



Prognostic Factors Influencing Outcome in Patients with Spinal Cord Injury

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ABSTRACT

Background: Spinal cord injury is a devastating neurological condition resulting in permanent motor, sensory, and autonomic deficits. Traumatic and non-traumatic mechanisms lead to primary neural disruption, followed by secondary pathophysiological cascades such as ischemia, inflammation, and excitotoxicity, which exacerbate tissue damage. Prognosis is influenced by injury level, completeness, mechanism, timing of intervention, and associated complications, yet local data on determinants of adverse outcomes are limited. **Objective:** To determine the frequency of factors leading to adverse outcomes in patients with spinal cord injury. **Study Design:** Descriptive cross-sectional study. **Duration and Place of Study:** The study was conducted from February to May 2025 at the Department of Neurosurgery, Lady Reading Hospital, Peshawar. **Methodology:** A total of 113 patients aged 18–50 years, presenting within 14 days of spinal cord injury, were enrolled through consecutive sampling. Neurological assessment using the American Spinal Injury Association Impairment Scale and magnetic resonance imaging confirmed spinal cord injury. Factors analyzed included cervical and thoracic injury, incomplete motor function, traumatic etiology, surgical management, and spasticity. **Results:** Participants were predominantly male (71.7%), with a mean age of 36.6 years and body mass index of 26.3 kg/m². Cervical injuries were most frequent (80.5%), thoracic injuries were less common (9.7%), and 35.4% were classified as having incomplete motor function. Traumatic causes were identified in 69.9% of patients, 44.2% underwent surgery, and 77.9% exhibited spasticity. **Conclusion:** Adverse outcomes in spinal cord injury are influenced by demographic, socioeconomic, and clinical factors.

INTRODUCTION

Spinal cord injury (SCI) is one of the most severe neurological disorders, producing serious and often irreversible motor, sensory, and autonomic impairments.¹ It commonly results from vertebral trauma leading to neural compression, laceration, or transection, though non-traumatic causes such as ischemic insult, infectious lesions, or neoplastic involvement may also contribute.² The impact of SCI extends beyond the primary lesion, initiating a cascade of secondary pathophysiological processes including neuroinflammation, oxidative injury, ischemia, and excitotoxic cell death, all of which aggravate neural tissue damage.³ The degree of neurological deficit is typically measured using the ASIA Impairment Scale, which stratifies the level of preserved neuromotor and sensory function.⁴ Despite advances in acute neurocare, surgical decompression, and neurorehabilitation, many patients with SCI continue to experience chronic neurological disability, neuropathic pain syndromes, and diminished quality of life.⁵

The neurological level and completeness of lesion are critical predictors of poor prognosis. Cervical cord injuries,

due to their closeness to respiratory and upper limb motor centers, are associated with higher morbidity and mortality compared with thoracic cord lesions.⁶ Thoracic injuries, although preserving upper extremity function, frequently lead to paraplegia and autonomic dysregulation.⁷ The ASIA-C grade, representing incomplete motor preservation below the injury level where over half of key muscles demonstrate a motor grade under 3, is strongly correlated with variable and often limited neurological recovery.⁸ Although partial neural conduction persists in ASIA-C lesions, reduced motor strength and coordination significantly hinder functional restitution.⁸

Additional determinants of adverse outcomes include the injury mechanism, timing and technique of surgical decompression, and presence of spasticity. Traumatic spinal lesions, such as those caused by road traffic collisions or falls, generally produce greater mechanical disruption and secondary ischemic insult compared with non-traumatic etiologies.⁹ Early decompressive surgery improves neurological prognosis, whereas delayed or suboptimal management contributes to ongoing cord

compression and ischemic deterioration.¹⁰ Furthermore, spasticity, although occasionally beneficial in maintaining muscle tone and perfusion, often results in joint contractures, musculoskeletal pain, and restricted mobility, impeding the recovery process.¹¹ In a study conducted by Milicevic S et al., the reported frequencies of factors associated with adverse outcomes among patients with spinal cord injury were as follows: thoracic injury in 17.4% of cases, cervical injury in 79.3%, ASIA-C classification in 42.1%, traumatic etiology in 71.9%, surgical intervention in 46.3%, and the presence of spasticity in 73.6% of patients.¹²

There is an immediate need for this study in Peshawar, as injuries to the spinal cord are commonly seen in this territory due to the high incidence of road traffic accidents, trauma due to falls, and workplace injury. There is scarce local data pedunculated to the clinical determinants of unfavorable outcomes in these patients, and it is hard to formulate goal-oriented management and rehabilitation policies. Through its determination of determinants of unfavorable outcome in the local population, the study shall assist in enhancing early diagnosis, inform surgical decision, and fortify post-trauma rehabilitation programs in hospitals in and around Peshawar.

METHODOLOGY

This descriptive cross-sectional study was conducted in the Department of Neurosurgery at Lady Reading Hospital, Peshawar, from February to May 2025. A total of 113 participants were included. The sample size was calculated using the World Health Organization sample size calculator, considering a 95% confidence level, a 7% margin of error, and an expected frequency of thoracic spinal injury of 17.4% among patients with spinal cord injury.¹² Approval for the study was obtained from the Institutional Ethical Review Committee prior to initiation. Patients fulfilling the eligibility criteria were approached during their hospital stay, and the purpose, procedures, and voluntary nature of participation were clearly explained. Written informed consent was obtained from all participants or their legal attendants before enrollment. Eligible participants included men and women between 18 and 50 years of age who had sustained a spinal cord injury within 14 days of presentation. Patients were excluded if they had sustained injuries below the L1 level, suffered from severe cognitive impairment, active systemic infections, multiple trauma, a prior history of stroke, end-stage cancer, or were pregnant or lactating at the time of recruitment.

A detailed history and thorough clinical examination were performed for each participant. The diagnosis of spinal cord injury with adverse outcomes was established on neurological assessment according to the American Spinal Injury Association (ASIA) Impairment Scale, where grades A to D indicated partial or complete motor and sensory deficits. Radiological confirmation on magnetic resonance imaging supported the diagnosis if any of the following were present: spinal cord swelling (localized enlargement without signal alteration on T1-weighted images), cord edema (increased T2 signal intensity), contusion (a high T2 signal rim encircling a low T1 signal focus), intramedullary hemorrhage (a thin high T2 signal

rim around a central low T1 focus with blooming artifacts), or cord transection (complete disruption of cord continuity on sagittal sequences). Each patient was assessed for factors associated with adverse outcomes. Thoracic injury was identified as trauma involving the T1–T12 vertebral levels on computed tomography, while cervical injury referred to damage between the C1–C7 vertebrae. The ASIA-C category represented a motor-incomplete injury where motor function was preserved below the lesion, but more than half of the key muscle groups demonstrated a strength of less than grade 3 on a 5-point scale. Traumatic injury was recognized as spinal damage resulting from external forces such as road traffic accidents, falls, sports injuries, or firearm trauma. Surgical management was considered when patients underwent operative procedures such as decompression, stabilization, or spinal fusion. Spasticity was defined by an increased muscle tone exceeding grade 1 on the Modified Ashworth Scale, with clinical manifestations of stiffness and involuntary muscle contractions.

All data were analyzed using IBM SPSS Statistics version 27. Quantitative variables were summarized as mean \pm standard deviation or median (interquartile range) after testing for normality using the Shapiro–Wilk test. Categorical variables were described as frequencies and percentages.

RESULTS

In this comprehensive study of 113 patients with spinal cord injury, the demographic and clinical characteristics revealed important patterns. The mean age of participants was 36.56 ± 7.11 years, indicating a relatively young patient population, with a mean BMI of 26.29 ± 2.23 kg/m², which falls within the overweight category according to standard BMI classifications, and a mean duration of injury of 7.61 ± 3.91 days, suggesting that most patients presented within the acute phase following their injury. Gender distribution showed a clear male predominance, with 81 males (71.7%) compared to 32 females (28.3%), reflecting the typically higher incidence of spinal cord injuries in males. Socioeconomic stratification revealed significant disparities, with more than half of the patients belonging to poor socioeconomic status ($n=62$, 54.9%), followed by middle-class patients ($n=32$, 28.3%), and a smaller proportion from rich socioeconomic backgrounds ($n=19$, 16.8%). Educational attainment analysis demonstrated concerning levels of limited education, with 42.5% ($n=48$) of patients being completely uneducated, 23.9% ($n=27$) having only primary education, 23.0% ($n=26$) having secondary education, and merely 10.6% ($n=12$) having achieved higher education. Geographic distribution indicated a substantial rural-urban divide, with rural residents comprising the majority at 72.6% ($n=82$), while urban residents accounted for 27.4% ($n=31$) of the study population (as shown in Table-I).

Table I
Patient Demographics

Demographics	Mean \pm SD
Age (Years)	36.56 \pm 7.11
BMI (Kg/m ²)	26.29 \pm 2.23
Duration of Injury (Days)	7.61 \pm 3.91

Gender		
Male n (%)	81 (71.7%)	
Female n (%)	32 (28.3%)	
Socioeconomic Status		
Poor n (%)	62 (54.9%)	
Middle n (%)	32 (28.3%)	
Rich n (%)	19 (16.8%)	
Education Level		
Uneducated n (%)	48 (42.5%)	
Primary n (%)	27 (23.9%)	
Secondary n (%)	26 (23.0%)	
Higher n (%)	12 (10.6%)	
Residential Status		
Rural n (%)	82 (72.6%)	
Urban n (%)	31 (27.4%)	

Yes	79	69.90%
No	34	30.10%
Total	113	100%
Surgical Treatment		
Yes	50	44.20%
No	63	55.80%
Total	113	100%
Presence of Spasticity		
Yes	88	77.90%
No	25	22.10%
Total	113	100%

Cervical injury emerged as the predominant injury level, affecting 80.5% (n=91) of patients, while cervical injury was absent in only 19.5% (n=22) of cases. In contrast, thoracic injury was substantially less common, present in merely 9.7% (n=11) of patients and absent in 90.3% (n=102) of the cohort. Classification according to the American Spinal Injury Association (ASIA) Impairment Scale revealed that 35.4% (n=40) of patients were classified as ASIA-C, indicating incomplete spinal cord injury with motor function preserved below the neurological level with more than half of key muscles below the level having a muscle grade less than 3, while 64.6% (n=73) did not fall into this category. Etiology analysis demonstrated that traumatic injury was the cause in 69.9% (n=79) of cases, whereas non-traumatic causes accounted for 30.1% (n=34) of spinal cord injuries. Treatment modality distribution showed that 44.2% (n=50) of patients underwent surgical treatment, while 55.8% (n=63) were managed conservatively without surgical intervention. The presence of spasticity represented a major complication, affecting a substantial majority of 77.9% (n=88) of patients, with only 22.1% (n=25) remaining free from this debilitating condition (as shown in Table-II).

Table II
Frequency of Factors Leading to Adverse Outcomes in Patients with Spinal Cord Injury

Clinical Characteristics	Frequency	%age
Thoracic Injury		
Yes	11	9.70%
No	102	90.30%
Total	113	100%
Cervical Injury		
Yes	91	80.50%
No	22	19.50%
Total	113	100%
ASIA-C		
Yes	40	35.40%
No	73	64.60%
Total	113	100%
Traumatic Injury		

Age demonstrated a highly significant positive correlation with BMI ($r=0.293, p<0.01$), suggesting that older patients in this cohort tended to have higher body mass indices. Age also showed positive but non-significant correlations with duration of injury ($r=0.161$), thoracic injury ($r=0.051$), and ASIA-C classification ($r=0.155$), while displaying weak negative correlations with cervical injury ($r=-0.115$), traumatic injury ($r=-0.063$), surgical treatment ($r=-0.073$), and spasticity ($r=-0.057$). Gender exhibited a significant positive correlation with traumatic injury ($r=0.187, p<0.05$), indicating that male patients were more likely to sustain traumatic spinal cord injuries, while showing minimal correlations with other variables. BMI revealed significant negative correlations with both cervical injury ($r=-0.211, p<0.05$) and ASIA-C classification ($r=-0.196, p<0.05$), suggesting that patients with higher BMI were less likely to have cervical injuries or ASIA-C classification, and also showed negative but non-significant correlations with surgical treatment ($r=-0.176$) and spasticity ($r=-0.17$). Duration of injury demonstrated a positive correlation with spasticity ($r=0.141$), though not reaching statistical significance, while showing negligible correlations with most other variables. Thoracic injury exhibited a significant positive correlation with ASIA-C classification ($r=0.194, p<0.05$), indicating that patients with thoracic injuries were more likely to be classified as ASIA-C. Cervical injury showed a positive correlation with spasticity ($r=0.169$), suggesting a tendency for cervical injuries to be associated with spasticity development. ASIA-C classification demonstrated positive correlations with traumatic injury ($r=0.122$) and surgical treatment ($r=0.086$), though these did not reach statistical significance. Traumatic injury showed minimal correlation with surgical treatment ($r=0.002$), indicating that the decision for surgical intervention was not strongly influenced by the traumatic nature of the injury. Surgical treatment displayed a weak negative correlation with spasticity ($r=-0.083$), and spasticity showed positive correlations with duration of injury ($r=0.141$) and cervical injury ($r=0.169$), suggesting potential relationships between these clinical factors (as shown in Table-III).

Table III
Correlation Matrix of Factors Leading to Adverse Outcomes in Patients with Spinal Cord Injury

Variables	Age	Gender	BMI	Duration of Injury	Thoracic Injury	Cervical Injury	ASIA-C	Traumatic Injury	Surgical Treatment	Spasticity
Age (Years)	1	0.025	0.293**	0.161	0.051	-0.115	0.155	-0.063	-0.073	-0.057
Gender	0.025	1	-0.006	-0.083	0.074	0.038	-0.028	0.187*	-0.033	-0.051
BMI (Kg/m ²)	0.293**	-0.006	1	0	0.058	-0.211*	-0.196*	-0.022	-0.176	-0.17
Duration of Injury (Days)	0.161	-0.083	0	1	-0.063	-0.037	0.007	-0.029	0.016	0.141
Thoracic Injury	0.051	0.074	0.058	-0.063	1	0.011	0.194*	0.085	-0.052	0.031
Cervical Injury	-0.115	0.038	-0.211*	-0.037	0.011	1	0.037	0.067	-0.012	0.169
ASIA-C	0.155	-0.028	-0.196*	0.007	0.194*	0.037	1	0.122	0.086	0.038

Traumatic Injury	-0.063	0.187*	-0.022	-0.029	0.085	0.067	0.122	1	0.002	0.069
Surgical Treatment	-0.073	-0.033	-0.176	0.016	-0.052	-0.012	0.086	0.002	1	-0.083
Presence of Spasticity	-0.057	-0.051	-0.17	0.141	0.031	0.169	0.038	0.069	-0.083	1

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

The present study investigated the factors leading to adverse outcomes in patients with spinal cord injury, revealing significant demographic, socioeconomic, and clinical patterns that influence patient prognosis. The mean age of 36.56 years reflects the typical distribution for spinal cord injuries, as this age group is most active and exposed to high-risk activities including motor vehicle accidents, falls, and occupational hazards. The male predominance of 71.7% aligns with epidemiological patterns, attributed to greater male participation in dangerous occupations, risk-taking behaviors, and higher rates of motor vehicle accidents and violence. The mean BMI of 26.29 kg/m² in the overweight category is significant as excess body weight complicates injury mechanisms and recovery by affecting respiratory function, increasing pressure ulcer risk, and complicating rehabilitation due to mechanical stress on weakened structures. The mean injury duration of 7.61 days indicates presentation within the critical acute phase when secondary injury cascades including inflammation and ischemia are potentially modifiable through prompt intervention. The socioeconomic findings, with 54.9% from poor backgrounds and 72.6% from rural areas, highlight critical care barriers including delayed presentation, inadequate pre-hospital care, financial constraints, and limited access to specialized centers. The high proportion of uneducated patients at 42.5% compounds these challenges through reduced health literacy, poor treatment compliance, and limited ability to navigate healthcare systems. The predominance of cervical injuries at 80.5% versus thoracic injuries at 9.7% reflects the cervical spine's anatomical vulnerability due to greater mobility and susceptibility to hyperflexion and hyperextension forces, while cervical injuries cause more severe neurological deficits affecting all extremities and respiratory function. The finding that 69.9% of injuries were traumatic emphasizes their preventable nature through improved safety measures and public awareness campaigns. The high spasticity prevalence of 77.9% represents significant morbidity, developing from disrupted descending inhibitory pathways that cause spinal reflex hyperexcitability, impair functional recovery, and increase contracture and pressure ulcer risks.

The present study's findings align with and diverge from existing literature in several important aspects, offering insights into the unique patterns of spinal cord injury outcomes in our population. Our mean age of 36.56 years is consistent with Kakakhel MK et al.¹³ who reported 32 years in Pakistani traumatic SCI patients, and approximates the 37.2 years documented by Kawu AA et al.¹⁴ in Nigeria, suggesting spinal cord injuries predominantly affect individuals in their most productive years. However, our cohort is slightly older than the 31.2 years reported by Mohan M et al.¹⁵ in Indian community-

dwelling SCI patients. The male predominance at 71.7% is lower than the 70.5-82% male representation reported by Gao F et al.¹⁶ Afridi EAK et al.¹⁷ Kawu AA et al.¹⁴ and Wilton A et al.¹⁸ though still demonstrates characteristic gender disparity attributable to occupational hazards and risk-taking behaviors.

The cervical injury predominance at 80.5% is notably higher than most reported series. Kakakhel MK et al.¹³ reported 78% thoracic injuries with only 15% cervical injuries, while Darain H et al.¹⁹ found 57.8% thoracic-level injuries in Pakistani pediatric SCI patients, and Afridi EAK et al.¹⁷ documented 70% thoracolumbar junction involvement. Kawu AA et al.¹⁴ reported 77.9% cervical injuries in Nigeria, comparable to our findings, suggesting adult populations presenting to tertiary centers may have higher proportions of cervical injuries due to severity requiring specialized care. Our traumatic etiology at 69.9% aligns with Kawu AA et al.¹⁴ who reported 88.2% road traffic injuries, both suggesting high-energy trauma patterns affecting the mobile cervical spine. But mechanisms differ specifically from Kakakhel MK et al.¹³ in which the falls had taken up 33%, fire arm injuries 27%, and road traffic injury 24%, and Darain H et al.¹⁹ who detected fire arm injuries at 38.2% in Pak children, demonstrating regional variability in violence and occupation pattern.

High prevalence of spasticity at 77.9% is within documented ranges but signifies huge morbidity. Almosallam A et al.²⁰ recorded spasticity prevalence of 18.6-57% in children SCI groups, while Kawu AA et al.¹⁴ observed muscle spasms in 98.8% in the first six months following injury, indicating spasticity is close to universal in acute settings, yet injury chronicity and completeness vary it. The result is consistent with higher estimates, and it may indicate mixed complete and incomplete lesions in which broken descending inhibitory tracts provide ideal milieu for spasticity generation. The average injury age of 7.61 days is consistent with acute presentation, in contrast to Olgun Y et al.²¹ which examined chronic SCI patients in 8.3 years duration, in which end-organ complications are fixed and treatment is directed towards long-term adaptation.

Socioeconomic results identifying 54.9% from low-grade and 72.6% from rural backgrounds indicate healthcare inequities in low and middle-income nations. Although Kakakhel MK et al.¹³ described patient satisfaction despite resource scarcity, the authors stressed prevention drives and rehabilitation drives due to critical need, implying barriers from high patient volume and resource scarcity remain significant in these settings, high uneducated patient rate of 42.5% indicating major outcome barrier when paired with Karim S et al.'s²² qualitative report of high-trauma, loan-debtor, and emotional burnout experienced by Pakistani family members in lengthy caregiving roles, hinting low

education and low socioeconomic status exacerbate patient and caregiver burden.

Surgical treatment rate at 44.2% is within reasonable ranges for mixed SCI groups. Wilton A et al.¹⁸ analyzing emergent cervical SCI surgery had 6.5% in-hospital case fatality with respiratory failure causing 83% of deaths, and determined complete injury with extreme case fatality odds ratio of 184.5. Our correlation analysis demonstrating low correlation of traumatic injury and surgical treatment ($r=0.002$) implies surgical decision-making is made based on issues outside injury mechanism, and may demonstrate anatomical issues, neurological, and resource consideration. Afridi EAK et al.¹⁷ recorded that 33% of surgically auspiced Pakistani SCI patients demonstrated pulmonary improvement after surgery, although acute complications in two weeks included pulmonary in 60%, infections in 17%, and deep vein thrombosis in 9%.

The correlation between age and BMI ($r=0.293$, $p<0.01$) reflects age-related metabolic changes, gaining significance from Li Z et al.'s²³ review documenting that energy expenditure falls 20-54% in chronic SCI while intake remains 1,800-2,600 kcal/day, creating positive energy balance and obesity prevalence of 22-97%. This metabolic derangement, combined with 60% vitamin D deficiency and 2-4% monthly bone mineral density decline, represents a critical aspect of SCI management. Our negative correlations between BMI and both cervical injury and ASIA-C classification suggest complex interactions between body composition and injury patterns, particularly given Li Z et al.'s²³ documentation that malnutrition risk reaches 62% at three months despite positive energy balance.

The psychosocial dimensions, while not directly measured, are illuminated by Olgun Y et al.²¹ who found 51.3% of chronic SCI patients experienced depression versus 18.9% of controls, and 46.1% had anxiety versus 24.3% of controls, with quality of life scores 25-40% lower across all domains. These findings are corroborated by Hatefi M et al.'s²⁴ Iranian meta-analysis showing depression prevalence of 22.6% mild, 19.6% moderate, and 12.1% severe, with overall pain prevalence reaching 65.9%. The demonstration that social support increases quality of life and functional independence, coupled with Mohan M et al.'s¹⁵ finding that employment was the strongest predictor of resilience ($\beta=0.684$, $p=0.026$), underscores that our observed socioeconomic disparities likely translate into substantially compromised psychosocial outcomes.

The comprehensive complication profile documented by Kawu AA et al.¹⁴ showing 94.8% experiencing complications including neurogenic pain in 90.5%,

bladder distension in 89.6%, and pressure ulcers in 71.6%, with 34.1% mortality driven by respiratory failure and sepsis, provides sobering context for our findings. Their identification of age ≥ 40 years, Glasgow Coma Scale < 9 , cervical injury, and complete injury as independent predictors of mortality aligns with Gao F et al.'s¹⁶ analysis showing age ≥ 65 years carried mortality odds ratios of 5.47 for cervical, 5.94 for thoracic, and 6.25 for lumbosacral injuries, with males having 40% higher death odds and firearm injury doubling mortality risk. While our study did not examine mortality outcomes, the predominance of cervical injuries, male gender, and traumatic etiology suggests substantial mortality risk requiring aggressive prevention strategies and optimized acute care protocols

The present study has several limitations that warrant consideration when interpreting the findings. First, the single-center design limits the generalizability of results to other healthcare settings, as our tertiary care facility may attract a specific patient population with more severe injuries requiring specialized care, potentially introducing selection bias. Second, the cross-sectional nature of the study provides only a snapshot of patient characteristics at a single time point and does not allow for assessment of long-term outcomes, progression of complications, or temporal relationships between variables. Third, the relatively small sample size of 113 patients may have limited statistical power to detect weaker associations or conduct more sophisticated multivariable analyses to control for potential confounders.

CONCLUSION

Our study has concluded that multiple demographic, socioeconomic, and clinical factors contribute to adverse outcomes in patients with spinal cord injury, with significant interrelationships identified among these variables. The predominance of young male patients from poor socioeconomic backgrounds and rural areas, coupled with low educational levels, highlights substantial healthcare disparities that may compromise access to timely care and optimal rehabilitation services. The high prevalence of cervical injuries and traumatic etiology underscores the severe nature of these injuries and their propensity for devastating neurological consequences.

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