Journal of Spine Practice November 2024
DOI: 10.18502/jsp.v4i1.17060

JOURNAL of SPINE PRACTICE

Research Paper

Neurological Recovery Following Surgical Intervention in Patients with Traumatic Spinal Cord Injury at the University Teaching Hospital in Zambia

Munosiya Mulemwa BSc[1]*, Joseph Lupenga MSc[2], and Martha Banda-Chalwe PhD[1]

[1]Department of Physiotherapy, School of Health Sciences, University of Zambia, Lusaka, Zambia
[2]Department of Epidemiology and Biostatistics, School of Public Health, University of Zambia, Lusaka, Zambia

ORCID
Munosiya Mulemwa: https://orcid.org/0009-0000-9776-4493; Joseph Lupenga: https://orcid.org/0000-0002-8220-6920; Martha Banda-Chalwe: https://orcid.org/0009-0006-1599-8696

Introduction

Traumatic spinal cord injuries cause long-term disability and functional impairment. Timely and proper surgical treatment improves neurological recovery and functional outcomes. However, in low-resource setting countries, surgical intervention is usually delayed raising concerns about the recovery of patients. Hence, this study investigated the neurological improvement of patients undergoing surgery for traumatic spinal cord injuries at the University Teaching Hospital in Lusaka, Zambia.

Methods

This was a retrospective study that included all eligible patients with traumatic spinal cord injury managed surgically at the University Teaching Hospital between 2018 and 2022. The study assessed neurological improvement by comparing the American Spinal Injury Association's neurological grading before surgery to that at discharge. Data was analysed using Stata 17, and the level of significance was set at 5%.

Results

Out of the 96 patients in the study, 45.8% showed neurological improvement of at least one grade after surgery. Patients with thoracic injuries showed lower improvement rates (25.0%) than those with cervical (55.0%) or lumbar injuries (65.0%), while those with incomplete injuries showed higher improvement rates (78.7%) ($p < 0.05$). Thoracic injuries were associated with reduced neurological improvement (AOR 0.21; 95% CI: 0.04 – 0.95, $p = 0.043$), while incomplete injuries were associated with higher neurological improvement (AOR 18.58; 95% CI: 6.11 – 56.51, $p < 0.001$).

Conclusion

Neurological improvement was poor for thoracic injuries and complete injuries, highlighting the necessity for further investigation into the specific structural features and mechanisms of injury that contribute to poor neurological improvement in thoracic injuries and the identification of effective recovery approaches for these patients.

Keywords: *surgery, traumatic spinal cord injury, neurological improvement, surgical intervention, recovery rate, ASIA grade*

Correspondence

Munosiya Mulemwa BSc

Department of Physiotherapy, School of Health Sciences, University of Zambia, Lusaka, Zambia

Email: munosiyamulemwa@gmail.com

Article History
Received: September 3, 2024
Accepted: September 29, 2024
Published: December 6, 2024

How to cite this article: Mulemwa M, Lupenga J, and Banda-Chalwe M. Neurological Recovery Following Surgical Intervention in Patients with Traumatic Spinal Cord Injury at the University Teaching Hospital in Zambia. J Spine Pract 2024;4(1):1–12. **DOI**: https://doi.org/10.18502/jsp.v4i1.17060

KnE Publishing

1. Introduction

Traumatic spinal cord injuries (TSCI) have the potential to cause severe morbidity and permanent disability. Spinal cord injuries (SCI) are characterised by disruption of axons, nerve cell projections that transmit signals, resulting in impaired signalling between the brain and body below the level of injury, causing loss of motor and sensory function [1,2]. The two leading causes of SCI are falls and road traffic injuries [3,4]. In 2019, an estimated 20.6 million people worldwide were living with SCI [4]. This number highlights the widespread nature of the condition and the significant number of people affected. In addition, the annual incidence of SCI was approximately 0.9 million cases, indicating the continued occurrence of new injuries each year [3,4].

Although survival rates have improved, many people who survive SCI still suffer long-term disability and functional impairment [5]. SCI is responsible for an estimated 6.2 million years lived with disability (YLDs) [4]. This emphasizes the profound and long-lasting impact of this condition on individuals' lives. To alleviate the devastating effects of TSCI, surgery plays a crucial role in managing TSCI by preventing further neurological deterioration through decompression and reducing immobility-related complications through stabilization [6]. Studies examining surgical interventions for spinal cord injury suggest that timely and appropriate surgical treatment improves neurological recovery and functional outcomes in patients with complete and incomplete spinal cord injury [7,8]. A meta-analysis of 15 studies revealed that patients with complete cervical traumatic SCI experienced more frequent improvement after early surgery than late surgery, with 22.6% improvement after early surgery and 10.4% after late surgery, while those with incomplete cervical TSCI experienced similar improvement between early (30.4%) and late surgery (32.5%) [9]. Furthermore, studies suggest that neurological recovery after TSCI is significantly associated with various factors, including injury factors such as severity, level, and mechanism of injury [10,11], socio-demographic factors such as age [11,12], and the timing of surgery [13,14].

Although timely surgical interventions improve neurological recovery and overall outcomes, there is a significant disparity in the timing and availability of surgical intervention between high-income countries and low- and middle-income countries (LMICs) due to differences in healthcare resources and infrastructure between these settings. High-income countries tend to have patients undergo surgery earlier [15]. Delayed surgical interventions in LMICs can have profound implications for patient recovery and long-term outcomes. Therefore, studying neurological improvement in this setting is crucial to understanding improvement rates after surgery. As such, this study was conducted in an LMIC to investigate the neurological improvement of patients undergoing surgery for TSCI at the University Teaching Hospital in Lusaka, Zambia.

2. Methods

2.1. Study Design

A retrospective study design was used to investigate neurological improvement following surgical intervention in patients with TSCI who were managed at UTH between January 2018 and December 2022.

2.2. Study Site and Study Participants

This study was conducted at the orthopaedics unit of UTH. The hospital is located within the capital of Lusaka, and it is the biggest and main referral hospital in the country, offering health services at the tertiary level. The study analysed records of patients with TSCI managed surgically at UTH between January 2018 and December 2022. The study included all records of patients with TSCI who had complete pre-operation and post-operation neurological examinations according to the American Spinal Injury Association (ASIA) neurological grading (A – D). Exclusion criteria included patients with TSCI who had missing information on the checklist or those with a concomitant brain injury. A total of 96 files met the inclusion criteria and were included in the study.

2.3. Data Collection

Data were collected from the patient records of the orthopaedics unit. The medical records of all patients with SCI from 2018 to 2022 were reviewed to identify the patients who suffered from TSCI and underwent surgical intervention. Data extracted included demographic data, clinical data, surgical data, and pre-operative and discharge ASIA grading. Data were collected using a checklist based on the reviewed literature on factors associated with neurological recovery. The outcome variable was a neurological improvement, measured by an improvement of one or more ASIA grades, comparing the change in ASIA grade before surgery with that at discharge. Independent variables collected from the files included age, sex, preoperative ASIA classification, level of injury, type of injury, cause of injury, type of surgery, indications for surgery, and days to surgery. Self-checks were conducted during the data collection process to monitor how the data was documented and ensure its completeness and accuracy.

2.4. Data Analysis

Data were analysed using the STATA version 17.0 software. Descriptive statistics were used to summarise and describe all participant characteristics. Categorical variables were summarised as percentages and frequencies. Continuous variables were summarised using medians and interquartile ranges because the data did not meet the assumption of normality. The neurological recovery variable was divided into binary categories, where neurological improvement meant an improvement of one ASIA grade or more. In contrast, no improvement meant no change in ASIA grade after surgery. Wilcoxon rank-sum test, Fishers' Exact and Chi-Square test were used to test the association between variables.

In addition, univariate and multivariable logistic regression analysis was performed to assess the association between potential predictors and neurological recovery and reported odds ratios (ORs) with 95% confidence intervals (95% CIs). Because the sample size was small, the final multivariable model was built by including all variables with p value < 0.05 in the univariate analysis. The Hosmer-Lemeshow test was used to assess the goodness of fit of the final models. The level of statistical Significance was assumed at p value < 0.05 level.

2.5. Ethical Issues

All procedures were performed under the Declaration of Helsinki, relevant legislation, and institutional guidelines and were approved by ERES Converge IRB (REF: No. 2023-July-004). Confidentiality was maintained by not extracting patient personal information or identifiers from hospital record files.

3. Results

3.1. Demographic, Clinical and Surgical Characteristics

From 150 medical records identified between 2018 and 2022, 47 patients were excluded due to missing information and seven due to a preoperative ASIA grade of E. The study included 96 patients who underwent surgery between 2018 and 2022. The mean age for the participants was 35.3 ± 13.6 years, and most were males, 77 (80.2%). The main causes of injury were road traffic crashes 42 (43.8%), falls 32 (33.3%), and blunt trauma 20 (20.8%). Concerning the level of injury, 40 (41.6%) of the participants had sustained cervical injuries, 20 (20.8%) had sustained thoracic injuries, and 36 (37.5%) had sustained lumbar injuries. Most of the study participants had complete injuries, 49 (51.1%), and the majority were under ASIA grade A 49 (51.1%) before the operation. The median time to surgical intervention was 27 days (15 - 47.5 days). Most surgical procedures were posterior spinal procedures 55 (57.3%), followed by anterior spinal procedures 28 (29.2%) and decompression procedures 12 (12.5%). The common indications for surgery were fractures and dislocations 77 (80.2%) (Table **1**).

Table 1. Demographic, clinical and surgical characteristics of patients with TSCI at UTH from 2018 - 2022.

Demographics	**Frequency**	**Percentage**
Mean age ± standard deviation	35.3±13.6	
Sex		
Female	19	19.8
Male	77	80.2
Total	96	100.0
Cause of injury		
Assault	2	2.1
Fall	32	33.3
Motor vehicle accident	42	43.8
Blunt trauma	20	20.8
Total	96	100.0
Level of injury		
Cervical	40	41.7
Thoracic	20	20.8
Lumbar	36	37.5
Total	96	100.0
Type of injury		
Complete	49	51.0
Incomplete	47	49.0
Total	96	100.0
Pre-operation ASIA grade		
A	49	51.0
B	17	17.7
C	14	14.6
D	16	16.7
Total	96	100.0

Table 1. Continued.

Demographics	Frequency	Percentage
Median days to surgical intervention (IQR)	27.5 (15-47.5)	
Type of surgery done		
Anterior spinal procedures	28	29.2
Decompression procedures	12	12.5
Posterior spinal procedures	55	57.3
Laminoplasty	1	1.0
Total	96	100.0
Indications for surgery		
Compression	19	19.8
Fractures and dislocations	77	80.2
Total	96	100.0

IQR = interquartile range

Table **2** shows that the distribution of injury levels (cervical, lumbar, thoracic) varies significantly across different ASIA score categories (p = 0.028). Thoracic injuries had a higher proportion of patients (51.0%) with the most severe injuries (ASIA grade A). Cervical injuries had a higher proportion of ASIA grade B and C categories. For ASIA grade D, the distribution was more even between cervical and lumbar injuries.

Table 2. Preoperative ASIA grade stratified by level of injuries among patients with TSCI at UTH from 2018 - 2022.

Preoperative ASIA score	Cervical	Lumbar	Thoracic	Total	Fishers' Exact
A	16 (32.6)	8 (16.3)	25 (51.0)	49 (100)	p = 0.028
B	9 (52.9)	2 (11.8)	6 (35.3)	17 (100)	
C	9 (64.3)	4 (28.6)	1 (7.1)	14 (100)	
D	6 (37.5)	6 (37.5)	4 (25.0)	16 (100)	

3.2. Neurological Improvement

Of the 96 patients, 44 (45.8%) showed improvement in neurological function after surgery (Table **3**), of which 38 (39.6%) improved by one grade, 4 (4.2%) by two grades, and 2 (2.2%) by three grades (Figure **1**).

3.3. Neurological Improvement by Demographic, Clinical and Surgical Factors

Median age was significantly higher in patients who improved (40.5 [26 – 48.5] years) compared to those who did not improve (32 [22 – 38] years) (p = 0.0133). Patients with thoracic injuries (25.0%) had a lower rate of improvement than patients with cervical (55.0%) or lumbar injuries (65.0%) (p = 0.005). Patients with incomplete injuries had a significantly higher rate of improvement compared to those with complete injuries (78.7% vs 14.3%) (p <0.001). In addition, patients with less severe spinal cord injuries, as indicated by lower ASIA scores, showed higher improvement in neurological function compared to those with more severe injuries (p <0.001). Factors such as sex, cause of injury, days before surgery, type of surgery, and indications for surgery did not show significant associations with neurological recovery (Table **3**).

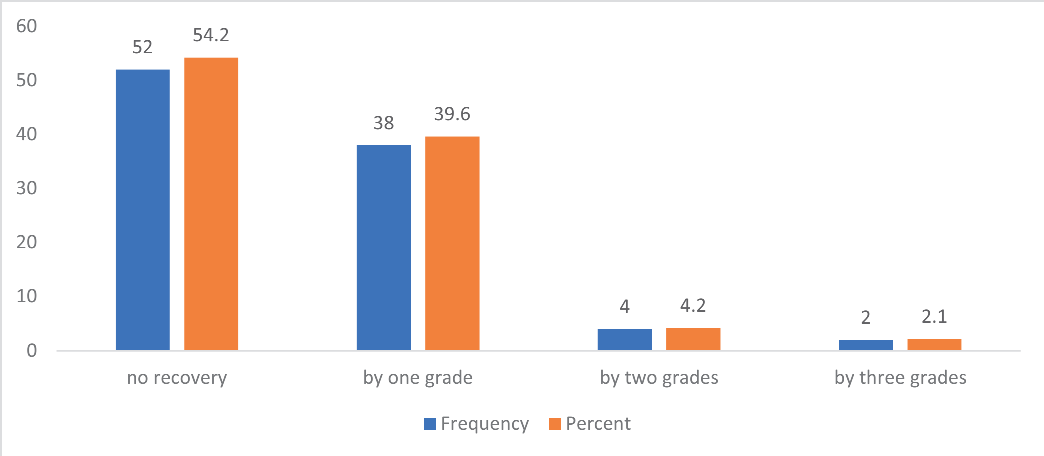

Figure 1. Extent of neurological improvement among patients with TSCI at UTH from 2018 - 2022.

Table 3. Neurological improvement after surgery stratified by demographic, clinical and surgical factors.

	Neurological functional recovery			
Variables	**No improvement**	**Improved**	**Total**	**p-value**
Prevalence of recovery	52 (54.2%)	44 (45.8%)	96 (100%)	
Median Age in Years (IQR)	32 (22 – 38)	40.5 (26 – 48.5)		**0.0133**[a]
Sex				
Female	11 (57.9%)	8 (42.1%)	19 (100%)	0.716[b]
Male	41 (53.2%)	36 (46.8%)	77 (100%)	
Cause of injury				
Assault	3 (100%)	0 (0%)	3 (100%)	0.563[b]
Fall	18 (56.3%)	14 (43.8%)	32 (100%)	
Motor vehicle accident	21 (50.0%)	21 (50.0%)	42 (100%)	
Blunt trauma	11 (55.0%)	9 (45.0%)	20 (100%)	
Level of injury				
Cervical	18 (45.0%)	22 (55.0%)	40 (100%)	**0.005**[b]
Thoracic	27 (75.0%)	9 (25.0%)	36 (100%)	
Lumbar	7 (35.0%)	13 (65.0%)	36 (100%)	
Type of injury				
Complete	42 (85.7%)	7 (14.3%)	49 (100%)	**<0.001**[b]
Incomplete	10 (21.3%)	37 (78.7%)	47 (100%)	
Pre-operation ASIA grade				
A	42 (85.7%)	7 (14.3%)	49 (100%)	**<0.001**[b]
B	6 (35.3%)	11 (64.7%)	17 (100%)	
C	2 (14.3%)	12 (85.7%)	14 (100%)	
D	2 (12.5%)	14 (87.5%)	16 (100%)	
Median time to surgical intervention (IQR)	32 (16.5 – 65)	23.5 (12.5 – 44.5)		0.251[a]
Type of surgery				
Anterior spinal procedures	14 (50.0%)	14 (50.0%)	28 (100%)	0.189[b]
Decompression procedures	4 (33.3%)	8 (66.7%)	12 (100%)	
Posterior spinal procedures	34 (61.8%)	21 (38.18%)	55 (100%)	
Laminoplasty	0 (0%)	1 (100%)	1 (100%)	

Table 3. Continued.

	Neurological functional recovery			
Variables	**No improvement**	**Improved**	**Total**	**p-value**
Indications for surgery				
Compression	7 (36.8%)	12 (63.2%)	19 (100%)	0.091[b]
Fractures and dislocations	45 (58.4%)	32 (41.6%)	77 (100%)	

IQR = interquartile range
[a] = Wilcoxon rank-sum test
[b] = Chi-Square test

3.4. Factors Associated with Neurological Improvement

In the univariate model, neurological improvement was associated with thoracic level of injury, incomplete injuries and age ($p < 0.05$). In the multivariable regression model, patients with thoracic injuries were 0.21 times less likely to improve neurologically after surgery than those with lumbar injuries (aOR 0.21; 95% CI: 0.04 – 0.95, p = 0.043). Furthermore, patients with incomplete injuries were 18.58 times more likely to experience neurological improvement than those with complete injuries (aOR 18.58; 95% CI: 6.11 – 56.51, p = < 0.001) (Table **4**).

Table 4. Analysis of factors associated with neurological improvement after surgery on patients with TSCI at UTH.

Variables	**cOR (95% CI)**	**P value**	**aOR (95% CI)**	**P value**
Age	1.03 (1.00 – 1.07)	0.016*	1.02 (0.98 – 1.07)	0.307
Sex				
Female	Ref			
Male	1.21 (0.44- 3.33)	0.716		
Cause of injury				
Blunt trauma	Ref			
Fall	0.95 (0.31- 2.93)	0.930		
Motor vehicle accident	1.22 (0.42- 3.56)	0.713		
Level of injury				
Lumbar	Ref		Ref	
Cervical	0.66 (0.22 – 2.00)	0.460	0.41 (0.09 – 1.86)	0.250
Thoracic	0.18 (0.05 – 0.59)	0.005*	0.21 (0.04 – 0.95)	0.043*
Type of injury				
Complete	Ref		Ref	
Incomplete	22.2 (7.67-64.22)	<0.001*	18.58 (6.11 – 56.51)	<0.001*
Period from injury to surgery	1.00 (0.99 – 1.01)	0.550		
Type of surgery done				
Anterior spinal procedures	Ref			
Decompression procedures	2 (0.49- 8.20)	0.335		
Posterior spinal procedures	0.62 (0.25- 1.55)	0.304		
Indications for surgery				
Compression	Ref			
Fractures and dislocations	0.41 (0.15- 1.17)	0.096		

cOR = Crude Odds Ratio
aOR = Adjusted Odds Ratio
CI = Confidence Level
* Significant at p < 0.05

4. Discussion

This study evaluated neurological improvement after surgery in patients with TSCI. Neurological improvement of at least one grade or more was observed in 45.8% of patients. Older age, less severe spinal cord injuries, and incomplete injuries showed greater neurological improvement, while thoracic injuries had a lower rate of improvement. Thoracic injuries were associated with a lower risk of neurological improvement, whereas incomplete injuries were associated with a higher risk of neurological improvement.

The study showed that road traffic crashes and falls significantly contributed to TSCI. This finding is supported by literature reporting that road traffic accidents and falls are the two main causes of SCI [3,4,16]. Focusing on preventing falls and traffic accidents could play a significant role in reducing the incidence and burden of TSCI. Even more worrying is the high number of patients with complete spinal cord injury, which is comparable to a previous study [16]. This raises concerns for patients' well-being and their quality of life, as complete injuries are associated with poor neurological recovery [11]. Therefore, the causes of TSCI need to be addressed to reduce the burden of TSCI.

In this study, 45.8% showed neurological improvement after surgery, with most showing a one-grade improvement. A similar rate of neurological improvement after surgery has been reported in previous studies from Pakistan (45%) [16], and Korea (46.5%) [17]. In contrast, significantly lower rates were reported in studies from Togo (15.3%) [18] and Tanzania (17%) [19]. The reasons for the differences in rates between studies are unknown but could be due to methodological differences and the extent of injuries. Additionally, most of the improvement occurred by one grade, confirming previous results [16]. Most patients showed no improvement or only one-grade improvement, probably due to the shorter follow-up (preoperative to discharge). A systematic review and meta-analysis suggested that shorter follow-up periods had significantly lower recovery rates for spinal cord injuries compared to long-term follow-up [10]. With this in mind, there is a possibility that the rate of improvement could improve over time.

Factors associated with improved neurological recovery included the level and type of injury. Less severe spinal cord injuries (ASIA grade D) showed greater neurological improvement compared to patients with more severe injuries (ASIA grade A), which supports previous studies [12,17]. In addition, the rate of neurological improvement varied depending on the type of injury, with the rate being higher for incomplete injuries than for complete injuries, supporting findings from previous studies [17]. Supporting existing literature, the study revealed that incomplete spinal cord injuries are more likely to experience neurological improvement than complete injuries [11]. This highlights the need for targeted research to optimize recovery from complete injuries.

Patients with lumbar injuries showed the highest improvement in ASIA grade, while thoracic injuries had a lower rate of improvement. In addition, thoracic injuries were less likely to improve neurologically after surgery than those with lumbar injuries. In a similar study, lumbar spine injuries were associated with a higher likelihood of neurological improvement than cervical spine injuries [17]. These findings align with existing literature indicating that the level of injury is a key predictor of recovery in TSCI [9–11]. [10] reported that recovery rates typically follow this pattern: lumbar injuries have the highest recovery rates, followed by cervical and thoracolumbar injuries, with thoracic injuries having the lowest recovery rates. Some authors attribute the low rate of recovery in thoracic spinal cord injuries to the reduced collateral vascular supply to the thoracic cord and the narrowness of the spinal canal compared with the cervical and lumbar regions [11]. Our findings could also provide insight into the poor recovery seen in patients with thoracic spinal cord injuries. The study revealed that thoracic injuries were associated with the most severe injury classification, ASIA grade A, which is known to be associated with poor neurological improvement. The poor neurological improvement associated with thoracic injuries could also indicate that traumatic impacts in the thoracic region tend to result in more severe injuries compared to the other spinal regions. However, further research is needed to learn more about the poor recovery and severe injuries associated with thoracic injuries.

Although age was significantly higher in patients who improved compared to those who did not, age was not found to be a significant predictor of neurological improvement after surgery. This confirms previous studies in which age was not a predictor of neurological improvement [16,19]. However, these results are in contrast to a previous study that showed greater neurological improvement was associated with younger age [12]. The difference in results can be attributed to several factors. Our study generally had younger participants (mean age 35.3±13.6 years) compared to the other study, whose mean age was 57.8±21.3 years, and also, the other study had a longer follow-up period than this study.

It has been suggested that early surgery is associated with better neurological improvement than late surgery [14,20]. However, no association was observed in this study, probably because most surgeries were performed late. The median time to surgery of 27 days suggests a relatively delayed surgical procedure and highlights the need to critically evaluate current practices and find ways to shorten the time to surgery. Reducing the time to surgery is critical considering that the literature suggests that early surgical intervention is an important factor in improving neurological recovery in patients with TSCI [13,14]. A similar median time to surgery (22 - 23 days) was reported in studies from Tanzania [19,21], but also a shorter average time to surgery of 3.6 ± 1.8 days was reported in Pakistan [16]. Some modifiable factors that contribute to delayed surgery include the time to transfer from the site of injury to the spinal cord injury ward, the time from medical assessment to completion of the surgical plan, and the time from completion of the surgical plan until the start of operations [22]. Difficulty accessing surgical implants and delays in transporting the patient to the referral hospital for surgery have also been cited as factors [23]. However, further studies are needed to better understand the factors contributing to the delays and to find ways to prevent them.

The study had limitations: Since the study was retrospective, some files may have been missing, which would have affected the number of patients with TSCI who underwent surgery. The sample size was small as the study was limited to five years due to difficulty identifying files before 2018. Furthermore, neurological evaluations were performed only using ASIA scores at discharge; hence, longer follow-up periods could report higher recovery rates. The study did not capture information about postoperative complications, which could also influence neurological improvement.

5. Conclusion

The study analysed neurological improvement in patients with traumatic spinal cord injuries. Neurological improvement was observed in 45.8% of the patients with TSCI, with the majority improving by one grade. Patients with less severe and incomplete injuries showed better improvement. The study revealed that thoracic injuries were associated with severe injury classifications, which are known for poor recovery. Further investigation into the specific structural features and injury mechanisms contributing to poor neurological improvement in thoracic injuries and the identification of effective recovery strategies for these patients. In addition, the delay in performing surgical procedures needs to be investigated and addressed to maximise patient recovery, as early surgery is associated with better recovery than delayed one.

Competing Interests

The authors declare that there is no conflict of interest.

Source of Funding

The study did not receive any funding.

Acknowledgement

The authors extend their gratitude to UTH Adult Hospital management for granting us permission to conduct the study at their facility.

Author Contribution

MM was involved in the conception and design of the study, data collection, data analysis and interpretation, drafting of the manuscript and critical revision of the manuscript. JL participated in the conception and design of the study, data analysis and interpretation, drafting the manuscript, critical revision of the manuscript. MBC were involved in the conception, design of the study and critical revision of the manuscript. All authors approved the final manuscript.

Data Availability Statement

The data underlying this article will be shared at a reasonable request by the corresponding author [MM].

References

[1] Patek M, Stewart M. Spinal cord injury. Anaesthesia & Intensive Care Medicine [Internet]. 2023 Jul 1;24(7):406–11. Available from: https://www.sciencedirect.com/science/article/pii/S1472029923000784

[2] Bennett J, Das JM, Emmady PD. Spinal Cord Injuries [Internet]. StatPearls Publishing; 2022 [cited 2024 Apr 23]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK560721/

[3] Ding W, Hu S, Wang P, Kang H, Peng R, Dong Y, et al. Spinal Cord Injury: The Global Incidence, Prevalence, and Disability From the Global Burden of Disease Study 2019. Spine [Internet]. 2022 Nov 1;47(21):1532–40. Available from: http://dx.doi.org/10.1097/BRS.0000000000004417

[4] GBD Spinal Cord Injuries Collaborators. Global, regional, and national burden of spinal cord injury, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol [Internet]. 2023 Nov;22(11):1026–47. Available from: http://dx.doi.org/10.1016/S1474-4422(23)00287-9

[5] Liu Y, Yang X, He Z, Li J, Li Y, Wu Y, et al. Spinal cord injury: global burden from 1990 to 2019 and projections up to 2030 using Bayesian age-period-cohort analysis. Front Neurol [Internet]. 2023 Dec 5;14:1304153. Available from: http://dx.doi.org/10.3389/fneur.2023.1304153

[6] Sandean D. Management of acute spinal cord injury: A summary of the evidence pertaining to the acute management, operative and non-operative management. World J Orthop [Internet]. 2020 Dec 18;11(12):573–83. Available from: http://dx.doi.org/10.5312/wjo.v11.i12.573

[7] Bourassa-Moreau É, Mac-Thiong JM, Li A, Ehrmann Feldman D, Gagnon DH, Thompson C, et al. Do Patients with Complete Spinal Cord Injury Benefit from Early Surgical Decompression? Analysis of Neurological Improvement in a Prospective Cohort Study. J Neurotrauma [Internet]. 2016 Feb 1;33(3):301–6. Available from: http://dx.doi.org/10.1089/neu.2015.

3957

[8] Sharif S, Jazaib Ali MY. Outcome Prediction in Spinal Cord Injury: Myth or Reality. World Neurosurg [Internet]. 2020 Aug;140:574–90. Available from: http://dx.doi.org/10.1016/j.wneu.2020.05.043

[9] Ter Wengel PV, De Witt Hamer PC, Pauptit JC, van der Gaag NA, Oner FC, Vandertop WP. Early Surgical Decompression Improves Neurological Outcome after Complete Traumatic Cervical Spinal Cord Injury: A Meta-Analysis. J Neurotrauma [Internet]. 2019 Mar 19;36(6):835–44. Available from: http://dx.doi.org/10.1089/neu.2018.5974

[10] Khorasanizadeh M, Yousefifard M, Eskian M, Lu Y, Chalangari M, Harrop JS, et al. Neurological recovery following traumatic spinal cord injury: a systematic review and meta-analysis. J Neurosurg Spine [Internet]. 2019 Feb 15;1–17. Available from: http://dx.doi.org/10.3171/2018.10.SPINE18802

[11] Kirshblum S, Snider B, Eren F, Guest J. Characterizing Natural Recovery after Traumatic Spinal Cord Injury. J Neurotrauma [Internet]. 2021 May 1;38(9):1267–84. Available from: http://dx.doi.org/10.1089/neu.2020.7473

[12] Nasi D, Ruscelli P, Gladi M, Mancini F, Iacoangeli M, Dobran M. Ultra-early surgery in complete cervical spinal cord injury improves neurological recovery: A single-center retrospective study. Surg Neurol Int [Internet]. 2019 Oct 18;10:207. Available from: http://dx.doi.org/10.25259/SNI_485_2019

[13] Qiu Y, Chen Y, Xie Y, Xie H, Dong J. Comparative analysis of the efficacy of early and late surgical intervention for acute spinal cord injury: A systematic review and meta-analysis based on 16 studies. Int J Surg [Internet]. 2021 Oct;94:106098. Available from: http://dx.doi.org/10.1016/j.ijsu.2021.106098

[14] Hsieh YL, Tay J, Hsu SH, Chen WT, Fang YD, Liew CQ, et al. Early versus Late Surgical Decompression for Traumatic Spinal Cord Injury on Neurological Recovery: A Systematic Review and Meta-Analysis. J Neurotrauma [Internet]. 2021 Nov 1;38(21):2927–36. Available from: http://dx.doi.org/10.1089/neu.2021.0102

[15] Chanbour H, Chen JW, Ehtesham SA, Ivey C, Pandey AK, Dewan MC, et al. Time to Surgery in Spinal Trauma: A Meta-Analysis of the World's Literature Comparing High-Income Countries to Low-Middle Income Countries. World Neurosurg [Internet]. 2022 Nov;167:e268–82. Available from: http://dx.doi.org/10.1016/j.wneu.2022.07.140

[16] Razaq MNU, Ali B, Khan MZ, Waqar M, Satar A, Khan MA. Neurological Recovery In Traumatic Spinal Cord Injuries After Surgical Intervention. J Ayub Med Coll Abbottabad [Internet]. 2018 Jan-Mar;30(1):58–63. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29504331

[17] Kim M, Hong SK, Jeon SR, Roh SW, Lee S. Early (≤48 Hours) versus Late (>48 Hours) Surgery in Spinal Cord Injury: Treatment Outcomes and Risk Factors for Spinal Cord Injury. World Neurosurg [Internet]. 2018 Oct;118:e513–25. Available from: http://dx.doi.org/10.1016/j.wneu.2018.06.225

[18] Doleagbenou AK, Djoubairou BO, Ahanogbe MKH, Egu K, Beketi AK, Kpelao E, et al. Surgical Management of Traumatic Spinal Injuries in Sylvanus Olympio Teaching Hospital. Anesthesia & Clinical Research [Internet]. 2022 Aug 17 [cited 2024 May 26];13(8):1–6. Available from: https://www.mongoliancardiology.org/abstract/jacr/surgical-management-of-traumatic-spinal- injuries-in-sylvanus-olympiornteaching-hospital-94370.html

[19] Magogo J, Lazaro A, Mango M, Zuckerman SL, Leidinger A, Msuya S, et al. Operative Treatment of Traumatic Spinal Injuries in Tanzania: Surgical Management, Neurologic Outcomes, and Time to Surgery. Global Spine J [Internet]. 2021 Jan;11(1):89–98. Available from: http://dx.doi.org/10.1177/2192568219894956

[20] Haghnegahdar A, Behjat R, Saadat S, Badhiwala J, Farrokhi MR, Niakan A, et al. A Randomized Controlled Trial of Early versus Late Surgical Decompression for Thoracic and Thoracolumbar Spinal Cord Injury in 73 Patients. Neurotrauma Rep [Internet]. 2020 Sep 18;1(1):78–87. Available from: http://dx.doi.org/10.1089/neur.2020.0027

[21] Leidinger A, Zuckerman SL, Feng Y, He Y, Chen X, Cheserem B, et al. Predictors of spinal trauma care

and outcomes in a resource-constrained environment: a decision tree analysis of spinal trauma surgery and outcomes in Tanzania. J Neurosurg Spine [Internet]. 2023 Apr 1;38(4):503–11. Available from: http://dx.doi.org/10.3171/2022.11.SPINE22763

[22] Thompson C, Feldman DE, Mac-Thiong JM. Surgical management of patients following traumatic spinal cord injury: Identifying barriers to early surgery in a specialized spinal cord injury center. J Spinal Cord Med [Internet]. 2018 Mar;41(2):142–8. Available from: http://dx.doi.org/10.1080/10790268.2016.1165448

[23] Teles AR, Ramos MB, Righesso O, Falavigna A. Surgical timing in traumatic spinal cord injury: current practice and obstacles to early surgery in Latin America. Spinal Cord [Internet]. 2022 Apr;60(4):368–74. Available from: http://dx.doi.org/10.1038/s41393-022-00789-8