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Distinguishing Inflicted versus Accidental Abdominal Injuries in Young Children

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Objectives: **To compare the presentation of young children with abdominal trauma caused by high-velocity accidental (HVA), low-velocity accidental (LVA), and inflicted injury, and to test the hypothesis that a delay in care is highly predictive of an inflicted injury.**

Methods: **We performed a retrospective chart review at an urban Level I pediatric trauma center between 1991 and 2001 of children younger than 6 years who were admitted with abdominal injuries and an Abbreviated Injury Scale (AIS) score ≥ 2. Charts were abstracted for demographic information, history of presentation, mechanism of injury, and diagnoses. Accidental injuries were defined as high velocity (motor vehicle crash or a fall from > 10 feet) or low velocity (household trauma, bicycle crash, or a fall from < 10 feet). Inflicted trauma was defined as a constellation of unexplained injuries, confessions by a perpetrator, or disclosure by the victim.**

Results: **Of the 121 children in the study, 77 (64%) had HVA injuries, 31 (26%) had LVA injuries, and 13 (11%) had inflicted injuries. Solid organ injuries (e.g., liver, spleen, and kidney) were most common in all groups, and abused children were significantly more likely to have suffered a hollow viscus injury ($p = 0.03$). Abused children were also significantly more likely to have suffered injuries with an AIS score >3 and combined hollow viscus and solid organ injuries than the HVA group or the LVA group ($p < 0.001$). Presentation for medical care occurred within 12 hours for 100% of the HVA group but only 65% of the LVA group, and 46% of the abuse group ($p < 0.001$). Presentation to care at greater than 12 hours was neither specific nor highly predictive of abuse, as some children with LVA injuries presented for care late despite developing symptoms shortly after their injury occurred (specificity, 65% [95% confidence interval, 45–81%]; positive predictive value, 39% [95% confidence interval, 17–64%]).**

Conclusion: **Young children with inflicted abdominal injuries are more likely to have more severe injuries, multiple injuries, and a delay in seeking care than young children with accidental abdominal trauma. However, delay in seeking care is not specific for inflicted injury and occurs in some children with LVA abdominal trauma.**

Key Words: **Abdominal trauma, Child abuse, Motor vehicle crash, Household trauma.**

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Major blunt abdominal trauma is a rare but particularly deadly form of child abuse. Only 1% of children hospitalized because of child abuse sustain intra-abdominal injury.[1–3] The mortality rate in this population varies from 45% to 50%, making abdominal trauma the second most common form of fatal physical child abuse.[1,4]

One reason that inflicted abdominal trauma has significant morbidity and mortality might be the difficulty in achieving a timely diagnosis. Early diagnosis is more problematic, given the rarity of intentional blunt abdominal trauma in pediatric patients, the inaccurate and misleading histories often provided by the caregiver, and the frequent lack of external abdominal bruising, even in cases of severe internal injuries.[1,3–6]

Another factor that may contribute to increased mortality is the delay to care that occurs frequently after an inflicted abdominal injury. Traditionally, a delay in seeking medical attention has been associated with inflicted abdominal trauma and is often considered to be suggestive of abuse.[1,5,7] Cooper and colleagues reported that the median delay in presentation to care among 22 children with inflicted abdominal trauma was 13 ± 9 hours.[1] Canty et al. reported that a third of abused children in their study with blunt trauma to the gastrointestinal tract presented after more than 24 hours had elapsed since the injury occurred.[7] Finally, Ledbetter et al. reported that in contrast to the 91% of accidentally injured children who presented for care within 3 hours, all of the children with inflicted injury had a delay in presentation to care.[5]

Given the evidence of the increased likelihood of inflicted abdominal injury among children who are brought to care long after an injury occurred, our hospital's trauma team and child protection team were surprised to encounter a small but significant number of children with accidental abdominal injuries who presented to care more than 12 hours after an injury occurred. This led us to question the value of 'delay to

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care' as an indicator for abuse among young children with accidental injuries. We thus conducted a retrospective study to compare the presentation of young children with accidental abdominal injuries versus inflicted abdominal injuries seen in our hospital. The primary goal was to report the characteristics of young children who present with abdominal injury resulting from accidental and inflicted causes. The secondary goal was to determine whether a delay in care as an isolated finding or in combination with other factors has sufficient sensitivity and specificity and predictive value to support the diagnosis of child abuse.

PATIENTS AND METHODS

A retrospective review was performed of children younger than 6 years old with blunt abdominal trauma who were admitted to a large, urban pediatric trauma center between January 1991 and September 2001. Children were included if they sustained intra-abdominal injury with an Abbreviated Injury Scale (AIS) score ≥ 2. The AIS is an anatomically based, consensus-derived system of classifying individual injuries by body region and severity[8] and has been widely used in other studies of pediatric trauma.[9–12] The scale ranges from 1 for minor injuries to 6 for lethal injuries.[8] Choosing an AIS score of ≥ 2 allowed us to identify those patients who had suffered injury to their intra-abdominal organs and exclude those with only minor abdominal wall injuries.

Among the children with abdominal AIS scores ≥ 2, we excluded those who had other significant injuries that may have prevented adequate assessment of abdominal symptoms at the time of their presentation. Specifically, children with clinical or radiologic evidence of head trauma and a Glasgow Coma Scale score < 14, children with spinal trauma, and children with significant thoracic trauma were excluded. In addition, children who were victims of inflicted injury but for whom no history of injury was provided (parents/caregivers denied any trauma) were excluded because an adequate assessment of the time that elapsed between when the injuries occurred and when the children presented for medical care was impossible.

Demographic information and data regarding injury outcomes, types of injuries, and the time that elapsed between injury and presentation for medical care were collected. The injury mechanisms were categorized as high-velocity accidents (HVA), low-velocity accidents (LVA), and abuse. The HVA group included motor vehicle crashes and falls greater than 10 feet. The LVA group was composed of falls less than 10 feet, bicycle crashes, and household trauma. The mechanism of injury was classified as abuse if the institutional child protection team at the hospital was asked to evaluate the child and if one of the following criteria were met: there were other unexplained injuries; a perpetrator confessed to injuring the child; or the child disclosed that the injury was inflicted. Any child for whom the child abuse team could not make a clear distinction between abuse or accidental trauma was not included in the study.

In addition to basic demographic variables, the primary predictors for which data were collected included time to care, severity of injury, and type of injury. Time to care was calculated as the time elapsed from when the initial injury occurred (on the basis of parent report) to when the child first presented for medical attention. The patients were classified as having presented for care within 2 hours, within 12 hours, or at greater than 12 hours. To better account for multiple abdominal injuries, we calculated a total AIS score for the abdomen by summing the individual AIS scores for the identified abdominal injuries for each individual. Severity of injury was dichotomized into those with a total AIS score of ≤ 3 (serious) and those with an AIS score of > 3 (severe to lethal). This total AIS score was obtained by summating all abdominal AIS scores that were > 2 for a given child. Finally, the types of injuries were classified as hollow organ injuries, including bowel and bladder injuries, and solid organ injuries, including liver, spleen, and pancreas and kidney injuries. Cases of adrenal injury or isolated gross hematuria in which a definitive diagnosis of bladder or kidney injury could not be made were classified as "other."

The data were described for each injury group using means and standard deviations for continuous variables and frequencies for categorical variables. Bivariate χ^2 analysis tested for the unadjusted association between study variables and the likelihood of inflicted injury. Because of small sample size, recursive partitioning was used to evaluate the specificity and positive predictive value of "delay to care" as an indicator of abuse, particularly when used in combination with other factors that have been traditionally associated with abusive injuries (e.g., young age and severity of injury).[3,5,13]

RESULTS

During the study period, 208 children younger than 6 years old who had sustained abdominal injuries with an AIS score of 2 or greater were admitted to the hospital. The records of 203 of the children (98%) were available for review. Of the 203 children, 63 were excluded because of associated neurologic injury, 7 were excluded secondary to severe thoracic injury, and 10 abused children were excluded because there was a denial of any trauma. One child was excluded because the injuries could not be classified as accidental or inflicted. An additional child was excluded because of the difficulty in identifying a time of initial injury. The remaining 121 cases were included in the study.

Of the 108 children with accidental trauma (89% of the total cohort), HVA trauma occurred in 77 children (63% of the total cohort) and LVA trauma occurred in 31 children (26% of the total cohort). The remaining 13 children (11% of the total cohort) sustained inflicted abdominal trauma. The determination of inflicted trauma was supported by confessions in 3 of the cases, disclosures by the children in 3 of the cases, and the existence of multiple injuries in 12 of the cases

Table 1 **Presentation of the 13 Children with Inflicted Abdominal Injuries**

Presentation	Abdominal Injuries	Extra-abdominal Injuries (n = 12)	Confession (n = 3)	Disclosure (n = 3)
2-yr-old who was noted to be ill appearing by a nurse at the drug rehab ilitation center where she lived	Liver laceration and renal contusion	None	Yes	No
4-yr-old who was heard crying by neighbors, who called the police	Liver laceration, liver and kidney hematoma, traumatic pancreatitis	Bruises, rib fracture, rhabdomyolysis	Yes	No
3-yr-old with lethargy and facial bruises after falling and hitting his head	Traumatic pancreatitis and hepatitis	Bruises, abrasions, pneumothorax	No	No
3-yr-old with lethargy, bloody emesis and no history of trauma	Liver laceration, pancreatic and duodenal transection	Bruises on face, torso, and extremities	No	No
4-yr-old with abdominal pain and lethargy after falling in the shower	Jejunal tear, traumatic hepatitis and pancreatitis, mesenteric hematoma	Bruises on face, abdomen, and limbs; rhabdomyolysis	No	Yes
4-yr-old with a history of lethargy and emesis after falling and hitting her head	Pancreatic transection, duodenal-jejunal perforation, liver lacerations, splenic and renal contusions	Bruises on head and abdomen, alcohol ingestion	Yes	No
1-yr-old with emesis, cough, respiratory distress, and lethargy	Liver laceration, traumatic pancreatitis	Bruises, burn, lung contusion, rib and radial fractures	No	No
3-yr-old with bruises, abdominal pain, and emesis after being alone with mother's paramour	Mesenteric and duodenal tear, ischemic colon, liver laceration, traumatic pancreatitis, retroperitoneal bleed	Bruises on head and torso, decreased rectal tone	No	Yes
2-yr-old with bruises after being alone with mother's paramour	Hepatic contusion	Bruises on entire body, bite marks	No	No
2-yr-old with irritability and no history of trauma	Liver laceration	Rib fractures, pulmonary contusion	No	No
3-yr-old with abdominal pain and emesis after his stepfather hit him	Traumatic pancreatitis, renal contusion	Bruises on torso and thigh	No	Yes
1-yr-old with bruises and irritability after being alone with his father	Liver laceration	Bruises on face, torso, subdural hematoma	No	No
4-yr-old with abdominal pain, scrotal pain, and emesis after being kicked by a classmate	Bile duct transection, mesenteric and colonic contusions, liver laceration	Yes—right groin hematoma	No	No

T1 (Table 1). A delay in care was not used to diagnose inflicted trauma in any of the 13 cases.

Characteristics of the study population are listed in Table T2 2. The mean age of all children was 49 months, and 21% of the children were younger than 3 years of age. Most children sustained injuries to solid organs (68%), whereas a minority of children had hollow viscus injuries (19%) or isolated hematuria or adrenal injury (25%). A small group of children (5%) had combined injury to hollow viscus and solid organs.

The comparison of accidental and inflicted injury groups T3 appears in Table 3. The abused children were significantly younger than the accidentally injured children ($p = 0.001$) (Table 3). More than half of the abused children were younger than 36 months old, but only 22% of the HVA group and 3% (one child) in the LVA group were younger than 36 months old. There was no statistically significant difference in gender or race between the abused and accidentally injured children, although among the accidentally injured children, those in the HVA group were significantly more likely to be African American and those in the LVA group were more likely to be Caucasian.

Some significant differences in types of injury were noted between the accidental and inflicted injury groups. The frequency of solid organ injuries was similar among the HVA, LVA, and abuse groups, but hollow organ injuries were significantly more likely to occur in the abused children

Table 2 Characteristics of the Study Population (n = 121)

Characteristic	Value
Age (mo)	
Median (range)	52 (1.2–71.7)
Mean (SD)	49 (16)
Race (%)	
Caucasian	47
African American	46
Other	7
Gender (%)	
Male	60
Female	41
Type of injury (%)	
Solid organ	68
Hollow viscus	18
Other[a]	25
Combined[b]	5
Time to care (hr)	
Median (range)	0.5 (0.17–336)
Mean (SD)	8.4 (33.3)
Severity of injury	
Mean (SD)	3.3 (2.3)
Median (range)	2 (2–18)

[a]Other category included adrenal injuries and cases of isolated hematuria that could not be further classified as bladder or renal injuries.

[b]Combined category included injuries to both a hollow viscus organ and a solid organ.

Table 3 Comparison of Accidental and Inflicted Injury Groups

	HVA (n = 77)	LVA (n = 31)	Abuse (n = 13)	*p* Value
Age (%)				
<36 mo	22	3	54	0.001[a]
Race (%)				
Caucasian	38	71	46	0.023
African American	55	23	54	
Other	8	6	0	
Gender (%)				
Male	55	74	54	0.155
Female	45	26	46	
Type of injury (%)				
Solid organ	61	74	92	0.056
Hollow viscus	14	16	46	0.031[a]
Other	32	16	0	0.019[a]
Combined	0	0	39	<0.001[a]
Time to care (%)				
< 2 hr	99	42	15	<0.001[a]
<12 hr	100	65	46	<0.001[a]
Severity of injury				
Mean AIS score (SD)	2.8 (1.5)	3.1 (1.2)	6.3 (4.7)	
Median (range)	2 (2–11)	3 (2–6)	4 (2–18)	0.011[b]
AIS score < 3 (%)	78	65	23	<0.001[a]
AIS score > 3 (%)	22	35	77	<0.001[a]

[a]Significant association among injury groups measured at $p < 0.05$.

[b]Significant *p* value for nonparametric comparison of the three groups.

F1 than in the HVA or LVA group ($p = 0.03$) (Fig. 1). The presence of both a hollow organ and a solid organ injury occurred exclusively in the abused group. There were also significantly more children with severe injuries (AIS score > 3) in the inflicted than in the accidental injury groups ($p < 0.001$).

Examination of time to care at ≤ 2 hours and ≤ 12 hours revealed more significant differences among the injury groups. All but one child involved in HVA trauma presented within 2 hours after the injury. Thirteen of the children (42%) in the LVA group presented within 2 hours and only 2 (15%) of the abused children were brought to medical attention within 2 hours ($p < 0.001$). By 12 hours, the majority, or 20 of the LVA-injured children (65%), were brought for medical care but only 6 (46%) of the abused children had been brought for care ($p < 0.001$).

Because of low sample size, particularly in the inflicted injury group, we pursued additional analysis with recursive partitioning to understand the potential importance of delay to care (presentation to care > 12 hours after the injury occurred) as an indicator of abuse. Figure 1 shows a cascade in which the combination of delay to care with increasing severity (AIS score > 3) can be used to increase the positive predictive value for detecting inflicted injury among the cohort. Because the HVA injuries usually present from the scene of the accident and are not suspicious for inflicted injury, these children are excluded from this analysis. As such, the prevalence of inflicted injury, once children with HVA trauma are excluded, is only 30% among children younger than 6 years of age. As a single indicator, this figure shows that delay to care has a specificity of only 65% which, given the prevalence of only 30% overall inflicted injury in the cohort, results in only a modest predictive value of 39%. However, when the group is further restricted to only those children with severe intra-abdominal injury (AIS score > 3), the specificity improves to 90%, yet the predictive value increases to only 67%. This increase in specificity is only modest, with three of nine children falsely labeled as abused using this combination of risk factors. Among the children with accidental injury, delay to care, and AIS score > 3 were a 4-year-old who sustained splenic lacerations from a fall from a jungle gym, a 5-year-old who sustained splenic lacerations from blunt impact with bicycle handlebars, and a 4-year-old who sustained a jejunal perforation after falling onto a rock.

DISCUSSION

Intentionally inflicted abdominal trauma carries a high mortality rate among pediatric patients but is a rare trauma mechanism. Because of its uncommon nature, the presentation of inflicted abdominal trauma in children has not been well studied. Several differences in the presentation of abdominal trauma among abused and accidentally injured pediatric patients were identified in this study, including age, type of injury, severity of injury, and the time to presentation

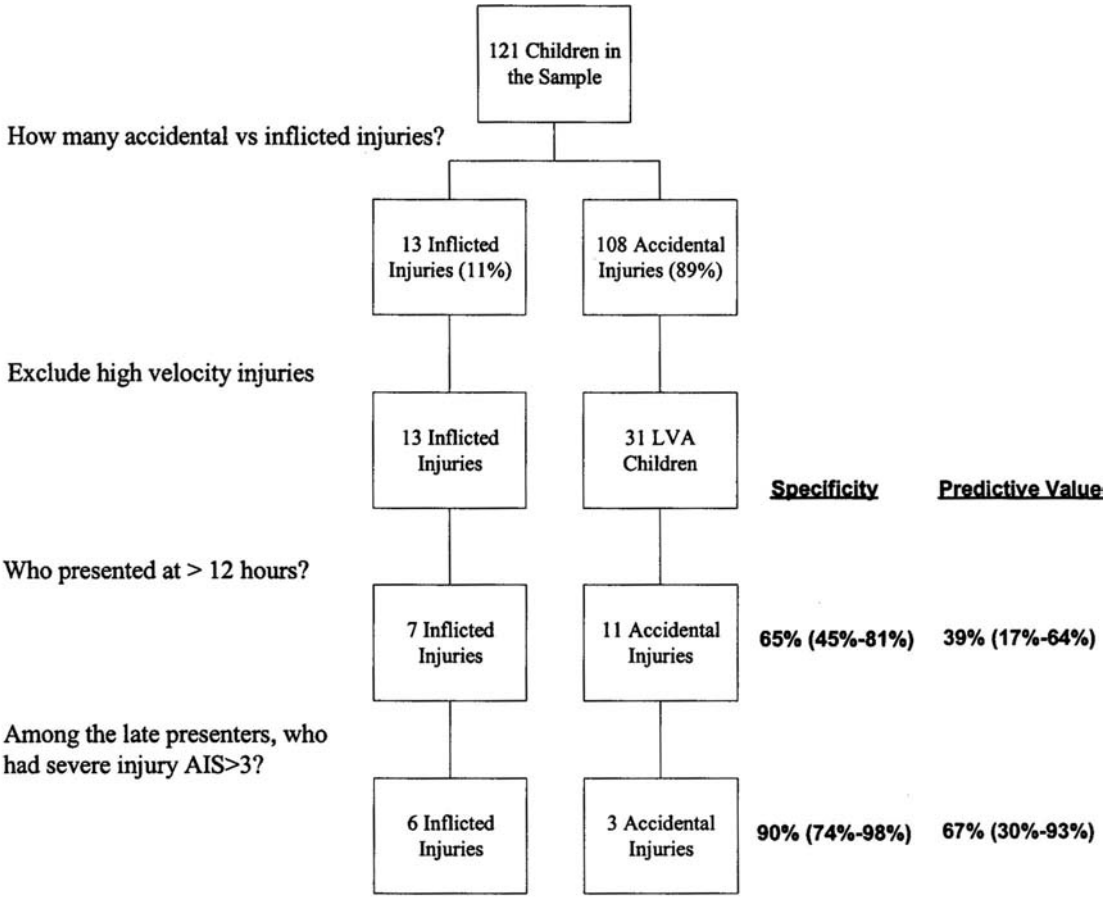

Fig. 1.

for care. By comparing children with accidental injuries to those with inflicted injuries, this study not only identified important clinical features associated with inflicted abdominal injury but allowed us to consider their individual importance to the determination of abuse.

We found a significant association of hollow viscus injuries and combined hollow viscus with solid organ injuries among the children with inflicted injury. In fact, none of our accidentally injured children sustained both hollow viscus and solid organ injuries. The differences in the injury pattern between intentional and accidental injury groups are consistent with earlier studies of nonaccidental abdominal injuries. Ledbetter et al. studied 156 pediatric patients with abdominal trauma. Only 8% of the accidentally injured children, compared with 65% of the intentionally injured children, had hollow viscus injuries.[5] Similarly, in our study, the rate of hollow organ injuries was almost three times higher among the abused children than among the accidentally injured children. These results suggest that when a child presents with a hollow viscus organ injury, particularly when another solid organ injury is present, a high index of suspicion of abuse must be maintained.

In addition, we found that whether used in isolation or restricted to children with more severe injuries, the predictive value of delay to care as an indicator of abuse rose only to 67%. This was mostly because the overall prevalence of inflicted injury among those with abdominal injuries younger than 6 years of age was only 30% in this cohort (when the HVA injuries were excluded). The inference is that one in three children with severe abdominal injuries resulting from household trauma who presented at $>$ 12 hours would be incorrectly labeled as abused if no other risk factors were considered. Although abuse is clearly more likely in this setting, such a finding suggests that clinicians should be conservative in their expert opinions on abuse when that opinion relies heavily on a family's delay in seeking care for their child.

This cautious approach to interpreting delay to care is also supported by emerging literature on pediatric abdominal injuries. Although there is some evidence that a delay in care for abdominal trauma is suggestive of abuse, there is also evidence that some children with accidental trauma, particularly to the bowel or pancreas, can also have delayed presentations.[14] Furthermore, the large proportion of abdom-

inal injuries that occur during motor vehicle crashes limits our understanding of time to presentation, because many children are brought directly from the scene of the crash to the hospital. In such cases, the time elapsed before the child presents for care is independent of the caregiver's response to a child's injury. As such, a strength of this current study is that it addresses this limitation by analyzing HVA and LVA injuries separately, and then by comparing LVA injuries with inflicted injuries.

There were several limitations in this study that may influence the results, including the retrospective nature of the study and the small sample size. Because the time to presentation was estimated from parent report of the time of injury, there is the potential for misclassification of these times. However, one might have expected parents to underestimate this period of time, particularly among those with inflicted injuries. The result of this bias would have been to falsely reduce the sensitivity of delay to care as an indicator for abuse without impacting specificity, which was the focus of this study. There was a potential bias in misclassifying accidentally injured children as abused based in part on a delay in presentation. However, such misclassification would falsely increase both the specificity and predictive value we reported. Seen in this light, the limited predictive value we report is even more striking. In addition, we limited the contribution of this bias by invoking objective criteria for abuse (e.g., perpetrator confession, child disclosure, other nonabdominal injuries) and by excluding any case for which the child protection team could not make a clear determination of abuse. Finally, the low sample size limited our ability to consider the contribution of multiple factors together as an indicator of abuse. Our recursive partitioning allowed us to consider the contribution of only two factors at one time, and it would have been helpful to also consider other factors in these analyses. For instance, the addition of age < 36 months to the analysis in Figure 1 would result in all of two children with inflicted injury to be correctly classified as abused, with 100% specificity and 100% predictive value. However, given the low sample size in this subgroup, the lower bounds of the confidence interval for this predictive value is only 16%, which becomes problematic for any inference about the likelihood of inflicted injury in this subgroup.

These limitations notwithstanding, this small study of intra-abdominal injuries in young children has helped to clarify the importance of clinical features that distinguish accidentally injured children from those with inflicted injuries. Although the presence of multiple injuries and a delay to care are associated with child abuse, neither approaches the specificity required to rely on those features alone for a diagnosis of abuse. Rather, such findings must be interpreted in light of other features of a child's history, namely, the age of the child, the mechanism of injury, and the presence of other injuries suspicious for abuse. Particularly in child abuse cases, where medical opinion can be a cornerstone for initiating social and legal interventions, it is essential that physicians understand the certainty that clinical findings have for indicating abuse. In the case of a child's time to presentation, this translates to the acceptance that a delay in care, although occurring more frequently among abused children, may also occur among children with significant injuries from low-velocity accidental trauma.

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