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Traumatic and non-traumatic spinal cord injury: Demographic characteristics, neurological and functional outcomes. A 7-year single centre experience

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ABSTRACT

Objective: The aim of this study is to evaluate demographic and clinical characteristics of a population affected by traumatic and non-traumatic spinal cord injury (SCI) and to analyze functional outcomes after rehabilitation.
Methods: This study involved 112 SCI patients (75 male and 37 female) admitted at the Neurorehabilitation Unit of the University Hospital of Messina. The neurological outcomes were evaluated according to the American Spinal Injury Association Impairment Scale (AIS) and by using length of stay, Functional Independence Measure (FIM) and Barthel Index (BI).
Results: NT-SCI patients were significantly older, numerous (75,89%) and affected by greater lesions when admitted, than T-SCI ones. Most of lesions were incomplete (93%) and associated with paraplegia (71%). FIM and BI outcomes are similar in both groups, even if T-SCI patients showed greater improvement when discharged. No significant differences were found in the length of stay. The most common complication in non-traumatic SCI group was urinary tract infection and this was observed in 25 patients (29,41%). Linear regression models explained 26% of the variance of LOS and 38% of the variance of functional outcome. Functional status on admission was the strongest determinant of LOS and completeness of the lesion was the strongest determinant of functional outcome. Etiology (traumatic versus non-traumatic) was a weak independent determinant of LOS but was not an independent determinant of functional outcome.
Conclusion: SCI patient's rehabilitation should be carried out by taking into account etiology of the injury. It is important to consider this information while developing the targets and planning of the rehabilitation program. In particular, older age negatively influence the degree of disability on admission and the entity of functional recovery in both populations. Non-traumatic lesions could have minor benefits after rehabilitation therapy if compared with traumatic ones.

1. Introduction

Introduction Spinal cord injury (SCI) has a worldwide incidence of between 10.4 and 83 cases per million per year.[1–3] Although patients with SCI have a great impact on the health-care system, few epidemiological studies of SCI are available. Spinal cord injury (SCI) worldwide incidence is between 40 and 80 cases per million inhabitants.[4] These lesions often result in a significant functional impairment of many activities of our daily living, including mobility, self-care and bladder, bowel and sexual functions. It is unclear how many people in the world are currently living with SCI but international incidence data suggest that every year between 250,000 and 500,000 people report a spinal cord injury. The largest part of these cases is traumatic, mostly caused by road traffic injuries, falls and acts of violence. Traumatic SCI (T-SCI) are more common in young adults and in the elderly; more than half of the patients are involved between 16 and 30 years and male represent about 80%. Non-traumatic SCI (NT-SCI) represents a significant rate of patients hospitalized in neurorehabilitation units. Multiple causes are

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recognized such as spinal stenosis, neoplastic lesions, inflammatory diseases, infections and vascular injuries.[5] Some authors compared NT-SCI patients and T-SCI ones and concluded that the former is older and commonly show incomplete lesions associated with paraplegia.[6] Although different studies analysed and reported data about the functional outcome of SCI patients, the presence of significant differences, regarding their rehabilitation recovery, related to the traumatic or non-traumatic aetiology of the lesions is still unclear. Guttman and co-workers have reported that one third of the 3000 SCI patients had a non-traumatic SCI.[7] The etiological causes of NT-SCI are related to spinal stenosis, tumor compression, vascular ischemia, transverse myelitis, neuronal motor disease, and syringomyelitis.[8] Some researches show that the ratio of older, female and retired patients is higher in the NT-SCI than the traumatic SCI group.[9] As NT-SCI patients are usually older, they usually also have diabetes, cardiovascular and pulmonary diseases, and poor memory and retention. These co-existing health problems could result in a decrease in the efficiency of rehabilitation and improvement of long-term functionality of the NT-SCI patients.[10] Only a few studies have investigated the complications after a rehabilitation program in patients of non-traumatic SCI.[11,12] The percentage of the non-traumatic SCI patients is quite high among SCI patients, therefore, it is important that we know the medical and functional response of these patients in order to understand the medical, personal, and family-related problems. The aim of this study is to compare demographic and lesion characteristics, stay in hospital, functional and neurologic outcomes of patients with T-SCI and NT-SCI admitted to our neurorehabilitation unit.

2. Materials and methods

2.1. Study design and population

A retrospective study on spinal cord injured subjects was carried out on a cohort of 152 SCI patients, hospitalized at the neurorehabilitation unit of the University Hospital of Messina, in a period of seven years. Because of 20 patients were affected by encephalomyelitis, 11 patients by multiple sclerosis, and 9 patients by severe trauma brain injury, with a concomitant involvement of superior cortical functions, the sample group was reduced to 112 patients. Inclusion criteria to rehabilitation unit were required: first hospitalization in a neurorehabilitation unit; aged over 15 years; complete data available for age, level and completeness of injury, inpatient rehabilitation lengths of stay, functional independence measure (FIM), and Barthel index (BI). Non-traumatic injuries represented a heterogeneous group, including degenerative (e.g., spondylarthrosis, spinal stenosis), neoplastic (primary and secondary tumors), vascular (e.g. ischemia, haemorrhagic events, artero-venous fistulas) and inflammatory (e.g. transverse myelitis, infections) diseases, for a total of 85 subjects (75,89%).

2.2. Set up and evaluation of outcomes

The outcome measures included demographic features (age and sex), aetiology (traumatic or non-traumatic), provenance of patient, neurological level of injury (NLI), clinical features (paraplegia or tetraplegia), extent of injury according to the American Spinal Injury Association Impairment Scale [AIS], lesion at time of admission (LTA) and length of stay (LOS). Functional status and evaluation of the activities of daily living (ADL) were assessed, by FIM and BI, on admission and at discharge. Differences among the NT-SCI injured subgroups were also analysed. The AIS represents the international standard to evaluate the impairment degree of SCI. This scale distinguishes 5°, from A or complete injury, to E equivalent to normal status, based on the injury completeness.[13–16] The FIM is an international scale used to assess physical and cognitive disability, concerned with the level of independence; it includes motor and cognitive FIM, with a total score ranges between 18 and 126 points, where the higher scores indicate more independence.[17] The BI is a standardized tool, widely used in rehabilitation assessment settings. It measures functional disability by quantifying the patient's performance in 10 ADL, including self-care (feeding, grooming, bathing, dressing, bowel and bladder care, toilet use) and mobility activities (ambulation, transfers and stair climbing). A score of 60/100 is the cut off at which patients move from dependence to independence.[18] Therefore, a score ranged between 80 and 100/100 defines an independent patient, between 60 and 79 needs a minimal help, between 40 and 59 partially dependent, between 20 and 39 very dependent, lower than 20 a very dependent patient in self-care and mobility ADL.[19] Since patients with low FIM and BI scores on admission showed a little improvement, whereas those with high FIM and BI scores on admission demonstrated a great effect, we integrated all data concerning to the improvements with those related to the rehabilitation effectiveness; the latter expresses the actual improvement as a proportion of potential improvement.[20] Besides the improvement and the effectiveness, rehabilitation efficiency was calculated, in order to measure the rate of functional improvement and the length of hospitalization.[21] All patients gave informed consent for their data to be included in a central database after name and address information had been removed.

2.3. Statistical analysis

Statistical univariate analysis was conducted by using SPSS for Windows 11.5. To investigate relationships between T-SCI and NT-SCI group regarding the following factors: age, sex, clinical features, LTA, LOS, FIM and BI scores on admission and at discharge, functional outcome indexes (efficiency, effectiveness, improvement). The between-groups comparisons of the mean values were carried out using the t-Student test, while the percentage variables were compared using the χ^2 test. The results are expressed as mean ± standard deviation (SD) for the continuous variables or as range with indication of extreme values. The level for statistical significance was set at $p < 0.05$. The influence of aetiology and other characteristics on LOS and functional outcome was analysed using stepwise backward regression analyses to reveal the most efficient regression model. All determinants were entered together, and the weakest determinant was eliminated at each step until all remaining determinants were related to the dependent variable.

3. Results

3.1. Patients characteristics, aetiologies and duration of hospital stay

Overall, the cohort of patients consisted of 112 patients, including 85 (76%) NT-SCI patients and 27 (24%) T-SCI ones, and the mean age was 60 ± 14.8 years (range, 22–87 years). In our cohort, 67% of the injured patients were male; this percentage was higher in T-SCI group (male 81%, female 19%). Non-traumatic patients were significantly ($p = 0.0005$) older than traumatic ones (T-SCI 52 *vs* NT-SCI 63 years). All demographic features are described on Table 1.

In the T-SCI group, the main frequent causes of trauma were road traffic accidents (48%), falls (37%), firearms (7%) and occupational injuries (7%). The aetiologies are detailed and related to age, sex and length of stay in Table 2. In the T-SCI group a prevalence of cervical lesions (44.5%) was found, compared to the NT-SCI group in which the thoracic column was more involved; lumbar injuries were poorly represented in both groups. Patients with NT/SCI had significant greater lesion ($p = 0.001$) to admission time (299 days) than patients with T/SCI (71 days), see Table 3. No significant differences ($p = 0.4$) were revealed for acute care LOS, that was longer for patients with traumatic lesions, see Table 4.

3.2. Neurological outcomes analysis

The majority of the injuries were incomplete (T-SCI 79% and NT-SCI 98%). Neurological status score on admission was worse in the

Table 1
- *Demographic, clinical, and neurological features.*

	Total	T-SCI	NT-SCI	*p* value
Sex				*0.06*
Male	**75** *(67%)*	**22** *(81%)*	**53** *(63%)*	
Female	**37** *(33%)*	**5** *(19%)*	**32** *(37%)*	
	Total	**T-SCI**	**NT-SCI**	***p* value**
Age				***0.0005***
Range	**22–87**	**22–77**	**25–87**	
Mean ± SD	**60** *± 14.8*	**52** *± 17.7*	**63** *± 12.6*	
	Total	**T-SCI**	**NT-SCI**	***p* value**
Completeness of injury				***0.0001***
Complete	**8** *(7%)*	**7** *(21%)*	**2** *(2%)*	
Incomplete	**104** *(93%)*	**20** *(79%)*	**83** *(98%)*	

	Total	T-SCI	NT-SCI	*p* value
Clinical presentation				*0,002*
Tetraplegia	**32** *(29%)*	**14** *(52%)*	**18** *(21%)*	
Paraplegia	**80** *(71%)*	**13** *(48%)*	**67** *(79%)*	
	Total	**T-SCI**	**NT-SCI**	***p* value**
Level of injury				***0.005***
Cervical	**30.5%**	**44.5%**	**26.0%**	
Cervical and Thoracic	**3.5%**	**15.0%**	**-**	
Thoracic	**57.0%**	**33.0%**	**65.0%**	
Lumbar-sacral	**9.0%**	**7.5%**	**9.0%**	

Table 2
- *Correlation among NT-SCI Etiologies, age, sex and duration of stay.*

Etiology	Mean age ± SD *[y]*	Sex prevalence *[M/F]*	Length of stay *[d]*
Degenerative (31%)	**63.5** *± 12.8*	**M** *69%*	**45** *± 24.5*
Inflammatory (25%)	**65** *± 11.1*	**M** *76%*	**55** *± 53.0*
Neoplastic (24%)	**57** *± 15.0*	**F** *55%*	**44** *± 27.1*
Vascular (21%)	**68** *± 9.3*	**M/F** *50%*	**65** *± 66.0*

traumatic group, while at discharge neurological outcomes were similar in both cohorts; a regression from the degree A was obtained only in non-traumatic patients, see Table 3.

3.3. Functional outcomes analysis

Although T-SCI patients presented lower total FIM and BI scores on admission, all scores were increased, and almost equivalent, at discharge in both cohorts; FIM improvement and effectiveness were significantly greater for T-SCI group, $p = 0.004$ and $p = 0.04$, respectively. BI showed the same trend, with a BI improvement significantly superior in traumatic group ($p = 0.026$), see Table 4.

No aetiology-related differences were revealed for functional outcomes in non-traumatic subgroups. The only significant difference was observed, between degenerative and vascular aetiologies, for FIM and BI on admission. In detail, on admission, patients with vascular injuries showed a lower independence for total FIM scores (FIM vascular 66 ± 21.2 *vs* FIM degenerative 82 ± 18.3) and greater dependence in ADL (BI vascular 34 ± 18.5 *vs* BI degenerative 50 ± 25). The best BI-related outcome was observed for inflammatory diseases (BI improvement = 20), whereas patient with vascular lesions showed better results in total FIM score (FIM improvement = 16), see Table 5.

The regression model of LOS explained 26% of the variance of LOS. Having a poorer functional status on admission was the strongest determinant of a longer LOS. Other significant determinants were the conditions of having a motor complete, a tetraplegic and a traumatic lesion (Table 6). The regression model of functional outcome explained 38% of the variance. Having a motor incomplete lesion, a paraplegic lesion and a younger age were determinants of better functional outcome. Aetiology has not determinant consequences for functional outcome.

4. Discussion

In our study, demographic and etiologic characteristics of SCI

Table 4
- *Functional outcome measures.*

	T-SCI	NT-SCI	*p value*
LTA (days)	71 ± *82.3*	299 ± *340*	*0.0008*[a]
Length of stay (days)	T-SCI	NT-SCI	*p value*
Mean ± SD	58 ± *41*	51 ± *44*	*0.4*
Range	16–177	10–285	
FIM score	T-SCI	NT-SCI	*p value*
Admission ± SD	68 ± *23*	75 ± *22*	*0.1*
Discharge ± SD	90 ± *28*	88 ± *23*	*0.7*
Improvement	22	13	*0.004*[a]
Efficiency	0.53	0.35	*0.058*
Effectiveness	42.2	29	*0.04*[a]
Barthel Index score	T-SCI	NT-SCI	*p value*
Admission ± SD	32 ± *27*	41 ± *23*	*0.09*
Discharge ± SD	60 ± *36*	58 ± *27*	*0.7*
Improvement	27	17	*0.02*[a]
Efficiency	0.69	0.46	*0.06*
Effectiveness	47	33	*0.06*

[a] Statistically significant.

Table 5
– *FIM scores, improvement, and BI improvement.*

FIM scores		FIM improvement
FIM vascular	**66** ± *21.2*	16
FIM degenerative	**82** ± *18.3*	
Total ADL		**BI improvement**
BI vascular	**34** ± *18.5*	20
BI degenerative	**50** ± *25,6*	

Table 3
ASIA Impairment Scale (AIS) on admission and at discharge.

	AIS Admission score (%)					AIS Discharge score (%)				
	A	B	C	D	E	A	B	C	D	E
T-SCI	**6** *(21*	**4** *(16)*	**11** *(42)*	**6** *(21)*	–	**6** *(21)*	**3** *(11)*	**6** *(21)*	**11** (42)	**1** *(5)*
NT-SCI	**2** *(2)*	**12** *(14)*	**30** *(36)*	**41** *(48)*	–	–	**14** *(12)*	**14** *(17)*	**55** *(66)*	**4** *(5)*
Total	**8** *(7)*	**16** *(14)*	**41** *(37)*	**47** *(42)*	–	**6** *(5)*	**13** *(12)*	**20** *(18)*	**67** *(60)*	**6** *(5)*

Table 6
– *Linear regression of determinants of LOS and functional outcome (N= 112).*

Independent value	Length of stay (LOS)			Functional outcome		
	β	t-value	p-value	β	t-value	p-value
Age	/	/	***NS***	***−0.187***	***−4.235***	***0.000***
Etiology [T/NT SCI]	***0.072***	***1.687***	***0.005***			***NS***
Clinical presentation [tetra/paraplegia]	***0.112***	***4.623***	***0.000***	***−0.165***	***−4.954***	***0.000***
Completeness of injury [complete/ incomplete]	***0.265***	***5.788***	***0.000***	***−0.212***	***−7.655***	***0.000***
	Adjusted R ^{2} = 0.26 *(F = 48.4; p < 0.001)*			***Adjusted R^2 = 0.38*** *(F = 63.1; p < 0.001)*		

patients observed in both cohorts were agree with the Italian worldwide literature.[22,23,24,25, and 26] Paraplegia was prevalent in NT-SCI group, whereas tetraplegia in T-SCI one. On admission, traumatic and non-traumatic patients presented similar degrees of neurological impairment, and approximately 20% of all patients classified as AIS C achieving a gain of one AIS degree at discharge. Concerning the score A, all nontraumatic injured patients regressed to an inferior impairment degree, while traumatic ones no improvements obtained of neurological status between admission and discharge. These results confirmed the major severity of the impairment in T-SCI patients and were similar to those described in the earlier literature.[22] On admission, the higher levels of autonomy compromission in T-SCI, could be related to a higher rate of associated lesions; moreover, these patients more frequently have been undergoing to major surgery.[27] At discharge, functional status was comparable in traumatic and nontraumatic cohorts, accounted approximately a BI mean score of 60. Patients who were traumatically injured got more improvement than the non-traumatic ones regard to BI scores ($p = 0.02$), passing from a status of severe dependence in ADL (BI 20–40) to an independence with supervision one (BI $\geq$ 60). Furthermore, BI efficiency and effectiveness were also higher in traumatic group, showing a trend of these patients to obtain a greater improvement, although without a statistical significance. In this study, analysis of FIM outcome revealed a significantly improvement between admission and discharge in traumatic SCI population ($p = 0.004$), showing greater FIM gain for traumatic injured.[28–30] In addition, the FIM effectiveness (T/SCI 42.2 vs NT/SCI 29) resulted significantly ($p = 0.04$) greater in traumatic SCI patients. Furthermore, also the FIM efficiency was near to the level of significance ($p = 0.06$). These results allow to state that traumatic SCI population has a major trend to functional recovery.[29] In regard to the analysis of non-traumatic myelopathy subgroups, the only significant difference has been observed in the FIM and BI scores between degenerative subset and vascular subset, the latter showing an higher grade of dependence in admission ADL. However, no significant differences were observed about functional outcomes, according to previous study.[26] Even though it had not statistical significance, the average LOS was longer for patients with traumatic SCI than for patients with non-traumatic SCI (T/SCI 58 ± 41 vs. NT/SCI 51 ± 44 days), which spent a mean shorter period in the neurorehabilitation unit. This result confirms international literature.[25,28,29,and 31] According to different reports,[17] NT/SCI patients generally presented a longer LTA - in our study it was 299 days. In fact, non-traumatic lesions often arise insidiously and gradually, whereby patients usually get a diagnosis only after a prolonged period of specialist examinations. As reported in previous studies,[29,32] traumatic patients showed a greater gain (improvement) in FIM and Barthel measures. In first instance, we can explain this result with the fact the T/SCI injured reported lower scores on admission and had a greater length of stay. Nevertheless, the major functional recovery of T/SCI patients has been valued with functional outcome indices as FIM effectiveness, that express an index independent of the score on admission. This study has limited sample size, particularly concerning the traumatic group. Patients were treated in a non-specialized rehabilitation centre as well, and they were not stratified based on spinal levels. Although a recent prospective observational cohort, study reported that patient preinjury and injury characteristics were sufficient to predict outcomes with no further explanation provided by comorbidity,[33–36] this aspect has not been analysed in the present study. We also do not provide long-term follow-up maintenance. LOS was longer for patients with traumatic SCI than for patients with non-traumatic SCI and etiology was an independent predictor of LOS in the regression analysis. In the regression analysis, etiology is not an independent determinant of functional outcome. The bivariate association of etiology with functional outcome in this study can therefore be ascribed to differences between both groups regarding lesions characteristics, and age. The independent influence of age on functional outcome may be based on a reduced ability to recover and the effect of co-morbidity in elderly patients. This study evidences that treatment of non-traumatic SCI in specialized rehabilitation centers might be at least as effective as treatment of traumatic SCI. Moreover, different approaches can furnish interesting information regarding the correct rehabilitation protocols by using for example FE medialization,[37–39] in order to investigate stress and strain shielding aging on the bony and soft tissues.[40–49]

5. Conclusions

Patients with non-traumatic SCI represent majority of our patients with spinal cord injury. Substantial and significant differences were observed between traumatic and non-traumatic spinal cord injured. These differences concern mean age, sex, neurologic impairment and injury extent on admission, lesion to admission time, and the entity of functional recovery. In particular, older age negatively influence the degree of disability on admission and the entity of functional recovery in both populations. Non-traumatic lesions could have minor benefits after rehabilitation therapy if compared with traumatic ones, cause their presentation is often insidious and slow the timing of diagnosis and the admission to a rehabilitation unit. This data suggest that can be useful a different planning of rehabilitation intervention in the different categories of spinal cord injury. In particular elaborating a specific rehabilitation plan in NT-SCI could lead to a better functional recovery of these patients.

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