RETROSPECTIVE ANALYSIS OF INJURIES SUSTAINED IN VEHICLE FRONT- AND BACK-OVERS IN A LEVEL I PEDIATRIC TRAUMA CENTER

A thesis submitted to the University of Arizona College of Medicine – Phoenix
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Dedication

I would like to dedicate this to my supportive wife and children. Thank you for your love. You are my ultimate treasure.

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Abstract

Motor vehicle accidents involving pedestrians are some of the most common and lethal forms of injury for children in the United States. Among younger children, a common mechanism of action for severe trauma is when a vehicle runs over the child in a forward or backward motion at low speed resulting in a blunt crush injury. This typically occurs in non-traffic settings including driveways, sidewalks, and roadways. Such incidents have been referred to in many different ways in the literature but for the purposes of this paper will be referred to as low speed vehicle run-overs. This is a retrospective chart review carried out at Phoenix Children's Hospital in affiliation with the University of Arizona College of Medicine-Phoenix that categorizes and examines the injuries sustained by patients involved in low speed vehicle run-overs occurring between December 2007 and August 2013. Fifty-five pediatric patients were included with a median age of 24 months and 6 of these patients were fatally injured. Internal injuries were common overall and significantly more common in children ≤24months. Over half of the cohort sustained fractures, with a 24% incidence of skull fractures. All fatalities were the result of traumatic brain injury. Twenty percent of victims required operative intervention. It was concluded that the severity of these types of incidents varies from minimal to life threatening and best care requires close and thorough evaluation by the trauma and emergency department teams.

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Introduction

Low speed vehicle run over (LSVRO) accidents are a global problem. Defined for the purposes of this paper as an incident where a vehicle moving from a stopped position runs over a pediatric pedestrian in a forward or backward motion in a non-traffic environment (most often driveway or parking lot) (1), LSVROs have proven difficult to study here in the United States even though the literature dates back as early as the 1964 (2). This has been attributed to inconsistent definitions and difficulty obtaining comparable data. In 2007, after recognizing that there was little emphasis on non-traffic related vehicle incidents, congress enacted the Safe, accountable, flexible, efficient transportation Equity Act: A legacy for Users (SAFETEA-LU) and the Cameron Gulbranson Kids Transportation Safety Act with provisions that required the development of a non-traffic injury and fatality surveillance. This mandated that the National Highway and Traffic Safety Administration (NHTSA) would begin accumulating data on non-traffic related injuries and fatalities via the Not-in-Traffic Surveillance (NiTS), ultimately unveiling the plight of LSVRO in the United States. In the latest NiTS report, published in April of 2014, the NHTSA showed that an average of 199 children were fatally injured each year in the US in forward and backward moving non-traffic related incidents between the years 2008 and 2011. They also confirmed that approximately 5000 children were injured annually in these incidents. Finally, their report emphasized that the population greatest at risk are those less than 5 years old. (3)

Obviously, injuries sustained in this mechanism of trauma can be devastating. Considering this, groups have focused on prevention efforts and studies have accumulated over the last decade examining various risk factors that may be addressed. Several studies were carried out in trauma centers in the US (1,4,5,6). These studies have begun to evaluate the associated factors with pediatric non-pedestrian collisions. The studies have also looked at severity of injuries sustained in such accidents and have tried to correlate with gender, age, ethnicity, vehicle type, and time of day of accident.

A handful of studies mention the injuries but with few clinical details. We set out to examine the injuries sustained in LSVROs and to describe the interventions used to treat these injuries as well as the hospital courses of the patients that sustaining these injuries. We hypothesized that there are trends in the injuries and intervention measures of these patients that when recognized could affect the triage and care of LSVRO victims. This information could be used to better prepare hospital physicians, surgeons, and nurses for what they might encounter when caring for a pediatric patient injured in an LSVRO mechanism. Also, it may point out areas where triage and intervention may be adjusted to better serve the patient and offer more appropriate and cost effective care. The primary goals of this study are:

1) Describe the clinical findings and injuries of pediatric patients involved in pediatric non-traffic pedestrian collisions.
2) Describe demographic characteristics of both patients and drivers in motor vehicle front-and back-over injuries including data about age, sex, relationship, and ethnicity.
3) Describe the environmental circumstances at the time of the injury, such as the location, type of vehicle, estimated speed during injury, and activity during injury.

Methods

In this study, charts were reviewed in a retrospective fashion of children less than 18 years of age who were evaluated at Phoenix Children's Hospital (PCH) for an injury that was sustained in a low speed vehicle roll over between December 2007 and August 2013. Subjects were initially identified from the trauma registry at PCH by ICD-9 code description "motor vehicle vs. pedestrian-backovers". This included codes E814.7, E818.7, E821.7, E822.7, E823.7, E825.7. Subjects were further screened by a single researcher using the medical record to include those who had been involved in a low speed vehicle run-over (LSVRO). For the purposes of this study, LSVRO was defined as an instance in which a vehicle moves from a stopped position and drives over a child in a forward or backward motion at low speed resulting in a blunt crush injury in a non-traffic setting. We used the same definition of Non-traffic setting as Rice et. al. (private and public parking facilities, private driveways, private roadways, and public or private open land) (1). Children who were injured when entering a roadway where a car was already in motion were excluded. Children who were injured when exiting an already moving car were also excluded. Finally, children who placed the vehicle in motion themselves and were then subsequently injured were also excluded.

The primary outcomes of this study are to evaluate the type of injuries (eg. Abdominal, head, extremity, etc.) and management of the patients.

The secondary outcomes are evaluating the environmental conditions and circumstances surrounding injury. The circumstances of the injury (e.g. location, vehicle details, activity) will be determined by review of trauma registry data. The trauma registry contains information about the injury mechanism, scene of injury, pre-hospital care, and clinical care during the patient's course.

Data variables were extracted from the subject's medical record and trauma registry by study personnel in a de-identified format. Data points included: demographics, mortality, injury diagnoses, injury severity score (ISS), total length of stay (LOS), PICU LOS, operative intervention, number of days (or hours) from injury to hospital admission, pre-existing

conditions, location of injury (e.g. driveway), direction (front or back over), vehicle details (make, model, and year), availability of vehicle technology (e.g. rear view camera), relationship of person driving the vehicle, family composition, and other details surrounding activity at the time of injury.

Data was accumulated into password secured spreadsheets and analyzed using Stata 11.0 (College Station, TX) by study personnel to describe the injury characteristics associated with and circumstances surrounding injury due to vehicle front- and back-overs. Proportions and comparison between groups was performed where necessary. Categorical data were compared with Fisher's exact test and continuous data were compared with Mann-Whitney U test.

These study methods were approved by an institutional review board at PCH and at the University of Arizona.

Results

General Statistics: There were 55 subjects identified as sustaining injuries in an LSVRO. Of these, 6 (11%) were fatally injured. Twenty-five of the subjects (58%) were Male. The median age of the subjects was 2 years 4months, with ages ranging from 1 to 16 years of age. Forty-five subjects (82%) were backed over with ten being injured when the vehicle was moving forward. Median length of stay at the hospital was 20 hours. Eleven of the 49 surviving patients required PICU stay with a median length of stay of 107 hours. A total of 11 patients required some type of invasive intervention or procedure and a list of those is found in Table 1.

Injuries: The highlights of the injury findings are found in Figure 1. Abrasions to at least one body region occurred in 78% (43) of incidents. 54% of victims (n=30) sustained a fracture and 50% (15) of patients sustained more than one fracture. Thirteen victims (24%) sustained skull fractures. Internal injuries were found in 19 patients and included 9 liver lacerations, 9 pneumothoraces, 8 lung contusions, 4 splenic lacerations, 2 cases of acute pancreatitis, 1 renal laceration and 1 pleural effusion. Twenty percent of subjects sustained severe head trauma (TBI) determined both by Head AIS and clinical signs of brain injury (altered mental status, coma, . All 6 fatalities were attributed to TBI. Of the subjects that sustained TBI, those who survived had a median abdominal abbreviated injury scale (AIS) of 3 whereas median abdominal AIS in non-survivors was a 0 (p=0.003).

Injuries and age: Injuries were compared between age groups of less than or equal to 24 months (n=25) and greater than 24 months (n=30) and the results are found in Figure 2. Fourteen children in the younger category had thoracic injuries compared to 5 in the older category, a statistically significant difference (p=0.04).

Patients transferred from other facilities: As is depicted in Table 2, thirty subjects were transferred to PCH from an outside hospital. Median length of hospital stay in subjects that were transferred was 34.5hrs and 5 hr in the group that were brought directly from the scene (p=0.04). However, injury severity score (ISS) in the two groups was not statistically different (6.5 in transferred, 5 in non-transferred, P=0.95)

Table 1: A list of the interventions performed

	Frequency n (%)
Intubation	4 (7)
Chest Tube	3 (5)
Closed Reduction of fracture	3 (5)
Subdural/Epidural drain placement	2 (4)
Ventricular shunt	1 (2)
Wound Debridement	1 (2)
Tendon repair	1 (2)
Skin Graft	1 (2)
Open Reduction and fixation	1 (2)
Craniotomy	1 (2)
Splenic Embolization	1 (2)
Pericardiocentesis	1 (2)

Figure 1: Injury highlights. A list of internal injuries, statistics on abrasions, skull fractures, TBI and other fractures

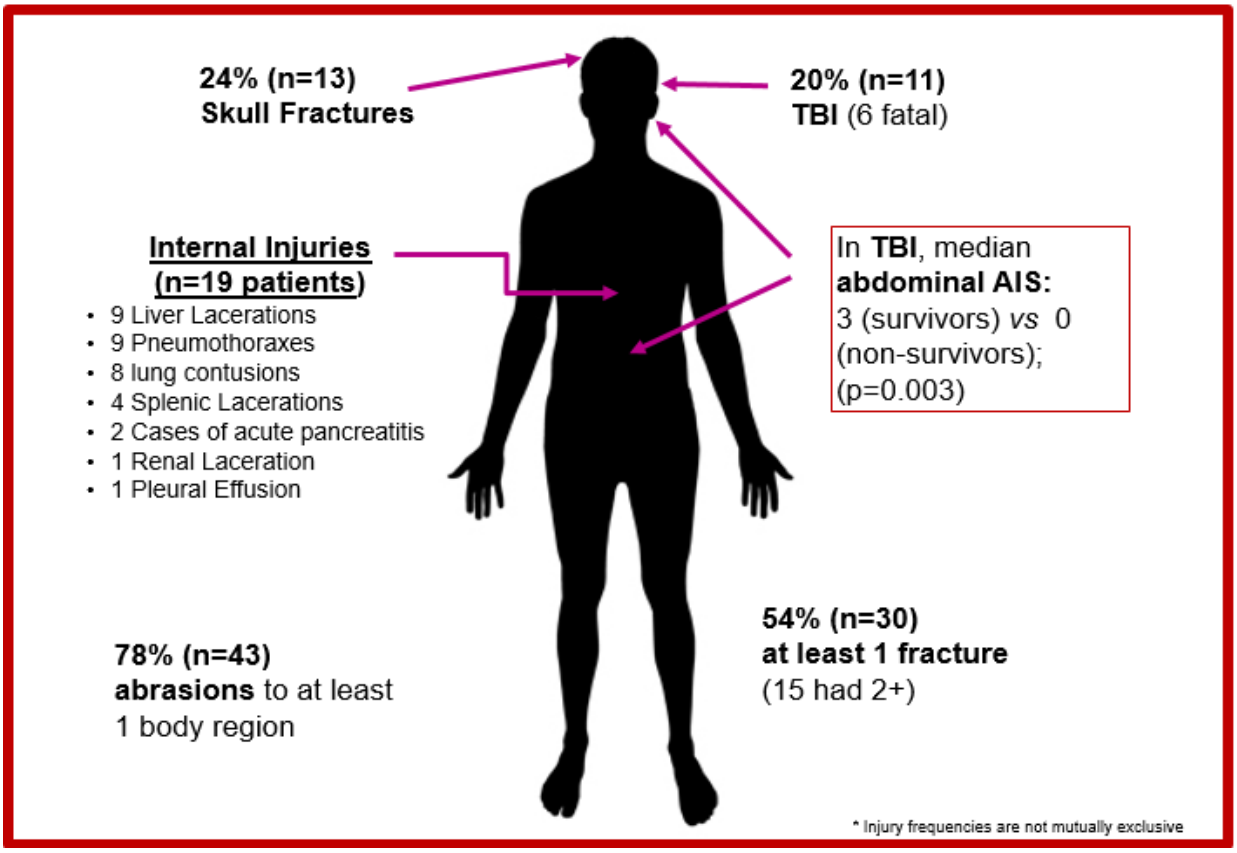

Figure 2: Injuries of victims less than 24 months old compared to those greater than or equal to 24months. (* This was statistically significant)

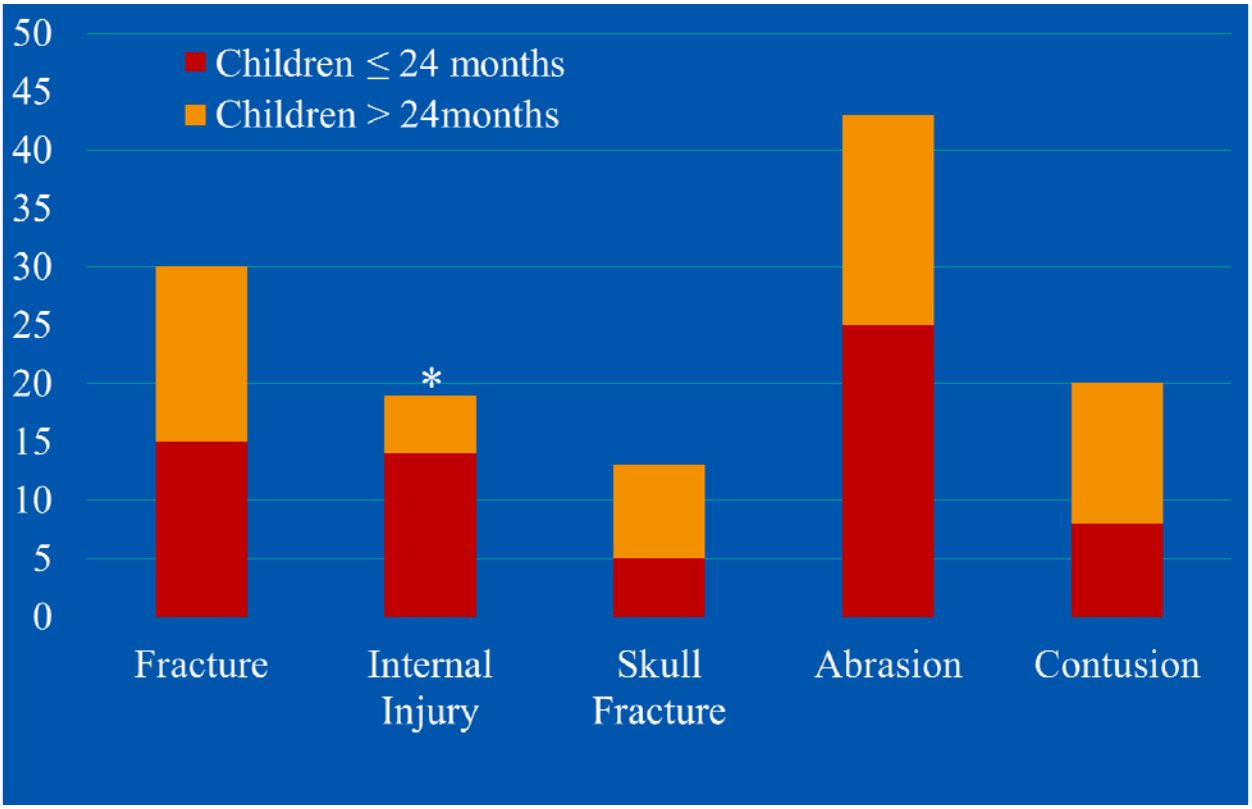

Table 2: Injury severity in transferred patients compared to those brought directly from scene.

	Transferred from outside hospital (n=30)	NOT transferred from outside hospital (n=25)	*P value*
Length of stay at PCH (hours) *Median [IQR]*	34.5 [16-88]	6 [3-40]	0.04
ISS *Median [IQR]*	6.5 [1-11]	5 [1-17]	0.95

Discussion

Eleven percent of the cohort was fatally injured. There was a nearly even gender distribution (27 male to 28 female). Other studies cited fatality rates from 6.3% (4) to 16% (7) and gender distributions that typically favor male (1) more than female. The median age of those fatally injured was found to be 6 months less than that of subjects who survived their injuries, and, though this was not found to be statistically significant (p=0.12), this was found to be consistent with several other studies (8).

Few studies examine the specific injuries sustained in LSVROs. Our study specifically tallied the injuries of each subject in the cohort. Abrasions were the most common injury. The lower extremities were the most common region, consistent with Rice et al (1) for abrasion followed by head, trunk, upper extremity, and hip. Fractures were the next most common injury with 54% of subjects sustaining a fracture, of which half had more than one fracture. Skull fractures were by far the most common fracture (n=13, 24%) followed by fractures of the pelvis (n=7, 13%), and lower extremities (n=5, 9%).

TBI was the most devastating of injuries, accounting for all 6 deaths and that is reflected in the difference in median ISS scores in the fatalities as opposed to the survivors. This was consistent with two earlier studies from Australia (9,10). Notably, survivors of TBI had a significantly higher abdominal AIS than non-survivors. This may suggest that the distribution of the weight of the vehicle differed between survivors and non- survivors with the distribution more directly applied to the cranial region in the non-survivors and a more dispersed distribution in survivors. Specific information about the region of the body that was run over may assist in pre-hospital care and triage of LSVRO victims.

When divided into groups by age, children less than or equal to 24 months had an increased rate of thoracic injury (statistically significant) and abrasions. However, they had fewer skull fractures and contusions and an equal amount of total fractures when compared to children older than 24 months. The differences in injuries with increasing age potentially suggests

differences in body size and proportions and correlates with potentially vulnerable body regions.

Phoenix Children's Hospital is a level 1 pediatric trauma center with a large catchment area and commonly receives transfers from outside facilities. More than half of the cohort in this study was transferred in from an outside facility and ultimately required a statistically significant longer length of stay. However, it does not seem that the increased length of stay was justified as there was no difference in ISS between the transferred and non-transferred groups. There may be other factors preventing discharge such as social concerns or transportation issues. Though the sample size of this study was small, future research examining these differences is warranted as this may be an optimum place to decrease the length of a patient's stay and further save costs.

From the data in this study, subjects can be placed in three categories. The first category includes victims that are fatally injured. In our cohort, the fatalities, all of which were caused by TBI, were pronounced dead very shortly after arrival to the hospital. The second group consists of children who are seriously injured and require hospital stay longer than 24 hours. The third and largest group includes patients with minor injuries that do not require hospital admission and result in hospital discharge within 24 hours. Management of the two highest acuity groups require multidisciplinary teams and often include orthopedic and neurosurgical presence. However, the third category of injuries can be treated in an outpatient setting, such as the emergency department, and can be discharged, with education and close follow up.

The first limitation of this study was that it was a retrospective rather than prospective analysis. Data was pulled from medical records and was limited by the coding and documentation of the individual providers. It is likely that some injures are missed or not documented and perhaps only the most life-threatening diagnoses were reported. Further, the types of questions we as a research team were able to ask were limited by what was available in the record. Another limitation is inconsistency and subjectivity in the recording of the AIS and ISS scales and also the broad definition of certain diagnoses. Lastly, this study's cohort was seen

in a level 1 trauma center potentially skewing the data toward more devastating injuries and potentially missing patients with minor injuries that were seen and discharged from lower acuity facilities.

Future directions

We did not include a review of intervention measures and the cost of these measures. Future studies could further classify this often devastating mechanism of injury and bring attention to its importance.

Future studies on LSVRO should continue to examine risk factors associated with these types of incidents and prevention. This has proven to be very difficult in the past because of the lack of trauma registries with readily accessible data on LSVRO incidents. A national registry, including data regarding environmental factors, vehicular data, and demographic data should be established. Ideally, we should be working internationally with countries such as Australia where extensive work has been done and continues to be carried out on the subject of LSVRO.

One key development in the last decade is the back- up camera, however its effectiveness has yet to be determined. Further evaluation of back-up cameras and other backing related technology needs to take place with in depth analysis of their effectiveness.

Finally, several active education campaigns are currently attempting to decrease incidence rates. Studies should be performed to evaluate the effectiveness of these campaigns and to discover the most optimum approach.

Conclusion

Children who are injured in an LSVRO are subject to a wide variety of blunt, crush injuries that span a full spectrum of acuity. The vast majority of LSVRO victims will be discharged home within 24 hours and have minor injuries. Victims transferred from another hospital were shown to have a longer length of stay even though their ISS was not statistically different, potentially suggesting a bias toward conservative treatment for patients transferred from other facilities. Because of the complexity of injuries sustained in LSVRO, it is imperative that a multi-disciplinary team be involved in evaluation and management of such patients including orthopedic surgery and neurosurgery. Ultimately, further work should be done to determine risk factors and the effectiveness of both preventative technology and educational endeavors.

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