

Functional Outcomes in Children with Abusive Head Trauma Receiving Inpatient Rehabilitation Compared with Children with Nonabusive Head Trauma

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Objective To compare clinical features and functional outcomes of age- and sex-matched children with abusive and nonabusive head trauma receiving inpatient rehabilitation.

Study design Children with abusive head trauma (n = 28) and age- and sex-matched children with nonabusive head trauma (n = 20) admitted to an inpatient pediatric rehabilitation unit from 1995-2012 were studied. Acute hospitalization and inpatient rehabilitation records were retrospectively reviewed for pertinent clinical data: initial Glasgow Coma Scale score, signs of increased intracranial pressure, neuroimaging findings, and presence of associated injuries. Functional status at admission to and discharge from inpatient rehabilitation was assessed using the Functional Independence Measure for Children. Outcome at discharge and outpatient follow-up were described based on attainment of independent ambulation and expressive language.

Results Children with abusive and nonabusive head trauma had similar levels of injury severity, although associated injuries were greater in those with abusive head trauma. Functional impairment upon admission to inpatient rehabilitation was comparable, and functional gains during inpatient rehabilitation were similar between groups. More children with nonabusive than with abusive head trauma attained independent ambulation and expressive language after discharge from rehabilitation; the difference was no longer significant when only children aged >12 months at injury were examined. There was variability in delay to obtain these skills and in the quality of gained skills in both groups.

Conclusions Despite more associated injuries, children with abusive head trauma make significant functional gains during inpatient rehabilitation, comparable with an age- and sex-matched sample with nonabusive head trauma. Key functional skills may be gained by children in both groups following discharge from inpatient rehabilitation. (*J Pediatr* 2014;164:613-9).

Abusive head trauma is a common cause of pediatric traumatic brain injury (TBI).¹ Compared with children with nonabusive head trauma, mortality and morbidity are consistently greater in children with abusive head trauma.²⁻⁴ Younger age at injury,^{5,6} more severe initial injuries,^{2,7-9} and higher rates of secondary injuries from hypoxia and/or ischemia^{2,8,10} may contribute to the worse outcomes observed after abusive head trauma.

For survivors of abusive head trauma, the neurodevelopmental outcome is often considered to be globally poor, though closer examination reveals a range of outcomes, especially in functional skills. Barlow et al examined a number of outcome variables at follow-up (mean 59 months postinjury) in 25 children with abusive head trauma. Although 68% of the children had neurologic or cognitive abnormality at follow-up, 60% of children were reported to have normal functional mobility, and 64% had normal to mildly impaired speech and language function.¹¹ On standardized testing evaluating neurocognitive development and adaptive behavior, Keenan et al demonstrated worse outcomes in children with abusive head trauma, who also accounted for a larger percentage of the reported clinical disabilities including speech delay or need for assistive mobility devices.⁴ Even though global outcome ratings are useful for broadly categorizing outcomes, they may not provide a clear picture of an individual's functional skills. In discussions of prognosis after abusive head trauma, caregivers often ask questions about expectations for development of discrete skills that can improve quality of life, such as independent ambulation (IA) and expressive language (EL).

DFQ	Developmental Functional Quotient
EL	Expressive language
GCS	Glasgow Coma Scale
IA	Independent ambulation
ICP	Intracranial pressure
LOS	Length of stay in a rehabilitation facility
TBI	Traumatic brain injury
TTA	Time from injury to admission to inpatient rehabilitation (time of acute hospitalization)
WeeFIM	Functional Independence Measure for children

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Funded by the Eunice Kennedy Shriver National Institute of Child Health and Development (K23HD061611 and T32HD007414-20). The authors declare no conflicts of interest.

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The need for inpatient rehabilitation is a marker for severity of injury, as it signifies the presence of substantial functional deficits at the end of the acute hospitalization. Interestingly, reports of the outcome of children with abusive head trauma admitted to inpatient rehabilitation are not available, though this is theoretically a group at high risk for poor outcomes. The purposes of this study were to compare clinical features of children with abusive head trauma admitted to an inpatient rehabilitation unit to age- and sex-matched children with nonabusive head trauma, to evaluate and compare functional changes during inpatient rehabilitation in children with abusive head trauma and nonabusive head trauma, and to evaluate and compare attainment of key skills (IA and EL) by children with abusive and nonabusive head trauma at discharge from inpatient rehabilitation and subsequent follow-up.

Methods

This is a retrospective review of children with or without abusive head trauma receiving acute inpatient rehabilitation for brain injury at a single academically affiliated rehabilitation hospital from 1995-2012. The practice at this hospital is to admit children with even the lowest levels of function after acquired brain injury for the purpose of addressing goals such as caregiver training, tolerance to positioning, and management of irritability while observing for improvements in the child's functional status. Children who had received inpatient rehabilitation at another facility prior to admission to this facility were not included. The Johns Hopkins Institutional Review Board granted approval for examination of data extracted from a clinical performance database and from review of medical records.

Abusive Head Trauma

Thirty-three patients with abusive head trauma were identified based on the *International Classification of Diseases, Ninth Revision* code 995 at the time of admission to inpatient rehabilitation. On record review, 28 of those patients had a diagnosis of abusive head trauma documented in acute care medical records (age range 2-51 months) and were included in analyses. A multidisciplinary child abuse team or maltreatment expert at a tertiary referral academic medical center confirmed the diagnosis of abusive head trauma in 19 children. For an additional 5 patients, the episode of abuse was either witnessed (2), the perpetrator confessed (2), or an arrest was made (1). The remaining 4 cases had a documented diagnosis of abusive head trauma, but the available medical records did not provide additional detail regarding how the diagnosis was reached.

Nonabusive Head Trauma

Age-matched patients with nonabusive TBI were identified by *International Classification of Diseases, Ninth Revision* code 854. Matches were chosen from admissions at any time from 1995-2012 based on closest matching age of injury

within 3 months. We additionally prioritized matches of the same sex and without weight-bearing restrictions from orthopedic injuries. Age-matched controls were available for 20 of the 28 patients with abusive head trauma (age range 2-53 months); there were no matches available for 7 of the 11 children with abusive head trauma at ≤ 9 months of age at injury. Of the 20 matched controls, 2 children had documented formal consultation by experts in abuse and maltreatment, who concluded that each injury was accidental. Three matches were of the opposite sex. One matched control had coexisting fractures but was cleared for full weight bearing 9 days after admission to rehabilitation (27 days prior to discharge). One potential match was excluded due to symptomatic late pseudoaneurysms thought to be unrelated to the injury. Mechanism of TBI among the matched controls was variable: 11 patients were involved in a motor vehicle accidents, and 7 of these patients were documented as properly restrained. Three children had a television fall on their head, and 1 was accidentally struck in the head with a horseshoe. Two children were struck by cars. The remaining 3 patients were involved in falls: one fall from a bed, another fall down concrete stairs, and a third fall from an approximately 12-foot-high window.

Glasgow Coma Scale (GCS) was defined as the first documented GCS score.¹² GCS was available for 19 of 28 patients with abusive head trauma and 18 of 20 patients with nonabusive head trauma.

Significantly increased intracranial pressure (ICP) was defined as direct documentation of elevated ICP in those undergoing ICP monitoring, requirement for neurosurgical interventions to relieve increased ICP (craniotomy or craniectomy), or neuroimaging reports of cerebral herniation or extensive cerebral edema with midline shift. Placement of an ICP monitoring device alone was recorded but not included in this variable unless there was clear documentation of increased ICP.

Neuroimaging findings were recorded from head computed tomography or brain magnetic resonance imaging reports or, if neuroimaging reports were unavailable (ie, for patients transferred from another institution), from documentation of results by a medical provider within admission or discharge records. All patients had head computed tomography results available, and brain magnetic resonance imaging reports were available for 18 children with abusive head trauma and 11 children with nonabusive head trauma. Presence was noted of subdural hematoma, epidural hematoma, subarachnoid hemorrhage, and intraparenchymal hemorrhage; the latter 3 were grouped as "other brain hemorrhage." Presence of skull fracture was also noted.

The following were considered risk factors for neurologic sequelae, which might affect the child's outcome: acute cerebral infarction/ischemia as documented in neuroimaging reports or clinical records, cardiac arrest or apnea requiring intervention, and documentation of status epilepticus during the acute hospitalization.

Retinal hemorrhage was evaluated by physician documentation of the presence or absence of unilateral or bilateral

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