

# Incidence and Clinical Significance of Abdominal Wall Bruising in Restrained Children Involved in Motor Vehicle Crashes

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**Background:** Children involved in motor vehicle crashes (MVC) can sustain bruising of the abdominal wall associated with seat belt restraint. The incidence of bruising and its relationship with significant intraabdominal injuries are not known.

**Methods:** An analysis of children involved in MVC between December 1998 and November 2002 was performed, using the crash surveillance database from the Partners for Child Passenger Safety (PCPS) project. Optimally (OR) or suboptimally (S-OR) restrained children aged 4 to 15 years were selected. The incidence of abdominal wall bruising was calculated then correlated with the type of restraint as well as any intraabdominal injury with an Abbreviated Injury Scale score  $\geq 2$ .

**Results:** A total of 147,985 children in 102,548 crashes met study criteria. An abdominal bruise was noted in 1.33% of the children ( $n = 1,967$ ; 881 OR and 1,086 S-OR). Significant intraabdominal injury was present in 309 children (0.21%, 95% CI 0.13 to 0.33), including 69 OR and 240 S-OR. The

sensitivity, specificity, and positive and negative predictive values of abdominal wall bruising for a significant intraabdominal injury were 73.5%, 98.8%, 11.5%, and 99.9%, respectively. Children with a bruise were substantially more likely to have an intraabdominal injury than children without a bruise. (Odds Ratio 232.1, 95% CI, 75.9 to 710.3) Among those children with an abdominal bruise, 1% required an abdominal operation ( $n = 20$ ).

**Conclusions:** Abdominal wall bruising was relatively uncommon in both OR and S-OR children. Among restrained children involved in MVC, those with a bruise were 232 times more likely to have a significant intraabdominal injury when compared with those without a bruise. It is imperative to pursue intraabdominal injury in children with a bruise of the abdominal wall after MVC.

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**M**OTOR VEHICLE CRASHES (MVC) are the leading cause of unintentional injuries in children.<sup>1</sup> Significant intraabdominal injuries such as hollow viscus injury can occur, especially if the child is inappropriately restrained.<sup>2</sup> While assessing children with blunt abdominal trauma in an emergency setting, any clinical tool that can increase the sensitivity for detection of a significant intraabdominal injury is beneficial. Bruis-

ing of the abdominal wall has been reported previously as an indicator of intraabdominal injury in series of children admitted to a hospital.<sup>3-7</sup> Abdominal wall bruising has been associated with the use of suboptimal restraint (eg, lap belt only), but its true relationship with the type of seat belt used, as well as its true incidence among a large representative sample of restrained children involved in MVC are not known. The relationship between abdominal wall bruising and significant intraabdominal injuries among restrained children also is unknown. The aims of this study were to estimate the incidence of abdominal wall bruising among restrained children involved in MVC as well as the relationship between abdominal wall bruising and significant intraabdominal injury. Furthermore, the type of restraint used was evaluated and compared with the occurrence of bruising and of significant intraabdominal injury.

## MATERIALS AND METHODS

An analysis of children involved in MVC between December 1998 and November 2002 was performed, using the crash surveillance database from the Partners for Child Passenger Safety (PCPS) project. PCPS consists of a large-scale, population-based, child-specific crash surveillance system created by utilizing the electronic insurance claims

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database at State Farm Insurance Co (Bloomington, IL) to identify cases for study. Telephone interviews and on-site crash investigations serve as the primary sources of data.

Crashes qualifying for inclusion were those involving at least 1 child occupant ≤15 years of age riding in a model year 1990 or newer State Farm-insured vehicle. Qualifying crashes were limited to those that occurred in 15 states and the District of Columbia, representing 3 large regions of the United States. Detailed descriptions of the study population and methods involved in data collection and analysis have been published previously.<sup>8</sup>

Drivers of sampled vehicles completed a telephone survey providing information on circumstances of the crash as well as injuries to all child occupants. Validated survey questions regarding injuries to children were designed to provide responses that were classified by body region and severity based on the Abbreviated Injury Scale (AIS) score.<sup>9</sup> This validated anatomic scoring system ranks the injury from 1 to 6 and represents the “threat to life” associated with the injury.<sup>10</sup> The injury is considered significant with a score of 2 and above.

Selection criteria for this study included restrained children aged 4 to 15 years with a significant (AIS score ≥2) abdominal injury. The presence or absence of abdominal wall bruising was recorded. Non-specific or unknown abdominal injuries were excluded when no clarification could be found using medical records or information from in-depth crash investigations. Associated vertebral injuries (defined as injury to the neck, spine, or back), as well as the need for abdominal surgery, were recorded. Restraint status of children was determined from the telephone survey. Children were classified as optimally restrained (OR) or suboptimally restrained (S-OR). Optimal restraint was defined based on current age and weight guidelines suggested by the American Academy of Pediatrics and the National Highway Traffic Safety Administration.<sup>11</sup>

The overall incidence of abdominal wall bruising was calculated, as well as the sensitivity, specificity, and negative and positive predictive values. The relative risk for significant intraabdominal injury and the number needed to treat (NNT) were calculated. The NNT was used to estimate the number of children with a bruise who would require further medical evaluation to avoid missing 1 child with a significant intraabdominal injury. Analyses were conducted using methods to account for the unequal probabilities of selection of the cases. The 95% Confidence Intervals (CI) were provided for all estimates. A *P* value of less than .05 was considered statistically significant. The Institutional Review Board at The Children’s Hospital of Philadelphia has annually reviewed and approved the study since 1998 (IRB 1998-1-1163).

**RESULTS**

For the 48 months of review, 147,985 children involved in 102,548 crashes were included in the PCPS database. A bruise of the abdominal wall was noted in 1,967 children (881 OR and 1,086 S-OR), which represented 1.33% of the children (95% CI 1.11 to 1.59). A significant intraabdominal injury was diagnosed in 309

**Table 1. Distribution of Restrained Children Involved in MVC According to Significant Intraabdominal Injury and Type of Restraint**

	Significant Intraabdominal Injury	
	Present	Absent
Type of restraint		
Optimal	69	77,151
Sub-optimal	240	70,526

**Table 2. Distribution of Restrained Children Involved in MVC According to Significant Intraabdominal Injury and Abdominal Wall Bruising**

	Significant Intraabdominal Injury	
	Present	Absent
Abdominal wall bruising		
Present	227	1740
Absent	82	145,893

children (69 OR and 240 S-OR), which represented 0.21% of the population studied (95% CI 0.13 to 0.33). Among those children with a significant intraabdominal injury, 20 (6.47%) required abdominal surgery, including 16 with and 4 without a bruise. Among those children with an abdominal bruise (n = 1,967), 1% required an abdominal operation (n = 20). There were 77,220 OR children, including 881 (1.14%) with a bruise of abdominal wall, of whom, 51 had a significant intraabdominal injury. The remaining population of 70,765 S-OR children included 1,086 (1.53%) with an abdominal bruise, of whom, 176 had a significant intraabdominal injury. The relative risk for a significant intraabdominal injury in a S-OR child was 3.80 (95% CI, 2.00 to 7.23; *P* < .001) when compared with an OR child (Table 1). The sensitivity and specificity of abdominal wall bruising for a significant intraabdominal injury were 73.5% and 98.8%, respectively. The positive and negative predictive values of abdominal wall bruising for a significant intraabdominal injury were 11.5% and 99.9%, respectively. The relative risk of a significant intraabdominal injury in a child with abdominal wall bruising was 232.1 (95% CI, 75.9 to 710.3; *P* < .0001) when compared with a child without bruising (Table 2).

Given the risks of abdominal injury in children with and without abdominal bruises (0.115 and 0.00056, respectively), the number needed to treat (NNT) was 8.7. Of the 147,985 children from the database, 171 sustained a vertebral injury (0.12%). When considering children with an abdominal injury (n = 309), 45 had an associated vertebral injury (14.56%), 43 of whom did have a bruise of the abdominal wall and 2 of whom did not (Table 3). Among children with intraabdominal injuries, the relative risk of having a concomitant vertebral injury was 9.34 (95% CI, 2.21 to 122.56; *P* = .09) for children with

**Table 3. Distribution of Restrained Children Involved in MVC With a Significant Intraabdominal Injury According to Associated Vertebral Injury and Abdominal Wall Bruising**

	Vertebral Injury	
	Present	Absent
Abdominal wall bruising		
Present	43	184
Absent	2	80

a bruise of the abdomen when compared with children without a bruise.

## DISCUSSION

Several studies have assessed the relationship between bruising of the abdominal wall and intraabdominal injuries.<sup>3-7</sup> Based on very selected groups of patients admitted to emergency or trauma centers, they have reported an incidence of abdominal wall bruising from 20% to 60% cases, a significant intraabdominal injury in 6% to 16%. Our study is based on a large-scale, child-specific crash surveillance system and is the first to allow a true estimate of the overall incidence of abdominal wall bruising among a broad population of children involved in MVC and to assess more accurately its relationship with intraabdominal injury. We found that abdominal wall bruising was relatively uncommon (1.33%) among all restrained children involved in motor vehicle crashes. Children with a bruise were substantially more likely to have a significant intraabdominal injury when compared with those without a bruise. The absence of an abdominal wall bruise was associated with a very low risk for intraabdominal injury (0.1%). This 99.9% negative predictive value is driven by the large population of children studied in crashes of all severity and the relative rarity of an abdominal bruise and significant abdominal injury. One should not assume that the absence of a bruise equates with the absence of injury, because a small fraction of these children can still suffer from intraabdominal injury and may require abdominal surgery (4 children in our study). Vertebral injuries have been associated with blunt abdominal injuries.<sup>12</sup> Among children with intraabdominal injuries, we found that vertebral injuries were 9.3 times more likely to occur in children with a bruise of the abdominal wall when compared with children without a bruise, although this did not reach statistical significance.

Hollow viscus are the most commonly injured intra-abdominal organs in restrained children involved in MVC.<sup>2,13-15</sup> However, the diagnosis of blunt intestinal injury remains a challenge, and delayed treatment can have significant consequences.<sup>16-18</sup> Therefore, any relevant clinical sign that can increase the index of suspicion and help with the diagnosis of intraabdominal injury is useful to both emergency and trauma teams. The overall incidence of significant intraabdominal injuries in restrained children involved in a MVC was 0.21%, affecting more than 300 children in our study. The NNT was 8.7 and confirmed the clinical relevance of abdominal wall bruising. That is, 9 children with an abdominal bruise need to be further evaluated to diagnose a significant intraabdominal injury in 1 child. Thus, it is imperative to pursue intraabdominal injury in every restrained child with a bruise of the abdominal wall after MVC.

An abdominal bruise was slightly more frequent among S-OR children (1.53%) than among OR children (1.14%). Our previously reported case series showed that S-OR children were nearly 4 times as likely to sustain a hollow than a solid viscus injury when compared with OR children.<sup>2</sup> In the current study, S-OR children were 3.8 times as likely to suffer a significant intraabdominal injury when compared with OR children, emphasizing the need for every child traveling in a car to be optimally restrained, as recommended in the AAP guidelines.<sup>11</sup>

In the assessment of children involved in motor vehicle crashes, information about the type of restraint used is of great value. Similarly, bruising of the abdominal wall is a reliable indicator of possible significant intra-abdominal injury and should always be looked for.

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