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ORIGINAL ARTICLE

Factors affecting outcome of acute cervical spine injury: A prospective study

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ABSTRACT

Background: Injury to the spine and spinal cord is one of the common cause of disability and death. Several factors affect the outcome; but which are these factors (alone and in combination), are determining the outcomes are still unknown. The aim of the study was to evaluate the factors influencing the outcome following acute cervical spine injury.

Materials and Methods: A prospective observational study at single-center with all patients with cervical spinal cord injury (SCI), attending our hospital within a week of injury during a period of October 2011 to July 2013 was included for analysis. Demographic factors such as age, gender, etiology of injury, preoperative American Spinal Injury Association (ASIA) grade, upper (C2-C4) versus lower (C5-C7) cervical level of injury, imageological factors on magnetic resonance imaging (MRI), and timing of intervention were studied. Change in 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) scale at 6 months follow-up.

Results: A total of 39 patients with an acute cervical spine injury, managed surgically were included in this study. Follow-up was available for 38 patients at 6 months. No improvement was noted in patients with ASIA Grade A. Maximum improvement was noted in ASIA Grade D group (83.3%). The improvement was more significant in lower cervical region injuries. Patient with cord contusion showed no improvement as opposed to those with just edema wherein; the improvement was seen in 62.5% patients. Percentage of improvement in cord edema ≤3 segments (75%) was significantly higher than edema with >3 segments (42.9%). Maximum improvement in FIM score was noted in ASIA Grade C and patients who had edema (especially ≤3 segments) in MRI cervical spine.

Conclusions: Complete cervical SCI, upper-level cervical cord injury, patients showing MRI contusion, edema >3 segments group have worst improvement in neurological status at 6 months follow-up.

Key words: Cervical spinal cord, factors influencing, injury, recovery

Introduction

Cervical spinal cord injury (SCI) accounts for 2–3% of all trauma patients and 8.2% of all trauma-related deaths.[1] Injury to the spinal cord is one of the common cause of severe disability and death. Suspicion, early diagnosis of injury, preservation of spinal cord function, and maintenance or restoration of spinal alignment, and stability are the keys to successful management. Approximately, 12,000 new cases (40 cases/million) are added each year to the existing 0.3–0.5 million victims, in the USA.[2] The situation is worse in developing countries like ours where the prevalence ranges from 236 to 750 per million.

The incidence of injury to the spinal cord is on a rise and the impact on the healthcare system, and economy is tremendous. Advances in emergency medical care/

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ambulance services have positively impacted outcomes in trauma; however, the situation for SCI still remains a cause of concern. There has been a major shift from conservative management for these injuries to decompression of cord, stabilization of the spine, early mobilization, and rehabilitation. However, prevention of secondary insult to the cord in the "golden hour" is paramount. Although there have been advances in achieving spinal stabilization and decompressions of the cord; functional outcomes are a matter of concern. Several factors influence the neurological outcome following cervical SCI. This study is an endeavor, to analyse these factors for their influence on outcome and to formulate guidelines for the management of patients with SCI.

Materials and Methods

A prospective observational, single-center, the nonrandomized study of all patients with cervical spinal injury attending Emergency Department within a week of injury, who were surgically managed in the Department of Neurosurgery, Nizam's Institute of Medical Sciences, Hyderabad were included in the study. Patient enrollment began in October 2011 and ended in July 2013. The study was approved by Institutional Ethics Committee. The inclusion and exclusion criteria are listed in Table 1.

Evaluation

All patients were assessed clinically by the American Spinal Injury Association (ASIA) scoring and grading system. Apart from clinical parameters, the demographic parameters such as age, gender, mechanism of injury, and timing of injury were also included in the study. Radiological evaluation for stability was assessed by White and Panjabi grading for cervical spine injury. All these patients had magnetic resonance imaging (MRI) done either at institute (1.5 Tesla) or at the referral center (0.3–1.5 Tesla). Quantification of damage in SCI was measured based on the mid-sagittal T1 and T2-weighted sequences. MRI findings were analyzed into two groups (a) contusion [Figure 1] and (b) edema [Figure 2] on the backdrop of time of injury and timing of MRI. For objective quantification of the length of lesion (edema/contusion), the mid-sagittal section of the MRI was divided based on the vertebral body and disc. The vertebral body was considered as two segments (upper and lower), and the adjacent disc was considered as an additional segment [Figure 3]. Based on this edema was grouped as (a) ≤3 segments and (b) >3 segments. The patients who presented within 8 h of injury were treated with an injection methyl prednisolone ($n = 2$) in accordance with National Spinal Cord Injury Study II (NASCIS II) recommendations. The patients were further divided arbitrarily into two groups as per the timing of surgery following the injury into early (≤1 week) and late (>1 week). The preoperative plan was decided by a collegium of neurosurgeons of the department in the preoperative period. Surgical decompression was performed until the appearance of dura with no intervening disc/posterior longitudinal ligament confirmed by an independent supervising senior consultant. All these patients were followed up in outpatient department at regular intervals. More than or equal to 1-grade change in ASIA grade from the date of admission to 6 months follow-up was taken as improvement. Functional grading was done by functional independence measure (FIM) scale at admission and 6 months follow-up.

Statistical analysis

Descriptive analysis of all explanatory variables and outcome variables was done. Sociodemographic variables such as age, gender, and clinical parameters such as the site of spinal injury, number of segments involved, and MRI findings were considered as explanatory variables. Clinical improvement and FIM score were taken as outcome variables. The association between the explanatory variables and outcome variables were assessed by calculating appropriate parameters such as odds ratio, mean difference, and percentage differences. *P* values, 95% confidence intervals were assessed by appropriate statistical tests like Chi-square test, *t*-test, or regression analysis. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp. was used for statistical analysis.

Table 1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Spinal injuries from C1-C7	Associated thoracolumbar and head injuries
Patients presented within a week following injury	Patients with penetrating injuries
Patients who were managed surgically	Patients who were managed conservatively or halotraction
	Arrival at institute after 7 days of injury
	Patients with severe autonomic disturbances such as systolic BP <85 mm of Hg, and heart rate <40

BP – Blood pressure

Figure 1: Magnetic resonance imaging cervical spine, mid-sagittal images showing a subluxation at C5/C6 level with normal images on T1 and central hypointensity with peripheral hyperintensity on T2-weighted, which was considered in contusion group

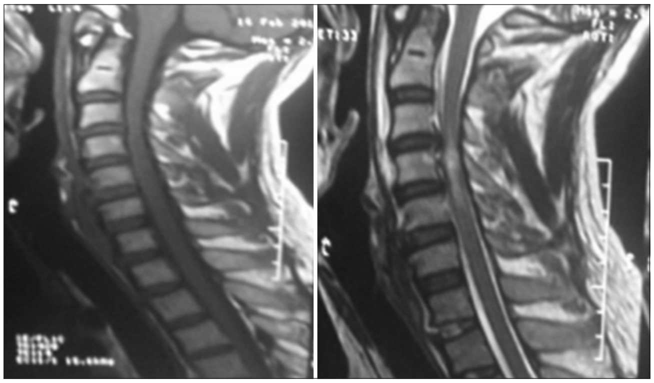


Figure 2: Magnetic resonance imaging cervical spine, mid-sagittal images with normal imaging on T1 and hyperintense on T2-weighted sequences, which was considered as edema group

Results

Study population

A total of 39 patients were enrolled during the study (October 2011 to July 2013). The descriptive analysis is provided in Table 2. A maximum number of patients in this study corresponds to 21–30 years (33%). The mean age for all patients in this study 35.13 years (ranging from 0 to 60 years). Age groups were divided into two categories; ≤30 years and >30 years for analysis. Among the patients 85% were males. Most common mode of injury was road traffic accidents (46%) followed by falls (43%). Patients with ASIA Grades A and D (30.8% each) were the most common to present to our institute, followed by Grade C (23.1%).

The percentage of improvement in ≤30 years group was 31.6% when compared to >30 years group where it was 60% which was statistically not significant [Table 3].

Clinical parameters

The initial neurological grade and follow-upgrade at 6 months labeled in Table 4. More than or equal to 1 ASIA grade change in neurological status from the date of admission to 6 months follow-up was taken as improvement. No patient in ASIA Grade A improved postoperatively at 6 months follow-up and 41.6% of patients died at 6 months. The improvement in ASIA Grade D was 83% followed by Grade C, which is around 78%. In our study, only one patient presenting with ASIA Grade B, who improved to Grade C at 6 months follow-up. Two-grade improvement noted in 2 patients of ASIA Grade C, who improved to Grade E at 6 months follow-up [Table 4].

Cervical level of injury

The low cervical injury below C4 level was more common than high cervical injury (at or above C4). Incomplete injuries (Grade A), there is no improvement in both groups. In incomplete injuries, the percentage of improvement is 71% in lower cervical injury compared with upper cervical injury where it was 60% but was statistically not significant [Table 5].

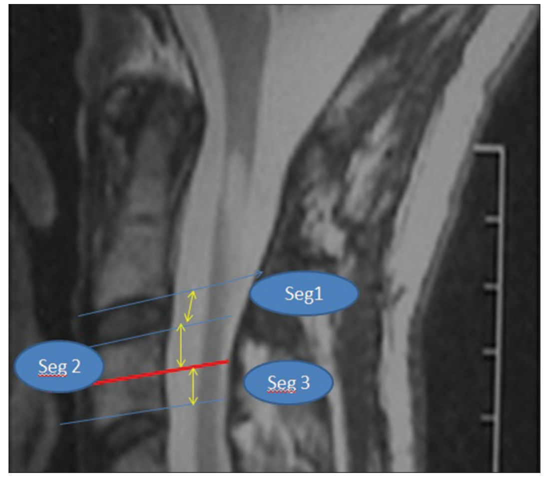


Figure 3: Magnetic resonance imaging mid-sagittal images showing the division of vertebral body as two segments and the disc as another segment

Table 2: Descriptive analysis of study participants (*n*=39)

Parameter	Frequency (%)
Age group	
30 and below	19 (48.7)
Above 30	20 (51.3)
Gender	
Female	6 (15.4)
Male	33 (84.6)
Mechanism of injury	
RTA	18 (46.2)
Fall	14 (35.9)
Others	7 (17.9)
Asia grade	
A	12 (30.8)
B	1 (2.6)
C	9 (23.1)
D	12 (30.8)
E	5 (12.8)
MRI	
Edema	
<3 segments	16 (41.0)
>3 segments	7 (17.9)
Contusion	9 (23.1)
Normal	7 (17.9)

RTA – Road traffic accident; MRI – Magnetic resonance imaging

Table 3: Statistical results of age groups and their improvement

Age groups	Improved (%)		Total (%)	Odds ratio	*P*
	Improved	Not improved			
30 and below	6 (31.6)	13 (68.4)	19 (100.0)	0.31	0.11
Above 30	12 (60.0)	8 (40.0)	20 (100.0)		

American Spinal Injury Association score

Maximum improvement in ASIA scores seen Grade C patients, average motor score improved by 25 points, sensory score (touch + pinprick) improved by 60 points. The least improvement presents in ASIA Grade A patients, in which motor score improved by 1 point, sensory score improved by 4 points.

Magnetic resonance imageology

Based on MRI findings, the percentage of improvement in edema group was 65.2%, whereas none in the contusion group improved [Table 6]. In subanalysis of edema group, the patients with edema ≤3 segments group, the improvement was high (75%) as compared to >3 segments group (42%). None of the patients in group with edema ≤3 segment died as compared to 42% patients in edema >3 segments group, which was statistically significant ($P = 0.003$) [Table 7].

Timing of surgery

Percentage of improvement in ≤7 days surgery group was 50% as compared to 44.8% in >7 days surgery group.

Functional independence measure score improvement

Maximum improvement in average FIM score at 6 months follow-up noted in ASIA Grade C, with improvement in average score from 60/126 to 102/126 [Graph 1]. Maximum improvement in average FIM sub score also noticed in ASIA Grade C, where self-care average score improved by 16.6 points, sphincter improved by 7.89, transfers improved by 9.3, and locomotion improved by 5.8 points. FIM score increased by 37 points in MRI edema group compared with contusion group which is improved by 11 points, which is statistically significant [Table 8]. The FIM score increased by 41 points at 6 months follow-up in early surgery group, whereas the gain in late surgery group was only 24 points.

Postoperative complications

Maximum follow-up was available for 20 months, with minimum follow-up of 6 months (average - 11.3 months).

Table 4: Improvement in American Spinal Injury Association grades at 6 months follow-up

Follow-up 6 months	ASIA grades					Total after 6 months
	A	B	C	D	E	
A	6	0	0	0	0	6
C	0	1	2	0	0	3
D	0	0	5	2	0	7
E	0	0	2	10	5	17
LF	1	0	0	0	0	1
Mortality	5	0	0	0	0	5
Total	12	1	9	12	5	39

No patient improved or deteriorated to Group B and hence Grade B has not been charted. ASIA – American Spinal Injury Association; LF – Lost to followup

Table 5: Comparison of upper versus lower cord injuries

Admission ASIA grades	Improved ASIA grades (%)			χ^2	P
	Improved	Static	Died + LF		
Upper cervical (C2-C4)					
A	0 (0.0)	1 (50.0)	1 (50.0)	10.20	0.116
C	3 (75.0)	1 (25.0)	0 (0.0)		
D	3 (75.0)	1 (25.0)	0 (0.0)		
E	0 (0.0)	2 (100.0)	0 (0.0)		
Lower cervical (C5-C7)					
A	0 (0.0)	5 (50.0)	5 (50.0)	25.459	0.001
B	1 (100.0)	0 (0.0)	0 (0.0)		
C	4 (80.0)	1 (20.0)	0 (0.0)		
D	7 (87.5)	1 (12.5)	0 (0.0)		
E	0 (0.0)	3 (100.0)	0 (0.0)		

ASIA – American Spinal Injury Association; LF – Lost to followup

Table 6: Outcome in relation to magnetic resonance imaging findings

MRI	Outcome (%)			Total (%)	χ^2	P
	Static	Improved	Died + LF			
Edema	4 (17.4)	15 (65.2)	4 (17.4)	23 (100.0)	11.153	0.001
Contusion	7 (77.7)	0 (0.0)	2 (22.2)	9 (100.0)		
Total	11 (34.4)	15 (46.9)	6 (18.8)	32 (100.0)		

MRI – Magnetic resonance imaging; LF – Lost to followup

Table 7: Subgroup analysis of edema groups

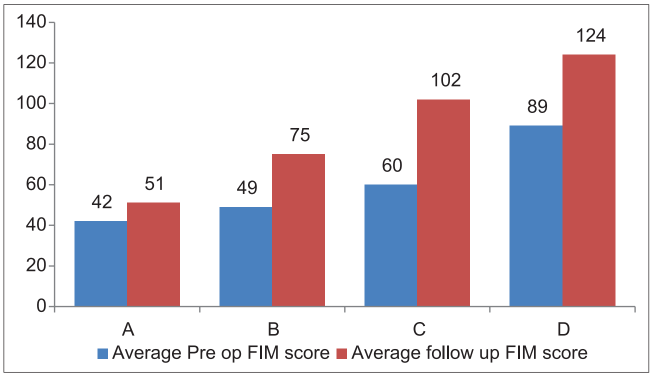
MRI	Outcome (%)			Total (%)	χ^2	P
	Static	Improved	Died + LF			
<3 segments	4 (25.0)	12 (75.0)	0 (0.0)	16 (100.0)	7.89	0.003
>3 segments	0 (0)	3 (42.9)	4 (57.1)	7 (100.0)		
Total	4 (17.4)	15 (65.2)	4 (17.4)	23 (100.0)		

MRI – Magnetic resonance imaging; LF – Lost to followup

Table 8: Association of functional independence measure scores with number of segments of injury (n=39)

MRI	Mean	Mean difference	P (independent sample *t*-test)	95% CI of the difference	
				Lower	Upper
Difference in overall FIM					
≤3 segments	32.37	29.23	0.060	−1.29877	59.76305
>3 segments	3.14				
Difference in self-care					
≤3 segments	15.25	7.82	0.19	−4.42	20.06
>3 segments	7.42				
Difference in sphincter					
≤3 segments	4.18	1.04	0.61	−3.20	5.29
>3 segments	3.14				
Difference in transfer					
≤3 segments	5.93	1.50	0.58	−4.17	7.18
>3 segments	4.42				
Difference in locomotion					
≤3 segments	4.75	1.75	0.41	−2.64	6.14
>3 segments	3.00				

FIM – Functional independence measure; MRI – Magnetic resonance imaging; CI – Confidence interval



Graph 1: Average pre- and post-operative functional independence measure scores

Postoperatively, 2 patients had chest infection, 1 patient had wound collection, 6 patients had bedsores, and two patients had urinary tract infection. Total five patients died at 6 months follow-up. Of 5 died patients, one died due to acute renal failure, two patients died due to chest infection, two patients died due to bedsore associated septicemia.

Discussion

An intent to improve the neurological and thence the functional status has led to numerous studies, evaluating various factors such as age, gender, etiology, ASIA grades, level of injury, and timing of surgery and their influence on the outcomes.

Demography and outcome

Age has been the point of contention for neurological outcome and functional recovery. Although SCI commonly affects the young in their productive ages, extremes of ages are not spared with approximately 5.4% of individuals in an elderly age group (>65 years). We had no patient in elderly age group, which could well be a bias in the healthcare and referral protocols. According to National Spinal Cord Injury Statistical Center (NSCISC, Birmingham, Alabama, 2012)[2], the average age at injury is 41 years with 80% of SCI reported in males. In this study, the average age was 35.12 years with 85% cases being males. Most common etiology, according to NSCISC, motor vehicular accidents corresponds to 39%. In this study, RTA contributed to 46.2% of cases. Published data favors good improvement for young individuals [Table 9]. However, our results were contrary with better improvement (60%) in >30 years when compared to ≤30 years (31.6%), which could well be explained by severe grade of injuries in younger patients.

Clinical parameters

Several studies have focused on initial neurological grade, the level of injury affecting outcome. Coleman and Geisler[8] opined that the severity of the injury was the primary predictor of outcome in acute SCI, reported that ASIA Grades C and D had marked recovery as compared to ASIA Grade B, which did better than Group A.

Table 9: Demographic comparison in literature

Author and year	Outcome
Waters *et al.* 1993[3]	Complete cervical injuries >65 years had worst prognosis
McKinley *et al.* 2003[4]	Older individuals have poorer outcome
Fisher *et al.* 2005[5]	Age <24 years better outcome
van Hedel and Curt 2006[6]	Poorer outcomes with increasing age
Pickett *et al.* 2006[7]	Mortality increases with age
Present study 2014	Age >30 years had better outcome Mortality higher in <30 years but statistically not significant

Vazquez *et al.*,[9] in their study for 173 traumatic cervical SCI patients concluded that rate of improvement was least in ASIA Grade A patients, and none of them were functional. In contrast, incomplete injury patients had better recovery. Shao *et al.*,[1] analyzed retrospectively, 1163 patients with cervical SCI, opined that higher level (C1-C4), with complete cervical SCI having worst outcome.

Burns *et al.*,[10] studied the effect of age and initial neurologic status on the recovery of ambulation in patients with incomplete injuries. They concluded that in patients with ASIA Grade D, prognosis for recovery to independent ambulation was excellent irrespective of age. For patients with ASIA Grade C, recovery to ambulation was related to age (<50 years - 91% patients improved; >50 years - 42% improvement).

In this study no patients in ASIA Grade A improved at 6 months, 100% of ASIA Grade B grade had improvement postoperatively which was not statistically significant as only one patient present in Grade B, who improved to Grade C at 6 months. Improvement was noted in 78% and 83% of patients with Grades C and D, respectively. No patient had neurological grade deterioration.

In this study, the comparison between upper and lower cervical injuries (at or above C4 vs. below C4) done. The incidence of lower cervical injuries was high (69%) when compared with high cervical injuries (31%). Incomplete injuries (Grade A), there is no improvement in both groups. In incomplete injuries, the percentage of improvement was more (71%) in lower cervical injury compared with upper cervical injury (60%). The average improvement in motor and sensory scores improved with increasing proportion as the severity of injury decreased (Grade A - 1 and 3.5, B - 22 and 26, C - 25 and 60, and D - 19 and 31).

Magnetic resonance imaging and outcome

A number of studies proved that MRI had been the gold standard in prognostication of cervical SCI. It allows good visualization of neurological tissues such as cord, ligaments, discs, vessels as well as soft tissues.

Kulkarni *et al.*, (1987)[11] were first to characterize three MRI signal patterns for the prognostication of acute SCI:

(1) Hemorrhage in the cord (2) edema of the cord and (3) a combination of hemorrhage and edema. Prognostication patterns used today are variations of these original patterns.

Silberstein *et al.*,[12] described the following MRI patterns, describing the four pathologies of acute SCIs (1) hemorrhage pattern (2) edema pattern (3) contusion pattern and (4) transaction pattern.

Ramón *et al.*,[13] described six patterns of MRI in acute SCI.

Provenzale,[14] described MRI evaluation of anatomic structures which can help, determine the cause and extent of the neurological deficit, the probable mechanism of injury, and the presence of spinal instability.

In the literature, sagittal T2 sequences had the highest correlation with patient prognosis as they can identify and measure the extent of edema and hemorrhage/contusion within the spinal cord.

Bozzo *et al.*,[15] in his review, reported that patients with normal MRI improved to ASIA Grade E regardless of their initial neurological status. He described, four signal patterns based on sagittal T2-weighted sequences are commonly used in the literature. Pattern 1 shows a normal MRI signal in the cord, Pattern 2 represents single-level edema, Pattern 3 is multi-level edema, and Pattern 4 is mixed hemorrhage and edema, which were in fact imbibed from previous studies.[16-18]

In this study, we modified Silberstein criteria. Few patients, either presented late (after 72 h of injury) or had MRI done at referral center (0.3–1.5 Tesla), we merged hemorrhage and contusion into single category and named as contusion group. It is analogous to type 1 and 2 patterns of Kulkarni *et al*. We had no patient in transaction pattern. MR imageology of cervical spine is categorized into two groups, named as edema and contusion groups. f 39 patients 59% ($n = 23$) patients had edema, 23% patients had contusion and 18% had normal MRI. A similar results noted in previous Kulkarni *et al*., Ramón *et al*., Bozzo *et al*., all of those showing edema was most common imageological finding. No patient in contusion group improved at 6 months follow-up, whereas the percentage of improvement in edema group was 65.2%, which was statistically significant ($P = 0.004$). Mortality in contusion and edema group was 45% and 13%, respectively, at 6 months. We did subanalysis on MRI, edema based on rostra caudal extent of edema in sagittal MRI T2-weighted image and noted improvement in 75% and 43% when edema was <3 and >3 segments, respectively.

Timing of surgery and outcome

Controversy exists regarding the timing of surgery in SCI. Proponents of both early and late surgery can be found in the literature. Until now 22 studies attempted to define optimal timing of surgery for acute traumatic SCI, 9 utilized the 24 h limit to define an early decompression,[19-27] 8 used 72 h,[28-35] and 4 used other benchmarks such as 8hrs, 48hrs, or 4 days.[36-39] Interestingly, none of the studies have reported adverse neurological outcomes with early surgical intervention.

All these studies have brought a paradigm shift in favour of early surgical intervention. The rationale behind this is based on the pathophysiology of acute SCI indicate that there are both primary and secondary mechanisms that lead to neurological injury. Preventing and mitigating the secondary mechanisms is where opportunity for neuroprotection lies and where most attempts at therapeutic intervention staged.

Fehlings *et al*., 2012 (STASCIS TRIAL),[40] in a multicenter, international, prospective study in adults aged 16–80 with cervical SCI, concluded that decompression before 24 h after injury is significantly associated with improved neurological outcome at 6 months follow-up.

In this study, due to delay in referrals, poor respiratory status and/or time for traction, there was a considerable delay before surgical decompression. Because of these reasons, we categorized into two groups such as those operated within 7 days of injury considered as early surgical group, those were operated after 7 days considered as late surgical group. The percentage of improvement was 50% in early surgical group ($\leq$7 days), whereas it was 45% in late surgical group ($\geq$7 days) and it was statistically not significant. Injection methylprednisolone as per NASCIS II trial was given to only 2 patients attended to Emergency Department within 8 h of injury. Among two patients, one patient with ASIA Grade A admission grade and operated within 24 h improved to Grade B at discharge. Unfortunately, this patient succumbed to death after 2½ months due to renal failure. The other patient who was ASIA Grade D at admission improved to ASIA Grade E at 6 months follow-up.

Functional outcome

There are very few systems which can effectively predict the outcome in terms of functional following SCI. FIM scoring system is often used to assess the disability at admission and also to predict the long-term outcome. All the patients in this study were analyzed by measuring FIM at admission and 6 months follow-up. Overall improvement in average FIM score for each grade was studied. For ASIA Grade A patients 9 points (from 42 to 51), for Grade B patients 26 points (from 49 to 75), for Grade C patients 42 points (from 60 to 102), and for Grade D patients 35 points (from 89 to 124) improved at 6 months follow-up. Subscores of FIM instrument contain 13 items in motor scales and 5 items in cognitive scales. A subanalysis of motor scales was done with 6 items for self-care, 2 items for sphincter control, 3 items for transfers, and 2 items for locomotion for each grade. In patients with ASIA Grade A ($n = 6$) overall self-care improved by 2.92 points, sphincter improved by 0.17 points, transfers improved by 1.92 points, and locomotion improved by 0.09 points. No significant improvement noted in ASIA Grade A patients. In patients with ASIA Grade B ($n = 1$) self-care, sphincter control, transfers, locomotion improved by 10, 4, 4, 1 points, respectively. In patients with ASIA Grade C ($n = 9$) self-care, sphincter control, transfers, locomotion improved by 16.6, 7.9, 9.3, 5.8 points, respectively. In patients with ASIA Grade D ($n = 12$) self-care, sphincter control, transfers, locomotion improved by 18.1, 3.2, 6, 6.3 points, respectively. MRI groups and FIM score analysis done. The FIM score was increased by 37 points at 6 months in people who had edema in MRI compared with contusion group where it was only 11 points which have got statistically significant ($P = 0.03$). In subanalysis of edema groups, the improvement in average FIM score was more in ≤3 segments group (32 points) compared with contusion group (3 points improved).

Limitations of study

This study has the following limitations.

The major limitations of this study were a small sample size, with nonuniformity in imaging, and timing of surgery. A multivariate analysis hence was not possible.

Conclusions

Incomplete cervical injuries (Grades C and D), lower cervical injuries (C5-C7), and patients having edema in MR imageology have better improvement when compared with complete, upper cervical injuries (at or above C4), MRI contusion group. The patients with edema ≤3 segments had better improvement when compared with >3 segments edema. Significant improvement in average FIM score noted in incomplete cervical injury patients, MRI showing ≤3 segments edema groups.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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