Associated Injuries in Patients with Traumatic Spinal Cord Injury

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Objective: This cross-sectional study assessed the type and frequency of injuries associated with traumatic spinal cord injury (TSCI).

Methods: The NTRACS Hospital Trauma Registry database of the Puerto Rico Trauma Hospital was reviewed for the medical records of all admissions with the International Classification of Diseases, 10th Revision, Clinical Modification codes S12–S14, S22–S24, and S32–S34 for the years 2019 through 2022. The injury characteristics recorded included neurological level, mechanism, severity score, hospital length of stay, and associated injuries.

Results: The median number of associated injuries per TSCI patient was 5, and 136 TSCI patients (93.8%) had more than 1 injury. Common injury diagnostic code groups included fractures of the ribs, sternum, and thoracic spine; injuries to intrathoracic organs; fractures of the cervical vertebra and neck; and fractures of the lumbar spine and pelvis. Notably, 88.3% of the TSCI patients had at least 1 injury that could complicate rehabilitation, with one-third having upper extremity fractures and 1 in 5 having a concurrent traumatic brain injury. There was a weak positive correlation between length of stay and the number of associated injuries, as well as with the injury severity score.

Conclusion: These findings indicate that associated injuries are prevalent in TSCI patients, potentially complicating acute care and patient outcomes. A consensus definition of associated injuries in TSCI—particularly those that can complicate rehabilitation—is needed.

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Traumatic spinal cord injuries (TSCIs) often lead to significant motor and sensory impairments, causing long-term limitations and restricted participation in work-related and/or societal activities. In the United States (including Puerto Rico), there are an estimated 18,000 new TSCIs each year, and approximately 302,000 patients live with a spinal cord injury (1). The financial burden is estimated at $1.7 billion, annually (2). Many patients with TSCI are admitted to trauma units with multiple associated injuries that may prolong the hospital length of stay (LOS), increase costs, and complicate rehabilitation efforts (3,4).

Associated injuries in trauma patients can have deleterious consequences, including prolonging the acute hospital LOS (5,6). For example, co-occurring TSCI and traumatic brain injury (TBI) can cause more functional deterioration than TSCI alone and decreased participation in rehabilitation. Concomitant TBI in a TSCI patient is also associated with suboptimal improvements in motor function and a lower likelihood of being discharged home (7). Associated injuries can also affect functional outcomes and LOS. For example, rehabilitation LOS is prolonged in TBI patients with low functional and cognitive admission scores (8), and the presence of fractures of long bones may limit participation in therapy. Patients with TSCI and multiple associated injuries are likely to be admitted to and discharged from a rehabilitation facility with lower functional status than those with a single injury, despite progressing to a similar degree (9). Complications during hospitalization after a TSCI, such as urinary tract infections, can affect rehabilitation outcomes (10). However, few publications have examined the association between TSCI and other injuries occurring in the same traumatic episode.

Common injuries associated with spinal trauma include head trauma, chest injuries, abdominal trauma, pelvic injuries, and limb fractures (3,11). A high incidence of TBI has been associated with cervical TSCI (12). A study reported a high prevalence of injuries associated with spinal trauma, reaching up to 79% in patients with thoracic spine injuries (13). This included patients with any type of spinal injury, not only those with TSCI. In those with a confirmed TSCI, 36.8% had at least 1 associated injury that, in some cases, might not have been sustained during the same traumatic episode (14). Another study reported that 56% of TSCI patients in its sample had at least 1 associated injury, with thoracic trauma and bone fractures being the most common (15).

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The purpose of this investigation was to describe injuries associated with TSCI in patients admitted to a trauma hospital. The importance of the present study is that it highlights the presence and relevance of associated acute traumatic injuries that may have an impact on patient care and outcomes. The specific aims were to 1) determine the most common associated injuries in patients with TSCI, 2) assess the prevalence of TBI associated with TSCI on admission, and 3) compare the prevalence of associated injuries by age group, mechanism of injury, anatomical level, and LOS. We hypothesized that 1) a substantial number of patients with TSCI were admitted with additional traumatic injuries, many of which may complicate rehabilitation (3,12–15); 2) the combination of TSCI and TBI was frequent (7); 3) the incidence of associated TBI was higher in cervical-level TSCI patients (12); and 4) the presence of a higher number of concomitant injuries was associated with a longer LOS in the trauma hospital (5,6).

Materials and Methods

This study is part of a larger investigation of TSCI in Puerto Rico (16). The study was approved by the Institutional Review Board of the University of Puerto Rico Medical Sciences Campus (protocol #22100030034).

Setting

The study was conducted with data from the Puerto Rico Trauma Hospital (PRTH), a level 2 trauma care facility. The PRTH serves as a teaching affiliate of the University of Puerto Rico School of Medicine, providing training for medical students and residents. The staff includes board-certified trauma surgeons and physicians from 19 other specialties, including neurosurgery, orthopedic surgery, and physical medicine and rehabilitation. In 2022, the total number of patient admissions to the PRTH was 1,483. The standard operating procedure for traumatic emergencies on the island of Puerto Rico is to transport all patients with major trauma to the PRTH, especially those with associated injuries. Thus, the PRTH's Trauma Registry Database (17) contains data from most, if not all, patients with TSCI on the island.

Study design, data source and collection

A retrospective analysis of records from patients admitted to the PRTHfrom January 1, 2019, through December 31, 2022, was conducted. Initially, codes from the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) were used to select patients admitted with a diagnosis of fractures to the cervical, thoracic, or lumbosacral regions in the NTRACS Hospital Trauma Registry (18,19). Patients for whom ICD-10-CM code groups S12–14, S22–24, or S32–34 were recorded on admission were included in the study. All the patients assigned ICD-10-CM codes for acute paraplegia (G82.2) or acute quadriplegia (G82.5) were also included. The medical records of the selected patients were reviewed for evidence of TSCI, and each diagnosis of TSCI was ultimately confirmed by one of the authors (MFM), who is an expert in trauma rehabilitation. Injuries associated with a TSCI were defined as injuries that were not directly responsible for the TSCI and were identified based on ICD-10-CM codes. Furthermore, associated injury code groups that complicate rehabilitation were defined as those that, in the authors' judgement, could delay admission to an inpatient facility or limit a patient's participation in therapy. The code groups for these injuries include TBI (S02.0, S02.1, S02.8, S02.91, S04.02–S06, S07.1, and T74.4) (20); fractures of the cervical vertebrae (S12.0–S12.6, except in cases of cervical TSCI); fractures of the ribs (S22.3–S23.5); fractures of the sternum (S22.2); fractures of thoracic vertebrae (S22.0, except in cases of thoracic TSCI); hemo/pneumothoraces (S27.0–S27.2); fractures of the lumbosacral spine (S32.0–S32.2, except in cases of lumbosacral TSCI); fractures of the pelvis (S32.3–S32.8); fractures in the upper extremities (S42, S52, and S62); and fractures in the lower extremities (S72, S82, and S92). The data collected included each patient's age at the time of injury, sex, mechanism of trauma, level of injury, injury severity score (ISS), and LOS.

Statistical analysis

Distributions of quantitative variables (age, number of injury diagnostic codes, number of injury diagnostic groups, ISS, and LOS) were described using medians and interquartile ranges (IQRs). The difference in the median LOS between the patients with injuries complicating rehabilitation and that of the patients without such injuries was assessed using the Wilcoxon–Mann–Whitney test. Correlations of LOS with the number of associated injuries and with the ISS were investigated using the Spearman's correlation coefficient. The chi-square and Fisher's exact tests were applied to assess differences in the proportions of the selected injuries by age group, sex, the anatomic level of TSCI, and the mechanism of injury. The chi-square test for trend was used to assess an observed increase in the frequency of fractures of the ribs with age. This test was also used to evaluate an observed inverse association between the anatomic level of TSCI and the prevalence of concomitant fractures of the lower extremities on admission. Data management, analysis, and visualization were performed with R (21), the RStudio integrated development environment (22), R Commander (23,24), and epiR (25).

Results

As previously published (16), the median age at the time of injury was 44 years (IQR = 31–62) and no significant differences (P = .50) were seen among the 4 years studied. Most of the patients (58; 40.0%) were in the 20- to 39-year age group. A substantial number (42; 29.0%) were 60 years old or older at the time of the injury. Eighty-five percent of the patients (123) were men, for a male-to-female ratio of 5.6:1.

Frequency and types of associated injuries

A total of 802 associated injuries were recorded in 145 patients with TSCI. The median number of injury diagnostic codes per patient was 5 (IQR = 3–7), and 136 patients had more than 1 injury code, for a 93.8% prevalence of associated injuries on admission. The 4 most common injury types, based on ICD diagnostic code groups, were fracture of rib(s), sternum, and thoracic spine (163; 20.3%); injury of other and unspecified intrathoracic organs (123; 15.3%); fracture of cervical vertebra and other parts of the neck (86; 10.7%); and fracture of lumbar spine and pelvis (81; 10.1%) (Table 1). These 4 diagnostic code groups accounted for 93 (64.1%), 87 (60.0%), 56 (38.6%), and 49 (33.9) patients, respectively (Table 2). The median ISS was 17 (IQR = 12–26).

Frequency of associated injuries that may complicate rehabilitation

Most of the TSCI patients had at least 1 associated injury complicating rehabilitation (128; 88.3%). In TSCI cases with such injuries, the median number of injury diagnostic groups was 2 (IQR = 1–3; maximum = 6).

Table 3 shows the number and proportion of patients with associated injuries that may complicate rehabilitation. Half of these patients had a rib fracture (65, 50.4%) or hemo/pneumothorax (68, 53.5%), one-third (41, 31.8%) had fractures of the upper extremities, and almost 1 in 5 had concurrent TBI (28, 19.3%). Fractures of the lumbosacral spine were more common among women (30.0% vs 12.0% in men; $P = .08$), and fractures of the upper extremities were more frequent in men (36.1% vs 10.0% in women; $P = .02$). However, the small number of women in our sample precludes the assessment of statistical differences by sex.

The frequency of associated injuries complicating rehabilitation in TSCI patients across age groups is shown in Table 4, and the data suggest a direct increase in the frequency of fractures with age (test for trend: $P < .001$). Fractures of thoracic vertebrae were more common in patients in the 60 years and older age group (8, 19.0%; $P = .07$). Fractures of the pelvis were present only in patients aged 40 years or older ($P = .07$). Fractures of the extremities were more frequent in the 40- to 59-year age group ($P < .05$).

Table 5 shows the associations between injuries and the anatomical level of the TSCI. About 1 in 5 patients with a cervical or thoracic TSCI also had a TBI ($P = .09$). These patients also presented a high prevalence of rib fractures on admission (25, 43.9%) and a high frequency of hemo/pneumothorax (23, 40.4%). One in 5 patients with a cervical TSCI also had fractures of thoracic vertebrae (12, 21.1%; $P < .001$). A similar proportion of cases with thoracic TSCI (13, 20.3%) also exhibited fractures of the lumbosacral spine, but the difference compared with patients with cervical TSCIs (6, 10.5%) may be attributed to sample variability ($P = .14$). Fractures of the lower extremities were more common in patients with lumbosacral TSCIs (test for trend: $P = .08$).

Table 6 presents the frequency of associated injuries that may complicate rehabilitation by mechanism of TSCI injury. About two-thirds of the TSCI cases from pedestrian injuries had a concomitant TBI (9, 60.0%); among cases from falls, 1 in 10 (5, 12.2%) had a TBI. Over 50% of TSCI cases also had concomitant rib fractures. These were commonly due to a fall (22, 53.7%) or a motor vehicle collision (21, 53.8%), a pedestrian accident (8, 53.3%), or a motorcycle collision (5, 55.6%). Fractures of the lower extremities were more frequent among pedestrians (5, 33.3%) and individuals involved in motorcycle collisions (2, 22.2%).

The median LOS for all the patients (n = 145) was 26 days (IQR = 14–44). There was a weak positive correlation between the number of associated injuries and LOS (Spearman's correlation coefficient = 0.16; $P = .05$), as well as a weak positive correlation

Table 1. Associated injury diagnostic codes in patients with traumatic spinal cord injury.

ICD-10-CM	Diagnosis	Number (%)
S22	Fracture of rib(s), sternum, and thoracic spine	163 (20.3)
S27	Injury of other and unspecified intrathoracic organs	123 (15.3)
S12	Fracture of cervical vertebra and other parts of the neck	86 (10.7)
S32	Fracture of the lumbar spine and pelvis	81 (10.1)
S36	Injury of intra-abdominal organs	49 (6.1)
S06	Intracranial injury	40 (5.0)
S42	Fracture of shoulder and upper arm	36 (4.5)
S02	Fracture of skull and facial bones	34 (4.2)
S01	Open wound of head	22 (2.7)
S52	Fracture of forearm	16 (2.0)
S37	Injury of urinary and pelvic organs	14 (1.7)
S82	Fracture of lower leg including ankle	14 (1.7)
S31	Open wound of abdomen, lower back, pelvis and external genitalia	13 (1.6)
S21	Open wound of thorax	12 (1.5)
	Other	99 (12.4)
Total codes		802 (100.0)

Table 2. Number of patients with traumatic spinal cord injury with most common associated injuries.

ICD-10-CM	Diagnosis	Number of patients (%)
S22	Fracture of rib(s), sternum, and thoracic spine	93 (64.1)
S27	Injury of other and unspecified intrathoracic organs	87 (60.0)
S12	Fracture of cervical vertebra and other parts of the neck	56 (38.6)
S32	Fracture of the lumbar spine and pelvis	49 (33.8)
S36	Injury of intra-abdominal organs	33 (22.8)
S42	Fracture of shoulder and upper arm	32 (22.1)
S06	Intracranial injury	26 (17.9)
S02	Fracture of skull and facial bones	23 (15.9)
S01	Open wound of head	16 (11.0)
S37	Injury of urinary and pelvic organs	13 (9.0)
S31	Open wound of abdomen, lower back, pelvis and external genitalia	13 (9.0)
S21	Open wound of thorax	12 (8.3)
S52	Fracture of forearm	12 (8.3)
S82	Fracture of lower leg including ankle	10 (6.9)
	Other	83 (14.9)

*Patients may have had multiple associated injuries of the same code but are counted only once. Total patients: 145.

Table 3. Number of patients with traumatic spinal cord injury with selected associated injuries that may complicate rehabilitation by sex.

Associated injuries (ICD-10-CM code groups)	Sex		Total n (%)*	p-value
	Male n (%)	Female n (%)		
TBI (S02.0. S02.1, S02.8, S02.91, S04.02, S04.03,S04.04, S06, S07.1, T74.4)	24 (22.2)	4 (20.0)	28 (19.3)	1.00
Fracture of cervical vertebrae (S12.0 – S12.6)**	7 (6.5)	2 (10.0)	9 (7.0)	0.63
Fracture of rib(s) (S22.3 – S23.5)	57 (52.8)	8 (40.0)	65 (50.4)	0.29
Fracture of sternum (S22.2)	3 (2.8)	2 (10.0)	5 (3.9	0.17
Fracture of thoracic vertebrae (S22.0) **	14 (13.0)	1 (5.0)	15 (11.6)	0.31
Pneumo/hemothorax (S27.0, S27.1, S27.2)	56 (51.9)	13 (65.0)	69 (53.5)	0.46
Fracture of lumbosacral spine (S32.0 – S32.2)**	13 (12.0)	6 (30.0)	19 (14.7)	0.08
Fracture of pelvis (S32.3 – S32.8)	12 (11.1)	3 (15)	15 (11.6)	0.70
Fracture in upper extremity (S42, S52, S62)	39 (36.1)	2 (10.0)	41 (31.8)	0.02
Fracture in lower extremity (S72, S82, S92)	14 (13.0)	2 (10.0)	16 (12.4)	1.00
Total	108 (100.0 %)	20 (100.0 %)	128 (100.0%)	

* Patients may have had more than one type of injury.
** Excluding patients with traumatic spinal core injury at this anatomical level

Table 4. Number of patients with traumatic spinal cord injury by age groups and selected associated injuries that may complicate rehabilitation

Associated injuries (ICD-10-CM codes)	Age group (years)			Total	p-value
	20 – 39 n (%)	40 – 59 n (%)	60+ n (%)		
TBI (S02.0. S02.1, S02.8, S02.91, S04.02, S04.03, S04.04, S06, S07.1, T74.4)	14 (24.1)	9 (20.0)	5 (11.9)	28	0.31
Fracture of cervical vertebrae (S12.0 – S12.6)	6 (10.3)	3 (6.7)	0 (0.0)	9	0.11
Fracture of rib(s) (S22.3 – S23.5)	7 (22.6)	35 (48.6)	23 (54.8)	65	< 0.001*
Fracture of sternum (S22.2)	1 (3.2)	2 (2.8)	2 (4.8)	5	0.84
Fracture of thoracic vertebrae (S22.0)	3 (5.2)	4 (8.9)	8 (19.0)	15	0.07
Pneumo/hemothorax (S27.0, S27.1, S27.2)	15 (48.4)	36 (50.0)	18 (42.9)	69	0.76
Fracture of lumbosacral spine (S32.0 – S32.2)	6 (10.3)	5 (11.1)	8 (19.0)	19	0.40
Fracture of pelvis (S32.3 – S32.8)	0 (0.0)	9 (12.5)	6 (14.3)	15	0.07
Fracture in upper extremity (S42, S52, S62)	7 (22.6)	27 (37.5)	7 (16.7)	41	0.04
Fracture in lower extremity (S72, S82, S92)	2 (6.5)	13 (18.1)	1 (2.4)	16	0.03
Total (patients may have suffered more than one injury)	58 (100.0)	45 (100.0)	42 (100.0)	145 (100.0)	-

*Chi-square test for trend.

of ISS with LOS (Spearman's correlation coefficient = 0.17; $P = .04$). The median LOS for cases with injuries complicating rehabilitation was 27 days (n = 129; IQR = 14–44)—17 (n = 16; IQR = 13–45) for those without such injuries ($P = .63$).

Discussion

Our findings highlight the presence and relevance of associated acute traumatic injuries in TSCI patients that may have an impact on patient care and outcomes. The most important findings of the present study are that 1) the occurrence of associated injuries was high; 2) most of the patients had associated injuries that could complicate rehabilitation; 3) TBI was a common concomitant injury, particularly in those with cervical and thoracic levels of injury; and 4) both the number of associated injuries and the ISS were positively correlated with LOS..

Frequency and types of associated diagnoses

Our findings show that most patients with TSCI are admitted to the trauma center with multiple associated injuries. This is compatible with a study conducted from 2011 through 2015 using the US National Trauma Data Bank, which study found that 63% of cervical, 79% of thoracic, and 71% of lumbar spinal injuries were accompanied by an associated injury (13). However, the case definitions used in that study were based on the ICD-9 classification codes and did not include further validation to confirm whether the injuries met clinical criteria for a TSCI, which may limit comparability with our findings. The prevalence of associated injuries in patients with TSCI has been reported to be 56% (15). This is lower than the prevalence in the present study, probably due to its use of a different definition of associated traumatic injuries, which included a smaller set of diagnoses. Furthermore, that study by Aito et al. (15) was restricted to cases admitted to a specialized spinal unit.

Similar to what was found by the study of Anandasivam et al. (13), the most common associated injuries in the present study were fractures of bones, particularly the ribs (64.1% of patients). In Taiwan, Chu et al. (3) studied associated injuries in patients with acute spinal trauma. However, the study team did not specify the locations of these injuries in their diagnoses (i.e., the locations of bone fractures), and most of their cases (72.4%) did not suffer a TSCI. In a separate study, the presence of thoracic and lumbar spine fractures correlated with rib fractures and visceral injuries, while cervical trauma was associated with a higher incidence of TBI (11). Similar to the study by Chu et al., the patients included in our cohort had spinal trauma, but not necessarily a TSCI.

Table 5. Number of patients with traumatic spinal cord injury anatomic level and selected associated injuries that may complicate rehabilitation

Associated injuries (ICD-10-CM codes)	Anatomic Level of TSCI: Cervical n (%)	Thoracic n (%)	Lumbosacral n (%)	Total	p-value
TBI (S02.0. S02.1, S02.8, S02.91, S04.02, S04.03, S04.04, S06, S07.1, T74.4)	11 (19.3)	16 (25.0)	1 (4.2)	28	0.09
Fracture of cervical vertebrae (S12.0 – S12.6)	N/A	8 (12.5)	1 (4.2)	9	0.43
Fracture of rib(s) (S22.3 – S23.5)	25 (43.9)	36 (56.2)	4 (16.7)	65	0.004
Fracture of sternum (S22.2)	2 (3.5)	3 (4.7)	0 (0.0)	5	0.85
Fracture of thoracic vertebrae (S22.0)	12 (21.1)	N/A	3 (12.5)	15	0.001
Pneumo/hemothorax (S27.0, S27.1, S27.2)	23 (40.4)	41 (64.1)	5 (20.8)	69	0.001
Fracture of lumbosacral spine (S32.0 – S32.2)	6 (10.5)	13 (20.3)	N/A	19	0.14
Fracture of pelvis (S32.3 – S32.8)	8 (14.0)	4 (6.2)	3 (12.5)	15	0.35
Fracture in upper extremity (S42, S52, S62)	14 (24.6)	20 (31.2)	7 (29.2)	41	0.71
Fracture in lower extremity (S72, S82, S92)	4 (7.0)	7 (10.9)	5 (20.8)	16	0.08*
Total patients (may have suffered more than one injury)	57 (100.0)	64 (100.0)	24 (100.0)	145 (100.0)	-

*Chi-square test for trend.
N/A – Not applicable

Frequency of associated diagnoses that complicate rehabilitation

We focused on those injuries that could have a negative impact on rehabilitation and/or the ability of the patient to actively participate in therapy. The prevalences of rib fractures, hemo/pneumothoraces, and fractures of the extremities was very high. Rib fractures can cause pain with trunk movement, which could limit transfers (e.g., moving from a bed to a wheelchair) and wheelchair use. They may also increase the need for pain medications and reduce a patient's ability to tolerate therapy. Patients can suffer from residual symptoms, including chest pain, shortness of breath, and fatigue. These symptoms can decrease exercise tolerance and complicate participation in rehabilitation. As with rib fractures, upper and lower extremity fractures can affect transfers, wheelchair mobility, and upper extremity use.

Fractures of the ribs, thoracic vertebrae, and the pelvis were more common in patients in the older age groups. Fractures of the extremities were more common in patients aged 40 to 59 years old. One-third of all the fractures and 73% of all the pelvic injuries occurred in elderly patients (65 years and older) (26). The mortality of elderly patients who suffered from a pelvic ring injury was high (27). Thus, clinicians should be vigilant for pelvic injuries in elderly TSCI patients.

There was a weak positive correlation between the number of associated injuries and LOS. The correlation between ISS and LOS was also positive but weak. A higher number of associated injuries is expected to affect hospital LOS because of increased complications, surgical needs, and longer coordination of care. However, these findings suggest that factors other than the number or severity of injuries are important determinants of LOS in TSCI patients. Only a few patients had no injuries complicating rehabilitation, which may have limited our ability to detect a statistical difference.

TSCI with associated TBI

Almost one-third (31.8%) of the patients in the present study had an associated TBI. Karamehmetoğlu et al. reported that head trauma was the most common associated injury in TSCI patients (28). Reported rates of TBI co-ocurring with TSCI in rehabilitation patients range from 20% to 60% (29–31). However, these reports are not restricted to the acute phaseof the injury. Mild TBI is the most commonly reported type of TBI in TSCI patients (29), but it is often underdiagnosed in the emergency department (32). Thus, the true rate of co-occurring TBI and TSCI in our study may be even higher.

A high frequency of TBI was observed across all age groups (Table 4), but it was more frequent in patients with cervical and thoracic levels of injury and less frequent in those with lumbosacral levels of injury (Table 5). Head injury has been reported as a common associated injury in both cervical (11,33) and thoracic trauma (34). The proportion of patients with associated TBI was higher in traffic collisions involving pedestrians and motorcycles (Table 6). This may have resulted from the high energy involved in these collisions, combined with the absence of the protection typically afforded by a car.

Patients with concurrent TSCI and TBI have been reported to have greater functional impairment on admission to a rehabilitation facility, less motor improvement, and a higher likelihood of being discharged home (7,8). Although TBI does not necessarily lead to chronic cognitive impairment, those with severe injury can suffer from deficits in memory, information processing speed, and executive function for up to 6 months after the initial injury (35). These cognitive deficits can affect participation in a rehabilitation program and interfere with the patient's ability to adjust to a new functional status, such as that associated with paraplegia or tetraplegia. Thus, the proper assessment of concomitant TBI in acute TSCI patients is imperative to guide the

Table 6. Number of patients with traumatic spinal cord injury by mechanisms of injury and selected associated injuries that may complicate rehabilitation*

Associated injuries (ICD-10-CM codes)	Mechanism of Injury							
	Falls n (%)	Handgun n (%)	Motor vehicle collisions n (%)	Pedestrian n (%)	Motorcycle n (%)	Other n (%)	Total	p-value
TBI (S02.0. S02.1, S02.8, S02.91, S04.02, S04.03, S04.04, S06, S07.1, T74.4)	5 (12.2)	2 (5.9)	7 (17.9)	9 (60.0)	3 (33.3)	1 (16.7)	27	< 0.001
Fracture of cervical vertebrae (S12.0 – S12.6)	3 (7.3)	0 (0.0)	4 (10.3)	1 (6.7)	0 (0.0)	1 (16.7)	9	0.27
Fracture of rib(s) (S22.3 – S23.5)	22 (53.7)	6 (17.6)	21 (53.8)	8 (53.3)	5 (55.6)	3 (50)	65	0.01
Fracture of sternum (S22.2)	2 (4.9)	0 (0.0)	2 (5.1)	1 (6.7)	0 (0.0)	0 (0.0)	5	0.67
Fracture of thoracic vertebrae (S22.0)	6 (14.6)	2 (5.9)	4 (10.3)	0 (0.0)	1 (11.1)	2 (33.3)	15	0.23
Pneumo/hemothorax (S27.0, S27.1, S27.2)	17 (41.5)	16 (47.1)	20 (51.3)	10 (66.7)	5 (55.6)	1 (16.7)	69	0.37
Fracture of lumbosacral spine (S32.0 – S32.2)	5 (12.2)	2 (5.9)	10 (25.6)	1 (6.7)	1 (11.1)	0 (0.0)	19	0.20
Fracture of pelvis (S32.3 – S32.8)	4 (9.8)	1 (2.9)	4 (10.3)	4 (26.7)	1 (11.1)	1 (16.7)	15	0.18
Fracture in upper extremity (S42, S52, S62)	11 (26.8)	12 (35.3)	8 (20.5)	4 (26.7)	4 (44.4)	2 (33.3)	41	0.62
Fracture in lower extremity (S72, S82, S92)	3 (7.3)	2 (5.9)	3 (7.7)	5 (33.3)	2 (22.2)	1 (16.7)	16	0.06
Total patients (may have suffered more than one injury)	41 (100.0)	34 (100.0)	39 (100.0)	15 (100.0)	9 (100.0)	6 (100.0)	144* (100.0)	-

*One record had no information about mechanism of injury.

acute treatment plan, the rehabilitation program, prognostication, and the education of the patient and his/her caretakers.

Clinical implications

The identification of concomitant injuries on admission to the trauma unit may lead to the early implementation of therapy protocols to increase mobility. Such protocols have been shown to reduce complications (36). In addition, rehabilitation protocols may be developed to address the effects of any concomitant injuries. For example, patients with rib fractures may benefit from pulmonary rehabilitation (37), while those with lower limb fractures may require upper limb strengthening. The detection of associated injuries can also inform clinical decisions regarding referrals to the next level of care (i.e., inpatient vs outpatient).

Study limitations

The present study has some limitations. In general, comparisons with some of the published studies are limited by the absence of a standardized definition of associated injuries.

Patients with TSCI may have been missed if the inclusion criteria were too specific. However, we believe the probability of missing cases is small, since all the patients identified by ICD-10-CM codes for acute paraplegia (G82.2) or quadriplegia (G82.5) were found to be included in the initial selection after the application of the inclusion criteria. Patients with no TSCI may have been misclassified (i.e., due to the use of one of the selected ICD-10-CM codes in a patient with no TSCI), artificially increasing the number of TSCI cases in our sample. We believe this is unlikely due to the subsequent individual review of medical records by experienced personnel.

It must be acknowledged that in some of the comparisons that were made, the groups were too small to reveal statistically differences. It is also possible that 1 or more associated injuries were not included. However, the associated injuries included in the present study are mostly major ones, and the possibility of missing them in a trauma registry is minimal. We included only those patients admitted to the trauma hospital and cannot account for those who died at the scene of the injury, during transit to the Trauma Hospital, or after admission to another hospital. However, the standard practice in Puerto Rico is to refer all TSCI patients to the PRTH.

Conclusion

Associated injuries were common in patients suffering from an acute TSCI, and many of those injuries may complicate rehabilitation. Clinicians on a trauma team should be aware of common injuries associated with TSCI that can complicate or impede participation in a rehabilitation program during acute care or a subsequent inpatient rehabilitation stay. A consensus definition of the associated injuries that complicate rehabilitation is needed to facilitate research in this area.

Resumen

Objetivo: Este estudio transversal evaluó el tipo y la frecuencia de las lesiones asociadas con la lesión traumática de la médula espinal (LTME). Métodos: Se revisó la base de datos del hospital en el Registro de Hospital de Trauma para los registros médicos

de todas las admisiones con los códigos ICD-10-CM S12–14, S22–24, S32–34 para los años 2019 a 2022. Se recopilaron las características de las lesiones, incluyendo el nivel neurológico, el mecanismo de la lesión, la severidad de la lesión, la duración de la estadía y las lesiones asociadas. Resultados: La mediana de las lesiones asociadas por paciente con LTME fue de 5, y 136 pacientes (93.8%) tenían más de una lesión. Los grupos diagnósticos más comunes de lesiones asociadas incluyeron fracturas de costillas, esternón, columna torácica; lesiones de órganos intratorácicos; fracturas de las vértebras cervicales y el cuello; y fracturas de la columna lumbar y la pelvis. Notablemente, el 88.3% de los pacientes con LTME tenían al menos una lesión que podría complicar la rehabilitación, con un tercio teniendo fracturas de extremidades superiores y uno de cada cinco con trauma cerebral concurrente. Hubo una débil correlación positiva entre la duración de la estadía y el número de lesiones asociadas, así como con la puntuación de la severidad de la lesión. Conclusión: Los hallazgos indican que las lesiones asociadas son prevalentes en pacientes con LTME, lo que podría complicar la atención aguda y los resultados del paciente. Se necesita una definición de consenso de las lesiones asociadas en LTME, particularmente aquellas que pueden complicar la rehabilitación.

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