

The Challenges of Managing Spine and Spinal Cord Injuries

An Evolving Consensus and Opportunities for Change

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The current Spine Focus Issue reflects the collective efforts of members of the Spine Trauma Study Group, and seeks to summarize as well as critically evaluate many of the key controversies related to the management of spinal trauma and spinal cord injury. Some of the topics discussed in this issue include the optimal timing for surgical intervention in spinal cord injury and central cord syndrome, the optimal treatment for both elderly and skeletally mature individuals with odontoid process fractures, management of pediatric spine trauma, rehabilitation strategies for the spinal injured patient, return to play guidelines, and variations in international practice patterns for the management of common spine trauma scenarios. The current Spine issue serves as an update to clinicians on these topics as well as a framework for stimulating new discussion and research in the field as a whole.

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Dedication to Henry H. Bohlman, MD, on Behalf of All the Authors in This Focus Issue

The contributors of this Focus Issue on Spinal Trauma wish to dedicate the issue to the memory of Henry H. Bohlman, MD, who died earlier this year at the age of 72. Dr. Bohlman made a huge contribution to the field of spine surgery in general and spinal cord injury in particular. He championed the concepts of neural decompression and meticulous restoration of spinal alignment and stability. These concepts live on through his written work and through the countless patients and trainees who benefited from his unique skills and teaching ability. The current Focus Issue of Spine summarizes the current state of the art on managing spine and spinal cord trauma and espouses many of the concepts championed by Dr. Bohlman. We trust that this issue will serve as a small but fitting testimony to Dr. Bohlman's impact in

spine surgery and spine trauma. By Michael G. Fehlings, MD, PhD, FRCS(C), on behalf of the authors of the current Spine Focus Issue on Spinal Trauma.

The clinical spectrum of spinal trauma is varied, depending largely on factors such as patient demographics, mechanism of trauma, spinal level involved, presence and degree of neurologic compromise, and extent of additional injuries. In light of this clinical heterogeneity, the establishment of definitive practice standards remains an important though challenging goal. The current Spine Focus Issue, which reflects the collective efforts of members of the Spine Trauma Study Group, seeks to discuss, summarize, and critically evaluate many of the key controversies related to the management of spinal trauma and spinal cord injury. When appropriate the focus issue articles used a well-established evidence-based medicine methodology.^{1,2}

A clinically relevant question is derived from experts in the field and then a systematic literature review is completed on the question. By synthesizing the most up to date, objective appraisal of the literature with clinical experience and expertise, practice recommendations around the question are established. The recommendations are either strong or weak, for or against a certain intervention. Strong means that practically all clinicians and patients would favor the choice, while weak means the majority would support it but some would not—based on risk benefits, preference, or cost. The uniqueness of this approach is that recommendations can be made despite lower quality evidence. This provides a very practical approach for care providers to apply in the day to day management of their patients.

In spite of previous attempts at developing general treatment algorithms for commonly encountered injury scenarios, treatment decisions remain inconsistent between trauma centers worldwide. In the first article, Lenihan *et al* describe the lack of consensus among spine surgeons across the world in managing 10 common spine trauma scenarios. In an attempt to introduce a systematic means of approaching spinal injuries, the subaxial cervical injury classification system and the Thoracolumbar Injury Classification and Severity Score have proven reliable in their respective domains. These classifications rely on clinical and radiologic information to predict injury stability and to direct treatment strategies based on a cumulative injury score. A particularly contested area in spinal trauma remains the management of odontoid fractures with specific controversies surrounding the

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Table 1. Summary of Evidence From Articles in Current Trauma Focus Edition

Article	Key Questions	Recommendations/Key Findings	Strength of Recommendation	Quality of Literature
Diversity and commonalities in the care of spine trauma internationally (Lenehan <i>et al.</i>)	N/A	(1) Prior studies have suggested significant variability in the management of spine trauma (2) Questionnaires based on 10 clinical spine trauma scenarios were administered to 77 experienced spine surgeons (3) Exists a lack of consensus among surgeons as to the optimum management	N/A	N/A
Optimal treatment for odontoid fractures in the elderly (Harrop <i>et al.</i>)	(1) What is the optimal management for Type II odontoid fractures in elderly patients? (2) What is the optimal non-operative treatment option for Type II odontoid fractures in elderly patients? (3) What is the optimal operative treatment option for Type II odontoid fractures in elderly patients? (4) What is the optimal management for Type III odontoid fracture in the elderly?	(1) Operative internal fixation and immobilization is the optimal treatment for Type II odontoid fractures in the elderly (2) Optimal nonoperative for Type II odontoid fractures in the elderly consists of immobilization in a hard collar (3) Posterior cervical arthrodesis is the optimal operative treatment option for Type II odontoid fractures in the elderly (4) Immobilization in a hard collar is the optimal management for Type III odontoid fractures in the elderly	(1) Weak recommendation (2) Strong recommendation (3) Strong recommendation (4) Strong recommendation	(1) Very low evidence quality (2) Very low evidence quality (3) Very low evidence quality (4) Very low evidence quality
Unique features of pediatric spinal cord injury (Parent <i>et al.</i>)	(1) What is the most effective means of stabilization of the spine in the pediatric spinal cord injury population? (2) What is the most effective treatment of post-traumatic spinal deformity in the pediatric spinal cord injury patients?	(1) Recommend the use of instrumentation in the unstable pediatric spinal column injury population (2) Recommend the use of traditional neuromuscular spinal deformity treatment techniques for the treatment of progressive spinal deformity following spinal cord injury	(1) Strong recommendation (2) Strong recommendation	(1) Very low evidence quality (2) Very low evidence quality
Spine trauma in the multiple trauma patient: early vs. late stabilization (Dimar <i>et al.</i>)	(1) What are the advantages of Early vs. Late spinal stabilization in the multiple trauma patient?	(1) Strong evidence throughout literature that early surgical stabilization consistently leads to shorter hospital stays, less days on mechanical ventilation and lower pulmonary complications. This benefit is seen in both cord injured and noncord injured patients	1) Strong recommendation	(1) Low evidence quality
Current practice in the timing of surgical intervention in spinal cord injury (Fehlings <i>et al.</i>)	(1) What is the role for early surgical decompression for patients with cervical SCI? (2) What is the role for early surgical decompression for patients with incomplete cervical SCI?	(1) Early surgical decompression (within 24 h) should be considered as part of the therapeutic management for any SCI patient (2) Very early decompression (with 12 h) should be considered for a patient with an incomplete cervical SCI	(1) Strong recommendation (2) Strong recommendation	(1) Moderate evidence quality (2) Low evidence quality
Surgical treatment of unstable Type II odontoid fractures in skeletally mature individuals (Patel <i>et al.</i>)	(1) What are the optimal indications for anterior treatment for unstable type II odontoid fractures?	(1) Optimal indications for anterior treatment of Type II odontoid fractures include horizontal or anterior-superior to posterior-inferior fracture obliquity, minimal fracture comminution, good bone quality, reducibility of the fracture, adequate radiographic visualization, and appropriate body habitus	(1) Strong recommendation	(1) Low evidence quality

(Continued)

Table 1. Continued

Article	Key Questions	Recommendations/Key Findings	Strength of Recommendation	Quality of Literature
	(2) What is the optimal anterior fixation in unstable type II odontoid fractures?	(2) The optimal technique for anterior treatment of Type II odontoid fractures is a single, anterior odontoid screw	(2) Strong recommendation	(2) Low evidence quality
	(3) What are the optimal indications for posterior treatment for unstable type II odontoid fractures?	(3) Optimal indications for posterior treatment of Type II odontoid fractures includes any of the indications for anterior treatment as well as fractures that are not reducible by closed means, the presence of significant fracture comminution and instability, anterior-inferior to posterior-superior fracture obliquity and instability, and disruption of the transverse atlantal ligament or instability of the atlantoaxial motion segment	(3) Strong recommendation	(3) Low evidence quality
	(4) What is the optimal posterior cervical fixation technique for unstable type II odontoid fractures?	(4) The optimal technique for posterior treatment of Type II odontoid fractures is rigid internal screw fixation	(4) Strong recommendation	(4) Low evidence quality
	(5) Given an unstable type II odontoid fracture that could be treated with either an anterior or posterior approach, which treatment would be optimal?	(5) In a Type II odontoid fracture that meets the optimal indications for either approach, anterior or posterior treatment can be utilized	(5) Strong recommendation	(5) Low evidence quality
	The urgency of surgical decompression in acute central cord injuries with spondylosis and without instability (Lenehan <i>et al.</i>)	(1) What is the optimal timing for surgical decompression in CCS patients with more profound neurologic deficit (ASIA C)?	(1) In ASIA C injuries central cord injuries with cervical spondylosis, the patient should be treated with surgical decompression as soon as it is technically feasible. (within 24 hr to 1 wk)	(1) Weak recommendation
(2) What is the optimal timing for surgical decompression in CCS patients with less severe neurologic deficit (ASIA D)?		(2) In ASIA D central cord injuries with cervical spondylosis, the patient should be initially treated non-operatively	(2) Strong recommendation	(2) Low evidence quality
Surgical decision making in acute sub-axial cervical spine trauma (Patel <i>et al.</i>)	(1) What is the optimal classification of sub-axial cervical trauma that can aid in management decisions?	(1) The Sub-axial Cervical Injury Classification (SLIC) system has been developed to address limitation of prior systems. Only the SLIC method encompasses aspects of management and prognosis and should be incorporated into the spine surgeon's trauma practice	(1) Strong recommendation	(1) Low quality evidence
High-energy contact sports and cervical spine injuries: What are the criteria for return to participation? (France <i>et al.</i>)	(1) Should patients with transient neuropraxia and canal stenosis return to play?	(1) Patients with transient neuropraxia should not return to full participation in high-energy contact sports if they have radiographic stenosis	(1) Weak recommendation	(1) Low evidence quality
	(2) Should patients with transient neuropraxia and no canal stenosis return to play?	(2) Patients with transient neuropraxia may consider return to full participation in high-energy contact sports if radiographic studies show no radiographic stenosis	(2) Strong recommendation	(2) Low evidence quality
	(3) Can patients with transient neuropraxia and canal stenosis return to play after surgical decompression?	(3) Surgical fixation with single-level anterior cervical discectomy and fusion to eliminate cervical stenosis is a strong recommendation as a treatment option to return to full-contact sport play	(3) Strong recommendation	(3) Low evidence quality

(Continued)

Table 1. Continued

Article	Key Questions	Recommendations/Key Findings	Strength of Recommendation	Quality of Literature
Therapeutic decision making in thoracolumbar spine trauma (Shaffrey <i>et al.</i>)	(1) What is the optimal classification of thoracolumbar trauma that can aid in management decisions?	(1) TLICS seems to be the best system available for therapeutic decision-making for TL spine injuries. However, prospective studies are needed to decide whether this scheme leads to better agreement among surgeons around the world and better clinical results for trauma victims	(1) Weak recommendation	(1) Moderate evidence quality
	(2) What is the optimal surgical approach for the treatment of thoracolumbar burst fracture in a patient with incomplete neurologic deficit?	(2) There is no evidence indicating that a specific surgical approach in the case of a TL burst fracture with incomplete neurologic deficit has any advantage as far as neurologic recovery is concerned	(2) Weak recommendation	(2) Moderate evidence quality
	(3) What is the importance of the Posterior Ligamentous Complex (PLC) in surgical decision making?	(3) Complete disruption of the PLC as determined collectively by morphological criteria using plain radiographs and CT is an indication for surgical intervention in TL burst fractures	(3) Strong recommendation	(3) Moderate evidence quality
Rehabilitation in spine and spinal cord trauma (Agrawal <i>et al.</i>)	(1) What are the most clinically relevant outcome measures of upper and lower limb function after SCI?	(1) For general motor function, the ASIA motor score together with the Spinal Cord Independence Measure is recommended. The ASIA motor score is also useful in assessing upper extremity motor function	(1) Strong recommendation	(1) Moderate evidence quality
	(2) What is optimal timing for the initiation of rehabilitation after SCI?	(2) Initiation of rehabilitation within 30 days of acute trauma leads to improved outcomes in spinal cord injured patients	(2) Strong recommendation	(2) Low evidence quality
Surgical management of post-traumatic syringomyelia after spinal cord injury (Okonkwo <i>et al.</i>)	Is surgical decompression of post-traumatic syringomyelia warranted in the setting of: (1) Development of new motor deficit? (2) Development of new sensory symptoms?	(1) Surgical decompression is warranted for patients developing a motor deficit in the setting of posttraumatic syringomyelia (2) Surgical decompression is not warranted for patients developing a sensory loss or pain syndrome in the setting of post-traumatic syringomyelia	(1) Strong recommendation (2) Weak recommendation	(1) Low evidence quality (2) Low evidence quality
	(3) Radiologic expansion?	(3) Surgical decompression is not warranted for patients with an asymptomatic but expanding posttraumatic syringomyelia	(3) Weak recommendation	(3) Low evidence quality
	(4) What is the optimal surgical treatment for post-traumatic syringomyelia?	(4) The preferred surgical technique for treatment of posttraumatic syringomyelia is spinal cord untethering and expansile duraplasty	(4) Weak recommendation	(4) Low evidence quality
	N/A	(1) Human trials have begun for riluzole, minocycline, anti-Nogo antibodies, Cethrin, and systemic hypothermia, and are about to begin for magnesium/polyethylene glycol, and human embryonic stem cell derived oligodendrocyte progenitors	N/A	N/A

N/A indicates not applicable; ASIA, American Spinal Injury Association; CCS, Central Cord Syndrome; TL, thoracolumbar; PLC, Posterior Ligamentous Complex.

efficacy of surgery in the elderly, the role of anterior *versus* posterior surgery and the optimal technique for surgical fixation. In the elderly, the consensus recommendation, though controversial, seems to support surgical fixation of Type II fractures while it is recommended that Type III fractures be treated conservatively with hard collar immobilization.

The timing of surgical management in spinal trauma remains the subject of intense debate. As compared to delayed management, early surgical stabilization of unstable spinal injuries leads to shorter hospital stays and greater improvement in a variety of clinical outcomes. Emerging basic science as well as clinical data in the context of spinal cord injury (SCI) supports the principle of achieving surgical decompression of the spinal cord within 24 hours of injury.^{3,4} The worldwide survey conducted by Fehlings *et al* in this issue, clearly indicates that although we lack a definitive answer regarding the relative efficacy of early surgery, a large proportion of the international spine community considers it a priority based on the available evidence. However, one exception to this principle is central cord injury in that there are widely divergent views on whether patients should be treated surgically at all and if so whether the intervention is best handled in an early or delayed fashion. Some of these divergent views reflect the spectrum of clinical presentation with central cord syndrome, which is based on the severity of initial neurologic injury, the degree of spinal canal stenosis, the age of the patient, and the presence of medical comorbidities. There is some agreement that those with a more profound central cord injury (ASIA C) may benefit from early surgical decompression, while those with less initial impairment can initially be treated nonsurgically.

There has been significant innovation in designing optimum rehabilitation strategies geared to help spinal trauma patients regain independence and it is shown that initiation of such a program within 1 month from the acute injury may help to improve functional recovery. In order to systematically quantify this recovery, the use of an outcome measure validated on this population (*i.e.*, ASIA motor score or SCIM) is recommended. For athletes sustaining a neuropraxic SCI in the context of cervical stenosis, guidelines have been suggested to help define the safety of timing in returning to play. Syringomyelia, is an uncommon but potentially debilitating complication arising in the chronic stages after SCI⁵ and should be managed surgically if neurologic deterioration occurs in its radiologic presence.

A myriad of recent scientific publications have yielded significant insight into the neurobiologic underpinnings of secondary injury after SCI.⁶ In attempt to translate laboratory discovery into bedside innovation many new pharmaceutical agents including riluzole, minocycline, and anti-Nogo antibodies are currently under investigation in the context of preliminary human studies.⁷ The majority of these agents have established preclinical efficacy by mitigating different pathways of secondary injury after SCI.

The above topics comprise some of the most relevant and controversial areas in spinal trauma today. The current spine trauma focus issue serves as an update to clinicians on these topics as well as a framework for stimulating new discussion and research in the field as a whole. Table 1 provides a comprehensive list of studies in this issue along with their “key findings.”

■ Key Points

- Spine trauma is an ever evolving field witnessing numerous advances in the past several years.
- A significant degree of controversy surrounds many of the topics in this field. However, there is remarkable consistency in the literature and in expert opinion in some areas where the quality of evidence in the literature may be low.
- The current Spine Focus Issue seeks to summarize as well as critically evaluate many of the key controversies related to the management of spinal trauma and spinal cord injury.

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