



Rehabilitation of the multiple injured patient with spinal cord injury: A systematic review of the literature



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ABSTRACT

Introduction: Patients with multiple injuries including spinal cord injury (SCI) have low survivability. Little is known for the effect of SCI in their rehabilitation process.

Purpose: To define differences in characteristics and outcomes during the rehabilitation of multiple injured patients with SCI compared to other polytrauma patients.

Materials and methods: Electronic libraries provided 425 relevant articles. Applying the criteria, 6 articles were eligible for inclusion in this review.

Results: The extracted data show that multiple injured patients with SCI have an increased length of stay (LOS) in rehabilitation. Initial functional levels, as also one- and two-years follow-up are also decreased. Similar results were found comparing SCI patients with or without multiple injuries: SCI patients with multiple injuries have an increased LOS and decreased functional levels compared with SCI patients. Finally, there was no relevance between the circumstances of the injuries, like acts of terror, and the expected rehabilitation outcome.

Conclusion: Due to the rarity of eligible articles and the lack of homogenous accessing tools, a meta-analysis was not possible. There is a lack of a universal evaluation strategy or tool, for the severity of the multiple injured patients aiming at the rehabilitation outcome prognosis. Multiple-injured patients with SCI have longer rehabilitation LOS and functional outcomes compared to other polytrauma patients. Prospective studies are needed for evaluation of the differences according to the severity and the complexity of the injuries and the rehabilitation outcome depending on different rehabilitation methods and strategies.

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Introduction

The mortality of a multiple injury with a spinal cord injury can reach 50%, most of them dying in the scene or a few hours later [1]. For the other 50%, surviving is the beginning of a long rehabilitation period. Although new pharmacological and engineering technologies emerge, the majority of the patients, from the most severely injured with quadriplegia to the slightly injured with a rapid recovery, will require continuous and strenuous rehabilitation, as so, to reach the maximum level of self-sufficiency. Most of rehabilitation professionals will have to overpass many psychological discrepancies along with the physical ones [2]. Motor and sensory impairments and/or autonomous nervous system deficits decrease the quality of everyday life of the patient [3].

There is a considerable amount of literature addressing many aspects of the rehabilitation process, from ICU until a two-year follow up of patients with polytrauma [4–7]. A retrospective study by Scivoletto et al. focused on the long-term functional and neurological outcomes of these patients [8]. Other cohort studies [9,10] compare traumatic and non-traumatic spinal cord injuries (SCI) but don't focus at polytrauma with SCI patients.

Since the complexity of polytrauma patients with SCI as well as traumatic brain injury (TBI) is vast [11], these studies involving TBI will be excluded. In this review, characteristics about the rehabilitation process of multiple injured patients with SCI will be addressed: Demographics of occurrence, morbidity/mortality outcomes, recording of the rehabilitation progress and the multiplex of recording tools, associating factors that play vital roles to the length of rehabilitation period (Length of Stay, LoS) and its outcomes according to the severity of the injuries. The aim is to define any differences in the aforementioned characteristics of multiple injured patients with SCI compared to other polytrauma patients.

Materials and methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were followed for this review.

Information sources and search strategy

We performed a computerised literature review using MEDLINE, ScienceDirect, Scopus and Cochrane databases. The following keywords were searched: “Spinal Cord Injury” AND “Polytrauma” OR “Multiple Trauma” OR “Multiple Injuries” AND “Rehabilitation” AND “Outcome”. The literature search was limited to human and English-language studies published between 1st January 1970 and 31st October 2018. The methodology used was registered at the International prospective register of systematic reviews, PROSPERO (Prospero ID: CRD42018104046).

The Medline database generated 64 references, while ScienceDirect, Scopus and Cochrane provided 310, 49 and 2 references respectively, totalling in 425 potential studies. After eliminating duplicates and applying eligibility criteria 24 articles remained. After reviewing the 24 articles, both reviewers (AP and VC) selected 6 studies that offered the proper data for this review. (Fig. 1)

Eligibility criteria

This work aims to review studies addressing directly or indirectly the differences of the rehabilitation process of multiple injured patients with or without Spinal Cord Injury (-ies) or Spinal Cord Injured patients with or without multiple injuries or Spinal Cord Injured Patients with multiple injuries of different severity. The inclusion and exclusion criteria are listed in Table 1. All included studies were required to identify differences of the rehabilitation process or outcome between these groups of patients even if it was not the aim of the selected study.

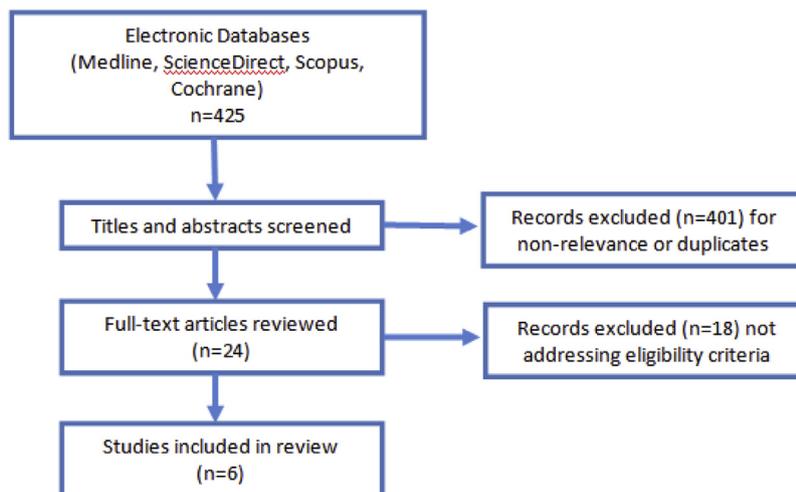


Fig. 1. Search strategy diagram for this systematic review.

Table 1
Eligibility criteria.

	Inclusion	Exclusion
Publication type	<ul style="list-style-type: none"> • Studies published after 1st January 1970 • Language: English 	<ul style="list-style-type: none"> • Editorials, letters, systematic reviews, meta-analyses, preliminary reports, expert opinions, conferences and textbooks
Population	<ul style="list-style-type: none"> • Patients with multiple injuries and SCI 	<ul style="list-style-type: none"> • Non-traumatic SCI • Patients with TBI • Animal studies
Outcome	<ul style="list-style-type: none"> • All available: Mortality, LoS, Functional outcomes 	<ul style="list-style-type: none"> • Studies not reporting differences or similarities between multiple injured patients with and without SCI or between SCI injured patients with or without multiple injuries or multiple injured patients with SCI of different severity
Study design	<ul style="list-style-type: none"> • Any study design 	

Appendix: SCI: Spinal Cord Injury; TBI: Traumatic Brain Injury; LoS: Length Of Stay.

Selection and data collection

Each abstract was reviewed by two of the authors (AP and VC) in order to remove duplicates and non-relevant studies based on our eligibility criteria and objectives of this review. The complete articles were also reviewed for identification of relevant studies in the bibliography for inclusion in this review. Data extraction was then performed, using a standardised table (Table 2). The collected data were identified as follow:

- Main author's name and year of publication
- Population type (demographics) and size, study design
- Global evaluation and rehabilitation outcome measurement tool used
- Data or information extracted

Results

Comparing outcomes of SCI patients with or without multiple injuries

Mortality-survivability

Quantity and/or quality of associated lesions play an important role in the survival of the injured SCI patient. In a descriptive manner, Lieutand et al. [1] conclude that deceased victims sustained twice much more associated lesions than survivors ($p < 0,0001$) and that associated lesions ($AIS \geq 4$) were 10 times more often observed in the deceased than in survivors.

Length of rehabilitation period (length of stay, LoS)

Increased rehabilitation LoS was found by all authors in multiple injured SCI patients. A mean difference of 1.9 months was found by Putz et al. [12]. Schivoletto et al. [8] found that rehabilitation LoS was increased in SCI patients with multiple injuries compared with monotraumatic SCI patients (SCI with multiple injuries LoS: $159.1 \pm 1d$, monotraumatic SCI: $130.4 \pm 84d$). Finally, Hebert et al. [3] associated increased LoS with increased ISS, which is the most usual case comparing polytraumatic with monotraumatic SCI patients.

Functional outcomes (FIM, SCIM, BI, WISCI II, ASIA MS, return to work)

Hebert et al. [3] as well, descriptively, in the same thinking pattern as mentioned above, found that polytraumatic SCI patients to have decreased FIM at discharge, at 1 and 2 years after discharge FU, decreased chance of returning to work and increased time period to return to work, comparing them with monotraumatic SCI patients. Similar SCIM scores but with difference in time consumed to achieve them were registered by Putz et al. [12]. Finally,

monotraumatic SCI patients scored better than their polytraumatic counterparts at all functionality scores and scales used by Scivoletto et al. [8]. It is important to mention, though, that no statistical significance was found in the above mentioned results.

Comparing the outcomes of multiple injured patients with or without SCI

Length of rehabilitation period (length of stay, LoS)

Double or triple the inpatient rehabilitation LoS was found in multiple injured patients with SCI compared with multiple injured patients without SCI in the work of Shwartz et al. [4]. This difference diminished when examining the outpatient rehabilitation LoS.

Functional outcomes (FIM)

At the same study (Schwartz et al.) [4], FIM after inpatient and outpatient rehabilitation was almost equal for multiple injured patients with or without SCI.

Comparing multiple injured with SCI patients in different conditions

Comparing multiple injured SCI patients with and without neurological improvement

An interesting study by Putz et al. [13] showed that multiple injured SCI patients without neurological improvement had an increased rehabilitation period (LoS) and a decreased starting, and after one-year follow-up, SCIM, comparing with the LoS and SCIM scores of multiple injured patients with neurological improvement. The difference of SCIM scores ($\Delta SCIM$) (SCIM at 1 year follow up - SCIM at the start of rehabilitation), for the two groups, was similar, though.

Comparing multiple injured SCI patients, terror victims and not-terror victims

Schwartz et al. [4] addressed the differences found in terror victims and not-terror victims, polytrauma with SCI patients. They did not find important differences in inpatient or outpatients LoS between the two groups. They also underline the fact quoting that terror-multiply injured with SCI-victims have the same rehabilitation LoS as any other traumatic SCI patient in Israel. FIM scores, after inpatient and outpatient rehabilitation, are similar as well.

Discussion

In our review, the differences in the rehabilitation process and outcome between multiple injured patients with or without SCI was attempted to be evaluated. It was found that multiple

Table 2
Standardised data extraction.

Author, Year	Population type (demographics)	Population size	Study design	Global Tool(s)	Data or Information extracted
Hebert J et al., 2000 [3]	Spine trauma patients, admitted to the University of Alberta Hospital (Canada)	830 Spine trauma patients, 595 spine trauma patients sustained polytrauma	Cross-sectional survey, Cohort study	ISS, LoS, FIM	Polytrauma Patients with increased ISS had increased LoS, decreased FIM at discharge, at 1 year and 2 years follow up. Increased rate of not returning to work and increased time period to return to work*
Lieutand T et al., 2010 [1]	Injured patients from MNMVA, in the Rhône area (France)	97,341 victims, 144 SCI patients, 15 SCI patients with polytrauma	Cross-sectional survey, Cohort study	n.a.	Survivability: "Deceased victims sustained twice much more associated lesions than survivors" ($p < 0,0001$), "Associated lesions ($AIS \geq 4$) were 10 times more often observed in the deceased than in survivors."
Putz C et al., 2010 [13]	Multiple Injured patients with Thoracic Spine Fracture, (neurological lesion level: T1-T12), Traumatic patients, early surgically (<24 and 24-72 h), 17men and 4 women rehabilitated at the Orthopaedic University Hospital Heidelberg (Germany), age 33 ± 12.5 SD years	21 multiple injured patients with paraplegia (Group1:14 patients without AIS change and Group 2:7 patients with AIS change)	Clinical Cohort study, Retrospective Analysis	PTS, AIS, LoS, SCIM	Group 1: Rehabilitation LoS: $6 \pm 2,148$ months, SCIM: $15,9 \pm 9,1$ (2 w)→ $63 \pm 15,3$ (1y FU) Group 2: Rehabilitation LoS: $4,43 \pm 1,813$ months, SCIM: $24,3 \pm 20,5$ (2 w)→ $78,7 \pm 14$ (1y FU)
Putz et al., 2011 [12]	Paraplegic patients (neurological lesion level: T1-T12), Traumatic patients, early surgically (<24 and 24-72 h), 24 men and 7 women rehabilitated at the Orthopaedic University Hospital Heidelberg (Germany), age: Group 1: 36 ± 12.9 SD years, Group 2: 33 ± 12.5 SD years	31 paraplegic patients (Group 1: 10 SCI patients, Group 2: 21 multiple injured patients with SCI)	Clinical Cohort study, Retrospective Monocentric Analysis	PTS, AIS, LoS, SCIM	Group 1: Rehabilitation LoS: $3,6 \pm 2,1$ months, SCIM: $75,7 \pm 19,2$ (6 months FU) Group 2: Rehabilitation LoS: $5,5 \pm 2,1$ months SCIM: $71,2 \pm 12,3$ (12 months FU)
Schwartz I et al. 2007 [4]	Terror victims, treated at Rehabilitation Dpt in a university hospital in Jerusalem, 48 men and 24 women, age 30 years (mean, range 9–76 years) and non-terror victims of similar distribution of injuries, age and sex, received 3 h of physical therapy and 3 h of occupational therapy weekly	72 multiple traumatised terror victims (Group 1.1: 47 without CNS involvement, Group 2.1: 19 with TBI and Group 3.1: 6 with SCI), 72 multiple traumatized non-terror victims of similar injury distribution (Group 1.2, Group 2.2 and Group 3.2 respectively)	Retrospective chart reviews	LoS, FIM	<u>Inpatient Rehabilitation LoS:</u> Group 1.1: $31,7 \pm 19,8d$, Group 3.1: $128,3 \pm 61,2d$ ($p = 0,003$) Group 1.2: $34,3 \pm 24,5d$, Group 3.2: $151 \pm 91,3d$ ($p = 0,003$) <u>Outpatient Rehabilitation LoS:</u> Group 1.1: $147,1 \pm 105,3d$, Group 1.2: $99 \pm 66,2d$, Group 3.1: $135,8 \pm 132d$, Group 3.2: $119,8 \pm 120,4d$ ($p > 0,5$) <u>Total Rehabilitation LoS:</u> Group 3.1: Similar to the total rehabilitation LOS of all traumatic SCI patients in Israel <u>FIM after inpatient rehabilitation:</u> Group 1.1: $106 \pm 13,4$, Group 1.2: $100 \pm 20,4$, Group 3.1: $97 \pm 19,6$, Group 3.2: $109,1 \pm 12,3$ ($p > 0,5$) <u>FIM after outpatient rehabilitation:</u> Group 1.1: $122 \pm 4,35$, Group 1.2: 114 ± 18 , Group 3.1: $108 \pm 12,2$, Group 3.2: $112 \pm 11,8$ ($p > 0,5$)
Schivoletto G et al. 2013 [8]	Traumatic SCI patients, admitted to the spinal unit in Rome (Italy) for their first rehabilitation treatment, 202 men and 43 women, age: $>12, 39,8 \pm 17$ (mean, SD) years	245 SCI patients, Group 1: 136 multiple traumatised SCI patients (100 without TBI), Group 2: 109 monotraumatic SCI patients	Cohort study, Retrospective analysis	LTA, LoS (rehabilitation), BI, RMI, WISCI II, ASIA MS	<u>LoS (rehabilitation):</u> Group 1: $159,1 \pm 1d$, Group2: $130,4 \pm 84d$ ($p = 0,03$) <u>BI (discharge):</u> Group 1: $64,5$ (mean) ($26,1$ SD), Group2: $67,0$ (mean) ($31,7$ SD) (p : n.s.) <u>RMI (discharge):</u> Group 1: $4,8$ (mean) (1 SD), Group 2: $6,1$ (mean) ($4,6$ SD) (p : n.s.) <u>WISCI II (discharge):</u> Group 1: $5,3$ (mean) ($7,8$ SD), Group 2: $8,8$ (mean) ($8,5$ SD) (p : n.s.) <u>ASIA MS (discharge):</u> Group 1: $57,7$ (mean) ($22,4$ SD), Group 2: 63 (mean) ($25,8$ SD) (p : n.s.)

Appendix: LoS: Length of Stay, FIM: Functional Independence Measure, MNMVA: Motorised and Non-motorised Vehicle Accidents, SCI: Spinal Cord Injury, n.a.: Not Available, SD: Standard Deviation, PTS: Polytraumaschlüssel, AIS: American Spinal Injury Association Impairment Scale, SCIM: Spinal Cord Independence Measure, FU: Follow Up, T: Thoracic, h: Hour(s), Dpt: Department, CNS: Central Nervous System, TBI: Traumatic Brain Injury, d: Day(s), LTA: Lesion to Admission time, BI: Barthel Index, RMI: Rivermead Mobility Index, WISCI II: Walking Index for Spinal Cord Injury II, ASIA MS: American Spinal Injury Association Motor Score, n.s. not significant.

* No numerical data are given.

injured patients with SCI who survived their trauma, had longer rehabilitation periods as in- or out-patients, beginning theirs with decreased functional levels compared with their non-SCI counterparts.

However, as of October 2018, there was not a single study that directly compared the differences between these two groups in all the aspects of the rehabilitation process. Most of the polytrauma patient studies with SCI included patients with TBI as well, but these had to be excluded to eligibility reason.

LOS was a universal measurement of the severity and the complexity of the injury (-ies) for the studied patients. Multiple injured patients with SCI had increased LOS compared with multiple injured patients without SCI. And again, multiple injured patients with SCI had increased LOS compared with SCI without other injuries. Unfortunately, there is not a universal guideline as to which point rehabilitation stops, making it an inappropriate measurement for meta-analysis.

FIM or SCIM scores were the parameters mostly used for measurement of the functional status of the patients. We found FIM was used when comparing patients with a variety of injuries and SCIM was used when comparing SCI patients. Only Scivoletto et al. [8] used RMI, BI, WISCI II and ASIA MS to compare their patients covering a large variety of functionality aspects. On the other hand, the time needed for patients to return to work and the capability to return to work was crucial for researching the sociological impact of multiple injuries. Then again, the motive for a patient to return to work may vary according, among other factors, to the social security program that takes benefits from.

ISS [14] or PTS [15] scores were the ones used for measurement of the severity of the injury. As discussed by Tejjink et al. [16], ISS is more analytical with a great variety of qualitative differences (i.e. burns). PTS, though, seems to be simpler and more “musculoskeletal” focused. Age, also, is being scored in the PTS. Lieutand T et al. [1] pinpointed that, including SCI, associated trauma with AIS equal to or greater than 4 (severe injury) plays an important role in the survivability of a victim. Although, new injury severity scores were developed, such as New ISS (NISS) [17], International Classification of Diseases Injury Severity Score (ICISS) [18], Revised Trauma Score (RTS) [19] and Trauma Score- Injury Severity Score (TRISS) [20] they are assessing, mainly, the survivability of a victim. A patient with an ISS score ≥ 16 is considered a severe or a multiple injured patient. Since, these, points can be scored from different body areas it is difficult for ISS (or PTS) alone to provide a prognosis of the rehabilitation outcome for a multiple injured patient with SCI.

During our literature search, some interesting articles were found, which we could not include in our review due to the presence of multiple injured with TBI patients' data included, along with the data taken from multiple injured with SCI patients. Nevertheless, some of them worth mentioning: Kaminski et al. [21] studied the predictor factors of rehabilitation outcome (measured by SCIM III). Polytrauma (in the form of increased ISS) was found playing an important role, after ASIA Light Touch score and total AIS grade. Richard-Dennis et al. [22], at the same time, in a similar study, also recognised ISS as an important factor for the rehabilitation outcome. Obviously, it is expected that the majority of multiple injured patients with SCI to have higher scores of ISS than mono-SC injured patients. The later author underlines the same result in a review article [22] that studied a plethora of associated factors that played a role in the rehabilitation outcome of patients with SCI. In a retrospective analysis of 1995, Sluis et al. [23], examining, 723, patients with ISS ≥ 16 (multiple injured patients) relates higher ISS and the presence of head, neck and thorax (SCI) with lower Glasgow Outcome Scale scores (GOS 3 & 4). Soberg et al. [7] associated a New Injury Severity Score (NISS) of 16 or higher as an important factor for increased (worse) score of

World Health Organization Disability Assessment Schedule II (WHODAS II). Finally, Vassend et al. [24] studied 75 multiple injured patients (19 of them having SCI) and found a decrease in psychological status at a 4-year FU, underlining the importance of dispositional optimism in rehabilitation outcome.

Our systematic review was an attempt, to present, in full detail, the differences in the rehabilitation outcomes between multiple injured patients with and without SCI. This is a unique study, mainly because there were not any studies addressing the subject directly. The few studies that fulfilled our inclusion criteria, needed to be carefully examined for the proper data to be collected. Another limitation of this systematic review is the lack of prospective studies. Thus, including a small number of retrospective studies with a kaleidoscopic variety of population types, characteristics, and measurement instruments a meta-analysis was not possible.

In this systematic review, patients with multiple injuries with SCI showed decreased survivability, increased LOS and decreased functional abilities in a given time period, compared with multiple injured patients without SCI or SCI only patients. The sets of injury studied (MNMVA and Terrorist Attack) doesn't seem to play an important role in the rehabilitation outcome. There is a great need for more, favourably prospective, studies to be performed so future researchers to be able to extract more and homogenous that will allow a meta-analysis. Finally, there is a need for an injury severity scoring tool that can be used for the prognosis of the rehabilitation outcome. This will be helpful for health service providers to strategically plan a more accurate rehabilitation program.

Declaration of Competing Interest

There is not a, known, conflict of interest that could influence this study.

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