Panacea Journal of Medical Sciences 2022;12(1):116–122

Content available at: https://www.ipinnovative.com/open-access-journals

Panacea Journal of Medical Sciences

Journal homepage: http://www.pjms.in/

Original Research Article

Factors affecting long term outcome in acute cervical spinal cord injury

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ARTICLE INFO

Article history:
Received 22-03-2021
Accepted 21-05-2021
Available online 30-04-2022

Keywords:
Spinal cord injuries
Functional improvement
Neurological status

ABSTRACT

Introduction: Spinal cord injuries are most commonly caused by motor vehicle accidents. The next frequent causes are falls and acts of violence, Sports-related spinal cord injuries. Drastic reduction in the mortality & morbidity was noticed with the better management of pressure sores, urinary tract infections and respiratory problems with the advent of modern rehabilitative methods.
Aims : To study clinical factors affecting long term outcome in acute cervical spinal cord injury patients,
Materials a nd Methods: A 2-year study Conducted between 2015-2017, 33 patients with acute cervical SCI were included in the study, admitted in the department of Neurosurgery, Osmania General Hospital.
Results : Maximum number of patients were in ASIA grade B 11/33 (33.33%), Neurological improvement- All patients improved in ASIA grade 'D' and none in ASIA grade 'A'. Percentage improvement in cord edema group was 52% and contusion group was 0%. Percentage of improvement in less than forty years age group was 45%: and more than forty years age group was 46.1%. Percentage of improvement in early surgery group was 60% and in the late surgery group was 33.33%.
Conclusion: Functional improvement in transfer, self-care and mobility was seen maximum in ASIA grade C. Amongst them, the 'transfers' function scored the maximum.

1. Introduction

From an economic, psychological, and social standpoint, SCI has a massive and far-reaching effect. Each year, about 10,000 new cases are identified in the United States, with an approximate incidence of 300,000 to 500,000 living victims.[1] Motor vehicle collisions are the most common cause of spinal cord injury. Falls and acts of aggression are the next most common causes. Children and teens are more likely to experience sports-related spinal cord injuries, while adults are more likely to sustain work-related injuries. Males in their teens or twenties make up the bulk of spinal cord injury patients. After the age of 65, the male preponderance decreases. More than half of all spinal cord injuries occur in the cervical region, almost a third occur in the thoracic, and the remainder occur in the lumbar region.

During World War II, Ludwig Guttmann proposed non operative management for these patients as the mortality was as high as 80-90%. Over the past two decades, there has been greater emphasis on research and a mortise renewal of interest in the management of spinal cord injuries. Drastic reduction in the mortality & morbidity was noticed with the better management of pressure sores, urinary tract infections and respiratory problems with the advent of modern rehabilitative methods. Development of spinal cord injury centers, improvement in transportation of these patients to the medical facilities, increased availability of CT and MR1 have contributed significantly to better management and improved outcome following these injuries.[2]

Early prediction of outcome is essential to counsel anxious patients and to make arrangements for the

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https://doi.org/10.18231/j.pjms.2022.022

treatment. Forecasting length of stay, costs and equipment is not possible without this information. Hence, the importance of early prediction of neurological and functional outcome of spinal cord injury is frequently stressed. Several factors influence the neurological outcome following cervical spinal cord injury including age, type and severity of injury, level of injury, associated autonomic dysfunction and pre-existing diseases. Use of pharmacological agents, management of hemodynamic parameters and early surgical intervention might have impact on outcome. In the present study we made an attempt to analyze the influence of these outcome affecting factors.

2. Materials and Methods

During 2-year study period (2015-2017), 33 patients with acute cervical SCI were included in the study, who were admitted in the department of Neurosurgery, Osmania General Hospital.

Following criteria were used for selection of patients.

2.1. Inclusion criteria

Cervical cord injuries involving C1 to C7, Patients presented to the emergency department within one week following injury, who were managed surgically, with long term follow up of minimum 1 year.

2.2. Exclusion criteria

Patients who were managed conservatively or on halo traction, with penetrating injuries such as gunshot wounds, with extremely severe autonomic disturbances with bradycardia less than 40 beats/minute and mean arterial pressure less than 90 mm of Hg, associated thoraco-lumbar injuries and head injuries and patients with uncertain and inadequate long-term follow-up.

The American Spinal Injury Association (ASIA) guidelines for assessing neurologic injury were used to evaluate each patient clinically. On both halves of the body, motor and sensory scores were determined based on the evaluation of 10 key muscles and 28 key sensory points. A wisp of cotton for soft contact and a sharp needle for pin prick are used in sensory examinations. ASIA grading forms were used to enter all of the information. Level of injury was determined by noting the most caudal segment with normal motor and sensory function on both sides of the body. The completeness of the injury is noted by the absence of the sacral sensation which includes sensation at the anal mucocutaneous junction as well as the deep anal sensation. Motor function at the lowest sacral segments is noted by the voluntary contraction of external anal sphincter on digital examination. Patients were graded into five groups from A to E according to ASIA impairment scale.

2.3. MR Evaluation

Many of these patients had MR imaging, which was done on a 1.5-T superconducting unit, either at our institute or elsewhere. In the sagittal plane, three series of imaging were performed. A 22-cm field of view, a 4-mm segment thickness with a 1 mm distance, and a 192 x 256 matrix were used to obtain T1 and T2 weighted spin-echo sagittal sequences. The TI-weighted images had the following parameters: 550/20/4 (TR/TE/excitations). 2500/85/2 with a 256 x 192 matrix and an echo train duration (ETL) of 8 for T2-weighted images and 2000/30,80/1 for quick recovery fast spin-echo acquisition images. An additional STIR image sequence was performed. The field of view incorporated the lower brain stem, the entire cervical spinal cord, and the upper thoracic region to T3.

2.4. Quantification of injury on Mr Images

Measurements taken on mid-sagittal MR images of both T1 WI and T2 WI were used to quantify spinal cord injury. The longitudinal boundary of the spinal cord hemorrhage or edema was located relative to the nearest adjacent spinal vertebral landmark to determine the location of the damage to the spinal cord. The upper and lower halves of each vertebral body were labeled segments 1 and 2, respectively, and the intervertebral disk under each vertebral body was classified segment 3. The position of the upper (rostral) and lower (caudal) limits of pathology were reported using this method to determine the length of pathology. The length was determined by the number of segments between the upper and lower limits. A senior neuroradiologist was in reporting these photographs.

Both of these patients were treated according to the institute's recommendations, which were based on the American Association of Spinal Cord Injuries' guidelines. Patients were operated on as soon as their cardiovascular and respiratory state (if they were deranged) could be stabilized. Surgical stabilization and decompression were conducted according to the case's specifications. All of these patients were followed up on at regular intervals in the outpatient clinic, with the most recent follow-up after a year being recorded in ASIA recording forms. Functional grading is done using functional independent measure at the end of one year. More than or equal to one grade change in the neurological status, from the date of admission to one year follow up, was taken as improvement.

To study the influence of age on outcome, Patients were classified into two groups of more than forty and less than forty years. The improvements in these age groups were compared. To study the influence of neurological status on outcome patients were grouped into five grades from A to E. Outcomes were compared between incomplete and complete injuries. Influence of MR imaging on outcome was studied by comparing the outcomes between cord edema and contusion. Based on the length of edema two groups were made, less than three segments and more than three segments and improvements in them were compared,

2.5. Statistical methods

Chi Square analysis was done to study the statistical association of each factor on outcome. Chi square values were obtained from which p values were derived. **P** <0.05 was taken as statistically significant. When the values in all the four cells of "four-fold table" was less than 5, "Yates correction" was done.

3. Results

Number of patients enrolled into the study was 33 and mean age is 37.72 years.

Follow up period is minimum one year, maximum 16 months.

Table 1: Demographic distribution

Age Groups	No. of Patients	Percentages
10-20	3	9
21-30	7	21
31-40	9	27
41-50	9	27
51-60	4	12
61-70	1	3
Gender		
Males	32	96.96%
Females	1	3.12%

Table 2: Asia grades

Asia Score	Asia Grades	Asia Grades - Improvement
A	7(21%)	0
B	11(33%)	2(18%)
C	9(27%)	7(78%)
D	6(18%)	6(100%)

When the improvements were compared between neurological grades significant statistical association was noted in 'complete' (A) and 'incomplete' (B, C, D) cord injuries chi square (c2) value was 7.4 p<0.05.

Table 3: Age groups - improvement

	Number of patients Improved	Percentage of patients
More than forty years	6	46.1%
Less than forty years	9	45%

When the improvements between the age groups less than 40 and more than 40 were compared, the chi square (c2) value was 3.84 p>0.05.

Table 4: Magnetic Resonance Imaging Patterns and improvement

	Number of patients	Percentage of patients
Edema	25	75.75%
Contusion	5	15.15%
MRI Patterns – Improvement		
Edema	13	52%
Contusion	0	0

When the improvements were compared between the cord contusion and cord edema groups, the chi square (c2) value was 4.58 p< 0.05.

Table 5: Cord edema groups

	Number of patients	Percentage of patients
More than 3 segments	12	48%
Less than 3 segments	13	52%
Cord Edema Groups – Improvement		
More than 3 segments	2	16.66%
Less than 3 segments	11	84.6%

When the improvements were compared between the cord edema groups namely less than 3 and more than 3 segments, the chi square (c2) value was 11.54 p< 0.01.

Table 6: Timing of surgery

	Number of patients
More than 7 days	18
Less than 7 days	15
Timing of Surgery - Improvement	
More than 7 days	6
Less than 7 days	9

When the improvements were compared between the early and delayed surgery groups, the chi square (c2) value was 2.34; p< 0.05.

4. Results

Maximum number of patients were in ASIA grade B 11/33 (33.33%). Neurological improvement-All patients improved in ASIA grade 'D' and none in ASIA grade 'A'. Functional improvement - Maximum improvement in FIM score was noted in ASIA grade 'C'. Percentage improvement in cord edema group was 52% and contusion group was 0%. Percentage of improvement in cord edema of 'three or less than three segments group' was 84.6% and 'more than three segments group' was 16.66%. Percentage of improvement in less than forty years age group was 45%: and more than forty years age group was 46.1%. Percentage of improvement in early surgery group was 60% and in the late surgery group was 33.33%.

Fig. 1: MRI Cervical Spine of the patient showed a diffuse disc bulge with central discprotrusion at C3-C4 and C4-C5 level causing compression of the spinal cord with altered signal intensity with in the cord.

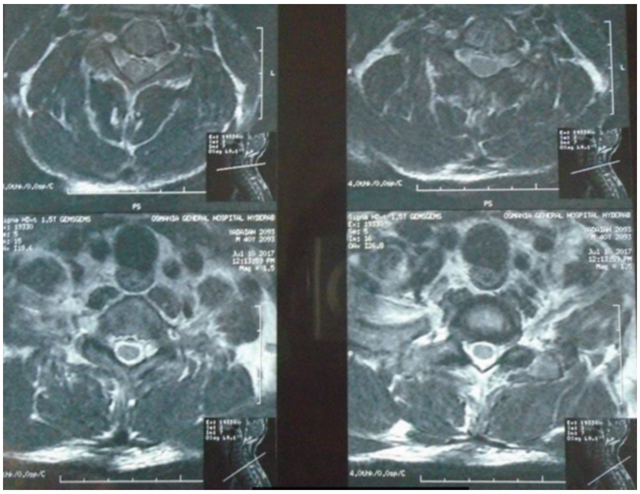

Fig. 2: MRI C spine axial cuts of the same patient. Patient underwent C3-C4 and C4-C5.

5. Discussion

Several factors determine the neurological outcome following cervical cord injury. They are age, type and severity of the injury, neurological level of the injury, neurological status at the time of injury, associated autonomic disturbances, preexisting disease and imagological appearance of cord injury on MRI etc. The influence of each factor has been extensively studied by various authors in previous studies. In the present study we analyzed the influence of four important factors on the outcome.

The overall improvement in spinal cord injuries was 45% in our series. When the improvement in each neurological grade is compared, as expected best was in grade "D" with 100% and worst in grade "A" with 0%(Gr-4). Although most of our patients are in grades A and B (18/33) we got a highly significant statistical association between initial neurological status and improvement (Gr-2) $p<0.05$ Waters et al reported an improvement of 27% in grade 0 muscles below the level of injury. In this study he also noticed that recovery was independent of neurological level from C4 to C8. Those groups of muscles two levels below the neurological level showed recovery in only 1% of the cases. In our series all the patients in grade A remained as Grade A and showed no trace of improvement C. Bumey re et al[3] in his study found that neurological outcome is determined by the completeness of injury. There was a significant difference in the improvements of complete and incomplete injuries. He reported 66 % of recovery incomplete and 14% of complete injuries. In our series also incomplete injuries scored fairly well with 57.6% of recovery. However none of our patients with complete cord injuries improved. The relative less improvement in incomplete cord injuries may be attributed to the more number of patients in ASIA grade B in our series compared to ASIA C and D grades(Gr 2).

Ducker et al[4] reported 34% of mortality at the end of one year in his series of 273 patents with complete cord injuries. Recovery in patients with ASIA grade A to C and D was found to be 6% and 7% in his series. In our series we noticed mortality of 42.8% at end of one year in patients with ASIA grade A. Though overall mortality was only 9%, all the patients who died were in grade A.Burns S.P Golding[5] while studying the effect age and neurological status on the outcome in 33 patients, reported that the recovery in patients with ASIA D independent of age. All the patients with ASIA D became ambulatory by discharge irrespective of age. However, in patients with grade C recovery was influenced by age. Recovery in less than 50 years age group was 91% compared to 42% in more than 50 years age group. A similar trend is observed in our series with 77% improvement in grade C and 100% improvement in grade D.

Old age is an adverse factor for the outcome in several diseases. Spinal cord injury is no exception to that. The incidence, etiology, pattern and outcome in the old age group are different from the young age. Although spinal cord injury is common at younger age, the occurrence of spinal cord injury in older patients is 5.4% who are more than 60 years of age.In our series we found more or less a similar incidence of 3%, in more than 60 years of age.

In elderly patients, injuries are due to trivial falls, which result in incomplete injuries. Whereas, in young patients, injuries are due to vehicular accidents which result in, complete injuries.[6] A similar pattern of injuries is observed in our series with all patients in older age group had trivial injuries.

Pattern of injuries in the old age group are different from younger age group. Older age group patients have injuries secondary to trivial falls and most often they are incomplete injuries. In younger patients complete injuries are more common due to high velocity injuries. In our series we got a similar trend. In less than 40 years of age group, 30% were complete 70% were incomplete whereas in more than 40 years 7.6% were complete and 92% were incomplete injuries. A similar trend was noticed by Atander et al[7] in his study of 41 patients with more than 50 years age. He reported an incidence of complete injuries of 31% and incomplete injuries of 68%.The improvement patterns when compared between less than 40 years and more than 40 years were 45 % and 46.1% respectively. This marginal difference did not give a statistical significance in our study(Gr-6; Tab-6).

When the improvement in the age groups was split in the individual neurological grades a better outcome in less than 40 years was noted in the grade B (40%). However, in ASIA grade C more than 40 year group showed improvement. These differences are due to smaller number of patients due to which no much significance can be deduced. Overall mortality in our series was 9%. When age groups and mortality is compared, mortality in less than 40 years is slightly higher (10%) compared to more than 40 years (7.6%). Although previous studies state that in older age group patients respiratory complications are high and mortality is high. This trend was not noticed in our series because majority of older patients have incomplete injuries. But the difference is only marginal. There was only one patient who died and he was in the old age group and he died of respiratory complications.

Previous investigators have described the MR imaging patterns of spinal cord injury and compared them with the neurological status.[8]Their observations, as well as our results, show that spinal cord edema is the most common imagological pattern in acute spinal cord injuries. Various classifications of imaging patterns have been put forward to associate the degree of neurological deficits and predict motor recovery, Siiberstein et al[9] classified MR appearances into contusion and edema and compared them with the pathological findings. Kulkarni et al[8] classified into three groups namely cord hemorrhage, edema and contusion. Ramon et al[10] broadened the patterns described by Kulkami[8] into six patterns.

We observed Silberstein et al[9] description, which included the terms contusion and edema. In our sequence, we use the word contusion to refer to a hemorrhage pattern defined by other authors. It's similar to Kulkami et al Type I and III pattern and Ramon. S. et al Type 1 and III pattern.[8,10] These lesions were referred to as hemorrhage/hematoma by both authors. A similar comparison between contusion and hemorrhage pattern was Drawn by Siiberstein et al whose classification of MRI pattern was followed in our series. Previous studies state that all cases with significant neurological deficits show some or other abnormality on MR imaging. However, in one report, Kalfas et al[11] described 6 patients with complete neurological deficits having normal cord at MR imaging. The reason given by them was the use of low field strength and its inability to detect minor changes in the cord. Similarly in our series we encountered three patients with neurological deficits having normal cord. All of them were in grade "D". Incidentally both of them underwent imaging outside our institute, the field strengths of which were not known. This indicates that proper field strength is necessary to detect and demonstrate minor changes in the cord.

In our series, analyses of the imagological findings showed that the numbers of patients with cord edema were 25, contusion 5 and normal cords were 3. It can be noted that edema is the most common imagological finding with incidence of 76% (Gr-7). A similar result was noticed in the previous studies by Adam Flanders et al[12](91%) and Kulkarni et al[8](63%) in which cord edema was the most common finding.

Cord edema that appears on magnetic resonance imaging (MRI) has been linked to a good recovery of neurological function, particularly when a small portion of the spinal cord is involved. In comparison to other types of injury, patients with fewer than three segments of cord edema recovered the most (84.6 percent). The majority of patients with cord edema have incomplete neurological deficits in addition to neurological recovery.

Seiden et al[13] discovered that the rostro caudal duration of edema was significantly associated with outcome in their analysis on the quantity of edema and outcome. In our study, 84.6 percent of patients improved in fewer than three segments, while 16.6 percent improved in more than three segments. There is a statistically relevant gap. This indicates that the period of edema is inversely proportional to the result. We discovered that neurological activity at presentation is the single best predictor of long-term neurological outcome, which is consistent with other research. Despite neurologically or motorically complete injuries at diagnosis, a large proportion of our patients recovered (11.11 percent). Both of the patients who improved had cord edema, indicating that MR imaging would help predict the outcome in addition to the clinical review. These results show the role of neural activity and MR findings in predicting the outcome on their own.

The right time to undergo surgery for a spinal cord injury is debatable. None of the studies were able to reach a consensus on the significance of early decompression and surgery timing. The evidence from animal models shows that decompression of the spinal cord enhances regeneration following spinal cord injury.

Patients will be put on cervical traction immediately after diagnosis of spinal instability. These patients will be taken up for surgery after the stabilization of vital parameters. In case if, there are no significant vital abnormalities then the patients will be taken up for the surgery at the earliest possible time. To study the influence of surgery on the outcome we divided our patients into two groups such as those operated within seven days and more than seven days following the injury. The definitions of early and late surgery groups is variable in several studies as noted below.

We chose our groups as <7 and >7 days because spinal cord injuries are not treated as emergencies at our institute. When the neurological outcomes of these two groups were compared, the early surgery group had a 60% improvement rate. The delayed surgery community saw a 33.3 percent increase. We were unable to find statistical significance between the two, implying that surgery timing has no effect on neurological recovery. A similar conclusion was Drawn by Botel et al,[14] Vacaro et al,[15] Vale et al[16] with surgeries performed at variable time periods. Levi et al 47 in his study, on 103 patients in complete and incomplete injuries reported worsening in neurological outcome by early surgery but reduced hospital stay. In his study he noted motor score improvements, in early and delayed surgeries as 37.2 & 45% in incomplete injuries and 3.9 & 4.5% in complete injuries. In our series though there is lack of statistical association we did notice a better outcome in early surgery group of 60%.

Acute traumatic spinal cord injury is frequently associated with systemic hypotension. The outcome in patients with autonomic disturbances in our series is as follows. There were 18 patients in ASIA grades A & B, out of which, 7 patients developed autonomic disturbances. Of these, 5 of them were in grade A and 2 in grade B. In grade A out of 7 patients, 5 patients developed autonomic disturbances. The neurological level of injury of all these patients was above C4 level. MR imaging patterns of these patients showed either a cord contusion or cord edema in more than three segments. During follow up, out of these five patients, three patients expired, who had cord contusion and the other two patients improved in autonomic disturbances but showed no neurological recovery. In grade B, out of eleven patients two patients developed autonomic disturbances. The neurological level in these two patients was also above C4. On MR imaging, one patient had cord contusion and the other had cord edema more than three segments. During follow up both these patients did not show any recovery. Thus it can be concluded that autonomic disturbances carry a bad prognosis. Development of autonomic disturbances is mainly determined by the level of injury.

It's difficult to determine morbidity and predict results after a spinal cord injury. Only a few devices are capable of accurately predicting the results of these accidents. The functional independent measure (FIM) scoring system is often used to determine impairment at the time of admission as well as to forecast long-term outcomes. The ability to perform a task (for example, bathing or dressing) necessitates the complex integration of motor power from different muscle classes, sensory inputs, motor reflexes, co-ordination, and psychological motivation. As a result, task performance tests provide a more complete picture of an individual's ability to execute useful motor skills than individual motor scores. All the patients in ASIA grade 'A' (n=7) remained in grade "A" only at one year follow up and did not show any improvement in FIM.

Out of eleven patients with ASIA grade B, two have progressed to grade C. However, no increase in FIM scores was observed in these patients (those who improved from B to C). Patients who progressed from grade C to grade D showed the greatest improvement in FIM. The FIM sub-score of move has improved the most (up to the level of complete independence). Both locomotion and self-scores showed the second-best growth. However, also in this category (whose sphincter control had improved from grade C to grade D), there was no significant change in sphincter control. This means that sphincter regulation is particularly susceptible to trauma, and recovery is often delayed. Patients in grade C who were followed up on in grade Cat did not display any change in FIM. There was no deficiency in FIM at the time of enrollment in ASIA grade D. As a result, no further progress in FIM was expected. Hall K M et al.[17] came to a similar conclusion, with the highest increase of FIM scores in ASIA grade C. Another important finding in our research was that cognition sub scores did not alter, suggesting that they are of no importance in the spinal cord injury patients who were included in the study. In their analysis, Hall K.M et al[17] also noted this.

6. Limitations of the Study

Limited number of patients. No uniformity of MR Imaging technical patterns. All MR imaging patterns of spinal cord injury were not encountered in the study. All patients were not operated by a single surgeon. No multivariate statistical analysis.

7. Conclusion

Single most important factor, which determines neurological improvement is the initial neurological status. Functional improvement in transfer, self-care and mobility was seen maximum in ASIA grade C. Amongst them, the 'transfers' function scored the maximum, prognosis is very bad in the presence of contusion on MR imaging. Edema pattern on MRI has better prognosis compared to contusion. Prognosis in edema groups is better when the extent of edema is less than or equal to three segments. Timing of surgery between less than 7 days and more than 7 days does not influence the outcome. Neurological recovery is not influenced by age (< 40 years and >40 years) although mortality is high in older patients.

8. Conflict of Interest

None.

9. Funding of Sources

No financial support was received for the work within this manuscript

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Cite this article: Rao PN, Rajamohan B. Factors affecting long term outcome in acute cervical spinal cord injury. *Panacea J Med Sci* 2022;12(1):116-122.