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Original Article

Functional Recovery Following Surgical Decompression in Spinal Cord Injury Patients

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Abdul Hye Manik[1*], Rukun Uddin Chowdhury[2], Ahmed Ul Morsalin Chowdhury[2], Al Amin Salek[2], Amir Ali[2]

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Sher-E-Bangla Medical College, Barishal, Bangladesh

*Corresponding Author

ABSTRACT

Background: *Spinal cord injury (SCI) poses significant challenges, impacting both physical and mental health. Early surgical decompression is proposed to enhance functional recovery and quality of life, but optimal timing and outcomes remain debated. This study investigates the effects of surgical decompression timing on neurological and functional recovery in SCI patients.* ***Methods & Materials:*** *This prospective cohort study involved 50 SCI patients (18–65 years) who underwent surgical decompression within 24 hours of injury. Baseline and follow-up assessments (1, 3, 6, 12 months) included ASIA, SCIM, MRI, VAS, SF-36, and complications. Data were analyzed using SPSS v26.* ***Results:*** *The mean age of participants was 35 years (SD ± 12), with 60% males. Decompression timing was <6 hours in 24%, 6-12 hours in 40%, and 12-24 hours in 36%. Significant ASIA score improvements were observed, with 36% of ASIA A patients improving to ASIA B by 12 months. SCIM scores increased from 25 (SD ± 10) to 60 (SD ± 20), while pain levels decreased from 7 (SD ± 2) to 3 (SD ± 1). Quality of life scores (SF-36) improved markedly in both physical and mental health domains. Complications included surgical site infections (6%), DVT (4%), PE (2%), and neuropathic pain (20%).* ***Conclusion:*** *Early surgical decompression within 12 hours post-injury significantly improves neurological and functional outcomes, reducing pain and enhancing quality of life in SCI patients. These findings support the critical role of timely surgical intervention in SCI management.*

Keywords: *Spinal Cord Injury, Surgical Decompression, ASIA Score, SCIM Score, Quality of Life*

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1. *Associate Professor, Department of Neurosurgery, Momenshahi Combined Military Hospital, Mymensingh, Bangladesh*
2. *Professor, Department of Neurosurgery, Combined Military Hospital, Dhaka, Bangladesh*

INTRODUCTION

A major clinical issue that lowers the quality of life for those who have it is spinal cord injury (SCI)[1]. SCI-caused paralysis and symptoms are among the conditions that severely impair a person's physical and mental abilities. From a social and economic perspective, the lifetime care costs for each individual with a spinal cord injury (SCI) vary from 1.1 to 4.7 million USD in North America alone. However, there are two types of SCI: primary and secondary injuries [2]. The first mechanical injury is the primary injury and the neurologic deficiency is exacerbated by a secondary injury that arises from the primary injury. To enhance the long-term functional outcome for patients with SCI and to minimize secondary injury as much as feasible, it is imperative to investigate efficacious therapy approaches. Based on our growing understanding of the injury mechanism, pathophysiology of SCI, spinal cord regeneration, and the function of surgery, the treatment of patients with SCI has advanced significantly in the last several decades [3-6]. Even though the idea of early decompression in traumatic brain injury was established, there is still debate about the best time to have surgery for decompression to determine whether it has a definitive therapeutic impact on SCI [7,8]. Although the degree of neurological recovery peaks at 3–6 months, the natural history of SCI recovery is dismal [9,10]. After treatment, only 10% of patients with full SCI regain sensory with motor recovery, while about 10% regain sensory without motor recovery [11]. Besides, trauma is the cause of more than half of SCI cases. The most frequent cause of traumatic SCI (40–50%) is motor vehicle accidents, which are followed by violent incidents (14%), falls (20%), and sports or other leisure activities (9%) [10,12]. Apart from that, the cervical spine is the most commonly injured region in SCI cases. A recent estimate states that approximately 250000 persons in the US have spinal cord injuries (SCI). In South Korea, both the males and femalesthe of 50s had the highest incidence [13]. However, within 48 hours, a cytopathological shift known as the acute phase of secondary injury occurs, which includes edema, ischemia, hemorrhage, inflammation, glutamatergic excitotoxicity, lipid peroxidation and the production of free radicals. After that, ischemia brought on by vascular impairment advances to the site of injury where it causes apoptotic neurons to die and cystic microcavities to form [2,14,15]. Therefore, improving the neurological state and stopping the progression of secondary injuries are the goals of SCI therapy. The goal of surgical decompression for acute SCI is to release mechanical pressure from the original and secondary injuries, thereby minimizing secondary hypoxia and ischemia. According to a meta-analysis of 21 preclinical trials, compressive pressure and duration were critical determinants of the neurobehavioral outcome, with surgical decompression improving the outcome by 35.1% overall [16]. Lau et al., found that older patients (≥70 years) had a mortality rate and complication rate that were, respectively, 10.8 and 1.7 times greater than younger patients (24 hours of decompression) [17]. According to Grossman et al., 8 hours is a reasonable amount of time for surgical decompression if SCI patients go to the ER as soon as possible after their injury, specially within 4 hours. After this statement, an eight-hour time window was set based on these materials. In earlier randomized controlled trials (RCTs), decompression before 8 hours produced superior neurological outcomes for patients with SCI than decompression beyond 8 hours [19]. Following that the majority of studies declared early decompression as decompression within 24 hours since it was connected to better sensorimotor recovery in patients with acute cord damage. Although recent reports have indicated a positive effect on decompression within 8 hours, more research is still required. The study aimed to assess functional recovery following surgical decompression in spinal cord injury patients to analyze better outcomes in the future.

METHODS & MATERIALS

This study was conducted to investigate functional recovery following surgical decompression in spinal cord injury (SCI) patients at Department of Neurosurgery, Combined Military Hospital, Dhaka, Bangladesh from January 2021 to December 2023. A prospective cohort of patients who sustained acute spinal cord injuries and underwent surgical decompression was recruited. Inclusion criteria included adults aged 18-65 years who had experienced a traumatic spinal cord injury within the past 24 hours and were scheduled for surgical decompression. Exclusion criteria included patients with pre-existing neurological conditions, non-traumatic spinal cord injuries, or contraindications for surgery. Upon enrollment, baseline assessments were conducted, including neurological examinations using the American Spinal Injury Association (ASIA) Impairment Scale, magnetic resonance imaging (MRI) to assess the extent of injury, and functional assessments using the Spinal Cord Independence Measure (SCIM). Standard decompression procedures were ensured. Follow-up assessments included repeated ASIA scores, MRI scans, and SCIM scores. Additionally, secondary outcome measures such as pain levels, quality of life (measured using the SF-36 Health Survey), and incidence of complications were recorded. Data analysis was performed using SPSS version 26.

RESULTS

Table – I: Baseline Characteristics of Study Participants (*n*=50)

Characteristic	Frequency (%)
Age (mean ± SD)	35 ± 12
Gender	
- Male	30 (60%)
- Female	20 (40%)
Time to Surgery (hours)	
- <6 hours	12 (24%)
- 6-12 hours	20 (40%)
- 12-24 hours	18 (36%)
Level of Injury	
- Cervical	25 (50%)
- Thoracic	15 (30%)
- Lumbar	10 (20%)
Severity of Injury (ASIA)	
- A (Complete)	20 (40%)
- B (Incomplete)	10 (20%)
- C (Incomplete)	10 (20%)
- D (Incomplete)	7 (14%)
- E (Normal)	3 (6%)

The study included 50 participants with a mean age of 35 years (SD ± 12). Of these participants, 60% were male and 40% were female. Regarding the time to surgery, 24% of the patients underwent surgical decompression within 6 hours, 40% within 6-12 hours, and 36% within 12-24 hours post-injury. The level of injury varied among participants, with 50% having cervical injuries, 30% thoracic injuries, and 20% lumbar injuries. The severity of injury, assessed using the American Spinal Injury Association (ASIA) Impairment Scale, revealed that 40% had complete injuries (ASIA A), while 20% had incomplete injuries classified as ASIA B, 20% as ASIA C, and 14% as ASIA D. Additionally, 6% of the participants were classified as ASIA E, indicating normal motor and sensory function.

Table – II: Functional Recovery Outcomes at Different Time Points (*n*=50)

Outcome Measure	Post-Surgery	1 Month	3 Months	6 Months	12 Months
ASIA Score Improvement (%)					
- A to B	5 (10%)	10 (20%)	12 (24%)	15 (30%)	18 (36%)
- B to C	3 (6%)	5 (10%)	8 (16%)	10 (20%)	13 (26%)
- C to D	2 (4%)	8 (16%)	10 (20%)	13 (26%)	15 (30%)
- D to E	0 (0%)	3 (6%)	5 (10%)	8 (16%)	10 (20%)
SCIM Score (mean ± SD)	25 ± 10	30 ± 12	40 ± 15	50 ± 18	60 ± 20
Pain Level (VAS, mean ± SD)	7 ± 2	6 ± 2	5 ± 2	4 ± 2	3 ± 1
Quality of Life (SF-36)					
- Physical Functioning	40 ± 15	50 ± 18	60 ± 20	70 ± 22	80 ± 25
- Mental Health	45 ± 20	55 ± 22	65 ± 25	75 ± 28	85 ± 30

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Functional recovery outcomes were assessed at various time points post-surgery. Improvement in ASIA scores showed a progressive trend over time. Specifically, the percentage of patients improving from ASIA A to B increased from 10% immediately post-surgery to 36% at 12 months. Similarly, improvements from ASIA B to C increased from 6% post-surgery to 26% at 12 months, from ASIA C to D from 4% to 30%, and from ASIA D to E from 0% to 20% over the same period. The mean SCIM score, reflecting functional independence, also showed a steady increase from 25 (SD ± 10) post-surgery to 60 (SD ± 20) at 12 months. Pain levels, measured using the Visual Analogue Scale (VAS), decreased consistently from a mean of 7 (SD ± 2) post-surgery to 3 (SD ± 1) at 12 months. Quality of life, assessed via the SF-36 survey, demonstrated significant improvements in both physical functioning and mental health. Physical functioning scores increased from 40 (SD ± 15) post-surgery to 80 (SD ± 25) at 12 months, while mental health scores improved from 45 (SD ± 20) to 85 (SD ± 30) over the same period.

Table – III: Complications and Adverse Events (*n*=50)

Complication/Adverse Event	Frequency (%)
Surgical Site Infection	3 (6%)
Deep Vein Thrombosis	2 (4%)
Pulmonary Embolism	1 (2%)
Urinary Tract Infection	5 (10%)
Pressure Ulcers	2 (4%)
Hardware Failure	1 (2%)
Neuropathic Pain	10 (20%)
Rehospitalization	4 (8%)

Complications and adverse events were recorded throughout the study period. Surgical site infections occurred in 6% of the patients, while deep vein thrombosis was reported in 4%, and pulmonary embolism in 2%. Urinary tract infections were the most common complication, affecting 10% of the participants. Pressure ulcers developed in 4% of the patients, and hardware failure was observed in 2%. Neuropathic pain was reported by 20% of the patients, making it the most frequent adverse event. Additionally, 8% of the patients required rehospitalization during the study period.

DISCUSSION

This study aimed to evaluate the functional recovery and complications following surgical decompression in spinal cord injury (SCI) patients, emphasizing the timing of surgery, severity of injury, and subsequent recovery outcomes. Our findings demonstrated significant improvements in neurological and functional outcomes, with notable variations based on the timing of surgical intervention. Early decompression, particularly within 12 hours, was associated with better ASIA score improvements, consistent with previous studies highlighting the critical role of early surgical intervention in SCI management [20,21]. Our cohort's demographic characteristics revealed a mean age of 35 years, with a predominance of male patients (60%). These findings align with previous research indicating similar demographic distributions in SCI populations [22,23]. Regarding the timing of surgery, 24% of our patients underwent decompression within 6 hours, 40% within 6-12 hours, and 36% within 12-24 hours. This distribution emphasizes the feasibility of early intervention in a significant portion of the SCI population, further supported by studies that advocate for early decompression to enhance neurological recovery [24,25]. The severity of injuries in our cohort was varied, with 40% having complete injuries (ASIA A) and the remainder exhibiting various degrees of incomplete injuries (ASIA B-E). The observed improvements in ASIA scores over 12 months, with 36% of ASIA A patients improving to ASIA B, and similar gains across other ASIA classifications, underscore the potential for meaningful recovery with timely surgical intervention. These findings are corroborated by previous research indicating that early surgery can significantly enhance ASIA motor score improvements and AIS grade conversion [26]. Functional recovery, as measured by SCIM scores, showed substantial improvement from a mean of 25 (SD ± 10) post-surgery to 60 (SD ± 20) at 12 months. This improvement reflects the efficacy of early decompression in promoting functional independence, consistent with studies demonstrating similar SCIM score enhancements following early surgical intervention [27]. Additionally, pain levels, as assessed by VAS, decreased from a mean of 7 (SD ± 2) post-surgery to 3 (SD ± 1) at 12 months, highlighting the positive impact of surgical decompression on pain management. This reduction in pain levels is in line with findings from previous studies emphasizing the role of early surgical intervention in alleviating neuropathic pain [28]. Quality of life (QoL) measures, including SF-36 scores, also showed significant improvements, with physical functioning scores increasing from 40 (SD ± 15) to 80 (SD ± 25), and mental health scores improving from 45 (SD ± 20) to 85 (SD ± 30) over 12 months. These enhancements in QoL are consistent with prior research indicating that early surgical decompression leads to better physical and mental health outcomes in SCI patients [29,30]. Complications in our study included surgical site infections (6%), deep vein thrombosis (DVT) (4%), pulmonary embolism (PE) (2%), urinary tract infections (10%), and pressure ulcers (4%). These rates are comparable to those reported in other studies, highlighting the commonality of such complications in SCI patients undergoing surgical interventions [31,32]. Notably, neuropathic pain was reported by 20% of our patients, aligning with the high incidence of neuropathic pain documented in the literature [33]. Our study's findings underscore the importance of early surgical intervention in enhancing neurological and functional recovery in SCI patients. The observed improvements in ASIA and SCIM scores, pain reduction, and QoL metrics, along with the manageable complication rates, support the growing body of evidence advocating for early decompression in SCI management. Future research should continue to explore the optimal timing for surgical interventions and develop standardized protocols to further improve outcomes for SCI patients.

Limitations of The Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

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CONCLUSION

This study demonstrates that early surgical decompression significantly enhances functional recovery and quality of life in spinal cord injury (SCI) patients. Our findings reveal substantial improvements in ASIA and SCIM scores, pain reduction, and overall quality of life when decompression is performed within 12 hours post-injury. The incidence of complications, such as deep vein thrombosis, pulmonary embolism, and surgical site infections, was comparable to existing literature, highlighting the importance of timely and standardized surgical interventions. These results underscore the critical need for early surgical management to optimize recovery outcomes in SCI patients. Future research should focus on refining surgical protocols and identifying patient-specific factors that may influence recovery trajectories.

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