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Functional outcomes in children with abusive head trauma receiving inpatient rehabilitation compared with children with non-abusive head trauma

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Abstract

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

Study design—Children with abusive head trauma (n = 28) and age, sex matched children with non-abusive head trauma (n = 20) admitted to one inpatient pediatric rehabilitation unit from 1995–2012 were studied. Acute hospitalization and inpatient rehabilitation records were retrospectively reviewed for pertinent clinical data: initial GCS 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 (WeeFIM). Outcome at discharge and outpatient follow-up was described based on attainment of independent ambulation and expressive language.

Results—Children with abusive and non-abusive head trauma had similar levels of injury severity although associated injuries were greater in 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 non-abusive than abusive head trauma attained independent ambulation and expressive language after discharge from rehabilitation; the difference was no longer significant when only children greater than 12 months of age at injury were examined. There was variability in delay to obtain these skills and quality of gained skills in both groups.

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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 non-abusive head trauma. Key functional skills may be gained by children in both groups following discharge from inpatient rehabilitation.

Abusive head trauma is a common cause of pediatric traumatic brain injury (TBI).[1] Compared with children with non-abusive 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 post-injury) in 25 children with abusive head trauma. Although 68% of the children had neurological 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 and expressive language.

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 non-abusive head trauma, to evaluate and compare functional changes during inpatient rehabilitation in children with abusive head trauma and non-abusive head trauma, and to evaluate and compare attainment of key skills (independent ambulation and expressive language) by children with abusive and non-abusive 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 ICD-9 code 995 at the time of admission to inpatient rehabilitation. Upon record review, 28 of those patients

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had a diagnosis of abusive head trauma documented in acute care medical records (age range 2 to 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 five patients the episode of abuse was either witnessed (2), the perpetrator confessed (2), or an arrest was made (1). The remaining four cases had a documented diagnosis of abusive head trauma, but the available medical records did not provide additional detail regarding how the diagnosis was made.

Non-abusive head trauma

Age matched patients with non-abusive TBI were identified by ICD-9 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 ≤ 9 months of age at injury. Of the 20 matched controls, two children had documented formal consultation by experts in abuse / maltreatment which concluded each injury was accidental in nature. 3 matches were of the opposite sex. One matched control had co-existing 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 pseudoaneuryms felt to be unrelated to the injury. Mechanism of TBI among the matched controls was variable: 11 patients were involved in motor vehicle accidents; 7 of these patients were documented as properly restrained. 3 children had televisions fall on their head, and 1 was accidentally struck in the head with a horseshoe. 2 children were struck by cars. The remaining 3 patients were involved in falls: one from a bed, another down concrete stairs, and one from an approximately 12 foot high window.

Glasgow Coma Scale (GCS) was defined as the first documented GCS score.[12] GCS was available for 19/28 patients with abusive head trauma and 18/20 patients with non-abusive 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 (CT) or brain magnetic resonance imaging (MRI) reports, or, if neuroimaging reports were unavailable (i.e. for patients transferred from another institution), from documentation of results by a medical provider within admission or discharge records. All patients had head CT results available, and brain MRI reports were available for 18 children with abusive head trauma and 11 children with non-abusive head trauma. Presence was noted of subdural hematoma (SDH), epidural hematoma, subarachnoid hemorrhage, and intraparenchymal hemorrhage; the latter three were grouped as “other brain hemorrhage.” Presence of skull fracture was also noted.

The following were considered risk factors for neurological 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 (RH) was evaluated by physician documentation of the presence or absence of unilateral or bilateral findings. Twenty-five of 28 children with abusive head trauma had ophthalmological reports. Of those with non-abusive head trauma, 8 children had documented ophthalmological evaluations, 5 in order to assess trauma related conditions such as orbital roof fractures.

Time to rehabilitation admission (TTA) was calculated as the number of days from acute care admission to admission to inpatient rehabilitation.

Rehabilitation length of stay (LOS) was defined as the number of days from inpatient rehabilitation admission to discharge.

Functional Independence Measure for Children (WeeFIM) is an 18-item, performance based instrument measuring functional skills in self-care, transportation/locomotion, and communication/social domains. The WeeFIM provides an objective measure of a child's functional abilities, grading performance on specific tasks on an ordinal scale of 1–7 reflecting increasing level of independence / reduced need for assistance. Full independence on all measures within the scale is expected by 7 years of age. Because the degree of independence on tasks is expected to depend on developmental age, WeeFIM scores are converted to a developmental functional quotient (DFQ). WeeFIM DFQs describe a child's functional skills as a percentage of those expected by age, based on a normative sample of WeeFIM scores.[13–15] WeeFIM DFQs for self-care, mobility, cognition, and total function were collected as part of clinical care at admission to and discharge from rehabilitation. Given the limited WeeFIM skills evaluated during infancy, WeeFIM data were used only from children who were at least 1 year of age at the time of admission, yielding WeeFIM data for 17/28 patients with abusive head trauma and 16/20 patients with non-abusive head trauma.

Independent ambulation (IA) and expressive language (EL) were chosen as important qualitative functional outcomes. IA was defined as documentation of ambulation in daily living without assistance from another person. EL was defined as use of spoken words for communication. Documentation of IA and EL was available for all patients at discharge; however, at discharge, 11 patients in the abusive head trauma group and 4 patients in the non-abusive head trauma group were younger than one year of age and thus not expected to have attained either of these milestones. Therefore, data on IA and EL at discharge were available for 17/28 patients with abusive head trauma and 16/20 patients with non-abusive head trauma.

All available medical records were evaluated to determine first documentation of attainment of IA and EL after discharge from inpatient rehabilitation. Three patients with abusive head trauma and 1 with non-abusive head trauma did not have follow-up documentation available and are excluded from IA and EL outcomes analyses (abusive head trauma N = 25, non-abusive head trauma N = 19). Additionally, the most recent clinical evaluations available were reviewed in order to provide a broader, qualitative description of outcomes.

Statistical Analyses

SPSS 21 was used for all statistical analyses; α was set at $p \leq .05$. Independent samples t-tests were used to analyze continuous demographic data. 2×2 Repeated Measures Analyses of Variance (ANOVAs) were used to examine differences in WeeFIM total and domain DFQ scores at admission and discharge and between the abusive and non-abusive head trauma groups as well as the interaction between time (admission and discharge) and group. As there was no difference in analyses involving DFQs with and without inclusion of the non-abusive head trauma control with weight bearing restrictions at admission to rehabilitation, this subject was included in final analyses documented. We analyzed group differences in attainment of key functional skills at discharge and follow up using Chi Square analyses and Fisher Exact Test where appropriate. Given prior reports of worse outcomes in younger children, the unequal between-group distribution of infants in our sample, and to provide consistency with the cohort examined via WeeFIM scores, we repeated the analyses regarding attainment of key functional skills including only children ≥ 12 months at the time of injury (abusive head trauma: 15/28; non-abusive head trauma: 16/20). The relationships among demographic, injury-related factors, and functional outcomes were further examined using Independent Samples t-tests, Chi Square analyses and Fisher Exact Test.

Results

Table I summarizes the demographic and clinical data in the abusive and non-abusive head trauma groups. There was no significant difference in age at the time of injury, despite 7 of 11 children with abusive head trauma ≤ 9 months of age at injury having no available match. 8 patients with abusive head trauma had ICP monitoring devices placed without documentation of elevated ICPs or further neurosurgical intervention, and 8 additional children with abusive head trauma had clear evidence of elevated intracranial pressures. Of children with non-abusive head trauma, 4 children had placement of an ICP monitoring device without documentation of elevated ICP, and an additional 8 patients had neurosurgical procedures or documented increased ICP.

Associated injuries with neurological impact occurred more frequently in those with abusive head trauma (68%) compared with non-abusive head trauma (15%) ($p < 0.001$). Specifically, associated injuries occurred in 19 patients with abusive head trauma: cerebral infarction/ischemia (n=9), cardiorespiratory arrest (n=6), and status epilepticus (n=9). Three patients with non-abusive head trauma had associated injuries: cerebral infarction/ischemia (n=1), cardiorespiratory arrest (n=1), and status epilepticus (n=1). Average TTA and LOS were similar between groups although the median LOS was longer for the abusive head trauma group (40 days) compared with the non-abusive head trauma group (23 days).

WeeFIM at admission and discharge

Repeated measures ANOVAs revealed that total and domain DFQ scores were significantly different from admission to discharge ($p < .001$). There were no significant differences between the abusive and non-abusive head trauma groups at admission or discharge. Additionally, there was no significant interaction between group and time. Follow up paired t-tests revealed that both groups showed significant improvement from admission to discharge on almost all WeeFIM scores. WeeFIM data are presented in Table II.

A case example of the mobility gains made during inpatient rehabilitation in a 33 month old patient with abusive head trauma provides a clinical description of function represented by WeeFIM DFQs. At the time of admission, the child was dependent in all mobility tasks, with functional skills equivalent to a 5 month old (Mobility DFQ = 16, based on WeeFIM scaled normative scores[15]). After 2.6 months of inpatient rehabilitation, this patient walked with minimal assistance and completed 75% of the work for transferring to a chair. Functional skills on WeeFIM mobility tasks at discharge were equivalent to a 14 month old (Mobility DFQ = 43, [15]).

Descriptors of function (IA and EL)

Table III depicts the number of children who attained IA and EL at the time of discharge from inpatient rehabilitation and at follow-up evaluation. Consistent with WeeFIM analyses, a similar percentage of children >12 months with abusive and nonabusive head trauma attained IA (59% vs 75%) and EL (59% vs 69%) by discharge from inpatient rehabilitation. Tables IV and V (available at www.jpeds.com) provide details on each patient including age at attainment of IA and EL and a description of function at the last available documentation (which ranged from the time of discharge to 16 years after discharge).

Overall, 64% of children with abusive head trauma gained IA, and a significantly higher percentage of children with nonabusive head trauma attained IA (95%) ($P = .03$). Ambulatory skills ranged from independent steps for in-home mobility to hemiplegic gait to age-appropriate community mobility and advanced gross motor skills. The median age of children who gained IA after discharge from rehabilitation was similar between groups (abusive head trauma HT: median age 26 months, range 14 – 30 months; non-abusive head trauma: median age 26 months, range 14 – 38 months). Additionally, IA was acquired, on average, 14 months after discharge (range 2–19 months) in children with abusive head trauma and 9 months (range 1–25 months) after discharge in the non-abusive head trauma cohort.

Expressive language skills ranged from single words used for basic communication to complete, fully articulated sentences and conversations. Although a higher percentage of children with non-abusive head trauma also attained EL (95%) compared with abusive head trauma (72%), this difference was not statistically significant ($p = .11$). EL was gained within a similar age range in both groups (abusive head trauma: median age 32.5 months, range 14 – 38 months; non-abusive head trauma: median age 26 months, range 14–48 months); Additionally, patients with abusive head trauma attained EL an average of 16 months after discharge from rehabilitation (range 7–31 months) compared with 7.4 months (range 1–25 months) in children with non-abusive head trauma.

To evaluate the relationship between age at the time of injury and functional outcomes, group differences were examined in the subset of children ≥ 12 months at the time of injury and, there was no longer a significant between group difference in attainment of IA ($p = .17$) or EL ($p = .60$). Furthermore, examining overall functional outcomes independent of mechanism of injury, children who attained IA and EL were older at injury than those who did not ($p = .045$ and $p = .08$ respectively). Children who experienced associated injuries were less likely to achieve IA ($p=.027$) than those who did not have secondary neurological insults. No other demographic or injury related factors were related to follow-up outcome of IA or EL.

Discussion

Children with abusive and non-abusive head trauma were similar with respect functional impairment at admission to inpatient rehabilitation and gains made during inpatient rehabilitation. This highlights the potential for children with abusive head trauma to make short-term functional gains and benefit from inpatient rehabilitation.

The use of age and sex matched populations of children with abusive and non-abusive head trauma is important, as younger age at injury has been associated with worse neurodevelopmental outcome,[5, 6] and sex may modify response to ischemic insults or brain injury.[16, 17] Although the groups were age matched overall, there were more children ≤ 9 months old at injury within the abusive head trauma group, consistent with the higher rate of abusive head trauma in infants. [18] The average age of children with abusive head trauma in our sample was 20 months which is older than many prior reports.[18, 19] This may reflect our inclusion of children through 5 years of age and a bias towards fewer but more impaired infants in our inpatient rehabilitation sample, as infants with sufficient feedings skills are commonly discharged from acute care to a home setting.

GCS and signs of increased ICP were similar between groups, reflecting similar injury acuity. Neuroimaging and RH findings are consistent with current understanding of abusive head trauma and suggest that our patients were appropriately categorized.[20] Associated injuries with neurological impact were significantly more common in children with abusive head trauma; ischemia/infarction and status epilepticus were both 6 times more common in abusive head trauma, and cardiorespiratory arrest/apnea was 4 times more common in abusive head trauma. This is consistent with prior reports of ischemia / infarctions[8, 10, 21], cardiorespiratory arrest / apnea [2, 22, 23], and post-traumatic seizures [6, 24] occurring more frequently in abusive head trauma. Similar to prior reports correlating severity of injury with disability in children with TBI,[2, 4, 19] the presence of associated injuries was associated with worse outcome in our sample. Distinguishing the independent contribution from mechanism and severity of injury on outcomes is difficult given the overlap in abusive head trauma and associated injuries. However, in our sample, there was no difference in TTA, indicating that duration of acute hospitalization was similar despite the increased associated injuries in children with abusive head trauma. Although not statistically significant, the longer LOS in rehabilitation for the children with abusive head trauma may reflect social factors associated with abusive head trauma which can complicate discharge planning or may reflect that children with abusive head trauma need additional time to gain a similar degree of skills.

Even though we were unable to examine quantitative functional gains during inpatient rehabilitation in children ≤ 12 months due to the lack of reliable standardized functional assessment tools for this population, we were able to assess the rate of achievement of IA and EL in children injured at all ages. More than 50% of children with abusive and non-abusive head trauma achieved these skills at the time of discharge from inpatient rehabilitation; as children admitted to inpatient rehabilitation typically do not have IA, this again highlights the opportunity for meaningful short-term functional gains from inpatient rehabilitation in children with brain injury.

Almost all children with non-abusive head trauma attained IA and EL after discharge from inpatient rehabilitation, whereas two thirds of children in the abusive head trauma group eventually gained IA and nearly three fourths gained EL within 31 months from rehabilitation discharge. The discrepancy in functional outcomes between children with abusive and non-abusive head trauma has been previously reported in a younger cohort of children.[2, 4, 8] Although the ability to ambulate and communicate have important implications for a child and family\s daily function, the quality of these skills was variable in this cohort. It is also important to note that children in both groups achieved IA and EL well beyond the developmentally expected age range and often more than 12 months from the time of discharge. This is consistent with prior reports of children attaining functional skills over several years following traumatic brain injury.[25]

When our analysis of IA and EL was limited to children at least 12 months of age at injury, there was no longer a significant difference in between-group outcome at follow-up. This is consistent with prior studies identifying worse outcomes in younger children with TBI[5, 6] though other studies have failed to find differences in outcome based on age. [25–27] This finding may also reflect the bias of our sample toward the most impaired infants. Larger studies with a matched sample of the youngest children would be useful for assessing differences in outcomes for infants with TBI.

Additional limitations of this study include small sample size with documentation ranging over a 17 year time period from multiple providers though drawn from a single rehabilitation unit; even though this was necessary to achieve even the relatively small sample size presented, it is possible that variations in care during that time period could have influenced outcomes. As admission practices vary among rehabilitation institutes, our cohort may differ from those admitted for inpatient rehabilitation elsewhere. Although WeeFIM data represent quantitative data acquired prospective as part of clinical care, the other data obtained through chart review are based on documentation which was occasionally incomplete. For instance, we were unable to evaluate long-term outcomes in cognition and behavior due to inconsistent documentation of these skills in the available records. We were also unable to gather complete data on family and socioeconomic factors that have also been shown to influence outcome after traumatic brain injury in children.[4, 28] Future studies designed to prospectively collect outcome data in a standardized fashion across multiple centers would be useful for better understanding the range of outcomes after abusive head trauma. Combining such outcome data with updated acute evaluations, such as biological markers and advanced neuroimaging techniques, will be useful for improving prognostication shortly after injury.

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List of abbreviations

GCS	Glasgow Coma Scale
WeeFIM	Functional Independence Measure for children
TBI	Traumatic brain injury
ICP	Intracranial pressure
SDH	Subdural hematoma
RH	Retinal hemorrhage
TTA	Time to rehabilitation admission
LOS	Length of stay
DFQ	Developmental functional quotient
IA	Independent ambulation
EL	Expressive language

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Table 1

Patient Characteristics

		AHT	n-AHT	p-value
		N=28**	N=20**	
Age	**Mean months (range)**	20 (2–51)	25 (2–53)	**.269**
Sex	**Female***	17 (61%)	12 (60%)	**1.0**
Markers of Injury Severity	**GCS 9–12***	2/19 (11%)	3/18 (17%)	**.426**
	GCS ≤ 8*	17/19 (89%)	15/18 (83%)	
	Increased ICP*	15 (54%)	10 (50%)	**1.0**
Neuroimaging	**SDH***	24 (86%)	8 (40%)	**.002**
	Other bleed*	8 (29%)	18 (90%)	**.001**
	Skull fracture*	9 (32%)	16 (80%)	**.001**
Associated Injury	**Positive RH***	24/25 (96%)	0/8	
	Neurological Injury*	19 (68%)	3 (15%)	**.001**
TTA	**Mean days (range)**	18 (5–49)	16 (6–47)	**.516**
Rehabilitation LOS	**Mean days (range)**	44 (7–113)	33 (5–97)	**.165**

*Number of subjects (%)

**N for all measures unless otherwise indicated in the denominator

GCS, Glasgow Coma Scale score; *ICP*, intracranial pressure; *SDH*, subdural hematoma; *DAI*, diffuse axonal injury; *RH*, retinal hemorrhage; *TTA*, time from injury to admission to inpatient rehabilitation (time of acute hospitalization); *LOS*, length of stay in inpatient rehabilitation facility

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Table 2

Change in Mean WeeFIM ® DFQs from Admission to Discharge Within and Between Groups*

	AHT N=17			n-AHT N=16			Difference between groups over time
	Admission ** **DFQ**	**Discharge** *** **DFQ**	**p-value**	**Admission** ** **DFQ**	**Discharge** *** **DFQ**	**p-value**	**p-value**
Self-Care	52	59	**.053**	48	59	**.007**	**.355**
Mobility	33	51	**.004**	33	55	**.001**	**.285**
Communication	46	61	**.016**	46	65	**.001**	**.267**
Total	42	54	**.006**	41	59	**.001**	**.160**

* Children > 12 months at the time of injury

** Difference in admission DFQs between groups is not statistically significant for any subset or total score

*** Difference in discharge DFQs between groups is not statistically significant for any subset or total score

DFQ, Developmental Functional Quotient: (Patient domain score / Expected domain score per age) × 100

Table 3

Attainment of Independent Ambulation (IA) and Expressive Language (EL)

At discharge from Rehabilitation ***(Excluding children ≤ 12 months at injury)***			
	AHT	**n-AHT**	**p-value**
	N=17	**N=16**	
IA	10 (59%)	12 (75%)	**.47**
EL	10 (59%)	11 (69%)	**.72**
At follow-up evaluation* *(Excluding children with insufficient follow-up documentation)*			
	N=25	**N=19**	
IA	16 (64%)	18 (95%)	**.03**
EL	18 (72%)	18 (95%)	**.11**
At follow-up evaluation *(Excluding children ≤ 12 months at injury and those with insufficient documentation)*			
	N=15	**N=16**	
IA	11 (73%)	15 (94%)	**.17**
EL	13 (87%)	15 (94%)	**.60**

*Age that IA and EL gained, months to gain IA and EL, as well as descriptors of final outcome can be found in Table 4 and 5 (online)

IA: Independent Ambulation; EL: Expressive Language

Table 4

AHT: Descriptors of Outcome

	Age at injury (months)	Walking at discharge	# of months to gain walking after discharge	Age *(months)*: Gained walking	Talking at discharge	# of months to gain talking after discharge	Age *(months)*: Gained talking	Age *(years)* at last documentation	Description of outcomes at last documentation*
1	2.0	N (< 1 yr)	12	14	N (< 1 yr)	12	14	1.9	IA: AA gait; EL: Speaking in words
2	2.0	N (< 1 yr)			N (< 1 yr)			5.9	IA: Spastic quadriplegia; EL: Nonverbal; Other: Total dependence for ADLs; G-tube; Minimal visual attention
3	3.0	N (< 1 yr)			N (< 1 yr)	31	35	14.1	IA: Spastic quadriplegia, power wheelchair; EL: Simple sentences; Other: VPS; Epilepsy
4	4.7	N (< 1 yr)			N			18.2	IA: Spastic quadriplegia; EL: Nonverbal; Other: Total dependence in ADLs; Intractable epilepsy; Cortical blindness; Profound ID
5	5.0	N (< 1 yr)			N (< 1 yr)			0.7	** IA: Moves all extremities; EL: AA (babbling)
6	5.1	N (< 1 yr)			N (< 1 yr)			16.1	IA: Spastic quadriplegia; EL: Babbles; Other: Total dependence in ADLs; Epilepsy; Cortical blindness
7	6.9	N	17	27	N	7	17	4.8	IA: Left hemiplegic gait; EL: AA; Other: Amblyopia
8	7.0	N (< 1 yr)	19	27	N (< 1 yr)			2.1	IA: Steps independently; EL: Babbling; Other: Intractable epilepsy; Independent feeding
9	7.4	N			N			10.5	IA: Spastic quadriplegia; EL: Nonverbal; Other: Total dependence in ADLs; G-tube; Cortical blindness
10	8.8	N (< 1 yr)	14	24	N (< 1 yr)	7	17	13.0	IA: Left hemiplegic gait; EL: Simple sentences; Other: Modified independence ADLs; ADHD; Cognitive / learning deficits
11	9.0	N (< 1 yr)	19	30	N (< 1 yr)	19	30	16.1	IA: Left hemiplegic gait; EL:AA; Other: Epilepsy;

	Age at injury (months)	Walking at discharge	# of months to gain walking after discharge	Age *(months)*: Gained walking	Talking at discharge	# of months to gain talking after discharge	Age *(months)*: Gained talking	Age *(years)* at last documentation	Description of outcomes at last documentation*
									Learning disabilities; Major depressive disorder
12	14.5	N			N			1.4	** IA: Not walking, Left hemiplegia; EL: No words, vocalizations; Others: Epilepsy; Cortical blindness
13	15.1	N			N	19	37	3.0	IA: Steps with moderate assist, primarily wheelchair; EL: Speaks in simple phrases; Other: Dependent for ADLs except feeding; “Trouble with memory”
14	15.7	Y			Y			1.5	IA: Steps, left hemiplegic gait; walker for community; EL: AA
15	16.5	N			N			3.9	IA: Quadriplegia; EL: Coos; Other: Total dependence in ADLs
16	18.0	N			N	18	38	4.0	IA: Steps with support, crawls well; EL: Speaks in words / few 2 word phrases; Other: Cognition below average
17	21.0	Y			Y			1.8	IA: AA; EL: AA
18	21.4	Y			y			2.4	IA: AA; EL: Words and mature jargoning; Other: Cognition low average
19	21.7	N	2	25	N	13	36	7.9	IA: AA; EL: AA; Other: ADHD; Poor vision; Cognition above - average
20	22.5	Y			Y			3.4	IA: AA; EL: Short sentences; Other: Epilepsy; Impulsive
21	25.9	Y			Y			10.8	IA: Right hemiplegic gait; EL: AA; Other: Epilepsy; ADHD
22	29.7	Y			Y			4.3	IA: Right hemiplegic gait; EL: AA; Other: Poor fine motor skills; Emotional regulation difficulty
23	32.6	Y			Y			7.5	IA: Left hemiplegic gait; EL: AA, dysarthria; Other: Epilepsy; ADHD; Mild ID

	Age at injury (months)	Walking at discharge	# of months to gain walking after discharge	Age *(months)*: Gained walking	Talking at discharge	# of months to gain talking after discharge	Age *(months)*: Gained talking	Age *(years)* at last documentation	Description of outcomes at last documentation*
24	35.0	Y			Y			13.8	IA: AA; EL: AA; Other: Behavioral / mood difficulties; AA Cognition
25	46.1	N			N			9.2	IA: Spastic quadriplegia; EL: Nonverbal; Other: Total dependence in ADLs; Intractable Epilepsy; Tracheostomy; G-tube; Profound ID
26	47.1	N			N			4.1	** IA: Spastic quadriplegia, right hemiballismus; EL: Nonverbal; Other: Total dependence in ADLs; Tracheostomy and Ventilator; G-tube; Cortical blindness
27	50.2	Y			Y			7.8	IA: Right hemiplegic gait; EL: Words; Other: ADHD; Visual field defect
28	51.4	Y			Y			7.8	IA: Right hemiplegic gait; EL: AA, dysarthria

* Information provided based on last available detailed documentation; missing information does not imply absence of a diagnosis

** Inadequate follow-up information available

AA: age appropriate; ADL: Activities of Daily Living; G-tube: Gastrostomy tube; VPS: Ventriculoperitoneal Shunt; ID: Intellectual Disability; ADHD: Attention Deficit/Hyperactivity Disorder

Table 5

n-AHT: Descriptors of Outcome

	Mechanism of Injury	Age at injury, in months	Walking at discharge	# of months to gain walking after discharge	Age at which gained walking, in months	Talking at discharge	# of months to gain talking after discharge	Age at which gained talking, in months	Age at last follow-up evaluation, in years	Description of outcomes at last documentation*
1	MVA (U)	2.0	N (<1 yr)			N (<1yr)			0.5	** IA: Rolls, right hemiplegia; EL: Coos; Other: Head lag
2	MVA (R)	4.0	N (<1 yr)	25	31	N (<1yr)	25	31	4.9	IA: AA; EL: Words, some 2 word phrases
3	Fall: bed to floor	5.0	N (<1 yr)	15	21	N (<1yr)	16	22	8.8	IA: Left hemiplegic gait; EL: AA; Other: ADHD, anxiety, ODD
4	MVA (R)	8.3	N (<1 yr)	5	14	N (< 1yr)	5	14	15.2	IA: AA; EL: AA; Other: ADHD, depression; Cognition low average
5	Struck by car	15.8	Y			Y			9.1	IA: AA; EL: AA
6	MVA (R)	16.6	Y			Y			5.8	IA: AA; EL: AA; Other: ADHD; Cognition low average
7	MVA (U)	17.0	Y			Y			1.4	IA: Right hemiplegic gait; EL: Words, few phrases; Other: Assists in ADLs
8	MVA (R)	19.4	N			N			2.5	IA: Asymmetric quadriplegia; EL: Nonverbal; Other: Total dependence in ADLs; Cortical blindness
9	MVA (U)	20.0	Y			N	2	24	8.7	IA: Right hemiplegic gait; EL: AA, dysarthria
10	Struck by car	21.6	N	1	23	Y			2.8	IA: Left hemiplegic gait; EL: AA
11	MVA (R)	23.4	Y			N	1	26	4.0	IA: Left hemiplegic gait; EL: AA, dysarthria
12	Fall: 12 feet from window	24.0	Y			Y			3.5	IA: AA; EL AA
13	TV fall on head	24.8	N	4	29	Y			2.3	IA: Steps, Community with reverse walker; EL: AA, dysarthria

	Mechanism of Injury	Age at injury, in months	Walking at discharge	# of months to gain walking after discharge	Age at which gained walking, in months	Talking at discharge	# of months to gain talking after discharge	Age at which gained talking, in months	Age at last follow-up evaluation, in years	Description of outcomes at last documentation*
14	Fall: concrete steps	27.0	Y			Y			4.7	IA: Abnormal gait; EL: AA, dysarthria; Other: ADHD; Cognition low average
15	MVA (U)	31.7	N	4	38	N	2	36	19.1	IA: Right hemiplegic gait, assists with climbing; EL: AA, dysarthria; Other: ADHD; Moderate ID
16	TV fall on head	34.0	Y			Y			2.9	IA: Right hemiplegic gait; EL: AA; Other: Impulsive
17	Hit with horseshoe	47.0	Y			N	1	48	4.3	IA: AA; EL: AA
18	TV fall on head	47.0	Y			Y			5.2	IA: AA; EL: AA
19	MVA (R)	47.4	Y			Y			11.9	IA: AA, poor balance; EL: AA, dysarthria; Other: ADHD; Cognitive Impairment; Learning disabilities
20	MVA (R)	53.0	Y			Y			5.8	IA: AA; EL: AA; Other: Post-trauma hydrocephalus, VPS

*Information provided based on last available detailed documentation; missing information does not imply absence of a diagnosis

**Inadequate follow-up information available

MVA: motor vehicle accident; R: restrained; U: unrestrained; AA: age appropriate; ADHD: Attention Deficit/Hyperactivity Disorder; ODD: Oppositional Defiant Disorder; ADL: Activities of Daily Living; ID: Intellectual Disability; VPS: Ventriculoperitoneal Shunt