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ORIGINAL ARTICLE

Traumatic and non-traumatic spinal cord lesions: an Italian comparison of neurological and functional outcomes

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Study design: Retrospective study.
Objective: To compare the rehabilitation outcomes of non-traumatic and traumatic spinal cord injury patients.
Setting: Spinal cord unit of a rehabilitation hospital in Italy.
Patients and methods: In total, 380 patients at first rehabilitation stay after the lesion (144 traumatic patients and 236 non-traumatic patients; 244 men and 136 women; mean age 46.1 ± 19.9 years; mean lesion to admission time 49.6 ± 39.8 days).
Interventions: Not applicable.
Measures: American Spinal Injury Association standards; Barthel index (BI), Rivermead mobility index and walking index for spinal cord injury. Statistical analysis: Poisson regression models with relative risks and 95% confidence intervals adjusted for the following confounders: age, sex, lesion level and Asia impairment. Models were stratified by age because a strong interaction between different variables and age was found.
Results: Traumatic and non-traumatic populations showed several significant differences with regard to age, level and severity of lesion. When adjusted for these factors patients with traumatic injuries showed a significantly lower BI score at admission and significantly better improvement in the BI score by discharge. The two populations were discharged with similar functional outcome. No significant differences were found with regard to the others outcomes.
Conclusions: In clinically stable patients, spinal cord injury etiology does not seem to affect the rehabilitative prognosis. At admission, traumatic patients show lower autonomy in daily life activities, probably because of the associated lesions that these patients often have. At discharge, traumatic and non-traumatic spinal cord lesion patients achieved similar results with regard to neurological and functional improvement.
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Keywords: traumatic spinal cord injury; non-traumatic spinal cord injury; outcomes

Introduction

The prediction of neurological and functional outcomes after spinal cord lesion (SCL) is essential to answer patients' questions regarding their functional potential and to understand the amount of resources required during inpatient rehabilitation and after discharge.[1] Furthermore, a precise knowledge of the course and of the factors affecting the natural recovery of SCL has become a scientific need as it is essential for the evaluation of the efficacy of new pharmacological and rehabilitative strategies.

Previously, several studies have been published examining the effect of various factors such as age,[2] neurological status at admission[3] and rehabilitation timing[4] on neurological and functional recovery after SCL. However, in spite of the high incidence of non-traumatic lesions, which is considered to vary between 25 and 80% of the total admission for spinal cord injuries, there are still few studies on the influence of different etiologies (namely traumatic vs non-traumatic) on SCL outcome;[5–11] this is probably due to the different features of the two populations with regard to age, lesion severity and lesion to admission time (LTA), which are well-known prognostic factors:[5] therefore, the two groups of patients are poorly comparable.

The aim of this work is to evaluate functional and neurological status at admission and discharge, and factors associated with functional status among patients with traumatic and non-traumatic SCLs.

Patients and methods

We retrospectively examined the charts of 380 patients with traumatic and non-traumatic spinal cord injury admitted to our spinal unit between 1996 and 2004 for their first rehabilitation treatment after the lesion. Patients were

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clinically stable, as the few cases who showed disease progression were excluded from the study. Whenever a patient was discharged or transferred for >3 weeks, the readmission was considered a second admission and the patient was excluded.

The following data were collected: age, sex, LTA; injury variables (etiology, associated injuries, medical complications at admission and major surgical intervention); these variables were recorded as dichotomous (for example, traumatic and non-traumatic for etiology and present–absent for the others). Associated lesions were: traumatic brain injury, non-vertebral fractures requiring surgery, severe facial injuries affecting sense organs, major chest injury requiring chest tube or mechanical ventilation, severe hemorrhaging or damage to any internal organ requiring surgery.

Neurological status included the American Spinal Injury Association (ASIA) standards:[12] motor scores, neurological level and ASIA impairment scale (AIS). Patients were considered as having an incomplete lesion if they showed motor and/or sensory function in the sacral segments (sacral sparing).[12] Neurological recovery was defined on the basis of improvement of motor scores and ASIA impairment grade.[2]

Functional status at admission and discharge was assessed by:

- Barthel index (BI) for activities of daily life independence;[13]
- Rivermead mobility index (RMI);[14]
- Walking index for spinal cord injury (WISCI).[15] As WISCI scores were not available from the original charts, following a procedure already used[2], they were retrospectively assessed from neurological clinical charts.

Gait ability, based on WISCI scale, was assessed as dichotomous: (1) walking patients—those who had home or community ambulation capacity, with or without braces or walking aids, but without physical assistance (mean WISCI score = 17.56; s.d. = 2.97) and (2) not walking patients—all the others (mean WISCI score = 0.37; s.d. = 1.79).

Motor scores, BI and RMI scores changes were calculated as the difference between discharge and admission scores.

We categorized bladder control and autonomy in bowel management according to previous studies.[16] Patients were divided into those who achieved normal bladder control and those with other emptying modalities. As to bowel, we categorized patients as having bowel management autonomy or not.

Finally, we recorded the incidence of complications during rehabilitation stay, the inpatient length of stay (LOS) and patient's destination at discharge.

Statistical analysis

Descriptive data analysis: descriptive values, expressed as mean ± s.d., were supplied for all continuous clinical data.

Poisson regression models were computed to assess the relative risks of traumatic and non-traumatic patients of showing various characteristics (age, gender, lesion level and AIS impairment). For outcome evaluation, the relative risks and 95% confidence intervals were adjusted for the following confounders: gender, age, lesion level and AIS impairment. LOS and LTA were excluded from the adjustment model because these variables were strongly correlated with lesion level and AIS impairment. Models were stratified by age because a strong interaction between different variables and age was found.

With regard to classification of the patients for the Poisson models, patients were grouped for age and lesion level. The two groups for age stratification were younger or older than 50 years, as previous studies showed that patients older than 50 years had a significantly worse outcome with regard to daily life activity independence, walking and mobility and bladder and bowel management.[2] With regard to level of lesion, we divided the patients in three groups: cervical, thoracic and lumbar. Differences were taken as significant if $P<0.05$.

Results

The entire group of 380 patients comprised 144 traumatic patients and 236 non-traumatic patients; there were 244 male patients and 136 female patients; mean age was 46.1 ± 19.9 years; mean LTA was 49.6 ± 39.8 days. The more frequent causes of trauma were motor vehicle accidents (51.4%, 52 patients with car accident and 22 with motorcycle accident) falls (27.7%), sport accidents (5.5%), gunshot wounds and suicide attempts (4% each). In the non-traumatic group, the more frequent etiologies were degenerative disease of the spine with spinal cord involvement (32%), vascular (24%), inflammatory (23%) and neoplastic diseases (21%).

Non-traumatic patients were significantly older than traumatic ones and showed a prevalence of thoracic lesions (particularly in the older group).

In the entire group, traumatic patients were more often males; when stratifying by age this difference disappeared in the group below 50 years, but was particularly evident in the older group. Furthermore, traumatic patients showed more complete lesions (especially in the older group) than non-traumatic patients (Table 1).

Associated lesions were present in 49% of the traumatic patients vs none of the non-traumatic ones ($P<0.001$); the incidence of SCI-related complications at admission was similar in the two populations; 92% of the traumatic patients underwent surgery vs 43% of the non-traumatic ones ($P<0.001$).

Adjusting the evaluation of the outcomes for the above mentioned variables (age, gender, level and completeness of lesion), patients with traumatic lesions showed a significant lower functional status at admission (BI 18.3 ± 16.7 vs 30.7 ± 24.8) than non-traumatic patients, but the significance of this finding disappeared when the population was stratified by age. However, motor scores, RMI scores and walking capability were comparable to those of the non-traumatic group (Tables 2 and 3). At discharge, both groups had a mean score of BI of approximately 60 points; BI

Table 1 Clinical features of the two groups

	All				*Patients <50 years of age*				*Patients ⩾50 years of age*			
	Traumatic				*Traumatic*				*Traumatic*			
	No	*Yes*	*RR*	*95% CI*	*No*	*Yes*	*RR*	*95% CI*	*No*	*Yes*	*RR*	*95% CI*
Age												
<50 years	54	102	1.00									
⩾50 years	182	42	**0.39**	**0.26–0.56**								
Sex												
Males	128	116	**1.91**	**1.26–2.91**	29	79	1.41	0.87–2.26	99	37	**4.30**	**1.68–11.00**
Females	108	28	1.00		25	23	1.00		83	5	1.00	
Lesion level												
Cervical	46	32	1.00		16	28	1.00		46	20	1.00	
Thoracic	104	34	**0.63**	**0.42–0.94**	25	38	0.87	0.53–1.82	110	15	**0.27**	**0.12–0.63**
Lumbar-sacral	32	21	1.00	0.66–1.52	13	35	1.16	0.70–1.92	23	7	0.68	0.23–2.00
ASIA at admission												
A	48	74	**2.59**	**1.52–4.41**	8	57	**2.01**	**1.07–3.78**	40	17	**5.50**	**2.08–14.50**
B	17	12	1.69	0.81–3.53	5	7	1.26	0.59–3.24	12	5	**3.61**	**1.10–11.90**
C	103	40	1.42	0.81–2.49	26	26	1.18	0.49–2.36	77	14	1.88	0.71–4.92
D	68	18	1.00		15	12	1.00		53	6	1.00	
Complications at admission												
No	191	93	1.00		47	68	1.00		25	169	1.00	
Yes	45	51	1.22	0.84–1.79	7	34	1.11	0.70–1.78	38	17	1.68	0.86–3.24

Abbreviations: ASIA, American Spinal Injury Association; CI, confidence interval; RR, relative risk.
RR has been adjusted for sex, lesion level, ASIA impairment at admission and age.
Bold values indicate statistical significant results.

increase was significantly higher in the traumatic group, but the significance of this finding disappeared with age stratification. Both groups showed a good increase in the RMI and of the motor score (Table 2). With regard to AIS improvement, walking capability, bladder control, bowel management autonomy, frequency of complications and destination at discharge, no differences were observed between the two groups (Table 3).

With regard to LOS, non-traumatic patients were more often discharged within 70 days, while traumatic patients had a higher frequency of discharge after 117 days, although this difference did not reach statistical significance (Table 3).

Discussion

The demographic characteristics of the two SCL populations studied and the distribution of the different non-traumatic etiologies are consistent with the reported characteristics for the general traumatic and non-traumatic populations with spinal cord pathology,[17] bearing in mind the selected nature of the population in this study.

Traumatic and non-traumatic patients presented with several significant group differences similar to previous reports.[2] Patients with traumatic lesions were significantly younger. They were more often men, but this difference disappeared in the group below 50 years; this is in line with recent epidemiological studies that showed an increased percentage of women in the traumatic SCI population[17] and could indicate a change in the epidemiology of these lesions, especially those related to street accidents (car and motorcycle accidents).

With regard to neurological outcome, traumatic and non-traumatic patients presented the same degree of neurological improvement, with approximately 25% of AIS A, B and C patients achieving an improvement of at least one ASIA impairment level between admission and discharge in both groups. This percentage is comparable to the one found by Citterio *et al*.[8] With regard to motor scores, traumatic patients presented generally lower scores although this difference did not reach significance. When comparing motor scores at admission and discharge traumatic patients tended to present a slightly better recovery but this difference was not significant. The substantial similarity between the two groups in both AIS and motor scores improvement is particularly noteworthy. In a large retrospective study involving 1085 non-traumatic patients and 250 traumatic ones, Catz *et al*.[7] found a better prognosis for neurological recovery (evaluated as AIS impairment increase) in non-traumatic patients. This study do not confirm this finding. The differences between the study of Catz *et al*. and the present one is probably related to differences in the methodology applied. In particular, the statistical approach used in this study allowed adjustment for confounding effects of age, sex, AIS impairment at admission and level of lesion that might have significantly different effects in the two populations. In any case, the paucity of studies on this topic makes it difficult to draw conclusions. More studies, especially with larger groups of patients, are needed.

Table 2 BI, RMI and MSs at admission and discharge

	All					*Patients <50 years of age*					*Patients 50 years or more of age*				
	Traumatic					*Traumatic*					*Traumatic*				
	No *Mean (s.d.)*	*Yes* *Mean (s.d.)*	*RR*	*95% CI*		*No* *Mean (s.d.)*	*Yes* *Mean (s.d.)*	*RR*	*95% CI*		*No* *Mean (s.d.)*	*Yes* *Mean (s.d.)*	*RR*	*95% CI*	
BI admission	30.7 (24.8)	18.3 (16.7)	**0.985**	**0.973**	**0.998**	33.0 (26.2)	18.7 (15.8)	0.985	0.969	1.001	29.9 (24.4)	17.2 (18.7)	0.981	0.959	1.005
BI discharge	63.3 (31.1)	64.4 (30.2)	1.003	0.996	1.010	75.8 (26.8)	69.1 (28.8)	1.030	0.994	1.012	59.3 (31.3)	52.5 (30.8)	1.003	0.989	1.016
BI improvement	32.6 (24.5)	45.9 (26.5)	1.007	1.000	1.014	42.78 (27.3)	50.45 (25.2)	1.007	0.998	1.015	29.34 (22.7)	34.48 (26.9)	1.010	0.996	1.025
RMI admission	1.96 (3.1)	0.73 (1.99)	0.898	0.794	1.016	2.14 (3.06)	0.76 (1.99)	0.916	0.786	1.067	1.91 (3.13)	0.64 (2.02)	0.844	0.660	1.078
RMI discharge	6.1 (4.8)	5.4 (4.5)	1.011	0.961	1.063	8.2 (4.9)	5.9 (4.6)	1.011	0.951	1.074	5.4 (4.6)	4.3 (3.9)	1.001	0.908	1.104
RMI improvement	1.14 (3.9)	4.72 (4.1)	1.031	0.983	1.081	6.04 (4.5)	5.13 (4.2)	1.023	0.968	1.081	3.52 (3.6)	3.66 (3.4)	1.047	0.947	1.157
MS admission	58.6 (17.4)	50.4 (18.2)	1.001	0.983	1.019	61.57 (17.37)	50.75 (19.12)	0.999	0.976	1.023	57.45 (17.33)	49.47 (15.70)	1.001	0.974	1.028
MS discharge	66.4 (20.3)	58.6 (23.2)	1.002	0.99	1.02	74.4 (20.6)	59.9 (24.5)	1.00	0.99	1.02	63.3 (19.3)	54.9 (18.7)	1.00	0.98	1.03
MS improvement	7.86 (10.1)	8.1 4 (10.1)	1.004	0.984	1.02	12.83 (12.7)	9.14 (10.8)	1.007	0.983	1.03	5.90 (8.2)	5.44 (7.7)	1.018	0.967	1.071

Abbreviations: ASIA, American Spinal Injury Association; BI, Barthel index; CI, confidence interval; MS, motor scores; RMI, Rivermead mobility index; RR, relative risk.
RR has been adjusted for sex, lesion level, ASIA impairment at admission and age.
Bold values indicate statistical significant results.

At admission, traumatic patients have a significantly lower level of independence in daily life activities. BI scores were significantly lower in the traumatic population. However, RMI scores, walking capacity and bladder control were comparable in the two populations. McKinley *et al*.[5] in 1999 found results partially comparable to the present ones: patients with non-traumatic lesions, at least those with incomplete tetraplegia had a better functional status at admission as evaluated by the functional independence measure. McKinley *et al*. attributed this difference to the fact that non-traumatic patients were more often motor incomplete (ASIA C and D) than their traumatic counterparts. Similar results have been reported by Ones *et al*.,[9] while Gupta *et al*.[10] did not find any difference between the two populations at admission. Unfortunately in both these studies a correction for the covariant effect of age and neurological impairment is lacking, so their results are difficult to interpret. Our results suggest another explanation. Owing to the statistical methodology, the confounding effect of AIS impairment was eliminated, therefore, the lower independence of traumatic patients could depend on non neurological trauma-related factors, such as major surgery sequelae, need to wear an orthotic and associated lesions. In this study, traumatic patients had a higher frequency of associated lesions and major surgery. As already shown in other studies,[18] these factors decrease the independence of these patients at admission, and slow the timing of rehabilitation. The trend to longer LOS of traumatic patients could also be related to this possibility. Non-traumatic patients usually have a longer LTA[4] and could have undergone rehabilitation treatment during this time that could produce an increase in their functional status. In this study, LTA was not considered because of its strict relation with AIS level in the statistical evaluation. Another study could address this aspect.

Functional status at discharge was comparable in the two populations. Traumatic patients showed a higher BI increase, a finding that could be explained by the lower scores at admission. Mobility (RMI), walking function and bladder and bowel management improvement were similar in the two populations. These results are in line with previous publications. New[19] examined the functional outcome of non-traumatic SCL patients and reported comparable results with regard to bladder management and walking capability. McKinley *et al*.[16] also reported that non-traumatic patients could have significant improvement after the rehabilitation treatment; however, when compared with traumatic patients, they achieve lower overall functional gains, but have a shorter LOS. Accordingly to these data, Osterthun *et al*.[11] reported that etiology was not a determinant of functional outcome of patients with SCLs.

At discharge both traumatic and non-traumatic patients showed a mean BI score of approximately 60 points, a pivotal score in which patients move from dependence to assisted independence, and which can be considered a cut-off score to be discharged at home.[19] However, both population showed a quite high risk (20%) of being institutionalized after discharge. This is probably the result of high age in our series; in fact, both in SCL and other neurological diseases,

Table 3 Other outcomes

	All				*Patients <50 years of age*				*Patients ⩾50 years of age*			
	Traumatic				*Traumatic*				*Traumatic*			
	No	*Yes*	*RR*	*95% CI*	*No*	*Yes*	*RR*	*95% CI*	*No*	*Yes*	*RR*	*95% CI*
Length of stay (tertiles)												
<70 days	95	29	1.00		20	21	1.00		75	8	1.00	
70–117 days	81	45	1.21	0.75–1.94	24	30	1.02	0.57–1.82	57	15	1.70	0.71–4.07
>117 days	56	65	1.38	0.85–2.25	9	48	1.20	0.66–2.19	47	17	2.35	0.98–5.64
Complications during stay												
No	180	101	1.00		45	78	1.00		135	23	1.00	
Yes	56	43	1.32	0.91–1.91	9	24	1.08	0.67–1.74	47	19	1.51	0.80–2.85
ASIA improvement												
No	175	108	1.00		34	74	1.00		141	34	1.00	
Yes	61	36	1.04	0.66–1.64	20	28	1.13	0.65–1.97	41	8	1.01	0.41–2.44
Walking at admission												
No	215	140	1.00		48	99	1.00		167	41	1.00	
Yes	21	4	0.55	0.18–1.66	6	3	0.59	0.16–2.19	15	1	0.48	0.06–4.06
Walking at discharge												
No	147	93	1.00		26	64	1.00		121	29	1.00	
Yes	89	51	1.36	0.87–2.12	28	38	1.26	0.73–2.17	61	13	1.78	0.76–4.17
Bladder emptying modalities												
Not spontanous	145	104	1.00		26	76	1.00		119	28	1.00	
Spontanous	91	40	1.31	0.78–2.21	28	26	1.05	0.53–2.06	63	14	1.83	0.79–4.26
Bowel voiding autonomy												
No	85	44	1.00		11	29	1.00		74	15	1.00	
Yes	151	100	0.23	0.78–1.70	43	73	1.03	0.64–1.65	108	27	1.54	0.76–3.10
Destination at discharge												
Hospital	48	35	1.00		8	22	1.00		40	13	1.00	
Home	188	109	0.92	0.62–1.36	46	80	0.98	0.60–1.61	142	29	0.88	0.44–1.73

Abbreviations: ASIA, American Spinal Injury Association; CI, confidence interval; RR, relative risk.
RR has been adjusted for sex, lesion level, ASIA impairment at admission and age.

age at injury is an important factor in the likelihood of institutionalization.[20]

Differences in outcomes and discharge destination are not due to different funding restrictions/streams for the traumatic vs non-traumatic injuries with regard to equipment, housing modifications, on-going rehabilitation, as the Italian Health Service warrants the same facilities to both populations.

This study presents some shortcomings that deserve further analysis.

The stratification of lesion level in cervical, thoracic and lumbar could be misleading because the outcome of high tetraplegia and high paraplegia are different to those of low tetraplegia and low paraplegia. A more detailed stratification should be recommended, but the number of subjects in our study did not allow further discrimination.

Non-traumatic patients could be expected to have a worse outcome because of concurrent pathologies (that is, the presence of cardiac or cerebral vascular disease in patients with vascular myelopathies) or because of the possible worsening of other etiologies (for example, the possibility that a myelitis represents the beginning of multiple sclerosis). With regard to the first issue, by adjusting the statistical model for age, we probably corrected for the incidence of concurrent pathologies in the two cohorts too. As to the possibility of disease worsening, as stated in the methods, patients who showed a disease worsening during their stay were excluded from the study. A follow-up study would help to clarify if patients with non-traumatic lesions have a worse outcome in the long term because of progression of disease.

Another bias could be the inclusion of non-traumatic patients with different etiologies; Ditunno[21] warned researchers regarding the risk of making generalizations regarding patients with non-traumatic SCLs, because this population includes different diseases with different prognoses. In our study, with regard to this issue, the number of subjects did not allow a more detailed analysis.

Conclusions

Two main conclusions may be driven from this study.

Patients with clinically stable non-traumatic lesions have an outcome comparable to patients with traumatic lesions.

This finding is of particular interest as concerns discharge destination and resources utilization. The outcome for these patients is determined by the characteristics of the lesion and by age, but not by etiology.

Second, our data underscore the concept that when we compare populations of patients with SCLs with different characteristics, it is necessary to adopt a statistical method to correct for the potential confounding effects of these characteristics.

Conflict of interest

The authors declare no conflict of interest.

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