

Injuries to Children Who Had Preinjury Cognitive Impairment

A 10-Year Retrospective Review

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Objective: To determine differences between hospitalized injured children who had preinjury cognitive impairments (IMPs) and children who had no preinjury cognitive conditions (NO).

Design: Comparative analysis, excluding fatalities, of patients with IMP (n=371) with patients with NO (n=58745), aged from 0 to 19 years.

Main Outcome Measures: Demographics, injury characteristics, injury nature and severity, use of resources, disability, and disposition at discharge from acute care.

Data Source: Medical records of children injured between January 1, 1989, and December 31, 1998, submitted to the National Pediatric Trauma Registry, Boston, Mass.

Results: Compared with children with NO, children with IMPs were more likely to be boys (72.5% vs 64.3%), to be older (53.1% vs 40.0%, aged 10-19 years), to be victims of child abuse (5.9% vs 1.6%), and to be individu-

als with self-inflicted injuries (2.2% vs 0.1%). They were more likely to be injured as pedestrians (19.9% vs 13.8%), less likely to be injured in sport activities (2.7% vs 6.9%), and less likely to sustain a penetrating injury (3.8% vs 8.3%). They were more likely to sustain injuries to multiple body regions (57.4% vs 43.7%) and the head (62.0% vs 45.1%), and to be severely injured. They were more likely to be admitted to the intensive care unit (52.6% vs 25.2), and their mean length of stay was twice as long (9.9 vs 4.8 days). They were also more likely to develop impairments from the current injury (46.6% vs 41.0%) and more likely to be discharged to a rehabilitation facility (11.1% vs 2.3%). The IMPs became worse in 75 children.

Conclusions: Preinjury cognitive impairments in a pediatric population had a significant effect on the causes, nature, severity of injury, and outcomes. Targeted prevention programs should consider the characteristics of this population.

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IT IS well established that outcomes from trauma in an adult population are dependent on the following several main variables: (1) host factors, (2) severity of injury, (3) time to definitive care, and (4) quality of care.¹ Specifically, host factors or comorbidity have been shown to exert a significant effect on mortality and the use of resources in numerous studies of adult patients with trauma.¹⁻⁵ Failure to consider the effect of comorbidity could potentially invalidate comparisons among subsets of trauma patients and result in underestimation of trauma severity in patients with diminished physiological reserves.^{6,7} The effect of comorbidity on outcomes has been well documented in adult trauma patients and has produced various assessment tools that quantify comorbid-

ity based on conditions frequently observed in an aging population.^{3,8-10}

Much less attention has been given to how preinjury conditions affect outcomes among pediatric trauma patients. While the prevalence of chronic conditions and disabilities among children are reasonably well documented,¹¹⁻¹⁵ very few studies^{16,17} address the effect of comorbidity on outcomes in pediatric trauma. The lack of these efforts may be because of the difficulty in identifying these children by relying on a list of diagnoses¹³ that may be inconsistent among clinicians and settings, may not convey the extent of morbidity for the child, and may be biased in favor of the child who has access to medical care. The current prevalent approach that uses consequences of disorders such as functional limitations instead of diag-

nostic labels^{13,14} offers a better opportunity to study the effect of comorbidity on pediatric trauma outcomes by grouping children with similar limitations instead of specific disorder.

This article determined whether the characteristics and outcomes of injuries to children who had preinjury cognitive impairment (IMP) differ from those children who had no preinjury cognitive conditions (NO). Based on the notion that children in the same age group are at risk for similar injuries, this study seeks to assess if children with IMPs exhibit a different pattern of injuries, including differences in external causes, nature, and severity; use of resources; and functional and disposition outcomes at discharge from acute care. The study's population consists of children injured between January 1, 1989, and December 31, 1998, who were admitted for an acute injury to hospitals participating in the National Pediatric Trauma Registry (NPTR), Boston, Mass.

METHODS

The NPTR is a database that contains information about many aspects of pediatric trauma, its causes and consequences. Data are voluntarily contributed to the NPTR by pediatric trauma centers or children's hospitals with pediatric trauma units.

The NPTR collects data on children and adolescents aged 0 through 19 years who are admitted to the hospital for an acute injury, including patients who are dead on arrival or who die in the emergency department. All injuries are included, with the exception of burns, poisoning, and near drowning. The operation, data management, and quality assurance of the NPTR have been described in detail elsewhere.¹⁸

The injuries recorded in the NPTR represent a subset of all the injuries occurring to children because the NPTR includes only those injuries that led to hospitalization. Also, because the participating institutions of the NPTR are hospitals specializing in the treatment of pediatric trauma, the proportion of severe cases reported to the NPTR is higher than that observed in all hospitals nationwide. The NPTR is a voluntary database, not a population sample, and precise population-wide incidence estimates cannot be made from NPTR data.

SUBJECTS

We extracted from the NPTR all the records of children who sustained an injury during the 10-year period January 1, 1989, through December 31, 1998, and were reported as having a cognitive impairment that existed prior to the current injury but no prior established physical, psychosocial, or substance abuse problem. We made the decision to exclude confounding conditions such as physical limitations (eg, blindness) or emotional disturbance (eg, depression) as they may cause a child to be erroneously labeled as having cognitive limitations. For comparison, we extracted from the NPTR all data on children who were injured in the same period and were reported as being free of any NO. This process identified 2 groups: the IMP group that was composed of 371 children, and the NO group that was composed of 58 745 children. The in-hospital fatalities were excluded. Because deaths often occur shortly after the arrival to the treating facility, the preinjury medical history of these patients is not recorded most of the time.

The conditions associated with the cognitive impairment included autism, Down syndrome, hydrocephalus, cerebral palsy, developmental delay, fetal alcohol syndrome, mental retardation, learning disability, and others. Of all of the injured children with cerebral palsy recorded in the NPTR, we in-

cluded in the study group only those who were reported as having an IMP but no significant motor limitations. Data were contributed by 68 hospitals, inclusive of 32 children's hospitals.

MAIN OUTCOME MEASURES

Variables analyzed included sex, age, characteristics of the injury event, severity of the injury, injured body region, admission to the intensive care unit, hospital length of stay, and function and disposition outcomes at discharge from acute care. The Injury Severity Scale (ISS) score measured the severity of the injury.¹⁹ In conformance with the computation of the ISS, body regions considered in the analysis were head and neck, face, thorax, abdomen, extremities, and skin.

Functional status was assessed at the time of discharge by rating the child's ability in the following 9 functional domains: vision, hearing, speech, self-feeding, bathing, dressing, walking, cognition, and behavior. Bowel and bladder control were added in 1995 to the other 9 functional domains to be consistent with the Functional Independence Measure, which is also collected by the NPTR. Using performance and neurological test results, a clinician rated the performance of the child in each functional area as being "age appropriate," "impaired," or "unable" [to perform the task]. In our analyses, the categories of impaired and unable were combined to reflect any degree of functional limitation. In addition, for each functional limitation, the clinician indicated whether it existed before the current traumatic event and, if so, whether it was worsened by the current injury. The functional limitations were assessed at the time of discharge from acute care; therefore, limitations that developed later were undetected. Also because of lack of follow-up data, subsequent improvement in functional outcome could not be tracked.

DATA MANAGEMENT AND ANALYSIS

Data analyses were performed using BMDP²⁰ statistical software. Comparisons were performed by χ^2 test, *t* test, and odds ratio (OR).

RESULTS

PATIENT CHARACTERISTICS

Sex

The sex distribution was statistically different between the 2 groups. Boys outnumbered girls in both groups; however, the proportion of boys was much higher among the children with IMPs than among the children with NO (72.5% vs 64.3%).

Age

Age was also different. The children with IMPs were on average older than the children with NO. In fact, 53.1% of the children with IMPs were aged 10 years or older vs 39.9% of the children with NO (**Table 1**).

INJURY EVENT CHARACTERISTICS

In both groups, most injuries were unintentional although a sizeable proportion of intentional injuries (including child abuse, assault, and self-inflicted; **Table 2**) were noted among children with IMP (12.4% vs 6.8%).

Table 1. Patient Characteristics by Group, National Pediatric Trauma Registry, 1989-1998*

Patient Characteristic	IMP Group (n = 371)	NO Group (n = 58 745)
Sex†		
Male	269 (72.5)	37 761 (64.3)
Female	98 (26.4)	20 627 (35.1)
Not available	4 (1.1)	357 (0.6)
Age, y†		
<1	4 (1.1)	2363 (4.0)
1-4	71 (19.1)	14 777 (25.2)
5-9	99 (26.7)	18 155 (30.9)
10-14	133 (35.8)	14 764 (25.1)
15-19	64 (17.3)	8686 (14.8)

Abbreviations: IMP, preinjury cognitive impairment; NO, no preinjury cognitive conditions.

*Data are given as number (percentage) of patients.

† $P < .01$, χ^2 test.

Table 2. Injury Event Characteristics by Group, National Pediatric Trauma Registry, 1989-1998*

Injury Event Characteristic	IMP Group (n = 371)	NO Group (n = 58 745)
Circumstance†		
Unintentional	320 (86.3)	54 337 (92.5)
Child abuse	22 (5.9)	954 (1.6)
Assault	16 (4.3)	2972 (5.1)
Self-inflicted	8 (2.2)	84 (0.1)
Other	5 (1.4)	398 (0.7)
Mechanism†		
Fall	106 (28.6)	5869 (27.0)
Pedestrian	74 (19.9)	8101 (13.8)
MVC	67 (18.1)	11 656 (19.8)
Other	39 (10.5)	5905 (10.0)
Bicycle	36 (9.7)	5222 (8.9)
Beating	15 (4.0)	1489 (2.5)
GSW and stabbing	14 (3.8)	4866 (8.3)
Motorcycle, ATV, and RV	10 (2.7)	1576 (2.7)
Sport	10 (2.7)	4061 (6.9)
Scene†		
Road	179 (48.2)	25 194 (42.9)
Private home	115 (31.0)	20 110 (34.2)
Public place	18 (4.8)	2900 (4.9)
Not available	17 (4.6)	2976 (5.1)
School	15 (0.4)	2247 (3.8)
Recreation area	15 (0.4)	4491 (7.6)
Other	12 (3.2)	827 (1.4)

Abbreviations: ATV, all-terrain vehicle; GSW, gunshot wound; IMP, preinjury cognitive impairment; MVC, motor vehicle crash; NO, no cognitive medical conditions; RV, recreational vehicle.

*Data are given as number (percentage) of patients.

† $P < .01$, χ^2 test.

Specifically, among the children with IMP, child abuse was reported 4 times more frequently than in children with NO (OR, 3.82; $P < .01$). Self-inflicted injuries, while uncommon, were much more likely to occur among the children with IMP (OR, 5.4; $P < .01$) (Table 2).

The external cause of injury was significantly different between the 2 groups. In particular, the children with IMP were more likely to be injured as pedestrians (OR, 1.55; $P < .01$), less likely to be injured while engaged in sports activities (OR, 0.37; $P < .01$), and less likely

to sustain an injury from a gunshot or a stabbing (OR, 0.43; $P < .01$) (Table 2).

The place where the injury occurred was also different, as could be expected from the distribution of external causes. Particularly, children with IMP were more likely to be injured on the road (OR, 1.24; $P < .01$) and less likely to be injured in recreation areas (OR, 0.51; $P < .01$) than the children with NO (Table 2).

NATURE AND SEVERITY OF INJURY

To document the nature of the injuries, we classified the injury diagnoses as follows. Up to 15 injury diagnoses can be recorded in the NPTR for each patient.

In agreement with the 6 body regions used in the computation of the ISS (ie, head and neck, face, thorax, abdomen, extremities, and external), we classified the children into the following 7 mutually exclusive groups: (1) those who sustained injury to the head with or without external injury (head); (2) those who sustained injury to the face with or without external injury (face); (3) those who sustained injury to the thorax with or without external injury (thorax); (4) those who sustained injury to the abdomen with or without external injury (abdomen); (5) those who sustained injury to the extremities with or without external injury (extremities); (6) those who sustained external injuries only (external); and (7) those who sustained injuries to the head, thorax, abdomen, and extremities in any combination with or without external injury (multiple). For those who sustained multiple injuries, we identified all cases in which the head was involved since head injuries are of particular interest in this population. Head injury was identified by the presence of 1 or more of the following *International Classification of Diseases, Ninth Revision, Clinical Modification* natural codes: 800-801, 803-804, and 850-854.

While there was no significant difference between the 2 groups for injuries to single body regions, the children with IMPs were more likely to sustain injury to multiple body regions (OR, 1.74; $P < .01$), and more likely to sustain head injuries, with or without concomitant injuries, to other body regions (OR, 1.98; $P < .01$) than children with NO (Table 3).

Children with IMPs sustained significantly more severe injuries than those with NO. As measured by the ISS score, the injuries among the children with IMPs were extremely severe (ISS score, 20-75), being at a rate 3 times higher than that observed among children with NO (Table 3).

OUTCOMES

On average, the children with IMP stayed in the hospital twice as long as the children with NO, that is, 9.9 days (median, 5.0 days) vs 4.8 days (median, 2.0 days) ($P < .01$, *t* test), and were admitted to the intensive care unit twice as frequently, that is, 52.6% vs 25.2% (OR, 3.3; $P < .01$).

At the time of discharge from acute care, the children with IMP were more likely to show evidence of new impairments than the children with NO (46.6% vs 41.0%; OR, 1.2; $P < .05$) and were more likely to be discharged to a rehabilitation facility (11.1% vs 2.3%; OR, 5.3; $P < .01$).

For a total of 75 children with IMP (1:5), their IMP became worse because of the current injury.

COMMENT

The role of preexisting conditions as they affect vulnerability to trauma and outcomes in a pediatric population has received minimal attention to date, with few exceptions.¹⁶ While there is a general sense among clinicians that children with cognitive impairment are more susceptible to injury, little or no documentation of this impression has been undertaken. Part of the problem relates to the complexity in defining "cognitive impairment" as definitions differ from state to state and from organization to organization. The difference in these data from various prevalence studies reflects this problem.

The 1994 US Office of Education data indicate that 4% of children have a specific learning disability. By contrast, a survey conducted by the Department of Education in Connecticut in 1996 found that 6.8% of the school-aged population has learning disabilities. Similar problems exist when investigating prevalence of autism, mental retardation, or any other form of cognitive impairment among children. No single definition exists to describe these conditions. For this study, we have taken the information provided by the caretakers to the hospital staff at face value and included children with cognitive issues ranging from learning disabilities through mental retardation in the IMP group. To avoid confounding conditions, we excluded children in whom the cognitive deficiency was associated with physical disability, a diagnosed mental health disorder, and/or psychosocial concerns. This, combined with the exclusion of children who did not require hospital admission and those who died, likely resulted in our lower than expected rate of 0.6% for children with IMP, although this rate is similar to that reported for mental retardation in a previous study.¹⁵

Boys outnumbered girls in our study, especially in the IMP group where a total of 72.5% of the children were male. This may reflect both the greater number of boys in general who are hospitalized for injury, as well as the greater prevalence of males among children with cognitive impairments. In fact, 75.0% of children with learning disability,²¹ approximately 75.0% of children with autism,²² and nearly 60.0% of children with mental retardation¹⁵ are male.

Age at the time of injury differed significantly between the 2 groups. A larger percentage of the IMP group presented after the age of 10 years than did in the NO group. This may reflect the cultural norm of giving children more autonomy as they get older combined with a relative lack of judgment about safety on the part of the IMP group.

The rate of self-inflicted injuries while very small in each group was 20 times higher (2.2%) among the children with IMP, as observed in a previous study.¹⁶ This small group of children who intentionally injured themselves stands out in that 7 of 8 sustained injuries from likely suicide attempts. The association of mental health disorders, specifically dysphoria and depression, with cognitive impairment is high. The numbers vary depending on the study, and data about children are scarce; how-

Table 3. Nature of Injury by Group, National Pediatric Trauma Registry, 1989-1998*

Variable	IMP Group (n = 371)	NO Group (n = 58 745)
Body region		
Total No. of head injuries	230 (62.0)	26 498 (45.1)
Multiple regions	213 (57.4)	25 644 (43.7)
Multiple regions and the head	168 (45.3)	16 919 (28.8)
Head	62 (16.7)	9579 (16.3)
External	20 (5.4)	6922 (11.8)
Extremity	57 (15.4)	12 249 (20.8)
Abdomen	11 (3.0)	2007 (3.4)
Face	3 (0.8)	1370 (2.3)
Thorax	0	518 (0.9)
Injury Severity Scale score†		
1-9	216 (58.2)	44 713 (76.1)
10-19	80 (21.6)	9906 (16.9)
20-75	59 (15.9)	3067 (5.2)
Not available	16 (4.3)	1059 (1.8)

Abbreviations: IMP, preinjury cognitive impairment; NO, no preinjury cognitive conditions.

*Data are given as number (percentage) of patients.

† $P < .01$, χ^2 test.

ever, for adults with mental retardation, the incidence ranges from 30% to 60%.²³ While we excluded from the IMP group children with reported mental disorder, it is possible that this was an underlying condition not yet diagnosed.

The occurrence of child abuse was much more frequent among the IMP group than the NO group: 5.9% vs 1.6%. This is not a surprising finding as other studies have reported the association between child abuse and preinjury medical history.²⁴⁻²⁶

The IMP group were more likely to be injured as pedestrians and less likely to be injured while engaged in sports activities compared with the NO group. The increased number of pedestrian injuries may be because of greater impulsivity and poorer judgment among those in the IMP group compared with their NO group peers. Given that the children with IMP were on average older, one could also postulate that more appropriate behavior was expected from these children than they were capable of, and because of that, they were not being watched as closely as needed. The lower injury rate in sports may simply reflect the lack of inclusion of children with IMP in recreational activities. In many communities there is little, if any, accommodation made for children with cognitive impairment to engage in sports with other children. The higher incidence of pedestrian injuries combined with the higher incidence of injuries caused by abuse likely explain the higher rate and greater severity of head injury and injury to multiple body regions observed in the IMP group.

Outcomes at the time of hospital discharge among the children with IMP were poorer than among children with NO. Consistent with their greater injury severity and higher frequency of head injuries, their length of stay in the hospital was twice as long, and the rate of admission to the intensive care unit was double that of the NO group. Sequelae to their injuries were reported more frequently among the children with preexisting IMP.

What This Study Adds

This study describes the nature, level of severity, place of injury, and outcome of children hospitalized because of an injury. It documents how these characteristics differ in a population of children with IMP compared with a group of typical children (ie, children with NO). It highlights the greater vulnerability of children with cognitive impairment to severe injury and proposes teachers, health care professionals, people with disabilities, and families be alerted to how and where these children are injured with the intent of preventing this unnecessary trauma and its sequelae.

One of 5 was reported to have worsened in areas of function that were previously impaired and 46.6% acquired new impairments at the time of discharge from acute care. They were 5 times more likely than the NO group to be referred to a rehabilitation facility, although this may be an effect of medical insurance.

There are inherent limitations to this study. As a retrospective review of data, we could only explore injury patterns to children. We could not examine why these injuries occurred. Our study focused on children who required hospitalization after injury. It excluded those children who were seen in the emergency department and discharged home for care as well as those who died. Therefore, it does not describe the general population of children who are injured.

CONCLUSIONS

Based on this evidence, it is clear that a cognitive impairment as a preinjury condition places children at high risk for poorer outcomes than the population with no pre-existing cognitive impairment. Professionals involved in the care of children with cognitive impairment need to alert parents and teachers to the increased vulnerability of this population. Programs on safety that more effectively reach this group and their caregivers need to be developed and disseminated. The mental health concerns of these children need to be better recognized and addressed. Parents should be given more psychological and physical support to reduce the incidence of abuse.

Despite its limitations, this study highlights the need to focus more thoroughly on the safety requirements of children with cognitive impairment. Most of the injuries are preventable with education and forethought. The cost of not preventing them is high to the injured individual, to his or her family, and to society.

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