

Residual Cognitive Disability after Completion of Inpatient Rehabilitation among Injured Children

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Objective To determine the prevalence and nature of residual cognitive disability after inpatient rehabilitation for children aged 7-18 years with traumatic injuries.

Study design This retrospective cohort study included children aged 7-18 years in the Uniform Data System for Medical Rehabilitation who underwent inpatient rehabilitation for traumatic injuries in 523 facilities from 2002-2011. Traumatic injuries were identified by standardized Medicare Inpatient Rehabilitation Facility–Patient Assessment Instrument codes. Cognitive outcomes were measured by the Functional Independence Measure instrument. A validated, categorical staging system derived from responses to the items in the cognitive domain of the functional independence measure was used and consisted of clinically relevant levels of cognitive achievement from stage 1 (total cognitive disability) to stage 7 (completely independent cognitive function).

Results There were 13 798 injured children who completed inpatient rehabilitation during the 10-year period. On admission to inpatient rehabilitation, patients with traumatic brain injury (TBI) had more cognitive disability (median stage 2) than those with spinal cord injury or other injuries (median stage 5). Cognitive functioning improved for all patients, but children with TBI still tended to have significant residual cognitive disability (median stage on discharge, 4).

Conclusions Injured children gained cognitive functionality throughout inpatient rehabilitation. Those with TBI had more severe cognitive disability on admission and more residual disability on discharge. This is important not only for patient and family expectation setting but also for resource and service planning, as discharge from inpatient rehabilitation is a critical milestone for reintegration into society for children with serious injury. (*J Pediatr* 2014;164:130-5).

Although injury is the leading cause of pediatric death, fatalities in injured children are rare (occurring in 5% of moderate to severe injuries^{1,2}). Despite high survival rates, the overwhelming majority of seriously injured children suffer physical, cognitive, and quality of life impairments. These children often require inpatient rehabilitation to promote function and recovery. Although there are many outcomes that can be measured after serious injury, 2 important and commonly measured domains are physical and cognitive functionality.

We recently demonstrated that even though children aged 7-18 years with traumatic injuries uniformly had severe physical disability on admission to inpatient rehabilitation, those with traumatic brain injury (TBI) demonstrated significant improvement in physical functioning at the time of discharge.³ Other prior research has focused on cognitive disability following various injuries in children. One large meta-analysis of 28 studies from 1988-2007 summarized neurocognitive outcomes for children after TBI and found that children with moderate TBI (defined as an initial Glasgow Coma Scale score of 9-12) and severe TBI (Glasgow Coma Scale score of 3-8) had more intellectual, executive functioning, and memory deficits compared with patients with mild TBI.⁴ There was a dose-response whereby the symptoms of patients with mild TBI resolved over time, and the most severely injured patients had persistent neurocognitive disability >24 months after injury. This study filled an important gap in the literature by quantifying the course of recovery and the prevalence of persistent long-term deficits among children with TBI. To date, however, there are no reports of more acute cognitive outcomes in a large, contemporary cohort of injured pediatric patients at the time of discharge from inpatient rehabilitation. Although it is useful to follow injured patients serially to determine their long-term outcomes, it is important to systematically

FIM	Functional Independence Measure
IRF-PAI	Inpatient Rehabilitation Facilities–Patient Assessment Instrument
LOS	Length of stay
SCI	Spinal cord injury
TBI	Traumatic brain injury
UDSMR	Uniform Data System for Medical Rehabilitation

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capture the functionality of patients on discharge from inpatient rehabilitation, as this is a critical stage for their recovery and reintegration into society.⁵ The goal of this current study was to determine the prevalence and nature of cognitive disability among severely injured children and adolescents requiring inpatient rehabilitation using a practical and clinically relevant staging system. We also wanted to examine the distribution of cognitive disability by clinically relevant groups of injuries. These findings would have implications not only for patient and family expectation setting during active rehabilitation but also for postrehabilitation planning for ongoing assistance and care.

Methods

This retrospective cohort study identified patients in the Uniform Data System for Medical Rehabilitation (UDSMR), with data from >829 rehabilitation centers, representing approximately 72% of the 1152 Centers for Medicare & Medicaid Services–designated inpatient rehabilitation facilities in the US.⁶ Evaluation of each inpatient in the database is completed using the Inpatient Rehabilitation Facilities–Patient Assessment Instrument (IRF-PAI)⁷ developed by the Centers for Medicare & Medicaid Services. The IRF-PAI includes demographic information (age, sex, race/ethnicity), hospitalization and diagnostic information (length of stay [LOS], payer, impairment codes, clinical diagnoses from *International Classification of Diseases, Ninth Revision* E codes), and functional status measured using the Functional Independence Measure (FIM) instrument. All UDSMR patients aged 7-18 years from 2002-2011 who completed rehabilitation immediately following an injury-related acute care hospitalization were included in the analysis.

Exposures

Individual injuries for each patient were identified using the 20 trauma-related IRF-PAI impairment codes assigned on admission to the rehabilitation center according to the injury or injuries for which each patient primarily required rehabilitation.⁷ The 20 codes were then grouped into the following 11 categories: TBI, TBI and multiple fracture/amputation, TBI and spinal cord injury (SCI), quadriplegia (complete), quadriplegia (incomplete or unspecified), paraplegia (complete), paraplegia (incomplete or unspecified), other SCI, SCI and multiple fracture/amputation, burns, and other multitrauma. Further consolidation into 4 broader categories was also used: any TBI, quadriplegia, paraplegia, or other (which included combinations of TBI and SCI, TBI and multiple fracture/amputation, SCI and multiple fracture/amputation, burns, or other multitrauma). These 4 categories were created to characterize the outcomes of children with clinically meaningful subgroups of disabling injuries from multitrauma, as defined by the center-assigned IRF-PAI impairment codes, and were retained after finding differences between these groups in our study of physical functionality.³

Outcomes

Functional status of patients was assessed using the FIM instrument,^{8,9} a valid and reliable measure of functionality,^{10,11} which has previously been used to evaluate trauma-related disability at short- and long-term intervals in children.¹²⁻¹⁴ The UDSMR database includes consistent FIM measurements documented by trained personnel on admission to and at discharge from the rehabilitation hospital. The FIM instrument is composed of 13 motor and 5 cognitive items, consisting of comprehension, expression, social interaction, problem solving, and memory. Each item can be scored from 1 to 7, with an absolute total FIM score of 18-126. Higher scores are associated with higher levels of functioning.

The primary outcome of this analysis was discharge cognitive functioning, based on a compilation of the variation in functioning across the 5 cognitive FIM items. Summary cognitive FIM scores have been categorized into a clinically relevant and previously validated staging system, consisting of 7 stages ranging from stage 1 (total cognitive disability) to stage 7 (complete cognitive independence).^{15,16} Each stage summarizes the variation in functioning across the 5 domains assessed into a clinically relevant set of thresholds for overall cognitive activity that the child must meet or exceed. Detailed definitions of each stage have previously been published.¹⁶ As an example, patients with stage 1 (total assistance) can provide only 25% of the effort necessary to communicate and express needs; those with stage 4 can communicate and express most needs but may still need prompting for problem solving and memory up to 50% of the time; and those with stage 7 (complete independence) can provide 100% of required communication and expression without aid or assistance.

Statistical Analyses

Standard descriptive statistics were used to summarize demographic variables, injury characteristics, and outcomes. Derived variables included the mean Δ stage (ie, the individual patient's average change in cognitive functioning stage from admission to discharge). ANOVA and χ^2 tests were used to examine demographic differences across the major injury subgroups. A paired *t*-test was used to compare these mean Δ stages within each injury impairment code. The differences in median LOS values in days across the impairment codes, and over time, were examined by using the Kruskal-Wallis test.

Results

From 2002 to 2011, there were 13 798 patients aged 7-18 years who completed trauma-related inpatient rehabilitation at the 523 facilities that cared for children. **Table I** shows the sample demographics across the 4 major injury subgroups. Statistically significant differences were seen for all demographics among subgroup, most notably that SCI patients were more likely to be male and older.

The **Figure** shows the distribution of admission and discharge stages for 4 subgroups: TBI, quadriplegia,

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