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The Initiation of Rehabilitation Therapies and Observed Outcomes in Pediatric Traumatic Brain Injury

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Abstract

Purpose: Pediatric traumatic brain injury (TBI) is associated with immense physical, emotional, social, and economic burden. This study examined timing and frequency of rehabilitation services provided by the inpatient interdisciplinary team in children admitted for a TBI. Understanding the timing and frequency of rehabilitation services could guide TBI recovery.

Design and Methods: This is a 3-year prospective observational study of previously healthy children (n = 35) admitted for a TBI to an urban Level 1 trauma hospital. Children with mild, moderate, and severe TBI were included. Initiation and frequency of the interdisciplinary rehabilitation team's care and neurocognitive-functional outcomes were analyzed. Outcome measures included the Glasgow Outcome Scale-Extended Pediatrics and the Speech Pathology Neurocognitive-Functional Evaluation at hospital discharge and first follow-up visit.

Results: The initiation and the frequency of rehabilitation services were found in all severities of TBI. Timing and frequency of services also aligned with varied severities. Children with moderate TBI showed the most improvement in Glasgow Outcome Scale-Extended Pediatrics and the Speech Pathology Neurocognitive-Functional Evaluation on their first follow-up visit, whereas children with mild and severe TBI demonstrated little change in outcome at their first follow-up visit and had varied services based on their hospital course.

Conclusion: Services by interdisciplinary rehabilitation teams were provided across all brain injury severity groups, despite the lack of comprehensive rehabilitation guidelines. Varied neurocognitive and functional outcome changes measured found children with moderate TBI had the greatest change in outcomes. Further research is warranted to assess the timing and frequency of services and their relationship to neurocognitive-functional outcomes.

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Keywords

Children; Functional outcomes; Head injury; Interdisciplinary; Neurocognitive outcomes; Rehabilitation

Introduction

Traumatic brain injury (TBI) is the leading cause of death and disability for children in the United States. In survivors, the cost of acute and rehabilitative care for neuropsychological deficits and motor disabilities has been estimated at $60 billion annually, with an average lifetime cost for a person with severe TBI ranging from $600,000 to $1,875,000 (Coronado et al., 2011). Schneier and colleagues reported an estimated 50,658 pediatric TBI-associated hospitalizations, which occurred in the United States in 2000, with more than $1 billion in total charges for inpatient care (Faul, Xu, Wald & Coronado, 2010; Schneier, Shields, Hostetler, Xiang, & Smith, 2006). The prevalence of disability among all persons who have sustained a TBI in childhood is unknown, but there is an estimated 2% of Americans who have a disability related to a TBI (Collins et al., 2014; Thurman, 2014). Caring for the traumatically brain-injured child includes early recognition, thorough assessment, implementing optimal neuroprotective strategies, and anticipating potential needs of the patient and his or her family (Popernack, Gray, & Reuter-Rice, 2015). To date, acute management of moderate and severe pediatric TBI guidelines exists to treat the acute injury phase of hospitalization (Kochanek et al., 2012). However, comprehensive pediatric TBI rehabilitation guidelines do not exist, allowing for variability of care and outcomes. The financial, physical, and emotional impact of the injury nationwide illustrates that TBI recovery is an area of research that deserves our attention.

Level 1 trauma centers that provide interdisciplinary services have been found to improve outcomes (Curtis et al., 2011). This was substantiated by a study examining children admitted to an American College of Surgeons Level 1 trauma center, where researchers found that children were more likely to receive rehabilitation therapy such as physical or occupational therapy (OT; Bennett, Niedzwecki, Korgenski, & Bratton, 2013). In addition, other studies have shown that, in adults who are admitted to a Level 1 trauma center with a TBI, they are more likely to receive TBI care based on the adult TBI guidelines (Hesdorffer & Ghajar, 2007; Hesdorffer, Ghajar, & Iacono, 2002). Tepas and colleagues (2009) found that, in children who sustained a TBI, delays in starting rehabilitation resulted in diminished outcomes and reduced efficiency of rehabilitative care.

There is a paucity of literature that describes access to interdisciplinary pediatric teams, early initiation of rehabilitative services, and ample resources, including technology, personnel, and time with providers, lead to better outcomes in TBI (Catroppa & Anderson, 2006; Popernack et al., 2015). There are several individual studies that address rehabilitation strategies and challenges for discrete problems after TBI, but none that examines the team, type, and timing of services (Popernack et al., 2015). Therefore, this study investigates the team, timing, and frequency of available rehabilitative services at a Level 1 pediatric trauma center for children admitted with a TBI. The study team was interested in describing

rehabilitation services provided to children with a TBI and whether there is a relationship between rehabilitation care and outcomes when measured at discharge and at the first follow-up visit.

Methods and Measures

Setting

Thirty-five children served as the sample for this study. These children were all admitted to a large, urban, Level 1 trauma center with a diagnosis of TBI from December 2012 through August 2014. Patients were enrolled after study institutional review board approval and parental consent. Eligibility included children of English- or Spanish-speaking families, ages 5 days to 15 years, who were previously healthy and sustained either a mild, moderate, or severe TBI. Children were excluded if they had a history of developmental delay, existing neurocognitive disorders, or nontraumatic (acquired) brain injuries. Patients were enrolled upon admission to the pediatric intensive care unit or pediatric stepdown unit, and enrollment was considered “Day 1” of the study.

Measures

Data Collection Procedures—Upon enrollment, prospective data (such as biological and physiological data) as well as data from the patient’s electronic health record (EHR) were collected. Data were collected only after admission to the pediatric intensive care unit or pediatric stepdown unit and focused on the first 8 days of hospitalization. Demographic information included a number of factors, such as, gender, age, race/ethnicity. We also collected the mechanism of injury, admission location, and length of stay (LOS). Injury severity was determined by a daily Glasgow Coma Scale (GCS).

The GCS score has a total of 15 points, with a higher score indicating a greater level of consciousness/responsiveness (Teasdale & Jennett, 1974). The use of the GCS score is considered a valid and reliable measure to assess neurologic status and is the most common measure used in TBI to define injury severity (Cicero & Cross, 2013; Nesiama, Pirallo, Lerner, & Hennes, 2012; Reith, Van den Brande, Synnot, Gruen, & Maas, 2016). The GCS determined by the trauma team in the emergency department was used in this study to determine the patient’s brain injury severity. A GCS score of 13–15 indicates a mild brain injury, a score of 9–12 indicates a moderate brain injury, and a score of 3–8 indicates a severe brain injury.

We examined admission, discharge, and daily notes written by members of the interdisciplinary rehabilitation team for all data that reflected rehabilitation therapies. The data collection timeframe consisted of the first 8 days or less (depending on LOS) of the hospitalization for a TBI. Data reflected the time to initiate rehabilitation services and the type and frequency of the therapies provided. The collection of data was performed by one member of the study team and validated by a second member of the team. Each patient was deidentified by an assigned study number. Data were captured in an excel database and was then organized by severity of injury (mild, moderate, severe). These data were used to assess the day of initiation of rehabilitation team services and the frequency of services over the

course of hospitalization. Each rehabilitation team services note was examined for specific common data elements (Table 1).

Outcome Measures—The Speech Pathology Neurocognitive-Functional Evaluation (SPNFE) is an institutional metric performed by pediatric speech pathologists trained in TBI evaluation and is performed either upon admission or when a child is determined medically stable. The SPNFE is derived from multiple standard measures and provides raw and standardized scores that are compared to normative data to define a cognitive and functional assessment. This age-adjusted evaluation is a primary determinate of the patient's plan of care. The testing captures the patient's developmental neurocognitive-functional abilities at the time of evaluation. Therefore, depending on the TBI severity, multiple evaluations may occur during hospitalization or after discharge as therapies continue. For the purposes of this study, levels of delay were assigned a numeric ordinal scale of 0 = *no delay*, 1 = *mild delay*, 2 = *moderate delay*, and 3 = *severe delay*. These numeric values allowed the research team to compare delay over two outcome time points: discharge from hospital and at follow-up visit.

The Glasgow Outcome Scale-Extended Pediatrics (GOS-E Peds) Scale categorizes a child's TBI neurofunctional outcome using an 8-point numerical scale (Beers et al., 2012). This scale accounts for the differences in developmental activities specific to children under the age of 17 years. The scale ranges from 1 to 8 (where 1 = *upper good recovery* and 8 = *death*). The GOS-E Peds Scale, although used in research to gauge a patient's recovery, was not used in the management of the patient to adapt their care.

Definitions of Primary and Secondary Teams—As part of the immediate resuscitation and daily care team, providers such as the bedside nursing, attending physicians, respiratory therapists, pediatric neurosurgery, pediatric neurology, and pediatric surgery were not examined. We appreciated these members to be involved in the patient's day-to-day care and recovery. We also appreciated that bedside nursing, who was integral to patient care and recovery, was also exclusively responsible for coordinating any and all care that directly related to rehabilitation. It was for these reasons that we chose not to include them as a separate rehabilitation care service.

Rehabilitation services vary by defined specialty and by the frequency of the therapy; therefore, we defined the rehabilitation teams as either primary or secondary. We defined the *primary rehabilitation team* as nutrition, OT, ophthalmology, physical therapy (PT), social work (SW), and speech–language therapy (SLT). The *secondary rehabilitation team* included the chaplain, child life specialist, lactation consultant, orthopedic surgery, otolaryngology, and pediatric hematology service. These providers were often consulted to address either an acute event or to direct a distinct treatment. We evaluated outcome measures using the SPNFE and the GOS-E Peds. These were used to examine if a relationship existed between the initiation and frequency of rehabilitation services with the patient's outcome at time of discharge and on the first follow-up visit. Discharge was defined as the last day of hospital care at the study site. Follow-up visits that occurred within 4–6 weeks of discharge by the pediatric neurosurgery team, speech pathologist, or neurologist were used to determine outcome.

Data Analysis

A descriptive analysis was performed using Microsoft Excel software to examine the demographic data such as gender and age and injury-related data such as severity, GOS-E Peds, and SPNFE and the individual patient and interdisciplinary team's interactions. To describe the timing of initiation of services and the frequencies of the team interactions, measures of central tendencies (mean) and measures of variability (standard deviation [*SD*]) were used. Outcome measures were compared upon discharge, and the first follow-up visit to understand if a change could be detected.

Injury severity groups were based on admission GCS (mild, moderate, and severe). The mean day of initiation of rehabilitation services for each injury severity group was calculated based on the date of the first encounter for each patient. The mean number of interactions for each injury severity group was calculated based on the number of daily interactions by the primary or secondary rehabilitation team.

Results

Sample Characteristics

Study participants were 62.9% male, with an average age of 5 years (60.31 months). Most of the patients were admitted for mild TBI. The mechanism of injury was differentiated by abusive head injury cases (37.1%) and accidental trauma cases (62.9%), and the mean LOS was 7.18 days (Table 2). Patients were enrolled at 4–37 hours (mean = 16 hours) after admission to the hospital.

Outcome Measures at Discharge and First Follow-up Visit

Figure 1 shows the mean outcome scores across all brain injury severities. At discharge, most of the SPNFE scores demonstrated no delay (60.0%) or mild delay (17.2%). At follow-up, we discovered that 21 children (60%) had no delay. The moderate delay group ($n = 2$, 5.6%) and severe delay group ($n = 3$, 8.6%) both saw an improvement of their neurocognitive-functional outcome scores. There were three participants with no SPNFE score at follow-up. A similar pattern exists between the GOS-E Peds and SPNFE scores at time of discharge and upon follow-up for both the mild and severe patients. However, in the moderate TBI patients, there was a distinct variation between both the scores and time points. Of note, six children were lost to follow-up. Of the 35 children enrolled, only 29 had a neurocognitive and functional recovery follow-up examination.

Frequency and Initiation of Care—In patients with a mild TBI, all received SLT and 70.8% received SW services (Figure 2). There were differences seen in the initiation and continued services by PT, OT, and ophthalmology. Although PT initiated care later than the other services, they appeared to have more consistent encounters with the patients (Figure 3).

In patients with moderate TBI, all patients received nutrition, ophthalmology, and SW services and two patients (66.7%) received SLT services (Figure 2). Both nutrition and SW, on average, appeared to initiate their services the earliest, whereas ophthalmology

encountered the patients later in their hospital course and had the fewest number of patient visits. Speech–language therapists saw the patients more on average than the other services. None of the patients with a moderate TBI received PTor OT during the first 8 days of hospitalization (Figures 2 and 3).

All severe TBI patients received nutrition, ophthalmology, SW, and SLT services (Figure 2). Twenty-five percent received OT services, and 50% received PT services. In patients with severe TBI, SW initiated their services the earliest and PT was the last to see the participant, beginning on average of 3.5 days after admission (Figure 3).

Discussion

Our single-center study findings show that four of the six rehabilitative services examined were initiated within the first 2 days of enrollment in all injury severity groups. Tepas et al. (2009) found that delayed initiation of rehabilitation in severe pediatric TBI affected best outcomes. Our severe population may support Tepas et al.'s (2009) findings in that our patients had the longest average lengths of time between enrollment and initiation of services. Most notably were both OT and PT at 3 and 3.5 days, respectively. Although we cannot attribute the timing and frequency of rehabilitation services to outcome, we did see some interesting trends. There was a decrease in mean GOS-E Peds of 0.29 between hospital discharge to the first follow-up visit, suggesting some neurofunctional improvement over time. The delay in initiation of OT and PT was likely due to endotracheal extubation occurring, on average, on Day 5 of hospitalization. Although we saw a decrease in the GOS-E Peds score, we did not see a change in the SPNFE score at discharge or at first follow-up visit. The SPNFE captures neurocognitive changes, and this lack of change may also suggest that in this population, with an isolated head injury, gross functional improvement occurs before neurocognitive recovery.

In our study, we saw the greatest improvement in the moderate TBI patients' mean GOS-E Peds and SPNFE scores from discharge to the first follow-up visit. There was a 0.84 decrease in the mean GOS-E Peds score and a 0.67 decrease in the mean SPNFE score. Initiation times were shorter for the moderate group versus the severe group. However, none of our moderate patients received PT or OT within the first 8 days of their hospitalization. Although we could not establish a causal link to timing or frequency of services and recovery, the lack of OT and PT services could be attributed to the patients' lack of motor delay. As with severe TBI, this group used similar services that likely aided in facilitating discharge.

Our largest group, children with mild TBI, saw no change in the GOS-E Peds and SPNFE scores at discharge and at the first follow-up visit. This could be attributed to their quick return to baseline, which is expected in mild TBI. They could also have benefitted by the early onset of rehabilitation evaluation and services. Although we cannot definitely link the timing and frequency of rehabilitation services to outcome, we did find that children admitted with mild TBI also use rehabilitation services. Because there is a tendency in acute TBI care to move patients with mild TBI through the hospital stay more quickly, there is little work describing which inpatient rehabilitation services support better outcomes.

Although there is a paucity in the literature, Wade and his team found that the goal behind patient throughput was most often attributed to limited needs postdischarge (Wade, Taylor, Drotar, Stancin, & Yeates, 1998). However, our data suggest that perhaps children with mild TBI have more needs than previously identified.

We found that the interdisciplinary rehabilitation team composition provided for the delivery of comprehensive care for the pediatric TBI patients. The teams addressed the patient's physical, emotional, psychological, and social needs in an effort to promote recovery and discharge home. We surmise that the timing and frequency of comprehensive rehabilitation services existed because of the study being conducted in a Level 1 pediatric trauma center with optimal services. The delivery of optimal rehabilitative care in this study also aligns with study findings that showed care provided by Level 1 trauma centers and treatment protocols were predictors of good outcomes (Hesdorffer & Ghajar, 2007).

Rehabilitation focuses on strategies to facilitate neurocognitive and functional recovery while managing comorbidities and minimizing complications. When the healthcare team begins discharge planning on the day of admission, it supports the goal of maximizing functional independence and reintegration into the child's family and community (Popernack et al., 2015). Early initiation of rehabilitation therapies has been shown to support this approach (Tepas et al., 2009). Our study provides information around the timing and frequency of rehabilitation services and supports the need for available comprehensive services for all children admitted to hospital with a TBI.

Recent guidelines on pediatric TBI assessments and management have attempted to establish best practices in pediatric acute TBI management (Kochanek et al., 2012). Vavilala et al. (2014) determined that strict adherence to the *2003 SCCM Guidelines for the Acute Medical Management of Severe Traumatic Brain Injury in Infants, Children, and Adolescents* was associated with significantly higher discharge survival and improved discharge GCS outcomes. They also demonstrated that, when clinical interventions were implemented, they were protective, regardless of treatment setting. In addition, it is known that children with severe TBI benefit from an interdisciplinary approach to the care (Adelson et al., 2003; Carney, Chestnut, & Kochanek, 2003; Vavilala et al., 2014).

In this study, the use of the acute management guidelines for TBI was standard of care for all patients admitted for TBI. There are very limited recommendations for rehabilitative strategies within the acute management TBI guidelines; however, Rivera and his team found that, for severe TBI, having a dedicated neurointensive care unit with specialists and rehabilitation services improved outcomes (Rivara, Ennis, Mangione-Smith, MacKenzie, & Jaffe, 2012). We believe the use of guidelines for acute TBI management is essential and that early initiation of comprehensive rehabilitation services and development of rehabilitation guidelines is imperative to promote outcomes.

Clinical Implications

This single-center study evaluated the timing and frequency of primary and secondary interdisciplinary rehabilitation teams' treatments to promote rehabilitation care of pediatric TBI patients. Our study yielded a neurocognitive-functional outcome in the moderate group

of patients that should warrant further attention. In this group, there seems to be a greater tendency toward improvement when treated by a comprehensive interdisciplinary team led by the nurse in a setting with ample resources. In addition, we found that mild TBI patients also provided rehabilitation services even though they had a shorter hospital course. Further investigation into interventions could actuate the foundations for guidelines to treat all severities of TBI in children that promote best outcomes.

Rehabilitation nurses are well positioned to lead the interdisciplinary team in the development of rehabilitation structures that define care teams and services for children with TBI. Rehabilitation nurses are integral in care coordination and global oversight of rehabilitative strategies for patients admitted with a TBI. Rehabilitation nurses are uniquely positioned to identify and advocate for best practice in rehabilitation. Those nurses who also have a particular expertise in pediatrics have exquisite understanding of developmental, neurocognitive, and functional abilities of children (Popernack et al., 2015). Their ability to recognize improvement over continued delay also empowers them to call upon the care team to reassess patient care needs. Their daily interaction with multiple rehabilitation team members also provides them with unique insights into the appropriate timing of daily therapies, communication gaps between teams and patients and families, rehabilitative services that may be needed but not present, and requirements for a successful discharge. The pediatric rehabilitation nurse is a key provider who can facilitate optimal care and, therefore, promote best outcomes.

Study Limitations

This descriptive study provided a single-center site landscape of rehabilitation in children with TBI. As expected, the limited sample size prevents statistical generalization. We appreciate that bias cannot be avoided in this single-center study with its own unique care attributes. Although this study did not assess the motivation behind the timing of the services, we were able to present data that provided some insight into the initiation and frequency of services provided to children who sustained a TBI. Although the study was limited to the first 8 days of hospitalization, we may have missed other rehabilitation services that were initiated after Hospital Day 9. We acknowledge that EHR data may include missing information; therefore, we used common data elements abstracted from the patient EHR to ensure consistency of the data collected. Although validated in severe TBI, the GOS-E Peds has not been reported as a measure of functional recovery in other TBI severity groups (Beers et al., 2012). It is not uncommon for pediatric speech pathologists to develop site-specific evaluation tools to measure neurocognitive recovery after TBI. However, we appreciate that it limits translation outside of our study. The attending team and standardized TBI care kept overall management variation to a minimum. In our patients with suspected nonaccidental trauma, especially in the mild TBI group, we attributed the prolonged LOS as a component of ongoing child protective medical evaluations. The extended LOS for evaluation is often needed to support additional resource allocation in abusive head injury patients (Peterson et al., 2014).

Conclusion

Crucial to a child's recovery after a TBI is the immediate stabilization and planned rehabilitation care by an interdisciplinary team of rehabilitation experts. Our results described the timing and frequency of rehabilitation services by such teams. Although direct linkages could not be made to improved outcomes as a result of these services, we could identify change in outcome over time. Literature supports the importance of rehabilitation services in their contribution to improving outcomes in children with moderate and severe TBI. However, children of all severities have varying rehabilitation needs and different outcomes. Future research is needed to better describe rehabilitation timing, frequency, and services provided for children with all severities of TBI and how their outcomes are impacted. This information could lead to the development of future rehabilitation guidelines that include all pediatric TBI severities and support improved long-term outcomes.

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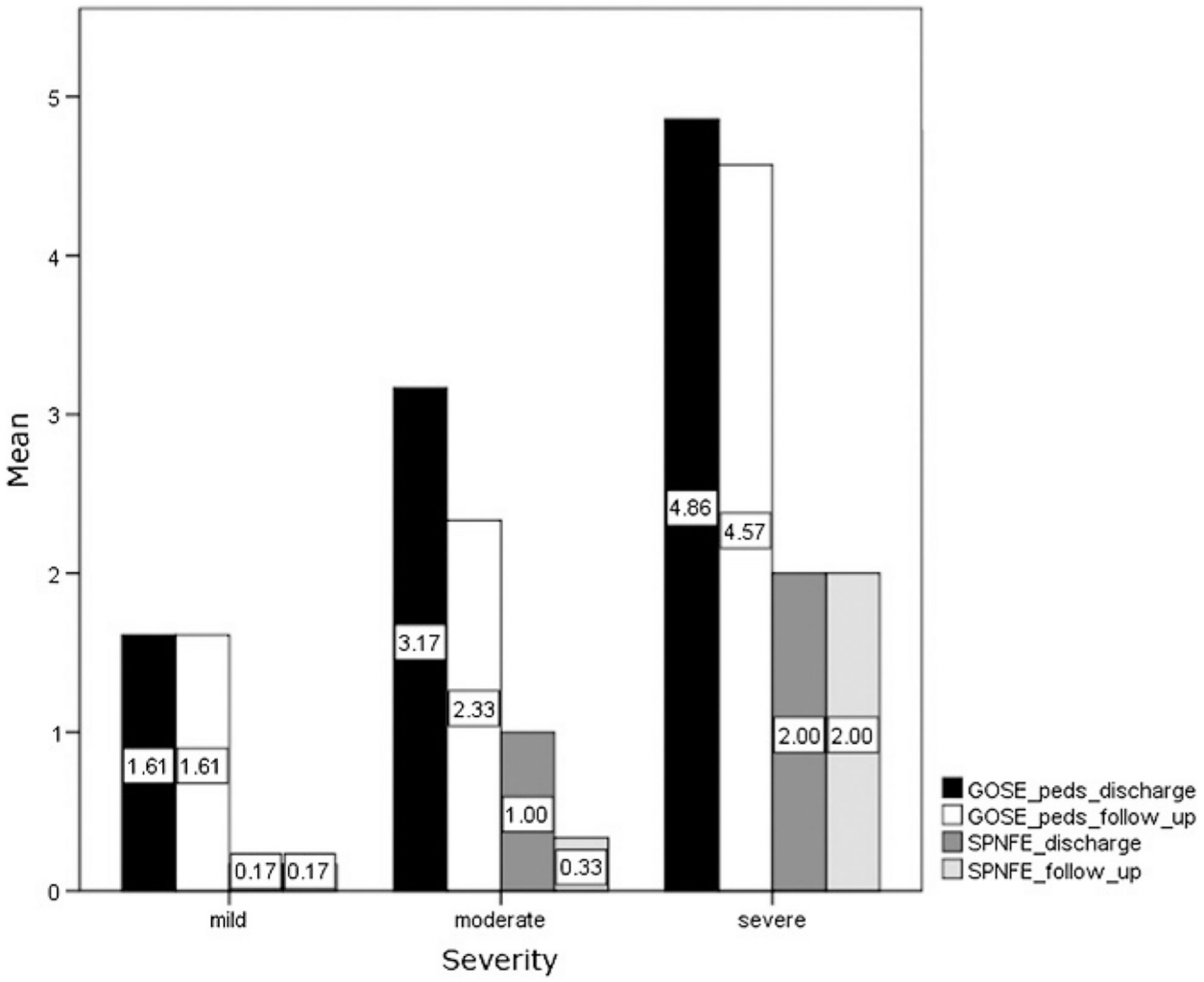

Figure 1.

Traumatic brain injury mean outcomes scores for the Glasgow Outcome Scale-Extended Pediatrics (GOS-E Peds) and Speech Pathology Neurocognitive-Functional Evaluation (SPNFE) at time of discharge and first follow-up visit.

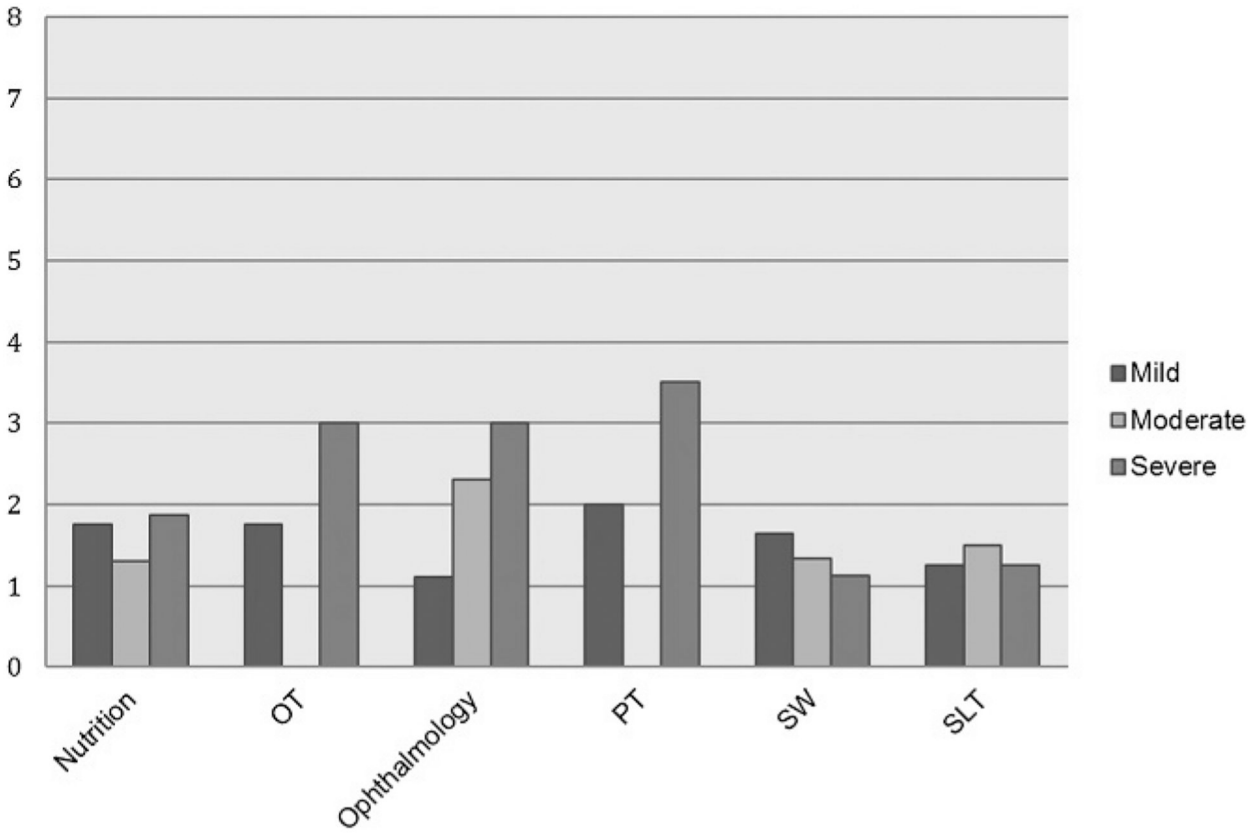

Figure 2.

Time of initiation of primary interdisciplinary team services (in days). Note: Patients may have received rehabilitation care, but not within the first 8 days of hospitalization. The patients with moderate traumatic brain did not receive occupational or physical therapy during their hospitalization.

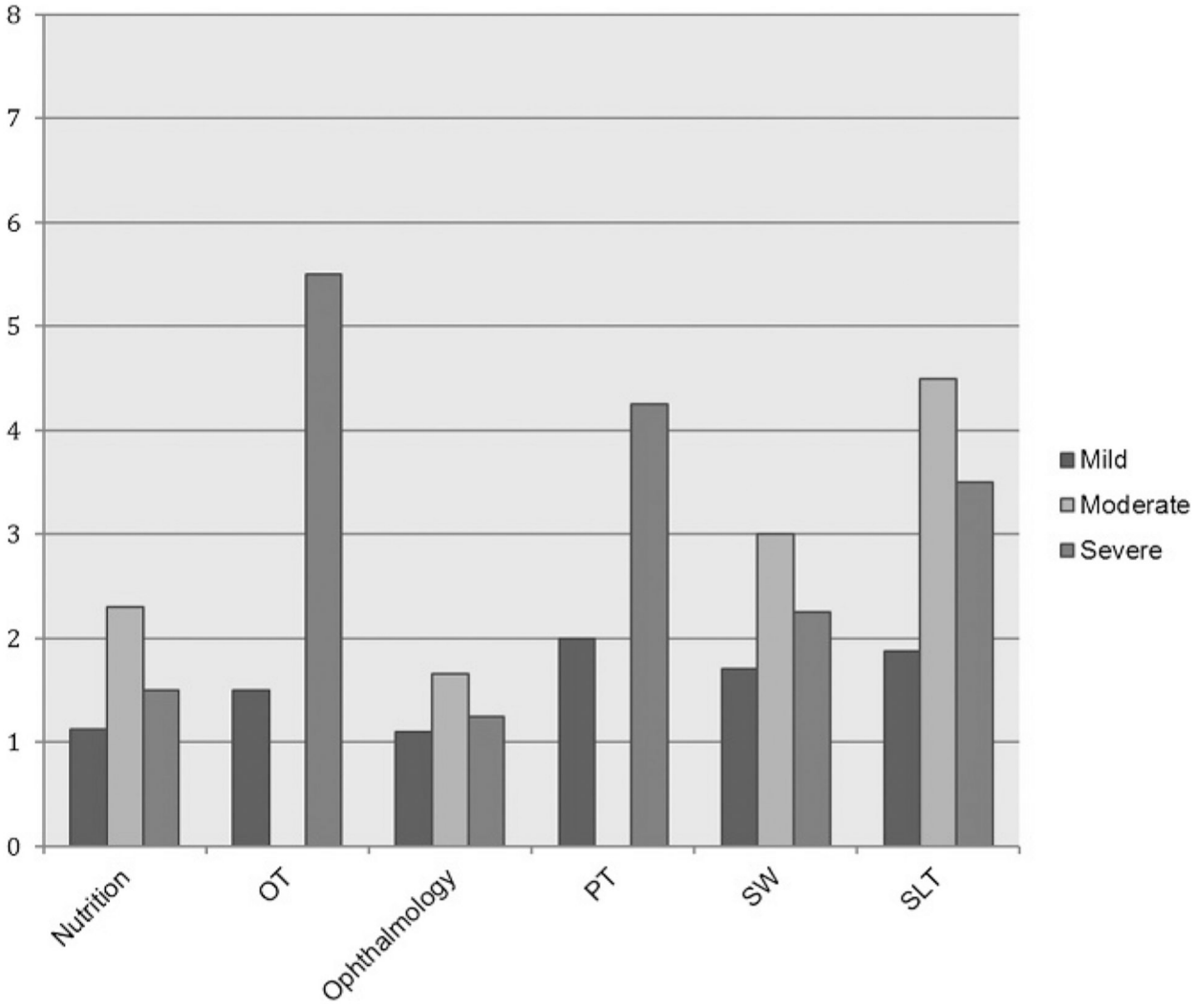

Figure 3.
Frequency of primary interdisciplinary team encounters within the first 8 days of hospitalization.

Table 1

Data collected from primary and secondary interdisciplinary team notes

Team	Data Collected From Note
Chaplain	• Inquiry about spiritual beliefs, values, practices • Life review, listening to patient's story • Meaning oriented—reflective listening
Child Life Specialist	• Education and strategies to assist with coping and normalizing hospitalization experience for patient and siblings • Playroom time or bedside activities engagement
Hematology	• Past medical history for bleeding and clotting disorders • Pertinent medication • Screening laboratory for bleeding and clotting disorders • Medication therapies and follow-up
Lactation Consultant	• Lactation interventions and support measures (if applicable)
Nutrition	• Anthropometrics • Food history and allergies • Current nutrition and diet orders • Biochemical data • Pertinent medications • Nutrition-focused physical findings • Estimated nutritional needs, including energy, protein, fluid • Weight gain
Occupational Therapy	• Fine motor skills • Pattern/manipulative skills • Neuromotor development • Visual tracking
Ophthalmology	• Past ocular history • Baseline eye exam • If optic dilation, include RetCam photographs • Slit lamp and fundus exam • Ancillary imaging studies
Orthopedic Surgery	• If applicable, follow-up imaging and results • Recommend for full skeletal survey and results • Muscle compartment checks
Otolaryngology	• Past auditory history • Identification issues for potential hearing loss • Medication therapies and follow-up
Physical Therapy	• Integumentary

Team	Data Collected From Note
	• Musculoskeletal physical findings
	• Neuromuscular status and integrity
	• Mobility (if applicable)
	• High-level motor skills
Speech-Language Therapy	• History as it related to include medical, developmental, school
	• Oral motor evaluation
	• Receptive language
	• Expressive language
	• Cognition
	• Motor speech/sound assessment
Social Work	• Psychosocial assessment and resources
	• Service consults (i.e., child protective team)
	• Pediatric intensive care unit or stepdown unit admission and ongoing hospitalization needs

Table 2

Sample characteristics

Characteristics		**Results, *N* = 35 (100%)**
Admission location, *n* (%)	Pediatric ICU	27 (77.1)
	Stepdown unit	8 (22.9)
Gender, *n* (%)	Male	22 (62.9)
	Female	13 (37.1)
Age in months, mean (*SD*)		60.31 (61.27)
Race	African American	12 (34.3)
	Caucasian	19 (54.3)
	Hispanic	3 (8.6)
	Multiracial	1 (2.8)
Injury severity, *n* (%)	Mild	25 (71.4)
	Moderate	3 (8.6)
	Severe	7 (20.0)
Mechanism, *n* (%)	Abusive head injury	13 (37.1)
	Fall	15 (42.8)
	Motor vehicle collision	1 (2.9)
	Other	6 (17.2)
Length of stay in days, mean (*SD*)		7.18 (6.54)