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Surgical Treatment in Neurocritical Care for Acute Spinal Cord Injuries

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Traumatic spinal cord injury (SCI) is common devastating injury which results in enormous socioeconomic burden. Multimodal approach to the patient is essential in neurocritical care for SCI patients. Among various treatment modalities, surgical decompression and stabilization plays an important role. This article highlights the issues regarding surgical management of neurocritical and neurointensive care for SCI. Although there are still some debate regarding the optimal timing for surgery in SCI patients, it is clear by previous literature that surgery has a specific benefit for neurocritical care in SCI patients and early surgery benefits specific SCI patients. The goals of surgery in SCI are correcting and reducing the broken biomechanical alignment and stabilizing it by instrumentation while decompressing the neural structures. By understanding the role of surgery in SCI neurociritcal care, we believe we can better access and treat these patients.

Keywords: Spinal cord injury; Neurointensive care; Neurocritical care; Spine

INTRODUCTION

Acute traumatic spinal cord injury (SCI) is a devastating condition which follows after high energy traumatic insult to the spinal cord, and the prevalence worldwide is more than 750 per million with annual increase[5]. As this type of injury usually leads to irreversible neurologic deficits, it finally results in huge social costs as well as great personal loss. The functional impairment following SCI and the socioeconomic burden is already well documented[1,9]. Although numerous previous studies have been introduced regarding the treatment for spinal cord injury and many new treatment modalities have been taken to the field, majority of hospitalized SCI patients still finally remain with residual neurologic deficits. Considering this impact of SCI on each patients personally, and also the social impact, proper approach to the individual patients and adequate selection of treatment modalities are of great interest.

When high energy insult occurs on the spinal cord, it gets damaged by two steps, which are primary and secondary injuries. It is a widely accepted concept that these two injury pathomechanisms lead to neurologic deficits[2,5,12]. Primary injury happens due to the initial impact on the spinal cord, and sudden spinal cord compression, and contusion while the secondary injury is rather a resultant cascade following the primary injury. The primary injury itself is irreversible, but there are some opportunity for neural salvation by minimizing the secondary

SCI and this is the point that most treatment modalities target. In a spinal surgeons perspective focused on neurocritical care, surgical intervention is also one of the therapeutic attempts targeting this point.

In this article, the focus is on the role of surgical intervention in neurocritical care for SCI patients with a brief review on the pathophysiology of SCI.

PATHOPHYSIOLOGY OF SCI

As briefly mentioned in the introduction, SCI following high energy trauma to the spinal cord is a result of initial primary injury accompanied with a subsequent secondary injury. Thorough understanding of this pathomechanism is a key step to understanding SCI itself, and it also provides a basis for SCI management not only medical but also surgical treatments.

Primary injury of the spinal cord occurs as a result of direct traumatic insult to the spine. It is commonly accompanied with breakage of the normal structural integrity of the spinal column, which results in compressive impact to the spinal cord. By this impact, direct trauma and description occurs to the neural tissues. At the same time, neuronal axons get damaged as well as blood vessels and cell structures of the spinal cord[10,16]. By this primary insult the cascade of SCI is started leading to secondary injuries.

The secondary injury of spinal cord which is triggered by the primary injury, is a cascade of pathologic changes and it evolves over days or weeks. Shortly after the microvascular breakage by primary injury, a focal development of intramedullary hemorrhage occurs and edematous change follows[10]. Hemorrhage and edema of the spinal cord does not only injure the neural axons of spinal cord, but also leads to impairment of proper blood perfusion within the cord. Impaired circulation then results in formation of microthrombus and vasospasm of microvasculature, which leads to more impaired circulation, finally a vicious cycle[12]. Another phenomenon of secondary injury after SCI includes necrotic change of the injured cord. By exacerbated ischemia of the spinal cord, breakage of cellular membranes and dysregulation of ions occur, and the cord gets necrotic within a short time[10,16].

Considering the pathophysiology of SCI, there is no possible treatment for the initial impact of primary injury. However, the pathomechanism of secondary injury following SCI should be considered as the target for treatment. In order to maximize the effect of treatment, breaking into the early steps of secondary injury should be done, both medically and surgically.

SURGICAL TREATMENT IN NEUROCRITICAL CARE FOR SCI

It is important to optimize treatment and care for SCI patients, in order to minimize the risk of any possible loss of neurologic function. The therapeutic approach to SCI is rather a complex of multimodal neurocritical care and treatments. Neurocritical care for SCI includes various treatment steps including early pre-hospital immobilization, acute phase medical treatment, administration of neuroprotective agents, and of course surgical decompression and stabilization. In this article, the focus is on the role of surgical treatment in SCI neurocritical care.

Early surgical intervention has a significant role in controlling the secondary injury by getting rid of the compressive force made by SCI. If left untreated, ongoing dynamic damage of spinal cord cannot be stopped, and this secondary injury leads to progressive worsening neurologic deficits[12]. Although surgical decompression and stabilization is a widely accepted therapeutic tool for SCI, there is still some points in debate regarding the timing of surgery or selecting right indications for surgery. In this section, we would like to discuss on these issues.

Rationale for surgical treatment

Surgical treatment for SCI cannot be defined in a uniform way. Each part of the spine ; cervical, thoracic, lumbar and sacral spines have each documented treatment principals, and they usually depend on both clinical and radiological classifications. In general, when considering the role of surgery in SCI, two gross points should be taken in to discussion. If the neural structure is mechanically compromised after trauma and SCI has occurred, proper decompression of the neural tissue is required. Another point is that if the primary insult has resulted in any displacement or instability of the spinal alignment, it should be reduced and then stabilized by proper instrumentations with or without instrumentation. Proper surgery can restore the mechanical stability and optimize clinical outcomes by giving the neural elements a chance to recover[15]. So, the need of decompression and stabilization with proper fusion is a key factor and should be always taken into account when making decisions whether to operate the patient or not in SCI neurocritical care.

As mentioned in the prior section, the primary insult and injury itself is irreversible, and the initiation of secondary insult is inevitable. However, we can minimize the damage of the spinal cord my properly managing the secondary insult, and this is why mitigating secondary cord injury is the main target of neurocritical care in SCI. Both restoration of spinal stability and decompression of neural tissues can break through the vicious

cycle of SCI by minimizing secondary injury[9,15].

Classification of Spinal Injuries and Surgical indications for SCI

Several points should be thoroughly taken into discussion when considering a SCI patient as a candidate for surgery. Bony fracture morphology, integrity of the posterior ligamentous complex, the trauma mechanism and of course the neurologic status of the patient should all be considered[5,15]. Prior to discussing about the surgical indications, the spinal injuries need to be well classified, both in order to well access the patients and also to decide proper treatment modalities according to the classifications. In this aspect, various classification systems have been introduced to support the physicians practice. Recently the Thoracolumbar Injury Classification and Severity Score (TLICS)[14] and the Subaxial Injury Classification (SLIC)[13] system are widely used as a classification tool for the thoracolumbar spine and cervical spine, respectively. (Tables 1 and 2) TLICS and SLIC have been developed as an alternative classification, as the formerly used systems were limited to classifying the injuries. TLICS and SLIC have advantage compared to those former classifications, not only regarding the simplicity and easy applicability but also by giving the physician a clue for surgical decisions.

Although there is an widely agreed consensus that surgical decompression and stabilization has a significant beneficial role for SCI patients[5,15], there is still debate regarding the documented indications for surgical intervention. In terms of "indications" for surgical treatment, there are only few, but significant indications. 1) Clinically and radiologically confirmed spinal cord compressive lesions with or without fractures, 2) SCI patient presenting with progressive neurologic deterioration and 3) significant instability proven by imaging studies[9,15].

Table 1. Thoracolumbar Injury Classification and Severity (TLICS) score system

Contents	Points
Injury morphology	
Compression	1
Burst	2
Translation/rotation	3
Distraction	4
Neurologic status	
Intact	0
Nerve root injury	2
Complete cord injury	2
Incomplete cord injury	3
Posterior ligamentous complex integrity	
Intact	0
Suspected/Intermediate injury	2
Definite injury	3

Non-surgical management for total score ≤ 3, surgeons decision for total score = 4 and surgical intervention for total score≥ 5

Table 2. The subaxial cervical spine injury classification system (SLIC)

Contents	Points
Injury morphology	
No abnormality	0
Compression/Burst	2
Distraction	3
Rotation/translation	4
Neurologic status	
Intact	0
Nerve root injury	2
Complete cord injury	2
Incomplete cord injury	3
Continuous cord compression	+1
Discoligamentous complex integrity	
Intact	0
Suspected/Intermediate injury	1
Definite injury	2

Non-surgical management for total score ≤ 3, surgeons decision for total score = 4 and surgical intervention for total score≥ 5

Optimal timing for surgical treatment

The optimal timing of surgery that may maximize the clinical prognosis of SCI patients are still controversial. For those whom come into the indications for surgical decompression, there are recent strong evidences that early decompression within 24 hours show better improvement than later surgeries. In a recent meta-analysis by Liu et al., the early decompression group presented significantly better neurologic outcome, earlier discharge and even a lower complication rate compared to later surgery group[8]. In 2012 Fehlings et al. reported a study called the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS), which was a large multicenter prospective cohort study on the timing of surgery after SCI[5]. 313 patients were involved and the clinical outcome were compared among groups; surgery within 24 hours after trauma and later than 24 hours after trauma. At 6 months post-operatively, early decompression group revealed 2.8-fold larger odds of 2 or more grades improvement in (ASIA) impairment scores. After the introduction of STASCIS study, early decompression surgery have become an feasible standard for making decisions regarding surgical timing, and many other studies have reported compatible results with this study[3,6-8,11]. Not only proven by

these evidence based clinical studies, it is already a widely agreed consensus by spinal surgeons. In 2010, Fehlings et al conducted a survey study asking for the preferred surgical timing to more than 900 active spinal surgeons[4]. More than 80% answered that they would operate a ASIA B or C patient within 24 hours, indicating that this timing is widely agreed by spinal surgeons. Therefore, medically stable patients without any other significant risk factors should be considered to be candidates for early surgery.

Recently, there are even some groups that insist that ultra-early surgery ; decompression within 6 to 8 hours after SCI, should be done for even better surgical outcomes. However, more clinical evidence is needed to support this results.

On the other hand, this favorable outcomes of early decompression after SCI are rather limited to those whom present ASIA B or C. ASIA D neurologic complete deficits failed to show any difference of improvement even after early surgery[7]. Another group of patients whom seem that they less likely benefit from early surgical decompression are those with central cord syndromes. Central cord syndrome patients whom had early decompression did not show significant clinical difference according to the timing of surgery[11].

SUMMARY

SCI usually results in devastating clinical outcomes, and proper neurocritical care is essential while managing these patients. Although there are still some debate regarding the optimal timing for surgery in SCI patients, it is clear by previous literature that surgery has a specific benefit for neurocritical care in SCI patients. The goals of surgery in SCI are correcting and reducing the broken biomechanical alignment and stabilizing it by instrumentation while decompressing the neural structures. Furthermore, by stabilization and decompression, minimizing the possible progressive secondary injuries to the spinal cord are the key role of surgery.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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