Research article

Inpatient rehabilitation outcomes in patients with malignant spinal cord compression compared to other non-traumatic spinal cord injury: A population based study

**Christian D. Fortin^{1,2}, Jennifer Voth², Susan B. Jaglal^{2,3,4,5,6},
B. Catharine Craven^{1,2,6}**

¹Division of Physiatry, Department of Medicine, University of Toronto, Toronto, ON, Canada, ²Toronto Rehabilitation Institute, University Health Network, Toronto, ON, Canada, ³Institute for Clinical Evaluative Sciences, Toronto, ON, Canada, ⁴Graduate Department of Rehabilitation Science, University of Toronto, Toronto, ON, Canada, ⁵Department of Physical Therapy, University of Toronto, Toronto, ON, Canada, ⁶Department of Health, Policy, Management and Evaluation, University of Toronto, Toronto, ON, Canada

Objective: To compare and describe demographic characteristics, clinical, and survival outcomes in patients admitted for inpatient rehabilitation following malignant spinal cord compression (MSCC) or other causes of non-traumatic spinal cord injury (NT-SCI).

Design: A retrospective cohort design was employed, using data retrieved from administrative databases.

Setting: Rehabilitation facilities or designated rehabilitation beds in Ontario, Canada, from April 2007 to March 2011.

Participants: Patients with incident diagnoses of MSCC ($N = 143$) or NT-SCI ($N = 1,274$) admitted for inpatient rehabilitation.

Outcome measures: Demographic, impairment, functional outcome (as defined by the Functional Independence Measure (FIM)), discharge, healthcare utilization, survival, and tumor characteristics.

Results: There was a significant improvement in the FIM from admission to discharge (mean change 20.1 ± 14.3 , <0.001) in the MSCC cohort. NT-SCI patients demonstrated a higher FIM efficiency (1.2 ± 1.7 vs. 0.8 ± 0.8 , <0.001) and higher total (24.0 ± 14.4 vs. 20.1 ± 14.3 , <0.001) FIM gains relative to MSCC cases. However, there were no differences between the MSCC and NT-SCI cohorts in length of stay (34.6 ± 30.3 vs. 37.5 ± 35.2 , $P = 0.8$) or discharge FIM (100.7 ± 19.6 vs. 103.3 ± 18.1 , $P = 0.1$). Three-month, 1-year, and 3-year survival rates in the MSCC and NT-SCI cohorts were 76.2% vs. 97.6%, 46.2% vs. 93.7%, and 27.3% vs. 86.7%, respectively. The majority (65.0%) of patients with MSCC was discharged home and met their rehabilitation goals (75.5%) at comparable rates to patients with NT-SCI (69.7 and 81.3%).

Conclusion: Despite compromised survival, patients with MSCC make clinically significant functional gains and exhibit favorable discharge outcomes following inpatient rehabilitation. Current administrative data suggests the design and scope of inpatient rehabilitation services should reflect the unique survival-related prognostic factors in patients with MSCC.

Keywords: Population, Rehabilitation, Spinal cord compression, Spinal cord diseases, Spinal cord neoplasms

Introduction

Malignant spinal cord compression (MSCC) resulting from the progression of malignant disease has the

potential to cause significant disability and decreased survival.¹ Metastatic epidural spinal cord compression, the most common subset of MSCC,² is the neoplastic metastasis to the spine or epidural space, causing true displacement³ and compression of the spinal cord.⁴ It can result in rapidly progressive pain and neurologic

Correspondence to: B. Catharine Craven, Toronto Rehabilitation Institute, Lyndhurst Centre, 520 Sutherland Drive, Toronto, ON M4G 3V9, Canada. Email: cathy.craven@uhn.ca

dysfunction,⁵ and is considered among the most severe consequences of cancer.⁶ The MSCC population is heterogeneous; however, common physical impairments that impact quality of life and functional independence include neuropathic and nociceptive pain, immobility, bowel and bladder dysfunction, and loss of skin integrity.⁷

Inpatient rehabilitation services will take greater prominence in the management of MSCC-related impairments with advances in its detection, medical and surgical management, and survival.⁸ A recent systematic review of retrospective cohort studies suggests that patients with neoplastic myelopathy achieve comparable gains in the Functional Independence Measure (FIM) score relative to their non-cancer counterparts with similar impairments.⁹ In the only study that has prospectively evaluated the efficacy of rehabilitation following MSCC, 12 non-ambulatory veterans with paraplegia secondary to spine metastases were non-randomly allocated to a two-week course of inpatient rehabilitation. Compared to a historical control group, the rehabilitation group exhibited improved pain, depression, and life satisfaction scores, along with prolonged survival, and greater independence in transfers; more importantly, there was an increased likelihood of home discharge compared to other veterans not receiving rehabilitation.¹⁰ A follow-up of the study cohort demonstrated that the benefits accrued from inpatient rehabilitation persisted until death.¹¹

A patient's decision to pursue inpatient rehabilitation following MSCC or a healthcare provider's decision to offer it will be tempered by the reality of limited survival. A meta-analysis of 38 studies of MSCC patients with paraplegia reports one-year survival rates ranging from 12 to 58%, with median survival ranging from 2.4 to 30 months.¹² Personal and economic factors should be considered when weighing the value, duration, content, and setting for optimal rehabilitation service delivery. In Ontario, inpatient rehabilitation is indeed the largest short-term system cost driver in the traumatic spinal cord injury population.¹³ Rehabilitation costs in the non-traumatic spinal cord injury (NT-SCI) population have not been reported in Ontario but are likely considerable. Among patients with MSCC, even more difficult to quantify is the opportunity cost of rehabilitation in terms of time away from family members and loved ones in the context of finite survival.¹⁴

Current research on rehabilitation following MSCC^{15–26} is comprised of predominantly small retrospective chart reviews with sample sizes ranging from 26²⁴ to 108^{25,26} patients, in a maximum of seven centers.¹⁶ Though some of these studies have compared

outcomes in patients with MSCC and traumatic spinal cord injuries,^{18,19} none have utilized a comparator NT-SCI cohort. A population-based study with a comprehensive analysis of survival and rehabilitation outcomes would be ideally suited to identify patient demographic and clinical characteristics that impact rehabilitation potential and outcomes. The objectives of this study are to describe demographic, impairment, functional outcome, discharge, healthcare utilization, survival, and tumor characteristics in patients admitted for inpatient rehabilitation following MSCC in Ontario, Canada, between 2007 and 2011, and to compare these variables to a representative NT-SCI cohort.

Methods

Setting

The approximately 12 million residents of Ontario are universally insured under a publicly-financed healthcare program, which covers a comprehensive array of services including inpatient and outpatient rehabilitation. Inpatient rehabilitation occurs in standalone facilities or in acute care hospitals that contain designated rehabilitation beds.

Design

A retrospective cohort study design was employed, using administrative data sets that were held securely in a linked, de-identified form and analyzed at the Institute for Clinical Evaluative Sciences (ICES). Demographic, impairment, functional outcome, discharge, healthcare utilization, survival, and tumor data for patients admitted to inpatient rehabilitation were examined and compared among patients with MSCC and NT-SCI.

Data sources

Data were retrieved from administrative healthcare databases²⁷ in Ontario, as described elsewhere.^{28,29} The Canadian Institute for Health Information Discharge Abstract Database (DAD) contains hospital records with, among other data, diagnoses as indicated by entries under the International Classification of Diseases and Related Health Problems, 10th Revision, Canadian Enhancement (ICD-10-CA).²⁷ The Ontario Registered Persons Database (RPDB) contains information regarding vital statistics, including deaths. The National Ambulatory Care Resource System (NACRS) database contains healthcare utilization data such as information regarding patient visits to emergency departments. The National Rehabilitation Reporting system (NRS) database contains a variety of data regarding patients discharged from inpatient

rehabilitation, including functional outcomes defined by FIM score, the level of neurologic spinal injury according to the International Standards for Neurological Classification of Spinal Cord Injury,³⁰ discharge reason, and discharge destination.³¹

Study population

The study population was comprised of patients admitted to inpatient rehabilitation in Ontario following an incident diagnosis of MSCC. Patients were considered to have an incident MSCC diagnosis if they had a hospitalization record containing ICD-10-CA codes corresponding to myelopathy (G99.2, 'myelopathy in diseases classified elsewhere'; G95.2, 'cord compression, unspecified'; and/or; G95.9, 'disease of the spinal cord, unspecified') and malignant neoplasia (C00-C97). An index event was defined as an admission to inpatient rehabilitation from 0 to 7 days following discharge from an acute care hospital for an incident diagnosis of MSCC, from April 1, 2007 to March 31, 2011.

The comparator group was comprised of patients with NT-SCI admitted to inpatient rehabilitation during the above four-year accrual period, excluding patients considered to have a diagnosis of MSCC, i.e. members of the study population. NT-SCI cases were identified from the Rehabilitation Client Groups (RCG) 04.1–04.13 in the NRS database.³¹ Patients are categorized into one of 17 RCGs, which best describes the primary reason for inpatient rehabilitation.²⁹ ICD-10-CA codes were not used to identify NT-SCI cases as this system is suboptimal in classifying and accounting for NT-SCI.²⁹ Utilization of the RCG coding system ensured that the incident diagnosis of NT-SCI was the primary reason for inpatient rehabilitation, over an ancillary one, thereby serving as an appropriate rehabilitation outcome benchmark following an incident diagnosis of MSCC.

Exclusion criteria for the MSCC and NT-SCI cohorts were age younger than 18 years, unspecified gender information and rehabilitation discharge after March 31, 2011. We also excluded cases with a past diagnosis of traumatic spinal cord injury using the respective databases from which the study cohorts were derived. Thus, we excluded patients from the MSCC cohort who had a hospitalization for a previous traumatic spinal injury in or after April 2002, the month the ICD-10-CA iteration became operative in the DAD database. ICD-10-CA codes corresponding to traumatic injury to all anatomic regions of the spinal cord were utilized, as described elsewhere.²⁸ Likewise, cases in the NT-SCI cohort were discarded if there was a previous inpatient rehabilitation admission for traumatic spinal cord injury, as

classified by the RCG groups in the NRS database, which was created in April 2000. A further exclusion criterion for the NT-SCI cohort was rehabilitation admission in the previous year, for the purpose of capturing incident cases only and minimizing the inclusion of cases of progressive myelopathy.²⁹ After initiating the process of data extraction, patients were excluded if there were no discharge data within the NRS database or if the reported death predated rehabilitation admission.

Outcome measures and variables

Demographic variables included age and gender. Clinical characteristics included the level of neurologic injury and primary tumor site. The primary tumor site was determined using ICD-10-CA codes recorded in the DAD database. Patients with entries corresponding to secondary malignancy (C77–C79), or an unspecified malignancy (C80, 'malignant neoplasm, without specification of site'), were classified as having an unknown or unspecified malignancy if there was no coexisting entry identifying the malignancy between April 1, 2006 to March 31, 2011. Patients with greater than one code from C00–C76 and C80–C96 were classified as having greater than one malignancy. We did not encounter the ICD-10-CA code C97 in any MSCC cases ('Malignant neoplasms of independent (primary) multiple sites').

Functional outcomes data included FIM motor and cognitive subscale scores,³² FIM change (the difference of FIM discharge and admission scores), and FIM efficiency (the quotient of FIM change and length of stay, in days). Discharge data included post-discharge living setting and reason for discharge. Healthcare utilization data included emergency department visits and readmission to acute care during inpatient rehabilitation, and rehabilitation length-of-stay. Survival was measured from the time rehabilitation admission. The rationale of calculating survival from the admission date was to demonstrate survival relative to the rehabilitation length of stay rather than generally from the time of diagnosis of MSCC or NT-SCI.

Data analysis

Descriptive statistics were performed to describe demographic, clinical characteristics, functional outcomes, and survival for the MSCC and NT-SCI cohorts. Differences between MSCC and NT-SCI cohorts with respect to age, functional outcomes, length of stay, acute care readmissions and emergency department visits, and survival (total days from rehabilitation admission) were examined using the Mann–Whitney

U test. χ^2 analyses were employed to compare differences in sex, discharge destination, reason for discharge, and 3-month, 1-year, and 3-year survival from the rehabilitation admission date. Kaplan-Meier analysis was conducted to estimate median, 3-month, 1-year, and 3-year survival for MSCC and NT-SCI cohorts, and the log-rank test was used to compare differences in survival between the two cohorts. Data were analyzed using SAS 9.3® (SAS Institute, Inc., Cary, NC, USA). All tests were two-tailed and *P*-values <0.05 were considered statistically significant. Cell sizes representing fewer than six patients were suppressed, for the purposes of protecting patients' privacy.

Ethics approval

The study was approved by ICES and the research ethics board of the Sunnybrook Health Sciences Centre.

Results

Demographic information and rehabilitation settings

The application of exclusion criteria yielded 143 patients in the MSCC cohort and 1,274 patients in the NT-SCI cohorts (Fig. 1). A total of 57 MSCC patients were excluded from the NT-SCI cases (the remaining 86 MSCC cases were classified into other RCGs, such as the Debility and Medically Complex groups). There were 41 and 59 rehabilitation sites or facilities represented by the MSCC and NT-SCI cohorts, respectively. There were no significant differences in age (*P* = 0.3) or sex (*P* = 0.6) between the two cohorts (Table 1). There were few patients with tetraplegia in the MSCC (<6) compared to the NT-SCI cohort (14.7%) and the vast majority of cases in both cohorts had an unspecified level of injury.

Functional measures

There were no significant differences in the total admission FIM scores (Table 1) and within the admission cognitive (33.2 ± 4.2 vs. 32.3 ± 4.4 , *P* = 0.2) and motor (47.4 ± 15.6 vs. 46.5 ± 16.3 , *P* = 0.5) FIM subscores for the MSCC and NT-SCI cohorts, respectively. No significant differences were observed in the discharge total, and cognitive FIM subscores between the MSCC and NT-SCI cohorts, but there was a significantly higher discharge motor subscore in the NT-SCI cohort (70.4 ± 16.8 vs. 67.5 ± 17.5 , *P* < 0.05). Wilcoxon signed rank tests demonstrated significant differences in FIM change scores in the total and motor (19.8 ± 13.8 , *P* < 0.001) subscores, but not the cognitive subscore (0.4 ± 2.0 , *P* > 0.05) within the MSCC cohort. Overall, NT-SCI patients demonstrated a higher FIM efficiency and

higher total, cognitive (0.7 ± 2.8 vs. 0.4 ± 2.0 , *P* < 0.001), and motor (23.4 ± 13.6 vs. 19.8 ± 13.8 , *P* < 0.01) FIM subscore gains relative to MSCC cases. There was greater variability of FIM efficiency in the NT-SCI cohort compared to the MSCC cohort (Fig. 2).

Survival and discharge characteristics

Survival rates were much higher in the NT-SCI cohort in total and at 3 months, 1 year, and 3 years compared to the MSCC cohort (Table 2). Approximately 25% of patients with MSCC died within three months of inpatient rehabilitation admission, and approximately another 25% survived greater than three years. Furthermore, median survival time from rehabilitation admission for the MSCC cohort was 9.5 months (288 days) vs. 36 months (1096 days) among the NT-SCI cohort (*P* < 0.0001).

No significant differences in inpatient rehabilitation length-of-stay were observed between the two cohorts. Patients with MSCC had twice as many readmissions to acute care facilities but similar numbers of emergency department presentations during the rehabilitation stay compared to the NT-SCI cohort, though data analyses revealed statistical significance in both cases. NT-SCI cohort members were more than twice as likely to be discharged home without paid services. However, there were comparable rates of home discharge (65.0% vs. 69.7%) and rehabilitation goals having been met (75.5% vs. 81.3%) in the MSCC and NT-SCI cohorts, respectively. Although a small minority of patients in the MSCC and NT-SCI groups failed to meet their rehabilitation goals, this was more likely to occur in the MSCC group (20.3% vs. 11.5%).

Tumor characteristics

Most MSCC cases were classified as having an unknown or unspecified primary tumor type (Table 3). The most common occurring primary malignancy sites in the MSCC cohort, in descending order, were prostate, myeloma, lymphoma, breast, and lung, followed by other sites for which there were fewer than 6 cases.

Discussion

This study demonstrates that, despite compromised survival, patients with MSCC make functional gains and meet their goals as a result of inpatient rehabilitation. There were comparable admission and discharge FIM scores along with similar lengths of stay between the two groups, suggesting that patients with MSCC make meaningful gains in rehabilitation despite the burden of underlying malignancy. Our finding of statistically higher FIM change and motor discharge FIM subscores

Figure 1 Cohort selection flow diagrams for the study (MSCC) and comparison (NT-SCI) cohorts.

in the NT-SCI may not be clinically significant, especially in the context of goals that are adapted for limited survival in patients with MSCC. Indeed, a majority of cohort members with MSCC were discharged home and met rehabilitation goals at comparable rates to the NT-SCI cohort. However, patients with MSCC were more likely to have rehabilitation interrupted by re-admission to an acute care hospital. Approximately a quarter of these patients died within three months of admission for rehabilitation services. Fortunately, approximately a quarter survived longer than three years.

To our knowledge, this is the first study that uses administrative data to compare rehabilitation, survival, and discharge outcomes in relatively large populations of patients with MSCC and NT-SCI. A single prior US population-based study of NT-SCI patients, based on Medicare data files from 479 rehabilitation facilities, showed significantly lower self-care and mobility discharge FIM subscores for patients with MSCC compared to those with other causes of NT-SCI, namely, degenerative spine disease and benign spinal neoplasia; however, this study did not report survival patterns and was limited to patients aged 65 to 74 years.³³ Our study reports data across a full spectrum of adult ages, with about 20% of patients under the age of 50. Furthermore, our study used population-based data that was from available from all rehabilitation facilities in Ontario, thereby minimizing the effect of site-to-site

differences in rehabilitation admission criteria and the spectrum of rehabilitation services offered.

This study also attempted to define rehabilitation outcomes as a function of primary tumor site. Unfortunately, we were unable to identify the primary malignancy in approximately one quarter of patients; however, the distribution of cases with defined neoplasia approximated the ranges previously reported, with prostate, lung, breast, and hematologic cancers as the highest represented malignancies in the MSCC cohort.^{2,4} Although the cases by individual tumor site were relatively small, our results might assist healthcare providers and patients in their decisions to offer or accept inpatient rehabilitation following MSCC. Of note in our study, breast cancer patients were among the youngest of inpatient rehabilitation patients following MSCC and had relatively prolonged survival from rehabilitation admission, suggesting that these patients spent relatively small proportions of their survival in rehabilitation. Conversely, of the patients who died during the study period, those with lymphoma had the lowest median survival, raising the possibility of excessive rehabilitation lengths of stay, especially for patients who favor family life over health and physical independence.³⁴ Future analyses of larger sample sizes may be better able to delineate rehabilitation outcomes by primary tumor sites.

The survival and outcome variables of patients with MSCC fall within the ranges reported in previously

Table 1 Demographic and impairment data, and FIM subscale outcomes of MSCC and NT-SCI cohorts, fiscal years April 1, 2007 to March 31, 2011

Variable	MSCC (N = 143)	NT-SCI (N = 1274)	P-value*
Age at admission			
Mean $\pm$ SD	62.7 $\pm$ 15.1	64.3 $\pm$ 15.1	0.3
Median	66	67	
≤ 50 years	30 (21.0%)	233 (18.6%)	
> 50 years	113 (79.0%)	1041 (81.7%)	
Sex			0.6
Male	76 (53.1%)	650 (51.0%)	
Female	67 (46.9%)	624 (49.0%)	
Level of injury			
Paraplegia	32 (22.4%)	85 (6.7%)	–
Tetraplegia	–	187 (14.7%)	
Unspecified**	111 (77.6%)	1002 (78.6%)	
Admission FIM***			0.5
Mean $\pm$ SD	80.2 $\pm$ 17.4	78.8 $\pm$ 17.9	
Median	80	80	
Range	19 to 114	17 to 120	
Discharge FIM***			0.1
Mean $\pm$ SD	100.7 $\pm$ 19.6	103.3 $\pm$ 18.1	
Median	107	110	
Range	93 to 114	97 to 116	
FIM change***			< 0.001
Mean $\pm$ SD	20.1 $\pm$ 14.3	24.0 $\pm$ 14.4	
Median	19	23	
Range	9 to 32	15 to 32	
FIM efficiency***			< 0.001
Mean $\pm$ SD	0.8 $\pm$ 0.8	1.2 $\pm$ 1.7	
Median	0.6	0.7	
Range	–0.1 to 4.3	–2.7 to 20.0	

*The Mann–Whitney *U* test was utilized for all analyses, except for sex, for which a χ^2 test was performed.

**Patients with tetraplegia grouped with 'Unspecified' for MSCC cohort, based on cell size restrictions. Statistical analysis was not performed because tetraplegic cases were consolidated into the Unspecified category.

***In the analysis of FIM scores, data from 119/143 of MSCC cases and 1131/1274 NT-SCI cases were utilized due to absent admission or discharge FIM scores.

published studies (Table 4). The present study diverges from others in that very few patients admitted with NT-SCI as their primary reason for rehabilitation (57/1409, 4.1%) had malignancy, based on the ICD-10-CA coding system. Other reports show a much higher percentage of NT-SCI cases, within the inpatient rehabilitation setting, attributed to neoplasia compared to other etiologies, particularly in studies from the U.S. (26%)³⁵ and Australia (20.1%).³⁶ Possible explanations for the differences include the fact that the above studies included patients with all forms of neoplasia, including benign tumors, and that the majority of our patients were classified as having other primary reasons (i.e. 'Neoplasms', or 'Other Orthopedic') for rehabilitation admission apart from NT-SCI, based on RCG groups in the NRS database. Regional differences in patient selection might be contributory to the apparent differences. Finally, we note that the Ontario-based study by Loblaw *et al.*³⁷ reported a higher prevalence of MSCC than we did (3458 vs. 2051 cases over five year periods), but this was likely due to the fact that it used

ICD-9 codes, which were more inclusive in their selection of MSCC cases. It was our goal to limit our analysis to those patients with incident malignancies extending to and displacing the spinal cord, rather than neoplasia, broadly defined, and causes of myelopathy indirectly related to malignancy.

A limitation of our study is its use of the FIM rather than the Spinal Cord Independence Measure (SCIM), a validated and sensitive tool in detecting functional improvements specifically in traumatic and non-traumatic spinal cord injury.^{38,39} Other limitations include the study's retrospective design and the use of administrative data that can be prone to a number of deficiencies such as underreporting, input errors or misclassification of patient characteristics, and missing data.⁴⁰ Indeed, prior Canadian studies have demonstrated that the ICD coding system failed to capture a small proportion of cases within the traumatic SCI and MSCC populations, after an audit of a longitudinal dataset and a chart review, respectively.^{37,41} On the other hand, the ICD-10-CA coding system likely cannot always allow

Figure 2 Distribution of FIM efficiency by MSCC and NT-SCI cohorts. Box plot of FIM efficiency scores displayed as median, lower and upper quartiles, and minimum and maximum values.

one to distinguish between myelopathy related to tumor progression to the spine versus other myelopathies known to occur in cancer patients resulting from medical treatment or the tumor itself, such as radiation-induced tumors or myelopathy, postoperative hemorrhage, or paraneoplastic processes.⁴² Also difficult to elucidate are cases of myelopathy unrelated to malignancy, including degenerative spinal stenosis and traumatic SCI. Thus, although MSCC is probable in study patients admitted for inpatient rehabilitation following a hospital admission for coexistent diagnoses of malignancy and myelopathy, we were unable to definitively confirm this diagnosis using administrative data.

Thus, further efforts are needed to ensure accurate and timely reporting of impairments when using the ICD coding system and also in developing databases

for NT-SCI patients to further subcategorize cancer-related myelopathy. The recognition that the ICD coding system was not specifically designed for research purpose⁴³ has prompted an initiative to generate approaches to enhance the value of the ICD system in the course of conducting population-level research. In the context of NT-SCI, the International Data Set committee of the International Spinal Cord Society (ISCoS) has established coherent data sets that could facilitate comparative research.⁴⁴ Such enhancements, would undoubtedly further research that focuses on rehabilitation outcomes in a variety of patient populations, including MSCC.

Further studies might focus on identifying prognostic factors that could be used to define intervention thresholds and functional targets following MSCC.⁷

Table 2 Survival, healthcare utilization, and discharge characteristics of MSCC and NT-SCI cohorts, fiscal years April 1, 2007 to March 31, 2011

Variable	MSCC (N = 143)	NT-SCI (N = 1274)	P-value*
Rehab length-of-stay (d)			
Mean $\pm$ SD	34.6 $\pm$ 30.3	37.5 $\pm$ 35.2	0.8
Median	26	28	
Range	1 to 198	1 to 254	
Emergency room visits during rehabilitation			
Mean $\pm$ SD	0.2 $\pm$ 0.4	0.1 $\pm$ 0.4	0.1
Patients with ≥ 1 visit	21 (14.6%)	118 (9.2%)	
Acute care re-admission during rehab			
Mean $\pm$ SD	0.3 $\pm$ 0.5	0.1 $\pm$ 0.4	<0.001
Patients with ≥ 1 re-admission	43 (29.9%)	148 (11.5%)	
Discharge destination			<0.01
Home without health services	21 (14.7%)	386 (30.3%)	
Home with paid services [†]	72 (50.3%)	502 (39.4%)	
Assisted living/residential care	10 (7.0%)	104 (8.2%)	
Boarding house/shelter/other	8 (5.6%)	65 (5.1%)	
Unknown	32 (22.4%)	217 (17.0%)	
Reason for discharge			<0.05
Goals met, discharge to community	91 (63.6%)	876 (68.2%)	
Goals met, referral/transfer to other unit/facility	17 (11.9%)	167 (13.1%)	
Goals not met, referral/transfer to other unit/facility or discharge to community	29 (20.3%)	146 (11.5%)	
Withdrew/moved/died in rehab	6 (4.2%)	85 (6.7%)	
Survival (days) ^{‡§}			
Deaths	1104 (72.7%)	169 (13.3%)	
Mean $\pm$ SD	480.9 $\pm$ 34.6	1009.0 $\pm$ 6.99	<0.001
Median	288	1096	
Range	14 to 2103	4 to 2053	
3-month survival	76.2%	97.6%	
1-year survival	46.2%	93.7%	
3-year survival	27.3%	86.7%	

*The Mann–Whitney *U* test was utilized for all analyses except for Discharge Destination and Reason for Discharge, for which chi-square tests were performed.

[†]Paid health services include home care/support, formal or informal, privately or publicly funded.

[‡]The Ontario RPDB database current to March 31, 2013 with potentially variable reporting near currency date.

[§]The log rank test was used to compare differences in survival between the two cohorts.

Various prognostic tools have been developed to assist clinicians in advising patients and devising treatment plans in patients with spine metastases and cord compression.^{45,46} One such tool, the modified Tokuhashi scale,⁴⁷ evaluates preoperative life expectancy in patients with spine metastasis and has been used in one study to retrospectively calculate the predicted life expectancy of MSCC patients admitted for inpatient rehabilitation.²³ Survival prediction

tools have recently been devised for patients who develop MSCC secondary to specific malignancies including prostate cancer,^{48,49} non-small cell lung carcinoma,⁵⁰ cancer of an unknown primary,⁵¹ and multiple myeloma.⁵² Population-based studies may be helpful creating or validating existing prediction tools, specifically for patients with MSCC, stratified by primary tumor site, who are admitted to inpatient rehabilitation.

Table 3 Demographic, survival, and length of stay (LOS) data of patients with MSCC, by primary tumor site

Primary tumor	Age (Mean $\pm$ SD)	Median survival (days) (Range)*	Rehab LOS** (days) (Mean $\pm$ SD)
Unknown/unspecified (N = 34)	67.4 $\pm$ 10.5	148 (14–2012)	28.7 $\pm$ 23.6
Prostate (N = 18)	70.8 $\pm$ 6.4	159 (16–1955)	39.6 $\pm$ 26.6
Multiple myeloma (N = 17)	67.1 $\pm$ 12.7	323 (122–881)	36.8 $\pm$ 28.6
Lymphoma (N = 12)	60.4 $\pm$ 21.0	96 (28–329)	37.5 $\pm$ 44.0
Breast (N = 10)	51.9 $\pm$ 12.3	669 (217–1504)	22.9 $\pm$ 8.8
Lung (N = 8)	62.4 $\pm$ 11.1	200 (59–555)	28.3 $\pm$ 10.5
Other*** (N = 44)	57.3 $\pm$ 17.8	100 (22–1451)	39.4 $\pm$ 37.2

*There were 111/143 patients living as of March 31, 2013, the currency date of the Ontario RPDB database.

**Length of Stay.

***Fewer than six patients in each of the following categories, by site of primary tumor: greater than one malignancy, hematologic malignancy other than lymphoma and multiple myeloma, renal, thyroid, ovarian, uterine, soft tissue malignancy, vertebral column malignancy, testicular, primary spinal cord malignancy, head and neck, hepatobiliary, melanoma, bladder, colorectal, and adrenal.

Table 4 Previously reported demographic, mean length of stay (LOS), mean survival, and functional outcome data (FIM Change/Efficiency) in patients admitted to inpatient rehabilitation following MSCC

Study	Mean age	Mean LOS (days)	Mean survival	FIM change (Efficiency)
Murray ¹⁵ (n = 27)	55	32.8–75.2*	77% 3-month survival [†] 58% 1-year survival [†]	NR
Hacking <i>et al.</i> ¹⁶ (n = 74)	57	111.7	423.7 days [‡]	NR
McKinley <i>et al.</i> ¹⁷ (n = 32)	61	27	101 days [‡]	NR
McKinley <i>et al.</i> ¹⁸ (n = 29)	57.8	25.2	NR	18.7 (0.88§)
McKinley <i>et al.</i> ¹⁹ (n = 34)	58	23	NR	19.7 (1.01§)
Guo <i>et al.</i> ²⁰ (n = 60)	NR¶	16.7	4.1 months ^{**,††}	NR
Parsch <i>et al.</i> ²¹ (n = 68)	54.9	50 ^{**}	11 months ^{**,‡‡}	22.0 (0.33§§)
Eriks <i>et al.</i> ²² (n = 97)	59	103	808 days [‡]	NR
Tang <i>et al.</i> ²³ (n = 63)	62.5	23 ^{**}	10 months ^{**,‡} (estimated)	19.0 (0.38)
Fattal <i>et al.</i> ²⁴ (n = 26)	57	161¶¶	12.7 months ^{**,‡‡}	69% with FIM change ≥ 10
Tan and New ^{25,26} (n = 108)	61.5 ^{**}	47.5 ^{**}	Primary: 9.5 months ^{**,‡} Secondary: 2.8 months ^{**,‡}	24.0 (0.33 ^{***})
Current Study, 2014 (N = 143)	62.7	34.7	344.3 days ^{††} 76.2% 3-month survival 46.2% 1-year survival 27.3% 3-year survival	10.0 (0.16 ^{†††}) 20.2 (0.8)

*Length-of-stay stratified by Frankel score.

[†]Reference date for survival calculation unspecified.[‡]Survival calculated from rehabilitation discharge date.[§]Transformed from FIM efficiency, which was expressed as FIM change per week.[¶]Not reported.^{**}Median values reported.^{††}Survival calculated from rehabilitation admission date.^{‡‡}Survival calculated from spinal cord injury date.^{§§}Reported values for 51/68 patients completing prescribed rehabilitation program.^{¶¶}Additional rehabilitation admission for 6 patients.^{***}Primary malignancy.^{†††}Secondary malignancy.

Conclusion

This population-based study of a relatively large cohort of patients with MSCC demonstrates the value of inpatient rehabilitation and the predictability of functional improvements and satisfactory discharge outcomes in the great majority of members within this population, notwithstanding diminished life expectancies. It is therefore important to consider rehabilitation in patients with MSCC, while establishing goals and target lengths of stay that account for their impairments and expected survival. Efforts to enhance the accuracy of population data and in creating a rational classification system of NT-SCI would help to further customize rehabilitation processes for subgroups of patients with malignant SCI.

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Disclaimer statements

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