Acta Biomedica Scientia

e - ISSN - 2348 - 2168
Print ISSN - 2348 - 215X

www.mcmed.us/journal/abs

Research Article

A RETROSPECTIVE COHORT ANALYSIS OF THE COST OF INPATIENT REHABILITATION AFTER SPINAL INJURY

Veluru Srinivasulu[1]*, Nagaraju M[2]

[1]Associate Professor, General Surgery, Indira medical college and hospitals, Chennai, Tamil Nadu, India.
[2]Associate Professor, General Surgery, Sri lakshminarayana Institute of medical sciences, Pondicherry, India.

ABSTRACT

A spinal cord injury (SCI) leads to a lifetime high direct and indirect cost that increases with severity. Although acute rehabilitation has the potential to significantly improve function, its cost has yet to be evaluated despite its potential to improve function. The direct costs associated with rehabilitation after spine injury were analyzed using a proprietary hospital database. Using a retrospective cohort method at a single center, we examined the costs associated with patients with acute, traumatic spine injuries treated at a tertiary facility from 2011 to 2017. According to the American Spinal Injury Association, for each patient (mean age 46.1/18.6 years, 76.3% males) who were identified, their impairment scores on admission were 32.1% A, 14.7% B, 14.7% C, 33.2% D, and 1.1% E. 179 patients (94%) received surgical treatment. The cervical spine suffered the greatest number of injuries (53.2%). After acute rehabilitation, functional impairment scores improved by 30.7, or 16.2. The cost of services included 86.5% for facilities, 9.2% for pharmacies, 2.0% for supplies, 1.5% for laboratories, and 0.8% for imaging. The cost of rehabilitation was unaffected by the level of injury, the severity of the injury, and prior inpatient surgical treatment. Based on a univariate analysis, a higher degree of injury severity ($p = 0.0001$, one-way ANOVA) and a higher level of injury in the spinal column ($p = 0.001$, one-way ANOVA) was associated with a longer rehabilitation stay. Nevertheless, length of rehabilitation stay was the most significant independent predictor of higher-than-median costs after taking into account other factors (risk ratio = 1.56, 95% CI 1.22-2.0, $p = 0.001$). Despite high upfront costs for spine injuries, rehabilitation substantially affects the cost of care. Reduced costs may be achieved by improving the effectiveness of rehabilitation.

Keywords :- Traumatic Spine Injury, Value-Driven Outcome, Spinal Cord Injury, Cost.

Access this article online	
Home Page: www.mcmed.us/journal/abs	**Quick Response code**

Received:**25.01.2021**	**Revised**:12.02.2021	**Accepted**:15.02.2021

INTRODUCTION

Three to six percent of all skeletal fractures involve a fracture of the vertebrae, while 54 cases of acute spinal cord injury (SCI) occur in every million U.S. residents. The overall in-hospital mortality rate for SCI approaches eight percent. Intensive acute rehabilitation is typically required and beneficial for SCI patients after initial stabilization and treatment. Based on age and injury level, each Veteran Healthcare Administration patient with spinal cord injury faces a lifetime health care cost between $1.1 million and $5.4 million [3].

Rehabilitating patients with spinal cord injuries and spinal cord damage inpatient is time- and resource-consuming. To achieve the best rehabilitation outcomes, it is imperative that teams of physiatrists, physical therapists, occupational therapists, and other medical professionals are well-trained and highly specialized [2]. In addition to traumatic brain injuries, polytrauma, and medical comorbidity, many patients have co-occurring conditions, which are associated with worse rehabilitation outcomes [4]. As well as the level and length of therapy, costs can be affected by the treatment intensity. Among Canadian research subjects with traumatic spinal cord injuries, rehabilitation costs accounted for the largest portion of overall health care costs (5).

Corresponding Author**: Veluru Srinivasulu**

There have been no previous studies on the true hospital-level costs associated with acute inpatient rehabilitation for patients with spinal cord injuries, including the breakdown of the costs for different SCI severity levels. Studying the direct costs of rehabilitation after spinal injury was the purpose of this study.

MATERIALS AND METHODS

Patient inclusion

We conducted a cross-sectional analysis of patients treated at the Department of Physical Medicine and Rehabilitation at our institution from January 2011 to December 2017 without obtaining informed consent from an internal database after receiving approval from the Institutional Review Board. All patients who were *18 years old or older, were in rehabilitation for chronic spinal cord injury, were being treated for a nontraumatic mechanism, or did not have complete clinical, radiographic, and cost data were excluded. We reviewed patient charts manually to ensure eligibility and to gather demographic, clinical, and surgical information. Subtotal costs were derived from a cross-referencing of patient records across a database of institutional costs.

Surgical procedures

There was a wide variety of spinal surgeries performed at our institution and at an outside hospital. In contrast, we consider those patients directly admitted to our institution as admitted patients while those referred to us after initial evaluation or surgical stabilization were considered transferred patients.

Analysis

Patients' age and gender were included in the demographic data. The American Society of Anesthesiologists (ASA) physical status system was used to determine the patient's status prior to surgery. These clinical records reveal the injury severity (AIS) score and injury level based on the American Spinal Injury Association (ASIA). From records of admissions and discharges, we derived the Functional Independence Measure (FIM). In addition, the length of stay (LOS) and discharge disposition were recorded.

As opposed to patient/insurer charges, the institutional database reports direct costs. An analysis of total and subcategory costs, as well as costs associated with imaging, supplies, implants, laboratories, and facilities, was completed. Doctor's fees were not accounted for. In addition to salaries for nonphysician healthcare staff, facility costs cover the costs of electricity, water, and hospital administration. The University does not disclose the actual dollar amounts. The percentages of total numbers are reported. As an alternative to presenting actual cost data, the mean percent of total cost was calculated. In order to calculate the fraction of patient contribution to the total cost, the costs for the entirety of the cohort of patients were totaled. This allows us to compare medians and standard deviations, patient totals, and subgroup costs. Not all costs are equal. Subgroup cost contribution was calculated by dividing the total by the sum of each patient's subgroup costs. The percentages are 100 percent in this context. The continuous variables were analyzed using a t-test to determine the means and standard deviations. A Chi-square test was used for noncontinuous variables. For the comparison of continuous variables, we used linear correlation, whereas for the comparison of multiple continuous variables we used a one-way analysis of variance with a Tukey post-hoc comparison. Factors associated with potentially higher costs than the median total cost were correlated using multivariate logistic regression. The multivariable analysis included variables in which the univariable analysis had a $p > 0.02$. Using the likelihood ratio (RR), we estimated the cost of patient rehabilitation based on clinical factors, injury severity, and level of injury. Statistics were analyzed using SPSS V20.0 (IBM Corp., Armonk, NY) with a significance level of p * 0.05.

RESULTS

190 patients were analyzed between 2011 and 2017. This table lists the demographics and characteristics of our patients. Our patients had 32.1% A/B/C/D/E AIS on admission, 13.0% Q/V AIS, and 33.2% D/V AIS. Ninety-four percent of patients received surgical treatment at our institution. It is estimated that 54.2% of all spinal cord injury cases occur in cervical spines, followed by 23.7% in thoracic spines and 15.3% in lumbar spines. In most cases, males (76.3%) were the patients. When comparing FIM scores at discharge and at admission with those at discharge, the functional status for the whole SCI cohort improved significantly.

Costs associated with rehabilitation facilities make up ninety percent of overall rehabilitation costs, followed by pharmacy costs (nine percent), and supplies, imaging, and laboratories make up the remaining ten percent. The cost of managing a facility also includes costs incurred for therapy and nursing.

Table 1: 190 spinal-cord-injured patients by demographics
FIM: Functional Independence Measure. ASIA refers to the American Spinal Injury Association.

Variable	Quantity
Years (*STD), Mean	46.1 ± 18.6

Gender (%), male	145 (76.3%)
Level of injury	
The neck	103 (54.2%)
The chest	45 (23.7%)
Pelvis	29 (15.3%)
Sacrum	2 (1.1%)
Cauda equina	9 (4.7%)
Not known	2 (1.1%)
Surgery (%)	
Nonexistent	9 (4.8%)
Higher education	127 (66.8%)
Others	52 (27.4%)
unidentified	2 (1.1%)
Patients admitted more than once	15 (7.9%)
Days to complete rehab after injury (*STD),	17.9 ± 42.4
(*STD) Average day-count from injury to surgery	1.8 ± 4.0
The average stay for rehabilitation (*STD), per day	32.9 ± 23.1
The average number of follow-up visits (*STD), per day	24.2 ± 25.6
The ASI score	
A	61 (32.1%)
B	28 (14.7%)
C	28 (14.7%)
D	63 (33.2%)
E	2 (1.1%)
None	8 (4.2%)
Average FIM score (±STD)	
During admission	56.2 ± 18.7
AFTER DISEASE	86.9 ± 25.6
DECLINE	30.7 ± 16.2
Disposition after rehabilitation (%)	
Hospitalization	4 (2.1%)
Others	16 (8.4%)
Household	60 (31.6%)
Assisted living	36 (18.9%)
Long-term care facilities	24 (12.6%)
None	50 (26.3%)

Table 2: 190 patients with spinal injuries underwent surgery
This procedure involves removing and fusing the anterior cervical disc

Surgery type	Case count
103 (54.2%) in cervical surgeries	
including two-level ACDF	18
fusion at two levels	8
bilateral ACDF and bilateral posterior fusions	2
with four-level posterior fusions	1
ACDF at three levels	9
Posterior 3 levels	13
2-level posterior fusion and 3-level ACDF	1
3 levels of ACDF, 3 levels of posterior fusion	2
ACDF with 3 levels and 5 levels of posterior fusion	1
3 level ACDF with 6 level posterior fusion	1
quadruple ACDF	2
quadruple posterior fusion	1
fusion of four levels	7
ACDF 5	1
Fusion of the 5 levels	9
posterior levels	9
fused at 7 levels	1
fusion at 8 levels	2
level 9 posterior fusion	1
Decompression only	7
removal of fragments	1
surgery not necessary	4
undetermined	2
chest (23.7%), 45	
fusions at 2 levels	1
anterior 3 level and 7 level posterior	1
fusion of 3 levels	11
fusion of four levels	2
fusion of five levels	9
fusion of six levels	8
fusion of seven levels	4
fusion of nine levels	1
fusion of 10 levels	2
decompression only	2
surgery not required	2

Decompression and vertebroplasty	1
unspecified	1
lower back, n = 29 (15.3%)	
fused at two levels	1
fusion at 3 levels	9
fused at 4 levels	4
fusions at 5 levels	6
post-fusions at 7 levels	1
without decompression	3
Surgery is not necessary	1
vertoplasty	1
unidentified	3
cranial (1,1%)	
fixation in the sacrum	1
surgery not required	1
Cauda equina, nine (5%)	
fusions at 3 levels	1
fused at 3 levels	2
posteriorly fused at 4 levels	1
posteriorly fused at 5 levels	2
posteriorly fused at 7 levels	1
compression	1
surgery not necessary	1
Unknown, n = 2 (1.1%)	

Table 3: Rehabilitation costs for spinal cord injuries
FIM: Functional Independence Measure; ASI: American Spinal Injury Association.

	Multivariate			Statistics		
Multiple	Probability Ratio	95% CI	Probability	Probability	95% CI	Probability
Result	0.999	0.981, 1.17	0.9			
Gender						
Women	1.16	0.54, 2.48	0.7			
Men	Reference					
Level of Injuries						
Cervix	3.26	0.56, 19.02	0.2	16.2	0, -	0.8
Chest	2.34	0.36, 13.78	0.4	3.0	0, -	0.9
Lumb	0.38	0.05, 3.06	0.4	1.4	0, -	0.98
Sacramento	-	-	-	-	-	-
Cauda equina	referent			referent		

undergoing surgery						
Not applicable	Referral					
Hospital Tertiary	0.31	0.06, 1.69	0.2			
Facility other	0.57	0.1, 3.24	0.5			
Rehab admissions multiple	0.82	0.24, 2.82	0.8			
Injured to rehabilitated	0.998	0.99, 1.005	0.6			
Surgery time after injury	0.97	0.89, 1.07	0.6			
Duration of rehabilitation	1.44	1.2, 1.7	0.0001	1.56	1.21, 2.0	0.001
Score of impairment assessed by SIA						
A	3.00	0.46, 19.8	0.3	-	-	1.0
B	12.75	1.26, 128.78	0.03	-	-	1.0
C	2.33	0.32, 16.82	0.4	-	-	1.0
D	0.19	0.03, 1.45	0.1	-	-	1.0
E	Reference	-	-	Reference		
changes in the FIM	0.99	0.98, 1.02	0.9			

DISCUSSION

Overall, our findings suggest the rehabilitation LOS has the greatest impact on rehab costs following acute, traumatic spine injuries. The spine injury population would benefit most from enhancing the efficiency of treatment and reducing length of stay. Additionally, injuries of greater severity and level were associated with longer LOS in most cases, but not all. The patient may also recover faster and be able to return home or receive outpatient services if the injury is less severe. Lesions classified as ASIA grade B were associated with a longer LOS than other lesions, suggesting that improved rehabilitation in this patient group may be key to controlling costs. We observed variation in cost across AIS grades and levels, which may suggest that other factors might contribute to some of the cost differences between patients. It might be possible to reduce costs by better understanding this variability.

In 2016, healthcare expenditures in the U.S. reached more than 20% of the national gross domestic product [12]. In the last decade, healthcare-related spending has become more expensive in nearly all areas of patient care, including pharmaceutical costs [13]. SCI literature reports that Selvarajah et al. found that $4.8 billion in hospital charges accrued for trauma SCI patients within the Nationwide Emergency Department sample period 2007-2009 [14]. In a study conducted in 2007, veterans hospital researchers found that the average direct cost per patient for SCI was $21,450, where complete cervical SCI was most costly and incomplete thoracic cervical SCI was least expensive (3). Among SCI patients at a single centre in Ontario, a recent study found that inpatient rehabilitation costs accounted for 58% of the total direct costs [5]. These studies did not provide data on the costs of rehabilitation specifically for people with spinal cord injuries.

The current study found several important results. Our study found that nearly 90% of total rehabilitation costs were related to the facility itself. The relative contribution of facility costs over pharmacy and other costs may be explained by the fact that inpatient rehabilitation typically requires fewer pharmaceutical interventions and laboratory studies compared with other healthcare settings (e.g., physical therapy, recreation). During rehabilitation, patients with spinal injuries continue to receive medications, therapy, and other services they receive after discharge from the hospital. However, the majority of the cost is attributed to acute rehabilitation. In studies conducted by our group, we have observed that facility costs are the most significant part of overall costs when device or instrument usage is not heavy (e.g., spine, endovascular). In terms of injury severity and anatomical spinal location, no significant difference in rehabilitation costs was observed. We hypothesized that injury severity would correspond with rehabilitation costs, but this finding surprised us, since ASIA classification is a measure of severity. The difference in costs was not statistically significant after adjusting for length of rehabilitation stay after there was a trend towards higher costs with greater injury severity (Figure2E). There was a significant difference in costs among severity and levels of injury, but long LOS was associated with high severity and levels. It may have been a case of underpowered statistical analysis. There

has been research that shows SCI patients whose injuries were less severe spent fewer days in the hospital and experienced lower inpatient costs [15]. Even after controlling for level and severity of injury, our results showed that LOS was the dominant cost driver. Standardizing treatments to reduce variability may potentially help reduce costs. Furthermore, by planning the transition of care for more significant injury patients, discharge readiness could be improved more rapidly.

Study limitations

There are limitations to this study. Only one health system was analyzed, so differences between the health systems cannot be analyzed. In that regard, the results presented herein may not be universally applicable to all rehabilitation facilities. Further, our study was conducted at a rehabilitation center affiliated with an academic institution, and its findings may not be representative of costs in other practice models. As the study population reflected the distribution of age, sexes, and AIS injury grades found nationally [16] , its age, sex, and AIS injury grade were all within the expected range. Although we have a relatively large study cohort for a rehabilitation cohort, it may be inadequately powered to capture the true scope and heterogeneity of patients with spinal cord injuries. It is hard to determine the direct relationship between rehabilitation and the eventual outcome of the patient, as well as the selection of the rehabilitation duration. A better understanding of the impact of rehabilitation on patient outcomes would require further prospective studies and adjustment for these variables. Using institutional databases as data sources does have limitations. In accordance with our agreement with the University, physician professional fees are not reported as a cost variable. We are unable to compare actual costs with those of other injured patients and therefore can only compare our center's costs with those of other rehabilitation centers because we are unable to analyze actual dollar amounts. The indirect costs of treating this population of patients, which are quite substantial, are also difficult to obtain. While this study has its limitations, it provides a useful insight into direct rehabilitation costs after spinal injury.

CONCLUSIONS

We present data on an inpatient rehabilitation program after a spinal injury at our institution. The majority of rehabilitation costs were incurred by the facility. Rehab costs were only independently predicted by the length of stay. The high upfront cost of care associated with spine injuries is largely a result of the need for rehabilitation. Reduced costs may be achieved by enhancing the effectiveness of rehabilitation and simplifying care.

REFERENCES

1. Traumatic spinal cord injury in the United States, 1993-2012. Jain NB, Ayers GD, Peterson EN, Harris MB, Morse L, O'Connor KC, Garshick E. *JAMA.* 313, 2015, 2236–2243.
2. Rehabilitation services provision and payment. Gutenbrunner C, Blumenthal M, Geng V, Egen C. *Am J Phys Med Rehabil.* 96, 2017, 35–40.
3. Health care costs for patients with chronic spinal cord injury in the Veterans Health Administration. French DD, Campbell RR, Sabharwal S, Nelson AL, Palacios PA, Gavin-Dreschnack D. *J Spinal Cord Med.* 30, 2007, 477–481.
4. Garlanger KL, Beck LA, Cheville AL. *J, et al.* Functional outcomes in patients with co-occurring traumatic brain injury and spinal cord injury from an inpatient rehabilitation facility's perspective. *Spinal Cord Med.* 41, 2018, 718–730.
5. Munce SE, Wodchis WP, Guilcher SJ, *et al.* Direct costs of adult traumatic spinal cord injury in Ontario. *Spinal Cord.* 51, 2013, 64–69.
6. Guan J, Karsy M, Bisson EF, Couldwell WT, *et al*. Patient-level factors influencing hospital costs and short-term patient-reported outcomes after transsphenoidal resection of sellar tumors. *Neurosurgery.* 83, 2018, 726–731.
7. Karsy M, Guan J, Abou-Al-Shaar H, *et al.* Letter to the Editor. Effect of facility costs in the treatment of neurosurgical patients using the Value Driven Outcome database. *J Neurosurg.* 129, 2018, 567–851.
8. Reese JC, Karsy M, Twitchell S, Bisson EF, *et al.* Analysis of anterior cervical discectomy and fusion healthcare costs via the value-driven outcomes tool. *Neurosurgery.* 84, 2019, 485–490.
9. Twitchell S, Abou-Al-Shaar H, Reese J, *et al.* Analysis of cerebrovascular aneurysm treatment cost: retrospective cohort comparison of clipping, coiling, and flow diversion. *Neurosurg Focus.* 44, 2018, 3.
10. Twitchell S, Karsy M, Reese J, Guan J, Couldwell WT, Dailey A, Bisson EF, *et al*. Assessment of cost drivers and cost variation for lumbar interbody fusion procedures using the Value Driven Outcomes database. *Neurosurg Focus.* 44, 2018, 10.
11. Abou-Al-Shaar H, Azab MA, Karsy M, Guan J, Couldwell WT, Jensen RL, *et al*. Assessment of costs in open microsurgery and stereotactic radiosurgery for intracranial meningiomas. *World Neurosurg.* 119, 2018, 357–365.
12. Hartman M, Martin AB, Espinosa N, Catlin A, *et al.* National health care spending in 2016: spending and enrollment growth slow after initial coverage expansions. The National Health Expenditure Accounts Team. *Health Aff (Millwood)* 37, 2018, 150–160.

13. Dieleman JL, Baral R, Birger M, *et al.* US spending on personal health care and public health, 1996-2013. *JAMA.* 316, 2016, 2627–2646.
14. Selvarajah S, Hammond ER, Haider AH, *et al.* The burden of acute traumatic spinal cord injury among adults in the United States: an update. *J Neurotrauma.* 31, 2014, 228–238.
15. Dukes EM, Kirshblum S, Aimetti AA, Qin SS, Bornheimer RK, Oster G. Relationship of American Spinal Injury Association Impairment Scale grade to post-injury hospitalization and costs in thoracic spinal cord injury. *Neurosurgery.* 83, 2018, 445–451.
16. National Spinal Cord Injury Statistical Center: facts and figures at a glance.

Cite this article:
A Retrospective Cohort Analysis of the Cost of Inpatient Rehabilitation after Spinal Injury. Acta Biomedica Scientia, 2017;7(1):1-3.

Attribution-NonCommercial-NoDerivatives 4.0 International