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ORIGINAL ARTICLE

# Neoplastic myelopathies and traumatic spinal cord lesions: an Italian comparison of functional and neurological outcomes

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**Background**: Although neoplastic spinal cord injuries (NSCIs) constitute ~25% of all non-traumatic spinal cord lesions, patients with such pathologies are seldom, if ever, admitted to specialized centers; further, their rehabilitation typically is short because of the perception that rehabilitation prolongs hospital stays unnecessarily and is reserved only for patients with very good prognoses.
**Study design**: This study is a retrospective analysis.
**Objective**: The objective of this study is to evaluate the neurological and functional outcomes of patients with NSCIs compared with those of patients with traumatic spinal cord injury (TSCI).
**Methods**: We evaluated 208 patients with TSCIs and 63 with NSCIs; using a matching cohorts procedure, 43 comparable couples were selected from each group. The measures used to assess these patients were the American Spinal Injury Association standards, the Barthel Index (BI), the Rivermead Mobility Index and the Walking Index for Spinal Cord Injury.
**Results**: In the general population, NSCI patients are older and have longer lesion-to-admission times and more incomplete lesions than TSCI patients. Therefore, the functional status at admission and outcomes differed between the groups. In the matching cohorts, TSCI patients had lower BI scores at admission than NSCI subjects. At discharge, the two groups had comparable functional outcomes. Neurological status was similar at admission and at discharge.
**Conclusions**: Although they had slightly disparate functional levels at admission, NSCI and TSCI patients had the same outcomes at discharge. Our data suggest that in a selected cohort of NSCI patients, rehabilitation is as successful as that in TSCI subjects and allows most patients to be discharged instead of being institutionalized.
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**Keywords:** traumatic spinal cord injury; neoplastic spinal cord lesion; outcomes

## Introduction

Because of recent pharmacological and surgical advances in the treatment of neoplastic diseases, patients are experiencing increased survival. Further, the incidence of lung, prostate and breast cancers (which are among the main causes of spine metastasis with cord compression) will probably increase in the future.[1] Thus, teams dealing with spinal cord injury (SCI) will be faced more often with requests to rehabilitate patients with neoplastic paraplegia.

To this end, many articles on the rehabilitation of neoplastic SCI (NSCI) patients have emerged in the last 15 years.[2–12] Most such studies, however, examined metastatic spinal cord compression only, and although they have demonstrated the benefits of rehabilitation in neoplastic patients with regard to pain, independence, prevention of complications and survival, they failed to make comparisons with traumatic SCI (TSCI) patients.[5–7,9–12] Thus, few studies have compared the outcomes of NSCI and TSCI patients, likely because of differences in prognostic factors (age, lesion severity and level, and lesion-to-rehabilitation hospital admission time) between these groups that render them incomparable.

The studies by McKinley *et al.*[2–4] have noted that NSCIs account for 10–15% of all SCI-related admissions in the United States and that neoplastic patients have greater independence at admission and shorter duration of rehabilitation. In these reports, their traumatic counterparts experienced greater functional improvements, leading the authors to conclude that traumatic patients have better results with regard to function because they have longer lengths of stay.

Catz[8] observed that the odds of any neurological recovery and functional neurological recovery are significantly higher

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in patients with neoplastic disease than in patients with traumatic lesions. The studies that we have discussed, however, were conducted in completely different settings from those of the present study, particularly with regard to the length of rehabilitation. Because disparities in the length of specialized rehabilitation have been reported to influence the outcome of SCI patients, a study of such a program's effects on neurological and functional recovery in a setting that provides 7–10 months of rehabilitation, mirroring the real-life European experience, is warranted.

The aim of this study was to evaluate functional and neurological outcomes in a selected cohort of patients with NSCIs and good prognosis for survival compared with TSCI patients.

## Patients and methods

We examined the charts of 208 patients with TSCIs and 63 with NSCIs, who were admitted to our Spinal Unit between 1996 and 2007 for their initial rehabilitation; the neoplastic group comprised patients with spinal cord compressions (metastatic tumors and extrinsic compressions) and primary spinal cord tumors (primarily ependymomas). All neoplastic patients underwent surgery for the lesion and received chemotherapy or radiotherapy. Admitted patients met the standard SCI rehabilitation criteria, were physically able to tolerate intensive rehabilitation and had a prognosis of survival of at least 6 months.

We recorded lesion-to-admission time (LTA, days), length of stay as in-patients (days), injury variables (etiology, associated injuries, medical complications and surgical interventions) and destination at discharge. These variables were recorded as dichotomous (traumatic/neoplastic for etiology and present/absent for the others).

The associated lesions were as follows: traumatic brain injury, non-vertebral fractures that required surgery, severe facial injuries that affected sensory organs, major chest injury that required a chest tube or mechanical ventilation, severe hemorrhaging and damage to any internal organ that required surgery. Medical complications comprised pressure sores, deep vein thrombosis, pulmonary embolism, heterotopic ossification and urological complications (excluding urinary tract infections). For the neoplastic population, the LTA refers to the first appearance of neurological symptoms.

Neurological status was assessed using the American Spinal Injury Association standards[13] by evaluation of motor scores (MSs), neurological levels and the American Spinal Injury Association Impairment Scale (AIS) grades. Neurological recovery was defined as an improvement of at least one AIS grade.

According to previous studies,[14] functional status at admission and discharge (within 48 h) was assessed by a single trained examiner (GS) using

- the Barthel Index (BI) for activities of daily independence;[15]
- the Rivermead Mobility Index (RMI) for mobility;[16] and
- the Walking Index for Spinal Cord Injury (WISCI).[17]
- MS, BI, RMI and WISCI score changes were calculated on the basis of the difference in scores between discharge and admission. MS, BI, RMI and WISCI efficiency scores were calculated as the ratio between the difference in score and the duration of treatment. Efficiency score provides a basis for measuring the success of rehabilitation with regard to the performance of an individual patient and the rehabilitation center; it has been used as an outcome measure in patients with SCIs.[14]

We defined bladder management independence as the achievement of normal bladder control or successful intermittent self-catheterization. Using criteria from previous studies, we recorded whether patients reached independence with regard to bowel management.[14]

Finally, on the basis of the WISCI scale, we determined the number of patients who were able to walk without physical assistance at admission and discharge,[18] and patient destinations at discharge.[14] Because Italian health policy permits longer lengths of stay than other countries, our guidelines stipulate that patients should be discharged when they attain the maximum independence that is allowed by their lesion or when their BI and RMI scores plateau (that is, having the same scores at two evaluations 20–30 days apart).

*Matching procedure*

To correct for the concurrent effects of differences between the two populations that influence neurological and functional recovery, we used a matching procedure with four matching variables:[8,14]

- *Level of lesion*: On the basis of previous studies, the patients fell into one of three levels: cervical, thoracic or lumbar. Within each level, there might have been differences in functional outcome because of the height of the lesion, but the number of patients in our study did not allow us to subdivide them.
- *AIS impairment*: Because AIS impairment seems to be the principal determinant of functional and neurological outcomes, we divided the patients by AIS grade.
- *Age*: A cutoff age of 50 years was selected; patients aged younger or older than 50 years experience different functional outcomes.[14]
- *LTA*: Patients were grouped by an LTA of $>$ or $<40$ days.

Each patient in the lesion group was identified by injury type, age and time and classified by etiology. Patients were selected from each etiology group to create matched dyads based on their classification. Ultimately, we selected 86 patients (43 dyads; Table 1).

*Statistical analysis*

Descriptive values, expressed as mean ± s.d., were provided for all continuous clinical data. The data on all patients were analyzed by Student's *t*-test for independent samples and by the $\chi^2$-test.

Data on the dyads were analyzed by the paired *t*-test; McNemar's $\chi^2$-test was used to assess differences in contingency.[14]

Differences were significant if $P<0.05$.

**Table 1** Dyads composition

| | *Age < 50 years* | | *Age > 50 years* | | *Total* |
|---|---|---|---|---|---|
| | *LTA < 40 days* | *LTA > 40 days* | *LTA < 40 days* | *LTA > 40 days* | |
| Cervical A | 1 | 1 | 0 | 0 | 2 |
| Cervical B | 0 | 0 | 0 | 0 | 0 |
| Cervical C | 1 | 2 | 2 | 2 | 7 |
| Cervical D | 3 | 0 | 0 | 0 | 3 |
| Thoracic A | 0 | 3 | 2 | 4 | 9 |
| Thoracic B | 1 | 0 | 1 | 0 | 2 |
| Thoracic C | 1 | 6 | 2 | 2 | 11 |
| Thoracic D | 0 | 2 | 0 | 0 | 2 |
| Lumbar A | 0 | 1 | 0 | 0 | 1 |
| Lumbar B | 0 | 0 | 0 | 0 | 0 |
| Lumbar C | 1 | 1 | 0 | 1 | 3 |
| Lumbar D | 1 | 0 | 1 | 1 | 3 |
| Total | 9 | 16 | 8 | 10 | 43 |

Abbreviation: LTA, lesion-to-admission time.

## Results

TSCIs were caused primarily by traffic accidents, followed in frequency by accidental falls and sports-related accidents (Table 2). NSCIs were predominantly due to low-grade malignant primary tumors of the spine or spinal cord (primarily ependymomas and Schwannomas). Of the 43 patients in the matching cohort, 10 had a secondary tumor (primarily hematological; Table 2). No patient died during the study period.

Of all patients, those with TSCIs were significantly younger ($P<0.001$) and had a shorter LTA ($P<0.001$) and a longer length of stay ($P=0.003$) than NSCI patients (Table 3). Further, TSCIs patients had a higher frequency of complete lesions ($P=0.001$) and lower MSs ($51.4\pm18.2$ versus $59.8\pm16.5$, $P=0.01$; Tables 3 and 4). With regard to the level of lesion, there was a significantly higher percentage of thoracic lesions in neoplastic patients ($P=0.001$; Table 4).

**Table 2** Aetiologies distribution

| *Traumatic aetiologies* | *Patients* | *Neoplastic aetiologies* | *Patients* | *Neoplastic aetiologies of the 20 patients not included in the matching comparison* | *Patients* |
|---|---|---|---|---|---|
| Car accident | 10 | Ependimoma | 7 | Ependimoma | 5 |
| Motorcycle accident | 6 | Schwannoma | 8 | Schwannoma | |
| Sport accident | 3 | Meningioma | 4 | Meningioma | 5 |
| Gunshot wound | 4 | Vascular tumors of the spinal cord | 7 | Vascular tumors of the spinal cord | 1 |
| Accidental falls | 13 | Glial tumors | 3 | Glial tumors | |
| Suicide attempt | 3 | Myeloma | 3 | Myeloma | 3 |
| Other | 4 | Lymphoma | 3 | Lymphoma | |
| | | Metastatic tumors | 4 | Metastatic tumors | 3 |
| | | Primary spine tumors | 4 | Primary spine tumors | 3 |

**Table 3** Complete group comparison results (Student's *t*-test for independent sample) and dyads comparison results (paired Student's *t*-test)

| *Complete group comparison* | | | | *Dyads comparison* | | | |
|---|---|---|---|---|---|---|---|
| | *Neoplastic (n = 63) Mean ± s.d.* | *Traumatic (n = 208) Mean ± s.d.* | P | | *Neoplastic (n = 43) Mean ± s.d.* | *Traumatic (n = 208) Mean ± s.d.* | P |
| Age (years) | 50.9 ± 16.8 | 39.1 ± 17.1 | <0.001 | Age | 44.5 ± 15.8 | 43.7 ± 17.7 | 0.67 |
| LTA (days) | 74.4 ± 81 | 50.3 ± 40.1 | 0.003 | LTA | 82.6 ± 90.9 | 56.7 ± 38.8 | 0.04 |
| LOS (days) | 89.9 ± 69.2 | 132.7 ± 78.1 | <0.001 | LOS | 92.1 ± 71.8 | 138.3 ± 94.3 | 0.001 |
| BI admission | 31.2 ± 25.5 | 19.7 ± 19.1 | <0.001 | BI admission | 27.6 ± 24.7 | 21.5 ± 18.4 | 0.1 |
| BI discharge | 63.2 ± 32.8 | 66.2 ± 20.3 | 0.5 | BI discharge | 62.8 ± 32.6 | 69 ± 27.1 | 0.2 |
| BI increase | 34.6 ± 28.5 | 46 ± 26.4 | 0.01 | BI increase | 35.3 ± 27.7 | 47.6 ± 24.6 | 0.02 |
| BI efficiency | 0.5 ± 0.6 | 0.5 ± 0.55 | 0.8 | BI efficiency | 0.5 ± 0.6 | 0.5 ± 0.6 | 0.7 |
| RMI admission | 1.8 ± 3.3 | 1 ± 2.4 | 0.06 | RMI admission | 1.4 ± 3 | 0.7 ± 2 | 0.2 |
| RMI discharge | 6.5 ± 5.3 | 5.6 ± 4.5 | 0.2 | RMI discharge | 6.5 ± 5.4 | 5.1 ± 4. 2 | 0.07 |
| RMI increase | 5.5 ± 4.9 | 4.8 ± 4.1 | 0.3 | RMI increase | 5.2 ± 5.2 | 4.4 ± 3.8 | 0.3 |
| RMI efficiency | 0.08 ± 0.12 | 0.05 ± 0.07 | 0.04 | RMI efficicency | 0.07 ± 0.1 | 0.05 ± 0.07 | 0.3 |
| WISCI admission | 1.9 ± 5.3 | 1.1 ± 4 | 0.2 | WISCI admission | 1.9 ± 5.3 | 0.7 ± 3.4 | 0.2 |
| WISCI discharge | 8.7 ± 8.7 | 6.9 ± 8.3 | 0.2 | WISCI discharge | 8.5 ± 3 | 7.2 ± 8.6 | 0.2 |
| WISCI increase | 7.7 ± 8.5 | 6.1 ± 7.8 | 0.2 | WISCI increase | 7.1 ± 8.5 | 6.4 ± 8.1 | 0.6 |
| WISCI efficiency | 0.13 ± 0.2 | 0.09 ± 0.16 | 0.03 | WISCI efficiency | 0.1 ± 0.2 | 0.08 ± 0.1 | 0.2 |
| MS admission | 59.8 ± 16.5 | 51.4 ± 18.2 | 0.01 | MS admission | 55.5 ± 15.6 | 56.8 ± 16.4 | 0.7 |
| MS discharge | 69.5 ± 21.4 | 59.9 ± 22.8 | 0.02 | MS discharge | 64.5 ± 22.6 | 68.2 ± 22.7 | 0.3 |
| MS increase | 10.7 ± 10 | 8.1 ± 10.1 | 0.2 | MS increase | 9.7 ± 10.4 | 12.4 ± 15.4 | 0.3 |
| MS efficiency | 0.08 ± 0.1 | 0.09 ± 0.2 | 0.8 | MS efficicency | 0.1 ± 0.2 | 0.1 ± 0.2 | 0.6 |

Abbreviations: BI, Barthel Index; LOS, length of stay; LTA, lesion-to-admission time; MS, motor score; RMI, Rivermead Mobility Index; WISCI, Walking Index for Spinal Cord Injury.

**Table 4** Complete group results ($\chi^2$-test)

| | *Neoplastic* (n = *63, %*) | *Traumatic* (n = *208, %*) | P |
|---|---|---|---|
| Sex (males) | 31 (49) | 166 (80) | <0.001 |
| *AIS level at admission* | | | |
| A | 12 (19) | 97 (47) | <0.001 |
| B | 4 (6) | 16 (8) | |
| C | 30 (48) | 58 (28) | |
| D | 17 (23) | 37 (17) | |
| *Lesion level* | | | |
| Cervical | 12 (19) | 65 (31) | <0.001 |
| Thoracic | 41 (65) | 86 (41) | |
| Lumbar | 10 (16) | 57 (28) | |
| AIS grade conversion | 21 (33) | 59 (28) | 0.45 |
| Associated lesions | 0 (0) | 103 (49) | <0.001 |
| Complications at admission | 6 (9) | 80 (38) | <0.001 |
| Complications during rehab stay | 21 (33) | 72 (34) | 0.8 |
| Walking independence at admission[a] | 6 (9) | 12 (6) | 0.3 |
| Walking independence at discharge[a] | 24 (38) | 76 (36) | 0.8 |
| Bladder management independence | 42 (66) | 169 (81) | 0.01 |
| Bowel management independence | 41 (65) | 153 (73) | 0.2 |
| Patients discharged at home | 50 (79) | 167 (80) | 0.9 |

Abbreviation: AIS, American Spinal Injury Association Impairment Scale.
[a]Assessed by the Walking Index for Spinal Cord Injury.

**Table 5** Dyads comparison (McNemar's $\chi^2$-test)

| *Sex* | *Neoplastic* | *Traumatic* | P |
|---|---|---|---|
| Sex (M/F) | 25/18 | 32/11 | 0.9 |
| AIS grade conversion | 15 | 16 | 1 |
| Associated lesions | 2 | 19 | <0.001 |
| Complications at admission | 5 | 27 | <0.001 |
| Complications during rehab stay | 12 | 18 | 0.02 |
| Walking independence at admission | 9 | 6 | 0.4 |
| Walking independence at discharge | 17 | 17 | 1 |
| Bladder management independence at discharge | 29 | 35 | 0.15 |
| Bowel management independence at discharge | 27 | 33 | 0.2 |
| Discharge at home | 33 | 29 | 0.45 |

Abbreviations: AIS, American Spinal Injury Association Impairment Scale; F, female; M, male.

On the basis of these differences, patients with TSCIs had worse functional status at admission, as evaluated by BI ($19.7 \pm 19.1$ versus $31.2 \pm 25.5$, $P<0.001$; Table 3), compared with neoplastic patients. At discharge, the neurological and functional outcomes of the two populations were comparable (Table 3).

In the matching cohorts, the traumatic group had significantly shorter LTAs and longer lengths of stay (Table 3). At admission, the traumatic group experienced complications more frequently and harbored more associated lesions (Table 5). With regard to neurological outcome, patients with NSCIs had an insignificant, slightly lower, frequency of AIS grade conversion (15/43 versus 16/43; Tables 5 and 6). Accordingly, MS at admission and discharge and changes in MS were comparable between the two cohorts (Table 3).

At admission, patients with TSCIs had a slightly worse functional status with regard to daily activities (BI), mobility (RMI) and walking (WISCI), but none of these differences reached statistical significance (Table 3). At discharge, BI scores were insignificantly higher in the traumatic cohort, and increases in BI were significantly greater in patients with TSCIs. RMI and WISCI scores at discharge were slightly, although insignificantly, lower in the traumatic group; increases in RMI were comparable in the two groups and increases in WISCI were higher in the non-traumatic group (Table 3).

The efficiencies of the four scales were comparable. Length of stay was significantly shorter in the neoplastic cohort (Table 5). Bladder voiding modalities, bowel management independence and discharge disposition were comparable between the two cohorts (Table 5). With regard to walking independence, there was no significant difference between the two cohorts at admission or discharge.

## Discussion

In this series, the etiology of TSCIs differed slightly from those of the patients studied by McKinley *et al.*,[4] in whom gunshot wounds were the second most frequent cause of lesions; in our series, the second leading cause of lesions was

**Table 6** AIS grade conversion in the dyads

| *Traumatic* | | | | | | | *Neoplastic* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *AIS grade at discharge* | | | | | | | *AIS grade at discharge* | | | | |
| | | A | B | C | D | E | | | A | B | C | D | E |
| AIS grade at admission | A | 10 | | 2 | | | AIS grade at admission | A | 11 | | 1 | | |
| | B | | 1 | 1 | | | | B | | 1 | 1 | | |
| | C | | | 10 | 11 | | | C | | 1 | 8 | 12 | |
| | D | | | | 6 | 2 | | D | | | | 7 | 1 |

Abbreviation: AIS, American Spinal Injury Association Impairment Scale.

accidental falls. The demographics of NSCI patients also differed from those of the patients studied by McKinley *et al*.[2–4] In our study, neoplastic patients accounted for 12.3% of total SCIs and constituted 22% of non-traumatic lesions, consistent with McKinley's findings and with more recent data in Europeans.[19] In the study by McKinley *et al*.,[4] however, 85% of lesions were metastatic tumors, but 76% of our patients had a primary tumor of the spine or spinal cord with low malignancy. This difference is likely due to disparate admission criteria.

Our results on the entire group of patients confirm McKinley's findings—patients with TSCIs and NSCIs differ significantly with regard to several determinants of outcome: age, LTA and completeness and level of the lesion.[4] In particular, incomplete lesions were more frequent in the neoplastic group, which also developed more thoracic lesions. Thus, the functional and neurological status of neoplastic patients as a group was better at admission, and MSs were higher at discharge. However, in the comparison of matching cohorts, patients with TSCIs and NSCIs experienced comparable neurological amelioration with regard to AIS grade conversion between admission and discharge and improvements in MS.

Only one other study has compared the neurological outcomes of patients with NSCIs and TSCIs,[8] reporting that NSCI subjects experience better neurological recovery compared with TSCI patients. Although the authors adopted a statistical procedure to correct for the confounding effect of other prognostic factors, as we did, they apparently included only patients with benign tumors, a difference that renders their findings only partially comparable to ours. Further, neurological status was assessed by the Frankel scale, which slightly differs from the AIS.

With regard to functional status, consistent with McKinley's data, in the matching cohorts, patients with TSCIs had slightly lower BI scores than those with NSCIs at admission. McKinley *et al*.[4] did not offer an explanation for this phenomenon, which we attribute to several factors. For example, time-limited non-neurological trauma-associated factors, such as the presence of associated lesions and complications (more frequent in the traumatic group), the need to wear an orthotic device (which is also more probable in traumatic patients) and the sequelae of major surgery, might effect greater functional impairments at admission,[20,21] but not at discharge, without affecting neurological status. Further, non-traumatic patients had longer LTAs and could have undergone rehabilitation that, although non-specific, could have ameliorated their functional status.

At discharge, TSCI and NSCI patients doubled their initial BI scores, which is consistent with the 66% improvement in the BI that was achieved by patients with metastatic spinal cord compressions in the study by Eriks *et al*.[7] At discharge, TSCI patients had slightly higher BI scores than those with NSCIs, and their improvement was significantly greater, likely because they started with lower scores.

The mean length of rehabilitation for NSCI patients is consistent with Eriks *et al*.[7] According to the study by McKinley *et al*.[4] and our findings, neoplastic patients have shorter rehabilitation stays. McKinley attributed this phenomenon to the need to discharge neoplastic patients prematurely because of their short life expectancy. Similar conclusions have been made by other groups that examined the outcome of patients with metastatic spinal cord lesions.[12] In our patients, the need for early discharge was avoided because of the nature of their tumors; most patients had a prognosis of several months or longer, which allowed protracted rehabilitation stays.

Thus, the longer lengths of stay of traumatic patients must be attributed to other factors. It is possible that the same factors that affect functional status at admission (that is, the presence of complications or the need to wear an orthotic device) influence the time that is required to achieve functional independence.[20,21] The comparable BI efficiency values between the two cohorts favor the hypothesis that traumatic patients need more time than their neoplastic counterparts to attain comparable levels of independence. Mobility (RMI) and walking capacity (WISCI) at admission and discharge were slightly lower in the traumatic group at admission and discharge; their increases in scales and efficiencies were comparable.

The two cohorts had the same outcomes with regard to bladder and bowel management. Bladder management in NSCI patients has been examined by Reitz,[22] who proposed a full bladder rehabilitation program (with intermittent catheterization) in patients with a life expectancy of more than 12 months and a more conservative program (with suprapubic catheters) in those with shorter life expectancies who have undergone palliative treatment. The authors justified the use of this approach with the need to discharge neoplastic patients early and the generally worse status and poor motivation of such patients. Our results are consistent with those of Reitz and demonstrate that, in a cohort of selected

patients with benign tumors or those with a good prognosis for survival, a comprehensive bladder rehabilitation program can be used as successfully as in TSCI patients.

Finally, traumatic and neoplastic patients had similar rates of returning home after discharge from rehabilitation (~80%). As discussed, discharge disposition and, in particular, the risk of being institutionalized are not influenced by the etiology of the lesion. As shown in patients with SCIs and other neurological diseases, discharge disposition depends primarily on the age of the patient[23] and on the level of independence in daily activities. A score of 60 points on the BI is the cutoff, above which patients move from dependence to assisted independence and can be discharged home.[24]

According to the data of Eriks *et al*.,[7] our patients with metastatic spinal cord compression experienced greater survival than previously reported. The median survival duration in these patients ranged from 3 to 6 months[25] and was longer in those who could walk than in those who could not.[5,26] The efficacy of rehabilitation in this particular subset of neoplastic patients has been demonstrated by Ruff *et al*;[9,10] patients who underwent rehabilitation had less pain, a better quality of life, higher levels of independence and greater survival. The latter is particularly relevant, because approximately half of the deceased patients with metastatic spinal cord compressions died because of complications of SCIs (such as pressure sores and pneumonia) rather than because of progression of neoplastic disease.[9,10] Specialized rehabilitation that focuses on bowel and bladder management, transfers and skin care might be efficacious in preventing SCI complications and improving the survival of these patients. Despite these findings, according to McKinley *et al*.,[27] few cancer patients (10–14%) are admitted to a spinal cord unit.

There are several limitations of this study. The chief limitation was the small number of NSCI patients who were included and that nearly one-third of this group could not be matched and were excluded from the analyses. Further, to obtain a sufficiently large sample of neoplastic patients, we included patients with primary spinal cord tumors and extrinsic compressions of the cord (mostly due to metastatic disease). It is possible that these two populations have different functional and neurological outcomes. Additional analysis to assess recovery in specific subgroups might generate further insight into the factors that determine the chances of recovery following a spinal cord lesion.

Despite the matching procedure, the neoplastic cohort had higher LTAs, likely because of various factors, such as the oncological workup, the need for these patients to undergo chemotherapy and radiotherapy and the paucity of dedicated beds for SCI patients. These differences might have constituted a bias of this study, because LTA influences SCI patient outcomes.[28]

Finally, the effects of chemotherapy and radiotherapy on neurological recovery were not examined, because there were too few patients.

*Conclusions*

Our results indicate that in a select group of neoplastic patients with good life expectancy, participation in a rehabilitation program significantly improves functional outcomes in patients with spine and spinal cord tumors, as demonstrated by improvements in the BI from baseline to discharge. To identify patients with long life expectancies who could benefit from such a program, prognostic indicators such as young age, incomplete SCI, good functional status at admission and the scoring system of Tokuhashi *et al*.[29] should be considered.[6,7]

## Conflict of interest

The authors declare no conflict of interest.

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