Results of Early Versus Delayed Decompression for Traumatic Cervical Spinal Cord Injury: A Single Center Prospective Study

Biswaranjan Nayak[1] Krishnamurthy B. H.[1] Arun Kumar[1] Sushanta Kumar Patro[1] Prafulla Kumar Sahoo[1] Debabrat Biswal[1] Abhijeet Chandankhede[1] Balwant Singh[1] Himanshu Bhusana Nayak[1] Dhanwantari Shukla[1]

[1]Department of Neurosurgery, Apollo Hospital, Bhubaneswar, Odisha, India

Address for correspondence Biswaranjan Nayak, MBBS, D.ORTHO, MS, DNB, Plot No-350/3137, Aradhan Nagar, Sundarapada, Bhubaneswar 751002, Odisha, India (e-mail: dr.bnayak@gmail.com).

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Abstract

Objective This study was done with the aim to compare the clinical outcome and patient's quality of life between early (within 24 hours post-injury) versus delayed (after 24 hours to 7 days) surgically treated patients of acute cervical spinal cord injury. The current study was based on the hypothesis that early surgical decompression and fixations in acute cervical spinal cord trauma are safe and are associated with improved outcome as compared with delayed surgical decompression.

Methods A total of 54 patients were recruited and divided into early decompression surgery group A (operated within 24 hours of trauma; $n = 25$) and late/delayed decompression surgery group B (operated between 24 hours and 7 days of trauma; $n = 29$). The patients in both groups were followed up, and comparative differences noted in the neurological outcome, quality of life, and bony fusion.

Results The early surgery group had lesser postoperative complications. In group A, 54.17% patients had 1 American Spinal Injury Association Impairment Scale (AIS) grade improvement, while 29.17% experienced > 2 AIS grade improvement ($p = 0.015$). In group B, the neurological improvement was 50 and 21.43%, respectively ($p = 0.003$). There was a significant improvement in the postoperative quality of life scores in early surgery group.

Conclusion Early surgery in patients with acute cervical spinal cord injury should be considered strongly in view of the lesser complications, better neurological recovery, and reduced mortality.

Keywords
- acute cervical spine injury
- delayed surgery
- early surgery
- neurological outcome

Introduction

Traumatic spinal cord injury (SCI) is on the rise globally with a prevalence rate of ~750 per million.[1] It is needless to say that SCI not only impacts the individual but the society in which we reside as well. Appropriate management focusing on reducing the extent of neural tissue damage and improving neurological outcomes after the spinal cord trauma is of paramount importance. The pathophysiology of acute SCI is perceived as a two-stage mechanism, primary and secondary, which finally quantify the neural injury.[2] The primary injury is caused by rapid spinal cord compression and contusion, which can initiate a spiraling cascade of deleterious events leading to secondary injury. So, the window of opportunity in managing SCI lies in targeting the prevention of these secondary mechanisms, where most attempts at therapeutic surgical intervention have been staged. Available current literature suggests that decompressive surgery of the spinal cord after SCI negates the secondary injury mechanisms and improves neurological outcomes.[3–15] In addition, it is also observed that the neuroprotective effect of surgical decompression varies inversely with the time elapsed from injury

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to the decompression.[8,15] This has led to the hypothesis that those undergoing early surgical decompression post-injury will experience less neural tissue damage with improved clinical outcomes as compared with injury matched patients treated conservatively or with delayed surgery. Uncertainties still persist in the potential neurological benefits of early vis-à-vis late surgical intervention after SCI along with their medical complications and have been sparsely reported.[16–19] Some studies favor less medical complications in patients who undergo decompressive surgery after SCI less than 72 hours after injury as compared with those who had surgical treatment after 72 hours.[19] Although spinal surgery carries inherent risks like neurological deterioration, bleeding, infection, dysphagia, and cardiorespiratory complications, various studies have also highlighted the beneficial effects of early surgical intervention for quicker patient mobilization, early transition to rehab, and possibly a shorter hospital stay, leading to decreased medical morbidity. Current available literature has failed to provide robust supportive evidence for this hypothesis. Only a single randomized controlled trial and several prospective studies have shown no significant benefit by early decompression. Again, optimal timing of surgery or what is early surgical intervention, is also a dilemma, although most centers have acknowledged less than 72 hours as early intervention.[16–19] In contrast, another systematic review pointed out that decompression within 24 hours resulted in improved outcomes compared with both delayed decompression and conservative treatment.[20] Based on the best available evidence, in our study we have adopted the 24 hours cutoff period to define early versus late decompressive surgery after SCI.[21] The aim of our study is to compare the neurological outcome and complication rate of early surgery (less than 24 hours post-injury) versus late surgery (24 hours to 7 days post-injury) with a follow-up period of at least 6 months after acute cervical spine injury. The current study was based on the hypothesis that early surgical decompression in acute cervical spinal cord trauma is safe and is associated with improved outcome as compared with delayed surgical decompression.

Methods

We conducted a single center prospective study at a tertiary care hospital, Bhubaneswar, Odisha, India, which has got all the expertise in the management of spinal trauma and SCI. Patient enrollment was done from July 2014 to June 2017. Proper patient consent and research ethics board approval and institutional review board approval were obtained for the study. The inclusion criteria of our study are both male and female aged 16 to 65 years, initial Glasgow Coma Scale (GCS) ≥ 14, cervical cord compression confirmed by magnetic resonance imaging (MRI), patient willing to give consent, and ready for follow-up. The exclusion criteria include cognitive impairment causing difficulty in neurological assessment, penetrating injury to neck, pre-injury neurological disorders (strokes, etc.), other life-threatening injuries which hamper early decompressive surgery, injury older than 7 days, and patients having high flexion knee and hinged prosthesis. At presentation, a detailed neurological examination was performed as per standards established by the American Spinal Injury Association (ASIA). The baseline Association Impairment Scale (AIS) grade was given to each patient at the time of admission. The primary outcome measure of interest will be ordinal change in AIS grade at timely follow-up. The 6-month time period for follow-up will be based on recommendations used in the National Acute Spinal Cord Injury Study (NASCIS) and Sygen trials as well as on the findings of previous natural history studies which demonstrate that the vast majority of neurological recovery occurs during this period. Other clinical parameters taken into consideration at the time of admission were age, gender, mechanism of injury, level of injury, and initial GCS score. At the time of study enrollment, each patient had undergone a plain radiograph of neck along with MRI study of their cervical spine and any definite compression of cervical spinal cord was looked for. As per the MRI, the site of compression and whether it's anterior or posterior compression or both were noted. We performed computed tomographic (CT) scan as per requirement of the patient for proper evaluation of bony injury. After proper initial clinical and radiographic evaluation, study eligibility was determined. After enrollment, subjects had undergone either early (< 24 hours after injury) or late (≥ 24 hours to 7 days post-injury) decompressive surgery of the cervical spinal cord as per time of presentation. We decided the surgical timing depending on the time elapsed post-injury at patients' hospital arrival and the time required to obtain diagnostic investigations. The particulars of the surgical intervention, such as the direction of approach (anterior versus posterior) and number of levels to be decompressed, were decided based on neurological and radiological findings. The type of instrumented fusion performed was based on the type of injury. Apart from the surgical management, all patients received appropriate medical support according to the 2002 American Association of Neurological Surgeons cervical SCI guidelines, which included permissive or induced hypertensive therapy (mean blood pressure > 85 mm Hg). Methylprednisolone was used as per the criteria and recommendations of the NASCIS-2 study. CT imaging or X-ray will be performed within 72 hours of surgery for all patients, to assess the spinal canal postoperatively. In case of postoperative neurological deterioration, repeat MRI scan was performed to evaluate the spinal cord and to exclude the presence of ongoing spinal cord compression. All patients were sent for postoperative rehabilitation.

After surgery, patients were analyzed in groups according to the timing of their operative intervention. We performed 1 and 6 months follow-up of neurological examinations at hospital discharge, postoperatively. Documentation of relevant inpatient postoperative complications was performed.

Statistical Analysis

All analyses will be performed using SPSS software version 20 (IBM Inc.). A p value of < 0.05 will be considered statistically significant.

Results

In this process, a total of 54 patients with acute cervical spine injury were studied. They were divided into two groups, A (early surgery—within 24 hours of injury) and B (after 24 hours to 7 days of injury). In group A, there were 25 patients and in group B, there were 29 patients. As per the protocol, we kept the data of their age, gender, type of cervical spine injury, its level, any associated injury, preoperative neurological status, investigations, type of surgery, any intraoperative or postoperative complication, postoperative neurological status, and mortality. The data were subjected to statistical analysis in line with the objectives of the study and results are discussed here. A for the demographic profile of the cases, out of the total 54 patients, in group A there were 4 females and 21 males and in group B there were 6 females and 23 males. It shows that cervical spine injury is more common in male, probably due to more outdoor activities in our location. The mean age of the 54 patients was 44.685 years with standard deviation of 13.598 years, with minimum and maximum in the range of 16 to 65 years. The mean age of group A was 35.84 years with standard deviation of 11.632 and group B was 52.93 with standard deviation of 8.271. It shows that the younger age group patient seeks early medical attention.

Mode of Injury

In our study, road traffic accident (RTA) was the most common cause for acute cervical spine injury, constituting 14 cases in group A and 17 cases in group B. It was followed by fall from a height, assault, and sports injury.

Level of Spinal Cord Injury

In our study, C5 to 6 (32% in group A, 37.9% in group B; overall 35.1%) and C6 to 7 (28% in group A, 27.6% in group B; overall 27.8%) are the most common level of injury, which constitutes more than 50% of cases. Multiple-level injury is also found in a significant number of patients (16% in group A, 10.4% in group B, overall 13.1%).

Type of Injury

In our study, traumatic cervical prolapsed intervertebral disc is the most common pathology (44% in group A, 48.23% in group B, overall 46.29%); other types of injury include vertebral body fracture, body fracture with dislocation, and only posterior column injury.

Associated Injury

In our series along with the cervical spine injury, the associated injuries are limb injury, chest injury, and facial injury.

Preoperative AIS Grade

In our study, AIS grade C is the most common score preoperatively which constitutes 44% in group A and 34.48% in group B. It is followed by AIS grade B and it constitutes 36% in group A and 27.58% in group B. The details given in (►**Table 1**).

Timing of Surgery

According to the presentation, we have divided the study population into two groups as described earlier. Group A constitutes the early surgery group (within 24 hours of injury) and group B constitutes late surgery group (24 hours to 7 days). In early group, the mean time of surgery is 16.56 hours with standard deviation of 3.512, and in late group, the mean time of surgery is 93.48 hours with standard deviation of 34.738.

Operative Procedure

Varieties of surgeries are performed depending on the type of injury, its location, severity, and neurological involvement. As disc prolapse is the most common pathology in our study, anterior cervical discectomy and fusion are the most common types of surgery we performed. Other types of surgery we have performed for various pathologies are anterior cervical corpectomy and fusion, anterior cervical discectomy and fusion with posterior cervical fusion, anterior cervical corpectomy and fusion with posterior fusion, anterior cervical corpectomy and fusion with posterior decompression and fusion, posterior cervical decompression and fusion.

Postoperative AIS Grade at Six Months Follow-Up

An improvement in at least 1 AIS grade is seen in 54.17% cases in early surgery group while 50% in late group. A change in 2 AIS grade is seen in 29.17% cases in early group and 21.43% in late group and a change of score 3 is seen in 4.16% cases in early group and none of the patients in late group. No change in AIS grade is observed in 12.50% cases in early group and 25% in late surgery group, while a deterioration of score 1 is seen in 3.57% cases in late surgery group and none in early surgery group. So, the result is clearly in favor of early surgery group as there is better chance of neurological recovery and lower chance of worsening. The details are given in (►**Tables 2** and **3**) and (►**Fig. 1**).

Complications

There are several types of complication observed during postoperative period. We encounter the pulmonary complication to be the most common one, followed by urinary tract infection, cardiac complications, systemic infection, etc. The rate of complication is much more in delayed surgical group, which may be due to delayed and poorer neurological recovery as compared with the early surgery group. In our

Table 1 Showing preoperative AIS grade in our series

Preoperative AIS grade	Group A	Group B	Total
A	3 (12%)	4 (13.79%)	7 (12.96%)
B	9 (36%)	8 (27.58%)	17 (31.48%)
C	11 (44%)	10 (34.48%)	21 (38.88%)
D	2 (8%)	7 (24.15%)	9 (16.68%)

Abbreviation: AIS, Association Impairment Scale.

Table 2 Change of AIS grade at 6 month postoperative follow-up in early surgery group

		Post-op AIS grade						
Initial AIS grade at presentation	Number of patients	A	B	C	D	E	Death	*p*-Value
A	3	1	1	–	–	–	1	0.015
B	9	–	1	4	3	1	–	
C	11	–	–	1	6	4	–	
D	2	–	–	–	–	2	–	
Total	25	1	2	5	9	7	1	

Abbreviation: AIS, Association Impairment Scale.

Table 3 Change of AIS grade at 6 month postoperative follow-up in late surgery group

		Post-op AIS grade						
Initial AISA score at presentation	Number of patients	A	B	C	D	E	Expiry	*p*-Value
A	4	2	1	–	–	–	1	0.003
B	8	1	1	3	3	–	–	
C	10	–	–	2	5	3	–	
D	7	–	–	–	2	5	–	
Total	29	3	2	5	10	8	1	

Abbreviation: AIS, Association Impairment Scale.

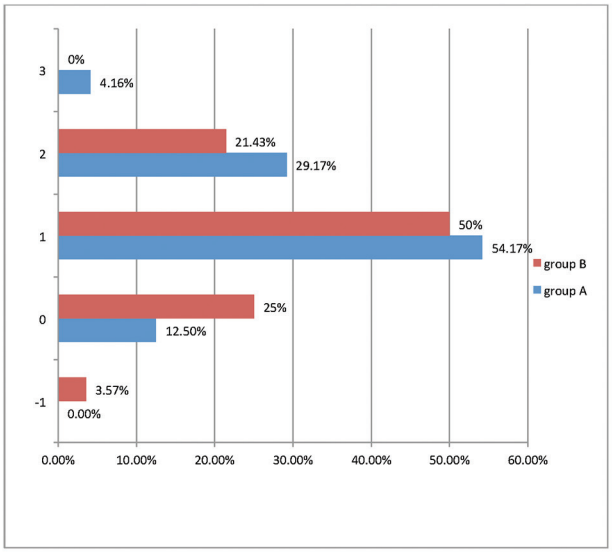

Fig. 1 Change of Association Impairment Scale grade at 6 month postoperative follow-up in late surgery group.

series, there are two mortalities, one in group A (4%) and one in group B (3.4%). Both deaths are due to initial low AIS grade and cardiopulmonary complications.

Discussion

There is convincing evidence from laboratory studies in various animal models that persistent compression of the spinal cord is a potentially reversible form of secondary injury and the neurological recovery was inversely related to the duration of compression, with statistically significant differences seen in all experimental groups.[6] In systemic review by La Rosa et al, all the studies published between 1966 and 2000 concluded that early (< 24 hours) surgical decompression in patients with incomplete injuries resulted in better neurological outcomes than patients treated with either delayed decompression (> 24 hours) or nonoperative treatment.[20] In the present study, we have compared the outcome of early surgery group and late surgery group in cervical spine injury. The variables under this study are nonchangeable variables (age and sex), different preoperative neurological conditions, and postoperative changes. We studied a total of 54 patients; in group A, there were 4 females and 21 males and in group B, there were 6 females and 23 males (p = 0.774). This small sample size is due to short duration of our study. Papadopoulos evaluated 91 patients with acute cervical SCI.[16] The mean age of the 54 patients was 44.685 years with standard deviation of 13.598 years with minimum and maximum in the range of 16 to 65 years. The mean age of group A is 35.84 years with standard deviation of 11.632 and group B is 52.93 with standard deviation of 8.271. It shows that the younger age group patient seeks early medical attention. The median age of SCI patients is 31.6 years with a 3:1 male predominance.[22] In our study, RTA is the most common cause for acute cervical spine injury; it constitutes 14 cases in group A and 17 cases in group B. It is followed by fall from a height, assault, and sports injury. According to Sekhon and Fehlings, accidental falls account for the greatest number of SCI, with motor vehicle accidents (MVA) second in occurrence in spinal injuries requiring hospitalization, but MVA is the most common injury mechanism according

to Hu et al.[23,24] We found C5 to 6 and C6 to 7 are the most common level of injury, which constitutes more than 50% of cases. Multiple-level is injury also found in a significant number of patients. According to Gupta et al most common level of injury is C5 to 6 followed by C6 to 7.[25] In our series along with the cervical spine injury, the associated injuries are limb injury, chest injury, and facial injury. According to Gupta et al, the associated injuries are also similar type.[25] In our study, AIS grade C is the most common score preoperatively which constitutes 44% in group A and 34.48% in group B. It is followed by AIS grade B and it constitutes 36% in group A and 27.58% in group B. AIS grade A score constitutes 12% and AIS grade D constitutes 8% in group A and 13.79% and 24.15% respectively in group B. According to Gupta et al, in early surgery group preoperative injuries were of AIS grade A in 43% patients, AIS grade B in 35%, while in late surgery group 46% patients were in AIS grade A and 24% patients in AIS grade B.[25] According to the presentation, we have divided the study population into two groups as described earlier. In the early group, the mean time of surgery is 16.56 hours with standard deviation of 3.512, and in late group the mean time of surgery is 93.48 hours with standard deviation of 34.738 ($p = 0.001$). Recently, Surgical Timing in Acute Spinal Cord Injury Study (STASCIS), the largest multicenter, international, cohort study for acute SCI, was published. The study recruited 313 patients out of which 182 patients underwent early (< 24 hours) decompression with a mean of 14.2 ± 5.4 hours until the surgery, while 121 patients in the delayed group underwent decompressive surgery with a mean time of 48.3 ± 29.3 hours until the surgery.[26] So, the data of our study is comparable to the above study. Varieties of surgeries are performed depending on the type of injury, its location, severity, and neurological involvement. As disc prolapse is the most common pathology in our study, anterior cervical discectomy and fusion are the most common types of surgery we performed. According to Vaccaro et al, anterior cervical corpectomy and fusion were the most common procedure performed in both groups followed by posterior cervical fusion.[18] An improvement of at least 1 AIS grade is seen in 54.17% cases in early surgery group while 50% in late group. A change in 2 AIS grade is seen in 29.17% cases in early group and 21.43% in late group, and a change of score 3 is seen 4.16% cases in early group and none of the patients in late group. No change in AIS grade is observed in 12.50% cases in early group and 25% in late surgery group, while a deterioration of score 1 is seen in 3.57% in late surgery group and none in early surgery group ($p = 0.015$ in early group and 0.003 in late surgery group). So, the result is clearly in favor of early surgery group as there is better chance of neurological recovery and lower chance of worsening. According to Gupta et al, 63% had improvement in AIS grade in both groups, 69% patients in early surgery group as compared with 59% patients in late surgery group. More than 2 AIS grade improvement was noted in 31% patients in early surgery and in 32% patients in late surgery group.[26] Thus, our study has similar result as the above study. According to Fehlings et al, the odds of at least 2 AIS grade improvement were 2.8 times more in the early surgery group.[26] There are several types of complication observed during postoperative period. We encounter the pulmonary complication (48% in group A and 62% in group B) to be the most common one, followed by urinary tract infection, cardiac complications, systemic infection, etc. The rate of complication is much more in delayed surgical group, which may be due to delayed and poorer neurological recovery as compared with the early surgery group. Our complication rate is somewhat comparable with Gupta et al where the pulmonary complications were noted in 35% patients in Group A as compared with 40% patients in Group B, which included infection, effusions, and ventilation-related complications. Systemic infections developed in 4% patient in Group A as compared with 11% in Group B. One patient in Group A developed trachea-esophageal fistula in postoperative period, which was managed conservatively. In STASCIS trial, there were no significant differences in complication in between two groups.[26]

In our series, there are two mortalities, one in group A (4%) and one in group B (3.4%). Both deaths are due to initial low AIS grade and cardiopulmonary complications. According to Gupta et al, mortality rate in Group A was 30% as compared with 45% in Group B.[26]

Conclusion

Early surgical decompression in acute traumatic cervical SCI is safe and is associated with improvement in neurological status, shorter hospital stay, and quality of life. Early surgical intervention prevents secondary injury to spinal cord. The early surgery group has less complications and mortality rate as compared with late/delayed surgical decompression in acute cervical spinal cord trauma patients. However, large randomized controlled study should be conducted to draw the final conclusion.

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Conflict of Interest
There is no conflict of interest.

Disclosure
None.

Contribution of the Authors
Conception, design of study, acquisition of data: Biswaranjan Nayak, Prafulla Kumar Sahoo, Debabrat Biswal; Analysis and/or interpretation of data: Biswaranjan Nayak, Sushanta Kumar Patro, Krishnamurthy B.H, Arun Kumar , Abhijit Chandankhede, Balwant Singh, Himanshu Bhusana Nayak, Dhanwantari Shukla.

Declaration of Authors
The manuscript has been read and approved by all the authors, that the requirements for authorship as stated earlier in this document have been met, and that each author believes that the manuscript represents honest work; we have not taken any fund from any source for conducting the study; there is no conflict of interest; there is nothing for disclosure.

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