Outcomes for Children Hospitalized With Abusive Versus Noninflicted Abdominal Trauma

WHAT'S KNOWN ON THIS SUBJECT: Data from pediatric trauma centers suggest that children with abusive abdominal trauma have higher mortality, longer hospitalizations, and higher hospitalization costs compared with children with noninflicted abdominal trauma.

WHAT THIS STUDY ADDS: This study included children hospitalized for abdominal trauma at all types of acute care hospitals across the country. It therefore provides a more representative sample of children hospitalized with abdominal trauma than previous studies.

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KEY WORDS

child abuse, abdominal trauma, hospitalization, outcomes, epidemiology

ABBREVIATIONS

AAT—abusive abdominal trauma

KID—Kids' Inpatient Database

ICD-9-CM—International Classification of Disease, Ninth Edition, Clinical Modification

CI—confidence interval

www.pediatrics.org/cgi/doi/10.1542/peds.2010-2096

doi:10.1542/peds.2010-2096

Accepted for publication Feb 23, 2011

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

Funded by the National Institutes of Health (NIH).

abstract

BACKGROUND: Abusive abdominal trauma (AAT) is the second leading cause of child abuse mortality. Previous outcome studies have been limited to data from trauma centers.

OBJECTIVES: The goals of this study were (1) to examine mortality, length of hospitalization, and hospital charges among a national sample of children hospitalized for AAT; and (2) to compare these outcomes with children with noninflicted abdominal trauma.

METHODS: Hospitalization data for children aged 0 to 9 years were obtained from the 2003 and 2006 Kids' Inpatient Database. Cases were identified using International Classification of Diseases, Ninth Revision, Clinical Modification and external cause of injury codes. Multivariable regression analyses were used to compare outcomes of children with AAT versus those with noninflicted injury.

RESULTS: Children with AAT were younger, and more often insured by Medicaid. Among children surviving to discharge, those with AAT had longer hospitalizations (adjusted mean [95% confidence interval (CI)] length of stay: 7.9 (6.6–9.3) vs 6.4 (6.1–6.7) days, $P < .01$) and higher charges (adjusted mean [95% CI] costs: \$24 343 [\$20 952–\$28 567] vs \$19 341 [\$18 770–\$20 131]; $P < .01$). Among children aged 1 to 9 years, those with AAT had higher mortality (adjusted rate [95% CI]: 9.2% [5.0%–16.1%] vs 2.7% [2.2%–3.2%], $P < .01$). There was no significant difference in mortality for children aged younger than 1 year.

CONCLUSIONS: Children hospitalized for AAT generally had poorer short-term outcomes compared with children with noninflicted abdominal trauma. Studies to explain these differences are needed. In addition, efforts to prevent these injuries and to assist families at risk should be supported. *Pediatrics* 2011;127:e1400–e1405

In 2006, there were ~3500 hospitalizations for abdominal trauma among US children 9 years old and younger. Nearly 6%, or just >200 of these hospitalizations, were for children with abusive abdominal trauma (AAT).¹ Among children aged younger than 1 year, 25% of all abdominal trauma was the result of child abuse.¹

Several studies have suggested that children with AAT have poorer outcomes than children with noninflicted injury; however, these studies included a select sample of children with inflicted abdominal trauma, limited to a single hospital or to pediatric trauma centers.^{2,3} The purpose of the present study was to examine a representative sample of young children with AAT to determine if an abusive mechanism is associated with poorer outcomes. We hypothesized that children with AAT would have higher mortality rates, longer hospitalizations, and higher charges for medical care than children with noninflicted abdominal trauma.

METHODS

The Kids' Inpatient Database (KID) is a database of inpatient hospital stays developed by the Agency for Healthcare Research and Quality as part of its Healthcare Cost and Utilization Project. It is the only all-payer inpatient care database for children in the United States. Data sets are released every 3 years, and each set contains a sample of 80% of all child acute care hospitalizations, with nearly 3 million hospitalizations from 36 states.

Specific data elements include up to 15 discharge diagnoses per hospitalization, up to 4 external cause of injury codes, patient demographics (age, gender, race, and insurance status), length of stay, procedures, and discharge disposition. The 2 most recent data releases are from 2003 and 2006. Hospitalizations for abdominal trauma were identified by using International

Classification of Disease, Ninth Edition, Clinical Modification (ICD-9-CM) codes 863.0 to 869.16 (abdominal organ injury) and 902.0 to 902.9 (abdominal vascular injury). A hospitalization was included in the analysis if any 1 of these ICD-9-CM codes was present in ≥ 1 of the 15 diagnosis variables contained in KID. Child abuse hospitalizations were identified by either an ICD-9-CM code for child abuse (995.5) or an external cause of injury code for inflicted injury (E-960–E-969).

Because the majority of child abuse injuries are identified in young children,⁴ cases were limited to children aged 9 years old or younger. All abdominal trauma hospitalizations for children ages 0 to 9 years were identified from the 2003 and 2006 KID databases and were combined into a single data file.

Specific outcomes examined included mortality, length of hospital stay, and total charges. In the KID databases, mortality is a dichotomous variable reflecting whether the child died before hospital discharge. Length of stay and total charges are both continuous variables.

Potential confounders/covariates examined included child's age, gender, race/ethnicity, payer, urban/rural residence, and income quartile of the residence zip code; all factors are included in KID data. Overall and regional severity of injury were also considered possible confounders; we hypothesized that adverse outcomes might be related to the overall injury severity or to the severity of the abdominal injury alone. Because injury severity is not included in KID data, the Injury Severity Score and the Maximum Abbreviated Injury Score were calculated from ICD-9-CM and external cause of injury codes using ICDMAP-90 software.^{5,6} The Injury Severity Score accounts for injuries in the 3 most severely injured body regions. The Modified Abbreviated Injury Score accounts for all body re-

gions; it also allows for calculation of injury severity for individual body regions. There were no differences in either of these scores or the maximum severity of abdominal injury between children with AAT and noninflicted injury. Therefore, these comparisons are not presented and were not included in the multivariable analyses.

Data Analysis

Demographic characteristics of children with AAT and noninflicted abdominal trauma were compared using χ^2 tests for dichotomous variables, Student's *t* tests for continuous variables, and Wilcoxon rank tests for nonnormal continuous variables. Because the values were very skewed, both means and medians were calculated for the length of hospital stay and total charges variables. Differences in demographic characteristics for each outcome were also compared with identifying potential confounders.

Multivariable linear regression models were created for the 2 continuous outcomes: length of stay and total charges. Children who died during hospitalization were excluded from these analyses to eliminate the effect of mortality early in hospitalization on length of stay and hospital charges. Because the hospital charges data were not normally distributed and were very skewed, a log transformation model for charges was developed. β coefficients and 95% confidence intervals (CIs) were calculated for the effect of AAT versus noninflicted injury on the length of stay and the log-transformed hospital charges. Estimated geometric mean charges and lengths of stay were calculated for children with both AAT and noninflicted injury.

A multivariable logistic regression model was created for the mortality analysis. An adjusted odds ratio and 95% CI for the effect of AAT versus non-

inflicted injury on the likelihood of mortality was calculated. Estimated mortality rates were calculated for children with both AAT and noninflicted injury. Because an interaction between age and mortality was identified, separate models were developed for children younger than 1 year of age and children aged 1 to 9 years.

All multivariable models included confounders that were identified in bivariate analyses as significant at a level of $P < .10$.

Because data on race were missing for approximately one third of children, all multivariable analyses were performed twice, once including race and once excluding race. None of the inferences changed significantly when race was included or excluded. Therefore, only models without race are presented in the results.

RESULTS

The combined 2003 and 2006 KID data included 234 children with AAT and 4200 with noninflicted abdominal injury. Sixty-four percent were male, and the mean age was 5.2 months. On bivariate analysis, children with AAT were younger than those with noninflicted injury, with a mean (SD) age of 2.0 (2.4) versus 5.4 (2.7) years ($P < .01$) (Table 1). Children with AAT were more likely to be a minority (AAT: 38.0% black and 27.2% Hispanic; noninflicted injury: 15.0% black and 20.1% Hispanic; $P < .01$), insured by Medicaid (74.8% vs 36.1%; $P < .01$), and live in zip codes with the lowest median income (41.0% vs 28.8%; $P < .01$). There was no significant difference in the percentage of males in the AAT and noninflicted groups.

Several significant differences were noted on bivariate analysis regarding outcomes for children with AAT compared with those with noninflicted injury (Table 2). For example, children with AAT had higher mortality rates

TABLE 1 Demographic Characteristics of Patient Populations: Children With Noninflicted Injury Versus AAT Aged 0 to 9 Years

Demographic Characteristic	Noninflicted Injury (<i>n</i> = 4200) ^a	AAT (<i>n</i> = 234) ^a	<i>P</i>
Age, mean (SD), y	5.4 (2.7)	2.0 (2.4)	<.01 ^b
Male gender, <i>n</i> (%)	2610 (64.1)	134 (59.0)	.12 ^d
Race, ^c <i>n</i> (%)			
White	1628 (56.2)	47 (29.8)	<.01 ^d
Black	435 (15.0)	60 (38.0)	
Hispanic	607 (20.1)	43 (27.2)	
Other	224 (7.7)	8 (5.1)	
Payer, <i>n</i> (%)			
Medicare/Medicaid	1512 (36.1)	175 (74.8)	<.01 ^d
Private	2224 (53.1)	33 (14.1)	
Self-pay/no charge/other	451 (5.1)	26 (1.2)	
Total used in analyses	4187	234	
Income quartile, <i>n</i> (%)			
Lowest quartile	1179 (28.8)	93 (41.0)	<.01 ^d
Quartile 2	1082 (26.4)	59 (26.0)	
Quartile 3	1007 (24.6)	59 (26.0)	
Highest quartile	823 (20.1)	16 (7.0)	
Urban/rural residence, <i>n</i> (%) ^e			
Large metropolitan	2118 (50.9)	131 (57.0)	.02 ^d
Small metropolitan	1234 (29.6)	72 (31.3)	
Micropolitan	477 (11.4)	19 (8.3)	
Noncore	333 (8.0)	8 (3.5)	

^a Sum of numbers in each demographic category may be less than total *n* because of missing data.

^b According to Student's *t* test.

^c Race percentages do not include children with no race data available (1306 children with noninflicted injury and 76 children with AAT).

^d According to χ^2 test.

^e Large metropolitan refers to counties in metropolitan areas with >1 million residents; small metropolitan refers to counties in metropolitan regions with <1 million residents; micropolitan refers to counties with an urban population of 20 000 to 49 999 adjacent to a metropolitan area; and noncore refers to all other counties.¹³

TABLE 2 Unadjusted Outcomes for Children With Noninflicted Injury Versus AAT

Outcome	Noninflicted Injury (<i>n</i> = 4200)	AAT (<i>n</i> = 234)	<i>P</i>
Died, <i>n</i> (%)	143 (3.4)	21 (9.0)	<.01 ^a
Died at age <1 y ^b	32 (14.5)	7 (9.1)	.22 ^a
Died at age 1–9 y ^c	111 (2.8)	14 (8.9)	<.01 ^a
Mean (SD) length of stay, d	6.3 (10.1)	9.9 (10.8)	<.01 ^d
Median (IQR) length of stay, d	4 (2–6)	6 (3–11)	<.01 ^e
Mean (SD) charges, \$	\$40 351 (71 377)	\$52 383 (65 611)	.01 ^d
Median (IQR) charges, \$	\$17 911 (9288–39 372)	\$28 570 (14 887–62 843)	<.01 ^e
Mean (SD) no. of procedures	1.9 (2.9)	2.8 (3.4)	<.01 ^d
Mean (SD) no. of discharge diagnoses	4.6 (3.5)	7.6 (4.1)	<.01 ^d
Disposition (excludes deaths), <i>n</i> (%) ^f			
Routine	3692 (88.0%)	182 (78.1%)	.058 ^a
Transfer to other acute hospital	107 (2.5%)	8 (3.4%)	
Other transfer	151 (3.6%)	15 (6.4%)	
Home health care	102 (2.4%)	6 (2.6%)	
Left against medical advice	1 (0.02%)	0 (0.0%)	
Unknown	1 (0.02%)	1 (0.4%)	

IQR indicates interquartile range.

^a According to χ^2 tests.

^b Denominators for these percentages are as follows: *n* = 220, <1 year; *n* = 3980, 1–9 years.

^c Denominators for these percentages are as follows: *n* = 77, <1 year; *n* = 157, 1–9 years.

^d According to Student's *t* test.

^e According to Wilcoxon rank test.

^f Examples of other transfers include transfer to skilled nursing facility or intermediate care. One child with noninflicted injury who left against medical advice and 1 child from each group with unknown disposition were excluded from the analysis because of small numbers.

TABLE 3 Length of Stay and Total Charges for Children With Noninflicted Injury Versus AAT According to Multivariable Analysis^a

Outcome	Adjusted Mean (95% CI)	P
Length of stay, d ^b		.03
Noninflicted injury (n = 4042)	6.4 (6.1–6.7)	
AAT (n = 212)	7.9 (6.6–9.3)	
Charges (geometric mean, \$) ^c		<.01
Noninflicted injury (n = 3948)	\$19 341 (\$18 770–\$20 131)	
AAT (n = 207)	\$24 343 (\$20 952–\$28 567)	

^a Includes only children who survived to discharge. Analyses conducted using linear regression for length of stay and transformed linear regression for charges.

^b Adjusted for age and insurance status.

^c Adjusted for age, insurance status, and urban/rural residence.

TABLE 4 Mortality Rates for Children With Noninflicted Injury Versus AAT According to Age Group From Multivariable Analyses^a

Outcome	Adjusted Percentage (95% CI)	P
Mortality age 1–9 y		<.01
Noninflicted injury (n = 3783)	2.7% (2.2–3.2)	
AAT (n = 113)	9.2% (5.0–16.3)	
Mortality age <1 y		.98
Noninflicted injury (n = 401)	9.7% (7.1–13.0)	
AAT (n = 120)	9.6% (5.4–16.5)	

^a Analyses conducted using logistic regression adjusting for insurance status.

(9.0% vs 3.4%; $P < .01$), longer lengths of stay (median [interquartile range]: 6 [3–11] vs 4 [2–6]; $P < .01$) and higher hospitalization charges (median: \$28 570 vs \$17 911; $P < .01$) compared with those with noninflicted injury. Children with AAT also had more procedures compared with those with noninflicted injury (mean [SD]: 2.8 [3.4] vs 1.9 [2.9]; $P < .01$).

On multivariable analysis, among children who survived to discharge, children with AAT had more than twice the odds of being hospitalized for longer than the median length of stay of 4 days (odds ratio: 2.4 [95% CI: 1.7–3.5]; $P < .01$) (data not shown). Those with abusive injury had an adjusted mean length of stay of 7.9 days (95% CI: 6.6–9.3) compared with 6.4 days (95% CI: 6.1–6.7) for those with noninflicted injury ($P = .03$) (Table 3). Mean charges were also higher among children with AAT. After adjustment for age, urban versus rural residence, and insurance status, the mean hospital charge for children with AAT was \$24 343 (95% CI: \$20 952–\$28 567) and the mean charge for children with noninflicted

injury was \$19 341 (95% CI: \$18 770–\$20 131) ($P < .01$).

Among children aged 1 to 9 years, those with AAT had significantly higher adjusted mortality rates compared with children with noninflicted injury (adjusted mortality rate [95% CI]: 9.2% [5.0–16.3] for AAT vs 2.7% [2.2–3.2] for noninflicted injury; $P < .01$) (Table 4). However, among infants, there was no significant difference in adjusted mortality rates between children with AAT versus noninflicted injury (adjusted mortality rate [95% CI]: 9.6% [5.4–16.5] for AAT vs 9.7% [7.1–13.0] for noninflicted injury; $P = .98$).

DISCUSSION

Our results found that children with AAT often have worse short-term outcomes when compared with children with noninflicted abdominal trauma. These outcomes include longer hospitalizations, higher charges, and higher mortality rates. The 1 exception was among infants, in whom mortality rates were not significantly different for children with AAT and noninflicted abdominal injury.

These outcomes are similar to those seen in several other studies of children with AAT and abusive head trauma.^{3,7,8} These studies found longer ICU and overall hospital stays,⁷ poorer short-term outcomes,⁷ and higher mortality rates^{3,8} for children with abusive injury when compared with children with noninflicted injury. Most studies have also found abusive injuries to be more severe,^{2,3,8} with the exception of the study by Keenan et al.⁷

In a 10-year retrospective review of abdominal trauma at a children's trauma center, Wood et al² found that children with abusive injuries had a higher number of injuries and more severe injuries than children with noninflicted injury. Trokel et al,³ examining data from the National Pediatric Trauma Registry, found higher mortality rates for children with AAT compared with those with noninflicted injuries. Both of these studies included only children hospitalized at designated children's trauma centers; therefore, the average injury severity was higher than what would be seen in a sample of all hospitals, such as found in the KID database.

Several reasons could explain the poorer outcomes among abused children. First, children with abusive injuries often present to the hospital with absent or misleading histories, as the caregiver either does not know what happened or does not want others to know. The absence of injury history may increase the likelihood of misdiagnosis and may delay appropriate treatment until the child has more obvious and life-threatening sequelae. The higher number of procedures in the abused children in our sample may reflect the need for more tests to make a diagnosis in the absence of an accurate history, and may partly explain the higher charges. In a review of abdominal trauma hospitalizations, Canty et al⁹ suggested that absent history could

lead to poorer outcomes. However, their data do not support the hypothesis, as 5 of 15 children with abusive injuries (33%) and 29 of 64 children with noninflicted injuries (45%) were diagnosed with abdominal injuries >4 hours after hospital presentation. Unfortunately, testing this hypothesis was not possible with the KID database because data regarding the time between presentation and diagnosis are not available.

Another possibility is that caregivers delay seeking care for children with abusive injuries because they are unaware of the history or they hope that the child will get better and avoid the need for medical care.^{2,9,10} Canty et al⁹ suggested this possibility as well. Of 79 children with blunt abdominal trauma in their case series, 8 had delayed presentations for medical care, and 5 of the 8 were children with abusive injuries. Wood et al² tested this hypothesis and found no significant differences in the proportions of abused and nonabused children with delays in seeking care.

A third possibility is that the types of abdominal injuries seen in abuse are different from injuries seen in noninflicted trauma. Several studies have shown that hollow viscous injury and pancreatic injury are more common in abused children.^{1,2,11,12} Hollow viscous injuries may present in a delayed fashion with peritonitis. By the time peritonitis develops, the child may be quite ill, require prolonged hospitalization, and have a high risk of mortality. Pancreatitis may present insidiously, causing confusion with other causes of vomiting and abdominal pain in children. By the time the diagnosis is made, the child may

be very ill and again require prolonged hospitalization.

A fourth possibility is that there are differences between children with AAT and noninflicted injury in the types and number of extra-abdominal injuries. Although such differences may exist, the lack of any difference in injury severity between the 2 groups suggests that factors other than differences in the type and number of extra-abdominal injuries are more likely to explain differences in outcomes.

Higher charges and longer hospital stays in the children with abusive injuries could also be the result of child protective services involvement. When there are concerns that a child may have been injured by a caregiver or household member, discharge may be delayed to establish a safety plan, remove a suspect from the home, or find foster or kinship care placement.

The finding that there was no difference in mortality among infants with abusive versus noninflicted abdominal trauma was surprising. This lack of difference is primarily explained by a high mortality rate for infants (9.7%) and a low mortality rate for older children (2.7%) with noninflicted injury. In contrast, mortality rates for infants with abusive injury were similar to those for older children (9.6% vs 9.2%). It is possible that because older children are ambulatory and active, they are more likely than younger children to sustain abdominal injuries from falls and contact sports, whereas infants who sustain noninflicted abdominal injuries do so primarily in automobile crashes, with a higher risk of fatality.

Our study does have limitations. First, although the KID database includes 80% of all child hospitalizations, it is not a perfect representation of all US hospitalizations. However, the database does provide a broader sample, with a presumed wider range of severity, than pediatric trauma databases. Another limitation was the absence of data on race for one third of the sample. Although our findings were the same whether race was included or excluded from the models, we were unable to look specifically at outcomes by race.

Strengths of our study should be noted. First, to the best of our knowledge, this is the first study to examine outcomes of AAT among children hospitalized at any acute care hospital, not just trauma centers. This allowed us to include children with injuries that might not have been severe enough to warrant admission to a trauma center. Our large sample size is also a strength, because it allowed us to stratify our data to examine outcomes according to age group.

CONCLUSIONS

Children hospitalized for AAT generally had poorer short-term outcomes compared with children with noninflicted abdominal trauma. Additional studies to explain these differences are needed. In addition, efforts to prevent these injuries and to assist families who have risk factors for maltreatment should be encouraged and supported.

ACKNOWLEDGMENT

Support for this work was provided by the National Institute of Child Health and Human Development, National Institutes of Health, grant 1K23HD055515-01A1.

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