brains of boxers was first described in 1928 by Martland who studied a 38-year-old retired boxer with advanced Parkinson-

ism, pyramidal tract dysfunction, ataxia, and behavioral abnormalities. The clinical manifestations in boxers have been characterized as cognitive, motor, and psychiatric symptoms. A spectrum of clinical symptoms may exist, including early difficulty with speech and coordination, the onset of tremor and attention deficits, and psychiatric symptoms. The last, or severe, stage of chronic brain injury in boxers includes pyramidal, extrapyramidal, and cerebellar dysfunction, as well as cognitive and more severe psychiatric abnormalities, termed *dementia pugilistica*. Risk factors that have been purported to increase a boxer's risk of injury include being a professional rather than amateur boxer, absorbing more punches rather than skillfully avoiding blows, greater sparring exposure, history of technical knockouts or knockouts, and overall poor boxing performance. Whether such chronic injury can occur in other sports such as soccer and American football is debatable.

### **Recent Initiatives: Reducing Spearing in Football, Studying Cumulative Brain Injury**

The Sports Medicine Committee has been involved with two recent initiatives on the national scene: reducing spearing in football and studying cumulative brain injury.

Robert Cantu, MD, and I have represented organized neurosurgery on the National Athletic Trainers Association/American Football Coaches Association (NATA/AFCA) Spearing in Football Task Force. Having met early in 2005, we reviewed new and intriguing data demonstrating that spearing has continued to be prevalent at all levels of organized football.

Spearing is considered as the intentional head down or head first contact or deliberate use of the helmet (including the facemask) in an attempt to punish an opponent. A 2001 study by Jonathan Heck, ATC, of NCAA Division I football games shows that of 20,837 penalties cited, only 25 were for helmet contact infractions. Compared to holding, which represents one out of six football penalties, spearing occurred once out of every 833 penalties and was called only once in every 50 games.

Several interesting facts resulted from Heck's study. First, not only was the incidence of calling this penalty extremely low, but it was also difficult for a game official to decide whether an athlete had an intent to punish or whether the contact was purposeful. Rule 2, Section 24, of the NCAA 2004 Rules and Interpretations book states that "spearing is the intentional use of the helmet (including the face mask) in an attempt to punish an opponent." Spearing may also occur during the process of blocking as well as carrying the ball, but most often it is associated with tackling. Unintentional head impact may also occur when the head is dropped just prior to impact. Both of these instances result in an axial loading mechanism with a potential for catastrophic vertebral column failure and paralysis. Spearing is not prevented by equipment, and initiating contact with the shoulder while keeping the head up is the safest form of play.

The task force recommended changing the rules to read, "No

player should use his helmet to butt or ram an opponent in an attempt to punish him, and no player shall strike a runner with the crown or top of his helmet in an attempt to punish him." Thus the word "intentional" was removed in an attempt to make the on-field interpretation and immediate flagging of the offender possible for the game officials. The task force recommendations were considered and approved by the NCAA Rules Committee and also by the NCAA Committee on Competitive Safeguards and Medical Aspects of Sport. The recommendations were incorporated into the 2005 NCAA Rule Book, and after this season the frequency of their use and their effectiveness will be assessed. The work of the task force will continue, and we are optimistic that the difficult semantics and interpretation issues will be overcome.

We are hopeful that the new rule will reduce the incidence of catastrophic cervical spine injury. There are several nuances to this rule and this particular injury, but one of them is the perception that ordinarily the player who is struck is the one at greatest danger. However, with spearing mechanisms, the striking player often is the recipient of the catastrophic injury.

The other issue which has come to the forefront this year concerns the potential for cumulative brain injury with years of contact football participation. In particular, it was reported that a National Football League player with 17 years of professional experience died with histopathological changes consistent with non-Alzheimer's dementia that was attributed to multiple head impacts during his playing career. The implication that a football player could have serial changes from cumulative and repetitive brain injury is new and has been compared and contrasted with the issue of pugilistic dementia.

In boxers, the histopathological changes from chronic and repetitive mild traumatic brain injury have been well described. The notion that a football player may also obtain similar changes is intriguing but thus far unproven. While studies of retired NFL players have found that mild cognitive impairment may be correlated with the incidence and frequency of concussion during the prior playing years, to suggest that NFL players may go on to sustain permanent cerebral damage leading to dementia needs further investigation. The Sports Medicine Committee has a task force composed of numerous experts, including a representative from the NFL's MTBI Committee, which will meet in 2006 to address this issue. We look forward to this work and to reviewing the available clinical material and medical literature to further shed light on this issue.

### **A Year of Advances**

During the last year, we have seen continued advances in the field of neurological sports medicine that have improved our knowledge of and ability to manage the athlete with central nervous system injury. The NFL's Committee on MTBI has published results of detailed clinical and game videotape analysis and laboratory experimentation

*continued on page 7*

## Athletics and Spinal Cord Injury: Cervical Stenosis Definition May Hold Key to Consensus

Howard Levene, MD, PhD, and James Harrop, MD

International competitive sports unite the world. Olympic competition causes interest across multiple societies as athletes directly compete for dominance and spectators vicariously experience thrills and disappointments. Unfortunately, these sports carry inherent dangers to the central nervous system. Updates in rules and protective gear have helped reduce injuries to athletes. However, athletes still suffer traumatic brain and spinal cord injuries on a routine basis. Specifically, SCI as observed in athletics can range from mild (contusions, burning hands syndrome) to tragic (permanent quadriplegia, death). In sports medicine, injuries of the head and neck account for 70 percent of traumatic deaths and 20 percent of permanent disability. Athletes comprise 10 percent of the 10,000 cervical spine injuries that occur in the United States annually. As neurosurgeons we certainly apply ourselves to treating the injured, but we also aim to prevent injury.

Many types of SCIs can occur during athletic events. These include fractures, contusions, concussions, and hemorrhage. According to the National Center for Sports Injury Research, all reported spinal hemorrhages are in the cervical region. Certainly, the cervical spine is the most mobile region of the central axis and therefore is most prone to injury. For this reason, attention to prevention and assessment of SCI in athletes focuses on the anatomy and the pathology of the cervical spine.

Ideally, one should be able to predict risk to an athlete based on his or her anatomy. In 1956, Wolfe and colleagues examined 200 asymptomatic individuals, obtained lateral spine radiographs, and measured sagittal diameter from the posterior aspect of the vertebral body to the spinolaminar line (9). As a result of this study, a sagittal diameter based on lateral plain radiographs of greater than 15 mm in adults is considered normal, while diameters less than 13 mm are considered stenotic.

However, morphological assessments based on films of the lateral cervical spine are subject to a multitude of possible errors. For example, a patient with broad shoulders may introduce further magnification due to distance from the radiographic plate. Neck posture and positioning during acquisition of the radiographs may also affect the result. Additionally, soft structures such as disk material or noncalcified hypertrophied ligaments typically are not visualized on these examinations. However, the soft tissues and ligaments may contribute significantly to injury as the spinal canal diameter may be reduced up to 30 percent during hyperextension due to buckling of the ligaments.

Realizing that measurements on plain radiographs are subject to magnification errors, Torg (7) and Pavlov (6) constructed a ratio to define cervical stenosis. In their classification, known as the Torg ratio, the anteroposterior diameter of the spinal canal is measured as the distance from the midpoint of the posterior aspect of the vertebral body to the nearest point on the corresponding spinolaminar line divided by the anteroposterior width of the vertebral body. Stenosis is defined as a ratio  $< 0.8$ .

This ratio has been investigated as a predictor of injury. Matsui and colleagues in 1989 compared spinal cord dimensions in 100 controls and in 42 patients with SCI and found that the injured group had sagittal diameters that were significantly smaller than in the control group (4). Unfortunately, efforts at using this ratio as a predictor of future injury have not been fruitful. The positive predictive value of having a low Torg ratio comes to a difference of 0.2 percent. Some athletes tend to have extra large vertebral bodies which would artificially lower the Torg ratio, making strict use of the Torg ratio problematic as a predictive screen.

However, the sagittal canal diameter may not be the only important factor for predicting adverse athletic SCIs. In fact, the relationship between the spinal cord diameter and osseous canal width as proposed by Cantu (1–3) may be the most important variable. This relationship, rather than being quantified by mathematical terms, may better be determined by observing for a cerebrospinal fluid reservoir around the cervical cord through studies such as magnetic resonance imaging, computerized tomography with contrast, or myelogram. Having no observable CSF around the cord or having a blockage of contrast dye is known as having a “functional stenosis,” and perhaps it is this subset of athletes that is at highest risk for injury.

Once an athlete is injured, the physician often is called upon to assess whether or not the athlete can return to the playing field. After a full physical and radiographic evaluation, the injured athletes can be placed into several categories. The categories are based on the severity of the SCI and the presence of cervical stenosis. There is no controversy about the extremes of the injury. Severely symptomatic athletes (central cord syndrome, Brown Sequard syndrome, permanent quadriparesis, etc.) are excluded from returning to play in contact sports. Athletes with more mild injuries, such as those with stingers, burning hands, or transient quadraparesis, as well as athletes with cervical stenosis, must make full recoveries prior to returning to play. It is the athletes with cervical stenosis who are asymptomatic that present the greatest source of controversy. This is especially heightened in professional sports, where players already have brief careers and large monetary sums are involved.

In those athletes, the anatomical assessment of the cervical canal becomes paramount, and two “schools of thought” have developed based on the assessments developed by either Torg and Pavlov or by Cantu. Torg advocates that the asymptomatic athlete with a ratio  $< 0.8$  may return to play with no contraindications with the stipulation that the athlete has no history of quadriplegia, neurological deficit, or underlying cervical spine abnormality. Cantu, however, recommends that participation in contact sports is absolutely forbidden in those athletes with documented functional spinal stenosis.

Morganti and colleagues studied 113 physicians who reviewed 10 case histories with no consensus in recommendations (5). This highlights the lack of consensus for predicting injury based on radiographic evidence.

No Contraindications	Relative Contraindications	Absolute Contraindications
Healed fractures	Prolonged symptomatic burner/stinger or transient quadriplegia > 24 hours	Previous transient quadriplegia
Certain congenital anomalies (single level Klippel-Feil excluding C0–C1, spina bifida occulta, Torg Ratio < 0.8 and asymptomatic)	Greater than three prior episodes of stinger/burner (the patient must have had full return to baseline with respect to cervical range of motion, neurological exam, and pain resolution)	Postsurgical patients
Degenerative or postsurgical changes (e.g. conservatively managed cervical degenerative joint disease with minimal pain, healed single level fusion with or without instrumentation)	Healed cervical fusion (anterior or posterior) two levels with or without instrumentation	Soft tissue injury, especially those suggesting dynamic instability
Fewer than three episodes of burner/stinger lasting < 24 hours, with full cervical range of movement and no neurological deficit		Certain radiographic findings (spear-tackler's spine, sagittal or coronal plane deformity, ankylosing spondylitis, basilar invagination)
One episode of transient quadriplegia with full cervical range of movement, no evidence of neurological deficit, no evidence of herniated nucleus pulposus or dynamic instability		

(from Vaccaro [8])

Complicating matters is the understanding that there are other underlying pathological conditions in the general public that need to be addressed when assessing the risks of sport-related injuries. For example, people with Down's syndrome have been active participants in the Special Olympics. It is known that they have hypermobility of the cervical spine and would theoretically be more vulnerable to injury.

Experienced clinicians have suggested guidelines such as those proposed by Maroon and Bailes, Torg and Ramsey-Emrhein, and Vaccaro. These guidelines as summarized by Vaccaro and colleagues (8) are presented in an abbreviated format in the table.

The controversy about athletic spinal cord injury and return-to-play issues hinges upon the definition cervical stenosis. The determination of anatomic measurements versus "functional" assessment as factors in predicting athletic SCI will continue to be the subject of intense study and debate. ■

## References

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that has further elucidated the mechanisms of MTBI. There has been greater understanding of the role of neuropsychological and other ancillary testing in the management of the athlete with MTBI, and we anticipate more sophisticated neuroradiological studies (such as imaging of white matter tracts) to contribute in the near future. We expect that our research with computerized analysis of boxing fatalities and study of retired professional athletes will add to our body of knowledge and assist us with prevention of serious injury or long-term consequences of athletic head injury. We also anticipate that other high-technology adjuncts, such as the implementation of embedded accelerometers, will allow further objectivity to be introduced real-time during contact sports, as well as constant improvement in equipment, rules, and prevention protocols.

Neurological sports medicine continues to be an evolving and progressive subspecialty of neurosurgery. It affects innumerable athletes at the student, professional and Olympic levels and will continue to develop further sophistication. We look forward to these and other developments as we understand the implications of repetitive cranial trauma of a seemingly mild nature and its effect on the central nervous system. In addition, the surgical treatment of spinal disorders in athletes, whether recreational or in organized activities, will continue to be important. I invite your comments and suggestions for further study concerning the above and other pertinent issues. ■

## AANS/CNS Section on Neurotrauma and Critical Care

5550 Meadowbrook Drive

Rolling Meadows, Illinois 60008-3852

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### Apply Online for Trauma Section Membership

An online application process for membership in the AANS/CNS Section on Neurotrauma and Critical Care recently became available, rendering the form that had been printed in previous newsletters obsolete. The new streamlined process decreases the time from application to membership, expediting the extension of Trauma Section benefits to new members.

*Applying is this easy:*

- 1) Go to [www.MyAANS.org](http://www.MyAANS.org).
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- 6) Complete and submit the application following the online instructions.

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