Research Article

Surgical management of patients following traumatic spinal cord injury: Identifying barriers to early surgery in a specialized spinal cord injury center

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Context/Objective: Early surgery in individuals with traumatic spinal cord injury (T-SCI) can improve neurological recovery and reduce complications, costs and hospitalization. Patient-related and healthcare-related factors could influence surgical delay. This study aimed at determining factors contributing to surgical delay in individuals with T-SCI.

Design: Prospective cohort study.

Setting: Single Level I trauma center in Québec, Canada.

Participants: One hundred and forty-four patients who sustained a T-SCI.

Interventions: None.

Outcome measures: Socio-demographic and clinical administrative data were collected during the pre-operative period. The cohort was stratified in early surgery, or ES (<24 hours post-trauma) and late surgery, or LS (≥ 24 hours post-trauma) groups. A multivariate logistic regression analysis using patient- and healthcare-related factors was carried out to identify the main predictors of LS.

Results: 93 patients had ES (15.6 ± 4.7 hours post-trauma), which is 31 hours earlier than the 51 patients in the LS group (46.9 ± 30.9 hours; $P < 10^{-3}$). The transfer delay from trauma site to the SCI center was 8 hours shorter (5.0 ± 3.0 hours vs 13.6 ± 17.0 ; $P < 10^{-3}$) for the ES group, and the surgical plan was completed 17 hours faster (6.0 ± 4.0 hours vs 23.3 ± 23.6 hours; $P < 10^{-3}$) than for the LS group. The occurrence of LS was predicted by modifiable factors, such as the transfer delay to the SCI center, the delay before surgical plan completion, and the waiting time for the operating room.

Conclusions: A dedicated team for surgical treatment of individuals with T-SCI, involving direct transfer to the SCI center, faster surgery planning and access to the operating room in hospitals dealing with emergencies from all subspecialties could improve surgical delay and increase the rate of patients undergoing ES.

Keywords: Delay, Pre-operative management, Prospective study, Spinal cord injury, Surgery

Introduction

Although relatively rare, traumatic spinal cord injuries (T-SCI) have a devastating impact on the physical and psychological status of patients by decreasing quality of life, social participation and productivity.^{1,2} The worldwide estimated incidence of T-SCI varies from 10.4 to 83 cases per million³ due to several regional differences⁴ and trends over time. In Canada, the age-

adjusted incidence of T-SCI is 51.4 cases per million in persons older than 64 years and 42.4 cases per million among those 15–64 years of age.⁵

T-SCI involve a significant financial burden on patients and the healthcare system. Costs of T-SCI to society were estimated in 2006 at 9.7 billion USD per year in the United States.⁹ In Canada, costs in the first year after T-SCI were estimated between 43 400 and 122 900 Canadian Dollars (CAD) (in 2002; 27,637–78,262 USD) depending on the severity of the neurological deficit.¹⁰

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While the majority of patients with an acute T-SCI will undergo surgery for stabilization and/or decompression of the spine, recent studies suggest performing early surgery, ideally within 24 hours of the injury.^{11–16} Early surgery reduces costs and length of hospital stay¹¹ and decreases complication rate.^{12,13} Santos *et al.*¹⁴ developed a simulation model in a Canadian SCI center showing that surgery within 24 hours post-trauma has indirect benefits on quality of life, life expectancy, neurological recovery and occurrence of complications in patients with tetraplegia. Our team showed that early surgery is associated with better neurological status and improvement in AIS grade among patients admitted for a complete cervical T-SCI.¹⁵ Early surgery may be considered as best practice for cervical T-SCI.¹⁶

Many factors can contribute to the surgical delay once the patient is admitted to a specialized SCI center. These include patient-related factors such as a contraindication to early surgery due to, among other reasons, severe traumatic brain injury with intracranial hypertension or concomitant life-threatening injury requiring emergent intervention prior to spine surgery (e.g. severe intra-abdominal or pelvic bleeding, aortic or cardiac injury), as well as healthcare-related factors due to the limited access to the operating room because of a high load of emergent cases. Potentially modifiable factors are transportation delays from the site of trauma, evaluation by the emergency trauma and spine teams, and availability of the operating room. Accordingly, Furlan *et al.*¹⁷ have shown that extrinsic factors, unrelated to the patient's health status, are mostly accountable for the delay between trauma and surgery. However, their study was conducted with a small sample of 63 patients and only cervical T-SCI, and did not account for other possible factors that could influence and delay surgery. Therefore, the objective of this study is to determine the factors contributing to surgical delay in individuals with T-SCI in a single Level-I trauma center specialized in the care of SCI. A secondary objective was to verify if the time intervals were different based on the severity of the neurological deficit of patients with T-SCI.

Materials and methods

Patients

A prospective cohort of 175 consecutive patients with a T-SCI admitted to a single Level I SCI-specialized trauma center between April 2010 and May 2015 was included in this study (138 males and 37 females; 46.4 ± 19.7 years old). Patients entered the cohort at the time of admission and were followed until discharge

from the acute care center. They were included if they sustained a spine trauma that involved a SCI and had surgery performed in our institution. Patients were excluded if the spine injury was below the L1–L2 intervertebral disc or if they were diagnosed with a pre-existing spinal stenosis without overt spine instability. The study was approved by the institutional review board and all patients were enrolled on a voluntary basis.

In the presence of a T-SCI associated with overt spinal instability and/or spinal cord compression, surgeons at our institution will usually proceed with surgery in an attempt to limit the secondary injury to the spinal cord, unless there is a medical contraindication to surgery. A multidisciplinary team composed of the trauma, spine surgery, and physical medicine and rehabilitation teams ensures the acute care of the patient. When the diagnosis is established and surgical treatment is indicated, the surgical unit is informed and the patient is placed on the waiting list, which also includes all surgical emergencies from other subspecialties. Prioritization of all surgical emergencies is under the responsibility of a coordinator.

Data collection and outcomes

Socio-demographic, clinical and administrative data pertaining to the pre-operative period were collected on a daily basis through a prospective database (Quebec Trauma Registry) for all patients admitted at our institution following a traumatic event.

The main healthcare related factor was delay to surgery which was broken down into specific intervals:

- I. Only for patients transferred to a community hospital (CH) prior to arrival at SCI center:
 - a. Delay between trauma and arrival at the CH;
 - b. Delay between arrival at the CH and the emergency room of SCI center;
- II. For all patients:
 - c. Delay between trauma and arrival at the emergency room of SCI center (corresponds to the sum of delays a. and b. for patients transferred from a CH);
 - d. Delay between arrival at SCI center and first medical assessment in the emergency room (ER);
 - e. Delay between first medical assessment in the ER and finalization of surgical plan, corresponding to the moment when the surgical request form is received by the operating room;
 - f. Delay between finalization of surgical plan and beginning of surgery;
 - g. Overall time spent in the emergency room.

Other healthcare-related factors were collected, such as the day patients were transferred to the SCI center, the day for finalization of surgical plan, the subspecialty of the physician performing the first assessment in the

ER of the SCI center, and the distance between the CH and the SCI center for patients not directly admitted to the SCI center.

Patient-related factors consisted of socio-demographic (age, sex) and clinical data: level of spine injury (cervical or thoracolumbar), severity of trauma as measured by the Injury Severity Score (ISS), the Charlson comorbidity index (CCI) providing a weighted score of patients comorbidities, and pre-operative severity of neurological deficit assessed from the American Spinal Injury Association scale (complete – ASIA A vs incomplete – ASIA B, C or D).

Data analysis

We stratified our cohort into two subgroups based on the surgical delay, i.e. time elapsed between the trauma and surgical incision. The early surgery (ES) subgroup included patients who had spine surgery within 24 hours post-trauma, and the late surgery (LS) group had surgery 24 hours or more post-trauma. Continuous data were compared between subgroups using Mann-Whitney *U* tests, while categorical data were compared using χ^2 tests. Continuous data were reported as means $\pm$ one standard deviation, and categorical data were reported as proportions and percentages.

We determined predictors of having LS rather than ES, by investigating 16 factors in a multivariate logistic regression. The patient-related factors were: 1) age; 2) sex; 3) pre-operative severity of neurological deficit (complete – ASIA A vs incomplete – ASIA B, C or D); 4) injury level (cervical vs thoracolumbar); 5) ISS; 6) CCI. The healthcare-related factors were: 7) transfer to a CH or direct admission to the SCI center; 8) delay in arrival at the CH; 9) delay of transfer from

CH to SCI center; 10) distance between CH and SCI center; 11) time in the ER of the SCI center; 12) delay in arrival at SCI center/first medical assessment; 13) subspecialty of physician performing first medical assessment in SCI center; 14) delay between first medical assessment and finalization of surgical plan; 15) delay between finalization of surgical plan and beginning of surgery; 16) day of the week (weekday or weekend day) surgical plan is completed and surgical request form is received by the operating room. All statistical analyses were performed using the IBM SPSS Statistics 21 software (IBM Corp, Armonk, NY, USA).

Results

Among the 175 patients who agreed to participate in the study, 15 were directly admitted from a CH to the specialized spine center without going through the ER, and 16 had surgery more than 7 days post-injury. These 31 patients were excluded from the analysis (leaving 144 patients) because of the potential bias due to the injury occurring outside the province of Quebec and urgent medical conditions that needed to be treated prior to the spine injury. Table 1 details the demographic and clinical characteristics of the 93 patients in the ES and 51 in the LS subgroups. Patients in the ES group were on average 8 years younger than those in the LS group ($P = 0.02$) and had a complete T-SCI in a greater proportion than the LS group ($P = 0.01$), which is consistent with epidemiological studies reporting a greater proportion of incomplete lesions in older patients.^{2,8} The proportion of males and females was the same in both groups, as well as the severity of trauma (ISS) and the comorbidity level (CCI).

Table 1 Demographic and clinical characteristics of patients with T-SCI operated within 24 hours and 24 hours or more post-trauma.

	ES (<24 h)	LS ($\geq$ 24 h)	P
N	93	51	
Surgical delay (mean $\pm$ SD)	15.6 $\pm$ 4.7	46.9 $\pm$ 30.9	$< 10^{-3}$
Age (mean $\pm$ SD)	41.2 $\pm$ 18.5	48.9 $\pm$ 20.1	0.02
Sex			
Male	78.5%	84.3%	0.40
Female	21.5%	15.7%	
CCI (mean $\pm$ SD)	0.25 $\pm$ 0.69	0.25 $\pm$ 0.64	0.82
ISS (mean $\pm$ SD)	27.1 $\pm$ 9.7	25.8 $\pm$ 12.4	0.14
Level of injury			
Cervical	46.2%	60.8%	0.10
Thoracolumbar	53.8%	39.2%	
Severity of neurological deficit			
Complete (ASIA A)	64.1%	42.0%	0.01
Incomplete (ASIA B-C-D)	35.9%	58.0%	

ES, early surgery; LS, late surgery; SD, standard deviation; ISS, Injury Severity Score; CCI, Charlson Comorbidity Index.

Table 2 Average delays ($\pm$ SD) encountered by patients operated within 24 hours post-trauma (early surgery) and 24 hours or more following trauma (late surgery).

Time interval (h)	ES (<24 h)	LS ($\geq$ 24 h)	P
Trauma—Arrival SCI center	5.0 $\pm$ 3.0	13.6 $\pm$ 17.0	$< 10^{-3}$
Trauma—Arrival other CH	1.2 $\pm$ 1.1	3.3 $\pm$ 4.9	0.002
Arrival at other CH—Arrival SCI center	3.8 $\pm$ 2.7	10.3 $\pm$ 15.6	$< 10^{-3}$
Arrival SCI center—Surgery	10.6 $\pm$ 4.3	33.3 $\pm$ 26.5	$< 10^{-3}$
Arrival SCI center—First assessment by MD	2.0 $\pm$ 1.6	3.1 $\pm$ 3.8	0.18
First assessment by MD—Surgical plan completion	6.0 $\pm$ 4.0	23.3 $\pm$ 23.6	$< 10^{-3}$
Surgical plan completion—Surgery	2.6 $\pm$ 2.2	7.0 $\pm$ 12.4	0.31
Trauma—Surgery	15.6 $\pm$ 4.7	46.9 $\pm$ 30.9	$< 10^{-3}$

ES, early surgery; LS, late surgery.

Comparison between early and late surgery subgroups

Interval between occurrence of trauma and arrival at SCI center

A minority of patients with T-SCI (14/144 or 9.7%) was directly transported from the site of trauma to the SCI center without prior transfer in a CH. This proportion was similar between the ES and LS subgroups (χ^2 test: 11% vs 8% of patients with T-SCI, respectively; $P = 0.57$). Not surprisingly, persons who had shorter times from trauma to SCI center were more likely to have ES ($P < 10^{-3}$; Table 2). The delay between trauma and arrival at the SCI center was longer for patients transported to a CH prior to the SCI center (CH: 8.6 hours $\pm$ 11.3 hours; SCI center: 2.4 hours $\pm$ 6.4 hours; $P < 10^{-3}$), which affected the total delay between trauma and surgery, although not significantly (CH: 27.3 hours $\pm$ 24.5 hours; SCI center: 21.0 hours $\pm$ 17.4 hours; $P = 0.09$). The distance between the CH and the SCI center was not different between patients who had ES or LS (ES: 83 $\pm$ 98 km; LS: 128 $\pm$ 159 km; $P = 0.26$). Only 6 patients (3 ES, 3 LS) were transferred to the SCI center by air transportation, from a distance ranging between 503 km and 647 km. All other patients were transferred by road transportation (ambulance, private vehicles, etc.).

The interval between trauma and arrival at the SCI center differed based on the severity of the neurological

deficit (Table 3). Patients with a complete T-SCI were transferred 4 hours faster to the SCI center ($P < 10^{-3}$), which was however not related to whether patients transit to a CH or are directly admitted to the SCI center. There were no differences in the transfer delay from the site of trauma to the SCI center whether patients had a cervical or thoracic/thoracolumbar lesion.

Intervals between arrival at SCI center and beginning of surgery

The delay between arrival at the SCI center and beginning of surgery was three times longer for T-SCI patients who had LS ($P < 10^{-3}$). It can be broken down into three major phases: delay between arrival at SCI center and first medical assessment in the ER; delay between the first medical assessment in the ER and surgical plan completion; and delay between surgical plan completion and beginning of surgery (Table 2). The only significant difference between ES and LS subgroups was for the time between the first medical assessment and completion of surgical plan, which was 4 times shorter and represented 56% of the waiting time for the ES group as compared to 70% of the waiting delay for the LS group ($P < 10^{-3}$; Table 2). There was no significant difference in the time waiting for the first medical assessment and in the delay between surgical plan completion and beginning of surgery between

Table 3 Average delays ($\pm$ SD) encountered by patients with a complete SCI and an incomplete SCI.

Time interval (h)	Complete SCI	Incomplete SCI	P
Trauma—Arrival SCI center	6.4 $\pm$ 12.0	10.2 $\pm$ 9.7	$< 10^{-3}$
Trauma—Arrival other CH	1.6 $\pm$ 2.8	2.4 $\pm$ 3.7	0.006
Arrival at other CH—Arrival SCI center	4.8 $\pm$ 10.8	7.8 $\pm$ 8.8	0.001
Arrival SCI center—Surgery	16.2 $\pm$ 17.9	21.7 $\pm$ 21.1	0.049
Arrival SCI center—First assessment by MD	2.0 $\pm$ 2.2	2.8 $\pm$ 3.1	0.021
First assessment by MD—Surgical plan completion	11.6 $\pm$ 17.2	13.0 $\pm$ 16.0	0.56
Surgical plan completion—Surgery	2.6 $\pm$ 2.7	5.9 $\pm$ 11.1	0.28
Trauma—Surgery	22.6 $\pm$ 22.6	31.9 $\pm$ 25.0	$< 10^{-3}$

Table 4 Logistic regression models for prediction of late surgery (≥ 24 hours post-trauma).

	B	SE-B	Wald	P	Odds (95% CI)
Delay of transfer from CH to SCI center	0.907	0.264	11.770	0.001	2.476 (1.475–4.157)
Delay surgical plan completion—surgery	0.906	0.279	10.541	0.001	2.474 (1.432–4.275)
Delay first medical assessment—surgical plan completion	1.036	0.275	14.242	0.000	2.819 (1.646–4.829)

the ES and LS subgroups. Only one patient was operated for another medical emergency before undergoing spine surgery. This patient required the placement of a cerebral shunt, which resulted in a delayed spine surgery that finally took place 96 hours post-trauma.

Seventy-four percent of patients with a complete T-SCI had ES, as compared to 53% of patients with an incomplete T-SCI ($\chi^2 = 6.450$; $P = 0.011$). The waiting time upon arrival at the SCI center was 5 hours shorter for patients with a complete T-SCI ($P = 0.049$) which contributed, along with the prompter transfer from the site of trauma to the SCI center, to the 9-hour shorter delay trauma-surgery as compared to incomplete patients with T-SCI ($P < 10^{-3}$; Table 3). There were no differences in the duration of each step of patient management once admitted at the SCI center based on the level of injury (cervical or thoracic/thoracolumbar).

Other healthcare-related factors affecting surgical delay

The proportion of patients who had ES or LS was different depending on the day of surgical plan completion and reception of the request form by the OR ($\chi^2 = 4.916$; $P = 0.027$), but not on the day patients with T-SCI were transferred to the SCI center. When the surgical plan was completed and the request form sent to the OR at the end of the week, i.e. between Friday and Sunday, 75% of patients underwent ES. This proportion dropped to 50% when decisions were made during weekdays, i.e. between Monday and Thursday.

There was also a relationship, although not significant, between the subspecialty of the first physician assessing patients upon arrival at the SCI center ER and whether patients were operated within 24 hours or later. Fifty-nine percent of patients who were examined by a spine surgeon had ES, whereas this proportion reached 81% when first assessed by the trauma team ($\chi^2 = 5.197$; $P = 0.07$). There was no relationship between the number of medical assessments received at the ER of the SCI center and the delay between trauma and surgery.

Using a multivariate logistic regression model, we determined that only healthcare-related factors were associated with being in the LS group. These factors were: transfer time between the community hospital and the SCI center, time between first medical assessment and surgical plan completion, and time between surgical plan completion and actual surgery (Table 4).

Discussion

The results of this study show that healthcare-related, modifiable factors are mainly responsible for the delay between trauma and surgery. The most important contributors are the time of transfer from the site of trauma to the SCI center, the interval between the first medical assessment and surgical plan completion, and the delay between surgical plan completion and beginning of surgery. Interestingly, no patient-related factors such as severity of trauma, severity of injury or age were related to surgical delay. This goes along the same lines as what Furlan *et al.*¹⁷ reported, while Samuel *et al.*¹⁸ observed that injury characteristics and pre-existing comorbidities were associated with longer surgical delays in patients with cervical T-SCI.

Our center is a Level-I trauma center serving as the tertiary referral center for T-SCI in western Quebec and as the single referral center for all ventilation-assisted T-SCI in Quebec. Therefore, patients with a T-SCI should systematically be transferred at our center for acute care management. However, our results showed that only 10% of them were directly transferred from the site of trauma to our SCI center. This might be due to the long distance between the trauma site and the SCI center in some patients, considering that hemodynamic instability can occur frequently and would be difficult to manage during transportation on long distances. Nevertheless, patients started being managed by the SCI specialized team within less than 2.5 hours post-trauma, which was 6 hours faster than for patients transported to another CH. Our 2.5-hour delay was also well below what was observed by Harrop *et al.*,¹⁹ where patients sustaining a T-SCI were transported to a Level I or II hospital within 5.2

hours in Pennsylvania. Finally, whether patients were transferred from a CH located at a long distance from the SCI center by air or road transportation did not seem to affect the surgical delay, since 3 out of the 6 patients transferred by air transport had LS surgery, with delays ranging between 28 hours and 96 hours. This goes along the same lines as what was reported by Harrop *et al.*,¹⁹ where long delays from trauma to arrival at the trauma center were observed in patients transferred by helicopter transportation.

The other step in management resulting in the greatest delay was the time between first medical assessment in the ER and surgical plan completion, which is consistent with what was already reported.^{17,18} It was unlikely related to the severity of trauma, since the ISS was similar between ES and LS patients. This interval was 4 times larger for patients who had LS, and was also one of the main predictors of undergoing LS. It represented 56% of the total waiting time for the ES group and 70% for the LS group. This is a smaller proportion of time than what was reported by Samuel *et al.*,¹⁸ where the inpatient waiting time represented approximately 90% of the total surgical delay. As well, Furlan *et al.*¹⁷ reported a 14-hour interval waiting for surgical decision in patients who had LS. This is more than 9 hours shorter than in our study, where patients who had LS waited approximately 23 hours between the first medical assessment and surgical plan completion. Need for medical stabilisation and treatment of more urgent injuries could have an impact on this delay, although the ISS was similar in both groups. This highlights the importance of the dedicated trauma team composed of general surgeons also trained in intensive care, which tend to decrease the waiting time for surgery.

Difficulty in access to specialized imaging (especially MRI) could also be involved, as well as the fact that most of the late surgeries were performed during weekdays. Indeed, it is possible that on some occasions, management of trauma patients arriving during weekdays and requiring surgery will depend upon the availability of the operating rooms and of the spine surgeons, considering the high number of elective cases being performed simultaneously. Also, some patients can be assessed more than once by doctors from different subspecialties while in the ER, such as neurosurgeons, intensivists, trauma specialists, etc., before the spine surgeon who will be establishing the surgical treatment plan. Although our analyses did not show differences in the proportion of ES and LS patients who had multiple medical assessments, this is a factor that most likely affects the time interval before surgical plan completion.

Samuel *et al.*¹⁸ have shown that only 44% of patients with a cervical T-SCI had surgery within 24 hours post-trauma, despite the growing body of evidence supporting the benefits of ES. This rate is below what was obtained in our study, where 64% of patients had ES. They also reported that the majority of patients with a complete cervical T-SCI, i.e. 57%, had ES, as compared to 49% of patients with an incomplete injury. This is consistent with our data, where the proportion of patients with a complete T-SCI undergoing ES was much larger than the proportion of patients with an incomplete T-SCI (74% vs 53%). Shorter waiting time in all steps of management was responsible for the smaller surgical delay for patients with a complete T-SCI.

Could the rate of patients operated within 24 hours post-injury be increased?

In our study, 64% of patients with T-SCI had ES while the remaining 36% had LS, with an average delay of nearly 46 hours. Based on the Canadian studies by Noonan *et al.*²⁰ and Furlan *et al.*,¹⁹ we calculated the number of patients enrolled in our study that could have been operated within 24 hours, had our delays been the same as reported in those studies. We considered the time of transfer from the CH to the SCI center, the delay between the first medical assessment and surgical plan completion, and the delay waiting for the operating room, which were the three main predictors of having LS.

Noonan *et al.*²⁰ demonstrated that direct transport of patients with T-SCI injured within a 20-minute drive of a SCI center significantly increases the number of patients directly admitted to the SCI center. Among patients previously transported to a CH in our study, 54 went to a CH located within 40 km of the SCI center. We can assume that these patients were most likely injured within a 20- to 30-minute drive from our SCI center. Had they been directly admitted to the SCI center, this would have resulted in a 42% rate of direct admissions, most likely resulting in a reduced surgical delay. If we consider that direct admission to the SCI center results in a 4-hour decrease in surgical delay,²⁰ 5 patients transported to a CH within 40 km of the SCI center would have been operated within 24 hours, which represents a 4% increase in ES rate.

With regards to the time waiting for surgical plan completion, Furlan *et al.*¹⁷ reported delays of 4 hours for patients who had ES and 14 hours for those operated later. This is much shorter than the delays obtained in our study, which were 6 hours and 23 hours for the ES and LS groups, respectively. Had this delay been 9 hours shorter for our LS patients, to be consistent with

Furlan's data, 17 additional patients would have had surgery within 24 hours post-trauma, resulting in a 12% increased ES rate. Finally, the other main predictor of LS was the delay between surgical plan completion and beginning of surgery, which was 4 hours longer for patients who had LS. This variable was not considered by Furlan *et al.*¹⁷ and Samuel *et al.*¹⁸ However, if we hypothesize that the average delay between surgical plan completion and beginning of surgery in the LS group was the same as the ES group, i.e. approximately 3 hours, there are 4 patients that would have ended up being operated within 24 hours post-injury.

Based on the growing clinical evidence that prompt surgery in patients with T-SCI is beneficial and favours better outcomes,^{12,13,15,16} changes in logistics to prioritize spine surgeries for T-SCI should be made. The time interval between T-SCI and beginning of surgery could further be reduced by avoiding transporting the patients to a CH when the trauma occurs in a short distance from a specialized SCI center, and by decreasing the waiting time for a surgical decision and the time for access to the operating room. Although this study was conducted in a single SCI center, results could certainly be generalized to other centers. Considering that the care delivery model used at our facility is comparable to what is observed in Canada, where SCI centers are high-volume patient flow Level I trauma centers in nearly all cases (14/15 acute centers; Noonan *et al.* 2012), the main challenge for providing timely care to patients with SCI resides in optimizing the transition delays between and within different phases of patient with SCI management, especially the pre-hospital and SCI center acute care phases. Instituting policies to ensure swift transfer and surgery post-injury for those with T-SCI can ultimately improve outcomes for these patients.

Acknowledgments

The authors acknowledge Anny-Jacques Bernier, medical archivist, for her help with data collection. Data was partially collected through the Rick Hansen Spinal Cord Injury Registry.

Disclaimer statements

Contributors None.

Funding This work was supported by the US Army Medical Department, Medical Research and Material Command [grant number W81WHX-13-1-0396].

Conflict of interest None.

Ethics approval None.

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