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Driveway Injuries in Children: Risk Factors, Morbidity, and Mortality

Evan P. Nadler, MD; Anita P. Courcoulas, MD; Mary J. Gardner, RN; and Henri R. Ford, MD

ABSTRACT. *Background/Purpose.* Injuries that occur around the driveway are not typically regarded as reportable to the police and thus are often underrecognized. The aim of this study was to characterize the pattern and consequences of motor vehicle collisions that occur in the driveway.

Methods. Over the past 13 years, 64 patients admitted to the Children's Hospital of Pittsburgh sustained motor vehicle-related injuries in a driveway. These injuries resulted from a vehicle driven by an adult driver striking a child (group 1) or a child shifting an idle vehicle out of gear (group 2). We compared demographic variables and outcome measures between the 2 groups.

Results. There was no difference in gender, injury pattern, Injury Severity Score, length of stay, or operations performed between the groups. Patients in group 1 were younger, smaller, had a lower Glasgow Coma Scale, and had poorer outcomes. The majority of collisions (~65%) in group 1 resulted from a truck or sport-utility vehicle going in reverse.

Conclusions. Younger children are more severely injured in driveway-related crashes, which are most likely to be caused by a truck or sport-utility vehicle going in reverse. These vehicles should be equipped with additional safety features such as extended mirrors to visualize small children. *Pediatrics* 2001;108:326–328; *motor vehicle collision, driveway, sport-utility vehicle, light truck.*

ABBREVIATIONS. MVC, motor vehicle collision; ISS, Injury Severity Score; GCS, Glasgow Coma Scale; LOS, length of stay; SUV, sport-utility vehicle.

A significant number of motor vehicle-related injuries in children occur in the driveway.¹ Unfortunately, because such injuries are not typically regarded as reportable to the police, the magnitude of this problem may be underestimated.² Driveway-related injuries most commonly result from children being struck by motor vehicles³; children falling out of motor vehicles⁴; or unsupervised children setting a motor vehicle in motion.⁵ We retrospectively reviewed our experience with such injuries in children to characterize the pattern and consequences of motor vehicle collisions (MVCs) that occur in the driveway. Our secondary aim was to define any specific risk factors in each subgroup that

could provide potential targets for injury-prevention initiatives.

MATERIALS AND METHODS

Between May 1986 and August 1999, 9820 patients admitted to the Benedum Trauma Program at the Children's Hospital of Pittsburgh were entered in the pediatric trauma registry. Each patient entered in the database is assigned a narrative description detailing the mechanism of injury. The trauma registry was searched using the e-codes: 813.6 bike versus MVC; 814.7 pedestrian versus MVC; and 818.1 fall out of car. Among the patients identified by these codes, only those who sustained driveway-related injuries as described in the narrative were included in the study.

Of the 9820 patients admitted to the Benedum Trauma Program, 66 (0.67%) sustained motor vehicle-related injuries in or around a driveway, as confirmed by review of their medical records. Two patients were excluded from additional analysis because they were transferred from another institution >1 week after their initial injuries and had incomplete records. The medical records of the remaining 64 patients formed the basis of the review.

The patients were divided into 2 groups based on their mechanism of injury. Group 1 consisted of children who were struck by a vehicle driven by an adult driver who was unaware of a child's presence in the driveway. Group 2 consisted of children who were injured as a result of a vehicle being set in motion by a child driver. Demographic variables compared between the 2 groups included age, gender, weight, and type of vehicle involved. Outcome measures analyzed included organ system injured, Injury Severity Score (ISS), Glasgow Coma Scale (GCS), mortality, length of stay (LOS), operations performed, and the need for extended rehabilitation in a specialized center.

Standard statistical software (StatgraphicsPlus, v. 3.1, Manugistics Inc, Rockville, MD) was used to obtain summary statistics, including means and standard deviations for all continuous variables. Frequency distributions were determined for categorical variables. Univariate comparisons of patient characteristics for the 2 groups were performed using the Student's *t* test for normally distributed data. The Mann-Whitney test was used to compare median values for skewed data. The χ^2 test of proportions was used for categorical data. If the expected value of any cell was <5, then Fisher's Exact test was used. All statistical analyses were conducted as 2-tailed tests with a significance level of .05.

RESULTS

Over the past 13 years, 64 children who sustained motor vehicle-related injuries in or around a driveway were admitted to our Level 1 pediatric trauma center. The mean age was 3.37 years with a nearly equal gender distribution (Table 1). Patients in group 1 were significantly younger (median age) and weighed less than those in group 2. Similarly, more children under 2 years of age, but fewer children greater than 5 years of age were struck by a vehicle driven by an adult (Table 1). Of the 20 children included in group 2, there were 5 drivers who were injured as occupants, 9 drivers who jumped out of the moving vehicle, and 6 pedestrians (children) who were struck when an unsupervised child set a vehicle in motion. More than 50% of the MVCs that resulted

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TABLE 1. Demographics of Children Injured in Driveway-Related Crashes

	Total (n = 64)	Group 1 (n = 44)	Group 2 (n = 20)
Age in y (mean)	3.37 ± 2.4	2.0*	4.5
<2		19 (43%)‡	3 (15%)
2–5		22 (50%)	9 (45%)
>5		3 (7%)‡	8 (40%)
Gender distribution (M/F)	1.1 : 1	1.4 : 1	0.67 : 1
Weight (kg)	16.3 ± 6.5	12*	18
Type of vehicle			
SUV or truck	31	28‡	3
Car	26	16	10
Not available	7	0	7

* $P < .001$ Mann-Whitney test versus group 2; ‡ $P < .05$ Fisher's Exact test versus group 2.

The patients were divided into 2 groups based on their mechanism of injury: group 1 consisted of children who were struck by vehicles driven by an adult driver, while group 2 consisted of children who shifted a vehicle out of gear, thus setting it in motion. Data for continuous variables are presented as the mean ± standard deviation for normally distributed data, and the median value for skewed data (age and weight, groups 1 and 2). Categorical data are presented as the ratio of the 2 variables.

in injury in our study involved a light truck or sport-utility vehicle (SUV). The percentage was even greater for patients in group 1 (64%). During the past 5 years, 15 of 24 children (63%) were injured in events where a light-truck or SUV was involved. However, this percentage was not statistically different when compared with the first 8 years of the study. The direction of the vehicle was documented in 54 of the collisions; >80% of the crashes occurred with the car in reverse. The vast majority (92%) of collisions occurred during the day.

The majority of the injuries were to the musculoskeletal system followed by head and chest trauma (Table 2). No significant differences were noted in the pattern of injuries between the 2 groups. The mean GCS was 13.3 with a median score of 15 (Table 3). Patients in group 1 had a significantly lower GCS than those in group 2. None of the outcome variables was normally distributed. Median LOS was 3 days and the median ISS was 10. There was no difference in the LOS or ISS between the 2 groups. There was an increased number of craniotomies in group 1 that did not reach statistical significance ($P = .17$, Fisher's Exact test). The complication rate was 8% and did not differ between the 2 groups. Four patients required admission to a rehabilitation facility, and 4 patients died before discharge; all of these patients were in group 1.

DISCUSSION

MVCs account for the greatest number of deaths in the pediatric population.^{6,7} A significant number of

infants and children also sustain motor vehicle-related injuries in noncrash events.² Such events, which typically involve slow-moving vehicles, often take place around the driveway. They most commonly result from children being struck by motor vehicles,³ children falling out of motor vehicles,⁴ or unsupervised children setting a motor vehicle in motion.⁵ The morbidity and mortality associated with these driveway-related injuries may be quite severe,⁸ especially if a crush injury to the head is sustained.⁹ We undertook this retrospective analysis to characterize the pattern and consequences of MVCs that occur in the driveway, and to define distinguishing risk factors that may provide a potential target for injury-prevention strategies.

Our data show that children injured in driveway-related crashes were on the average <4 years old with a near equal gender distribution. The median ISS in our series was 10. The musculoskeletal system was the most common organ system injured, though head and chest injuries occurred in >30% of patients. Furthermore, children in group 1 who were on the average 2 years of age and <12 kg in weight had a significantly poorer outcome than children in group 2 who were older and larger in weight. Although the smaller weight may only be a reflection of the younger age in this group, it is also possible that it is a reflection of size. Thus a small 3-year-old may be at higher risk than a large 2-year-old. The poor outcome in group 1 was likely attributable to closed head injuries that resulted from an adult driver in a light pick-up truck or SUV backing over a child's head.

TABLE 2. Pattern of Injuries in Children Injured in Driveway-Related Crashes

	Total (n = 64)	Group 1 (n = 44)	Group 2 (n = 20)
Musculoskeletal	36 (56%)	22 (50%)	14 (70%)
Head	21 (33%)	17 (39%)	4 (20%)
Chest	21 (33%)	15 (34%)	6 (30%)
Abdomen	18 (28%)	10 (23%)	8 (40%)
Pelvis	12 (19%)	8 (18%)	4 (20%)

The patients were divided into 2 groups based on their mechanism of injury: group 1 consisted of children who were struck by an adult driver, while group 2 consisted of children who shifted a vehicle out of gear, thus setting it in motion. Data represent the number of injuries to each organ system and the percentage of patients with such injuries. There was no statistical difference in injury distribution between the 2 groups.

TABLE 3. Outcome Measures in Children Injured in Driveway-Related Crashes

	Total (n = 64)	Group 1 (n = 44)	Group 2 (n = 20)
GCS	13.3 ± 3.9	12.5 ± 4.5†	15 ± 0
LOS	3	3	3
ISS	10	10.0	9.5
Operations	19 (30%)	12 (27%)	7 (35%)
Organ systems:			
Head	7	6	1
Abdomen	4	2	2
Pelvis	4	1	3
Musculoskeletal	4	3	1
Deaths	4 (6%)	4 (9%)	0
Poor outcomes (rehab or death)	8 (12%)	8 (18%)‡	0

† $P < .001$ Student's *t*-test versus child drivers; ‡ $P < .05$ Fisher's Exact test versus child drivers. The patients were divided into 2 groups based on their mechanism of injury as described. Data for continuous variables are presented as the mean ± standard deviation for normally distributed data and the median value for skewed data. Categorical data are presented as the number of patients for each variable. Poor outcome was arbitrarily defined as death or need for transfer to a rehabilitation facility.

Indeed, the GCS for children in group 1 was significantly lower than that for group 2. It is interesting to note that children who set a vehicle in motion were not as severely injured as those who were struck by vehicles driven by an adult driver. This observation was presumably attributable to the slow speed of the vehicle at the time of injury, as evidenced by the smaller number of head injuries in this group.

More than 85% of all injuries in group 1 were sustained while the car was in reverse. These findings are similar to other reports by Patrick et al⁸ and Agran et al,¹⁰ who reported that approximately 80% of driveway-related crashes occurred with the car moving backward. Pick-up trucks or SUVs were the most common vehicles involved in these collisions in our series, similar to the findings by Brison et al.³ In fact, these vehicles accounted for nearly two thirds of all injuries sustained over the past 5 years, perhaps reflecting the recent surge in their popularity, although the increase in pick-up truck or SUV-related crashes did not reach statistical significance. Thus, it is important for consumers and manufacturers of these vehicles to be aware of the potential injuries that may ensue from their use.

Our cohort is strikingly similar to the one described by Patrick et al.⁸ The mean age in their series was 3.4 years, with males comprising 59% of the group. These authors reported a mean ISS of 12, with a similar pattern of injury. However, the LOS for their patients was twice that in our study. The mortality rate was 16%, compared with 6% in our study. It is unclear why their patients had such a high mortality rate, although we can speculate that they may have had a higher proportion of children struck by an adult driver than our study.

CONCLUSION

Our data show that children <2 years of age, and <12 kg are more severely injured in driveway-related crashes. The crashes most frequently involve a

light truck or SUV going in reverse. Parents of young children must be educated regarding the perils of the driveway. In particular, children should never be left unattended around the driveway and motor vehicles should be locked (windows and trunk) when left in the driveway. Parents should also discourage the use of the driveway as a recreational area. Additionally, vehicle manufacturers should be alerted to the underrecognized dangers of truck and SUV ownership. If these vehicles are equipped with additional safety features such as extended mirrors to visualize small children, significant reductions in the number and severity of driveway-related injuries may be realized.

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