

CASE REPORT

Beyond the Injury Level: Functional Outcome Variability in Cervical Spinal Cord Injury: A Case Series

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ABSTRACT

Introduction: Spinal cord injury (SCI) is damage to the spinal cord that causes motor, sensory, and autonomic dysfunction. Global incidence ranges from 13 to 220 cases per one million people. Many complications are irreversible.

Objective: To describe and compare three patients with SCI at different injury levels and examine variations in rehabilitation outcomes using the ADL scale and ASIA Impairment Scale.

Methods: This descriptive observational study included three hospitalized male patients with SCI. Collected data consisted of age, etiology, time to admission, comorbidities, neurological status, autonomic dysfunction, ADL level, ASIA classification, and rehabilitation interventions.

Results: The cases showed different neurological and functional outcomes. Case 1 (T10 to L1, ASIA A) had complete motor loss in the lower limbs, impaired proprioception, and total dependence in ADL. Case 2 (C3 to C7, ASIA B) showed severe motor deficits with incomplete sensory preservation and remained fully dependent. Case 3 (C5 to C6, ASIA B) demonstrated better recovery potential, including improved upper limb strength and partial sensory preservation. All patients experienced urinary and bowel dysfunction. Differences in age, injury level, completeness, comorbidities, and early surgical care contributed to outcome variation. Based on the ICF framework, these differences reflect variations in body functions, activities, and participation. Community-based rehabilitation may support long-term independence.

Conclusion: SCI outcomes depend on lesion level, completeness of injury, age, comorbidities, and early multidisciplinary management. Incomplete injuries, especially ASIA B, show better potential for neurological and functional recovery. The use of ICF principles can guide rehabilitation goals and improve functional independence.

Keywords: Spinal Cord Injury, Neurorehabilitation, Fully Dependent, Partial Dependent, ICF 2021

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INTRODUCTION

Spinal cord injury (SCI) is defined as structural or functional damage to the spinal cord or cauda equina that results in varying degrees of motor, sensory, and autonomic impairment.¹ These neurological deficits may significantly affect mobility, independence, and overall quality of life. Globally, SCI remains an important health problem, with an estimated incidence ranging from 13 to 220 cases per one million population, with similar rates reported in both developed and developing countries.^{1,2} Such epidemiological variation reflects differences in healthcare systems, trauma prevention strategies, and demographic factors across regions.²

The causes of SCI are broadly categorized into traumatic and non-traumatic mechanisms. Traumatic SCI commonly arises from vertebral fractures, dislocations, or spinal cord compression due to traffic accidents, falls, or sports injuries.¹ In contrast, non-traumatic SCI may be caused by conditions such as arthritis, neoplasms, infections, or degenerative disc disease, which progressively compromise the integrity of the spinal cord.¹ Regardless of etiology, SCI frequently results in significant long term disability, dependency in daily activities, and persistent autonomic disturbances.¹

SCI also imposes a substantial socioeconomic burden. In the United States, lifetime care costs for individuals with SCI are estimated at 5 to 9 million USD per patient, while the annual economic impact in Australia is reported to be approximately 2 billion USD.¹ These financial burdens arise from acute hospitalization, prolonged rehabilitation, assistive devices, long term management of complications, and reduced productivity among patients and caregivers.¹

Despite advances in emergency care and rehabilitation medicine, the underlying pathogenic mechanisms of SCI, particularly the secondary injury processes involving inflammation, oxidative stress, and neuronal cell death, remain incompletely understood.¹ This contributes to the generally poor prognosis of SCI, as many patients experience limited neurological recovery and face irreversible complications such as chronic pain, bladder and bowel dysfunction, spasticity, and recurrent infections.¹ Consequently, SCI continues to pose a major

challenge in clinical management and long term rehabilitation.

The objective of this study was to describe and compare the clinical characteristics of three patients with SCI presenting at different injury levels. This study aimed to highlight the variations in neurological and functional recovery observed during hospitalization, as well as the factors that may contribute to these differences. Furthermore, the study sought to examine the relationship between rehabilitation outcomes and functional assessments, specifically the Activities of Daily Living (ADL) scale and the ASIA Impairment Scale.

This study employed a descriptive observational design and included three hospitalized male patients diagnosed with cervical spinal cord injury. Clinical information collected for each patient consisted of age, etiology, time from onset to hospital admission, comorbidities, motor and sensory findings, autonomic function, Activities of Daily Living (ADL) status, ASIA Impairment Scale classification, and the rehabilitation interventions provided during the course of care.

CASE DESCRIPTION

Case 1

A 68-year-old man presented with acute bilateral lower-limb weakness that developed one hour after undergoing kyphoplasty and vertebral biopsy at the T10 level. Two months before admission, he had experienced progressive back and abdominal pain that interfered with daily activities. Initial radiological evaluation revealed severe vertebral compression at T10, suspicion of a destructive lesion, and multilevel degenerative disc disease, prompting the decision for surgical intervention. Prior to surgery, the patient was fully independent, able to walk, drive, and perform all activities of daily living without bowel or bladder disturbances.

During the procedure, bone cement was noted to extend posteriorly, raising concern for spinal cord irritation or compression (see figure 1). Although part of the cement was removed, the operation lasted longer than expected. One hour postoperatively, the patient experienced complete motor loss in both legs, followed by progressive sensory loss until anesthesia ensued. He also developed bowel dysfunction characterized by loss of defecatory urge and inability

to feel flatus, although bladder sensation remained partially intact under catheterization.

Physical examination revealed moderate illness, stable vital signs, and intact consciousness (GCS 15). Neurologically, the patient exhibited flaccid paraplegia with preserved upper-limb strength and complete motor loss in both lower limbs. Sensory impairment was noted at the T10 dermatome, accompanied by urinary incontinence, constipation, and a sacral pressure ulcer. Laboratory findings were largely normal except for a mildly reduced eGFR. Electrophysiological studies demonstrated severe mixed sensorimotor polyneuropathy and absent conduction across the lumbosacral pathways.

MRI of the thoracolumbar region revealed a severe T10 compression fracture with bone-cement extension into the vertebral body, moderate canal stenosis, and a possible spinal cord lesion. Additional findings included L1 compression fracture, disc degeneration from L1 to S1, Schmorl's nodes, and a suspicious lesion at T4. Histopathology from the biopsy revealed poorly differentiated adenocarcinoma, indicating metastatic bone disease. PET scan supported the presence of a suspected primary prostate tumor with metastatic involvement of T10 and L1.

Based on clinical, imaging, and pathological findings, the final diagnosis was complete spinal cord injury at T10-L1 (ASIA A) secondary to metastatic vertebral compression complicated by postoperative cord damage. Emergency management included airway stabilization, intravenous fluids, high-dose methylprednisolone following the NASCIS protocol, immobilization, urinary catheterization, analgesia, antibiotics, and multidisciplinary consultation. Prognosis was guarded due to the complete nature of the injury, metastatic disease, and significant functional decline.

Case 2

A 62-year-old man presented with progressive quadriparesis one year following a bicycle accident in May 2023. During the initial trauma, he fell onto his neck after being struck by a car, resulting in immediate loss of motor function in all limbs. He was taken to a local hospital and underwent cervical posterior stabilization on May 29, 2023, for suspected fracture and instability. Postoperatively, he remained tetraplegic with complete sensorimotor impairment below the cervical region and loss of bowel and bladder control.

Over the subsequent six months, the patient developed worsening lower-limb spasticity, muscle spasms triggered by tactile stimulation, and recurrent abdominal discomfort. He became fully bedbound, developing urinary incontinence requiring suprapubic catheter placement by May 2024, and severe bowel dysfunction requiring manual evacuation every two days. The patient also reported progressive stiffness, pain, and fatigue that hindered rehabilitation.

The patient had been previously active, engaging in daily walking and cycling. His medical history included uncontrolled hypertension after the accident and a history of coronary artery disease treated with PCI in 2014. On admission, he appeared moderately ill with stable vital signs and good nutritional status. Neurological examination revealed spastic tetraparesis with full strength in the upper limbs and complete motor loss in the lower limbs. Reflexes showed hyperreflexia and pathological signs including Babinski, Hoffman, and Tromner bilaterally. Sensory findings included hypesthesia at T9-T10 and loss of proprioception in the lower limbs. Cranial nerve examination was largely normal except for mild left buccinator weakness.

Routine laboratory investigations were within normal limits. Cervical MRI demonstrated multilevel disc bulging, facet arthrosis, retrolisthesis at C5-C6, signs of mild cervical spinal cord myelomalacia, foraminal stenosis, and canal narrowing consistent with chronic cervical myelopathy from traumatic injury (see **figure 2**).

Taken together, the patient was diagnosed with chronic traumatic cervical spinal cord injury, complete (ASIA A), accompanied by severe spastic tetraparesis and disabling autonomic dysfunction. Management included airway support, methylprednisolone according to protocol, collar immobilization, intravenous fluids, urinary catheterization, bowel management, and multidisciplinary rehabilitation. Prognosis was limited due to the chronicity of the injury, complete neurological deficit, and comorbid cardiovascular disease.

Case 3

A 20-year-old male student presented with acute tetraparesis after diving into a shallow swimming pool and striking the bottom with his head. The patient immediately experienced paralysis of all extremities, numbness in the arms, loss of sensation in the legs, and inability to control urination or

defecation. He was initially treated at a regional hospital before being referred for further management. Prior to the injury, he was healthy, with no significant medical or familial disease history.

On arrival, he was alert with stable vital signs. Primary survey revealed intact airway, breathing, and circulation, with neurologic deficits consistent with cervical spinal cord injury. Motor examination showed upper-limb strength of 2/2, which later improved to 3/4, while lower-limb strength remained at 1/1. Pathological reflexes, including Babinski and Chaddock signs, were positive. Sensory examination demonstrated hypesthesia from C6 to T3 and anaesthesia from T4 downward. Autonomic dysfunction included urinary retention requiring catheterization, impaired bowel evacuation, and decreased sweating.

Radiological evaluations confirmed a burst fracture of C5 with retropulsion of bone fragments into the spinal canal, causing significant (54%) stenosis and spinal cord compression. MRI revealed myelopathy and hematoma at C4-C6, mild

retrolisthesis of C5-C6, and disc bulging with annular tear contributing to moderate canal stenosis (see figure 3). Laboratory testing showed anaemia and leucocytosis consistent with acute trauma.

The patient was diagnosed with incomplete cervical spinal cord injury at C5 (ASIA B) with compressive myelopathy. Initial management included cervical immobilization with a collar, intravenous fluids, high-dose methylprednisolone following NASCIS protocol, catheterization, bowel care, sensory and motor stimulation, and advice for gradual mobilization with log-rolling technique. Planned definitive management included anterior cervical corpectomy and fusion (ACCF) with posterior spinal fusion (PSF). Rehabilitation medicine consultation recommended breathing exercises, sensory-motor stimulation, positional changes, and use of a Philadelphia brace.

Prognosis was guarded but more favourable compared with the other cases due to the incomplete nature of the lesion, younger age, and potential for surgical decompression and structured rehabilitation.

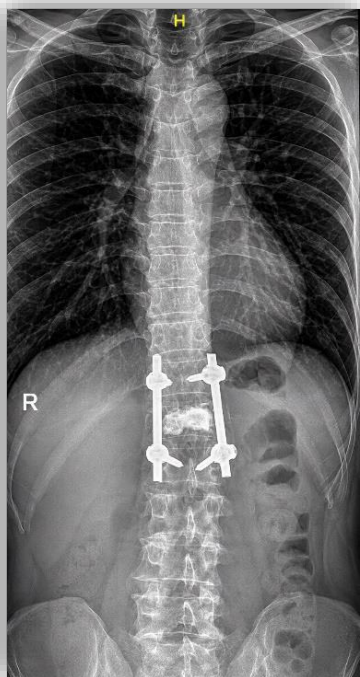


Figure 1. Postoperative thoracolumbar X-ray

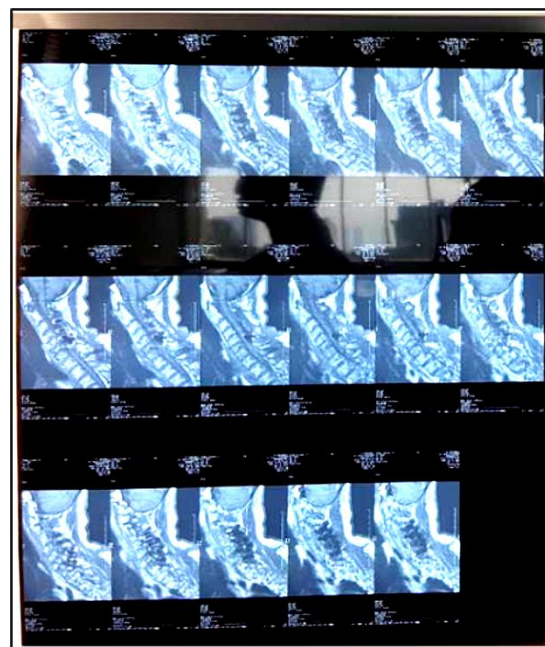


Figure 2. Cervical MRI showing disc bulging and canal stenosis from C3 to C7 with reduced spinal cord myelopathy

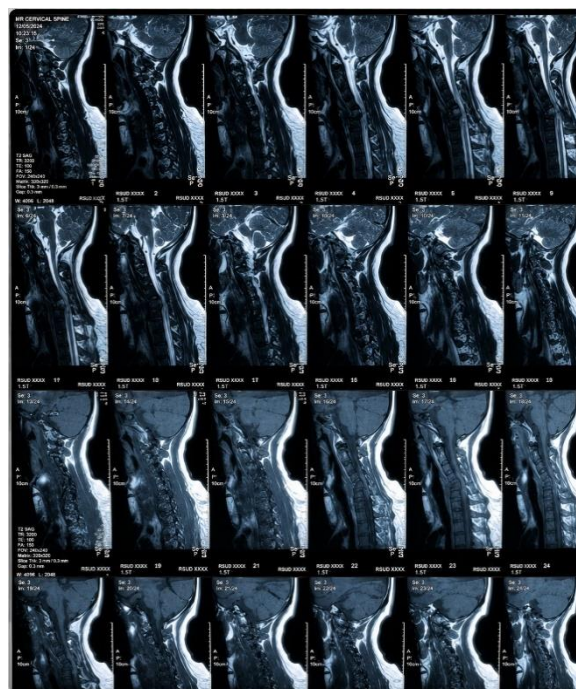


Figure 3. Cervical MRI demonstrating C5 burst fracture with retrolisthesis, posterior ligament sprain, C4-C6 myelopathy and hematoma, and C5-C6 disc bulging with annular tear leading to moderate canal and foraminal stenosis.

Table 1. Case Characteristics of Patients

Variable	Case 1	Case 2	Case 3
Age	68 y.o.	62 y.o.	20 y.o.
Etiology	Iatrogenic, Degenerative	Trauma	Trauma
Location of Lesion	Th 10 - L1	C3 - C7	C5 - C6
Onset	1 h	1 h	30 min
Comorbidities	Type 2 DM, Hypertension, Prostate Ca	CAD post-PCI, Hypertension	Obesity grade I
Motor Function	UE: 5/5; LE: 0/0	UE: 0/0; LE: 0/0	UE: 3/4 (prev. 2/4); LE: 1/1
Sensory Function	Hypesthesia below T10, impaired proprioception	Hypesthesia below C4, impaired proprioception	Hypesthesia C6-T3, anaesthesia T4-S5, impaired proprioception
Autonomic	Urinary retention, constipation	Urinary retention, bowel incontinence	Urinary retention, bowel retention, hypohidrosis
Therapy	Acute: Oxygen, fluids, Methylprednisolone, Rehabilitation: UE AROM, LE PROM, tilt table, wheelchair training, TLSO	Acute: Oxygen, fluids, Methylprednisolone, Surgery: Cervical stabilization, Rehabilitation: UE PROM, LE PROM, Respiratory exercise, Sitting balance, Tilt table, Transfer training, Assistive devices	Acute: Oxygen, fluids, Methylprednisolone, Surgery: Decompression + posterior fusion, Rehabilitation: UE AROM, LE PROM, Respiratory exercise, sitting balance, Tilt table, Transfer training, Strengthening training, Assistive devices
ADL	Total dependent (4)	Total dependent (1)	Total dependent (1)
ASIA Classification	ASIA A (Complete)	ASIA B (Incomplete)	ASIA B (Incomplete)

*Abbreviations: ADL = Activities of Daily Living; AROM = Active Range of Motion; ASIA = American Spinal Injury Association; CAD = coronary artery disease; Ca = Cancer; DM = Diabetes Mellitus; h = hour(s); LE = Lower Extremity; PCI = Percutaneous Coronary Intervention; PROM = Passive Range of Motion; SCI = Spinal Cord Injury; Th = Thoracic; TLSO = Thoraco-Lumbo-Sacral Orthosis; UE = Upper Extremity; y.o. = years old.

The three patients demonstrated distinct neurological profiles and functional outcomes. Case 1, who sustained a T10 to L1 injury with an ASIA A classification, presented with complete motor loss in both lower limbs, impaired proprioception, and absence of light-touch and pin-prick sensation below the lesion level. Autonomic dysfunction included urinary retention and constipation. His ADL score indicated total dependence, and no meaningful motor recovery was observed during hospitalization.

Case 2, with a C3 to C7 lesion and an ASIA B classification, showed severe weakness in all extremities, with partial preservation of sensory modalities. Motor strength remained markedly reduced, particularly in the lower limbs, and functional mobility was significantly limited. He experienced urinary and bowel dysfunction, required full assistance for daily activities, and demonstrated minimal improvement throughout the rehabilitation period.

Case 3, with a C5 to C6 lesion and an ASIA B classification, exhibited better recovery potential compared with the other two cases. He demonstrated gradual improvement in upper limb strength, especially in elbow flexion and wrist extension, along with partial sensory preservation from C8 to T3. Autonomic disturbances were present but managed effectively. His ADL performance showed measurable functional gains, including improved sitting balance and increased ability to participate in transfers and basic mobility tasks. Planned early decompression and his younger age may have contributed to this more favourable trajectory.

Across all cases, urinary retention and bowel dysfunction were consistently observed. Variations in outcomes appeared strongly influenced by factors such as age, lesion level, completeness of injury, comorbidities, and the timing of surgical and rehabilitative interventions. When interpreted using the ICF framework, these differences reflect distinct patterns across body functions, activity limitations, and participation levels. Case 3 demonstrated the greatest potential for progress toward long-term independence, while Cases 1 and 2 remained dependent in most domains.

DISCUSSION

The Outcomes following SCI are influenced by several recognized prognostic factors, including neurological level of injury, completeness based on the ASIA Impairment Scale, age, and medical comorbidities. These determinants are consistent with

current SCI classification and functional outcome frameworks described within the International Classification of Functioning, Disability and Health (ICF) issued by the World Health Organization.³ In this case series, these factors contributed significantly to the heterogeneity in recovery outcomes among the three patients.

Case 1, who sustained a T10 to L1 lesion and was classified as ASIA A, demonstrated the poorest prognosis. Complete injuries are associated with limited potential for neurological recovery, and poorer outcomes are more pronounced in older adults and in patients with significant comorbidities.³ The presence of metastatic bone disease and hypertension further restricted functional gains, resulting in persistent dependence in all activities of daily living. Case 2, with a C3 to C7 lesion classified as ASIA B, also exhibited severe deficits. Although incomplete lesions generally have a better prognosis than complete ones, recovery in this patient was constrained by underlying coronary artery disease and uncontrolled hypertension, conditions that adversely affect rehabilitation endurance and physiological reserve.³

In contrast, Case 3 demonstrated a more favourable recovery trajectory. This patient sustained an incomplete cervical lesion at C5 to C6 (ASIA B) and was substantially younger, without significant comorbidities. Younger age and incomplete injury levels are associated with greater neurological improvement and higher functional potential, aligning with previous outcome trends in SCI rehabilitation literature.³ Early surgical decompression was planned for this patient, consistent with the updated AO Spine & PRAXIS guidelines, which recommend decompression within 24 hours when feasible to improve neurological outcomes and reduce secondary injury pathways.^{4,5}

Hemodynamic optimization is a cornerstone of early acute SCI management. All three patients were managed under the principle of maintaining adequate spinal cord perfusion and preventing hypotension, in alignment with guideline recommendations emphasizing the importance of sustaining appropriate mean arterial pressure targets in acute SCI.^{4,5} These measures are essential to prevent secondary ischemic injury and support tissue oxygenation.

The use of high-dose methylprednisolone sodium succinate (MPSS) remains controversial. According to the clinical practice guideline by Fehlings et al., MPSS may be considered as an option

when administered within eight hours of injury but is not recommended as a routine therapy due to potential adverse effects.⁶ In this series, steroid use was applied selectively in accordance with these recommendations.

Autonomic dysfunction including urinary retention, bowel dysregulation, and impaired sweating was observed across all cases. These findings underscore the importance of structured bladder and bowel programs, consistent with the Paralyzed Veterans of America (PVA) clinical guidelines, which highlight catheterization strategies, scheduled bowel care, and caregiver education as essential components of long-term autonomic management in SCI.⁷

Rehabilitation strategies were individualized based on patient capacity and neurological level. For Case 1, rehabilitation focused on preserving upper-limb strength, developing wheelchair skills, and preventing pressure injuries. Case 2 required respiratory monitoring, preservation of upper-limb function, tilt-table mobilization, and extensive assistance with mobility. Case 3, who demonstrated greater neurological potential, was able to focus on sitting balance, transfer training, and progressive strengthening exercises. These tailored approaches align with PVA guidelines emphasizing targeted, function-oriented rehabilitation for maximizing independence.⁷

Interpretation of the cases using the ICF framework highlights the multidimensional nature of impairment, activity limitation, and participation restriction in SCI. The variability in outcomes across the three cases reflects differences in biological factors, environmental supports, and personal characteristics. Community-based rehabilitation (CBR), supported by family and environmental resources, may further enhance long-term participation and functional independence, in accordance with WHO ICF principles.³

Beyond physical and functional recovery, long-term outcomes in SCI also depend critically on psychological health, cognitive integrity, and effective management of chronic complications. A recent meta-analysis showed that individuals with traumatic SCI have significantly elevated risks of psychiatric disorders (anxiety, depression, mood disorders), substance use, and even dementia when compared to non-injured populations.⁸ This underscores the necessity of integrating mental health screening and support into long-term care plans.

Cognitive impairment is another often-overlooked dimension: following SCI, survivors may

experience deficits in attention, processing speed, memory, and executive function all of which can severely limit their participation, social reintegration, and quality of life.⁹ Given these risks, regular neurocognitive evaluation and tailored cognitive rehabilitation should be standard components of comprehensive aftercare, especially in patients with long life expectancy.

Finally, chronic SCI often leads to progressive secondary complications, for which pharmacological management strategies are still evolving. A 2024 systematic review summarized contemporary evidence on therapies for chronic SCI sequelae including spasticity, autonomic dysfunction, neuropathic pain, and neuro-regeneration efforts.¹⁰ Although curative treatments remain elusive, combining pharmacological therapies with rehabilitation, assisted devices, and environmental adaptations may ameliorate symptoms and improve patient comfort and participation.

CONCLUSION

Outcomes in spinal cord injury are influenced by several key factors, including the neurological level of the lesion, completeness of injury, patient age, comorbidities, and the timing of multidisciplinary management. Patients with incomplete lesions, particularly those classified as ASIA B, show a greater potential for neurological improvement and functional recovery compared with individuals who sustain complete injuries. Early and well-coordinated intervention that encompasses medical stabilization, surgical evaluation, autonomic care, and structured rehabilitation is essential for achieving optimal outcomes. The application of the International Classification of Functioning, Disability and Health framework can guide individualized rehabilitation planning and support long-term functional independence.

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