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Early Decompression in Acute Spinal Cord Injury : Review and Update

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Spinal cord injury (SCI) has a significant negative effect on the quality of life due to permanent neurologic damage and economic burden by continuous treatment and rehabilitation. However, determining the correct approach to ensure optimal clinical outcomes can be challenging and remains highly controversial. In particular, with the introduction of the concept of early decompression in brain pathology, the discussion of the timing of decompression in SCI has emerged. In addition to that, the concept of "time is spine" has been added recently, and the mortality and complications caused by SCI have been reduced by providing timely and professional treatment to patients. However, there are many difficulties in establishing international clinical guidelines for the timing of early decompression in SCI because policies for each country and medical institution differ according to the circumstances of medical infrastructure and economic conditions in the surgical treatment of SCI. Therefore, we aim to provide a current review of timing of early decompression in patient with SCI.

Key Words : Spinal cord injuries · Surgical decompression, early · Timing.

INTRODUCTION

Spinal cord injury (SCI) is a serious clinical problem that compromises the quality of life for affected individuals[10]. Individuals paralysis and symptoms cause by SCI are known as one of the condition that causes devastating physical and mental disability. From a social and financial point of view, the lifetime cost of care per person with disability from SCI range from 1.1 to 4.7 million USD in North America alone[50]. Similarly in South Korea, the high cost and long-term hospitalization for treatment imposes a great economic burden on individuals and their families, which in turn places a significant financial burden on the national health care system[25]. Therefore, it is necessary to explore effective therapeutic strategies to prevent secondary damage as much as possible and to improve long-term functional outcome in patients with SCI. The treatment of patients with SCI has made tremendous progress over the past few decades based on knowledge of the injury mechanism, pathophysiology of SCI, spinal cord regeneration, and the role of surgery[7,9,30,49]. After the concept of early decompression was established in traumatic brain injury[33,34], early decompression has been discussed and applied in

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SCI. However, optimal timing of surgical decompression is still controversial in determining the clear therapeutic effect for SCI. In this article, we provide an updated review of acute SCI with a focus on optimal timing for surgical decompression.

EPIDEMIOLOGY OF SCI

The natural history of SCI recovery is pessimistic, but the degree of neurological recovery peaks at 3–6 months[1,3]. Incomplete quadriplegia (45%) is most frequent degree of injury by SCI, followed by incomplete paraplegia (22%), complete paraplegia (20%), and complete quadriplegia (13%)[15,50]. After treatment, about 10% of patients with complete SCI regain sensory without motor recovery, and only 10% regain sensory with some degree of motor recovery[38]. More than half of SCI is caused by trauma. Motor vehicle accidents are the most common cause of traumatic SCI (40–50%), followed by falls (20%), violence (14%), and sports or other recreational activities (9%)[3,26,50]. Traumatic SCI occurs mainly in males about 80%, and 2/3 occurs in people younger than 30 years of age. However, the incidence of fall-related SCI increases with age[15,43]. The most frequent injury site for SCI is the cervical spine, among which high cervical spines above C5 level are relatively more common[50]. According to a recent report, in the United States, approximately 54 cases of traumatic SCI per 1 million in unite states occur annually, resulting in an incidence of 12000 cases per year[3,50]. Therefore, there are about 250000 patients living with SCI in the United States[50]. Nationally, New Zealand has the highest incidence of 85 cases per 1 million people, and the country with the lowest incidence was Spain with eight cases per 1 million people[37]. According to a recent report using the database of the Health Insurance Review and Assessment Service of South Korea, the age-adjusted average incidence of SCI was 26.4 persons per million people, and the mean age was 59.5 years for men and 54.9 years for women. The highest incidence in men was 50s and in women was 70s. Overall, the highest incidence occurred in the 50s[14]. In South Korea, the reason why SCI is common in people in 50s is related to the following facts. It is a fact that the risk of traumatic SCI is rapidly increasing due to the high frequency of OPLL in the elderly group and the rise of degenerative spinal disease due to the rapid increase in the elderly population. The annual incidence of ossification of the posterior longitudinal ligament (OPLL) in South Korea is 199–371 per million people, peaking at the age of 60–75[32]. The incidence of SCI is also the most common in the elderly group in Japan, and the reason is the same as in South Korea[31,36]. Therefore, the aging of South Korean society can lead to a rapid increase in SCI in the elderly population, and this must be reflected in the method to prevent SCI and the national medical finance.

PATHOPHYSIOLOGY OF SCI

SCI can be divided into primary and secondary injuries[2]. As we know, the primary injury is an initial mechanical injury which is the direct result of mechanical forces at the time of injury, and a secondary injury is resulting from the primary injury and exacerbating the neurologic deficit. The acute phase of secondary injury occurring within 48 hours is a cytopathological change involving edema, hemorrhage, ischemia, inflammation, lipid peroxidation, glutamatergic excitotoxicity, and formation of free radicals. Thereafter, ischemia due to vascular compromise further progresses to the injury site, leading to necrosis of apoptotic neurons and the formation of cystic microcavities[2,4,48]. Therefore, direct mechanical compression from primary injury and progressive edema and hemorrhage at the injury site induce mechanical pressure on nerve cells and microvascular circulation, extending nerve injury site and exacerbating the neurologic deficit. So, the therapeutic issue of SCI is to prevent progression of the secondary injuries and improve the neurological status.

UPDATE OF EARLY SURGICAL DECOMPRESSION FOR ACUTE SCI

Surgical decompression for acute SCI is aimed at reducing secondary hypoxia and ischemia by relieving mechanical pressure on primary and secondary injuries. A meta-analysis of 21 preclinical studies reported that surgical decompression improved the neurobehavioral outcome by 35.1% overall, and that compressive pressure and duration were very important as factors influencing the outcome[6].

Update on the usefulness of early decompression in subpopulations

There is not yet a high-evidence study comparing the efficacy and safety of early and late decompression in a subpopulation with different patient characteristics. However, in some studies, this was analyzed and reported at the level of suggestion[45]. In the subpopulation according to age, there is no study comparing the effectiveness and safety of early decompression and late decompression between younger and older people. However, there is a recent study comparing the clinical outcome of surgical management between younger and older patients with acute cord injury. According to Lau et al.[28], the complication rate and mortality rate of older patients (≥70 years) were 1.7 times and 10.8 times higher than those of younger patients (<70 years), respectively. However, there was no difference in discharge American Spinal Injury Association impairment scale (AIS) grade and AIS grade change between the two groups. In the subpopulation according to the degree of cord injury, patients with AIS B, C, and D injury at C2-L2 level before surgery had an additional 6.3 motor point motor recovery improvement with early (≤24 hours) decompression than with late (>24 hours) decompression. In patients with AIS A injury, there was no beneficial effect of early decompression on motor recovery. However, in patients with AIS A or B injury, early decompression resulted in a shorter hospital stay[17]. Also, as the AIS went from A to D at admission, when decompression was performed within 12 hours, the conversion rate from AIS grade at admission to better AIS grade at discharge was higher[39]. Moreover, ultra-early (≤12 hours) decompression showed more improvement in AIS than decompression after 12 hours, regardless of the degree of preoperative cord injury. In particular, it has been reported that even in patients with AIS A injury, if ultra-early decompression was performed, the AIS grade improved up to stage 1 or 2 after surgery[12]. However, although only for cervical cord injury, other studies have reported that timing of decompression (ultra-early, <12 hours; early, 12–24 hours; and late, >24 to 138.5 hours) does not affect AIS grade conversion, and intramedullary lesion length on preoperative magnetic resonance imaging is a major predictor of postoperative neurologic outcome[11]. In a subgroup analysis according to the use of preoperative steroids, early (≤24 hours) decompression in patients receiving preoperative steroid showed more improvement in pin prick score, light touch score, and total motor score than late (>24 hours) decompression. There was no significant difference in total motor score improvement between early and late decompression in patients who did not receive steroids before surgery[35].

Update on timing for early decompression

As mentioned earlier, there have been many clinical studies on the effect of early decompression in SCI. However, it was difficult to standardize the time due to heterogeneity in the definition of "early" for each study, and there was a limit in achieving strong recommendation. Most of the studies that see the time threshold of the definition of "early" as 24 hours, this time window is most appropriate to define "early"[21]. Furthermore, A prospective, multicenter study, the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS) in 2012, defined "early" as first 24 hours, and reported that decompression within 24 hours after SCI was associated with improved neurologic outcomes showing at least grade 2 AIS improvement at 6 months follow up[19,20]. Later, many studies reported the efficacy of early decompression (within 24 hours) in patients with SCI[21,42,44]. However, the timing of decompression for acute SCI remained controversial. In particular, in patients with central cord syndrome without instability, since spontaneous improvement may occur, decompression of the sensitive and fragile spinal cord due to injury may result in neurologic worsening. In 2017, AOSpine (Arbeitsgemeinschaft für Osteosynthesefragen spine) reviewed the efficacy, and safety of early (≤24 hours) versus late (>24 hours) decompression in patients with SCI[45]. The effects of early decompression on neurologic improvement in SCI patients varied according to the study and injury level. There was no difference at other levels, but at the cervical cord level, early decompression showed statistically and clinically significant improvement 6 months after decompression. In addition, there was an effect of 6-point improvement on the AIS in patients with AIS B, C, and D, but not in AIS A. In patients with acute central cord syndrome without instability, the total motor score improved at 6 and 12 months in early decompression, but there was no difference in AIS improvement between early and late decompression group. The rates of complications also did not differ between the two decompression groups[45]. Based on these contents, in the same year, AOSpine presented a clinical practice guideline for the timing of surgical decompression in patients with acute SCI[18]. They suggested that early decompression should be considered as a treatment option in

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adult patients with traumatic central cord syndrome and that early decompression should be offered at any level in adult patients with acute SCI. Previous animal study has reported that spinal cord ischemia caused by swelling and hemorrhage reaches peaks at 8 hours after injury[16]. Grossman et al.[23] suggested that if SCI patients visit the emergency room immediately after injury, most arrive within 4 hours, and that 8 hours to surgical decompression is a realistic goal. Based on these contents, an 8-hour time window was established. In previous randomized controlled trials[13], decompression within 8 hours in SCI patients showed better neurological results than more than 8 hours. In a study comparing the decompression within 8 hours versus 8–24 hours, neurologic outcome is better in decompression within 8 hours than 8–24 hours after injury[27]. More recently, many papers have reported the positive impact of decompression within 8 hours after injury[29,46,47]. However, in some studies, the definition of 'within 8 hours after injury' was measured as the time taken after arriving at the emergency room. Therefore, it is difficult to directly compare the results of remaining studies. Also, in the narrow time window of 8 hours, consumption of 1 or 2 hours is very important. In actual clinical practice, surgical intervention within 8 hours after injury is practically difficult due to availability of operating room, transport time to hospital, and lack of availability of medical team. There is also a study that reported negative results for early decompression. Tanaka et al.[40] analyzed the patients by dividing them into an early group (within 24 hours) and a late group (from 25 hours to 7 days). The length of intensive care unit stay, in-hospital mortality, and survival rate were not different between the two groups[40]. A meta-analysis study from pooling of individual patient data from four high-quality, prospective, multicenter acute SCI datasets, including data from December 1991 to March 2017 also concluded that there is a 36-hour time window for neurologic benefit and suggested a 36-hour time window for high probability of neurologic improvement. Subject of the exact timing of surgery for decompression after SCI is still very controversial[5,8,19,22,24]. In that sense, the Prospective, Observational European Multicenter (SCI-POEM) study, which compares the neurological outcomes of decompression within 12 hours and after 12 hours after injury, has recently completed enrollment of 300 people and will publish the results soon[41]. The results will be very helpful in finding the best cut-off point of timing of decompression after SCI.

CONCLUSION

According to the most recent clinical practice guidelines, most studies define early decompression as decompression within 24 hours, and early decompression was associated with superior sensorimotor recovery in patients with acute cord injury. In addition, early decompression showed good clinical results in subpopulation analysis according to the degree of cord injury and whether or not steroids were used before surgery. Recently, a good effect on decompression within 8 hours has been reported, but many studies are still needed.

AUTHORS' DECLARATION

Conflicts of interest

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

Informed consent

This type of study does not require informed consent.

Author contributions

Conceptualization: BJL, JHJ; Data curation : BJL, JHJ; Formal analysis : BJL, JHJ; Methodology : BJL, JHJ; Project administration : BJL, JHJ; Visualization : BJL; Writing - original draft : BJL; Writing - review & editing : JHJ

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