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Original Article

Anterior cervical discectomy and fusion for subaxial cervical spine injuries; management challenges and early outcome in a neurosurgical center

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ABSTRACT

Background: Anterior cervical discectomy and fusion (ACDF) is an effective technique in managing subaxial cervical spine injury (SCSI). The study highlights the experience and challenges of ACDF for SCSI in a sub-Saharan neurosurgical center.

Methods: The medical records of the patients who had ACDF for SCSI over 6 years in Memfys Hospital, Southeast Nigeria were reviewed. Relevant data collated include patient demographics, clinical presentation, radiologic images, operative management, and complications. All patients had right-sided ACDF after resuscitation. The follow-up period was at least 3 months.

Results: Eighty-one patients had ACDF, with male preponderance (8:1) and a mean age of 38.9 ± 12.4 years. Motor vehicular accident was the most common injury mechanism (71.6%), and the majority (59.5%) were ASIA A. C5/6 was the most common level of injury (40.7%), and the mean subaxial cervical spine injury classification system (SLIC) score was 7.8 ± 1.40. Fifty-eight (71.6%) patients presented late (>48 h after injury). ASIA A injuries, high SLIC score, and late presentation were associated with higher complication rates (P = 0.02, 0.000, and 0.0001). Dysphagia was the most common complication and was self-limiting. Improvement in neurological status was 84.75% and 10.4% for incomplete and complete injuries, respectively. Only 5% had access to onsite emergency medical services, three patients had comprehensive insurance, and rehabilitation services were available to 35.8% on discharge. The 30-day mortality was 8.6%.

Conclusion: ACDF for SCSI is associated with good outcomes in patients with incomplete spinal cord injury. Challenges in management in our setting were related to poor emergency medical services, late presentation, low insurance coverage, and limited rehabilitation services.

Keywords: Anterior cervical discectomy and fusion, ASIA A injuries, Dysphagia, Subaxial cervical spine injury

INTRODUCTION

Cervical spine injury accounts for about 50% of traumatic spinal injuries in African studies, with more than two-thirds involving the subaxial cervical spine.[17,19] This high propensity for injury

is related to its relatively extreme mobility and less robust musculoligamentous support. Subaxial cervical spine injuries (SCSIs) are often associated with severe neurologic deficits, tremendous economic burden, and negative impact on the quality of life.[18,26]

Management of SCSI is faced with numerous challenges which directly or indirectly affect outcomes, especially in low- and middle-income countries.[25] These challenges also contribute to the complications encountered in managing these patients. Some of these challenges have been identified in previous studies and range from lack of prehospital care to postdischarge patient rehabilitation.[1,17,25] Comprehensive management of SCSI is financially demanding, and as such, treatment is usually delayed or planned treatment thwarted due to problems of poor insurance coverage and out-of-pocket payment in resource-poor countries.

Anterior cervical discectomy and fusion (ACDF) offers numerous advantages, including decompression of neural elements, restoring cervical alignment, and improving mechanical stability.[6,24] This management technique has been adopted worldwide as the procedure of choice for unstable SCSI, with almost 137,000 cases performed annually in the United States.[4] In contrast to developed countries, constrained health financing, paucity of experts capable of performing such complex procedures, and limited insurance, among others, are peculiarities in low and medium-income countries that negatively impact outcomes[3,21,25]

The study evaluated the perioperative complications, early outcomes, and challenges in managing SCSI with ACDF in a private referral center in sub-Saharan Africa.

MATERIALS AND METHODS

This is a retrospective analysis of ACDF cases done between January 1st, 2017, and January 1st, 2023, in Memfys Hospital, a tertiary neurosurgical hospital in southeast Nigeria. The inpatient records were reviewed, and data were obtained, including demographic information, surgical characteristics and operation details, postoperative complications, and outpatient data.

All consecutive adult patients who had ACDF for SCSI following trauma were included in the study. Exclusion criteria were all ACDF performed for nontraumatic cervical spine pathologies. In addition, traumatic cervical spine injuries managed nonoperatively or with posterior decompression and fixation were excluded.

On admission, all patients were resuscitated following the advanced trauma life support protocol, and the post resuscitation American Spinal Injury Association (ASIA) impairment scale was recorded for each patient. All patients had cervical spine computed tomography (CT) scans and magnetic resonance imaging (MRI) [Figure 1] on admission to enable surgical planning. The subaxial cervical spine injury classification system (SLIC) score was obtained after independently reviewing the MRI and CT scan findings, as well as the patient's neurological status as described by Vaccaro *et al*.[22] Patients who had locked facets had immediate preoperative reduction with Gardner-Wells tongs under fluoroscopic guidance before surgical intervention.

Surgical technique

All patients had standard right-sided ACDF using the modified Smith-Robinson technique performed by the same surgical team. Through a right-sided skin crease incision, a subplatysmal flap was developed. The investing layer of the deep cervical fascia was opened. The middle layer of the deep cervical fascia and carotid sheath were exposed, and the carotid artery was palpated. Complete dissection of the middle layer of the deep cervical fascia and retraction of the carotid sheath laterally and the musculovisceral column medially revealed the prevertebral layer of deep cervical fascia and the anterior longitudinal ligament. The operative level was confirmed by intraoperative fluoroscopy with a marker in the disc space. Retractors were then placed beneath the longus colli muscles to minimize tension on the esophagus and carotid sheath. An incision is made in the anterior annulus using the uncus on either side as the lateral border of the decompression. Caspar distraction pins were placed in the middle of adjacent vertebral bodies to aid visualization. Disc material was evacuated under the microscope with the aid of curettes and pituitary rongeur until the posterior longitudinal ligament was visualized. Endplate preparation was performed using a high-speed burr. Trial sounds were used to determine the proper size of the allograft, iliac crest bone graft, or cage. After graft placement, traction or distraction employed during the procedure was removed, and the anterior plating was done and placed flush with the anterior border of the vertebra body. Screws were angled medially, and the final position was confirmed by intraoperative X-ray. After meticulous hemostasis and wound irrigation, the wound was closed in layers over an active drain.

Postoperative care

Patients had overnight stays in the high-dependency unit or longer when indicated. Active chest and limb physiotherapy was commenced immediately. Mobilization was done within 24–48 hours after surgery. Complications following surgery were identified, and appropriate treatments were instituted. Patients were discharged when clinical conditions were satisfactory and followed up in the outpatient department. Immediate postoperative X-rays were obtained, and further imaging was done where necessary [Figure 2]. Patients were followed up for at least 3 months after surgery, and the ASIA grade was documented.

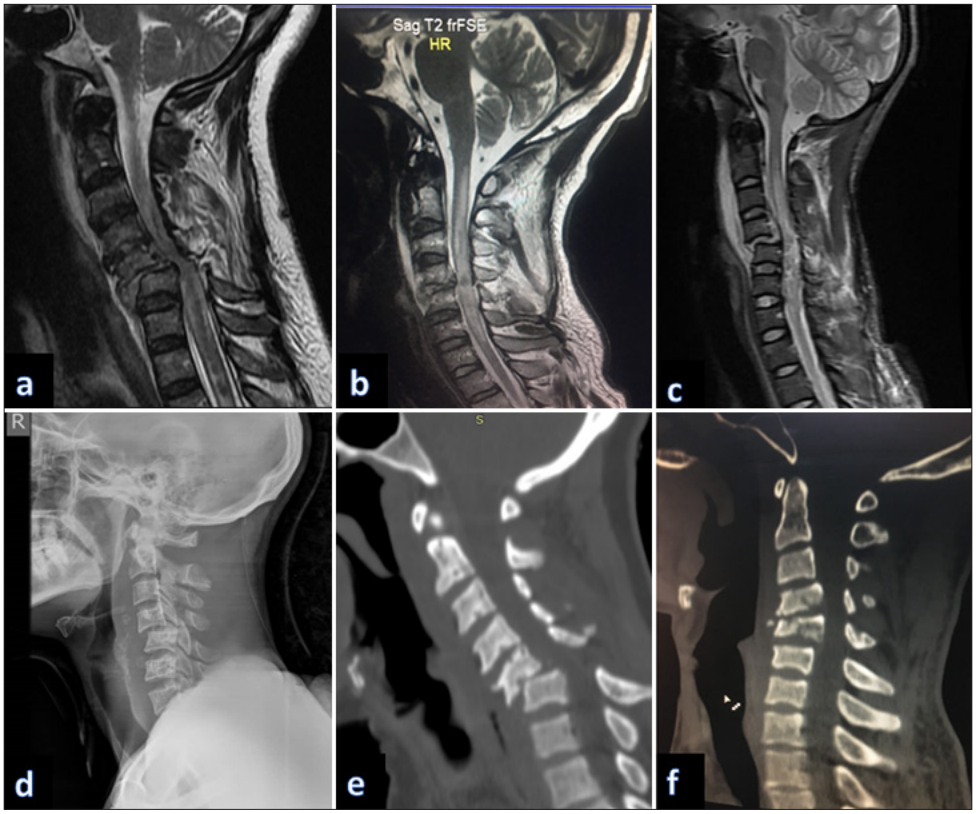

Figure 1: (a-f) Preoperative images of patients with cervical spine injuries. (a-c) Cervical spine MRI showing severe cervical cord injuries with ascending edema up to C1. (d) Cervical spine X-ray showing C4/5 anterolisthesis and bilateral locked facet. (e) CT scan shows C5 vertebra body fracture with >50% anterolisthesis and a bilateral locked facet (not shown in the image). (f) CT scan showing C4 and C5 vertebral body fractures with posterior element injuries.

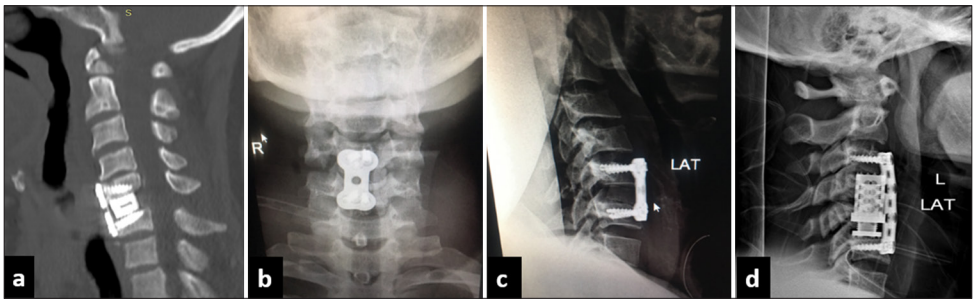

Figure 2: (a-d) Postoperative images of ACDF for SCSI (a) CT scan showing C5/6 ACDF using titanium cage and anterior plating (b) Cervical spine anteroposterior X-ray showing C5/6 ACDF (c) Lateral view showing C5/6 fusion using a tricorticate bone graft (d) 2-level corpectomy and fusion using an expandable titanium cage and anterior plating. SCSI- subaxial cervical spine injury.

Statistical analysis

Descriptive analysis was used to determine the means and standard deviation of the variables, and it was presented in charts and tables. Chi-square and student's *t*-test were used to compare categorical and continuous variables, respectively. A $P < 0.05$ was considered significant. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 20.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Basic demographics

One hundred twenty-one patients were seen over the study period, and 81 met the inclusion criteria and were included in the study. There was a male preponderance (8:1). The mean age of the patients was 38.9 ± 12.4 years, with the age distribution showing a bimodal pattern with peak age at 25–

34 years [Figure 3]. Motor vehicular accident was the most common cause of SCSI (71.6%), and more than half (59.5%) of the patients had complete cervical spine injury (ASIA A). Most injuries occurred at the C5/6 (40.7%) and C6/7 (23.4%) levels. The mean SLIC score was 7.8 ± 1.4, with more than two-thirds of the patients having a high SLIC score of ≥7. Table 1 shows the injury characteristics of the patients. Six patients had associated mild head injuries, which were managed nonoperatively. Three had closed fractures (one femoral and two tibial fractures), two had blunt chest injuries, and one had a contiguous stable thoracic vertebral fracture.

Operative results and outcome

Most patients (72.6%) had an autologous bone graft, 15% had polyetheretherketone cages, and titanium cages were used in 12.3%. All patients had anterior plating as a component of the ACDF, and zero profile cages were not used. Seventy-two patients had one level fixation, nine patients had two level fixation, and corpectomy was done in five patients. Only 15% had surgery within 24 h of arrival. The delayed surgery was mainly related to unstable cardiovascular status (40.7% had symptomatic bradycardia and/or recurrent hypotension requiring intervention) or other concomitant injuries that precluded immediate surgical intervention.

About 34.5% of the patients had one or two grade improvements on the ASIA scale. Only five patients with ASIA A injury improved, with a recovery rate of 10.41%. Other ASIA grades showed a better recovery rate than ASIA A injuries, with a mean recovery rate of 84.75% (63.6% were fully functional-ASIA E at 3-month follow-up). Two patients with ASIA C injuries worsened [Table 2]. The 30-day surgical mortality was 8.6%; all except one were ASIA A, and the cause of death was primarily due to respiratory failure.

Complications and challenges in care

Dysphagia was the most common complication in the study (35.8%), most of which occurred in the immediate postoperative period. They were mild and self-limiting except for two patients who had persistent dysphagia on follow-up, though not distressing and did not affect their quality of life.

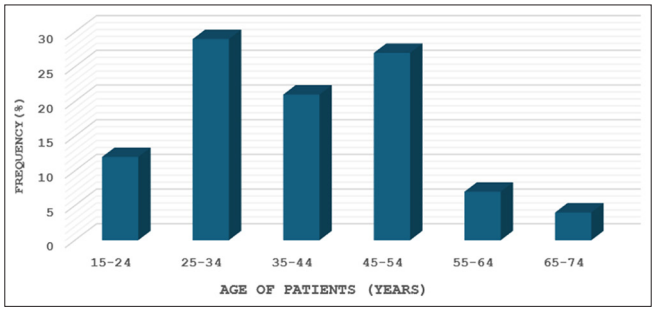

Figure 3: Age distribution of patients.

Table 1: Patient injury characteristics.

Injury characteristics	Frequency	Percentage
Mechanism of injury		
Motor vehicle accident	58	71.6
Motorbike crash	11	13.6
Fall from height	7	8.6
Contact sports	2	2.5
Others	3	3.7
ASIA impairment scale		
A	48	59.5
B	6	7.4
C	10	12.3
D	13	16.1
E	4	4.9
Level of subaxial cervical spine injury		
C3/4	10	12.3
C4/5	17	21.0
C5/6	33	40.7
C6/7	19	23.4
C7/T1	2	2.6
SLIC score		
5	13	16.0
6	10	12.3
7	33	40.7
8	17	21.0
9	7	8.6
10	1	1.2
Injury-presentation interval (hours)		
<24	12	14.8
24–48	11	13.6
49–96	14	17.3
>96	44	54.3

SLIC: Subaxial cervical spine injury classification system, ASIA: American spinal injury association

Table 2: ASIA impairment scale score at admission and postoperative/follow-up.

Preoperative		Postoperative ASIA score					
ASIA grade	Total	A	B	C	D	E	Recovery rate (%)
A	48	43	3	2	0	0	5/48 (10.41)
B	6	0	2	2	2	0	4/6 (66.7)
C	10	0	2	0	3	5	8/10 (80)
D	13	0	0	0	1	12	12/13 (92.3)
E	4	0	0	0	0	4	4/4 (100)

Recovery rate was poor for ASIA A injured patients (10.41%). Only two patients worsened from ASIA C to ASIA B on follow-up. The mean recovery rate in incomplete injury was 84.75%, ASIA: American Spinal Injury Association

One patient had esophageal perforation and was managed conservatively with the cardiothoracic surgeon without sequelae. Other complications are outlined in Table 3. Complete spine-injured patients had a higher incidence of symptomatic bradycardia (P = 0.000) and hypotension (P = 0.001) [Figure 4]. Furthermore, a higher SLIC score was associated with a statistically significant risk of recurrent hypotension (P = 0.000) [Figure 5]. Patients with complete SCSI and higher SLIC scores had higher complication rates (P = 0.02 and 0.000, respectively) [Table 4].

Six patients had implant-related complications, out of which five had graft/plate dislodgment and/or screwed back out. One patient had implant subsidence. Only three patients (3.7%) had re-do surgery due to symptoms related to the implant, while the others remained symptom-free.

About 71.6% (58 patients) presented to our facility after 48 h of injury and more than half after 5 days [Table 1]. Late presentation was associated with a higher complication rate (P = 0.0002). About 95% of the patients did not have access to onsite emergency medical services, as first responders were passersby, and transportation from the accident scene was by vehicles without facilities for advanced life support or cervical stabilization. Only three patients had comprehensive insurance coverage for surgical expenses and rehabilitation services. Others had bill expenses paid out of pocket. All patients had inpatient rehabilitation services; however, only about one-third (35.8%) could sustain such services on discharge.

DISCUSSION

Cervical spine injury is a potentially devastating injury to the patient, family, and society. This is more so in sub-Saharan Africa, where healthcare and economic challenges further negatively impact survival chances and functional outcomes.[25] The current study evaluated the perioperative complications, early outcomes, and management challenges for SCSI patients who had ACDF in a low-resource setting.

Table 3: ACDF-related complications.

Complication	Frequency	Patients (%)
Dysphagia	29	35.8
Odynophagia	8	9.8
Superficial SSI	3	3.7
RLN injury (change in voice)	2	2.4
Esophageal perforation	1	1.2
Radicular/root pain	1	1.2
CSF leak	1	1.2
Winged scapula	1	1.2
Implant related	6	7.4

SSI: Surgical site infection, RLN: Recurrent laryngeal nerve, CSF: Cerebrospinal fluid, ACDF: Anterior cervical discectomy and fusion

As reported in the literature, the C5/6 level is the most injured cervical spine segment as it forms the fulcrum of the subaxial neck movement.[11,25] Similar findings were noted in this study as 40.7% of SCSI involved in this segment. A study among asymptomatic individuals in our subregion showed that the C5/6 level has the least space available for the cord, and this may be responsible for the higher incidence of injury at this level following high-energy trauma.[15,16] In addition, our population seems to have a higher incidence of congenital cervical canal stenosis, a known risk factor for cervical myelopathy.[16]

Controversies exist on the optimal timing of surgery for SCSI.[2,9,13,24] Gupta *et al.*[7] showed that early surgery (within 48 h of injury) is associated with a lesser complication rate, early discharge, reduced mortality, and improved neurological outcome. Levi *et al.*[9] argued that there is no statistically significant difference in outcome in their study between early and late surgical intervention; however, early surgery allows for quicker rehabilitation and possibly reduces hospital costs. Furthermore, some authors seem to favor ultra-early intervention (within 12 hours of injury) in select

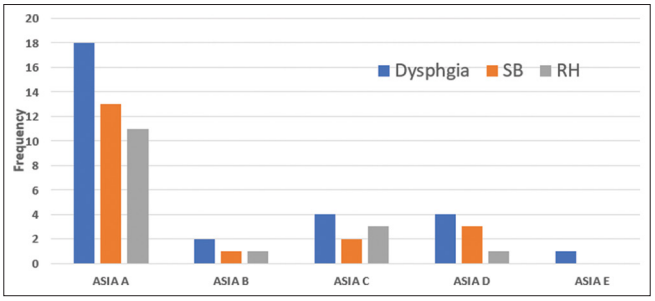

Figure 4: Comparing ASIA grade and incidence of complications (dysphagia, symptomatic bradycardia, and recurrent hypotension). Shows ASIA A injured patients had more SB, RH, and postoperative dysphagia (P < 0.001). ASIA: American Spinal Injury Association, SB: Symptomatic hypotension, RH: Recurrent hypotension.

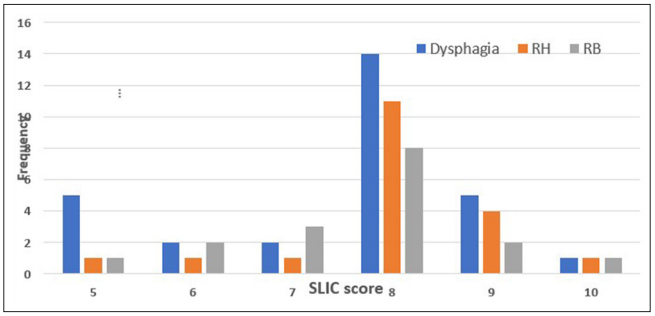

Figure 5: Comparing SLIC score and incidence of complications (postoperative dysphagia, symptomatic bradycardia, and recurrent hypotension). Shows a higher SLIC score ≥8, which was associated with more complications (P = 0.05). SLIC: Subaxial cervical spine injury classification system.

groups, as it halts secondary spinal cord injury and alleviates the effect of ongoing compressive injury from vertebral instability or extruded discoligamentous elements.[2,13]

Peculiarities of spinal cord injuries in sub-Saharan Africa make early intervention difficult. There is usually a delay in referral from primary care facilities to tertiary centers where manpower and facilities are available for surgical intervention. In addition, many patients present with severe spinal cord and systemic injuries that require extended resuscitative effort before surgery. It was found in this study that 71.6% of the patients presented after 48 h of SCSI, and 40.7% had an unstable cardiovascular system that required specialized care and intensive unit admission before surgical intervention. This explains why early surgery within 24 h was possible in only 12 patients. Furthermore, ASIA A injuries and high SLIC scores, a predominant pathologic grade seen in our series, were associated with a statistically significant higher incidence of symptomatic bradycardia and recurrent hypotension. This contrasts with reports from developed countries where coordinated response, swift transfer to trauma centers, and early presentation and surgical intervention are practiced.[2,13,23,24] A population-based cohort study in Canada by Wilson *et al*. found that 88.4% reached the site of definitive care within 6 h of injury, and 53.3% had surgery within 24 h.[23]

The incidence of dysphagia varies in literature and ranges from 1.7% to 67%[4,5,11,18]. Etiological factors differ and have been attributed to edema of the pharynx or esophagus occurring following difficult intubation and retraction injury or postoperative soft-tissue swelling. Other rare causes include recurrent laryngeal nerve injury, esophagal injury, pharyngeal plexus denervation, and hematoma formation.[20] They usually resolve in the early postoperative period and require no further intervention. However, prolonged or chronic dysphagia from scarring, adhesions, or implant-related complications requires further investigation and treatment.[4,11] In this study, dysphagia occurred in 35.8% of the patients. Nevertheless, most were transient and resolved in the immediate postoperative period. None of the patients had significant symptoms that required re-operation.

Recurrent laryngeal nerve injury characterized by voice change was seen in two patients; one had ACDF at C5/6 and the other at C6/7, and both improved remarkably on follow-up. Second surgery due to implant-related complications was done in 3.7% of our patients. This was mainly due to hardware malfunction or graft dislodgment following screw backout. The indication for repeat surgery was worsening neurology in two patients and debilitating neck pain in one. There was no report of adjacent segment diseases in our series, and may be related to the short duration of follow-up. Construct failure requiring re-do surgery has been reported in the literature with an incidence of 0.88–5%.[6,11,20] Surgeon-related factors, including suboptimal screw and graft placement with resultant screw backout and hardware malfunction secondary to manufacturer error, are common causes of implant failure. Patient factors contributing to implant failure include smoking, malnutrition, osteoporosis, implant-related infection, and systemic diseases.[4,11]

Neurological improvement of patients with ASIA A injury was poor in this study, as only 10.41% showed some minor gains in motor and sensory function; however, none were fully independent of follow-up. This is similarly reported in other studies as most ASIA A injuries result in permanent cord dysfunction with associated lifelong disability and need for assistance in activities of daily living.[17,24,25] Incomplete spinal injured patients had better outcomes with recovery rates between 66.7% and 100% in this study; however, only 63.6% were fully functional (ASIA E) at follow-up. We recorded a high mortality rate (8.6%) primarily resulting from respiratory complications following complete cord injury. This was similarly reported by a study in the central part of Nigeria [25], and other studies in the subregion have recorded an in-hospital mortality rate of up to 26%.[8,17,26] This is in sharp contrast to developed countries where low mortality rates are reported (0.1–2.3)[6,11] and is directly related to effective coordinated emergency medical services, availability of early intervention, especially in specialized trauma centers, and excellent rehabilitation services.

Nigeria's comprehensive medical insurance coverage rate is <5% and most healthcare bills are settled out of pocket.[3,21] This constitutes a major challenge in total spine care, which is overtly capital-intensive. Neuroimaging services, intensive care, and procuring spinal implants, pharmaceutical products, consumables, and rehabilitation costs are expensive. These costs are transferred directly to the family and caregiver, which may not be practicable in many cases considering the multidimensional poverty rate in Nigeria at 63%, and about four in ten live below the poverty line.[3,14] Some even resort to traditional healers for solace. The authors recommend urgently implementing a coordinated governmental policy to address these issues, including improving health insurance coverage, strategic health care planning, improved budgetary allocation to health, and training for healthcare providers.

More than half of the patients in our series (59.5%) had complete spinal cord injury. This unusual pattern of presentation seen in low-income countries could be attributed to the poor adherence to the use of protective devices, including the use of seatbelts by motorists, the paucity of on-the-scene interventions, and equipped ambulance services to convey injured spinal patients, thereby worsening the severity of the neurological deficit before arrival to the tertiary center.[10] As seen in this study, only 5% of patients had access to onsite emergency medical services, and most

Table 4: Test of significance with SLIC grade, level of injury, and ASIA grade.

Test statistics	SLIC grade	Level of injury	ASIA grade
Dysphagia			
Chi-square	23.759	12.207	33.241
Degree of freedom	5	4	4
P-value	0.000*	0.016*	0.000*
Symptomatic bradycardia			
Chi-square	11.000	3.105	19.526
Degree of freedom	5	3	3
P-value	0.050	0.376	0.000*
Recurrent hypotension			
Chi-square	9.875	2.500	17.000
Degree of freedom	2	3	3
P-value	0.007*	0.475	0.001*

*Significant ($P<0.05$), df: Degree of freedom, SLIC: Subaxial injury classification system, ASIA: American Spinal Injury Association

evacuation was done by nontrained personnel. These factors, coupled with delayed presentation, may have accounted for our series' high level of complete injuries. A preventive approach by the government and other stakeholders aimed at reorientating road users on speed control and the importance of the use of protective devices, improving the quality of road networks, setting up emergency medical services, and early transfers to level one care hospitals are essential to reduce the incidence of cervical spine injury and improve outcome in our subregion.

Rehabilitation is essential for cervical spine injury as it ensures optimal recovery of function and reintegration into society. It is long, expensive, and exhaustive, requiring a multidisciplinary team consisting of a physiotherapist, occupational therapist, social workers, and others as necessary.[12] In our setting, in-hospital rehabilitation services were routinely available; however, only one-third could sustain such services on discharge, which is related to unavailability in most rural areas and prohibitive cost. The education of the immediate family and caregivers is essential for optimal outcomes. A series of counseling sessions involving the patients and relatives with hospital-designated psychologists, physical therapists, and spiritual counselors were employed during the admission period and continued after discharge to enhance full physical and psychological reintegration into society. The psychosocial and economic challenges of SCSI are enormous, and without insurance support, the immediate family bears the cost. Government-run regional rehabilitation centers with pooled manpower and resources may offer solutions after hospital discharge, ensuring adequate physical therapy and psychological support.

CONCLUSION

ACDF for SCSI is associated with good outcomes in incomplete spinal cord injury. Except for the benefit of early stabilization and mobilization, neurological recovery was poor in ASIA A patients. Dysphagia was the most common complication in our series and was self-limiting in most patients. Challenges in management were related to poor emergency medical services, late presentation, low insurance coverage, and limited rehabilitation services. A multipronged approach involving intensive education of family members and caregivers, universal health insurance coverage, improved governmental budgetary allocation to health, and training for health care providers is urgently needed to ameliorate the burden of SCSI in our subregion.

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Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent.
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Conflicts of interest: There are no conflicts of interest.
Use of artificial intelligence (AI)-assisted technology for manuscript preparation: The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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