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Inflicted Traumatic Brain Injury: Relationship of Developmental Outcome to Severity of Injury

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Brain injury · Cerebral infarction · Child abuse · Cognition · Outcome · Infants · Children · Shaken baby syndrome

Abstract
Inflicted traumatic brain injury (TBI) is a frequent consequence of physical child abuse in infants and children. Twenty-eight children who were 2–42 months of age when hospitalized for moderate to severe TBI were enrolled in a prospective, longitudinal study of neurobehavioral outcome following acquired brain injury. Relative to a comparison group, the children with inflicted TBI had significant deficits in cognitive, motor and behavioral domains when assessed with the Bayley Scales of Infant Development-II 1 and 3 months after the injury. Nearly half of the injured children showed persisting deficits in attention/arousal, emotional regulation and motor coordination. Greater injury severity, as indicated by lower coma scale scores, longer periods of unconsciousness and the presence of edema/cerebral infarctions was associated with poorer outcomes in all domains.

Traumatic brain injury (TBI) and physical child abuse represent major public health concerns for infants and preschool-aged children. TBI occurs in approximately 12% of confirmed cases of physical child abuse; the majority of children are less than 2 years of age [1]. Studies of consecutively admitted infants and preschoolers with TBI reported rates of inflicted injury ranging from 4 to 24% [1–3]. Mortality and mobidity rates are elevated in young children with TBI. The high mortality rate from TBI in children aged 0–4, which is over twice that in children aged 5–12 [3], appears related to the elevated incidence of assault in infants and young children. Homicide is the second commonest cause of injury fatalities in children and adolescents; 23% of fatalities due to inflicted injury occur in children less than 5 years of age [4]. Although assault causes approximately 5% of brain injuries in children 1–4 years of age, it produces 90% of serious brain injuries [4].

The long-term morbidity from cerebral injury associated with shaken baby [5] or shaking impact [6] syndrome is striking. The majority of studies of shaken baby syndrome or inflicted TBI are retrospective reviews of clinic or hospital records of children identified as sustaining injuries secondary to physical abuse. Comparison of findings across studies is limited by the different terminology used, variation in subject selection criteria and study design,

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and emphasis on different outcome domains. Despite methodological limitations, available studies of children surviving inflicted brain injury indicate a high rate of persistent neurologic injury: Normal neurological examinations were reported in only 11–41% of surviving children [7–12]. The most frequent abnormal neurological findings included (1) hemiplegia, quadriplegia, or diplegia (33–100%) [7–9, 13], (2) blindness or severe visual impairment (20–41%) [2, 7, 9, 11] and (3) persistent vegetative state or mental retardation (35–50%) [7, 11, 12, 14, 15]. Studies using the Glasgow Outcome Scale [16] indicated strikingly high rates of unfavorable outcomes; moderate and severe disabilities were reported in 64–80% [14, 15] of consecutive admissions. Developmental outcome is poorer in children with inflicted TBI than would be predicted based on the severity of parenchymal damage and impairment of consciousness [15].

The purpose of the present study was to examine longitudinal cognitive status, motor development and behavioral outcomes in a well-defined group of children hospitalized for inflicted TBI.

Method

Subjects

Cognitive, motor and behavioral outcomes were evaluated prospectively in 28 children under the age of 43 months who were hospitalized at either Hermann Children's Hospital or Texas Children's Hospital in Houston, Texas for moderate to severe TBI. The children were enrolled in a prospective, longitudinal study of neurobehavioral outcome following acquired brain injury. Inclusion criteria were: (1) moderate to severe TBI, (2) no known premorbid neurologic or metabolic disorder, (3) no history of prior TBI and (4) gestational age ≥ 32 weeks. Computed tomography (CT) of the brain was performed on the first day of hospitalization in each child and brain magnetic resonance imaging (MRI) was obtained for 50% within 2 weeks of admission. Injuries were considered to be suspicious for inflicted injury if there were inconsistencies in the clinical presentation, history and neuroimaging findings. Similar to the algorithm devised by Duhaime et al. [2] to detect probable inflicted injury, injuries incompatible with the stated mechanism of injury (e.g. bilateral subdural hematomas and retinal hemorrhages with a history of falling from a couch; multiple skull fractures, multiple intracranial hemorrhages and bilateral cephalohematomas with a history of falling 4 feet) and unexplained injuries (e.g. no history of trauma in conjunction with intracranial injuries and old skeletal fractures) were presumed to indicate assault. Additional variables commonly associated with inflicted injury such as delay in seeking treatment and inconsistent or changing history were also considered. Skeletal surveys and fundoscopic examinations were performed on all children with suspected abusive injuries. The presence of retinal hemorrhages or previous fractures was considered to be strongly suggestive of abuse. Determination of probable abuse was based on the assessment of the Children's Protection Committee at each hospital and Harris County Children's Protective Services. The external cause of injury was presumed to be assault (shaken baby/shaking impact syndrome).

The severity of TBI was determined using the Glasgow Coma Scale (GCS) score [17], the duration of impaired consciousness, and CT/MRI findings. Since the GCS score was developed for adults, the motor and verbal scales were modified to accommodate the behavioral capabilities of children from birth to 35 months of age. Spontaneous movement in infants aged 0–6 months and goal-directed movements in children aged 7–35 months were considered comparable to following commands in older children. 'Cries' and 'cries to indicate need' were regarded as equivalent to the verbal scale items 'confused' and 'oriented'. Duration of impaired consciousness was defined as the number of days a child was unable to follow a one-stage command or engage in goal-directed movements as indicated by the modified GCS motor scale. Moderate TBI was characterized by injuries producing lowest post-resuscitation GCS scores from 9 to 12; GCS scores from 9 to 15 with CT/MRI evidence of extraaxial bleeding, intraparenchymal hemorrhage or edema, or impaired consciousness persisting for < 24 h. Severe TBI consisted of lowest post-resuscitation GCS scores from 3 to 8 or impaired consciousness persisting for at least 24 h.

A group of 28 uninjured comparison children under the age of 42 months was recruited from children born at the hospitals at which the TBI children were hospitalized, from federally subsidized well-baby clinics and from community notices. Children in the uninjured comparison group met criteria 2–5 for entry into the study.

Procedure

Written informed consent to participate was obtained from the children's guardians. The initial evaluation was conducted an average of 1.6 months after the injury. Follow-up evaluations occurred 3 months after the initial assessment.

Outcome Measures

The Bayley Scales of Infant Development-II [18] yield mental and physical development indices based on direct assessment of the child's cognitive and motor competencies. Bayley indices were corrected for prematurity.

The Bayley Behavior Rating Scale is based on the examiner's observations during the testing. Several domains of behavior are assessed at different ages: attention/arousal (1–5 months), orientation/engagement (6–12 months), emotional regulation (13–42 months) and motor quality (1–42 months). Motor quality, the only factor to span the entire age range, assessed tone, fine and gross motor control, and the quality of movements. The attention/arousal factor tapped the level and consistency of arousal and alertness as well as the child's interest in the testing activities. Orientation/engagement assessed enthusiasm, initiative and exploration. Emotional regulation consisted of items related to temperament including activity level, affect, frustration tolerance and adaptation to change. Scores from each domain are classified as 'within normal limits', 'questionable' or 'nonoptimal'. For statistical analysis, questionable and nonoptimal behavior ratings were classified as nonoptimal.

The Glasgow Outcome Scale (GOS) [16] was rated at discharge from the hospital and at the follow-up for all children with inflicted TBI. The GOS is a 5-point scale encompassing the following categories: 1 = good recovery, 2 = moderate disability, 3 = severe disability, 4 = persistent vegetative state, and 5 = death. Since this scale was developed for adults, the criteria were adjusted for infants and children. Good outcome referred to a return to age-appropriate or preinjury levels of functioning. Moderate disability was assigned if the child had (1) a significant reduction in cognitive functioning from estimated premorbid levels, (2) motor deficits including hemiparesis interfering with daily living activities or (3) the child was referred for outpatient rehabilitation therapies. Severe disability was assigned if (1) cognitive scores were in the deficient range, (2) severe motor deficits were present, such as lack of age-appropriate postural control or ambulation, or (3) the child was referred for inpatient rehabilitation. The criteria for persistent vegetative state were unchanged and reflected the presence of day/night cycles and total dependence for daily care.

Design

To evaluate differences in average group performance, a mixed design was used with the group (inflicted TBI, comparison) as the between-subjects factor; time of testing (baseline and 3 months) and task (mental, physical) were the withing-subjects factors. Using a multivariate approach to repeated measures analysis of variance, a 2 (group) × 2 (time) × 2 (task) analysis was completed for the mental and physical development indices and the total score from the Behavior Rating Scale of the Bayley Scales of Infant Development-II. Because standard scores are not available for the Behavior Rating Scale subscales, χ^2 was used to determine significant differences in the distribution of behaviors rated as within normal limits ($\geq$10th percentile) or nonoptimal (<10th percentile); χ^2 was also used to compare the distribution of mental and motor scores across groups.

Table 1. Demographic and birth variables for inflicted TBI and comparison groups

Variable	Group	
	inflicted TBI (n = 28)	comparison (n = 28)
Mean age, months	9.28 (8.59)	9.43 (8.25)
Socioeconomic status		
Low	9	6
Middle	19	19
High	0	3
Ethnicity		
African-American	7	12
Anglo-American	12	10
Hispanic	8	4
Other/multiethnic	1	2
Gender*		
F	21	14
M	7	14
Mean gestational age, weeks	38.61 (1.9)	39.14 (1.01)
Mean head circumference[1], cm	33.58 (1.83)	32.43 (4.35)
Mean birthweight, kg	2.94 (0.58)	3.39 (0.51)
Mean Apgar scores – 5 min	8.85 (0.4)	8.96 (0.52)
Mean length at birth, cm	48.67 (3.01)	50.84 (3.95)*
Mean days hospitalized	2.78 (4.1)	1.71 (0.94)

* $p < 0.05$, ** $p < 0.01$. Figures in parentheses are SD.
[1] Only available in 28 children.

Results

Demographic and Injury Variables

The inflicted TBI and comparison groups were similar for age [$F(1,55) = 0.0$, $p < 0.95$], ethnicity [$\chi^2(3,56) = 3.16$, $p < 0.37$] and socioeconomic status [$\chi^2(4,56) = 6.54$, $p < 0.16$], as assessed on the Hollingshead Four Factor Index [19]. The groups were also comparable on financial resources based on the Family Resource Scale [20] [$F(1,48) = 0.07$, $p < 0.79$]. Comparison of birth discharge histories revealed that the inflicted TBI group had significantly lower weight, [$F(1,49) = 8.40$, $p < 0.01$] and length [$F(1,47) = 4.11$, $p < 0.05$]. Five-minute Apgar scores, gestational age and duration of hospitalization were similar across the groups. Demographic and birth variables are presented for both groups in table 1.

CT/MRI findings for the inflicted TBI group obtained within 1 week of hospital admission revealed that all children had extra-axial hemorrhages. Subarachnoid hemorrhage was noted in 10. Subdural hemorrhage was visualized frequently in supratentorial convexity (18), infratentorial (11) and interhemispheric (19) locations. Edema/infarction, which occurred in 8 children, most commonly involved cortical and basal ganglia regions. Edema/infarction developed 2–4 weeks after the injury in 4 of the 8 children. Intracerebral hemorrhagic contusions, which occurred most commonly in cortical regions, were visualized in 4 children. Neuroimaging findings suggestive of prior abnormality were observed on the acute scans obtained within 24 h of admission in 11 children (10 had ventriculomegaly, 9 had subdural hygroma and 9 had cortical atrophy). Ten of the children had skull fractures, and all had associated scalp swelling. Six additional children had scalp swelling in the absence of skull fractures. Neurologic abnormalities included hemiparesis in 5 children and retinal hemorrhages in 21 (19 bilateral, 2 unilateral). Seizures were present in 15 children during the hospitalization.

Bayley Mental and Physical Development Indices

Interaction effects for the group × time × task, group × time, group × task and time × task analyses of mental and physical development indices were not significant. The main effects for time and task were nonsignificant. Scores neither increased nor decreased significantly over the follow-up in either the inflicted TBI or comparison groups. Mental and physical developmental indices were

Table 2. Mean Bayley Mental and Physical Developmental Indices at baseline and 3 months follow-up

Index	Group	
	inflicted TBI (n = 28)	comparison (n = 28)
Mental development		
Baseline, mean	79.64 (15.51)	98.71 (9.00)*
Three months, mean	82.14 (14.63)	97.71 (9.43)*
Physical development		
Baseline, mean	80.07 (16.02)	101.28 (9.43)*
Three months, mean	81.89 (19.47)	100.46 (10.86)*

* $p < 0.001$. Figures in parentheses are SD.

Table 3. Proportions of children with impaired Bayley Behavior Record scores at baseline and 3 months follow-up

Domain	Group	
	inflicted TBI (n = 28)	comparison (n = 28)
Baseline		
Attention/arousal	11/13*	2/12
Emotional regulation	5/15	3/16
Orientation/engagement	6/15**	1/16
Motor quality	15/28*	1/28
Three months		
Attention/arousal		
Emotional regulation	12/26*	0/23
Orientation/engagement	7/25**	1/22
Motor quality	12/28*	3/28

* $p < 0.001$; ** $p < 0.03$.

similar within each group, suggesting comparable levels of performance across the two domains. Main effects for group were obtained for both the mental [$F(1,111) = 18.21$, $p < 0.0001$] and physical [$F(1,111) = 15.87$, $p < 0.0001$] scores. At baseline, the inflicted TBI group scored significantly lower than the comparison group on both the mental [$F(1,54) = 31.65$, $p < 0.0001$] and physical [$F(1,54) = 28.71$, $p < 0.0001$] developmental indices. As indicated in table 2, the mean mental score for the injured children was 79.6 (9th percentile) while the comparison children averaged 98.7 (48th percentile). At the 3-month follow-up, the inflicted TBI group continued to score below the comparison children in both mental [$F(1,55) = 22.60$, $p < 0.0001$] and motor [$F(1,55) = 19.43$, $p < 0.0001$] domains.

The distribution of mental and motor scores was evaluated at baseline and follow-up. Scores were categorized as follows: <70 (deficient), 70–79 (borderline deficient), 80–89 (low average) and ≥90 (average to above average). The distributions of mental [$\chi^2(3,56) = 20.67$, $p < 0.001$] and physical [$\chi^2(3,56) = 15.73$, $p < 0.001$] developmental indices differed across groups at the initial assessment. Differences in distributions persisted at the follow-up evaluation in both mental [$\chi^2(3,56) = 19.33$, $p < 0.001$] and physical [$\chi^2(3,56) = 16.74$, $p < 0.001$] indices.

Behavior Rating Scale

Although the group × time interaction was nonsignificant, the main effects for group and time were significant. The inflicted TBI group had less favorable total Behavior Rating Scale centile ranks than the comparison group [$F(1,111) = 25.89$, $p < 0.0001$] at both baseline [$F(1,55) = 14.81$, $p < 0.005$] and the 3-month evaluation [$F(1,54) = 11.26$, $p < 0.005$]. Mean centiles increased from baseline to the 3-month follow-up in both groups [$F(1,54) = 6.21$, $p < 0.05$. Because the individual Behavior Rating Scale domains differ by age, each domain was analyzed separately and the degrees of freedom reflect changes in the sample size. At baseline, the inflicted TBI group had lower mean centile scores for the attention/arousal [$F(1,24) = 5.90$, $p < 0.05$], orientation/engagement and motor quality [$F(1,55) = 19.94$, $p < 0.0001$] scores; emotional regulation scores were similar across groups. By the follow-up, infants with inflicted TBI showed continuing deficits on the motor quality [$F(1,55) = 13.03$, $p < 0.001$] and emotional regulation scales [$F(1,48) = 8.20$, $p < 0.01$] relative to the comparison group. A trend was obtained for orientation/engagement scores to also be lower following inflicted TBI [$F(1,48) = 3.39$, $p < 0.07$].

Examination of the distribution of scores confirmed that more children with inflicted TBI than comparison children had total scores in the nonoptimal range at baseline [$\chi^2(1, n = 56) = 9.64$, $p < 0.002$] and at follow-up [$\chi^2(1, n = 56) = 6.09$, $p < 0.01$. At the initial evaluation, the inflicted TBI group had a significantly higher number of children with impairments in attention/arousal [$\chi^2(1, n = 25) = 11.54$, $p < 0.001$], motor quality [$\chi^2(1, n = 56) = 17.15$, $p < 0.001$] and orientation/engagement [$\chi^2(1, n = 31) = 5.04$, $p < 0.025$]. The distribution of emotional regulation scores was similar in the two groups (table 3).

Evaluation of total Behavior Rating Scale ratings obtained at the 3-month follow-up revealed no significant change in the frequency of nonoptimal scores for either group [$\chi^2(1, n = 56) = 1.74, p < 0.19$]. As only 7 children were under the age of 6 months, the attention/arousal category was eliminated from the analyses. The inflicted TBI group continued to have a higher rate of impairment than the comparison children in motor quality [$\chi^2(1, n = 56) = 7.38, p < 0.01$], and orientation/engagement [$\chi^2(1, n = 47) = 4.56, p < 0.05$]. In contrast to baseline, the number of children in the inflicted TBI group with nonoptimal emotional regulation increased [$\chi^2(1, n = 49) = 14.05, p < 0.001$].

Glasgow Outcome Scale

The GOS was used to evaluate neurobehavioral outcome after inflicted TBI. As in previous studies of GOS scores in young children, the scores were very stable from hospital discharge to the 3-month follow-up [21, 22]. The majority of children had a moderate disability (17/28). Severe disability was noted in 4/28 children and remained stable throughout the follow-up. The number of children rated as having a good recovery increased from 6 at baseline to 7 at the follow-up, as one child improved from moderate disability to good recovery. No children were in a persistent vegetative state.

Injury Severity

Coma Scores. The depth and duration of impaired consciousness were significantly related to Bayley scores. As depicted in table 4, the lowest post-resuscitation GCS score was significantly positively correlated with Bayley mental, physical and behavior scores at baseline and 3-month intervals. The duration of impaired consciousness was significantly negatively correlated with all scores except the follow-up Behavior Rating Scale score. Overall, the duration of impaired consciousness was most strongly related to the outcome measures.

Cerebral Edema/Infarction. As previous research identified that cerebral edema/infarction was the single variable most predictive of behavioral outcome after early TBI [23], we examined outcome in children with inflicted TBI with and without edema/infarctions visualized on MRI scans. Children with edema/infarcts obtained significantly lower mental [$F(1,27) = 8.02, p < 0.001$] and motor [$F(1,27) = 10.15, p < 0.005$] scores than other children with inflicted injuries. Examination of the recovery of mental and physical abilities over the follow-up interval revealed no increase or decrease in mental scores [$F(1,27) = 1.15, p < 0.79$]. However, a significant interaction between edema/infarction and motor scores was obtained [$F(1,27) = 4.26, p < 0.05$]. The mean physical development centiles of the children with edema/infarcts decreased while scores of children with no infarcts increased from baseline to the 3-month follow-up (fig. 1). The group mean of TBI children without edema/infarction was in the low-average range on both mental and physical indices at baseline and follow-up. In contrast, children with cerebral edema/infarcts had mean scores in

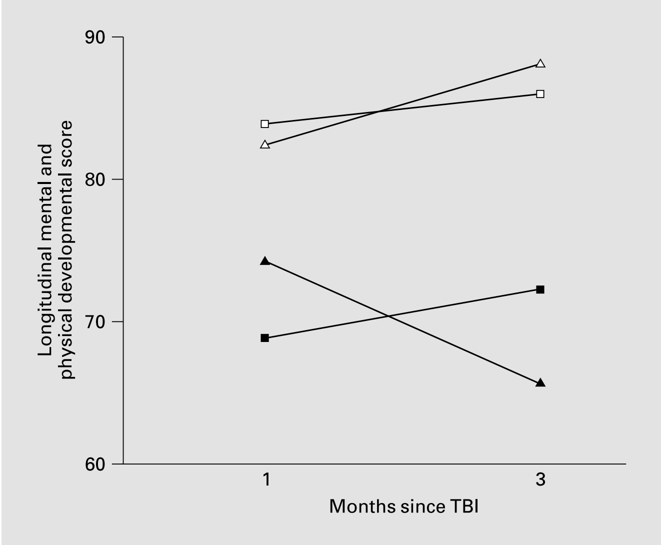

Fig. 1. Mental and physical developmental indices were significantly lower in children with inflicted TBI who sustained cerebral edema/infarctions than in children without infarctions. Physical developmental scores decreased over the follow-up, suggesting that children with infarcts failed to develop motor skills at age-appropriate rates. ■ = Infarct – mental; □ = no infarct – mental; ▲ = infarct – motor; △ = no infarct – motor.

Table 4. Pearson product-moment correlation coefficients for Bayley scores and indices of injury severity

Bayley index	Duration of impaired consciousness	Lowest GCS score
Mental		
Baseline	0.48**	0.36
Three months	–0.61****	0.44*
Motor		
Baseline	–0.49**	0.36
Three months	–0.53**	0.56***
Behavior record		
Baseline	–0.38*	0.47**
Three months	–0.35	0.37*

* p < 0.05; ** p < 0.01; *** p < 0.005; **** p < 0.001.

the delayed/deficient ranges at baseline and follow-up; mean scores ranged from 65 to 74.

More children with infarcts than children without edema/infarcts scored in the nonoptimal range on the Behavior Rating Scale at baseline [$\chi^2(1, n = 28) = 5.18, p < 0.02$]. However, the distribution of the groups was similar at the 3-month follow-up [$\chi^2(1, n = 28) = 2.53, p < 0.1$].

Discusssion

In comparison to a group of children from similar socioeconomic backgrounds, young children with inflicted TBI had significant decrements in cognitive and motor domains. The decrement was present upon initial assessment approximately 1 month after the injury and persisted during the 3-month follow-up. Unlike school-aged children and adolescents with TBI, who characteristically show significant increases in cognitive and motor scores from an initial assessment to 3- to 6-month follow-up evaluations [24–26], the recovery curves of the children with inflicted TBI were flat. This pattern of recovery suggests a persisting deficit in mental and physical outcomes with no significant 'catch-up' or improvement in scores. At the 3-month follow-up, the mean mental and physical development indices approached the 12th percentile for the injured children and the 50th percentile for the comparison children. Cognitive and motor scores were similar, suggesting a comparable degree of disruption across these outcome domains.

Behavioral variables showed a similar pattern of limited recovery in children with inflicted TBI. At baseline, 40% had impairments in energy, interest and toy exploration, 54% had deficits in motor tone or coordination and 85% had deficits in attention or arousal. By the 3-month follow-up, nearly half of the children also had deficits in regulation of affect, frustration tolerance and adaptation to change. These ratings are similar to reports of the raised incidence of attentional difficulties, emotional dysregulation, aggression, low frustration tolerance and affective lability in maltreated children [27–29].

Cognitive, physical and behavioral outcomes were significantly related to indices of neurological injury. The GCS score, duration of impaired consciousness, and MRI findings were consistently related to outcome measures. Greater injury severity as indicated by the depth of unconsciousness, duration of impaired consciousness and presence of cerebral edema/infarctions was associated with poorer outcomes in all domains evaluated. Our findings are similar to those of Gilles and Nelson [30], who identified generally poor outcomes in children with non-accidental injuries who developed either focal or diffuse cerebral hypoattenuation. Cerebral hypoperfusion, which occurs most frequently in children <24 months of age, represents a key pathophysiological finding associated with poor outcome following severe TBI [31].

Neuroimaging findings were strongly related to developmental outcomes. Cerebral edema/infarctions produced significantly more adverse outcomes on mental, physical and behavioral outcome measures. Children with edema/infarcts had particularly notable deficits on the physical development index; their performance increased less over the follow-up than is expected as a function of increasing age. Therefore, the age-corrected standard score decreased as the children's performance declined relative to other children. This failure to develop new skills at an expected rate after the injury may underlie the delayed deficits commonly hypothesized to occur following early brain injury.

Neonatal variables differentiated the groups. Although gestational age, Apgar scores and duration of hospitalization were similar, the inflicted TBI group had lower birthweight and length. This finding corroborates earlier studies of the developmental status of maltreated children that identified low birthweight as a risk factor for subsequent abuse [32, 33]. In some children, adverse developmental factors may also predate specific postnatal abusive incidents [34] and further contribute to poor developmental outcomes. Parents of low-birthweight infants should be targeted for abuse prevention programs as well as intervention programs that emphasize the development of positive parenting skills.

Synthesis of the literature on shaking impact syndrome, shaken baby syndrome and inflicted TBI is difficult due to the great variability in injury variables and outcome measures across studies. Outcomes need to be broadened to include relevant dimensions of children's posttraumatic experiences. The focus of most studies is on the presence/absence of a limited group of specific neurologic, cognitive or behavioral outcomes. This results in a narrow characterization of outcome that does not include the functional impact of the injury on subsequent health, physical and cognitive development, social competence and the family system. It is clear that these children will require a variety of social and academic/therapeutic services throughout their lifespan to address visual, cognitive, physical, social and economic consequences of early inflicted injury.

Despite the expanding literature on the adverse effects of child maltreatment, there are few studies of developmental outcomes in well-defined groups of children experiencing different forms of maltreatment. Most studies evaluate heterogeneous samples of children including children with unspecified abuse, failure to thrive, neglect, sexual abuse and/or emotional abuse. Children with neurologic impairment or with a history of head injury have often been excluded from outcome studies [35–37]. Even in children with no history of brain injury, physical abuse and neglect are often associated with a variety of neurological and developmental abnormalities [7, 36, 38]. Psychometric evaluation of maltreated children frequently discloses a reduction in intelligence, motor and/or language scores relative to either published normative standards for age [34] or relative to comparison groups of children with no history of maltreatment [5, 35, 39, 40]. A major challenge in characterizing the effects of inflicted brain injury involves dissociation of the effects of brain injury from effects of maltreatment and sociodemographic variables. Studies comparing outcome in maltreated children who differ in terms of the presence/absence of brain injury would assist in clarifying the consequences of inflicted brain injury.

To enhance the literature on the neurologic, developmental and social consequences of inflicted TBI, investigators need to report similar demographic variables, indices of injury type and severity, neurologic findings and developmental outcome data. Basic outcome variables should include the proportion of children with normal versus abnormal neurological findings; measurement of height, weight and head circumference; visual disturbance; epilepsy; neuropsychological status. In addition to reporting group means on outcome variables, the distribution of scores should also be examined. Characterization of outcome in broad domains such as provided by the GOS is essential to identify the degree of disability (e.g. persistent vegetative state versus moderate disability) and the relationship between outcome and the use of community resources (rehabilitation therapies, special education programming, residential placement, psychiatric intervention, vocational services) as well as intellectual and social outcomes. Assessment of outcomes in infants and young children is also complicated by the relative scarcity of standardized outcome measures. Prospective, longitudinal research designs and outcome measures assessing functional, social and physical outcomes are needed to characterize the long-term consequences of children with inflicted brain injuries.

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