Research Article

The impact of acute management on the occurrence of medical complications during the specialized spinal cord injury acute hospitalization following motor-complete cervical spinal cord injury

Andréane Richard-Denis[1,2], Debbie Erhmann Feldman[2], Cynthia Thompson[1], Jean-Marc Mac-Thiong[1,2,3]

[1]Hôpital du Sacré-Coeur, Montréal, Canada, [2]Faculty of Medicine, University of Montreal, Montreal, Canada, [3]Hôpital Sainte-Justine, Montreal, Canada

Context/Objective: Determine the impact of early admission and complete perioperative management in a specialized spinal cord injury (SCI) trauma center (SCI-center) on the occurrence of medical complications following tetraplegia.
Design: A retrospective comparative cohort study of prospectively collected data involving 116 individuals was conducted. Group 1 (N=87) was early managed in a SCI-center promptly after the trauma, whereas Group 2 (N=29) was surgically and preoperatively managed in a non-specialized (NS) center before being transferred to the SCI-center. Bivariate comparisons and multivariate logistic regression analyses were used to assess the relationship between the type of acute care facility and the occurrence of medical complications. Length of stay (LOS) in acute care was also compared.
Setting: Single Level-1 trauma center.
Participants: Individuals with acute traumatic motor-complete cervical SCI.
Interventions: Not applicable
Outcome measures: The occurrence of complications during the SCI-center stay.
Results: There was a similar rate of complications between the two groups. However, the LOS was greater in Group 2 (p=0.04). High cervical injuries (C1-C4) showed an important tendency to increase the likelihood of developing a complication, while high cervical injuries and increased trauma severity increased the odds of developing respiratory complications.
Conclusion: Although complication rates were similar in non-specialized and specialized centers, peri-operative management in a non-specialized center required a longer length of stay. Prompt transfer to a SCI-center may optimize the care trajectory by favoring earlier transfer to rehabilitation.

Keywords: Spinal cord injury, Complications, Specialized centers, Tetraplegia, Acute care

Introduction

Spinal cord injury (SCI) is a devastating event causing significant long-term neurological and functional impacts. Although the incidence of SCI is relatively low as compared to other traumatic injuries, it is estimated that 86,000 persons are currently living with a SCI and half of this number sustain tetraplegia.[1] Patients with tetraplegia are particularly prone to complications as they may suffer from multisystem impairments and severe mobility restriction. This is particularly true during the acute care hospitalization, as the neurologic deficit is at its peak and associated traumatic injuries requiring additional surgical procedures may be present. As a result, the rehabilitation process may be delayed and individuals may be prone to developing complications.

Correspondence to: Andréane Richard-Denis, MD, Department of Medicine, Hôpital du Sacré-Coeur de Montréal, 5400 Boul. Gouin Ouest, Montréal, Quebec, Canada, H4J 1C5. Email: andreane.rdenis@gmail.com

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The occurrence of complications following SCI is associated with increased hospital length of stay (LOS), costs of care and mortality rate,[2,3] and may also impact neurological and functional outcomes.[4,5] While the occurrence of acute complications remains frequent,[6] studies geared towards the improvement of SCI care led to the establishment of specialized acute care centers. Although there are no clear requirements to define them, SCI-centers usually comprise multidisciplinary coordinated care with the objective of optimizing neurological and functional outcomes as well as promoting social reintegration.[7,8]

Managing motor-complete cervical SCI remain a clinical challenge and require the integration skills of many specialists and urgent medical stabilization care.[9] Once medical stabilization is reached, prompt transfer to SCI-center is recommended.[7,8] In Canada, specialized acute care centers are tertiary care designated centers developed to help patients who have sustained an acute SCI and were showed to improve recovery, decreased hospital resources utilization and overall mortality rate.[2,7,8,10,11] In this way, early transfer is recommended (<48 hours) but this recommendation relies on limited evidence (Level V - panel opinion).[8] On the other hand, recent studies have suggested that emergent spinal surgery could improve neurological recovery,[12,13] decrease the incidence of complications[14,15] and reduce costs and length of stay.[16] Thus, after stabilizing a patient with acute cervical TSCI, a decision has to be made whether a prompt surgery at the non-specialized (NS) regional center or direct transfer to the SCI-center should be prioritized. So, optimal timing for transfer to SCI-center should also be established with respect to the spinal surgical procedure and on the amount of specialized perioperative care provided. This is particularly important for motor-complete cervical SCI, as this condition is associated with limited neurological recovery and a high risk of complications.[17]"

Although some studies have addressed the impact of specialized acute SCI-centers on the occurrence of complications,[3,18,19] these studies either compared individuals managed in a NS or a SCI-center for the entire acute care hospitalization, or by comparing individuals transferred at some point to the SCI-center, regardless of the time spent in the NS center. In addition, patients sustaining severe tetraplegia were not specifically examined. Thus, the hypothesis underlying the current study is that complete perioperative and surgical management in a specialized SCI-center will decrease the occurrence of complications. Accordingly, the purpose of this study was to compare the occurrence of complications between patients surgically and preoperatively managed in a non-specialized center (NS) before being transferred to the SCI-center versus individuals promptly transferred to a SCI-center for complete surgical and perioperative management. As a second objective, this study also evaluates the association between the timing of admission to the SCI-center (type of facility- SCI-center vs. NS center) and the occurrence of medical complications during acute care hospitalization using a multivariate regression analysis.

Methods

Patients

We conducted a retrospective cohort study including 116 adult patients (92 males; 24 females) aged 46.0±19.3 years old, consecutively admitted to a single Level I SCI-specialized trauma center between April 2008 and November 2014. The institutional review board approved this study. The severity of the injury was assessed using the ASIA (American Spinal Injury Association) International Standards for neurological classification of SCI. All subjects included in this study sustained a motor-complete cervical traumatic SCI, which was defined as a grade A or B severity on the ASIA impairment scale (AIS), consisting of no preserved motor function through sacral segments.[20] All patients were treated surgically to decompress and stabilize the spine in order to minimize secondary injury to the spinal cord. Individuals treated non-surgically or sustaining a cervical SCI with milder neurological deficits (AIS-C or D, including central cord syndrome) were excluded, as they are recognized to experience better neurological and functional outcomes.

Our cohort was subdivided into two groups based on the timing of admission to the specialized center. Group 1 included 87 individuals "early" transferred to the SCI-center, while Group 2 included 29 patients "lately" transferred to the SCI-center. "Early" transfer was defined as transfer and admission to the SCI-center *prior to the surgical management* in order to received complete peri-operative management by a specialized multidisciplinary team, while Group 2 consisted of 29 patients transferred to the SCI-center *for postoperative management only*. More clearly, patients from Group 2 received pre-operative, surgical and immediate post-operative management in a NS center before being transferred to the SCI-center. Patients from Group 1 could also be first transformed to a NS center after their trauma, but were all surgically managed in the SCI-center.

The organization of SCI care may vary from one province and one country to other. In Quebec, Canada, all

patients sustaining a traumatic spinal cord injury should be directed to one of the two designated acute care centers (SCI-center) according to its location: one center serving the eastern, while the other serves the western part of the province. This system was established in the late 70′s in order to allowed centralization of patients and improve standard of care. Although there are no specific requirements to define these centers in Canada, they are all based on similar characteristics in terms of medical management and rehabilitation resources. Also, in our province, many patients are first transported to non-specialized centers following their SCI. Even if our provincial government strongly encourage prompt transfer to the SCI-center in the pre-operative phase, some non-specialized centers may choose to transfer patients only after surgical management.

Since specialized centers are dedicated to traumatic SCI acute care in our province, they comprise important specific clinical features to this clientele. The SCI-center involved in the current study comprises a specialized multidisciplinary approach that addresses medical, functional, psychological, and social issues. This SCI team is composed of, but not limited to trauma, intensive care, spine surgery and physical medicine and rehabilitation specialists, as well as many therapists and clinical nurses experienced in SCI care. Rehabilitation therapies were provided continuously throughout the hospitalization since admission. Perioperative care in the specialized SCI-center follows evidence-based recommendations for the acute care of SCI patients.[8] Specific clinical protocols are used to systematically manage bowel and bladder care and prevent venous thrombosis, pressure ulcers, contractures, malnourishment and aspiration. A physical medicine and rehabilitation specialist directed the acute rehabilitation process, applying interventions to promote functional and neurological recovery and coordinating the transfer to a functional rehabilitation facility once the patient's condition does not require additional active medical or surgical intervention.

Data collection and outcomes

All data pertaining to the hospitalization at the Level I SCI-specialized acute center was prospectively collected by research assistants. For patients in Group 2, chart review was required to collect information pertaining to the presence of complications upon admission to the SCI-center.

An independent medical archivist performed the retrospective data collection for the following variables: age, sex, body mass index (BMI) and trauma severity as measured by the Injury Severity Score (ISS).[21] The ISS was dichotomized into high (≥ 26) and low trauma severity (<26), based on the observed median value of 26. The neurological level was defined as the most caudal segment with normal motor and sensory function bilaterally and was used to discriminate between high cervical levels (C1 to C4) and lower cervical levels (C5 to C8). The severity of the SCI was assessed at arrival to the SCI-center using the AIS. The presence of a concomitant traumatic brain injury (TBI) was also noted as well as the smoking status (past or active smoking vs. non-smoking). The surgical delay was defined as the time (in hours) between the trauma and the spinal surgery (time of skin incision), and was dichotomized as <24 hours or ≥ 24 hours post-trauma.

Non-neurologic complications

The main outcome (main dependent variable) was the occurrence of non-neurological medical complications during the hospitalization at the SCI-center. A non-neurological complication is defined as a secondary condition developing and diagnosed after the initial trauma, as opposed to a condition directly due to the trauma. Since information regarding the occurrence of complications during the hospitalization in the NS center (prior to transfer to the SCI-center) was generally absent in the transfer records of patients for both groups, this information could not be collected in the present study. However, complications developed previously in the NS center but still present at admission to the SCI-center were noted for both groups.

The following complications were considered: 1) overall respiratory complications, 2) pneumonia, 3) urinary tract infections (UTI), and 4) pressure ulcers (PU). These complications were shown to be the most frequent in acute care hospitalization following SCI.[14] Pneumonia were analyzed separately in the direct comparison analyses since it a very frequent complication in acute tetraplegia.[22] The complication rate refers to the proportion of patients who developed at least one of the above-mentioned complications (including respiratory complications) during their stay at the specialized SCI center, and was expressed as a percentage. The overall respiratory complications included pneumonia, acute respiratory distress syndrome, pulmonary embolism, bronchitis, atelectasis, pulmonary oedema, and pneumothorax. Since the incidence of respiratory complications is high in patients with acute tetraplegia, the occurrence of respiratory complications was also analyzed independently as a sub-analysis. Respiratory complications were diagnosed using clinical features and were confirmed by a radiologist using chest X-rays.[23]

UTI were diagnosed using criteria from the 2006 Consortium for Spinal Cord Medicine Guidelines, based on the presence of significant bacteriuria, pyuria, and signs and symptoms of UTI.[24] Finally, the presence of PU was diagnosed based on the clinical guidelines defined by the National Pressure Ulcer Advisory Panel.[25]

Analysis

T- tests and χ^2 tests were first used to compare baseline characteristics between the two groups (Table 1). Normality of the distribution was assessed using the Kolmogorov-Smirnov test with a significance level set at 0.05. Comparison of the occurrence of medical complications between the two groups was also done using χ^2 tests.

In order to identify independent predictors of the occurrence of medical, and more specifically, respiratory complications during acute care hospitalization (while accounting for confounding patient and injury characteristics) multivariate regression analyses were completed. Our analyses were performed in two steps, in order to optimize our multivariate regression model performance. As a first step, bivariate analyses were done using χ^2 and *t*-tests (for categorical and continuous variables respectively) between patient and injury characteristics and the occurrence of medical complication. Then as a second step, variables that showed an effect ($P \leq 0.1$) with the outcome were included as covariates in the occurrence of medical complications during acute care in a multivariate logistic regression model. A subanalysis was performed for the occurrence of respiratory complications (dependant variable), in order to identify specific predictors of this specific outcome. In other words, analyses were carried with the occurrence of at least one medical complication (overall respiratory, UTI and/or PU) and the occurrence of any respiratory complications as dependent variables in two separate multivariate logistic regression models.

In order to better evaluate the impact of the occurrence of complications, the length of stay (LOS) in the SCI-center was also compared between both groups. IBM SPSS Statistics Version 21 (IBM Corp., Armonk, NY, USA) software package was used for all statistical analyses.

Results

Patient characteristics

The entire cohort for our study consisted in 116 subjects who sustained a traumatic motor-complete cervical SCI. There were 87 patients in Group 1 (SCI-center), while 29 (NS center) were in Group 2.

Socio-demographic and clinical characteristics are shown in Table 1. There were no significant differences between the two groups in terms of age, sex, severity of the SCI (AIS grade), neurologic level of injury, ISS, surgical delay and mortality rate. However, 52.9% patients from Group 1 had a TBI, which was nearly twice as many as for Group 2 (27.6%; $P = 0.02$).

Approximately 70% of individuals experienced at least one complication during the hospital stay at the SCI-center, which was similar for both groups (Table 2). When looking at individual types of complications, there were no differences between the two groups with respect to respiratory complications, pneumonia, UTI and PU.

Patients who were preoperatively managed in the SCI-center (Group 1) were sent sooner to the intensive rehabilitation facility as compared to patients of Group 2 (NS center) (Table 3). Indeed, following their stay in the NS center (mean of 27 days), patients from Group

Table 1 Demographic and clinical characteristics of patients early and lately transferred to a SCI-center following a motor-complete cervical SCI (N=116).

Characteristics		Early transfer (SCI-center-Group 1)	Late transfer (NS center-Group 2)	P-value
N	—	*87*	*29*	—
Age	Mean (SD)	46.0 (19.4)	48.1 (19.3)	0.95
Sex	% Male	78.2	82.8	0.79
ISS	% Higher trauma severity (≥26)	50.6	58.6	0.52
ASIA grade	A	65.5	82.8	0.10
	B	34.5	17.2	
Neurological level	% C1-C4	51.7	62.1	0.39
TBI	% TBI	52.9	27.6	0.02*
In-hospital death	% Deceased	9.2	6.9	0.70
Surgical delay	% <24h post injury	46.0	31.0	0.20
Smoking status	% active or previous smoking	47.1%	44.8%	1.00

N, number of subjects; ISS, Injury severity score; TBI, Traumatic brain injury.

Table 2 Comparison of medical complications and length of stay according the type of perioperative acute care facility following a motor-complete cervical traumatic SCI.

Occurrence of complications		Timing of admission to the SCI-center		P-value
		Group 1 (early transfer)	Group 2 (late transfer)	
At least one (one or more)	%	71.3	72.4	1.00
Overall respiratory	%	54.0	51.7	0.83
Pneumonia	%	47.1	41.4	0.67
Pressure ulcer	%	36.8	34.5	1.00
Urinary tract infection	%	20.7	31.0	0.31

2 were hospitalized in the SCI-center for an additional 20-day period on average (mean of 77.3 and 56.6 days, for Groups 2 and 1 respectively). It is important to note that the surgical delay was similar for both groups (SCI vs. NS center) (Table 1).

Two variables were significantly associated with the overall occurrence of medical complications following bivariate analyses (Table 4) and were then included as potential predictive factors of the occurrence of complications in the multivariate logistic regression model: 1) the neurologic level of injury, and 2) the trauma severity (ISS). The timing of admission to the SCI-center (Group 1 or 2) was also included as a third independent variable in the multivariate regression model despite its non-significance in the bivariate analysis, because it was our main independent variable. Results show that a higher level of cervical injury (C1 to C4) showed a tendency towards increased likelihood of developing a medical complication, with an odd ratio of 2.2 (P = 0.07) (Table 5). In other words, individuals sustaining a high cervical traumatic motor-complete SCI tended to be at higher risk (2.2 times more likely) to develop at least one medical complication (among respiratory complication, PU and ITU) during acute care hospitalization.

Finally, three variables were associated with the occurrence of respiratory complications following bivariate analyses (Table 6) and were subsequently included as potential predictive factors of the occurrence of respiratory complications in the multivariate logistic regression model: 1) the neurologic level of injury, 2) age, and 3) the trauma severity (ISS). Again for the same reason, the timing of SCI-admission (Group 1 or 2) was also included in the multivariate regression model as the fourth independent variable. Results show that a higher level of cervical injury (C1 to C4) and higher trauma severity were significantly associated with the occurrence of respiratory complications, with odd ratios of 3.3 and 2.6 respectively (Table 6). In other words, individuals sustaining a high cervical traumatic motor-complete SCI and higher burden of

Table 4 Factors associated with medical complications and with respiratory complications: Bivariate analysis (N=116).

	Medical complications	P	Respiratory complications	P
Group 1 (early transfer)	71.3%	1.00	54.0%	0.83
Group 2 (late transfer)	72.4%		51.7%	
Male	72.8%	0.61	55.4%	0.50
Female	66.7%		45.8%	
ISS<26	63.6%	0.10*	40.0%	0.01*
ISS≥26	78.7%		65.6%	
AIS-A	72.8%	0.66	56.8%	0.31
AIS-B	68.6%		45.7%	
Level C1-4	79.4%	0.06*	66.7%	0.03*
Level C5-8	62.3%		37.7%	
TBI	66.7%	0.31	56.5%	0.58
No TBI	75.8%		50.0%	
Surgical Delay				
<24h	71.4%	1.00	51.0%	0.71
≥24h	71.6%		55.2%	
Smoker	70.4%	0.84	55.6%	0.71
Non-smoker	72.6%		51.6%	
Age	44.8±18.5 (complications) 49.1±21.1 (no complications)	0.28	45.2±17.5 (complications) 47,0±21.3 (no complications)	0.03*

SCI, Spinal cord injury; NS, Non-specialized; ISS, Injury severity score; AIS, ASIA impairment scale; TBI, Traumatic brain injury; *P is significant if ≤0.2 (only for bivariate analyses).

Table 3 Hospitalization length of stay (LOS) in patients with a motor-complete cervical spine injury early and lately transferred to the SCI-center (Group1 and 2).

Hospitalization stay (in days)			Early transfer (SCI-center-Group 1)	Late transfer (NS center-Group 2)	P-value
Prior to SCI-center admission	Regional center (NS center)	Mean (SD)	1.2 (7.4)	27.4 (26.5)	<0.001*
From admission to discharge of the SCI-center		Mean (SD)	56.6 (51.5)	77.3 (44,2)	0.04*
Total acute care hospitalization		Mean (SD)	57.6 (53.1)	104.7 (54.2)	<0.001*

ICU, Intensive care unit; NS, non-specialized center; *P is significant if <0.05.

Table 5 Factors associated with the occurrence of medical complication during the acute care hospitalization using multivariate logistic regression analyses (N=116).

Variable	Odd ratio	95%CI	P-value
Timing of admission to the SCI-center			
Group 1 (early transfer)	1[d]	—	
Group 2 (late transfer)	1.1	(0.4; 2,9)	0.87
Neurologic level of injury			
C1–C4	2.2	(0.9; 5.1)	0.07
C5–C8	1[d]	—	
ISS			
<26	1[d]	—	
≥26	2.0	(0.84; 4.5)	0.12

1[d], reference category; ISS, Injury severity score, *P is significant if ≤0.05.

associated traumatic injuries were 3.3 times more likely to develop respiratory complications during acute care hospitalization.

Discussion

This study assesses the occurrence of complications during the acute hospitalization phase with respect to the timing of admission of the SCI-center following a motor-complete cervical SCI. Results of this study indicate that the rate of medical complications during the SCI-center stay was similar for individuals early and lately managed in the SCI-center (Group 1 or 2). However, results also suggest that individuals transferred to the SCI-center after spinal surgery, were hospitalized significantly longer in acute care.

The rate of medical complications in this study was nearly 70% for both groups, which is at the higher end of previously reported data, ranging from 20% to 84% worldwide.[6,26–28] This great variability may be attributed to the different methods and definitions employed. Data on complications in this study were collected prospectively, similar to Grossman *et al.*[28] who also used a prospective data collection and reported a rate of 84% in patients with complete SCI. Others used a retrospective data collection and may have not had a complete picture of all the medical complications.[6,26,27]

Table 6 Factors associated with the occurrence of respiratory complications during the acute care hospitalization using multivariate logistic regression analyses.

Variable	Odd ratio	95%CI	P-value
Timing of admission to the SCI-center			
Group 1 (early transfer)	1[d]	—	
Group 2 (late transfer)	0.7	(0.3; 1.8)	0.50
Neurologic level of injury			
C1–C4	3.3	(1.5; 7.4)	<0.01*
C5–C8	1[d]	—	
Age	0.99	(0.9; 1.0)	0.60
ISS			
<26	1[d]	—	
≥26	2.6	(1.2; 5.8)	0.02*

1[d], reference category; ISS, Injury severity score; *P is significant if ≤0.05.

Specialized acute care SCI-centers improve outcomes and decrease the occurrence of complications following a SCI.[7,11] Surprisingly, results of this study did not confirm the initial hypothesis of this study of a lower occurrence of medical complications in Group 1, since the complication rate was similar between the two groups. Moreover, the timing of admission to the SCI-center was not predictive of the occurrence of medical complications in our regression models. It is however important to underline that complications developing in the NS center and resolved at the time of admission in the SCI-center were not included in the current study. It is thus possible that the number of complications was underestimated in Group 2, considering that the average stay in the NS center prior to transfer was considerable (27.4 ± 26.5 days), ample time to develop a complication and for it to resolve. On the other hand, the rate of medical complications for Group 1 might have been overestimated since there was a higher proportion of concomitant TBI in this group, which was found to be is a risk factor of complications following SCI.[29,30]

Considering that complete acute care management in a NS center was previously shown to be associated with a higher complication rate,[7,11,18] referral to a SCI-center following surgery seems beneficial in order to prevent the expected increase in complication rate for patients managed exclusively in a NS center. Lowering the complication rate following surgery in a NS center to a level similar to that achieved with complete management in a SCI-center could require additional efforts and resources, as suggested by the longer LOS in the SCI-center for Group 2 despite a mean of 27 days already spent in the NS center. Moreover, 10.3% of patients in Group 2 were admitted to the SCI-center with existing complications developed during their stay at the NS-center, which would require additional care from the SCI-center team in order to promote the healing process but also to prevent recurrence.[31] Since the rate of AIS-A was slightly higher in Group 2 (however not significant (P = 0.1)), we have performed an additional comparison analysis suggesting that the rate of respiratory complications for Group 1 and 2 was similar for C1–4 and C5–8 levels (P = 0.61 and P = 0.33

respectively). This additional result supports our discussion, since we believe that a similar rate of complications may be attributed to two things: 1) the fact that complications that have occurred prior to the SCI-center admission were not collected in this study; 2) higher SCI-center resources were required in order to catch up the complication rate achieve in Group 1 (completely managed in the SCI-center).

The occurrence of medical complications during the SCI-center stay was associated with a high level of cervical SCI. Motor-complete SCI is recognized as the main predictor of worst neurological and functional outcomes[13,17] and is a predictive factor for the occurrence of acute complications.[6] Since only motor-complete tetraplegia was included in this study, the level of injury was expected to be a significant predictor of complication occurrence. Indeed, individuals sustaining higher level of cervical SCI may suffer from severe respiratory and cardiovascular dysfunction[9] as well as severe mobility restriction, dependency for activities of daily living, bed mobility and transfers,[22,32] which may ultimately lead to medical complications.

The occurrence of respiratory complications was associated with the level of cervical injury and higher trauma severity. High cervical motor-complete SCI is typically associated with severe respiratory, cardiovascular and mobility dysfunction.[9] More particularly, C1–C4 patients may sustain a combined dysfunction of the inhalation and exhalation muscles, leading to respiratory insufficiency, increased airway resistance and impaired secretion clearance.[33] Moreover, dysphagia is also frequently diagnosed in the acute and subacute periods following the injury.[34] As a result, these individuals are particularly prone to respiratory infections and complications; they also may require mechanical ventilation assistance and prolonged intensive care stay.[35]

The LOS in the SCI-center was significantly longer for individuals transferred after surgery in a NS center. Many factors could influence the acute care LOS, including early admission to specialized SCI-center.[7,36] Indeed, early management by a specialized multidisciplinary team may help to optimize the use of hospital resources and facilitate eventual transfer to the functional rehabilitation center.[2,37] SCI-centers deal with a larger population of patients with SCI, and may therefore be better at early recognition and prevention of risk factors contributing to common complications. Thus, we may hypothesized that a higher intensity of hospital resources was required to manage patients that have not benefit from a specialized multidisciplinary approach from the pre-operative phase.

The purpose of this study was essentially to evaluate, in terms of medical complications, consequences of a late transfer to SCI-center. However, it is also important to hypothesized reasons for such retention in NS center for Group 2. To do so, a better understanding of the healthcare system involved in this study is primordial. In Quebec, all patients sustaining a traumatic SCI should be directed to one of the two designated acute care centers (SCI-center) according to its location: one center serving the eastern, while the other serves the western part of the province. This designation was established in the late 1970s in order to allowed centralization of patients and improve standard of care. In our province, many patients are first transported to NS centers following their SCI. Even if our provincial government strongly encourage prompt transfer to the SCI-center in the pre-operative phase, some non-specialized centers may choose to transfer patients only after surgical management. In that context, preference of the families or preference of the patient for specific institutions is less likely to explain retention from Group 2. Then, patients or injury characteristics seem also unlikely to have caused retention since both groups were similar on all aspects ($P > 0.05$) except for a significant higher number of TBI in Group 1, which rather contradicts retention for Group 2 (as they may be similarly injured or less). Location of the injury could also be a plausible cause. In fact, emergent conditions such as medical instability, serious associated injuries, or simply the fact that some patients may have not be first suspected of SCI should justify transfer to the nearest NS center in first place, particularly in remote patients. But according to our legislation, transfer to the SCI-center should be performed prior to spinal surgery when medical stabilization is reached, which is supported by results of this study. We should also mention that the great majority of patients from Group 2 were managed in hospitals located within less than 10 km away from our SCI-center. It is therefore difficult to issue conclusions for retention of patients from Group 2.

Finally, even if this study was performed in a specific healthcare system, our results remain relevant elsewhere, as all patient with traumatic SCI require hospitalization in acute care setting. In other words, every healthcare system should aim to decrease complication rate and acute care resources (in terms of length of stay). This paper essentially suggests that prompt transfer of patients with motor-complete tetraplegia before surgical management to a specialized or dedicated facility is beneficial.

Study limitations

The main limitation of this study is the small number of patients, particularly for Group 2, limiting the statistical power of this study, thus a type 2 error is not excluded. Also, since patients in Group 2 came from different hospital centers, patient management may vary in the different centers, which may have influenced our results and limit the external validity of this study. Thus, a prospective multicenter study including a higher number of patients, and recording of the complication occurrence from the injury (in the pre-transfer phase in Group 2) should be addressed in the future.

Data pertaining to the surgical intervention was not collected in this study. However, since the surgical delay was similar and the purpose of spinal surgery following an acute cervical SCI remains realignment and decompression of the spinal canal for both groups, it is unlikely that differences in the surgical procedure influenced the results of this study.

Conclusions

This study suggests that the complication rate is similar for subjects managed in a non-specialized center (NS-center) and specialized center following a traumatic motor-complete cervical SCI. However, management in a NS-center was significantly associated with delayed admission to intensive functional rehabilitation. Although the occurrence of medical complications prior to the SCI-center was not retrieved in this study, our results still suggest that perioperative management in a NS-center may require higher hospital resources utilization (in terms of length of stay in the NS-center and in the SCI-center) in order to reach similar complication rate than individuals managed from the pre-operative phase in a specialized SCI-center. Prompt transfer to a SCI-center before surgery for motor-complete cervical SCI may optimize the care trajectory by favouring earlier transfer to rehabilitation.

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