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Trends in Patient Care for Traumatic Spinal Injuries in the United States: A National Inpatient Sample Study of the Correlations With Patient Outcomes From 2001 to 2012

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Study Design. A retrospective database review.

Objective. The aim of this study was to examine whether patient characteristics, distribution of care, and patient outcomes for spinal cord injury (SCI) in the United States have changed between 2001 and 2012.

Summary of Background Data. Although patient outcomes after cranial injury are better at high-volume centers with specialized, multidisciplinary teams, similar assessments have not been done for spinal injuries.

Methods. We retrospectively reviewed the National and Nationwide Inpatient Samples for the years 2001, 2002, 2011, and 2012 to identify patients with spinal fracture with or without SCI. The demographic characteristics of the patient cohort, clinical course, hospital characteristics, interhospital transfer, and disposition were statistically analyzed relative to patient mortality, total hospital costs, and length of stay. How these data changed over this 11-year period was also evaluated.

Results. A total of 159,875 cases were identified, with 141,737 fractures without SCI and 18,138 SCIs with or without fracture. There was a statistically significant decrease in the percentage of patients transferred with spine injury from 4.2% to 3.4% ($P < 0.001$) from the early years to the later years and in patient transfers for SCIs (8.1% *vs.* 6.5%, $P < 0.001$). Interestingly, the overall mortality rate (3.5% *vs.* 3.6%) remained unchanged ($P = 0.679$), but mortality from SCI increased (6.6–7.4%, $P = 0.021$).

Conclusion. From 2002 to 2012, the rate of interhospital transfer of spinal injury patients declined, while the mortality rate for patients with SCI increased. Interestingly, there was an increase in transfers after spinal surgery at the index hospital. The decentralization of spine care may be responsible for the increase in mortality.

Key words: centralization, high-volume trauma center, interhospital transfer, mortality rate, multidisciplinary care, outcomes, spinal cord injury, spinal surgery, spine, trauma.

Level of Evidence: 4

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The focused treatment of patients with severe traumatic injuries at high-volume trauma centers has improved clinical outcomes.[1–4] Processes that enable efficient and early delivery of care, including access to multidisciplinary teams, protocol-driven treatments, specialized training of physicians and nurses, and dedicated intensive care units are some of the benefits these comprehensive centers provide patients with traumatic spine and spinal cord injury (SCI). Survival benefits attributed to treatment at high-volume centers have been observed in patients with traumatic brain injury, stroke, and subarachnoid hemorrhage[4–9]; however, a recent study of patients after acute ischemic stroke found that patients who were transferred from one facility to another had higher hospital costs, worse discharge disposition, and higher mortality when compared with patients admitted directly.[5] Similar data regarding patient outcomes have not been published for patients with SCI.

The care of patients with traumatic spine injuries in general and SCI in particular is complex. Pathophysiological alterations can lead to cardiopulmonary dysfunction, systemic hypotension, and increased susceptibility to infections. Concurrent

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systemic injuries are common. SCI patients have high rates of hospital readmission in the first year after injury and those with chronic SCI have high rates ongoing as well.[10–12] The lifetime direct costs of care for patients sustaining SCI can range from \$2.1 to \$5.4 million dollars for an individual injured at the age of 25 years, and these costs are rising with improved life expectancy and increasing care costs.[13]

Recent work has highlighted the potential for complexities, inefficiencies, and interhospital transfer to negatively impact outcomes.[5,14] Given the trend toward centralization of care at high-volume centers for patients with complex medical problems, we sought to examine whether patient characteristics, distribution of care, and patient outcomes for SCI in the United States have changed between 2001 and 2012.

MATERIALS AND METHODS

Study Population

Patient encounters were extracted from the National Inpatient Sample and the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality for the years 2001, 2002, 2011, and 2012.[15,16] The NIS databases are a publicly available, all-payer, inpatient sample of discharge records from nonfederal hospitals in the United States. Data selection was performed using diagnosis codes from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM), as well as the Clinical Classifications Software for ICD-9-CM (CCS; www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp). A 10-year period was selected to allow enough time to identify a shift in health care delivery on a national level. The year 2012 was the most recent year that NIS data were available at the time of data collection. Because SCI occurs relatively infrequently, data were collected in 2-year increments and then compared.

To identify patients with spinal injuries, the following ICD-9-CM diagnosis codes were utilized: 805 (fracture of vertebral column without mention of SCI), 806 (fracture of vertebral column with SCI, and 952 (SCI without evidence of spinal bone injury), which corresponded to CCS codes 227 (SCI) and 231 (other fractures). As hospital reporting of diagnostic ICD-9-CM codes was limited to 15 before 2009 and later expanded to 25, it is possible that the relevant ICD-9-CM codes are excluded in some cases. Therefore, the CCS composite scores provided better capture of all patients with SCI. Operative spinal interventions were identified by CCS codes 3 (laminectomy; excision intervertebral disc) and 158 (spinal fusion). Other relevant operative interventions related to the care of spine-injured patients, namely, CCS codes 34 (tracheostomy; temporary and permanent) for tracheostomy placement and 71 (gastrostomy; temporary and permanent) for percutaneous gastrostomy tube placement, were also assessed and classified as adjunctive surgical procedures.

Patient demographic factors including age, sex, race, and primary expected payer were extracted. Admission details such as day of the week, transfer status, spinal surgical intervention, adjunctive surgical intervention, and discharge disposition were also collected. In addition, hospital characteristics including geographic region, size, teaching status, ownership, and location population density (urban versus rural) were included. Hospital size categories are specific to the region, population density, and teaching status of each hospital. For each encounter, the total reported charges were used as a representation of the amount the hospital billed for their services.

Statistical Analysis

Data were grouped into two-year blocks (2001/2002 and 2011/2012) to examine differences in the distribution and management of spinal trauma over a 12-year period. Dependent variables explored were patient mortality, total hospital costs, and length of stay. Descriptive statistics were computed and comparative analyses were performed between 2001/2002 and 2011/2012 for all patients, as well as within the subgroup of patients with SCI. Variables that do not follow a normal distribution, such as length of stay and total charges, were presented as median and interquartile range (IQR), and we used nonparametric tests including the Mann–Whitney U test for the evaluation of these variables. Normally distributed variables were compared using the unpaired Student t and Pearson Chi-square statistical tests. All data analyses were performed using the Statistical Package for Social Sciences, version 23 (IBM Corp., Armonk, NY). A value of $P < 0.05$ was considered statistically significant.

RESULTS

A total of 159,875 traumatic spine cases were identified, including 141,737 fractures without SCI and 18,138 SCIs with or without fracture. The proportion of patients with spinal trauma who sustained SCIs declined from 12.4% to 10.6% over the 12-year period ($P < 0.001$). Patient demographic and injury characteristics are presented in Table 1. Overall, patients treated in 2011/2012 were significantly older (58.5 *vs.* 62.1 years, $P < 0.001$), were more frequently Black or Native American ($P < 0.001$), and were less likely to have private insurance ($P < 0.001$) than those treated in 2000/2001. There was no statistically significant difference in the proportion of SCI patients with and without accompanying spinal fractures ($P = 0.74$) between the two time periods.

Table 2 presents the hospital characteristics for all patients with spinal injuries. There was no significant difference in the regional distribution of cases between 2001/2002 and 2011/2012 among the Northeast, Midwest, South, and West regions of the United States ($P = 0.20$). However, more patients were treated at large *versus* small/medium-sized, teaching *versus* nonteaching, private *versus* government, and urban *versus* rural hospitals (all $P < .001$). The results were similar when examining only those patients with SCIs.

The rates of interhospital transfer, hospital encounter parameters, interventions, patient outcomes, and total

TABLE 1. Patient Demographics and Injury Characteristics

		2001–2002	2011–2012	*P*
Age	Mean (±St Dev)	58.5±24.4	62.1 ± 22.9	<0.001*
Sex				
	Male	31,850 (49.1)	46,388 (49)	0.256
Race				<0.001*
	White	37,064 (80.7)	69,043 (79.3)	
	Black	3055 (6.6)	6343 (7.3)	
	Hispanic	3742 (8.1)	7040 (8.1)	
	Asian	902 (2.0)	1714 (2.0)	
	Native American	145 (0.3)	560 (0.6)	
	Other	1042 (2.3)	2364 (2.7)	
Primary expected payer				<0.001*
	Medicare	29,216 (45.3)	47,917 (50.6)	
	Medicaid	4201 (6.5)	7591 (8.0)	
	Private	21,972 (34.1)	26,211 (27.7)	
	Self-pay	4435 (6.9)	6737 (7.1)	
	No charge	235 (0.4)	404 (0.4)	
	Other	4466 (6.9)	5819 (6.1)	
Spinal injury characteristics				
	Spine fracture	56,781 (87.6)	84,956 (89.4)	<0.001*
	Spinal cord Injury	8060 (12.4)	10,078 (10.6)	
	w/ Fracture	4646 (7.1)	5834 (6.1)	0.74
	w/o Fracture	3414 (5.3)	4244 (4.5)	

All values are reported as n (%) unless otherwise indicated.
**Statistical significance.*

charges are reported in Table 3. There was a statistically significant decrease in both transfers received (6.3% to 5.8%) at reporting hospitals as well as transfers out (4.2% to 3.4%) in all patients and within the SCI subgroup (transfers in 11.1% to 9.0%, transfers out 8.1% to 6.5%, all $P < .001$). Over the same period, there was an increase in the performance of any spinal surgical procedure before patient transfer among all spine injury patients from 8.2% to 10.4% ($P = 0.004$). In the SCI cohort, a much higher proportion of patients underwent any spinal or any other surgical procedure before transfer, and there was a statistically significant increase in both between 2001/2002 and 2011/2012 (any spinal procedure 22.8–30.3%, $P = 0.002$ and any other procedure 64.2–72.1%, $P = 0.002$).

Although the length of stay decreased from a median of 5 to 4 days for all patients and from 8 to 7 days in SCI patients ($P < 0.001$ and $P = 0.001$, respectively), the rate of spinal surgical procedures increased by 2.0% in all patients and 11.2% in SCI patients ($P < 0.001$). There was no change in the rates of tracheostomy and an increase in percutaneous gastrostomy tube placement for SCI patients ($P = 0.78$ and $P = 0.001$, respectively). The overall mortality rate (3.5% in 2001/2002, 3.6% in 2011/2012) remained unchanged ($P = 0.679$), but the mortality rate in the SCI patient cohort increased (6.6–7.4%, $P = 0.021$) over the study period. Median total charges were significantly higher in all patients ($15,083 *vs*. $39,250) and the SCI subgroup ($36,621 *vs*. $95,373) between 2001/2002 and 2011/2012, as well as between the SCI and non-SCI patients (all $P < 0.001$), exceeding the rate of inflation by more than 200%.

We also compared hospital course parameters, overall mortality, and total hospital charges between directly admitted patients and those received in transfer (Table 4) across the data set for all years. Length of stay was significantly longer for transfer patients with (10 *vs*. 7 days, $P < 0.001$) and without SCI (7 *vs*. 5 days, $P < 0.001$). Although there was no difference in mortality for all patients ($P = 0.57$), there was a significantly lower mortality rate in transferred SCI patients (7.3% *vs*. 4.8%, $P < 0.001$). Interestingly, median total charges were higher for transfer patients overall ($P < 0.001$), but were significantly lower in SCI patients received in transfer ($62,842 *vs*. $56,111, $P < 0.001$).

DISCUSSION

Several studies have demonstrated an association between volume and clinical outcomes in patients with severe traumatic injuries.[1–4] For complex and less-common medical problems, such as SCI, high-volume trauma centers provide a setting for the concentration of qualified personnel and resources to optimize care. This is the basis for the centralization of patients with traumatic injuries at regional health care systems, which address injury prevention, prehospital management, treatment in the acute setting, and post-

TABLE 2. Hospital Characteristics for All and Spinal Cord Injury Patients

		All Patients			SCI Patients		
All Patients		**2001–2002**	**2011–2012**	***P***	**2001–2002**	**2011–2012**	***P***
Hospital region				0.20			0.58
	Northeast	10,685 (16.5)	15,891 (16.7)		1290 (16.0)	1634 (16.2)	
	Midwest	15,432 (23.8)	22,878 (24.1)		1841 (22.8)	2377 (23.6)	
	South	26,173 (40.4)	37,926 (39.9)		3219 (31.9)	3946 (39.2)	
	West	12,551 (19.4)	18,339 (19.3)		1710 (21.2)	2121 (21.0)	
Hospital size by bed number				<0.001*			<0.001*
	Small	6429 (9.9)	8667 (9.2)		528 (6.6)	536 (5.4)	
	Medium	16,220 (25.0)	20,980 (22.4)		1950 (24.2)	2049 (20.7)	
	Large	42,192 (65.1)	64,158 (68.4)		5582 (69.3)	7328 (73.9)	
Teaching status				<0.001*			<0.001*
	Nonteaching	32,681 (50.4)	38,225 (40.7)		2672 (33.2)	2692 (27.2)	
	Teaching	32,160 (49.6)	55,580 (59.3)		5388 (66.8)	7221 (72.8)	
Ownership				<0.001*			<0.001*
	Government	44,725 (69.0)	41,979 (44.8)		6331 (78.5)	4922 (49.7)	
	Private, Non-profit	11,854 (18.3)	40,771 (43.5)		1178 (14.6)	4169 (42.1)	
	Private, Profit	8262 (12.7)	11,055 (11.8)		551 (6.8)	822 (8.3)	
Population density				<0.001*			<0.001*
	Rural	9705 (15.0)	8175 (8.7)		659 (8.2)	399 (4.0)	
	Urban	55,136 (85.0)	85,630 (91.3)		7401 (91.8)	9514 (96.0)	

All values are reported as n (%).

*Statistical significance.

TABLE 3. Comparison of Transfer Rates and Outcome Measures for All Patients and SCI Patients

	All Patients			SCI Patients		
	2001–2002	**2011–2012**	***P***	**2001–2002**	**2011–2012**	***P***
Transfers in	4109 (6.3)	5499 (5.8)	<0.001*	893 (11.1)	910 (9.0)	<0.001*
Transfers out	2718 (4.2)	3246 (3.4)	<0.001*	654 (8.1)	653 (6.5)	<0.001*
With any spine procedure	224 (8.2)	338 (10.4)	0.004*	149 (22.8)	198 (30.3)	0.002*
With any procedure	1591 (58.5)	1904 (58.7)	0.925	420 (64.2)	471 (72.1)	0.002*
LOS, median (IQR)	5 (3.0–9.0)	4 (3.0–8.0)	<0.001*	8 (4.0–17.0)	7 (4.0–15.0)	0.001*
Any spine procedure	6792 (10.5)	11838 (12.5)	<0.001*	2867 (35.6)	4712 (46.8)	<0.001*
Tracheostomy	2262 (3.5)	3053 (3.2)	0.003*	883 (11.0)	1091 (10.8)	0.78
PEG placement	1313 (2.0)	2060 (2.2)	0.051	440 (5.5)	667 (6.6)	0.001*
Tracheostomy or PEG	2664 (4.1)	3790 (4.0)	0.23	956 (11.9)	1253 (12.4)	0.242
Mortality	2288 (3.5)	3403 (3.6)	0.679	526 (6.6)	750 (7.4)	0.021*
Total charges, median, IQR	$15,083 ($7650.75–34,360.25)	$39,250 ($20,047.25–85,489.25)	<0.001*	$36,621 ($14,700–87,177)	$95,373 ($39,524–206,589.50)	<0.001*

All values are n (%) unless otherwise indicated.

*Statistical significance.

IQR indicates interquartile range; LOS, length of stay; PEG, percutaneous gastrostomy tube; SCI, spinal cord injury.

TABLE 4. Outcome Comparison of Direct Admission and Transfer in All and SCI Patients

	All Patients			SCI Patients		
	Direct Admission	Transfer	*P*	Direct Admission	Transfer	*P*
Length of stay, median (IQR)	5 (3.0–8.0)	7 (3.0–12.0)	<0.001*	7 (4.0–15.0)	10 (5.0–20.0)	<0.001*
Mortality, n (%)	5339 (3.6)	352 (3.7)	0.57	1189 (7.3)	87 (4.8)	<0.001*
Total charges, median (IQR)	$27,501 ($12,657–63,520.75)	$30,865 ($13,629.50–74,229.75)	<0.001*	$62,842 ($24,371–155,338)	$56,111 ($22,410–129,899)	<0.001*

*Statistical significance.

IQR indicates interquartile range; SCI, spinal cord injury.

hospital care. The establishment of comprehensive trauma systems has led to a reduction in mortality, with trauma centers outperforming nontrauma hospitals.[17,18]

In contrast to the trend of centralizing care of traumatic injuries at specialized and comprehensive trauma systems, our results demonstrate a decrease in the proportion of SCI patients transferred to a high-volume center, an increase in surgical procedures performed in SCI patients before transfer, and an increase in mortality from SCI. SCI patients are undergoing more operations at low-volume and nontrauma hospitals, but there has not been a concomitant increase in survival. Patients who were directly admitted had a higher mortality rate than those who were transferred. These findings suggest that many SCI patients may not be receiving optimal care when admitted to a low-volume or nontrauma hospital and that they may benefit from transfer to a high-volume trauma center earlier in their treatment course.

Although SCI was previously considered to be an injury in young persons, the mean age of patients with SCI has increased over the past few decades.[19,20] The incidence of SCI in patients aged ≥65 years is increasing and accounts for a larger proportion of total SCI cases, in part because of the growing size of the elderly population.[21] Advanced age is associated with higher mortality, longer hospitalization, increased likelihood of discharge to a skilled nursing facility, and poorer clinical outcomes.[19,20,22] Thus, patients with SCI often have complex medical problems and stand to benefit from the type of multidisciplinary care present at designated trauma centers that manage a high volume of similar injuries.

The results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS) indicate that decompressive surgery within the first 24 hours after trauma could improve neurological outcomes.[23] Some argue that transferring patients with spinal instability before decompressive and stabilization surgery may negatively impact functional outcomes and, in fact, may be harmful. Because STASCIS was conducted in high-volume institutions that specialized in the management of spinal trauma and SCI, it is not yet known whether early surgery performed in a nontrauma hospital or low-volume center would confer the same functional benefit. An appraisal of the cases included in STASCIS revealed that systems-related issues may delay the transfer of SCI patients to a center that can deliver definitive care.[24] The time spent in a nontrauma hospital waiting for a specialist consultation, diagnostic tests, and transportation were modifiable causes that resulted in unnecessary delays for spinal cord decompression. Current evidence demonstrates that better outcomes occur when there is prompt transfer of the hemodynamically stable SCI patient to a spine trauma center for evaluation and surgical treatment.[23]

Early surgical decompression for SCI is associated with a shorter stay in the intensive care unit and a decrease in the frequency of secondary complications.[25] Early decompression may also reduce costs. A cost-utility analysis demonstrated that early decompression may save roughly $58 million per quality-adjusted life year gained for patients with complete SCI and $500,000 per quality-adjusted life year gained for patients with incomplete SCI.[26] These estimates, however, did not account for prehospital care or transfer to the spine trauma center. The expenditure could be substantial because four separate care episodes need to be accounted for transport to the first hospital, care at the first hospital, transfer to the specialty center, and finally definitive care at the specialty center. As the stroke literature demonstrates, patients requiring transport experience delays in definitive care that contribute to an increase in adverse outcomes at a higher overall cost.[5] We found that transferred SCI patients also required longer hospitalizations than patients admitted directly even though more patients underwent surgery before transfer. In addition, our work demonstrated higher costs in transfer patients overall, but reduced costs in the SCI cohort that may be related to surgical intervention having been performed before transfer. Future studies on SCI should include these additional costs in cost-utility models to determine whether early transfer to a spine trauma center for definitive treatment is cost-effective.

Since its inception, the NIS databases have undergone several revisions that include changes to sample design, coding modifications, and alterations of the data structure. Changes in data elements and values, such as diagnosis and procedure codes, occurred annually. This evolution of the NIS databases increases the variability of the data set, which creates difficulty in identifying true trends on an annual basis. To increase the generalizability of our study results, we aggregated data in 2-year intervals and compared data sets that were 10 years apart. Longitudinal analysis with additional time points could help further elucidate these trends; however, the frequent changes to the NIS databases over the study period limit such a granular analysis.

There are other important limitations to this study. First, the data collected were obtained from patient registries that were not designed to address our specific study questions. Therefore, we are unable to determine a causal relationship between a decrease in the number of patients transferred to high-volume centers and increased mortality from SCI. In addition, the observed increase in in-hospital mortality may be the result of better resuscitation in the field allowing more critically injured patients to survive to admission. For example, atlanto-occipital dislocation, a condition considered immediately fatal in the past,[27] has more recently been shown to be survivable, at least in part due to improvements in pre-hospital care.[28,29] Finally, patient diagnosis and procedural data are reliant upon the accuracy of ICD-9 coding. In a previous study, coding error rates were found to vary among states and by hospital within states.[30]

Despite these limitations, our findings identify important areas for future research in SCI. It is worrisome that SCI patients were transferred less frequently to higher levels of care and experienced higher mortality over our study period; however, it is not known whether clinical outcomes for SCI are better at high-volume centers. Further, it is unclear whether performing surgery before transfer is deleterious and thus associated with poor outcomes. Although fewer patients were treated in small and rural hospitals, the larger hospitals are not necessarily SCI centers or even Level I trauma centers. Major tertiary care centers also provide these patients access to the latest technology, coordinate care teams, and investigational treatments through clinical trials. Considering the increase in mortality observed during the study period, SCI patients may benefit from centralization of care to specialty centers that have resources to provide comprehensive care for these patients.

➢ Key Points

- ❑ From 2002 to 2012, the rate of interhospital transfer of traumatic spinal injury patients declined.
- ❑ During the same time period, there was an increase in mortality and an increase in transfers after spinal surgery in patients with spinal cord injury.
- ❑ Future research should investigate whether high-volume hospitals with specialized multidisciplinary teams lead to better clinical outcomes in patients with spinal cord injury.

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