Dear Colleagues,

When physicians advise athletes with spine injuries whether and when to return to play, the stakes can be very high. That’s a clear theme of the several return-to-play–related articles in our “Spine & Brain in Sport” special section of this year’s Spinal Column from Cleveland Clinic’s Center for Spine Health.

Yet the prospects for safe return to play can vary greatly depending on an athlete’s spine condition. While return to collision sports is generally not advisable after cervical cord neurapraxia when there is significant spinal canal narrowing (p. 9), safe return to play is increasingly the rule for adolescents following spinal fusion for scoliosis (p. 12). Our series also addresses return-to-play considerations after treatment for spondylolysis and spondylolisthesis (p. 13) and after concussion in student athletes (p. 15) — a topic that has increasingly captured the nation’s attention.

We round out our “Spine & Brain in Sport” section with a profile of unprecedented investigations our researchers are conducting on the biomechanics of brain injury in boxing (p. 18). By combining imaging, behavioral evaluation and impact studies, our team aims to quantify the acute effects of head impacts more comprehensively than has ever been done before.

Of course, most of our activity in the Center for Spine Health extends beyond sports-related care, and the rest of the issue focuses on notable developments in quality improvement, research and the education of tomorrow’s spine surgeons. Bookending the issue is a pair of contributions that represent two distinct but essential aspects of the job of all spine medicine caregivers: vigilance about healthcare value, and empathy.

We start with a focus on healthcare value in an update on the Cleveland Clinic Spine Care Path (p. 3). This article offers a window into how we are using the care path as the organizing principle to align our services to provide patients with the highest-quality care in the most timely and efficient manner possible.

We conclude with the case of a patient with an intramedullary cervical spine tumor (p. 24), but it’s a case report with a twist. We focus on how our spine specialists communicated with their young patient, explaining the nuances of a diagnosis that did not involve malignancy but whose cure nevertheless required highly risky surgery. This vignette underscores the importance of putting ourselves in our patients’ shoes — and the rewards of doing so when the outcome is exceptionally good.

From healthcare value to empathy to sports care, this issue captures the breadth of contemporary practice in spine medicine and surgery. I hope you find it helpful to your practice, and I invite your feedback at bell@ccf.org.

Respectfully,

Gordon R. Bell, MD
Director, Center for Spine Health
Cleveland Clinic Neurological Institute
Dear Colleagues,

Despite increased spending for spine care and a marked rise in the utilization of imaging and interventional and surgical procedures, the functional outcomes of treatment have been declining. Though there is broad consensus among multiple evidence-based clinical practice guidelines for back care, variability in diagnosis and treatment of spinal disorders remains extreme and is influenced by both practitioner specialty and geographic location. The new Cleveland Clinic Spine Care Path has been created to improve the value of spine care by reducing unnecessary and costly variability in management while improving patient outcomes.

From Algorithm to Guides

Developed with multidisciplinary input from medical spine specialists, spine surgeons, physical therapists, chronic pain specialists and acute pain management physicians, the Spine Care Path is designed to provide an evidence-informed clinical road map to assist practitioners in managing the full range of spinal disorders. As outlined in last year’s edition of this publication (see page 4 at clevelandclinic.org/spinalcolumn2012), the care path began with a work-flow diagram outlining the progression of evaluation and management across the continuum from acute through chronic symptoms, incorporating medical, interventional, surgical, psychosocial and rehabilitation components.

Further evolution of the care path has included development of narrative care path “guides.” The guides for back, neck and radicular pain are designed as clinical manuals for use by the practitioner. They succinctly describe in useful detail the appropriate steps in patient management with supportive rationales and evidence. The guides also provide suggestions for assessment of patient outcome and process measures to be obtained at specific points along the care timeline.

In essence, development of the care path has led to a sharper focus on measuring the value of care, including both patient outcomes and clinical process.

Organizing Principle for Spine Care Delivery

The Spine Care Path and accompanying guides delineate a detailed timeline for delivery of care across the full spectrum of symptoms, involving a wide range of providers: primary care physicians, nurse practitioners and physician assistants, physical therapists, medical and interventional specialists, surgeons, behavioral health clinicians, and rehabilitation specialists.

Development of the care path has raised important questions about the organization of the delivery system for spine care, particularly as we focus more and more on high-quality, value-based care for populations. The care path serves as the organizing principle for realigning our services — providers and locations — to provide the highest-quality care in a timely manner to patients at all points along the continuum.

Among the issues we are addressing is the need to match appropriate clinicians to patients at various stages of care. For example, acute back pain is common and generally resolves with simple therapy. For patients without red flags, imaging is rarely required. Providing such patients prompt access to care with back education and advice on activities to try may be best achieved using physical therapists or nurse practitioners as entry-level providers. When back pain persists, the care path defines when referral to medical spine specialists, spine surgeons or behavioral health professionals is indicated.

As we are increasingly expected to manage the care of large populations, the care path provides a framework for defining the best mix of providers and required support services and locations to address patients at the various points along the spine care continuum.

Documenting Outcomes and Process Through the EMR

Implementation of the Spine Care Path provides a great opportunity to develop a continuous quality improvement model for spine care. By capturing patient
outcome measures in various domains — including pain, function and mood — and defined process measures such as imaging use and appropriate referrals, the care path is designed to provide information on the clinical effectiveness of treatment. The ability to capture and analyze these data and modify care as required is facilitated by integration of the care path into the electronic medical record (EMR).

In the Center for Spine Health, patient-reported outcomes — including the nine-item Patient Health Questionnaire (PHQ-9) for mood, the Pain Disability Questionnaire (PDQ) for function and a numerical pain score — are captured at each visit through Cleveland Clinic’s Knowledge Program® (an interactive database that elicits patient-reported validated outcome measures throughout the course of care) and recorded in the EMR. Through use of the care path, important clinical data elements have been identified for inclusion in structured documentation to be embedded in the EMR. These retrievable data sets will facilitate retrospective study of the process, the cost of an episode of care and the episode’s impact on clinical outcomes.

**Continued Refinement: ‘Bolt-Ons’ and Next Steps**

Ongoing evolution of the Spine Care Path includes extending, refining and standardizing treatment limbs such as physical therapy or specialty referrals through what we call “bolt-ons” to the original work-flow algorithm. Physical therapy provided for spinal disorders varies from application of passive modalities including heat, massage and traction to active exercise programs ranging from core strengthening to mechanical diagnosis.
A Smartphone Companion to the Spine Care Path

The Cleveland Clinic Spine Care Path will soon be complemented by a new Cleveland Clinic smartphone application (working name: MySpine) that patients with acute back pain can use as a self-care tool in the early stages of management (in the absence of red flags). The app, developed for both the iOS and Android operating systems, includes the following:

- Educational content about back pain
- Tools for daily pain monitoring and incident reporting
- Videos and images demonstrating recommended exercises
- A post-exercise survey
- Data reports for progress assessment
- Tools for appointment scheduling and clinician messaging

Designed as a companion to the care path during a patient’s first six weeks of management, the app is currently in beta testing.

and therapy (MDT, or the McKenzie method). The bulk of evidence suggests that active exercise programs are superior to passive modalities, but comparisons are lacking. Using a best-evidence model, we are developing a standardized physical therapy approach to managing back pain. In addition to physical therapy, bolt-ons are currently in development for emergency department patients (Figure 1), patients with vertebral compression fractures and surgical patients.

The Spine Care Path is now being piloted at a couple of family health centers in the Cleveland Clinic health system. We are monitoring its operation in real-world practice and collecting information on resource utilization for comparison with pre-implementation levels. We look forward to sharing and applying our observations and continuing refinement of this dynamic management tool.

KEY POINTS

Recent evolution of the Cleveland Clinic Spine Care Path includes introduction of narrative care path guides and “bolt-ons” to add detailed recommendations in areas such as emergency care and postsurgical care.

The care path serves as a framework for defining the best mix of providers, support services and treatment locations to optimize value and patient outcomes across the spine care continuum.

Integrating the care path into the EMR provides an ideal opportunity to develop a continuous quality improvement model for spine care through the ability to capture, analyze and modify care practices.
Knowledge Program Data Collection Tool Boosts Quality — and Puts Spinal Care Assumptions to the Test

By E. Kano Mayer, MD; Ajit Krishnaney, MD; and Tagreed Khalaf, MD

This year marks the fifth year of systemwide use of Cleveland Clinic’s data collection system known as the Knowledge Program®. Several years ago, our Neurological Institute leadership had the vision to create a quality and outcomes tracking system capable of prospectively embedding multidomain performance data (outcomes data measuring function, quality of life, depression, anxiety, pain, etc.) into the patient’s electronic medical record. The aim was to attach these patient-reported data to every facet of care throughout the Neurological Institute, including the Center for Spine Health. The resulting system — the Knowledge Program — has become integral to our delivery of high-quality care and is being expanded for use in Cleveland Clinic institutes beyond the Neurological Institute.

Every month huge volumes of data collected via the Knowledge Program are analyzed and used to improve quality and address controversies in care management. A summary of yearly outcomes data, largely derived from the Knowledge Program, is available in the Neurological Institute’s Outcomes book, which is available online at clevelandclinic.org/outcomes.

From Leap of Faith to Vital Value Tool

Initially the Knowledge Program was a leap of faith. Today the data collected allow Cleveland Clinic to position its institutes and centers at the forefront of the value-based purchasing model. The Knowledge Program shows its greatest utility in demonstrating treatment efficacy and outcomes to insurers, employers, government agencies and the public. In an age of increasing transparency, individuals want to know they are tipping the risk curve as well as the cost curve in their favor and away from expensive, unproven procedures backed only by marketing.

Sampling of 2012 Outcomes

Cleveland Clinic’s 2012 Outcomes books reflect ongoing efforts at continuous quality improvement with simultaneous efforts to benchmark our diagnosis-specific treatments against the best prospective research findings available. The most important baseline measure is the rate at which patients and providers complete their respective performance measures at every visit to provide a longitudinal view of patients’ health over a treatment episode. To that end, the Center for Spine Health achieved a mean Knowledge Program completion rate of 75 percent in 2012, which is up from just under 70 percent in 2011.

Among other important Center for Spine Health data for 2012:

• Postoperative readmissions were reduced to a monthly mean of 7.0 percent averaged over the year, down from a mean of 7.9 percent in 2011.

• The overall mortality rate continued to decline and, at 0.09 percent, remained superior to recent national benchmarks of 0.3 percent¹ and 0.4 percent².

Questioning Assumptions with Outcomes Data

Robust outcomes tracking has also led us to question previous assumptions common among physicians who treat spinal disorders. A long-standing assumption holds that co-existing depression may reduce the benefit that patients derive from surgery or spine interventions. The multidomain performance measures we have embedded in the Knowledge Program reveal a trend toward improved or resolved depressive symptoms in the majority of patients who undergo common spine surgeries.

For example, in 2012 approximately 32 percent of patients with a symptomatic lumbar disk herniation had preoperative findings of at least moderate depression, defined as a Patient Health Questionnaire-9 (PHQ-9) score greater than 9. Following spine surgery, 65 percent of these patients had a clinically significant improvement in depression, defined as a PHQ-9 score reduction of five points or more (Figure 1), over a mean
follow-up of 186 days. Moreover, 29 percent of patients with symptomatic lumbar disk herniation had findings of at least moderate depression prior to a single spinal epidural injection. A clinically significant improvement in depression (defined as above) was seen in 60 percent of these patients after lumbar spinal injection and was maintained over a mean measurement interval of 157 days, with repeat measurements taken over 12 months (Figure 2).

Overall, approximately 80 percent of patients with symptomatic disk herniation who did not respond to conservative care and underwent surgery noted improvement in functional status as measured by the Pain Disability Questionnaire (PDQ) and improvement in health-related quality of life as measured by the EuroQOL instrument (EQ-5D) over 157 days of follow-up (Figure 3).

Findings from our Outcomes book bring into question whether preprocedure depression is indeed a negative prognostic indicator, as suggested by literature to date. Our findings seem to indicate that spinal procedures (surgery and injections) provide post-procedure physical and psychological benefits that would not be obvious from the prior published literature. These findings were echoed over multiple diagnoses and surgical interventions, including lumbar surgery for spinal stenosis, cervical surgery for disk herniation and surgery for cervical spondylotic myelopathy. This unexpected result has led to new prospective research initiated by former spine surgical fellow David Anderson, MD, and staff surgeon Ajit Krishnaney, MD.

More Data-Driven Inquiry Underway

Ongoing research is focusing on the potential incongruity of other long-standing assumptions in the treatment of spinal disorders. The most notable example is the finding that 70 percent of Center for Spine Health patients with symptomatic lumbar disk herniation had only one injection within a 14-month measurement period. In those with second injections, the mean interval to the second injection was 136 days, and
Standard beliefs among spine specialists — like the notion that a “series of three” epidural injections is required — seem not to be borne out by three years of prospective observation cohorts.

the median was 124 days. Only 9 percent of patients went on to have surgery in the 14-month measurement period, in contrast to a rate of 48 percent of patients requiring surgery over a four-year period after spinal injections in a recently published study.3

Standard beliefs among spine specialists that a “series of three” epidural injections is required, that a majority of patients with disk herniation will require surgery and that conservative care produces inferior results seem not to be borne out by three years of prospective observation cohorts. More stringent controlled studies are needed, but good outcomes work is leading the way in generating new scientific questions.

We look forward to keeping colleagues across the nation apprised of new insights into the treatment of spinal disorders through a rigorous commitment, backed by our powerful Knowledge Program tool, to tracking patient-reported performance measures.

References
Return-to-Play Decisions Following Cervical Spine Injuries: With Limited Data, Can We Avoid Putting Necks on the Line?

By Gordon R. Bell, MD

Spinal injuries, particularly neck injuries, are among the most feared and dangerous injuries in sports. Decisions about if, and when, a player may safely return to competition can be difficult. Because the necessary scientific data to inform such decisions are generally incomplete, return-to-play decisions are too often ambiguous and subjective.

Focus on Football

Football is the sport most commonly associated with cervical spine injuries. Data from the National Center for Catastrophic Sports Injury Research indicate that some 1.8 million Americans play football, including 1.5 million at the junior and senior high school level, 75,000 at the college level, and 2,000 at the professional level.

Helmets: What’s Good for Heads Can Be Bad for Necks

A review of football head and neck injuries from 1959 to 1963 found that rates of intracranial hemorrhage and intracranial death were two to three times greater than rates of cervical spine fracture/dislocation or cervical quadriplegia. In contrast, a study of football injuries from 1971 to 1975 revealed a dramatic reversal in injury rates, with the incidence of cervical spine fracture/dislocation exceeding the rate of intracranial hemorrhage and death by twofold to fourfold. This study found that, compared with 1959-63, there was a 66 percent reduction in intracranial bleeds and a 42 percent reduction in craniocerebral deaths but a 204 percent increase in cervical spine fractures and dislocations.

This striking shift from head injuries to spine injuries was attributed to the modern football helmet, whose superior protection of the head paradoxically promoted playing techniques that put the neck at risk for potentially catastrophic injury. Specifically, a headfirst tackling technique known as spearing, in which the player hits with the crown of his helmet, results in straightening of the cervical spine and axial loading of the spine on impact. The resulting axial forces are not dissipated as well as when the spine is lordotic, which can result in failure of the spine with the potential for spinal cord injury (see sidebar and figures on page 10). Spearing accounted for an estimated 52 percent of the quadriplegia injuries in football from 1971 to 1975.

Philadelphia orthopaedic surgeon Joseph Torg, MD, was instrumental in describing the significance of spearing as a cause of spinal cord injury. His landmark work resulted in the National Collegiate Athletic Association’s adoption of rules in 1976 to eliminate spearing in collegiate football, which led to an immediate 50 percent reduction of quadriplegia in collegiate football. The incidence of quadriplegia has since continued to fall, to a current rate of less than 0.5 per 100,000 athletes.

Concussion to the Spinal Cord

In 1986 Torg coined the term cervical cord neurapraxia (CCN) to describe a concussion to the spinal cord as a result of an on-field collision. CCN is a transient motor and/or sensory disturbance, lasting less than 24 hours, that Torg found to occur in approximately 7.3 per 10,000 athletes in a 1984 survey of nearly 40,000 college football players. In Torg’s view, CCN is a distinct and separate entity from spinal cord injury resulting in quadriplegia.

Notably, approximately 50 percent of players experiencing a transient episode of CCN who decide to return to play experience a second such episode. The risk of experiencing a second episode is inversely proportional to the size of the cervical bony canal, as athletes with narrow canals are more likely to experience another episode than are those with larger canals.

Spinal Canal Size Matters Most

When faced with an athlete who experienced a transient episode of CCN, the physician’s role is to determine whether there is a structural abnormality that could put the athlete at risk for another transient episode of CCN or a potentially catastrophic permanent spinal cord injury. Unfortunately, the data to guide such decisions are incomplete. At minimum, however, the physician can tell the patient that if his canal diameter is less than normal, he has a risk of experiencing another transient episode. Exactly what that risk is depends on how narrow the canal is. A normal canal diameter (14 mm
Images from an Illustrative Case

Cervical X-rays and MRIs from a 25-year-old professional football player who sustained several episodes of leg weakness and gait unsteadiness following head-on collisions.

Top left: A lateral cervical X-ray showing reversal of normal cervical lordosis with frank kyphosis. Lordosis is protective and helps to dissipate forces from an axial collision. Straightening of the spine and kyphosis can result in axial forces being transmitted to the vertebral bones and result in fracture or other catastrophic spine injury. Top right: Lateral cervical MRI showing a C4-5 disk herniation with narrowing of the cervical spinal canal. Bottom left: Axial MRI at C4-5 showing the midline disk protrusion indenting the cervical spinal cord. Bottom right: Postoperative lateral cervical X-ray showing a two-level fusion at C3-4 and C4-5. The initial surgery was a single-level anterior cervical discectomy and fusion (ACDF) at C4-5 that eliminated the herniation and cord compression but did not completely address the kyphosis. Because the patient continued with symptoms of cord compression with residual kyphosis at C3-4, he underwent a second ACDF at C3-4. He did not return to football and has not experienced further gait abnormality.
on MRI) is associated with an approximately 5 percent risk of a subsequent CCN episode, whereas a narrow canal (9 mm or less) is associated with a more than 50 percent risk of recurrence.

Whether another transient episode could lead to permanent spinal cord injury is unknown, although Torg thinks not. Others hold a contrary view, but it would seem the risk is low. The long-term effect of one or more episodes of CCN on spinal cord function is also unknown. Only recently, for example, have we begun to appreciate the long-term effect of multiple concussions on brain function. It seems intuitive that the potential exists for long-term sequelae following multiple episodes of CCN.

Return-to-Play Consensus Points

There is general agreement that return to play is permitted in the following circumstances:

- A healed fracture with normal alignment
- A small, asymptomatic cervical disk herniation
- A single episode of CCN with normal studies and no functional stenosis

Similarly, there is general agreement that return to play is contraindicated under the following circumstances:

- Persistent neurological deficit or myelopathy
- Myelomalacia of the spinal cord by MRI, which indicates signal changes within the substance of the spinal cord
- An unhealed spinal fracture or ligamentous instability
- Congenital anomalies of the occiput-C2 region
- Multiple episodes of CCN

Points of Contention — and the Author’s Perspective

More controversial is whether an athlete should return to a collision sport following even a single episode of CCN when there is evidence of significant narrowing of the spinal canal with spinal cord compression. Some authors refer to this as functional stenosis with a reduced functional reserve — a significant reduction or elimination of the “cushion” of cerebrospinal fluid surrounding the spinal cord. Based on my review of this subject, I would be very reluctant to return a player to a collision sport following an episode of CCN in the presence of significant functional stenosis.

Return-to-play decisions after spinal cord injury are difficult, and the price to be paid for a wrong decision can be high. As long as objective data to guide these decisions remain limited, it seems prudent that an athlete with an episode of CCN in the presence of functional stenosis be advised to avoid collision sports.

### KEY POINTS

- Return-to-play decisions following cervical spine injuries in collision sports can be difficult, as objective data to guide such decisions are limited.
- About 50 percent of football players who return to play after a transient episode of cervical cord neurapraxia (CCN) experience a second such episode. The risk of a second episode is inversely proportional to the size of the cervical bony canal.
- There is general agreement that return to play is permissible in several circumstances and contraindicated in several others. More controversial is whether an athlete should return to a collision sport after even a single episode of CCN when there is significant spinal canal narrowing with spinal cord compression.
Return-to-Play Considerations in Idiopathic Scoliosis and Spondylolysis/Spondylolisthesis

Idiopathic scoliosis and spondylolysis/spondylolisthesis have some important factors in common from a patient management perspective. Both are relatively common problems in children and adolescents, and because both are seen most frequently in youth who are active and athletic, safe return to sports is an issue that often looms large in their management.

Cleveland Clinic spine specialists approach return-to-play considerations in these conditions by recognizing that sports, dance and similar activities are immensely important to many adolescent patients’ quality of life. Yet we temper that recognition with a caution not to put patients at risk from a return to activity that is excessive or premature. Two of our specialists outline Cleveland Clinic’s approach to return-to-play issues in these respective conditions.

After Spinal Fusion for Scoliosis, Safe Return Is Increasingly the Rule

By Ryan C. Goodwin, MD

Spinal fusion surgery remains the gold-standard treatment for progressive idiopathic scoliosis and is best performed in the teenage years. For treatment to be successful, fusion must occur before progression to full activity, irrespective of the technique used. For the many scoliosis patients who are involved in athletics, this puts a particular premium on judicious return-to-play decision-making.

Confirming Fusion Is Imperative

With the advent of segmental instrumentation — specifically, segmental pedicle screws — safe return to sports and other physical activities has become commonplace among patients with idiopathic scoliosis who undergo spine fusion surgery. It is now routine practice to permit return to many aggressive activities such as contact sports once a solid fusion has occurred.

Because there is no specific imaging modality that will confirm a solid fusion, careful clinical examination and scrutiny of radiographs are essential to ascertain whether a solid fusion has occurred. Once the clinician has determined that a solid fusion is present — typically six months postoperatively in a healthy adolescent — sports and other aggressive activities may be resumed as tolerated. Figure 1 (opposite page) presents images from a representative case.

When Managing Expectations Matters Most

Although return to sports after spine fusion surgery is more common today than in the past, it is important that patients and families have realistic expectations about the postoperative course, including return to sports, before patients undergo the procedure.

Literature suggests that patients whose lowest level of fusion is at T12 or L1 have the highest percentage of full return to sports. As the fusion mass extends distally to L2 and L3, the likelihood of a return to sports decreases. Patients with fusions to L4 and below are unlikely to return to sports or activities requiring significant movement and flexibility.

Sports like soccer, basketball, volleyball, track and swimming are all activities in which an adolescent with a successful fusion for deformity is likely to be able to participate. Activities such as ballet and gymnastics are more difficult to return to following fusion, but there is a high likelihood of return to full activity when the most distal fusion level is T12 or above. Fusion to the lumbar spine significantly decreases rates of return to these activities that require significant flexibility.

True collision sports such as football and rugby should be avoided by all post-fusion patients. Some surgeons advocate permanently excluding ice hockey too, but many others permit participation in this highly aggressive sport after an informed discussion with the patient and family.
For Spondylolysis/Spondylolisthesis, Pain Control Guides Return to Play

By Russell DeMicco, DO

Made up of the Greek roots for “vertebra,” “break” and “slipping,” spondylolysis refers to a defect in the pars interarticularis (the segment of the vertebral arch lying between the superior and inferior articular processes) and spondylolisthesis refers to a defect with slipping of one vertebra on another.

Both conditions are relatively common in children and adolescents. Spondylolysis may be present in 5 to 10 percent of a normal population and is the most common cause of spondylolisthesis. There is a higher incidence of spondylolisthesis in certain populations, including athletes — particularly gymnasts, divers, football linemen, tennis players, divers and rowers.

Essentials of Evaluation

Physical exam findings may include tight hamstrings, crouched or waddling gait, or even palpable step-off. Although history and physical exam findings may raise the level of suspicion, the diagnosis is confirmed with imaging.

Standing anteroposterior and lateral lumbar radiographs (Figure 2) help define any underlying alignment concerns that may be missed on studies while the patient is lying down. Spondylolysis can be appreciated on oblique lumbar radiographs. Advanced imaging studies (MRI, CT, and bone scan with SPECT) can provide greater detail and help determine the treatment course. The Meyerding grading classification is used to describe the degree of slippage of the upper vertebra on the lower one:

- Grade I, < 25 percent
- Grade II, 25 to 49 percent
- Grade III, 50 to 74 percent
- Grade IV, 75 to 99 percent
- Grade V, 100 percent (spondyloptosis)

The most common type of spondylolisthesis is the isthmic or spondylolytic spondylolisthesis, which can be divided into subtypes as follows:

- Spondylolytic fatigue fracture of pars interarticularis
- Elongated but intact pars
- Traumatic (acute pars fracture)

Symptoms may include dull, aching low back pain that is worsened with athletic endeavors. Repetitive flexion/extension motion is thought to be a key factor in development of spondylolysis and aggravation of painful symptoms.

Treatment Considerations

The treatment of patients with spondylolysis or spondylolisthesis ranges from observation to restriction of activities/athletics, bracing and surgery. Simple medications (e.g., acetaminophen or NSAIDs such as ibuprofen or naproxen) and education are often the first steps in management.

Advanced imaging aids in determining the acuity of spondylolysis. Response to bracing is more predictable and favorable with acute process without evidence of
bony sclerosis. The braces/spinal orthoses are used to maintain lumbar flexion to counteract extension forces through the pars.

Because activity restriction can be a component of early management in many cases, return-to-play considerations can be difficult. Here is our general guidance for management of these conditions:

- The baseline recommendation for a patient with an incidental and asymptomatic pars defect is usually no restriction of activity and annual radiographs through skeletal maturity.
- For a patient with up to 25 percent slippage without symptoms, the recommendation may be no restriction of activity and semiannual radiographs.
- The plan for a symptomatic patient with slippage up to 50 percent includes activity modification and physical therapy with development of a home exercise program involving core work/abdominal strengthening, postural control and hamstring stretching.
- Surgical intervention may be indicated for patients with recalcitrant pain despite good conservative care or patients with progressive neurologic decline or progressive slippage beyond 25 to 50 percent.

Thankfully, the number of patients undergoing surgery for these problems is low compared with the total identified. Imaging is useful in identifying problems and guiding management.

**Bottom Line on Return to Play**

Surgical options include repair of the pars defect or segmental fusion across the disk. When surgery is needed, the surgical approach used and the path to return to play are typically decided among the spine physician, the patient and his/her family, and the patient’s athletic trainer or physical therapist. Return to play is determined on a case-by-case basis with input from all the above parties. Healing of a spondylolysis is confirmed when resolution of edema can be seen on certain MRI sequences (STIR sequences are best; T2- and T1-weighted images also may show pathology). Pain is typically the factor that limits return to play, so if we can control pain and allow healing, most patients will successfully return.

**KEY POINTS**

Following spinal fusion surgery for adolescent idiopathic scoliosis, most patients can safely return to all but the most aggressive collision sports, as tolerated, once the surgeon is fully confident that a successful fusion has been achieved.

A more distal fusion level for idiopathic scoliosis is a negative predictor of return to activity at previous levels. Patients with fusions to L4 and below are unlikely to return to activities requiring significant movement and flexibility.

Because activity restriction can be a component of early management of spondylolysis/spondylolisthesis, return-to-play considerations can be difficult. Following successful surgery, most patients can successfully return to play.
‘When in Doubt, Sit Them Out’
Return to Play After Concussion: Preventing Cumulative Concussive Injuries in Student Athletes
By Richard Figler, MD

When a young athlete sustains a concussion, the brain usually does a remarkable job of healing itself if given the opportunity. Unfortunately, some athletes get in the way of the process. They may have a “warrior mentality” about returning to play and not letting their teammates down, or they simply may not recognize persistent symptoms such as headache or balance issues.

Physicians who treat concussions play an important role in guiding return-to-play decision-making following concussion, especially as it relates to ensuring that young athletes do not return to collision sports prematurely. We follow specific return-to-play guidelines at Cleveland Clinic and advocate erring on the side of caution: “When in doubt, sit them out.”

A Team Effort — Including Spine Specialists
Cleveland Clinic’s Concussion Center is committed to evaluating and managing concussed patients using a comprehensive, multidisciplinary approach. The center offers concussion evaluations and management through a collaborative team effort involving primary care sports medicine physicians, neurologists, neurosurgeons, neuropsychologists, certified athletic trainers, vestibular therapists, radiologists, neuro-ophthalmologists and researchers.

When appropriate, we refer to spine specialists, especially in cases of high-trauma, high-velocity injuries in which the brain pathology may respond but neck and cranial irritation persists along with symptoms such as dizziness. With whiplash-type injuries, sometimes symptoms such as persistent neck pain and mobility can be more debilitating than the actual concussion when it comes to recovery. Those symptoms also need to be resolved before an athlete can return to play.

When Concussion Risk Is Greatest
Collision sports such as football, lacrosse and sometimes wrestling present the greatest risk for concussive injury. For example, more than 1 million U.S. youth play high school football every year, and over the course of a season, the risk of concussion for an individual player is about 10 percent.

Student athletes who sustain one concussion have a three to six times higher risk of sustaining a repeat concussion. While genetics may be a factor, athletes who participate in high-collision sports clearly have a greater risk of a second injury.

In recent years, media attention has focused on rare but catastrophic incidents in which student athletes have returned to play prematurely and suffered from second-impact syndrome, in which a second concussion is sustained while the brain is still healing from a previous concussion. In certain scenarios, two concussions stacked on top of each other in this way can cause diffuse swelling and loss of blood control in the brain, which can result in severe disability and, rarely, death.

More commonly, athletes who return to play prematurely and sustain another concussion a short time later may experience cumulative injury or cumulative symptoms that prolong recovery to several weeks or months rather than the typical one to two weeks. These types of injuries not only affect athletes’ ability to participate...
in sports but can also significantly impact concentration and performance in school.

Legislation and Media Help Curb Catastrophic Cases

In response to these issues, more than 40 states (including Ohio earlier this year) have enacted legislation regarding return to play for student athletes. The laws generally require referees, coaches and trainers to remove athletes from practices or games following a suspected injury, and athletes cannot resume participation until they are formally cleared by a designated healthcare professional.

Pulling athletes off the field immediately after an injury paves the way for a faster recovery. Quick removal from play is especially important in youth who may have sustained a concussion but may not experience symptoms, such as headache, until hours later, as symptoms may be delayed.

A Stepwise Protocol Should Guide Return

Return-to-play decisions should be based on the athlete’s symptoms as well as on neurophysical and neuropsychological signs. Once athletes are back to symptom-free mental activity, they may resume physical activity according to a stepwise protocol. If post-concussion patients begin a moderate amount of exercise and remain asymptomatic before, during and after, they typically can continue to progress through.

As a general rule, if athletes have no recurrence of symptoms as they progressively increase activity, this suggests they are back to a normal state. The best way to gauge a normal state is to compare the current condition with the pre-injury baseline. While specific baseline tests or parameters can be used, it is also critical for athletes to be forthright about their symptoms.

More Clinical Tools than Ever

The clinical teams that treat sports-related injuries have more resources and tools than ever to assess student athletes and ensure they are free of both mental and physical symptoms at rest and with activity before we return them to participation. These resources include:

- Consensus statements by national and international specialty groups that provide recommendations on concussions and return to play. These include the 4th International Conference on Concussion in Sport\(^1\), the American Medical Society for Sports Medicine (amssm.org), the American Academy of Pediatrics (aap.org) and the American Academy of Neurology (aan.com).

- The SCAT3™ and Child-SCAT3™ standardized tools for evaluating athletes for concussion (Sport Concussion Assessment Tool; available at cattonline.com). These two tools — for children 13 years or older and children 5 to 12 years old, respectively — are based on the consensus statement from the 4th International Conference on Concussion in Sport\(^1\), held in 2012, and include symptom evaluation, cognitive assessment, balance examination and coordination examination.

With more media and legislative attention on these issues, rates of catastrophic concussion have decreased significantly, but more education and awareness are needed.

**KEY POINTS**

Young athletes can have a “warrior mentality” about getting back in the game that may lead them to minimize concussion symptoms. Clinicians need to be aware of this phenomenon and err on the side of caution when clearing athletes for return to play.

Athletes who return to play prematurely and soon sustain a repeat concussion may experience cumulative injury that prolongs recovery and compromises school performance. This type of compounded injury can occasionally be catastrophic, leading to severe disability or death.

The Cleveland Clinic Concussion (C3) App for the iPad allows for baseline assessments and monitoring of athletes to help guide return-to-play decisions, especially when used in conjunction with a newly developed care path integrated with the electronic medical record.
Cleveland Clinic App Brings Objective Assessment to the Sidelines

Cleveland Clinic has developed a proprietary application for the iPad that enables objective, affordable, point-of-care assessment of symptoms associated with concussion in young athletes.

The Cleveland Clinic Concussion (C3) App takes advantage of the iPad’s built-in gyroscope and accelerometer to collect position and time-series data, together with linear and angular acceleration data, to assess balance and concussion symptoms while an athlete performs clinical balance tests with an iPad strapped to the waist (see photo, opposite page). The functions assessed by the app also include cognitive tasks the athlete performs on the tablet screen. The app analyzes data to provide specific measures of the athlete’s postural stability, information processing, reaction times, visual and working memory, and dynamic visual acuity at a given point in time.

After baseline data are collected for individual athletes at the start of a season, the C3 App can be deployed in the locker room or on the sidelines for immediate concussion assessment if an athlete sustains a head injury. Results can be compared with the athlete’s baseline results to improve the chances of an accurate diagnosis.

Reassessments with the app are performed frequently throughout recovery, to monitor progress and guide management — including return-to-play decisions. Follow-up assessment is facilitated by a data visualization tool we call the “Performance Polygon” (Figure 1) to allow easy visual monitoring of recovery to baseline levels (outer trace in polygon) over various time points (represented by the colored tracings) in each cognitive and functional domain assessed. SRT = simple reaction time; CRT = choice reaction time; VOR = vestibular ocular reflex; BESS = Balance Error Scoring System; CAP = cognitive assessment profile.

Athletes and their parents aren’t always happy when we need to make the decision that an athlete isn’t ready to return to play. But if we use established guidelines and objective criteria to guide these decisions, it’s never a mistake to deny clearance to an athlete who remains symptomatic.

We work hard to educate athletes that their brain health is far more important than the numbers on a scoreboard. As I have told my patients, “You get one brain and that’s it — we need to protect it as long as we can.”

Reference
Biomechanics of Brain Injury in Boxing: New Studies Take Broadest and Deepest Look to Date

By Adam Bartsch, PhD; Jay Alberts, PhD; and Edward Benzel, MD

The sports concussion crisis has fueled much research assessing concussion through imaging, behavioral evaluation or impact studies, but little to no research has combined these three modalities for a comprehensive examination of the acute effects of head impacts in combat sports. Until now.

Boxing Biomechanics Study

Researchers from the Center for Spine Health’s Spine Research Laboratory are joining with colleagues from Cleveland Clinic’s Concussion Center and Lou Ruvo Center for Brain Health on an investigation we call the Boxing Biomechanics Study. We are using all three modalities — imaging, behavioral assessment and evaluation of impact dynamics — to begin to pinpoint the dose of head impact that produces brain changes linked to neurodegenerative disease. Our aim is to assess and refine this three-pronged data-gathering approach in a small group of boxers and mixed martial arts fighters to build toward prospective longitudinal studies in large numbers of athletes tracked over years or decades.

We began the Boxing Biomechanics Study earlier this year and expect to report final results in 2014. We are enrolling 10 boxers or mixed martial artists in Las Vegas who are evaluated over one to two days as follows:

- They undergo a baseline brain MRI and a baseline assessment of motor and cognitive functions via the Cleveland Clinic Concussion (C3) App for the iPad® 2 (see sidebar).

- They take part in a sparring session wearing the Cleveland Clinic Intelligent Mouthguard (Figure 1) to capture head impact data. The Intelligent Mouthguard, developed by Spine Research Laboratory and Concussion Center researchers, is equipped with sensors to measure linear and rotational head movement in real time. These data are compared with neurological and motor test results from after the sparring session to drive a computer-based brain model that helps diagnose and pinpoint brain injuries.

- Right after the session, they undergo a post-sparring C3 App assessment and brain MRI.

We are analyzing and correlating data from all three modalities in this initial group of 10 fighters in the hope that this approach will prove to be a comprehensive, “one stop” data collection strategy for assessing and quantifying the dose of head impact causing neurodegenerative changes. After we refine our data collection and technologies based on these findings, our next steps will be to expand the study population closer to 100 fighters and ultimately to 1,000 or more.

Likewise, we hope to extend follow-up assessments to years and even decades if we can follow fighters who turn professional — a prospect facilitated by the Lou Ruvo Center’s presence in Las Vegas. This presence, paired with Cleveland Clinic’s deep concussion expertise, uniquely positions us to comprehensively pursue new insights into how impact-related brain injury occurs, how it relates to clinical deficits, and which types of impacts do and do not cause concussion or other forms of traumatic brain injury.

KEY POINTS

Cleveland Clinic is conducting an unprecedented study combining neuroimaging, behavioral assessment and evaluation of impact dynamics in professional fighters to begin to pinpoint the dose of head impact that produces brain changes linked to neurodegenerative disease.

We plan to build on these findings to design prospective longitudinal studies involving large numbers of fighters tracked over years or decades.

One of our first follow-on studies, now underway with funding from the Federal Aviation Administration, aims to determine the level of head impact that causes loss of consciousness and the functional deficits that immediately follow.
Next Studies Take Flight with FAA Grant

One of our follow-on studies to the Boxing Biomechanics Study is now getting underway. This investigation, funded by a three-year grant from the Federal Aviation Administration (FAA), aims to determine the level of head impact that causes a human to lose consciousness.

The FAA is also looking to identify the types and degrees of functional deficits present right after a person loses consciousness and how long it takes to recover from those deficits following various degrees of impact. For the FAA, the findings have implications for safety procedures in the event of a pilot’s loss of consciousness and for determining if recovery could be swift enough to permit timely exit from an aircraft. Because boxers and mixed martial artists represent essentially the only population of humans in whom it is feasible to study the threshold of consciousness loss, our work on the Boxing Biomechanics Study has optimally prepared Cleveland Clinic for performing this type of research.

The study for the FAA is being conducted in fighters during professional fights, as loss of consciousness is rare during sparring sessions. We are spending the first 12 months of the study modifying the Intelligent Mouthguard for use in professional fights, which requires placement of the device’s battery in the mouthpiece rather than the headgear, and coordinating use of the Intelligent Mouthguard with the C3 App for the new research questions at hand. The next 12 months will involve collecting data with the modified mouthguard and C3 App from a series of professional fights. The final 12 months will involve data analysis and additional data collection from fights as needed.

A Coordinated Concussion Research Vision

As our studies of the biomechanics of impact-induced brain injury evolve, we are grateful for the comprehensive resources Cleveland Clinic brings to bear to help curb the concussion crisis. Our studies marrying the physics and acute clinical effects of brain injury are complemented by other Cleveland Clinic investigations utilizing pathbreaking radiology methods, novel blood biomarkers, genomic testing and pioneering pathology methods to better understand concussion and its prevention and treatment. They are part of an unparalleled and well-coordinated institutional vision to protect the brains of athletes, warriors and others from damaging impacts. We look forward to sharing our results and helping to advance this vision.

The C3 App in the Boxing Biomechanics Study

The Cleveland Clinic Concussion (C3) App promises to change the trajectory of sports concussion evaluation by enabling objective, affordable point-of-care assessment of symptoms associated with concussion (see sidebar on the app on page 17 in preceding article).

Here’s how the C3 App is being used in the Boxing Biomechanics Study: After baseline data are collected for a fighter, the app can be deployed at ringside if the fighter sustains a significant head impact. The app analyzes data to provide objective and specific measures of changes from baseline in cognitive and motor function, balance, and postural stability. When a concussion occurs, reassessments with the app are performed frequently to monitor recovery in each of several functional and cognitive domains. Follow-up assessments are plotted using a data visualization tool we call the “Performance Polygon” (see example on page 17 in preceding article) to allow easy visual monitoring of recovery to baseline levels over time in each domain assessed.
In the five decades since their osteoinductive potential was first characterized, a multitude of bone morphogenetic proteins (BMPs) have been discovered and studied intensively. At the forefront of this group of soluble, low-molecular-weight glycoproteins is recombinant human BMP-2 (rhBMP-2), thanks to its unique, robust capacity to induce bone formation. BMP-2 participates in several signaling pathways and has roles in many important functions, including bone and cartilage growth and embryologic development.

rhBMP-2 has received much attention in recent years due to controversy regarding its use in spine surgery. While rhBMP-2 was extolled after initial randomized controlled trials demonstrated high fusion rates without use of autogenous bone graft (a perceived merit of the product), more recent reports of associated complications have led some to halt or limit use of rhBMP-2 in fusion procedures. These controversies have challenged the spine community to more extensively investigate the relative risks and benefits of rhBMP-2 in spine surgery.

A Promising Alternative to Autogenous Bone Graft

The success of spine fusion surgery is often contingent on achieving solid bony fusion at the surgically treated levels. Autogenous bone graft, typically obtained from the patient’s iliac crest, is considered the gold standard for graft material to promote fusion. It is osteoconductive, osteoinductive and osteogenic. Unfortunately, using iliac crest bone graft can be associated with morbidity, including donor-site pain.

rhBMP-2, first approved by the FDA in 2002 for use with the LT-CAGE™ Lumbar Tapered Fusion Device in single-level anterior lumbar interbody fusion (ALIF) procedures, was thought to obviate the need for iliac crest bone graft. Since its approval, rhBMP-2 has been used off label for fusion surgery in other regions of the spine. In 2011-2012, between 148,000 and 165,000 patients received InFUSE™ Bone Graft, the commercialized recombinant form of BMP-2, as part of spine surgery. The rapid adoption of rhBMP-2 by spine surgeons was undoubtedly spurred by positive early trials reporting that rhBMP-2 improved fusion rates, reduced operative time and blood loss, and had few to no complications.

Complications Cloud the Promise

Within a few years, however, reports of numerous complications were published. In the first systematic review of complications associated with rhBMP-2,¹ we identified 31 articles between 1990 and June 2009 that reported a mean incidence of 44 percent graft resorption, 25 percent graft subsidence and 27 percent interbody cage migration for posterior lumbar spine interbody fusion. Other notable adverse events included heterotopic bone formation, seroma formation and postoperative radiculitis. For anterior cervical fusion, the studies reported a mean incidence of 5.8 percent postoperative soft tissue problems, such as dysphagia and difficulty breathing. Reports related to the adverse events in the anterior cervical spine led the FDA to issue a notification in July 2008 warning surgeons of potential minor and major complications of rhBMP-2.

Insights from the Cleveland Clinic Experience

We proceeded to retrospectively study the Cleveland Clinic experience to identify complications associated with rhBMP-2 in lumbar fusion.² We reviewed all patients between January 2002 and September 2010 who received rhBMP-2 with posterior/transforaminal lumbar interbody fusion (PLIF/TLIF), posterolateral fusion (PLF) or ALIF. Overall, 547 patients were reviewed, with a mean follow-up of 17 months. No differences in complication rates were found among the various surgical approaches, and, notably, complication rates were similar to those of historical controls who did not receive rhBMP-2. Since rhBMP-2 is now frequently reserved for “harder to fuse” patients, such as smokers or those with a history of previous spine surgery, it is noteworthy that in our cohort these two factors were significantly associated with an increased incidence of complications such as radiculitis, reoperation and pseudoarthrosis.
In the aforementioned study, urologic complications were rarely reported. However, urologic complications, particularly retrograde ejaculation (RE) associated with ALIF, received substantial attention following a report from Stanford University that RE occurred more frequently in patients receiving rhBMP-2 compared with control patients. To determine the Cleveland Clinic experience, we retrospectively investigated all male patients who had undergone ALIF with (n = 59) and without (n = 51) rhBMP-2 between 2002 and 2010. We found that the incidence of overall urologic complications did not differ between the two groups, occurring in 22 percent of those receiving rhBMP-2 vs. 20 percent of controls. There was likewise no significant difference in rates of RE, which was reported by 8 percent of patients in both groups. Notably, only one patient had RE recorded in the electronic medical record, and only after telephone interviews with specific questions about urologic complications did we identify the extent of this complication (though it was not associated with rhBMP-2 use).

Turning Research Attention Back to Benefits Too

The limitations of retrospective reviews are well recognized, however, and prospective evaluation of rhBMP-2 is needed to fully understand the risk-benefit ratio of this biologic. Understanding the complications is important for evaluating the utility of rhBMP-2 in spine surgery, but it is not enough. Defining the benefits of rhBMP-2 is needed as well. We are currently systematically reviewing the literature to identify the reported fusion rates, a correlate to clinical success, associated with lumbar spine surgery. We have found that when the reported data are analyzed in combination, ALIF and PLF have significantly higher fusion rates in those who received rhBMP-2 as compared with controls, but there is no difference in fusion rates between groups for PLIF/TLIF. Moreover, there is limited long-term fusion rate evidence for PLIF/TLIF. Our understanding of both the advantages and disadvantages of rhBMP-2 is far from complete, and further prospective investigation is needed before conclusions can be drawn.

Role-Refining Quest Continues

The fact that BMP-2 forms bone is indisputable, as it is demonstrated by a multitude of preclinical and clinical studies. A mounting body of evidence suggests that its osteoinductive potential is largely predicated on the type of biological environment (i.e., type of fusion performed), the dose and the carrier of BMP-2 used. Early enthusiasm for rhBMP-2 and its potential to obviate the need to use the patient’s own bone for fusion certainly has been tempered by its more recently defined adverse event profile. One other important consideration is the financial cost associated with use of this biologic, which is beyond the scope of this article. In the coming years, it is likely that the attention now focused on the merits, drawbacks and costs associated with rhBMP-2 will ultimately help define its optimal indication and application for spine fusion procedures.

References


KEY POINTS

Complication rates associated with rhBMP-2 in various thoracolumbar and lumbar fusion procedures are between 8 and 20 percent for wound infection, radiculitis, pseudoarthrosis and reoperation.

Previous spine surgery and current smoking status are significantly associated with postoperative complications in patients receiving rhBMP-2 regardless of the surgical approach.

Among men undergoing anterior lumbar interbody fusion, approximately 20 percent reported urologic complications and 8 percent reported retrograde ejaculation, with no significant difference between those who did and did not receive rhBMP-2.
Resident training faces a multitude of changes. Duty hour restrictions impose limits on training time and the total number of cases performed by residents while in training. Given the lack of a corresponding decrease in clinical workload, there remains less time for educational activities. Additionally, healthcare system evolution has reduced resident autonomy in the operating room (OR) compared with what staff experienced during their training.

Changing Landscape Demands New Teaching Techniques

To adapt to these changes and maintain a high standard for our graduating trainees, educators are being forced to devise smarter educational techniques. We can no longer rely on the “sponge” educational concept — i.e., if trainees spend enough time in the hospital and OR, they will absorb enough to reach a critical threshold in knowledge base and surgical technique.

Following a model from the aviation industry, other specialties, such as general surgery and urology, have adopted simulator training.1-5 However, computer simulation is better suited to on-screen modalities such as laparoscopy and endovascular therapy. Although some preliminary spine simulators have been developed for screw placement, these simulators leave something to be desired in terms of realism, anatomic detail and translation to the OR.6

We believe there is no substitute for hands-on experience. Visuospatial skills and muscle memory cannot be developed through reading. In the OR, residents do not have the freedom afforded by the laboratory environment. In the current healthcare climate, there is greater emphasis on reducing OR time, so trainee education is balanced against maintaining flow in the OR. Additionally, the laboratory affords opportunities to take surgical risks that cannot be taken in the OR due to the spine’s proximity to critical neurovascular structures.

How We Did It

In 2011, we began a formal educational dissection curriculum for Cleveland Clinic neurosurgery residents in postgraduate years (PGY) 2 through 5. Time was blocked on Friday afternoons once a month for six residents to leave their clinical duties to attend. We alternated between sessions for PGY 2-3 and PGY 4-5 residents in order to tailor activities to different baseline knowledge and skill levels.

Starting from scratch in early 2010, we needed about a year to secure laboratory space, equipment and funding for specimens. Funding was obtained largely from industry, with smaller contributions from the institution. Care was taken to structure agreements with industry for grant money to be given to the department for educational use only, free from any industry influence and in accordance with current guidelines for physician-industry interactions. Because of initial space and budget limitations, the curriculum’s first year covered solely skull base surgery approaches. In 2012-2013, we incorporated a focused curriculum for spine and peripheral nerve surgery.

Advantages of an Institutionally Based Lab Curriculum

While national courses provide a reasonable alternative, there are several key advantages of an institutionally based laboratory curriculum:

- It is easier for programs to coordinate blocking of time for residents to get away from clinical duties.
- There are fewer burdens on residents in terms of cost and travel.
- Courses tend to overwhelm attendees with a large volume of information packed into several days, resulting in fatigue and diminishing interest. Focused sessions of three to five hours allow trainees more time to prepare and reflect on a few key learning points. This promotes information retention.
- An institutional curriculum allows programs to cover rare procedures and compensate for any institutional case volume deficiencies.
We certainly recognize the hurdles in forming such a curriculum, including the need to secure instrumentation, lab space and specimens. Faculty interest and availability are also prerequisites, as is resident time away from clinical duties. For centers that find these barriers too burdensome, courses remain a good second option.

The formation of a standardized or suggested trainee dissection curriculum by governing organizations would help training programs during the start-up phase. A dissection guide would also serve as a good educational resource for residents during their training.

Next Steps and Conclusions

Given the overwhelmingly positive response from our residents, we plan to expand the number of sessions from 12 a year to 14 to 18 a year. Other plans include:

• Developing formal tools to measure resident surgical skills in the lab for constructive feedback
• Conducting research studies to determine the actual impact of a formal lab dissection curriculum

Incorporating a formal spine and peripheral nerve dissection curriculum into our neurosurgical training program has been a resounding success. Establishing a similar program involves overcoming multiple barriers, including the need to obtain space, equipment, funding for specimens, and resident and faculty availability. We believe a formal lab dissection curriculum can augment training in ways that simulators and courses cannot. Development of suggested curriculum or dissection guides focused on resident trainees would ease the transition.

References


KEY POINTS

We have incorporated a lab-based formal spine and peripheral nerve dissection curriculum into our neurosurgical training program. The curriculum has met with overwhelmingly positive response from residents in its first two years.

A formal lab dissection curriculum can augment training in ways that simulators and national courses cannot. However, establishing one requires faculty and residency availability and the ability to secure lab space, equipment and specimen funding.

Our plans for the curriculum include developing instruments to measure surgical skills in the lab for more constructive feedback and conducting research to quantify the curriculum’s impact.
Intramedullary Cervical Spine Tumor: A Case Study in Helping Patients Navigate a Risky Road to Success

By Edward Benzel, MD; Ajit Krishnaney, MD; and Ann Harrington, MSN, CNS

Sometimes life comes at our patients fast. Consider Kristen, a young lady who sought care at Cleveland Clinic’s Center for Spine Health a few years ago, when she was 28. Life was quite good for Kristen: She had married Nick in 2009, and they shared dreams of having a family and building a fulfilling life together. Her zest for life was palpable. Suddenly, however, her world began to collapse. First she had a miscarriage eight weeks into her first pregnancy. Then she had a skin lesion removed that proved to be malignant melanoma. Throughout all this, she was experiencing escalating neck pain, which she largely ignored because of all her other stressors. As the pain progressively worsened, she developed problems with balance and coordination. MRI of her spine revealed yet another problem — an intramedullary cervical spine tumor (i.e., within the substance of the spinal cord; Figure 1).

This newest, and perhaps most challenging, of her problems forced Kristen to confront her mortality. Her expectations of a long and productive personal and family life had already been threatened by the miscarriage and her melanoma diagnosis. While it seemed as though her melanoma was cured by surgery, she was now confronted with this new diagnosis and the many risks associated with removing a tumor from the main corridor — the spinal cord — connecting her brain with the environment in which she lived.

The Inevitable Questions

Kristen voiced a litany of concerns and questions: “Holy cow! This tumor is inside my spinal cord?” “I have sooo many other problems.” “Why me?” “Where did this come from?” “How did it get so big with so few symptoms?” “Is it malignant?” “Can I be cured?” “How in the world do you take this out without paralyzing me?”

The Spine Specialist Responds

“Well, Kristen, these are all great questions. In fact, they are very similar to those asked by nearly all patients who have this problem. Let’s start by addressing ‘Why me?’ Simply stated, bad luck — particularly considering your miscarriage and your diagnosis of a malignant skin tumor. No one knows why or how these tumors begin or grow. The good news is that your spinal cord tumor is likely a benign tumor. However, it is situated in a very bad location: the cervical spinal cord. Since it is benign, it grew slowly — very slowly. Likely, your spinal cord adapted to the gradually expanding tumor over time. That’s why you had so few symptoms before this large tumor was diagnosed. We must emphasize that this tumor is not malignant. How do we know? Well, if it were malignant, a tumor of this size would have grown rapidly and not allowed the spinal cord to gradually adapt. If it were malignant, Kristen, you would be paralyzed.

“Kristen, as few as two to three decades ago, neurosurgeons did not operate on patients with spinal cord tumors of this kind (intramedullary). Then, a few surgeons began successfully removing such tumors. Today these tumors can be resected (removed), often with cure. These operations are very risky, however. They involve an incision in the spinal cord followed by tumor removal. The ultimate success is related to multiple factors, the most important of which may be tumor type. Your tumor is likely benign and resectable, but it’s not without substantial risk, including the possibility of developing weakness in your arms or legs, loss of sensation over your body, or loss of bowel or bladder function. You could become dependent on a ventilator or even have complete paralysis, like that experienced by Christopher Reeve. Other risks include medical complications associated with any surgery, such as heart attack, stroke, blood clots in the legs or lungs, wound infection, the need for additional surgery, or even death, to name just a few. The tumor type dictates its resectability and the potential for cure.”

Case Continued: Successful Surgery, Rocky Postop

Kristen absorbed the information and sought counsel from family and friends. After much discussion, Kristen decided to have surgery. Two intraoperative photographs of the surgical bed after resection are shown in Figure 2.
Figure 1. Spine MRIs showing the intramedullary cervical spine tumor.

Figure 2. Intraoperative photographs of the surgical bed after resection.

Figure 3 (above). Postoperative MRIs showing complete resection of the tumor.

Figure 4 (left). Postoperative X-rays showing spinal implants to stabilize the spine after surgery.
The surgery was uneventful, but Kristen had a challenging postoperative course. As is often the case with intramedullary cervical spine tumors, she was substantially worse neurologically after the surgery. In fact, most patients do not achieve a level of function that is comparable or superior to their preoperative level. Most postoperative patients, like Kristen, experience a moderate to significant decline in function. Kristen lost the ability to walk normally for several weeks, but she gradually improved over six months to her normal baseline level of function. Postoperative MRI demonstrated complete resection of the tumor, without evidence of recurrence at two-year follow-up (Figure 3). The X-rays in Figure 4 show spinal implants required to stabilize the spine after surgery.

**Perspective on the Risk Two Years Out**

In spite of Kristen’s string of bad luck, she prevailed. Six months after surgery, she achieved a neurological outcome that was near normal — a truly remarkable recovery. During this time frame, however, a second pregnancy ended in another miscarriage. Regardless, Kristen and Nick demonstrated courage and fortitude. She recently gave birth to her daughter, Reagan, a wonderful reward for all her trials and tribulations. As Kristen’s smile shows (Figure 5), she is glad she took the risk associated with her spinal cord surgery.

“It’s sobering to think that 25 years ago, I likely would have been relegated to a treatment course that ultimately would have led to a fatal outcome,” Kristen says. “Surgery can be curative, and I am glad to have chosen the surgical route. It simply has made it all worthwhile.”

**KEY POINTS**

| Selected patients with intramedullary spinal cord tumors can expect long-term recurrence-free survival (i.e., cure), but not without definable, often substantial, risk. |
| New neurological deficits following surgery are often transient, improving to baseline or near baseline over weeks to months to years. |
| In skilled hands, surgery for selected intramedullary spinal cord tumors can be effective (curative) and performed with a reasonable risk/benefit profile. |
SPINE CARE STAFF

The below staff from the Center for Spine Health, the Center for Regional Neurosciences and other parts of the Neurological Institute see patients for spine-related care at Cleveland Clinic’s main campus and at multiple community hospitals and family health centers throughout Northeast Ohio.

Gordon R. Bell, MD
Director, Center for Spine Health

Daniel J. Mazanec, MD
Associate Director, Center for Spine Health

Adam Bartsch, PhD
Director, Spine Research Laboratory

Edward Benzel, MD
Chairman, Department of Neurological Surgery

Jeremy Amps, MD

Lilyana Angelov, MD, FRCS(C)

Toomas Anton, MD

William Bingaman, MD

Samuel Borsellino, MD

Edwin Capulong, MD

Edward Covington, MD

Russell DeMicco, DO

Carrie Diulus, MD

Alef Eltomy, MD

Michael Eppig, MD

Todd Francis, MD, PhD

Frederick Frost, MD

Kush Goyal, MD

Raqeeb Haque, MD

Garett Helber, DO

Augusto Hsia Jr., MD

Iain Kalfas, MD

Kambiz Kamian, MD

Tagreed Khalaf, MD

Ajit Krishnaney, MD

Andre Machado, MD, PhD

Jahangir Maleki, MD, PhD

Manu Mathews, MD

E. Kano Mayer, MD

Robert F. McLain, MD

Don Moore, MD

Thomas Mroz, MD

R. Douglas Orr, MD

Tiffany Perry, MD

Anantha Reddy, MD

Teresa Ruch, MD

Judith Scheman, PhD

Richard Schlenk, MD

Santhosh Thomas, DO, MBA

Deborah Venesy, MD

Fredrick Wilson, DO

Adrian Zachary, DO, MPH

CME EVENTS

in Spine Medicine from Cleveland Clinic

FEBRUARY 21-23, 2014
Seventh Annual International Symposium on Stereotactic Body Radiation Therapy and Stereotactic Radiosurgery
Course Directors: Lilyana Angelov, MD; Gene Barnett, MD; Edward Benzel, MD; Samuel Chao, MD; John Suh, MD
The Naples Beach Hotel & Golf Club, Naples, Fla.

MAY 4-9, 2014
World Spine VI (May 4-6)
Cleveland Spine Review — World Spine Jamaica (May 7-9)
Course Directors: Edward Benzel, MD, and Mehmet Zileli, MD
Hilton Rose Hall Resort, Montego Bay, Jamaica

JULY 10-15, 2014
Cleveland Spine Review
Course Directors: Edward Benzel, MD; Douglas Orr, MD; Richard Schlenk, MD; Marc Eichler, MD; Greg Trost, MD
Lutheran Hospital, Cleveland, Ohio

For more information on these or other Cleveland Clinic CME programs in spine medicine, contact Martha Tobin at tobinnm@ccf.org or 216.445.3449.
Resources for Physicians

Physician Directory. View our staff online at clevelandclinic.org/staff.

Same-Day Appointments. Cleveland Clinic offers same-day appointments to help your patients get the care they need, right away. Have your patients call our same-day appointment line, 216.444.CARE (2273) or 800.223.CARE (2273).

Track Your Patients’ Care Online. Establish a secure online DrConnect account for real-time information about your patients’ treatment at Cleveland Clinic at clevelandclinic.org/drconnect.

Critical Care Transport Worldwide. To arrange for a critical care transfer, call 216.448.7000 or 866.547.1467. Learn more at clevelandclinic.org/criticalcaretransport.

CME Opportunities: Live and Online. Visit ccfme.org to learn about the Cleveland Clinic Center for Continuing Education’s convenient, complimentary learning opportunities.

Outcomes Data. View Outcomes books at clevelandclinic.org/outcomes.

Clinical Trials. We offer thousands of clinical trials for qualifying patients. Visit clevelandclinic.org/clinicaltrials.

Executive Education. Learn about our Executive Visitors’ Program and two-week Samson Global Leadership Academy immersion program at clevelandclinic.org/executiveeducation.

About Cleveland Clinic

Cleveland Clinic is an integrated healthcare delivery system with local, national and international reach. At Cleveland Clinic, more than 3,000 physicians and researchers represent 120 medical specialties and subspecialties. We are a nonprofit academic medical center with a main campus, eight community hospitals, more than 75 northern Ohio outpatient locations (including 16 full-service family health centers), Cleveland Clinic Florida, Cleveland Clinic Lou Ruvo Center for Brain Health in Las Vegas, Cleveland Clinic Canada, Sheikh Khalifa Medical City and Cleveland Clinic Abu Dhabi.

In 2013, Cleveland Clinic was ranked one of America’s top 4 hospitals in U.S. News & World Report’s annual “America’s Best Hospitals” survey. The survey ranks Cleveland Clinic among the nation’s top 10 hospitals in 14 specialty areas, and the top in heart care for the 19th consecutive year.