The Impact of Specialized Centers of Care for Spinal Cord Injury on Length of Stay, Complications, and Mortality: A Systematic Review of the Literature

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Abstract

Specialized centers of care for spinal cord injury (SCI) were first established in 1944 in England. The objective of these centers is to improve care and neurological recovery of patients suffering from a spinal cord injury. An interdisciplinary group of experts composed of medical and surgical specialists treating patients with SCI formulated the following questions: (1) Is there any evidence to suggest that specialized centers of care in SCI decrease the length of patient stay? and (2) Is there evidence that specialized centers of care for SCI reduce mortality and secondary complications? A systematic review of the current evidence was performed using multiple databases to answer these two specific questions. Two independent reviewers graded each paper using the Black and Downs method. Recommendations were then formulated based on the evidence available and were reviewed by a panel of experts using a modified Delphi approach. Two recommendations were formulated and both received complete agreement from a panel of experts. The first recommendation is “Early transfer of a patient with traumatic SCI to a specialized center of care should be done promptly to decrease overall length of stay.” The second recommendation is “Early transfer of patients with traumatic SCI to an integrated multidisciplinary specialized center of care decreases overall mortality, and the number and severity of complications.”

Key words: hospitalization; spinal cord injury; systematic review

Introduction

SPINAL CORD INJURY (SCI) tertiary care designated centers have been developed to help improve clinical outcome and neurological recovery in patients suffering from acute spinal cord injury (ASCI), with an estimated incidence of 15–40 cases per million population (Sekhon and Fehlings, 2001). The total SCI care system hospital charges per patient were over \$250,000 in 2003, and have likely risen since then. The first spinal cord injury centers were established in the U.K. under the supervision of Sir Ludwig Guttman in 1944 in Aylesbury, England. Guttman’s philosophy was that rehabilitation following SCI should not be dissociated from the acute treatment period. Several SCI centers have since appeared, mostly in developed countries, with the objective of improving the care and neurological recovery of patients with SCI.

This systematic review of the literature was undertaken to evaluate the benefits of centers of excellence in the treatment of SCI, and to review the evidence regarding improvements in outcome for patients treated in SCI centers vs. community hospitals. A Cochrane review of the existing literature found no randomized clinical trials surrounding SCI centers. The authors thus concluded that the current evidence is insufficient to “comment on the benefits of early referral to SICs in patients with traumatic SCI” (Jones and Bagnall, 2004). The limitation of the Cochrane approach is that it is limited to randomized controlled trials and controlled trials.

The current review was done to evaluate the following two questions: (1) Is there any evidence to suggest that centers of expertise in SCI decrease the length of patient stay? and (2) Is there evidence that centers of expertise in SCI reduce mortality and secondary complications?

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Methods

A systematic review of the literature in three online databases (EMBASE, Medline, and the Cochrane database) was performed for articles matching the search criteria published before June 2009. The following search strategy was used: ("Spinal Cord Injury" OR "Paraplegia" OR "Quadriplegia") AND ("Hospitalization" OR "Length of Stay" OR "transfer" OR "Referral and Consultation"), all mapped to subject heading, including all subheadings, and searched as keywords. This returned a total of 761 abstracts. The search was then limited to English language abstracts and human-subject studies. Case reports of fewer than 10 patients were excluded. The abstracts were then read by title and relevant abstracts were reviewed. Full-length articles of interest were then obtained. All articles were then reviewed according to the method of Downs and Black (Downs and Black, 1998) by two independent reviewers.

A total of 15 articles were kept at the end of this process and reviewed. An evidentiary table was prepared (Table 1).

Data compilation

The following data were then compiled in the evidentiary table: study design, population, treatment or therapeutic measure, outcome measure, study purpose, and key results. The evidentiary table was then used to answer the two study questions.

Results

Is there any evidence to suggest that specialized centers of care in SCI decrease the length of patient stay?

A total of 10 retrospective studies including three case-control studies and seven retrospective cohort studies were identified to answer this question.

In a study evaluating the benefits of early admission to an organized Spinal Cord Injury Care System, DeVivo and associates (DeVivo et al., 1990) reviewed all admissions at one center over a 13-year period (1973–1985). They reviewed the medical records of 794 SCI patients, of which 284 had been admitted within 1 day of injury. They compared this group to 377 patients that were admitted later, mainly for rehabilitation. Four groups were formed based on neurological involvement (paraplegia incomplete, paraplegia complete, quadriplegia incomplete, and quadriplegia complete). For all but complete quadriplegics, the acute care LOS was considerably shorter for the early-admission group. Total LOS was also significantly shorter for both the paraplegia complete (LOS 81.7 vs. 95.5 days) and quadriplegia incomplete (LOS 79.2 vs. 108.0 days) groups.

In another study comparing rehabilitation times following SCI between 185 patients treated in a specialized short-term care unit and 153 patients in general hospitals, (Heinemann, 1989), total time at the rehabilitation center was no different. The duration from time of injury to transfer to the rehabilitation center was almost twice as long for non-center patients. Center patients also had greater daily gains during rehabilitation, although their level of injury did not differ from the non-center patients.

A study evaluating the effect of the implementation of specialized acute spinal cord injury units (ASCIU) in the

province of Ontario compared 351 pre-ASCIU patients (1947–1973) with 201 ASCIU patients (1974–1981) (Tator et al., 1995). Although the management of patients over the two periods was probably not equivalent, LOS was decreased by nearly 50% (86.9 vs. 48.2 days). In another retrospective study of the same ASCIU cohort, the authors found that LOS was directly related to injury severity, complications, and time delay to admission, with patients admitted after 48 h having a significantly longer LOS than those admitted before 48 h (Tator et al., 1993).

Oakes and colleagues (Oakes et al., 1990) evaluated the effect of early admission to a comprehensive trauma center for patients with spinal cord injury. They compared early and late transfer for both paraplegics and quadriplegics, and their effect on LOS and medical complications. The acute and overall LOS for the early-admission group with quadriplegia was significantly decreased (3 vs. 75 days and 131 vs. 197 days, respectively), with both groups spending equivalent amounts of time in the rehabilitation phase. This was also the case for the paraplegia group, with the acute and overall LOS being significantly lower for the early-admission group (6 vs. 59 days and 93 vs. 126 days, respectively). The late-admission group also experienced 45% more complications than the early-admission group.

Review of larger databases (Becker and DeLisa, 1999; Chen et al., 1999) has shown that LOS has steadily decreased over the past 20–25 years. In the Model system, total LOS was 144 days when the system began collecting data, and this had decreased to approximately 69 days by 1999. Acute LOS has decreased by approximately 50%, and rehabilitation LOS has decreased by 60%. The reasons for this are probably multifactorial, but these changes are certainly related in part to the Model system.

Finally, a retrospective cohort study of all patients admitted to a spinal injury center between 1985 and 1988 (Aung and el Masry, 1997) demonstrated a significant difference between three subgroups of patients, both paraplegics and quadriplegics. The three groups were composed of patients admitted within 1 week of injury (group 1), between 1 week and 2 months (group 2), and more than 2 months after injury (group 3). The total hospitalization time was shown to be significantly different between the three groups, with groups 1 and 3 showing a significant difference, as well as groups 2 and 3 for the paraplegia group, and groups 1 and 3 for quadriplegic patients.

Is there evidence that specialized centers of care in SCI reduce mortality and secondary complications?

A total of eight retrospective studies were identified, including two retrospective case-control studies.

The study by DeVivo and colleagues (1990) found no major difference in the incidence of most medical complications, except for pressure ulcers that developed during acute care. All delayed-admission patients except for the neurologically-incomplete paraplegics had a higher likelihood of developing pressure ulcers. Early-admission patients saw a decrease in the rate of pressure ulcers over time, but this was not the case for the late-admission group. Also of note, early-admission patients with incomplete lesions were less likely to develop pulmonary emboli (0.7% vs. 5.4%, $p=0.05$), and complete quadriplegics were more likely to develop pneumonia (37.1% vs. 19.1%, $p=0.02$).

TABLE 1. STUDY DESIGN, POPULATION, TREATMENT OR THERAPEUTIC MEASURES, OUTCOME MEASURES, STUDY PURPOSES, AND KEY RESULTS OF THE STUDIES

Author/Country	Title	Study design			D&B score	Results (list main outcomes first, provide the results for each outcome and <i>p</i> -value)
		Type	Population	Treatment		
De Vivo et al., 1990	Benefit of early admission to a comprehensive trauma center for patients with spinal cord injury	Retrospective review	Patients admitted within 1 day of injury who received all subsequent care within the system were compared with patients who received their acute care services elsewhere and who were admitted to the system solely for rehabilitation. Both patient groups were comparable with respect to age, neurologic level, and extent of spinal cord lesion.	The data abstracted from each patient's medical records were reviewed and the comparability of the groups was assessed.	20	No statistically significant differences were observed between the early and delayed admission groups for year of injury, neurologic level, and extent of spinal cord lesion at admission to the system, or use of mechanical ventilators during acute care ($p > 0.05$), although a slightly higher proportion of patients in the early-admission group had spinal fusions (41% vs. 33%; $p = 0.029$), and halo traction (31% vs. 19%; $p < 0.001$). The effect of the differences in spinal fusions and halo traction is unclear. Early-admission patients were also slightly younger (average = 29.5 years), than their delayed admission counterparts (average = 32.0 years; $p = 0.027$). The small age difference should not bias the comparison of lengths of stay, hospital charges, and risks of developing secondary medical complications between the early- and delayed-admission patients. Early-admission patients had substantially shorter acute care LOS than their delayed-admission counterparts (e.g., LOS for paraplegia/incomplete for early admission was 22 days vs. 30.7 days for delayed admission; $p = 0.0229$).
Heinemann et al., 1989	Functional outcome following spinal cord injury: A comparison of specialized spinal cord injury center vs. general hospital short-term care	Retrospective study	Patients with SCIs who were admitted to the Rehabilitation Institute of Chicago (RICH). Patients were referred either from general hospitals (non-center patients) or from the Northwestern Memorial Hospital SCI Unit (center patients)	Patient charts were reviewed. Relevant data were collected and compared.	19	Mean MBI scores were similar for the two groups at the time of rehabilitation center admission ($F_{1,321} = 3.37$, $p = \text{not significant}$) and discharge ($F_{1,319} = 1.43$, $p = \text{not significant}$). Center patients stayed 2.8 days less than non-center patients in rehabilitation, and length of rehabilitation. Length of hospitalization was statistically unrelated to referral source ($F_{1,319} = 0.98$, $p = \text{not significant}$). Center patients made functional gains with significantly more efficiency (8.3%) than did non-center patients (6.9%; $F_{1,319} = 13.47$, $p < 0.001$).
Tator et al., 1984	Management of acute spinal cord injuries	Retrospective review	144 Patients with SCI ranged in age from 12–83 years (mean 34 years, median 27 years). The minimum follow-up was 6 months for complete cord injuries, and 12 months for incomplete injuries.	Detailed information on patients, collected on a systems analysis basis and reviewed.	19	In the 144 patients, the median interval from the time of injury to admission at Sunnybrook was 4.9 h. This represents an improvement over the median interval of more than 12 h in the period 1948–1973; 10 of the 144 patients (6.9%) died in hospital compared with 50 of the 358 patients (14%) in an earlier study. Patients with complete cord injuries had a longer mean stay (54.1 days). The halo program was an important factor in reducing hospital stay for patients with acute cord injury and for those with cervical spine injuries without neurologic deficits. The latter were often discharged home within 2 weeks of injury, and many were able to return to work in their halo vests. The results of the urologic management program were excellent in terms of reducing morbidity from urologic causes.
Tator et al., 1993	Complication and costs of management of acute spinal cord injury	Retrospective review	220 consecutive patients admitted to the acute SCI unit from 1974–1981	Information on each patient was gathered and included demographic information, presence and type of pre-existing spinal abnormalities, type of pre-existing spinal abnormalities, type of accident causing the injury, delay between the accident and admission to the unit, the level and type of injury to the vertebral column, the level and severity of the cord injury, and the anatomical location and severity of non-spinal injuries	18	The average LOS was 49.8 days, the average CPD was \$214, and the average total CPD was \$10,035 (in 1974 Canadian dollars). The mean LOS, the mean CPD, and the mean CPD for female patients were all slightly lower than for males, but the differences were not significant (two-tailed <i>t</i> -test for LOS, $p = 0.28$; CPD, $p = 0.13$; CPD, $p = 0.35$). LOS, CPD, and CPD were examined in relation to patient age at admission and no significant relationship was identified (LOS, $p = 0.65$; CPD, $p = 0.34$; CPD, $p = 0.60$). Scored on the 10-point spinal scale, patients with more severe cord injury had significantly longer LOS and higher CPD; the mean LOS increased from about 30 days for patients with mild injuries (grades 7, 8, and 9) to about 60 days for patients with more severe injuries (grades 1 and 2), while mean CPD increased from about \$6000 for patients with milder injuries to about \$12,000 for patients with severe cord lesions, both highly significant findings. Severity of cord injury had no effect on CPD (linear regression: LOS, $p = 0.0066$; CPD, $p = 0.48$; CPD, $p = 0.0062$).

(continued)

TABLE 1. (CONTINUED)

Author/Country	Study design				D&B score	Results (list main outcomes first, provide the results for each outcome and p-value)
	Title	Type	Population	Treatment		
Stover et al., 1999	History, implementation, and current status of the National Spinal Cord Injury Database	Retrospective review	Inception SCI cohort admitted to a Model system from 1976–1995	Patient charts were reviewed. Relevant data were collected and a database was created.	8	To organize and maintain a national SCI database of this type involves prioritization of variables to be collected, as well as sampling both data collection time frames and numbers of enrollees. The difficulties and costs in assembling, operationalizing, and collecting a large set of variables across Model systems located throughout the country cannot be overemphasized.
Tator et al., 1995	Neurological recovery, mortality, and length of stay after acute spinal cord injury associated with changes in management	Retrospective review	Patients with ASCI originating from the province of Ontario. Patients must have been admitted within 30 days following closed SCI and have received no definitive management of the ASCI at another institution prior to transfer to the ASCIU.	Patient charts were reviewed and divided into two groups: an ASCIU group (patients admitted to the ASCIU at Sunnybrook Medical Center from 1974–1981), and pre-ASCIU group (patients admitted to the Toronto General Hospital from 1947–1973).	19	Patients treated in the ASCIU had a significant reduction in the mortality rate of almost 50% ($p=0.02$), a significant reduction in the LOS of almost 50% ($p<0.001$), and a significant increase in the neurological recovery, consisting of a doubling of the score on the neurological recovery scale utilized ($p<0.001$). Multiple regression analysis showed that the reduction in mortality rate was significantly influenced by differences in the admission variables between the two groups.
Yarkony et al., 1990	Spinal cord injury care system: 15-year experience at the Rehabilitation Institute of Chicago	Retrospective review	Male/female: 83%/17%; Caucasian: 64%; mean age 27.9 years; 36% vehicle accidents; admitted to the program within 1 year of injury. Injuries were limited to root avulsion or peripheral nerve injuries. Exclusion of patients without injury within the neural canal	Data for patients were collected and are reported in this article.	13	LOS and days hospitalized prior to admission to the RIC has decreased over the years. Patients are now being transferred to the RIC in a mean of 36.5 days. LOS at RIC averages 82.8 days for quadriplegics and 54.3 days for paraplegics, with an overall average of 68.1 days. Mean MBI scores improved from 13.8 on admission to 46.1 on discharge for quadriplegics, and 37.7 on admission to 74.4 on discharge for paraplegics. Age did not affect functional abilities in quadriplegic or in incomplete paraplegic patients.
Oakes et al., 1990	Benefit of early admission to a comprehensive trauma center for patients with spinal cord injury	Retrospective review	Patients with traumatic SCI; admission within 1 year of injury; followed-up for at least 1 year	Medical data were recorded and analyzed	14	Median time from injury to admission was 11 days for quadriplegics and 21 days for paraplegics; this was used to define the early and late groups. The early quadriplegic group began rehabilitation 2.94 days post-injury, the late quadriplegic group 74.87 days post-injury ($p<0.01$). Time in rehabilitation did not differ (128.22 days for early; 122.61 for late). But total hospitalization from injury to discharge was 131.16 days for the early quadriplegic group, and 197.27 for the late quadriplegic group ($p<0.01$). Average duration of pre-rehabilitation care for the paraplegic groups was 6.19 days (early) and 58.58 days (late) ($p<0.01$). Time in rehabilitation was the same for both paraplegic groups, but total hospitalization was shorter for the early admission group (82.91 days vs. 125.90 days, $p<0.01$).
Celani et al., 2001	Spinal cord injury in Italy: A multicenter retrospective study	Multicenter retrospective study	Consecutively admitted adult patients with SCI	Examined medical records of patients admitted to rehabilitation centers	16	The time from event to admission to a rehabilitation center exceeded 30 days (average $\pm$ standard deviation: T/SCI, 54.6 $\pm$ 43.7 days; NT/SCI, 166.9 $\pm$ 57.4 days; $p<0.001$); pressure ulcers on admission were present in 34.1% ($p<0.000$) of T/SCI and 17.1% of NT/SCI patients. The average LOS in a rehabilitation center was 143.1 $\pm$ 89.1 days for T/SCI, and 91.7 $\pm$ 78.9 days for NT/SCI. Frankel grades improved by 1 or more in 34.4% of T/SCI and 34.1% of NT/SCI patients. The presence of pressure ulcers on admission, rehabilitation LOS, and neurologic improvement on discharge correlated highly with severe neurologic damage on admission in both T/SCI and NT/SCI patients, as well as with management of the patient immediately before admission to a rehabilitation center, mainly in NT/SCI patients.
Sipski et al., 2004	Effects of gender on neurologic and functional recovery after spinal cord injury	Retrospective review; case series	People admitted to an model spinal cord injury system (MSCIS)	Patients charts were reviewed. Relevant data were collected and compared.	20	Changes in ASIA motor index total scores, from system admission to 1-year anniversary, were significantly greater for women than men with either complete ($p=0.035$) or incomplete ($p=0.031$) injuries. Functional comparison of men and women, using the FIM motor subscale, revealed that men had higher FIM motor scores at rehabilitation discharge among those with motor-complete injuries, except for those with injury at the C1–C4 and C6 neurologic levels. Women with motor-incomplete high tetraplegia (C1–C4 levels) had higher discharge FIM motor scores than did similarly-affected men. There were no significant differences in FIM motor scores among men and women with other levels of motor incomplete SCI.

(continued)

TABLE 1. (CONTINUED)

Author/Year/ Country	Study design			DeB score	Results (list main outcomes first, provide the results for each outcome and p-value)
	Title	Type	Population		
Becker and DeLisa, 1999	Model spinal cord injury system trends, and implications for the future	Retrospective review; examining changes of model spinal cord injury systems	Individuals with acute traumatic SCI	10	Young patients have equal likelihood of cervical or thoracic injury, older patients show a threefold to fourfold increase in probability of a cervical injury. African Americans are nearly nine times more likely than whites to be injured as a result of violence, and Hispanics are five times more likely than whites to be injured as a result of violence. In some large cities, SCI occurs commonly in minority populations as a result of violence; 43% of traumatic SCI was caused by motor vehicle accidents, with the remaining 57% resulting from fall/hit by object (21.9%), interpersonal violence (18.9%), sport injuries (11.2%), and other (4.9%). Nearly 90% of all model system patients are admitted within 72h after injury, and more than 75% are admitted within 24 h. Patients tend to have both decompression and fusion/fixation done concurrently. Acute care LOS has decreased by approximately 50%, and rehabilitative LOS by 60% over a 24-year period. Most SCI patients achieve nearly perfect FIM cognition scores by discharge.
Pickett et al., 2003	Traumatic spinal cord injury in Ontario, Canada	Retrospective review/epidemiological analysis	All acute care injury hospitalizations in Ontario (includes only injuries resulting from the transfer of energy); admissions were studied for April 1, 1994, through March 31, 1999	12	Annual age-standardized rates declined from a maximum of 46.2 hospitalizations per 1 million population (95% confidence interval 42.1,50.3) to 37.2 per 1 million (95% confidence interval 33.8,41.0). Male rates declined over the study period, whereas female rates remained stable. Leading external causes included unintentional falls (1030 of 2385 [43.2%]), especially among the elderly, and transport injuries (1021 of 2385 [42.8%]), especially among those aged less than 40 years. Intentional injuries were most commonly seen among those aged 20–39 years (48 of 86 [55.8%]). Misclassification of some elder fall cases as spinal cord injuries is a methodological concern.
Demetriades et al., 2005	The effect of trauma center: Designation and trauma volume on outcome in specific severe injuries	Retrospective review/ data bank study	Patients >14 years of age having Injury Severity Scores (ISS) > 15, were alive on admission, and had at least one of the following severe injuries: aortic, vena cava, iliac vessels, cardiac, grade IV/V liver injuries, quadriplegia, or complex pelvic fractures.	19	Level I centers had significantly lower mortality (25.3% vs. 29.3%; adjusted odds ratio [OR] 0.81; 95% confidence interval [CI], 0.71,0.94; $p=0.004$), and significantly lower severe disability at discharge (20.3% vs. 33.8%, adjusted OR 0.55; 95% CI 0.44,0.69; $p<0.001$) than Level II centers. Subgroup analysis showed that cardiovascular injuries ($n=2004$) and grade IV–V liver injuries ($n=1415$) had a significantly better survival in Level I than Level II trauma centers (adjusted $p=0.017$ and 0.023, respectively). Overall, there was a significantly better functional outcome in Level I centers (adjusted $p<0.001$). Subgroup analysis showed that Level I centers had significantly better functional outcomes in complex pelvic fractures ($p<0.001$) and a trend toward better outcomes for the rest of the subgroups. The volume of trauma admissions with ISS scores >15 (<240 vs. ≥240 cases per year) had no effect on outcome in either Level I or II centers.
Jones et al., 2004	Spinal injury centers (SICs) for acute traumatic spinal cord injury (review)	Review of databases: compare randomized controlled trials and controlled trials	Patients admitted to SICs	12	No randomized controlled trials or controlled trials were identified that compared immediate referral to an SIC with delayed referral in patients with a traumatic SCI. All of the studies identified were retrospective observational studies and of poor quality.

(continued)

TABLE 1. (CONTINUED)

Author/Country	Study design					D&B score	Results (list main outcomes first, provide the results for each outcome and p-value).
	Title	Type	Population	Treatment	Outcome measure		
Chen et al., 1999	Medical complications during acute rehabilitation following spinal cord injury: Current experience of the model systems	Review of databases	Persons with new SCI entered into the NSCISC database between 1996 and mid-1998. Mean age of patients = 36.5 years (SD = 16.9 years). male/female: 79%/21%	Survey and analysis of data in the National SCI Statistical Center (NSCISC) database	Patient demographics, mechanisms of injury, clinical outcomes	20	The number of days from injury to admission to rehabilitation has steadily decreased, resulting in the increased potential to develop common secondary medical complications during rehabilitation hospitalization. Pressure ulcers occurred with high frequency and were found to have developed in 23.7% of patients during rehabilitation. Autonomic dysreflexia and atelectasis/pneumonia also occurred with relative frequency during rehabilitation. Conversely, deep vein thrombosis and pulmonary embolism decreased, most likely because of greater awareness of their potential to develop, as well as improved methods of prophylaxis. Cardiopulmonary arrest and gastrointestinal hemorrhage occur with relatively small frequency. The frequency of renal complications is difficult to gauge because of the decreasing number of patients who have any renal testing performed during rehabilitation hospitalization. The mean LOS in rehabilitation has decreased from 92 days before 1992 to 50 days since 1996 ($t = 35.008$, $p < 0.001$).
Aung and Masry, 1997	Audit of a British centre for spinal injury	Retrospective study	New admissions to the Midlands Centre for Spinal Injuries. Average age 44.2 years	Patients were divided into 3 groups: group 1 included early admission, in which the patients were admitted within 1 week of injury; group 2 included delayed admission, in which patients were admitted over 1 week but within 2 months from injury; group 3 included late admissions, for whom patients were admitted over 2 months from injury.	Patient characteristics, type of injuries, time of admission, outcome parameters, and LOS	16	The results show a significant reduction in the incidence of pressure sores in the early-admitted patients, and demonstrate the lowered incidence of both preventable and non-preventable complications, as well as reduction of hospitalization time. Average hospitalization of paraplegic patients varied among the three groups (group 1 = 19 weeks; group 2 = 22 weeks, and group 3 = 74 weeks; $p < 0.001$).

D&B, the method of Downs and Black (1998); LOS, length of stay; SCI, spinal cord injury; MBI, modified Barthel index; CPD, cost per day; CPS, cost per stay; ASCIU, acute spinal cord injury unit; ASCI, acute spinal cord injury; T/SCI, traumatic spinal cord injury or traumatic SCI; NT/SCI, nontraumatic spinal cord injury or nontraumatic SCI; FIM, functional independence measure.

In the study comparing pre-ASCIU and ASCIU periods (Tator et al., 1995), mortality was found to be significantly affected, both for complete and incomplete neurological injuries. In the pre-ASCIU group, 49 patients died (14%) compared to 15 patients (7.5%) in the ASCIU group ($p=0.022$). The most important decline was in the complete group, which saw a decrease from 22.1% to 12.1% in the ASCIU group. The decline was not as substantial in the incomplete group, which decreased from 10.1% in the pre-ASCIU group to 7.8% in the ASCIU group. The complications in the same ASCIU population were associated with a longer LOS and an increase in the total cost of care (Tator et al., 1995).

The benefits of early admission on complications was also shown in a study by Oakes and associates (Oakes et al., 1990). Again, in this series the late-admission group had more complications in the quadriplegic group, who experienced 45% more complications than the early-admission group. This trend was not seen in the paraplegic group.

In the study by Aung and el Masry (1997), the occurrence of pressure sores was reduced in the early-admission group (less than 1 week), compared to the group admitted between 1 week and 2 months, and the group admitted more than 2 months after injury.

In the only study examining medical complications specifically in the rehabilitation period, the authors reported a frequency of 23.7% for pressure ulcers. The authors noted that this may be due to the decreasing LOS in the acute centers, making it more common for medical complications to occur in the rehabilitation setting. (Chen et al., 1999).

Discussion

The Model system in the United States has 14 centers collecting data on patients and three centers responsible for patient follow-up. The Model system has a multidisciplinary approach to the patient with an acute SCI. There are other centers in the United States that treat patients with SCI, but a complete list of these was not available for this review. There are 15 active sites in Canada that are part of the Rick Hansen Registry for SCI, representing 35 facilities including acute SCI centers and rehabilitation units. These specialized centers of care represent nearly all acute and rehabilitation centers treating patients with acute SCI in Canada.

There are no clear requirements or guidelines to determine what a specialized center of care should have available in the U.S. or in Canada. The authors of this review, however, feel that the following features should be taken into consideration when determining what represents a specialized center of care. First, these centers should be located inside or within close proximity of a Level 1 trauma center. A dedicated spinal surgery team with 24-hour on-call coverage should be mandatory. Rapid 24-hour access to an MRI and operating room is also a prerequisite. A "spinal unit" would not only represent a physical space, but would also encompass a wide range of specialists (e.g., physiotherapist, occupational therapist, physiatrist, spine surgeon, nurse coordinator, social worker, and psychologist). Easy referral to a long-term SCI rehabilitation center would also be a logical part of a specialized center of care. The number of SCI patients treated each year should be closely monitored, as expertise in treating these injuries is probably closely related to seeing a certain volume of cases per year. Although the exact number of cases per year

needed to maintain a given level of expertise is unknown (Macias et al., 2009), studies have clearly shown a reduction in the number of paralysis in Level 1 and 2 trauma centers, especially those with higher surgical volumes (odds ratio 0.67). These higher surgical volumes are in contrast with non-trauma centers, where higher caseloads are associated with worse outcomes. This is probably due to the less-than-optimal structure for caring for patients with a traumatic SCI.

Specialized centers of care have radically changed the way patients with SCI are treated. The current systematic review of the literature identified several cohort studies and a few case-control studies, looking at both LOS and complications following transfer to a center of expertise, as well as neurological recovery following admission to a specialized center of care. Length of stay is consistently decreased with early admission to an organized SCI care system. Acute care hospitalization is reduced by almost 50% when patients are treated in a specialized short-term care center. There is also good evidence that delaying transfer of a patient past 48 h significantly increases the overall length of stay. These findings must be taken in context, as it is possible that patients with more severe injuries or more comorbidities may not be transferred as early as other patients, making these findings not as significant. Although the evidence reviewed is weak, it all points in the same direction, namely that specialized centers of care consistently reduce LOS and complications, and improve neurological recovery.

The following recommendations were therefore formulated and presented to a panel of experts:

Recommendation #1: Early transfer of a patient with traumatic SCI to a specialized center of care should be done promptly to decrease overall length of stay.

Recommendation #2: Early transfer of patients with traumatic SCI to an integrated multidisciplinary specialized center of care decreases overall mortality, as well as the number and severity of complications.

Both recommendations were greeted with complete agreement. Although the evidence presented was weak, the strength of the recommendations in both cases was strong, as each received complete agreement from a panel of medical and surgical experts through a modified Delphi approach.

Summary

This systematic review of the literature has shown a reduction in length of stay and decreased overall mortality following early transfer to specialized centers of care for SCI patients. The proposed guidelines both reflect that early transfer of patients with SCI to specialized centers is strongly recommended.

Author Disclosure Statement

No competing financial interests exist.

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