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Original Article

FACTORS INFLUENCING NEUROLOGICAL OUTCOME OF SURGICALLY MANAGED SUBAXIAL CERVICAL SPINE INJURY

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Abstract:

Background: *Subaxial cervical spine (from cervical 3rd to 7th vertebral level) injury has a catastrophic impact over patient's quality of life, personal, social, psychosocial and financial aspect with potentially devastating outcomes. Several factors play role in the management, evaluation, surgical decision-making process, improved outcome and prognosis of these patients. But which factors determine outcome significantly is still a topic of debate. Objective: The purpose of this study was to analyze and evaluate the factors influencing neurological outcome of subaxial cervical spine injury following surgical intervention.*

Materials and method: *This prospective observational study was conducted among 27 Patients with traumatic subaxial cervical spine injury in the Department of Neurosurgery, Chittagong Medical College and Hospital, Chattogram. Demographic factors such as age, gender, etiology of injury, preoperative American Spinal Injury Association (ASIA) grade, C3-C4 versus C5-C7 cervical level of injury, radiological factors on Magnetic Resonance Imaging (MRI), and timing of intervention were studied. Change in the neurological status by one or more ASIA grade from the date of admission to 6 months follow-up was taken as an improvement. Functional grading was assessed using the Functional Independence Measure (FIM) score at 6 months follow-up.*

Results: *Out of 27 analyzed cases all were male except one with most of the patients was in the age group of 21-30 years. Fall of heavy objects over head was the most common injury (44.4%) followed by fall from height (25.9%). 5 (18.5%) patients were expired during 6 months period. One, two and three grade improvement in ASIA grade was observed respectively in 55.6%, 22.2% and 3.7% patients. A total of 22 patients were categorized into the improved group and 5 patients into the not improved group. Age, sex, preoperative clinical and radiological features were not significantly different between these two groups. Maximum improvement in average FIM score was noted in ASIA grade C, with improvement in average scores from 81.50 to 110.75. Patients with preoperative Maximum Spinal Cord Compression (MSCC) d"30% and edema in d"3 segments of the spinal cord had significantly higher mean FIM scores than their counterpart.*

Conclusion: *Maximum spinal cord compression and level of edema in MRI werethe two significant factors for improved neurological outcome after 6 months follow-up, in patients with traumatic subaxial cervical spine injury.*

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Keywords:
Sub Axial Cervical Injury, Spinal Injury, Traunatic Cervical Injury, Surgical Outcome

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Introduction

Subaxial cervical spine injury is the most common injury in cervical spine region. Approximately, 65% of cervical spine injury is subaxial. [1] For its unique weight-bearing, flexible features and substantial mobility about two-thirds cervical fractures and three-quarters cervical dislocations are associated with spinal cord injury. [2] The management of subaxial cervical spine injury with spinal cord involvement is one of the most challenging aspects in the context of favorable outcome.

Almost 2.5 million people worldwide live with SCI, experiencing immense personal, psychosocial, social and financial burden. [3] That's why; a universal comprehensive treatment strategy with proper assessment of potential prognostic predictors is time demanding to reduce the catastrophic events of morbidity and mortality.

In our country the main mode of cervical spine injury are fall from height, road traffic accident, heavy object fall over head or neck, accidental injury during carrying heavy object over head or neck, physical assault, shallow water diving, scarf injury, bull attack, bullet injury and sports injury. [4] Mechanism of injuries are flexion, extension, lateral flexion, compression, distraction and rotation, and by the simultaneous or sequential effects of these factors.

In an intent to improve the neurological and functional status has led to numerous studies, evaluating various factors such as age, gender, mechanism of injury, ASIA (American Spinal Injury Association) grades, severity of injury, co-morbid conditions, concomitant head injury, pathological disease, spinal shock, level of injury, use of steroids, timing of surgery, surgical approaches and their influence on the outcome.

Gupta et al.[5] analyzed three quantitative parameters (lesion length, MCC and MSCC) and nine qualitative parameters (vertebral fracture/subluxation, facet joint subluxation/dislocation, cord edema, hemorrhage/ contusion, cord compression, epidural hemorrhage, traumatic disc herniation, ligamentous injury and pre/ paravertebral collection) to determine the potential predictors. MCC, cord edema and cord hemorrhage were found to be significantly related with outcome.

Often there is a dilemma in choosing between surgical and conservative approach. For this, Vaccaro et al. [6] established the Subaxial Injury Classification (SLIC) system which is now widely accepted by clinician for its efficiency in surgical decision making process and profound inter and intra-observer reliability with reproducibility. This classification includes ligamentous injury, fracture morphology and neurological status. A SLIC score of >4 is indicated for surgery.

For assessment of neurological status ASIA impairment scale and to evaluate functional outcome FIM (Functional Independence Measure) score is internationally recognized. Postoperative neurological improvement was found better in patients presenting with better preoperative ASIA grade. [7]

Among the factors, the optimal timing of surgery remains most controversial one. Surgical Timing in Acute Spinal Cord Injury Study (STASCIS) at 2012 demonstrated that nearly 20% patients of early surgery group (within 24 hours) had at least a two ASIA grade improvement at 6 months follow-up in comparison to only 9% of patients showing two grade improvement in the delayed surgery group. Eric et al. [1] stated that, after resuscitation and hemodynamic stabilization, decompression and stabilization should be performed as quickly as possible. No differences were evidenced with anterior and or posterior approach in aspect of neurological recovery. Both should be chosen according to fracture morphology and patient specific factors.[8]

Use of corticosteroids in SCI is found to be another debatable topic. But NASCIS trial II and III stated that concerning the beneficial and risk aspects early use of corticosteroids within 8 hours of injury can be given. [9]

To minimize the secondary cord injury cascades and early introduction to maximum functional recovery, proper spinal stability, quick rehabilitation and ensuring a quality life with less financial burden a standard treatment strategy is a time demanding necessity. By emphasizing the critical factors influencing the outcome, this study was conducted to figure out which factors significantly affect neurological and functional outcome.

Materials and Methods

This Single institutional study ethics approval was granted by the local institutional ethics board. Written informed consent was obtained from all patients or guardians. It was a prospective intervention based observational study conducted in the Department of Neurosurgery, Chattogram Medical College and

Hospital, Chattogram, Bangladesh from September 2019 till September 2020. Consecutive sampling technique was applied based on selective inclusion criteria- where patient who had traumatic subaxial cervical spinal injury, age between 18 to 65 years, subaxial Spine Injury Classification (SLIC) score >4 and only surgically managed patients were included in the study. Patient below 18 years and above 65 years having Injury or fractures at upper cervical, thoracic, lumbar, sacral regions and both extremities, penetrating or gunshot injury, pathological fractures with concomitant traumatic brain injury, chest trauma, abdominal trauma, cerebral vascular disease, cognitive impairment preventing neurological assessment, medically unstable patient, unfit for surgery or denied surgery were excluded from the study.

Data were collected in predesigned, tested structured case record form. After reaching the diagnosis from MRI , CT scan and plain X-ray of cervical spine and selecting the patients based on inclusion and exclusion criteria, all routine investigations for general anesthesia was done. Gardner-Wells skull tong traction with appropriate weight was given for closed reduction preoperatively. Surgical approach was finalized by surgeon mostly by Anterior cervical decompression and fusion. Post operative neurological outcome was assessed by ASIA impairment scale. Follow-up was done on 1stPostoperative Day (POD), 7th (POD), 14th POD and after 6 weeks and then 3rd and 6th month.

All the data were checked and edited after collection. Then the data was entered into computer andstatistical analysis of the results being obtained by using windows based computer software devised with SPSS (Statistical Package for Social Science) Windows version-23. Continuous data was reported as the means ± SD or median and interquartile range. Qualitative or categorical data was described as frequencies and proportions. Independent sample t-test was used for comparisons of mean between independent groups. Proportions were compared using Chi-square and Fischer exact test. Paired t-test was used to compare the paired quantitative data. Statistical significance was defined as p-value < 0.05 and confidence interval was set at 95% level.

Results:

During the period from 4th September 2019 to 3rd September 2020 a total of 38 patients were found. Among them 27 patients fulfilling the selection criteria were enrolled to analyze and discuss the factors influencing neurological outcome of subaxial cervical spine injury patients following surgical intervention. The results and observations are presented in the following tables and graphs:.

Table-I

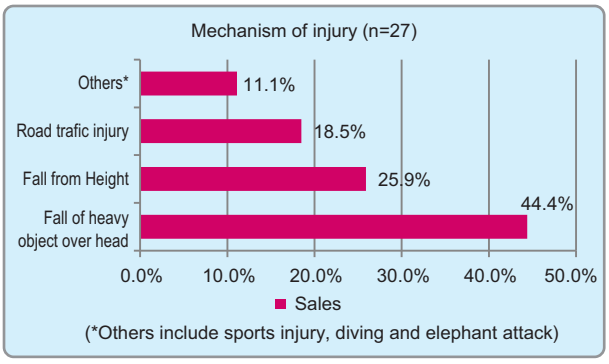
Demographic characteristics of the patients (n=27)

Variables	Frequency (%)*
Age group	
≤ 20 years	4 (14.8)
21-30 years	9 (33.3)
31-40 years	3 (11.1)
41-50 years	7 (25.9)
>50 years	4 (14.8)
Mean (±SD) age, years	36.41 (±14.55)
Age range, years	18-65
Sex	
Male	26 (96.3)
Female	1 (3.7)

*Data were expressed as frequency (percentage) if not otherwise mentioned.

Demographic characteristics of the patients are tabulated in Table 1. It depicts that, the mean age of the patients in this study was 36.41 years (ranging from 18-65 years). A maximum number of patients in this study correspond to 21–30 years (33.3%). Except one (3.7%) all other patients were (96.3%) were males.

Figure 1 shows that, most common mode of injury was impact by heavy object from above reported in 12 (44.4%) patients followed by fall from height in 7 patients (25.9%) and RTA in 5 (18.5%) patients. Injury during diving, sports injury and elephant attack was reported by one patient each as the cause of SCI in the study.



(*Others include sports injury, diving and elephant attack).

Figure 1: *Distribution of the patients by cause of SCI*

Figure 2 shows that, only 3 patients (11.1%) had cervical injury at C3-C4 and rest had C5-C7 cervical injury. Majority of the cases (11/27, 40.7%) had injury at the level of C5-C6, followed by the level of C4-C5 in 5 patients (18.5%).

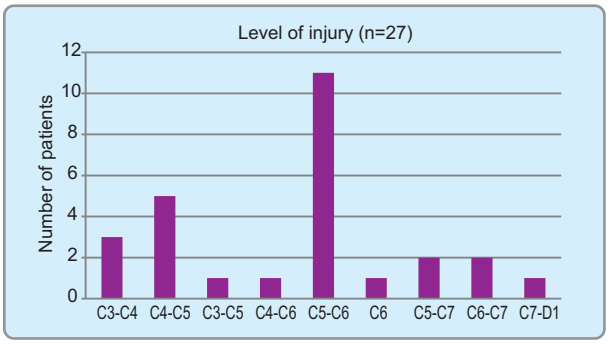


Figure 2: *Level of SCI in the patients.*

Majority of the patients had pre-operative ASIA grade C (29.6%), followed by Grade A (25.9%), Grade B (25.9%) and Grade D (18.5%). None of the patients were in Grade E. Pre-operative SLIC score was > 4 for all patients. Preoperative MSCC >30% and preoperative edema on MRI > 3 segments were present in respectively 48.1% and 63% of the patients.

Table-II

Preoperative clinical characteristics of the patients (n=27).

Variables	Frequency (%)
Preoperative ASIA grade	
Grade A	7 (25.9)
Grade B	7 (25.9)
Grade C	8 (29.6)
Grade D	5 (18.5)
Grade E	0 (0)
Preoperative SLIC score	27 (100.0)
Mean ±SD	6.78±0.97
Range	5-9
Preoperative bowel-bladder involvement	15 (55.6)
Preoperative MSCC	
≤30%	14 (51.9)
>30%	13 (48.1)
Preoperative edema on MRI	
≤3 segments	10 (37.0)
>3 segments	17 (63.0)
Preoperative hemorrhage	
No	21 (77.77)
Yes	6 (22.23)
Preoperative FIM	
Motor [Median (IQR)]	30 (15-75)
Motor & cognitive [Median (IQR)]	65 (50-110)

Data were expressed as frequency (percentage) if not otherwise mentioned. MSCC: Maximum Spinal Cord Compression; FIM: Functional Independence Measure. IQR: Inter Quartile Range.

In this cohort of 27 patients only in 4 (14.8%) cases it was possible to do the surgery within one week from the event. Majority (85.2%) of the patients were operated more than one week after the events.Majority of the patients (92.60%) were operated through anterior approach (n=25), only one (3.70%) operated by posterior approach and combined approach was done in only one (3.70%) patient (Figure 3).

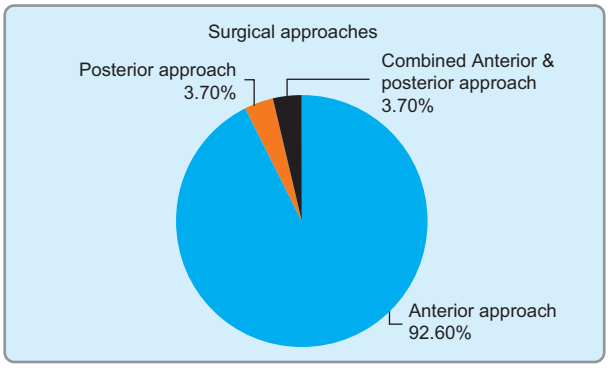


Figure 3: *Surgical approaches of the patients (n=27)*

In the final follow-up, majority of the patients had ASIA grade E (29.6%) and Grade D (29.6%), followed by Grade C (18.5%), Grade B (11.1%) and Grade A (11.1%). Bowel-bladder dysfunction persisted in 8 (29.6%) patients. Edema on MRI > 3 segments were present in 29.6% patients in final follow-up.

Table-III

Postoperative clinical characteristics of the patients (n=27)

Variables	Frequency (%)
Postoperative ASIA grade	
Grade A	3 (11.1)
Grade B	3 (11.1)
Grade C	5 (18.5)
Grade D	8 (29.6)
Grade E	8 (29.6)
Postoperative bowel-bladder involvement	8 (29.6)
Postoperative Hemorrhage	
No	21 (77.77)
Yes	6 (22.23)
Postoperative edema on MRI	
No edema	3 (11.1)
< 3 segments	16 (59.3)
>3 segments	8 (29.6)
Postoperative FIM	
Motor [Median (IQR)]	63 (37-90)
Motor & cognitive [Median (IQR)]	98 (72-125)

Data were expressed as frequency (percentage) if not otherwise mentioned. MSCC: Maximum Spinal Cord Compression; FIM: Functional Independence Measure. IQR: Inter Quartile Range.

Table IV shows that, majority of the patients (19/24, 70.4%) had uneventful postoperative period. Five (18.5%) patients expired in the post-operative follow-up period up to 6 months. The most common complication was chest infection & bed sore respectively observed in 4 (14.8%) and 4 (14.8%) patients followed by neck pain (11.1%), dysphagia (11.1%), MODS (11.1%) and device failure (3.7%). It is to be noted that, most of these complications were observed in the patients who expired during the follow-up period.

Table-IV

Postoperative complications

Complications*	Frequency (percentage)
No complications	19 (70.4)
Neck pain	3 (11.1)
Dysphagia Bed sore	3 (11.1)4 (14.8)
Chest infection	4 (14.8)
MODS	3 (11.1)
Instrument or device failure	1 (3.7)
Mortality	5 (18.5)

*Include multiple responses; MODS: Multi Organ Dysfunction Syndrome.

Out of 7 patients with pre-operative ASIA grade A, 3 (42.9%) patients improved to grade B and 1 (14.3%) improved to grade C. However, 3 (42.9%) patients with preoperative ASIA grade A, either had no improvement or expired. Out of 7 patients with preoperative ASIA grade B and 8 patients in ASIA grade C all had at least one ASIA grade improvement. Similarly among 5 patients with preoperative ASIA grade D, majority (4/5, 80%) had improvement in their postoperative period (Table V).

For the further analysis, 27 patients were categorized into two groups: Improved (who had more than or equal to one ASIA grade change in neurological status from the date of admission to 6 months follow-up) and not improved (who had no improvement in neurological status from the date of admission to 6 months follow-up or died). Table VII shows that, majority of the patients (81.5%) had improvement following surgery.

Table VII depicts that, comparatively higher proportion of patients with age 30 years and below had poor outcome but the difference was not statistically significant (p=0.557). Regarding sex, as there was only 1 female patient out of 27 patients it was not possible to assess the association between sex and

Table V

Change in ASIA grade at 6 months follow-up in comparison to preoperative ASIA grade

Preoperative ASIA grade	Number	Postoperative ASIA grade				
		A	B	C	D	E
A	7	3 (42.9)	3 (42.9)	1 (14.3)	0 (0)	0 (0)
B	7	0 (0)	0 (0)	4 (57.1)	2 (28.6)	1 (14.3)
C	8	0 (0)	0 (0)	0 (0)	5 (62.5)	3 (37.5)
D	5	0 (0)	0 (0)	0 (0)	1 (20.0)	4 (80.0)
Total	27	3 (11.1)	3 (11.1)	5 (18.5)	8 (19.6)	8 (29.6)

P=<0.001; obtained from Chi- square test.
Data were expressed as frequency (percentage).

Table-VI

Distribution of the patients according to their final outcome (n=27)

Outcome after 6 months follow-up	Frequency (%)
No improvement	5 (18.5)
One grade improvement	15 (55.6)
Two grade improvement	6 (22.2)
Three grade improvement	1 (3.7)

Table VII

Association between demographic characteristics and surgical outcome

Variables	Outcome		P value*
	Improved (n=22)	Not Improved (n=5)	
Age			
30 years and below	10 (45.5)	3 (60.0)	0.557
Above 30 years	12 (54.5)	2 (40.0)	
Sex			
Male	21 (95.5)	5 (100.0)	0.627
Female	1 (4.5)	0 (0)	

*P values were derived from Fischer exact test.

surgical outcome. However, the only female patient had favorable outcome following surgery in the study.

Proportion of the patients who had injury at C5-C7 level, had pre-operative bowel and bladder involvement, having preoperative MSCC score >30%, had preoperative hemorrhage, had edema in more than 3 segments in MRI and had surgery within one week of their injury had unfavorable outcome (static + died) compared to their counterpart (Table VIII). However, none of these differences were statistically significant.

More SLIC scores (Injury/fracture morphology, Disco-ligamentous Complex and Neurological status) indicate injury severities. Mean (±SD) preoperative SLIC scores in patients stratified by their surgical outcome are shown in Figure 8. It depicted that, patients with favorable surgical outcome had comparatively lower score than the patients who died or failed to show any improvement following surgery (6.68±0.99 versus 7.20±0.84 respectively). However, the differences was not significant statistically (p=0.292, obtained from independent sample t-test).

Post-operative mean FIM score was comparatively higher in patients above 30 years compared to their counterpart without any statistical significance (p 0.126). Similarly no significant higher trend in mean FIM scores were observed in C3-C4 vs. C5-C7; in patients who had surgery after one week of event compared to the patients who had surgery in less or equal to one week of the event. On the other hand patients without preoperative Bowel and Bladder involvement, without preoperative hemorrhage and patients with <30% preoperative MSCC had significantly higher postoperative mean FIM scores compare too their counterpart (Table IX).

Table-VIII

Association between preoperative clinical characteristics and surgical outcome

Variables	Outcome		P value*
	Improved (n=22)	Not improved (n=5)	
Level of injury			
C3-C4	3 (13.6)	0 (0)	0.381
C5-C7	19 (86.4)	5 (100.0)	
Preoperative Bowel and Bladder involvement			
No	11 (50.0)	1 (20.0)	0.223
Yes	11 (50.0)	4 (80.0)	
Preoperative MSCC			
≤ 30%	13 (59.1)	1 (20.0)	0.114
>30%	9 (40.9)	4 (80.0)	
Preoperative Hemorrhage			
No	18 (81.82)	0 (0)	0.0009
Yes	3 (18.18)	5(100.0)	
Preoperative edema			
≤ 3 segments	9 (40.9)	1 (20.0)	0.382
>3 segments	13 (59.1)	4 (80.0)	
Interval of surgery			
≤ 1 week	4 (18.2)	0 (0)	0.308
>1 week	18 (81.8)	5 (100.0)	

*P values were derived from Fischer exact test.

Table-IX

Association between different preoperative factors with postoperative mean functional independence measure scores

Variables	Post-operative FIM score		P value†
	Mean	SD	
Age			
30 years and below	86.23	29.978	0.126
Above 30 years	102.50	23.283	
Level of injury			
C3-C4	108.00	30.315	0.383
C5-C7	93.00	27.329	
Preoperative BB involvement			
No	110.00	17.909	0.007
Yes	82.40	28.043	
Preoperative MSCC			
<30%	108.00	19.717	0.006
>30%	80.31	27.977	
Preoperative Hemorrhage			
Absent	112.00	19.4	0.007
Present	84.24	26.5	
Interval of surgery			
≤ 1 week	88.75	28.906	0.650
>1 week	95.70	27.753	

†P values were derived from Independent sample t-test.

Table-X

Mean change of FIM scores in different grade of preoperative ASIA grade

Preoperative ASIA grade	Mean ± SD of FIM scores		Mean difference (95% CI)	P value*
	Postoperative	Preoperative		
A	60.43±11.19	49.14±0.69	11.29 (0.79-21.78)	0.039
B	90.71±21.88	61.86±3.24	28.86 (8.61-49.10)	0.013
C	110.75±14.96	81.50±7.11	29.25 (16.92-41.57)	0.001
D	122.40±6.95	111.20±0.83	11.20 (3.38-19.02)	0.016

*Paired sample t-test; CI: Confidence interval.

Figure 4 shows that, those patients who had preoperative edema in ≤3 segments had significantly higher postoperative mean FIM score compared to the patients who had edema in >3 segments (112.4±19.4 vs. 84.24±26.5, p 0.007).

Maximum improvement in average FIM score at 6 months follow-up was noted in ASIA grade C, with improvement in average scores from 81.50 to 110.75. Patients with other preoperative ASIA grade also had significant improvement in their FIM scores (Table X).

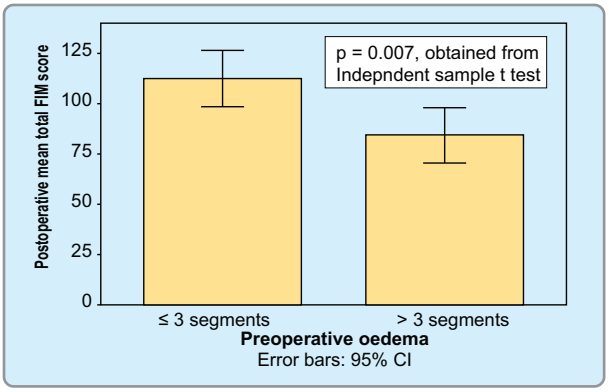


Figure 4: *Association between preoperative edema and postoperative functional independence measure score.*

Discussion

For cervical SCI patients, with column instability or neurological deficits, surgical decompression of the spinal cord and the restoration of vertebral alignment are the gold standard treatment. In the past, many authors suggested a delayed surgical treatment to reduce postoperative complications rate but recent studies have shown that an early decompression (<24 hours) may facilitate a postoperative neurological improvement probably due to the prevention of the secondary mechanisms of damage in acute SCI. In our country perspective and in the setting of public health tertiary care hospital, early (<24 hours) surgery is not always feasible. In the present study, surgical results of patients with subaxial cervical SCI who have operated in CMCH within 4 days to 30 days from trauma were evaluated to determine the factors associate with neurological outcome.

The 27 patients who met the inclusion criteria were characterized as 7 cases of fall from height injury (25.9%), 5 cases of RTA injury (18.5%), 12 cases of heavy object fall injury (44.4%), and other 3 cases with diving, sports and elephant attack injury. All of them were categorized as traumatic subaxial cervical spinal injury confirming by using imaging technique of having spinal cord involvement. The follow-up period was 6 months. Postoperatively, 4 (14.8%) had chest infection and 1 patient had device failure. Out of 27 patients 5 (18.5%) patients expired during the follow-up period and there was no patient lost to follow-up. Of 5 died patients, three died due to MODS, two patients died due to chest infection. The ultimate goal of surgical intervention for subaxial CSI was stabilization of spine, restoration of spinal anatomy, decompression of neural elements, thereby promoting the neurological recovery and early facilitation of rehabilitation. In the present study, good functional outcome following surgical intervention was achieved in 22 (81.5%) cases.

Different studies have evaluated influence of various factors such as age, sex, etiology, preoperative ASIA grades, level of injury and timing of surgery on the outcomes. [10-12] Age has been the point of controversy for neurological outcome and functional recovery. In this study the average age of the patients was 36.41 years and a maximum number of patients (33.3%) correspond to 21–30 years. Although SCI commonly affects the young in their productive ages, extremes of ages were not spared with approximately 5.4% of individuals in an elderly age group (>65 years).[13] In the present study only one patient was in elderly age group (65 years of age) and unfortunately died following surgery. Younger patients with deficits have a better prognosis than older ones in the same neurological conditions whose outcome may be influenced by comorbidities. [10,14] On the contrary Cao et al., [2] did not observe any significant association between age of the patients and prognosis after surgical treatment in cases of subaxial cervical SCI.

Current study indicated a trend of better outcome in terms of both ASIA grade and FIM scores in older patients (age >30 years) compared to younger patients (age d”30 years). This dissimilarity could be explained by severe grade of injuries in younger patients in the present study. It is to be noted that, sample size was not adequate to provide a valid conclusion regarding the association between age and surgical outcome of the present study. Interestingly, a recent study [12] which included 39 patients also observed better improvement (60%) in >30 years when compared to d”30 years (31.6%). However, the association between age and surgical outcome of the present study and the study of Srinivas et al., [12] were not statistically significant.

According to National Spinal Cord Injury Statistical Center (NSCISC 2013), 80% of SCI reported in males and large epidemiological studies [13] also demonstrated nearly five-fold predominance of men in their study population. In the current study, 96.3% cases were males. Though it was intended in the present study to evaluate the relation of sex and surgical outcome, due to under representation of female (only one patient) it was not possible to reach any valid conclusion regarding the influence of sex on surgical outcome. The only female patient in the current study had favorable outcome (preoperative ASIA grade was A and post-operative ASIA grade was B).

Regarding the cause of injury the current data indicated that, most common mode of injury was impact by heavy object from above followed by fall from height. Previous large scale epidemiological studies from developed countries indicated that RTAs were the leading cause of SCIs followed by high distance falls. [12-14] In the current study, RTA was the cause of injury in about one fifth (18.5%) of the patients.

Several studies have focused on initial neurological grade affecting outcome. The ASIA grade at admission appeared to be the most important element that can influence the postoperative outcome. [2,12,14] In this

study 14.3% and 42.9% of patients with preoperative ASIA grade A, improved to grade B and grade C respectively and rest of the 42.9% with preoperative ASIA grade A had no-improvement or expired. All of the patients with preoperative ASIA grade B and C had at least one ASIA grade improvement. Similarly majority (80%) of the patients with preoperative ASIA grade D had improvement in their postoperative period in the current study. Srinivas et al., [12] noted no improvement in the patients with ASIA Grade A at 6 months whereas 100%, 78% and 83% of patients with Grades B, C and D respectively had improvement postoperatively. Dobran et al.,[10] opined that the severity of the injury was the primary predictor of outcome in acute SCI, reported that ASIA Grade D improved in 78.1% of the cases while patients in grade B improved in 66.6%. Interestingly similar to the present study Dobran et al., [10] observed that, three months after the trauma 3 patients out of 18 with ASIA grade A improved, probably due to the spinal shock that alters the actual initial clinical assessment.

The level of injury was another factor found to affect outcome in different studies [12-15]. It is generally accepted that the most injured spinal level is at 5th and 6th cervical vertebra, as this level has greatest range of flexion or extension stress and therefore most susceptible to trauma. Premkumar & Pathiarasakumar [16] showed 35% of patients with cervical spine injuries, the commonest level being C5-C6, in a series of 214 patients. In the present study, most common level of injury was C5-C6 fracture dislocation (40.7%) followed by C4-C5 level. Srinivas et al., (2017) reported that, the percentage of improvement was more (71%) in C5-C7 cervical injury compared with C3-C4 cervical injury (60%). In the current study, all of the patients had subaxial CSI and out of 27 patients only 3 (11.1%) had injury at C3-C4 level and others had injury below this level. Similar higher incidence of C5-C7 cervical injury was also reported by other authors.[12]

In this study, preoperative hemorrhage was found statistically significant (p-value: 0.0009) in association with good neurological outcome and also in association with postoperative FIM score (p-value: 0.007). Here, in 18 patients no preoperative hemorrhage or contusion were found and hemorrhage or contusion were found in 9 patients. Among them postoperatively 21 had no hemorrhage or contusion and all of them had improvement in neurological outcome. Only 6 patients had hemorrhage or contusion and among them only one patient improved. In this study, hemorrhage or contusion was taken as single hemorrhage group. Miyanji et al. [17] also found that intramedullary hemorrhage and cord swelling were key predictors of neurologic recovery after traumatic cervical SCI.

Recently, there is a paradigm shift in favor of early surgical intervention in cases of SCI. Fehlings *et al.,* [11] in a multicenter, international, prospective study in adults aged 16–80 years with cervical SCI, concluded that early decompression before 24 hours after injury is significantly associated with improved neurological outcome at 6 months follow-up. In this study, due to delay in referrals, poor medical condition and financial constraints, there was a considerable delay before surgical decompression. Because of these reasons, patients were categorized into two groups such as those operated within 7 days of injury considered as early surgical group and those were operated after 7 days considered as late surgical group in the present study. The percentage of improvement was 100% in early surgical group (d”7 days), whereas it was 78.3% in late surgical group (>7 days) but it was not statistically significant.

In selection of approaches , Premkumar & Pathiarasakumar [16] showed anterior approach directly encounter the injured elements and make easier to proceed with decompression, reduction, grafting and stabilization ; whereas for locked facet injuries, old cases, to remove excess fibrous tissue around the fracture elements posterior and/or combined approach is helpful. In this study, among 27 patients majority (92.60%) cases were approached anteriorly. Only one was approached posteriorly and combined approach was done for one.

All the patients in this study were analyzed by measuring FIM score before surgery and 6 months follow-up. Overall improvement in average FIM score for each grade was studied. For ASIA Grade A patients 11 points, for Grade B patients 29 points, for Grade C patients 29 points and for Grade D patients 11 points improved at 6 months follow-up. The management of subaxial cervical spine trauma has been facilitated following the publication of the Subaxial Injury Classification (SLIC) and severity scale by the Spine Trauma Study Group [6]. In the current study patients with preoperative SLIC score >4 were included. It was suggested previously that, patients with SLIC score 4

points can treated either conservatively or surgically but patients with SLIC score of >4 points generally have rotational or distractive injuries (such as facet fractures-dislocations and floating lateral mass), and should be referred for surgery regardless of their neurological deficits [9].

MRI groups and FIM score analysis was also done in the current study. The six months FIM score was significantly higher in patients who had edema in d"3 segments in MRI compared with patients with edema in >3 segments which have got statistically significant (p = 0.007). Similar significant higher improvement in mean FIM score was also noted in patients with preoperative MSCC <30% compared to MSCC >30% [2,17].

To determine the independent factors influencing the neurological outcome of surgically managed subaxial cervical SCI patients, multivariate analysis was planned initially in the present study. However, probably due to small sample size multivariate analysis was not possible. Previously Cao et al., (2019) concluded that, time from injury to operation, SLIC score, and MSCC are independent risk factors for poor prognosis of cervical SCI patients with subaxial cervical fracture-dislocation after surgical treatment. It was realized in the current study that a larger case series was needed to better validate its statistical significance.

Conclusion:

Patient presented with intramedullary hemorrhage, preoperative edema, maximum spinal cord compression, preoperative ASIA grade had found to be the important predictors for better neurological improvement after 6 months follow-up in surgically managed subaxial cervical spine injury patients. On contrary, other factors like patient's age, sex, level of injury, timing of surgery, approach of surgery and SLIC score were not found statistically significant with the neurological outcome.

Limitations of the study

This study had few limitations- sample size was small with nonuniformity in imaging and timing of surgery. There was no control group to compare the outcome and most important short follow-up period, which made it unable to comment on long term recovery and bone fusion.

Recommendation:

Multi-centered, controlled and randomized studies with larger sample size are recommended for determination of the factors influencing neurological outcome of surgically managed subaxial cervical spine injury patients.

Conflict of interest:

None to Disclose.

Ethical approval: Approved by the Institutional Review Board, Chittagong Medical College.

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