MedCrave Step into the World of Research

International Physical Medicine & Rehabilitation Journal

Research Article

Open Access CrossMark

Dual diagnosis: the prevalence of brain injury and spinal cord injury in the pediatric population and its impact on length of stay

Abstract

Objective: To determine the prevalence of pediatric patients with dual diagnosis of traumatic brain injury and spinal cord injury (DDS) to patients diagnosed with spinal cord injury (SCI) and to determine how the presence of a brain injury affects rehabilitation outcomes and length of stay.

Design: A 9-year retrospective chart review of patients with pediatric spinal cord injury admitted for inpatient rehabilitation was completed.

Setting: A 28- bed Pediatric Inpatient Rehabilitation Unit of a tertiary care regional referral center.

Participants: 212 pediatric patients, ranging from 0 to 21 years of age who sustained a traumatic or non-traumatic spinal cord injury requiring admission to acute rehabilitation between January 2008 and December 2017.

Interventions: N/A

Results: The mean age of the population was 9.9 years at the time of admission. The average length of time from the injury to admission was 20.4 days. This patient population was 54% male and 46% female. Overall, 31.6% of children with SCI had concomitant brain injury, with 50% of children with traumatic SCI sustaining a brain injury. The length of stay was 25.9 days for patients with SCI alone; however, it was 38.2 days for children with DDS.

Conclusion: The incidence of DDS in the traumatic pediatric spinal cord injury population is relatively common and appropriate screenings should be anticipated. Patients with DDS have the potential to achieve similar functional gains as SCI patients without brain injuries but appropriate adjustments should be made to their plans of care, including adjusting expected length of hospital stay.

Keywords: pediatric, spinal cord injury, brain injury, dual diagnosis, length of stay, rehabilitation, wee FIM

Volume 5 Issue 1 - 2020

Joshua A Vova, Phyllis Palma, Elise McClanahan

Department of Physical Medicine and Rehabilitation, Department of Rehabilitation, Children's Healthcare of Atlanta, USA

Correspondence: Joshua A Vova, MD, Children's Healthcare of Atlanta, Department of Physical Medicine and Rehabilitation, 1001 Johnson Ferry Road, Atlanta, GA 30342, Tel 404-785-7172, Fax 404-785-3808, Email Joshua.Vov@choa.org

Received: January 06, 2020 | **Published:** January 21, 2020

Abbreviations: DDS, dual diagnosis; LOS, length of stay; SCI. spinal cord injury; TBI. traumatic brain injury; BI, brain injury; FIM, functional independence measure; ISNCSCI, international standards for neurological classification of spinal cord injury assessment

Introduction

The presence of dual diagnosis (DDS) of spinal cord injury (SCI) and traumatic brain injury (TBI) has been reported in the adult literature to be 25 – 74%.[1–4] However, little is known about the incidence of concomitant TBI and SCI in the pediatric population[4]. The rehabilitation of a SCI can be further complicated by the physical and cognitive impairment of a superimposed TBI.[5,6] This may play a significant role in the strategies and outcomes of the rehabilitation course.

On a pediatric inpatient rehabilitation unit, data is utilized to establish expected hospital length of stay (LOS) and to guide therapeutic plans of care. Decisions should be based upon age-appropriate resources in addition to specific diagnoses and realistic functional goals. LOS for pediatric acute inpatient rehabilitation varies according to admission diagnosis and common impairment groups.[7] Among the impairment groups, those with longer lengths of stay are BI and SCI, often due to a combination of medical complexity and need for extensive patient and family education. The overall plan of care for each patient is determined, in large part, by the severity of their injury and how that impacts function across all domains (broadly, motor, self-care, and cognitive skills), measured by the WeeFIM (Functional Independence Measure for children). The motor function of children after pediatric SCI largely depends upon neurological level and completeness of injury and this guides the estimation of length of stay (LOS) at the beginning of inpatient rehabilitation. Even in patients with severe impairments (e.g. high cervical complete SCI), WeeFIM motor scores have been shown to improve with intervention.[8] All of these potential gains, however, can be significantly impacted by the cognitive effects of a BI. The purpose of this study is to compare the pediatric patients with DDS to patients diagnosed with SCI in order to ascertain how outcomes, LOS and treatment plans are affected by these diagnoses.

Methods

Study design: Study was conducted by retrospective chart review of patients admitted to the inpatient rehabilitation unit at Children's Healthcare of Atlanta, Atlanta, GA from January 1, 2008 through December 31, 2017. Those included for review were those with a primary diagnosis of traumatic or non-traumatic SCI**.** Patients were evaluated for inclusions in this study were identified by injury diagnosis codes. Once patients were identified for inclusion, an in-depth chart review was conducted, including collection of data outlined below, with more in-depth identification of the cause of the spinal cord injury and an analysis to determine the presence of co-occurring BI.

Study population: Subjects were admitted to the inpatient rehabilitation unit at *Hospital* from January 1, 2008 through December 31, 2017 with a diagnosis of traumatic or non-SCI. Subjects ranged from 6 months to 21.3 years in age at the time of injury. Subjects were excluded from the review if their primary diagnosis was not traumatic or non-traumatic SCI. During their inpatient rehabilitation admission, patients participated in daily physical therapy, occupational therapy, and speech therapy, when appropriate. Functional status was evaluated upon admission and discharge by the patient's primary therapist from each discipline using the WeeFIM.

Procedure: The investigators conducted chart reviews in the electronic medical health record for all participants who met the inclusion criteria. Institutional Review Board (IRB) approval was obtained. Demographic information and information regarding the nature of the spinal cord injury was collected, including: patient name, medical record number, date of birth, admission date, discharge date, date of death (if applicable), LOS in acute care, LOS in inpatient rehabilitation, age at injury, time from injury to admission, mechanism of injury, neurologic level of injury, ASIA assessment, diagnosis impairment code, ventilator parameters (when applicable), admission WeeFIM scores, discharge WeeFIM scores, length of stay efficiency, and insurance. The protocol was randomly monitored for treatment fidelity by two co-investigators who reviewed 10% of the cases.

Measures

Functional Independence Measure for Children (WeeFIM): an 18-item, performance-based measure that assesses mobility, self-care, and cognition in the rehabilitation setting.[9] Items are rated on a 7-point scale that characterize levels of dependence and independence. This measure was administed at time of admission, discharge and at 1-2 week intervals throughout their time on inpatient rehabilitation unit. This instrument is widely accepted outcome measure for treatment response, has been well validated and has demonstrated good interrater reliability.[10,11]

International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) assessment: a standardized assessment used to describe the extent and severity of a patient's SCI. The ISNCSCI exam is graded on a scale of A to E, with level A representing lack of sensation or motor function below the level of the injury, including the sacral segments, and level E representing normal motor and sensory function.[12] This exam has been shown to be reliable primarily in adult patients and children aged 6 years and older.[13–15] For patients unable to participate in a full ISNCSCI exam, either due to age or cognitive impairment, a modified INSCSCI exam was performed. For the sensory portion of the exam, stimuli are presented at the dermatomal sites corresponding with those on the standard INSCSCI, with sensory function documented as "responds to light touch" or "does not respond to light touch" at each dermatomal site. Motor function is determined based on active movement in the muscles corresponding to the myotomes tested in the standard ISNCSCI exam. This is graded as a "0" or a "+." A "0" is given if the patient does not demonstrate active movement in an anti-gravity position for the muscle associated corresponding myotome, and a "+" is given if the patient does demonstrate active movement in an anti-gravity position. Neurological level is documented as "consistent with" the corresponding neurological level on the standard INSCSCI exam. This, however, is an in-house tool, and inter-rater reliability has not yet been established. MRI imaging, if available, were used as an adjunct in determining level.[16,17]

Data Handling and Analysis

Statistical analyses were conducted using SAS 9.2 (Cary, NC). Statistical significance was assessed at 0.05 level. Descriptive statistics were reported for all demographic, clinical and outcomes variables. Chi-square tests were used to assess the association between the outcome variable, DDS patient (y/n) and other categorical variables. Two sample t-tests or Wilcoxon-rank sum tests were used to assess for differences between injury groups with respect to continuous measurements.

Results

A total of 212 SCI pediatric patients met the inclusion criteria. The mean age of the population was 9.9 years at the time of admission, of which 53.8% were male and 46.2% were female. The average length of time from the injury to admission was 11.0 days. Patients were further stratified into SCI of traumatic (53.8%, n = 114), vs. non-traumatic etiologies (46.2%, = 98), such as spinal cord tumor or demyelinating disease. Sixty-seven (31.7%) children has DDS, of which 47.8% were males and 52.2% were females. Of the 114 patients with traumatic injuries, 57 patients (50%) were diagnosed with DDS, whereas only 10% of patients with non-traumatic injuries were diagnosed with DDS.

In Table 1, all variables are summarized for the entire population and then the DDS and SCI break-outs are compared. Tables 2 and 3 similarly show summary statistics for the trauma and non-trauma breakouts of DDS and SCI. Categorical variables are summarized as N (%) and Chi squared or Fisher's Exact tests were used as appropriate to test statistical significance. Where noted, some sub-categories containing very few counts were omitted from the statistical testing. The continuous variables are presented as mean (standard deviation) and population differences were tested using a Student's t-test.

Tables 1–3 provide a summary of patient demographics and clinical measures for the entire sample as well as for each outcome group (DDS and SCI only). There were no significant differences in gender, but there was a statistically significant difference in age of the time of injury, 7.7 years in the DDS group and 11.2 years in the SCI group. ($p < 0.001$). Injury time to admission and LOS were significantly longer in patients with DDS, with those patients spending an average of 26.1 days in acute care (vs. 17.8 days in SCI) and 38.2 days in inpatient rehabilitation (vs. 25.9 days in SCI).

Patients with DDS were more likely to have motor complete (AIS A or B) than a motor incomplete (AIS C or D) injury, 76.1% of all DDS (traumatic and non-traumatic) with AIS A or B injury vs. 22.4% of all DDS with AIS C or D injury. Both the SCI and the DDS group were more likely to have cervical or thoracic level injuries, but DDS patients were less likely to have lumbar or sacral level injuries than those with SCI (6% in the DDS group vs. 20% in the SCI group).

Citation: Vova JA, Palma P, McClanahan E. Dual diagnosis: the prevalence of brain injury and spinal cord injury in the pediatric population and its impact on length of stay. *Int Phys Med Rehab J.* 2020;5(1):30‒37. DOI: 10.15406/ipmrj.2020.05.00225

Table 1 Comparisons between DDS and SCI

Variable	Level	Total	DDS	SCI	P-Value
		N (%)	N (%)	N (%)	
		N=212	N=67	N=145	
Sex	F	98 (46.23)	35 (52.24)	63 (43.45)	0.233
	M	114 (53.77)	32 (47.76)	82 (56.55)	
Trauma	Non-Traumatic	98 (46.23)	10 (14.93)	88 (60.69)	<.001
	Traumatic	114 (53.77)	57 (85.07)	57 (39.31)	
AIS	A	81 (38.94)	40 (60.61)	41 (28.87)	<.001
	B	28 (13.46)	11 (16.67)	17 (11.97)	
	C	47 (22.6)	6 (9.09)	41 (28.87)	
	D	52 (25)	9 (13.64)	43 (30.28)	
Mechanism of Injury*	Disease Process	76 (36.02)	10 (14.93)	66 (45.52)	<.001
	Fall	21 (9.95)	9 (13.43)	12 (8.28)	0.243
	GSW	26 (12.32)	4 (5.97)	22 (15.17)	0.058
	MVA	60 (28.44)	42 (62.69)	18 (12.41)	<.001
	Surgery	19 (9)	1 (1.49)	18 (12.41)	0.01
Age at Time of Injury - Mean (SD)		10.14 (6.34)	7.76 (5.94)	11.24 (6.23)	<.001
Age at Admission - Mean (SD)		9.93 (6.19)	7.63 (5.8)	11 (6.09)	<.001
Acute Care Time - Mean (SD)		20.44 (20.88)	26.09 (20.53)	17.83 (20.6)	0.007
Length of Stay - Mean (SD)		29.76 (16.1)	38.18 (16.37)	25.88 (14.44)	<.001
Location of Injury	C	79 (37.26)	34 (50.75)	45 (31.03)	0.007
	L	32 (15.09)	4 (5.97)	28 (19.31)	
	S	1 (0.47)	0 (0.00)	1 (0.69)	
	T	100 (47.17)	29 (43.28)	71 (48.97)	
Completeness of Injury	C	82 (38.86)	40 (59.7)	42 (29.17)	<.001
	I	129 (61.14)	27 (40.3)	102 (70.83)	
Self-Care Admission - Mean (SD)		17.33 (9.72)	11.91 (6.12)	19.83 (10.06)	<.001
Self-Care Discharge - Mean (SD)		29.72 (14.71)	22.09 (12.87)	33.25 (14.19)	<.001
Self-Care Wee-FIM Change - Mean (SD)		12.39 (8.95)	10.18 (9.19)	13.41 (8.68)	0.014
Mobility Admission- Mean (SD)		8.68 (5.41)	6.1 (3.25)	9.87 (5.79)	<.001
Mobility Discharge - Mean (SD)		17.38 (8.3)	12.85 (7.8)	19.48 (7.69)	<.001
Mobility Wee-FIM Change - Mean (SD)		8.7 (6.2)	6.75 (6.61)	9.61 (5.81)	0.002
Cognition Admission - Mean (SD)		25.03 (11.14)	18.25 (10.54)	28.17 (9.99)	<.001
Cognition Discharge - Mean (SD)		27.19 (10.34)	23.06 (10.87)	29.1 (9.53)	<.001
Cognition Wee-FIM Change - Mean (SD)		2.16 (4.02)	4.81 (5.48)	0.93 (2.27)	<.001
Admission Wee-FIM - Mean (SD)		51.13 (23.01)	36.36 (17.02)	57.95 (22.24)	<.001
Discharge Wee-FIM - Mean (SD)		74.33 (31.13)	58.18 (29.25)	81.79 (29.16)	<.001
Wee-FIM Change - Mean (SD)		23.2 (14.97)	21.82 (17.58)	23.84 (13.61)	0.407
Vent Dependent (Initial)	N	173 (81.6)	45 (67.16)	128 (88.28)	<.001
	Y	39 (18.4)	22 (32.84)	17 (11.72)	
Vent Dependent (Discharge)	N	184 (86.79)	49 (73.13)	135 (93.1)	<.001
	Y	28 (13.21)	18 (26.87)	10 (6.9)	
Disease Process	Disease	76 (78.35)	10 (100)	66 (75.86)	0.112
	Surgical	21 (21.65)	0 (0.00)	21 (24.14)	

Table 2 DDS descriptive stats by trauma

Variable	Level	Non-traumatic	Traumatic	P-Value	Metrics
		N=10	**N=57**		
AIS	A	2 (20)	38 (67.86)	<.001	N (%)
	B	2 (20)	9 (16.07)		N (%)
	C	5 (50)	1 (1.79)		N (%)
	D	1 (10)	8 (14.29)		N (%)
Location of Injury	C	5 (50)	29 (50.88)	0.738	N (%)
	L	1 (10)	3 (5.26)		N (%)
	T	4 (40)	25 (43.86)		N (%)
Completeness of Injury	C	2 (20)	38 (66.67)	0.011	N (%)
	I	8 (80)	19 (33.33)		N (%)
Self-Care Admission		15.8 (11.48)	11.23 (4.44)	0.244	Mean (SD)
Self-Care Discharge		26.4 (16.79)	21.33 (12.09)	0.254	Mean (SD)
Self-Care Wee-FIM Change		10.6 (9.58)	10.11 (9.21)	0.877	Mean (SD)
Mobility Admission		9.3 (6.86)	5.54 (1.65)	0.119	Mean (SD)
Mobility Discharge		16.2 (10.67)	12.26 (7.14)	0.142	Mean (SD)
Mobility Wee-FIM Change		6.9 (6.92)	6.72 (6.62)	0.937	Mean (SD)
Cognition Admission		21.9 (11.42)	17.61 (10.36)	0.239	Mean (SD)
Cognition Discharge		25.4 (11.69)	22.65 (10.77)	0.465	Mean (SD)
Cognition Wee-FIM Change		3.5 (4.01)	5.04 (5.69)	0.418	Mean (SD)
Admission Wee-FIM		47 (25.99)	34.49 (14.45)	0.169	Mean (SD)
Discharge Wee-FIM		68 (36.39)	56.46 (27.84)	0.253	Mean (SD)
Wee-FIM Change		21 (18.3)	21.96 (17.62)	0.874	Mean (SD)
Vent Dependent (Initial)	N	7 (70)	38 (66.67)	1	N (%)
	Y	3 (30)	19 (33.33)		N (%)
Vent Dependent (Discharge)	N	8 (80)	41 (71.93)	0.717	N (%)
	Y	2 (20)	16 (28.07)		N (%)

Table 3 SCI by Trauma

Variable	Level	Non-traumatic	Traumatic	P-Value	Metrics
		N = 88	**N = 57**		
AIS	A	10 (11.63)	31 (55.36)	<.001	N (%)
	B	13 (15.12)	4 (7.14)		N (%)
	C	31 (36.05)	10 (17.86)		N (%)
	D	32 (37.21)	11 (19.64)		N (%)
Location of Injury	C	26 (29.55)	19 (33.33)	0.649	N (%)
	L	17 (19.32)	11 (19.3)		N (%)
	S	0 (0.00)	1 (1.75)		N (%)
	T	45 (51.14)	26 (45.61)		N (%)
Completeness of Injury	C	10 (11.49)	32 (56.14)	<.001	N (%)
	I	77 (88.51)	25 (43.86)		N (%)
Self-Care Admission		20.72 (10.05)	18.47 (10.01)	0.191	Mean (SD)
Self-Care Discharge		34.44 (13.53)	31.4 (15.08)	0.209	Mean (SD)

Table continue

Variable	Level	Non-traumatic	Traumatic	P-Value	Metrics
		N = 88	N = 57		
Self-Care Wee-FIM Change		13.73 (8.33)	12.93 (9.24)	0.591	Mean (SD)
Mobility Admission		10.76 (6.17)	8.49 (4.88)	0.021	Mean (SD)
Mobility Discharge		20.24 (7.36)	18.3 (8.09)	0.138	Mean (SD)
Mobility Wee-FIM Change		9.48 (5.56)	9.81 (6.22)	0.74	Mean (SD)
Cognition Admission		28.38 (9.7)	27.84 (10.5)	0.755	Mean (SD)
Cognition Discharge		28.95 (9.42)	29.32 (9.78)	0.824	Mean (SD)
Cognition Wee-FIM Change		0.58 (1.65)	1.47 (2.92)	0.038	Mean (SD)
Admission Wee-FIM		59.9 (22.36)	54.95 (21.93)	0.192	Mean (SD)
Discharge Wee-FIM		83.64 (28.29)	78.95 (30.49)	0.346	Mean (SD)
Wee-FIM Change		23.74 (13.32)	24 (14.16)	0.911	Mean (SD)
Vent Dependent (Initial)	N	81 (92.05)	47 (82.46)	0.08	N (%)
	Y	7 (7.9	10 (17.54)		N (%)
Vent Dependent (Discharge)	N	85 (96.59)	50 (87.72)	0.049	N (%)
	Y	3 (3.41)	7 (12.28)		N (%)

Overall, the subjects with DDS had lower scores on the Wee-FIM for self-care, mobility, and cognition at admission (all with $p< 0.001$), and at discharge, differences between the groups remained. Despite the difference in total score, the absolute change in their scores from admission to discharge tended to be similar, with the exception of cognition. Patients with TBI showed significantly more improvement (relative to their baseline admission scores) compared to patients without TBI ($p<0.001$).

Table 4 (and its sub-tables) present data on LOS for all patients (DDS and SCI) based upon age and level of injury, with table 4a focusing on the age groupings for the WeeFIM, and table 4b focusing on ages groupings based on structural development. Similarly, the sub-tables for table 5 present data on Wee-FIM changes for all patients (DDS and SCI) based upon age and level of injury, with table 5a focusing on the age groupings for the WeeFIM and table 5b focusing on ages groupings based on structural development.

Table 4 Comparisons between DDS and SCI in traumatic injuries

Variable	Level	Total	DDS	SCI	Metrics
		114	57 (50)	57 (50)	N (%)
AIS	A		38 (66.67)	31 (54.39)	
	B		9 (15.79)	4 (7.02)	
	C		1 (1.75)	10 (17.54)	
	D		8 (14.04)	11 (19.30)	
	Indeterm-inate		1 (1.75)	1 (1.75)	
Location of Injury	C		29 (50.88)	19 (33.33)	N (%)
	L		3 (5.26)	11 (19.3)	
	S		0 (0.00)	1 (1.75)	
	T		25 (43.86)	26 (45.61)	
Completeness of Injury	C		38 (66.67)	32 (56.14)	N (%)
	I		19 (33.33)	25 (43.86)	
Self-Care Admission			11.23 (4.44)	18.47 (10.01)	Mean (SD)
Self-Care Discharge			21.33 (12.09)	31.4 (15.08)	Mean (SD)
Self-Care Wee-FIM Change			10.11 (9.21)	12.93 (9.24)	Mean (SD)
Mobility Admission			5.54 (1.65)	8.49 (4.88)	Mean (SD)
Mobility Discharge			12.26 (7.14)	18.3 (8.09)	Mean (SD)

Table continue

Variable	Level	Total	DDS	SCI	Metrics
Mobility Wee-FIM Change -			6.72 (6.62)	9.81 (6.22)	Mean (SD)
Cognition Admission			17.61 (10.36)	27.84 (10.5)	Mean (SD)
Cognition Discharge			22.65 (10.77)	29.32 (9.78)	Mean (SD)
Cognition Wee-FIM Change			5.04 (5.69)	1.47 (2.92)	Mean (SD)
Admission Wee-FIM			34.49 (14.45)	54.95 (21.93)	Mean (SD)
Discharge Wee-FIM			56.46 (27.84)	78.95 (30.49)	Mean (SD)
Wee-FIM Change			21.96 (17.62)	24 (14.16)	Mean (SD)
		114	57 (50)	57 (50)	N (%)
Vent Dependent (Initial)	N	85 (74.56)	38 (66.67)	47 (82.46)	N (%)
	Y	29 (25.44)	19 (33.33)	10 (17.54)	
Vent Dependent (Discharge)	N	91 (79.82)	41 (71.93)	50 (87.72)	N (%)
	Y	23 (20.18)	16 (28.07)	7 (12.28)	

Discussion

Identification and diagnosis of a BI in the setting of a SCI is essential for designing and implementing a rehabilitation program to best fit the patient's needs. In our study, almost one-third of patients had DDS. However, 50% of the SCI obtained from a traumatic etiology had DDS, which is consistent with literature in the adult population.[1–4]

Historically, children have been considered more vulnerable to TBI due their larger head size in proportion to their bodies, weak neck musculature, higher brain water content, and decreased myelination.[18] Children under the age of eight years are thought to be more vulnerable to cervical SCI due to the anatomy of the developing spine. Notably, in children, the primary fulcrum of motion at the neck is C2-C3, as opposed to C5-C6 in adults, and C2 does not completely fuse until approximately age twelve.[19] Pediatric patients are typically associated with higher risk of cervical SCI due to incomplete ossification of the cervical spine, large head to body ratio, horizontal arrangement of the facets, weak neck musculature and elastic ligaments and support structures.[20] Based upon this, it was hypothesized that there would be a higher incidence of traumatic cervical SCI in pediatric patients when compared to the adult SCI population. From the traumatic population in this cohort, there were 42.1% with cervical level injuries, 44.7% with thoracic level injuries, and 13.2% with lumbar/sacral level injuries. Statistically, our results were nearly identical to a study that included 941 subjects with pediatric SCI[8]. However, when comparing our results to the National Spinal Cord Injury Statistic Center 2018, they cite a rate of 54.4% for cervical SCI in the adult population,[21] which is lower than our pediatric cohort.

In our study population, 50% of the patients with traumatic SCI had DDS. This was further stratified to 60% of the traumatic cervical SCI and 49% of the thoracic SCI had DDS. The mean age of patients with DDS in our sample was 7.7 years, as opposed to a mean age of 11.24 years in patients with SCI, lending some credence to the theory that children under the age of 8 years may have a greater risk of sustaining DDS given their anatomical differences.

The high prevalence of DDS in injuries of traumatic etiology, emphasizes the need for screening in acute and post-acute care settings. Appropriate identification can help to direct caregiver training and designate appropriate social and transition services, as well as optimize functional gains. A number of studies, primarily in the adult population, have found that brain injury is under diagnosed in patients with SCI. A retrospective study of 409 veterans with SCI demonstrated that only 18 patients (4%) had traumatic brain injury noted on the problem list in their medical chart, while 99 (24%) were later identified as having a traumatic TBI.[22] A retrospective review by Sharma et al, revealed that 58.5% of patients admitted to their SCI rehabilitation program were later identified to have a TBI with no diagnosis of such in acute care[4]. Poor recognition of BI may be due to significant discrepancies between identification of DDS in the continuum of care between acute care hospitalization and transfer to inpatient rehabilitation.[23] Pediatric data is lacking; the literature identifies several case studies but no incidence has been identified.[24,25]

In an acute hospitalization, a TBI may be overlooked when components of the patient's medical care, such as intubation, sedation or pain management may mask deficits. TBI may be even more difficult to identify in the younger pediatric population who have a limited ability to participate in advanced cognitive testing or whose poor performance may be attributed to the psychological effects of the traumatic experience. Research has shown that using a pediatric Glasgow Coma Scale (GCS) in children younger than 2 years old is less reliable than the standard GCS for older children in identifying TBI.[26] A negative CT scan in the emergency department does not preclude the presence of a brain injury which are better identified on MRI studies[27] or by functional testing. Patients with mild TBI may be even more difficult to identify since conventional imaging studies are often normal in these patients, and cognitive deficits tend to be subtle.[28,29] In an acute care situation, knowledge of DDS is crucial as it may guide medical management as well as increase awareness of potential medical complications such as seizures, dysphagia, dysautonomia, neuroendocrine issues, motor and cognitive dysfunction.[30]

This study demonstrates that both acute care length of stay and rehabilitation LOS were significantly longer in our patients with DDS as compared to patients with SCI alone. Both the DDS group and the SCI group showed significant changes in their overall WeeFIM score from admission to discharge across all age groups. Both groups, however, by the end of their inpatient rehabilitation course, had similar overall WeeFIM changes. This suggests that both groups can be expected to make comparable functional gains over their respective

LOS, with adjustments to the plan of care if the patient has been identified as having a BI.

When comparing outcomes between the two groups in our study, there is a significant difference in WeeFIM change between DDS and SCI for the individual categories of self-care, mobility, and cognition. However, the overall WeeFIM change between the 2 groups was not significantly different. The cognitive component related to DDS may help to account for this. Understandably, patients with SCI have much higher Wee-FIM scores for cognition on admission than those with DDS, since these patients should be at their cognitive baseline. This facilitates better participation in occupational and physical therapy to allow for more gains in self-care and mobility. Conversely, DDS patients have significant cognitive decline from their baseline, allowing for greater cognitive gains, while potentially accounting for less ability to participate in self-care and mobility. The effect of severe TBI on SCI motor recovery may be more significant in patients with paraplegia rather than tetraplegia, due to diminished motor recovery potential.[3]

Studies that compare rehabilitation outcomes of adult patients with DDS had lower motor FIM scores,[3,5] longer acute rehabilitation LOS,[3] have increased rehabilitation costs and greater demands on clinical resources when compared to patients with SCI alone.[6] Our findings suggest that by adjusting expectations for LOS, we can expect comparable gains between the groups. Based upon our data, it would be reasonable to expect that patients with DDS would need approximately two additional weeks in a rehabilitation program to achieve similar gains as patients with SCI. A recent study in the adult literature noted that inpatient LOS increased by only 9.3 days in mild TBI and 5.6 days in moderate and severe TBI.[31] However, the authors noted that there was a decrease in FIM efficiencies and final outcomes in these patient populations and did suggest that these patient populations might, in fact, need longer acute inpatient rehabilitation LOS.

Cognitive deficits associated with traumatic brain injury may inhibit learning. Pediatric patients, depending upon their age and baseline cognition, may only be able to participate in limited cognitive testing. These patients are further affected because brain injuries have the potential to longitudinally impact new learning. Furthermore,[32–34] cognitive impairments such as memory and problem-solving limitations make it difficult to learn new information and to adapt to new mobility and self-care skills.[3,33–35]

Limitations

There are recognized limitations in this study. First, given the retrospective nature of the study, we relied exclusively on documentation in the medical record. While the co-investigators reviewed a select number of patient records, it is possible that there were errors in the medical record itself or in the review process. Furthermore, our DDS population was not stratified into mild, moderate and severe brain injuries, which may have provided different insights into length of stay and FIM efficiency data. Additionally, as the understanding of brain injury has evolved in recent years, it is likely that, in the early years of data collection, dual diagnosis was under recognized during the rehabilitation course.

There are inherent limitations in the classification system (AIS impairment scale) for spinal cord injury in children. Multiple studies have shown that the test is not reliable in children aged 5 years or younger.[8,36–38] We have used a modified AIS examination developed within our institution for this population, but it has not been validated. Therefore, AIS impairment scale classification may not be accurate in younger children.

This study also did not take into account neuropsychologic testing or psychosocial variables. Severity of BI affects the patients' abilities to participate in both testing and completion of functional tasks. Severity of BI by objective factors were not stratified in this patient population. When calculating LOS data , other factors in the pediatric population include insufficient family support, poor parental compliance during family education session, and issues of custody.[7] These were also not excluded.

Conclusion

To our knowledge, this is the first study evaluating pediatric SCI patients for presence of DDS, followed by examination as to how this diagnosis affects outcomes and LOS in this patient population. Given a large sample size over a nine-year period, there is data to support that DDS is relatively common, particularly in children with traumatic cervical and thoracic SCI. Rehabilitation plans of care need to be adjusted appropriately in these patients, given that patients with DDS can be expected to make similar functional gains as patients with SCI, provided that they have an increased LOS. Additionally, these patients face a number of obstacles as they age, and further studies will be beneficial to develop programs to ease the transition to adulthood. Longitudinal studies are needed to follow DDS patients into adulthood and compare their outcomes to SCI population.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contributions

JV and PP conceived the review protocol, participated in the screening and selection of subjects, writing the protocol and report, conducting the search, and analyzing data, interpreting results, updating reference lists, and writing the draft. MEM participated in writing the draft, analyzing the data and interpreting the data.

Funding

No financial assistance was received in support of the study.

Statement of ethics

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research. Compliance with ethical standards.

Acknowledgements

None.

Conflict of interest

The authors declare that they have no conflict of interest.

References

1. Macciocchi S, Seel RT, Thompson N, et al. Spinal cord injury and co-occurring traumatic brain injury: assessment and incidence. *Arch Phys Med Rehabil*. 2008;89(7):1350–1357.

2. Em H, Ge E, Rekand T, et al. Traumatic spinal cord injury and concomitant brain injury: a cohort study. *Acta Neurol Scand Suppl*. 2010;122(190):51–57.
3. MacCiocchi S, Seel RT, Warshowsky A, et al. Co-occurring traumatic brain injury and acute spinal cord injury rehabilitation outcomes. *Arch Phys Med Rehabil*. 2012;93(10):1788–1794.
4. Sharma B, Bradbury C, Mikulis D, et al. Missed diagnosis of traumatic brain injury in patients with traumatic spinal cord injury. *J Rehabil Med*. 2014.
5. Macciocchi SN, Bowman B, Coker J, et al. Effect of co-morbid traumatic brain injury on functional outcome of persons with spinal cord injuries. *Am J Phys Med Rehabil*. 2004;83(1):22–26.
6. Bradbury CL, Wodchis WP, Mikulis DJ, et al. Traumatic brain injury in patients with traumatic spinal cord injury: clinical and economic consequences. *Arch Phys Med Rehabil*. 2008;89(12 SUPPL.):S77–S84.
7. Kim CT, Greenberg J, Kim H. Pediatric rehabilitation: trends in length of stay. *J Pediatr Rehabil Med*. 2013;6(1):11–17.
8. Allen DD, Mulcahey MJ, Haley SM, et al. Motor scores on the functional independence measure after pediatric spinal cord injury. *Spinal Cord*. 2009;47(3):213–217.
9. James EG, Carl VG, Kenneth JO. Uniform data system for medical rehabilitation. WeeFIM II. 2006;6.
10. Ottenbacher KJ, Msall ME, Lyon NR, et al. Interrater agreement and stability of the Functional Independence Measure for Children (WeeFIM(TM)): Use in children with developmental disabilities. *Arch Phys Med Rehabil*. 1997;78(12):1309–1315.
11. Msall ME, DiGaudio K, Rogers BT, et al. The functional independence measure for children (WeeFIM). *Clin Pediatr (Phila)*. 1994;33(7):421–430.
12. Marino RJ, Barros T, Biering-Sorensen F, et al. International standards for neurological classification of spinal cord injury. *J Spinal Cord Med*. 2003;26Suppl 1(6):S50–56.
13. Roberts TT, Leonard GR, Cepela DJ. Classifications in brief: american spinal injury association (ASIA) impairment scale. *Clin Orthop Relat Res*. 2017:475(5):1499–1504.
14. Vogel L, Samdani A, Chafetz R, et al. Intra-rater agreement of the anorectal exam and classification of injury severity in children with spinal cord injury. *Spinal Cord*. 2009;47(9):687–691.
15. Mulcahey MJ, Gaughan JP, Chafetz RS, et al. Interrater reliability of the international standards for neurological classification of spinal cord injury in youths with chronic spinal cord injury. *Arch Phys Med Rehabil*. 2011;92(8):1264–1269.
16. Samdani AF, Fayssoux RS, Asghar J, et al. Chronic spinal cord injury in the pediatric population: does magnetic resonance imaging correlate with the international standards for neurological classification of spinal cord injury examination?. *Spine (Phila Pa 1976)*. 2009;34(1):74–81.
17. Fehlings MG, Tetreault LA, Aarabi B, et al. A clinical practice guideline for the management of patients with acute spinal cord injury: recommendations on the type and timing of rehabilitation. *Glob Spine J*. 2017;7(3_supplement):231S–238S.
18. Krach LE, Gormley ME, Ward M. Traumatic brain injury. In: Alexander MA, Matthews DJ, editors. 5th ed. Pediatric rehabilitation: principles and practice. 2015.
19. Lustrin ES, Karakas SP, Ortiz AO, et al. Pediatric cervical spine: normal anatomy, variants, and trauma. *RadioGraphics*. 2003.
20. Hornyak JE, Wheaton MW, Nelson VS. Chapter 16: spinal cord injuries. In: pediatric rehabilitation: principles and practice. 2015.
21. National spinal cord injury statistical center, birmingham A. 2018 annual statistical report for the spinal cord injury model systems. 2018.
22. Creasey GH, Lateva ZC, Schussler-Fiorenza Rose SM, et al. Traumatic brain injury in U.S. Veterans with traumatic spinal cord injury. *J Rehabil Res Dev*. 2015;52(6):669–676.
23. Sikka S, Vrooman A, Callender L, et al. Inconsistencies with screening for traumatic brain injury in spinal cord injury across the continuum of care. *J Spinal Cord Med*. 2017;0(0):1–10.
24. Sneed RC, Stover SL. Undiagnosed spinal cord injuries in brain-injured children. *Am J Dis Child*. 1988.
25. Bicknell JM, Fielder K. Unrecognized incomplete cervical spinal cord injury: Review of nine new and 28 previously reported cases. *Am J Emerg Med*. 1992;10(4):336–343.
26. Borgialli DA, Mahajan P, Hoyle JD, et al. Performance of the pediatric glasgow coma scale score in the evaluation of children with blunt head trauma. *Acad Emerg Med*. 2016;23(8):878–884.
27. Liu J, Kou ZF, Tian YQ. Diffuse axonal injury after traumatic cerebral microbleeds: An evaluation of imaging techniques. *Neural Regen Res*. 2014.
28. Ellis MJ, Leiter J, Hall T, et al. Neuroimaging findings in pediatric sports-related concussion. *J Neurosurg Pediatr*. 2015.
29. Rose SC, Schaffer CE, Young JA, et al. Utilization of conventional neuroimaging following youth concussion. *Brain Inj*. 2017: 31(2):260–266.
30. Kushner DS, Alvarez G. Dual diagnosis: Traumatic brain injury with spinal cord injury. *Phys Med Rehabil Clin N Am*. 2014;25(3):681–696.
31. Garlanger KL, Beck LA, Cheville AL. Functional outcomes in patients with co-occurring traumatic brain injury and spinal cord injury from an inpatient rehabilitation facility's perspective. *J Spinal Cord Med*. 2018;41(6):718-730.
32. Health T, Medicine E, Ewing-Cobbs L, et al. Late intellectual and academic outcomes following traumatic brain injury sustained during early childhood. *J Neurosurg Pediatr*. 2006;105(4):287–296.
33. Gorman S, Barnes MA, Swank PR, et al. Recovery of working memory following pediatric traumatic brain injury: a longitudinal analysis. *Dev Neuropsychol*. 2017;42(3):127–145.
34. Mandalis A, Kinsella G, Ong B, et al. Working memory and new learning following pediatric traumatic brain injury. *Dev Neuropsychol*. 2007;32(2):683–701.
35. Araujo GC, Antonini TN, Anderson V, et al. Profiles of executive function across children with distinct brain disorders: traumatic brain injury, stroke and brain tumor. *J Int Neuropsychol Soc*. 2017;23(7):529–538.
36. Mulcahey MJ, Gaughan J, Betz RR, et al. The international standards for neurological classification of spinal cord injury: reliability of data when applied to children and youths. *Spinal Cord*. 2007;45(6):452–459.
37. Chafetz RS, Gaughan JP, Vogel LC, et al. The international standards for neurological classification of spinal cord injury: intra-rater agreement of total motor and sensory scores in the pediatric population. *J Spinal Cord Med*. 2009;32(2):157–161.
38. Carroll A, Vogel LC, Zebracki K, et al. Relevance of the international spinal cord injury basic data sets to youth: an Inter-Professional review with recommendations. *Spinal Cord*. 2017;(December 2016):1–7.