Driveway motor vehicle injuries in children

Andrew J A Holland, Rhea W Y Liang, Shailinder J Singh,
David N Schell, Frank I Ross and Daniel T Cass

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Abstract

Objectives: To describe the frequency, nature and outcome of driveway injuries in children.

Design: Retrospective case series of driveway-related injuries in children under 16 years of age admitted to the New Children's Hospital (NCH), New South Wales, from November 1995 to February 2000, and deaths reported to the New South Wales Paediatric Trauma Death (NPTD) Registry from January 1988 to December 1999.

Main outcome measures: Circumstances of injury; type and number of injuries identified.

Results: 42 children were admitted to our institution with driveway-related injuries over four years and four months. These represent 12% of all children admitted with pedestrian motor vehicle injuries. Fourteen deaths (including one of the children admitted to NCH) were reported to the NPTD Registry over 12 years, accounting for 8% of all paediatric pedestrian motor vehicle deaths reported to the registry. Typically, the injury involved a parent or relative reversing a motor vehicle in the home driveway over a toddler or preschool-age child in the late afternoon or early evening. Four-wheel-drive or light commercial vehicles were involved in 42% of all injuries, although they accounted for just 30.4% of registered vehicles in NSW. These vehicles were associated with a 2.5-times increased risk of fatality. In 13 of the 14 deaths, the cause was a severe head injury not amenable to medical intervention.

Conclusions: Driveway injuries in children account for a significant proportion of paediatric pedestrian motor vehicle injuries and deaths in NSW. Prevention represents the only effective approach to reducing deaths from this cause.

Trauma is the leading cause of death and disability in children after the first year of life.[1] In children with major injuries (defined as an Injury Severity Score[2] greater than 15), motor vehicle accidents have consistently been the most common cause of injury.[3-6] Within this group, children as pedestrians frequently suffer the most severe injuries as a consequence of their small size in relation to motor vehicles.[3,4,7] As paediatric pedestrian motor vehicle injuries predominantly involve young school-age children,[8,9] conventional prevention campaigns have been directed toward these age groups.[3,9,10]

A recognised clinical scenario in children is traumatic asphyxia with associated visceral injuries resulting from low-velocity compression of the torso.[11,12] Typically, a motor vehicle reverses over a toddler or older pre-school child in a driveway or car park.[7,13] In these cases, the pliability of a child's skeleton and soft tissues, together with the ability of the applied force to be distributed over the short time of the impact, often allows a good outcome.[7,12,13] This clinical scenario has been variously termed the driveway, back over, crush, non-traffic or low-

velocity motor vehicle injury in the United States, but has not been well described in Australia.[4,6,13-18]

We examined the experience of the New Children's Hospital, Westmead, (NCH) with driveway injuries, together with a review of cases reported to the New South Wales Paediatric Trauma Death (NPTD) Registry. Our objectives were to ascertain the extent of this problem, the nature of injuries, and the outcomes, in order to determine the optimal intervention strategy.

Methods

We performed a retrospective review of records of children younger than 16 years admitted to NCH or reported to the NPTD Registry with driveway injuries. Data were collected on the age of the child; the date, time and location of the injury; the vehicle type and driver of the vehicle; how the accident occurred, including documented safety features restricting access to the driveway; and the injuries identified, together with the surgical interventions, complications, and final outcome.

The ethics committee of the NCH approved the study.

Admissions to NCH: Data were collected from November 1995 (when the NCH opened) to February 2000. Patients were identified prospectively from the paediatric trauma database compiled by the trauma research nurse. In addition, a retrospective search was made of the case notes of all children admitted to NCH as a result of a pedestrian motor vehicle injury to ensure no cases had been missed.

Patients were either admitted directly to NCH from its catchment area of Sydney's western suburbs or transferred via the New South Wales Newborn and Paediatric Emergency Transport Service from peripheral centres.

NPTD Registry: The NPTD Registry records all deaths resulting from trauma of children under 16 years of age in NSW that are reported to the coroner. Data were available from inception of the database in January 1988 to December 1999. The police statement and coroner's report, together with the postmortem findings, were reviewed for children who had died following a driveway injury.

Results

Driveway injuries and deaths identified

Box 1 summarises data on the 55 children injured or killed and the circumstances of the injuries, and Box 2 details an illustrative case.

Admissions to NCH: There were 42 children admitted with injuries sustained as a result of a driveway motor vehicle injury, representing 12% of the 354 children admitted to NCH with pedestrian motor vehicle injuries. Thirteen patients had been transferred from another hospital. One of the children died. Twenty-six (63%) of the children who survived were under three years of age. Boys accounted for 74% of the children admitted.

NPTD Registry: There were 14 deaths from driveway injuries, including one of the 42 children admitted to NCH, reported over the 12-year period. These deaths represented 8% of the 174 pedestrian motor vehicle deaths reported to the registry over the same interval. Children who died were generally younger than patients admitted to NCH. Boys were again over-represented (78%).

Circumstances of the injuries and deaths

Although 41 (82%) injuries occurred in the afternoon or evening (most between 4:00 pm and 7:00 pm), six (43%) of the fatalities occurred in the morning. There was no marked seasonal association, although 30% of the injuries took place in the summer months, when children would be more likely to be playing outside.

A relative of the child or a family friend was the driver in 39 cases, including 12 of the 14 injuries leading to death.

A four-wheel-drive (4WD) or light commercial vehicle (LCV) was involved in 34% of injuries in which the child survived, compared with 64% of those with a fatal outcome. Overall, these vehicles accounted for 42% of all injuries. They were associated with a 2.5-times greater risk of fatality compared with other motor vehicles. In 42 cases, the vehicle reversed over the child; 4WDs and LCVs accounted for 19 of these cases.

Documentation of access limitation to the driveway was available in only three cases; in two this involved a front door only, and in one a fence gate, all of which had been left open.

Nature of injuries

Box 3 summarises the injuries identified. For 13 of the children who died, the cause of death was a severe, crushing head injury that involved at least one of the wheels of the vehicle passing directly over the child's head. All but one of the children with a severe head injury died either at the scene of the injury or in the emergency department of the receiving hospital.

One child without a head injury died in transit as a result of hypovolaemic shock from a near-complete transection of the right lobe of the liver.

In the children who survived, there was a lower incidence and severity of head and neck injuries and a greater incidence of limb trauma compared with children who died. In the surviving children, head injury was usually a consequence of a fall to the ground or cerebral oedema from traumatic asphyxia secondary to compression of the torso.

Results of treatment

Fourteen patients admitted to NCH required 18 procedures; most involved skin grafting or treatment of displaced fractures. One patient with cardiac tamponade secondary to myocardial injury had a non-therapeutic laparotomy at a country hospital for hypotensive shock that subsequently responded to pericardiocentesis.

Final outcome was recorded as satisfactory or good for 34 of the 41 survivors, with a full return to normal activities and no significant physical or psychological

sequelae. Active clinical and social problems were identified in seven patients (Box 4).

Discussion

Driveway injuries in children have usually been considered a minor public health problem,[13] perhaps as a result of a combination of misclassification and the failure of non-fatal injuries to be reported to the police.[7,8,14,16,19] The NSW Roads and Traffic Authority, which is responsible for compiling most motor vehicle injury statistics in NSW, does not collect data on driveway injuries because they occur on private land. Our figure of a frequency of more than 1 in 10 pedestrian motor vehicle accidents involving children that require admission seems representative of more recent data, although miscoding and under-reporting may have resulted in some cases being missed.[6]

Of great concern was the number of fatalities associated with this injury mechanism: 8% of the total number of paediatric pedestrian motor vehicle deaths. Published figures range from 10.7% in New Zealand to 20% in the US, suggesting that our figure is representative.[7,18] Male predominance is a feature of most traumatic injuries,[4,8,13,14,16,19] and was particularly noticeable in our series, even below the age of five years. Our data suggest a marked difference between boys and girls in their exploratory behaviour that occurs from an early age.[20]

A family member or person known to the child was the driver in 86% of fatalities reported to the NPTD Registry; this high incidence is a feature of other series.[7,14,17,18] Clearly, the psychological consequences must be devastating to the family, friends and neighbours.[18]

Our results suggested a link between fatal outcome, age of the child and the size and weight of the vehicle involved.[14] Both 4WDs and LCVs accounted for a much higher number of the fatalities in our study than would be expected from their prevalence on the roads. They account for less than 30.4% of registered motor vehicles in NSW (Australian Bureau of Statistics, Motor Vehicle Census 1998, personal communication), but were involved in just under two-thirds of the deaths and were associated with a 2.5-times greater risk of fatality compared with other motor vehicles.

Motoring and child safety organisations and health visitors should alert parents and relatives of young children to these findings to encourage greater awareness of the risks these vehicles pose to both toddlers and preschool children. Road safety organisations need to emphasise that the risk of injury appears to be particularly great when reversing in a driveway with this type of vehicle -- the increased ride height potentially reduces visibility and makes identification of a young child much more difficult, even with the use of convex mirrors or a wide-angle lens.[15,16]

In some prestige vehicles, a proximity-warning device, consisting of ultrasonic transceivers located in the bumpers, at an extra cost to the customer of between $900 and $1600, allows detection of objects within 50 cm to 70 cm of the bumper and above a height of 30 cm. Although the effectiveness of such devices has not been proven in this situation, their wider introduction in high-risk vehicles

may help reduce the frequency of this injury.[4,16]

As nearly all the deaths involved massive head injuries not amenable to medical intervention, prevention represents the only effective approach to reducing fatalities.[14-16,18] We suggest that an effective form of injury prevention is urgently required, particularly in view of evidence that this injury is often associated with shared driveways.[21] The frequent subdivision of redeveloped residential blocks in urban areas might be expected to lead to an increase in these injuries.[22]

The optimal prevention would appear to be clear separation of the driveway and garage from the children's play area by a physical barrier such as a fence, wall or self-locking gate.[16,21] There are risks to the inquisitive child not only from moving vehicles but also automatic garage doors and unattended vehicles.[4,23] Although the construction of circular driveways might decrease the incidence of these injuries, such an approach would be impractical in most urban situations.[4] The use of reversing alarms in passenger vehicles appears unlikely to be effective given that the group most at risk of injury, toddlers and preschool children, are too young to appreciate the significance of the alarm and act with appropriate speed.[4,17]

We recommend that the same degree of vigilance taken with regard to swimming pool safety should be applied to the driveway, and that legislation should be introduced to limit access to this area either by design or the use of temporary fencing.[18,21] As an interim measure, we advocate extreme caution be exercised by parents, relatives and neighbours of young families when reversing out of driveways, particularly in vehicles with restricted rear view vision and at greater risk of causing fatal injury, such as four-wheel-drives, vans and trucks.

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Authors' details

New Children's Hospital, Royal Alexandra Hospital for Children, University of Sydney, NSW.
Andrew J A Holland, BSc, FRCS, FRACS, Research Fellow and Clinical Lecturer, Department of Surgical Research;
Frank I Ross, BAppSc(Nurs), MPH, Clinical Nurse Consultant, Department of Surgical Research;
Daniel T Cass, PhD, FRACS, William Dunlop Professor of Paediatric Surgery;
Rhea W Y Liang, MB, ChB, Surgical RMO, Department of Paediatric Surgery;
Shailinder J Singh, FRCS (I), FRCS (Paed Surg), Clinical Fellow, Department of Paediatric Surgery;

David N Schell, MB BS, FRACP, Consultant Paediatric Intensivist, Paediatric Intensive Care Unit.
Reprints: Mr Andrew J A Holland, Department of Surgical Research, The New Children's Hospital, Royal Alexandra Hospital for Children, PO Box 3515, Parramatta, NSW 2124. AndrewH3ATnch.edu.au

1: Summary of children injured and the circumstances of injuries*

	Survivors (*n*=41)	Deceased (*n*=14)
Age		
Median	23 m	18 m
Youngest	13 m	8 m
Oldest	13 y 1 m	3 y 1 m
Sex		
Boys	31	11
Girls	10	3
Time of day		
Morning	8	6
Afternoon	33	8
Driver		
Parent/relative	30	9
Friend/neighbour	7	3
Other/unknown	4	2
Type of vehicle		
Car	26	4
4WD	8	6
LCV	6	3
Unknown	1	1
Direction of travel		
Forwards	9	2
Reversing	30	12
Both directions	1	0
Unknown	1	0

*There were no statistically significant differences between survivors and deceased. 4WD=four-wheel-drive. LCV=light commercial vehicle.

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2: Illustrative case of a typical driveway motor vehicle injury

Unknown to his parents, a 20-month-old boy was playing in the driveway at home. The back door was open and there was no fencing restricting access to the driveway. The father was reversing his four-wheel-drive vehicle out of the garage when he felt a bump. He stopped and discovered his son underneath the vehicle between the tyres. The father pulled the child from

underneath the vehicle and then called an ambulance.

On arrival at the referring hospital, the child was alert but distressed and uncooperative. Clinical examination revealed bilateral conjunctival haemorrhages and facial petechiae characteristic of traumatic asphyxia (Figure).

There was an abrasion of the lower chest and anterior abdominal wall, with a tyre mark on the left shin. Radiological investigations, including a computed tomography scan of the head, chest and abdomen, revealed mild cerebral oedema, pulmonary contusions of both lower lobes, a subcapsular splenic haematoma and a minimally displaced fracture of the upper third of the left tibia.

The boy was transferred to the New Children's Hospital, where his injuries were treated non-operatively. He required intubation for worsening gas exchange, but was able to be extubated within 72 hours. He was discharged home 12 days after the injury and was completely well three months later. Both parents required extensive counselling by a social worker. They no longer own the vehicle.

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3: Driveway motor vehicle injuries identified in children

	New Children's Hospital* (*n*=41)	NPTD Registry† (*n*=14)
Head and neck injuries		
Soft tissue injury	18 (44%)	9 (64%)
Concussion	6 (15%)	0
Skull fracture	1 (2%)	11 (79%)
Facial fracture	3 (7%)	1 (7%)
Cerebral oedema/contusion	1 (2%)	5 (36%)
Cerebral laceration	0	6 (43%)
Intracranial haemorrhage	0	6 (43%)
Avulsion cerebellum	0	1 (7%)
Retinal haemorrhage	1 (2%)	0
Cervical spine injury	0	1 (7%)
Totals	30 injuries in 24 patients	40 injuries in 13 patients
Torso injuries		
Soft tissue injury	19 (46%)	6 (43%)
Rib fractures	1 (2%)	3 (21%)
Pneumothorax	1 (2%)	0
Pulmonary contusion/laceration	2 (5%)	7 (50%)
Cardiac tamponade	1 (2%)	0
Mediastinal/retroperitoneal haematoma	0	2 (14%)
Splenic injury	1 (2%)	1 (7%)
Hepatic injury	1 (2%)	4 (29%)
Renal and pancreatic injuries	0	2 (14%)
Thoracic spinal injury	1 (2%)	0
Pelvic fracture	6 (15%)	2 (14%)
Totals	33 injuries in 27 patients	28 injuries in 13 patients
Limb injuries	3 (7%)	0

Soft tissue injury: upper limb Soft tissue injury: lower limb Upper limb fractures Lower limb fractures	10 (24%) 6 (15%) 8 (20%)	0 1 (7%) 0
Totals	27 injuries in 25 patients	1 injury in 1 patient

*Injuries in children admitted to the New Children's Hospital with non-fatal injuries from November 1995 to February 2000. †Injuries in children reported to the New South Wales Paediatric Trauma Death (NPTD) Registry from January 1988 to December 1999.

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4: Adverse outcomes among survivors of driveway motor vehicle accidents

- Incomplete spinal cord injury with lower limb weakness and neurogenic bladder
- Retinal haemorrhage with visual impairment
- Unequal leg length and gait disturbance from lower limb fracture
- Epiphora secondary to nasolacrimal duct injury associated with facial fracture
- Residual left ptosis secondary to closed head injury
- Significant varus deformity from upper limb fracture
- Prolonged social work and psychological counselling of one family