Research Article

Inconsistencies with screening for traumatic brain injury in spinal cord injury across the continuum of care

Seema Sikka^{1,2}, Angela Vrooman ¹, Librada Callender^{1,2}, David Salisbury¹, Monica Bennett², Rita Hamilton^{1,2}, Simon Driver^{1,2}

¹Baylor Institute for Rehabilitation, Dallas, Texas, USA, ²Baylor University Medical Center, Dallas, Texas, USA

Abstract: Objective: Explore how traumatic brain injury (TBI) is screened among spinal cord injury (SCI) patients across the continuum of care.

Design: Retrospective chart review

Setting: Emergency department, trauma, inpatient rehabilitation

Participants: 325 patients with SCI from inpatient rehabilitation facility (IRF) between March 1, 2011 and December 31, 2014 were screened. 49 eligible subjects had traumatic SCI and received care in adjoining acute care (AC) hospital.

Outcome Measures: Demographic characteristics and variables that capture diagnosis of TBI/SCI included documentation from ambulance, emergency department, AC, and IRF including ICD-9 codes, altered mental status, loss of consciousness (LOC), Glasgow Coma Score, Post Traumatic Amnesia (PTA), neuroimaging, and cognitive assessments.

Results: Participants were male (81%), white (55%), privately insured (49%), and aged 39.3 ± 18.0 years with 51% paraplegic and 49% tetraplegic. Mechanisms of injury were gunshot wound (31%), fall (29%), and motor vehicle accident (20%). TBI occurred in 65% of SCI individuals, however documentation of identification of TBI, LOC, and CT imaging results varied in H&P, discharge notes, and ICD-9 codes across the continuum. Cognitive assessments were performed on 16% of subjects.

Conclusions: Documentation showed variability between AC and IRF and among disciplines. Imaging and GCS were more consistently documented than LOC and PTA. It is necessary to standardize screening processes between AC and IRF to identify dual diagnosis.

Key Words: Traumatic brain injury, Spinal cord injury, Brain injury, Rehabilitation

Introduction

Improved awareness and identification of concurrent traumatic brain injury (TBI) and spinal cord injury (SCI) has been facilitated by a growing number of studies reporting dual diagnosis as a clinically significant subgroup of patients. Estimates vary based on the sample population and method of determining potential TBI, and is detected in upwards of 50-74% of SCI admissions.¹⁻⁵ The importance of accurate detection can have immediate ramifications for care. For example, some studies have shown dual diagnosis patients have increased rates of cognitive, behavioral and psychological changes

that result in greater cost, care burden and worse reintegration into the community with effects lasting years after the initial injury.^{2,6-10}

However, the ability to identify concurrent TBI and SCI is challenging due to inconsistency of appropriate screening and a tendency to rely upon a single variable such as altered mental status (AMS), loss of consciousness (LOC), Glasgow coma scale (GCS), post traumatic amnesia (PTA), or neuroimaging for diagnosis.^{4,9,11} More sophisticated systems that integrate all of these variables are preferred, but often not feasible, given the injury circumstances. The majority of TBIs detected in conjunction with SCI are mild in severity,⁴ and there can be much variety in initial presentation and recovery.¹² Complicated mild TBI, identified by positive

Correspondence to: Librada Callender, Baylor Institute for Rehabilitation, 909 North Washington Avenue, Dallas, TX, 75246, USA. Email: Librada.callender@bswhealth.org

radiographic findings, has been linked in some studies to greater cognitive and behavioral sequelae resulting in recovery curves in line with moderate severity TBI.^{12–15}

Specific risk factors such as motor vehicle collision, falls, cervical level SCI, complete SCI and alcohol intoxication at initial trauma are associated with a greater need to screen for a potential TBI.¹⁶ However, there has been evidence of frequently missed TBI diagnosis with up to 58.5% of missed TBI.¹⁷ Interestingly, these studies found that most missed diagnoses occurred for patients not injured in motor vehicle crashes.^{16,17} Such findings, in conjunction with the variability of screening strategies across acute medical settings, were the impetus of this study.

The primary objectives of this study were to: (1) examine different methods of identification of TBI for individuals with SCI within the medical record, (2) describe the consistency of TBI diagnosis across the continuum of care, (3) describe the services provided to individuals with dual diagnosis (e.g., cognitive therapy via psychology and speech therapy), and (4) identify differences in Functional Independence Measure (FIM) change based on presence or absence of TBI in SCI. Additionally, we discuss how this data has helped us formulate a plan to improve screening and treatment from acute admission through the continuum of care.

Methods

This retrospective study was completed after approval from the local Institutional Review Board to ensure all procedures were ethical. All patients were initially admitted to a local Level 1 Trauma Center and then transferred to an inter-connected inpatient rehabilitation facility as part of the continuum of care. The inpatient rehabilitation facility includes both SCI and TBI dual-certified physicians and dedicated teams of therapists specializing in the care of individuals who are diagnosed with SCI or TBI. However, there is not currently a dedicated team or specific protocol to treat dual diagnosis patients.

Patient selection

Subjects included in the screening process were patients that had an etiological diagnosis of SCI and were admitted to inpatient rehabilitation from the inter-connected Level 1 trauma center between March 1, 2011 and December 31, 2014. Initial data extraction revealed 325 subjects who admitted to the inpatient rehabilitation unit had an etiological diagnosis of SCI which included both traumatic and non-traumatic SCI. Subjects were excluded if they had a diagnosis of non-traumatic SCI (e.g. spinal stenosis without traumatic injury, tumor)

or if they arrived from a hospital outside of our hospital system as sufficient records pertaining to TBI screening and severity indicators were not consistently present. This resulted in 49 eligible subjects.

Data collection

Patient demographic information including: gender, age, race, ethnicity, etiology of injury, dates of treatment, and level of SCI were collected. To identify the presence of a co-occurring TBI, ambulance, emergency department, acute trauma care, and inpatient rehabilitation admission and discharge notes were reviewed for the documentation of LOC, GCS, PTA, and neuroimaging based on criteria from previous studies.^{4,9,11} Furthermore, we reviewed physician admission notes, discharge summaries, and ICD-9 codes for documentation of TBI diagnosis. Each variable was used as diagnostic criteria to identify our rate of TBI in this SCI sample, and then classified by severity of TBI based on GCS (no TBI = 15; mild = 13–14; moderate = 9–12; and severe = 3–8).⁴ If subjects had a normal GCS of 15, they were considered mild severity if they screened positive for LOC, PTA or neuroimaging. The rate of TBI diagnosis was examined across the continuum of care.

Both acute care and inpatient rehabilitation charts were reviewed to look for evidence of neuropsychological or speech therapy consults. Individual psychology notes were then reviewed to determine the presence or absence of any commonly used cognitive TBI screening measurements. Finally, discharge recommendations were reviewed to capture any recommendation for outpatient cognitive therapy. Admission and discharge FIMs, as well as discharge disposition, were also retrieved from eRehabdata (an inpatient rehabilitation outcomes system).

Statistical analysis

All data was summarized using counts and percentages for qualitative variables and means and standard deviations or medians and interquartile ranges for quantitative variables. Comparisons between FIM at admission, FIM at discharge, FIM gain and FIM efficiency were performed using two sample t-tests. Moderate to severe TBI, mild TBI, and no indication of TBI were further compared using Kruskal-Wallis tests with Bonferroni adjusted post-hoc analysis for significant results. All analysis was performed using SAS 9.4 (Cary, NC) with a 5% significance level.

Table 1 Summary of patient demographic information stratified by TBI.

Demographic Characteristic	All (N=49)	TBI (N=32)	No indication of TBI (N=17)
Age	39.3 ± 18.0	39.9 ± 18.7	38.0 ± 17.2
Male Gender	40 (81%)	25 (78%)	15 (88%)
Hispanic Ethnicity	4 (8%)	3 (9%)	1 (6%)
Race			
American Indian/ Alaska Native	1 (2%)	1 (3%)	0 (0%)
Asian	2 (4%)	1 (3%)	1 (6%)
Native Hawaiian/ Pacific Islander	1 (2%)	1 (3%)	0 (0%)
Black or African American	18 (37%)	13 (41%)	5 (29%)
White or Caucasian	27 (55%)	16 (50%)	11 (65%)
Insurance Type			
Private	24 (49%)	14 (44%)	10 (59%)
Self-pay/uninsured	18 (37%)	13 (41%)	5 (29%)
Medicare	7 (14%)	5 (16%)	2 (12%)

Results

The mean age of subjects upon admission to inpatient rehabilitation was 39.3 ± 18.0 . Subjects were mostly male (81%) and white (55%). Most subjects had private insurance (49%) followed by self-pay or uninsured (37%). Table 1 summarizes the demographic characteristics of subjects stratified by presence of TBI.

The most common mechanism of injury for patients with SCI who had indication of TBI was fall (34%), and for no indication of TBI was gunshot wound (47%). Median GCS score upon admission to the ED for all participants was 15 regardless of indication of TBI. There were more tetraplegics among those with indication of TBI (59%), and more paraplegics among those with no indication of TBI (71%). Most participants with indication of TBI had a cervical level of injury (56%). The majority of participants were motor incomplete injuries (59%) (classified as C-D on the American Spinal Injury Association Impairment Scale [AIS]) in both groups. Median inpatient rehabilitation length of stay was similar between both groups at 32 days. The majority across all groups discharged to private residence (86%) after inpatient rehabilitation. Table 2 summarizes injury characteristics stratified by indication of TBI.

In Table 3, the frequency of patients with a TBI is presented based on the different modes of identification including GCS, LOC, positive imaging and PTA as documented throughout the medical record. GCS was recorded for all patients based on EMS and/or ED documentation, while PTA was only ever documented in the trauma psychology notes. 65% of the 49 subjects with traumatic SCI met criteria for diagnosis of TBI.

Table 2 Summary of injury characteristics stratified by TBI.

Injury Characteristic	All (N=49)	Any indication of TBI (N=32)	No indication of TBI (N=17)
Mechanism of Injury			
Motor vehicle	10 (20%)	7 (22%)	3 (18%)
Motorcycle	3 (6%)	3 (9%)	0 (0%)
Bicycle	1 (2%)	1 (3%)	0 (0%)
Gunshot Wound	15 (31%)	7 (22%)	8 (47%)
Water Sports	2 (4%)	2 (6%)	0 (0%)
Other Sports	2 (4%)	0 (0%)	2 (12%)
Fall	14 (29%)	11 (34%)	3 (18%)
Pedestrian	2 (4%)	1 (3%)	1 (6%)
GCS total score, median (min-max)	15 (3–15)	15 (3–15)	15 (15–15)
Paraplegic or tetraplegic			
Paraplegic	25 (51%)	13 (41%)	12 (71%)
Tetraplegic	24 (49%)	19 (59%)	5 (29%)
SCI level			
Cervical	23 (47%)	18 (56%)	5 (29%)
Thoracic	17 (35%)	11 (34%)	6 (35%)
Lumbar	9 (18%)	3 (9%)	6 (35%)
ASIA impairment Scale			
A - Complete	14 (29%)	10 (31%)	4 (24%)
B - Sensory Incomplete	5 (10%)	3 (9%)	2 (12%)
C - Motor Incomplete	12 (24%)	5 (16%)	7 (41%)
D - Motor Incomplete	17 (35%)	13 (41%)	4 (24%)
Unknown	1 (2%)	1 (3%)	0 (0%)
Rehab LOS, median (IQR)	32 (17–51)	33 (16–55)	27 (19–45)
Discharge Disposition			
Private Residence	42 (86%)	26 (81%)	16 (94%)
Nursing Home	4 (8%)	4 (13%)	0 (0%)
Adult Home	1 (2%)	1 (3%)	0 (0%)
Hospital	1 (2%)	1 (3%)	0 (0%)
Other	1 (2%)	0 (0%)	1 (6%)

Table 4 highlights where the TBI was first identified across the continuum of care. The rows indicate how frequently the TBI continued to be documented as the subject progressed through the continuum of care. For example, in the first column of Table 4, 7 patients (22%) had a documented TBI (as defined by either LOC, GCS<15 or diagnosis of TBI) on the EMS report. Of those 7 patients, only 6 (86%) were identified with a TBI in the ED admission note, 4 (57%) had

Table 3 Frequency of patients with a TBI based on different modes of diagnosis.

	N=49
TBI from any source	32 (65%)
TBI from GCS (<15)	16 (33%)
TBI based on LoC	23 (47%)
TBI from imaging	10 (20%)
TBI from PTA (n=47)	10 (21%)
TBI Severity	
None	17 (35%)
Mild	18 (37%)
Moderate	3 (6%)
Severe	11 (22%)

Table 4 Patients documented with TBI at each stage of their health care interaction.

Initial Identification						
Continued Identification	EMS (n = 7/ 22%)	ER (n = 20/ 63%)	Imaging results (n=10/ 31%)	Acute care admission (n=18/56%)	Acute care discharge (n=19/59%)	Inpatient rehab admission (n=18/56%)
EMS	-	6 (43%)	4 (40%)	6 (33%)	6 (32%)	5 (26%)
ER	6 (86%)	-	8 (80%)	13 (72%)	11 (58%)	11 (61%)
Imaging results	4 (57%)	8 (57%)	-	9 (50%)	9 (47%)	9 (47%)
Acute care Admission	6 (86%)	13 (93%)	9 (90%)	-	15 (79%)	12 (63%)
Acute care Discharge	6 (86%)	11 (79%)	9 (90%)	15 (83%)	-	14 (74%)
Inpatient Rehab Admission	5 (71%)	11 (79%)	9 (90%)	12 (67%)	14 (74%)	-
Inpatient Rehab Discharge	4 (67%)	9 (64%)	10 (100%)	11 (61%)	12 (63%)	14 (74%)

positive imaging, 6 (86%) had documented TBI in the acute care history and physical, 6 (86%) had documented TBI in the acute care discharge note, 5 (71%) had a documented TBI in inpatient rehabilitation history and physical, and 4 (67%) had documented TBI in the inpatient rehabilitation discharge summary. Note that one of the 32 patients that were identified as having a TBI only had PTA identified in the psychology note, and are not included in Table 4, as they were not documented with TBI in the medical record, had a GCS = 15, and did not have positive imaging findings.

When looking at the psychological health information, 10 (31%) of the 32 patients that were identified with TBI had documented findings of PTA in the acute care trauma psychology note. 14 (44%) of the 32 patients with TBI and 9 (53%) of the 17 patients without TBI had pre-existing psychological comorbidities documented in either the acute care trauma psychology note or the inpatient rehabilitation psychology note. 12 (38%) of the 32 patients with TBI and 5 (29%) of the 17 patients without TBI were recommended for cognitive therapy follow up in the acute care psychology discharge summary. 15 (47%) of the 32 patients with TBI were recommended for cognitive therapy follow up in the inpatient rehabilitation psychology discharge summary, while none of the patients without TBI were. In the inpatient rehabilitation setting, 14 (44%) of the 32 patients with TBI (0% without TBI) received cognitive testing by speech therapy or neuropsychology. The cognitive measures used by clinicians ranged from simple screening of mental status (e.g., Montreal Cognitive assessment, Orientation Log, Cognitive Log) to more thorough testing of cognitive domains (e.g. Repeatable Battery for the Assessment of Neuropsychological Status, or the Neuropsychological Assessment Battery).

Finally, we looked at FIM at admission and discharge to inpatient rehabilitation and stratified by TBI (see Table 5). Motor FIM, Cognitive FIM, and total FIM

Table 5 Summary of FIM at rehab admission and discharge stratified by TBI.

	All	Any indication of TBI (N = 32)	No indication of TBI (N = 17)	p-value
FIM Admission				
Motor	24.9±12.2	22.3±11.3	29.8±12.6	0.0386
Cognitive	26.7±5.5	25.5±5.8	28.8±4.2	0.0456
Total	51.6±14.1	47.8±13.0	58.6±13.8	0.0093
FIM Discharge				
Motor	54.8±17.7	51.2±18.5	61.6±14.2	0.0483
Cognitive	31±4.4	29.9±4.7	33.1±2.8	0.0046
Total	85.8±19.5	81.1±20.4	94.7±14.2	0.0183
FIM Gain	34.2±15	33.3±15.7	36.1±14.0	0.5391
FIM Efficiency	1.5±1.3	1.6±1.5	1.3±0.7	0.4685

were significantly higher ($p = 0.0386$, $p = 0.0456$ and $p = 0.0093$ respectively) for patients without TBI upon admission and similar results were seen upon discharge ($p = 0.0483$, $p = 0.0046$, and $p = 0.0183$ respectively). When further examining the subgroup with TBI and controlling for TBI severity, significant differences between moderate to severe TBI and no indication of TBI groups were seen in Total FIM admission scores ($p = 0.0320$) and Total FIM Discharge scores ($p = 0.0367$). Additionally, significant differences between mild TBI and no indication of TBI groups were seen in Cognitive FIM discharge ($p = 0.0062$).

Discussion

This study reinforces the inconsistency of accurate detection of TBI among SCI patients.^{3,4} First and foremost, the lack of standardized screening across the continuum of care is evidenced by the variable timing of initial TBI identification. This is congruent with many reports in the literature of the difficulty in accurately diagnosing mild TBI and the current variability in diagnostic criteria.¹⁸

Our results highlight how healthcare provider discipline may impact the accuracy of screening and/or

detecting potential TBI. Specifically, severity variables such as GCS and LOC are often favored in the ED settings, but are still documented inconsistently. GCS was the sole severity indicator documented for all patients in our system, yet only 50% of the dual diagnosis sample would be categorized as having TBI based on this scale alone. The remaining 50% (GCS = 15) had other severity indicators suggestive of TBI, emphasizing the need to use multiple data points when screening for TBI. Although PTA has been shown to be a sensitive tool to capture TBI and predict long term outcome,¹⁹⁻²¹ this technique was used only by the trauma psychologist and rehabilitation consultants in the trauma setting. This may speak to lack of familiarity with PTA as an indicator of potential TBI and predictor of outcome.

The need for early and accurate detection of TBI in the SCI population is related to appropriate medical care and rehabilitation planning.² The risk of misdiagnosis is magnified by the inconsistency of severity related variables being communicated across service lines and providers. For example, of those patients who had documentation of LOC, GCS < 15, or abnormal CT findings in the ED setting, only 72% had TBI listed on their hospital admission paperwork and 52% had TBI listed on their inpatient rehabilitation admission. It is evident there is need to improve the accuracy of documentation of clinical findings and diagnoses that follow patients across care settings. This challenge speaks to the need of hard wiring documentation requirements among SCI patients to facilitate the awareness of a potential or confirmed TBI. Without such processes, the more immediate medical concerns may overshadow the need for recognition and treatment of TBI.

A review of FIM scores support the differing levels of motor and cognitive functioning among the dual diagnosis patients. The lower admission and discharge scores among the TBI group must be considered in light of patients potentially having more severe SCIs. FIM gain and efficiency is not significantly different between any indication and no indication of TBI groups showing that both groups experience gains at similar rates. Furthermore, it is interesting to note that after stratifying by severity of TBI, mild TBI had significantly lower cognitive FIM discharge scores compared to those with no indication of TBI, which may be attributed to decreased or delayed identification of TBI in this population. Future studies should examine the impact of TBI severity and efficiency in the long term. Concerns for TBI may not be raised until a transition to the inpatient rehabilitation setting where the cognitive demands

increase and more subtle residual cognitive problems can impact treatment.

The findings of our study highlight areas of improvement for diagnosis and treatment of dual diagnosis patients in a variety of settings that includes failure to appropriately document within medical records. A key point of intervention should be increased education of potential TBI symptoms following SCI and appropriate screening for providers spanning across the continuum of care. Individuals with SCI should be screened by experienced rehabilitation professionals at the earliest opportunity to optimize detection of TBI and help guide care planning. Furthermore, standardizing TBI screening variables to assess potential LOC and PTA into electronic medical records for at risk SCI patients would improve detection. Such documentation should then follow the patient automatically in subsequent medical records to clarify the presence or absence of TBI. A dual diagnosis track for SCI patients with concurrent TBI has been implemented in select rehabilitation sites and warrants consideration as a standard of care even in the acute setting.^{2,4,11}

Limitations

We noted certain limitations while conducting this project. First, documentation practices varied across the continuum. We found that there was no singular place for quality metrics to identify TBI because of inconsistent documentation templates and practices. Therefore, we cannot be certain whether or not TBI was identified in clinician daily notes, as we restricted data collection to history and physicals, and discharge summaries. Additionally, we only looked at TBI patients that came to inpatient rehabilitation from our hospital system's acute trauma setting due to our ability to access the medical record across the continuum. The lack of identification of TBI in SCI exists in all hospitals that feed into our inpatient rehabilitation hospital, and we weren't able to identify the prevalence of TBI for outside hospitals due to lack of access to their complete medical records.

Conclusion

The impetus of this study was concern about inconsistencies in TBI diagnosis and communication of the diagnosis across settings. The confirmatory findings warrant discussion about system level changes to improve patient care. Such changes could include mandated TBI screening questions and documentation within electronic records across settings that is automatically included in discharge notes. The co-occurrence of SCI and TBI also supports regular implementation of dual diagnosis tracks within inpatient rehabilitation systems.

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Conflicts of interest None.

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ORCID

Angela Vrooman <http://orcid.org/0000-0003-0273-7156>

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