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Injury severity of pedestrians, bicyclists and motorcyclists resulting from crashes with reversing cars

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ABSTRACT

Objective: Pedestrians, bicyclists and motorcyclists can suffer serious injury in road traffic crashes. To date, no studies examine the injury severity within this vulnerable cohort following collisions with reversing cars.
Material and methods: Our institution prospectively maintains a database including medical and technical information regarding traffic accidents in our area, including urban and suburban regions. In a retrospective review of this database, the authors describe the injury severity of pedestrians, bicyclists and motorcyclists following traffic crashes involving reversing cars. Injury severity was described using the abbreviated injury scale (AIS) as well as the maximum abbreviated injury scale (MAIS).
Results: This study included 234 crashes occurring between 1999 and 2012. The lower extremity was injured most often while also suffering more severe injuries with a median AIS of 1 compared to 0 in all other documented body regions. The upper extremity was injured second most often. AIS ranging from 4 to 6 were infrequent. AIS 3 however, was documented for the legs in 4.3% of patients. MAIS 0, 1, 2, 3, 5 and 9 were found in 1, 164, 46, 14, 1, and 8 patients in the study cohort, respectively. Pedestrians and motorcyclists were seriously injured in 9.1% and 9.6% of cases, respectively. In contrast, no bicyclists suffered serious injuries. As to the zone of impact, most collisions occurred at the rear center of the vehicle (35%) followed by rear left (26%), rear right (20%), side rear (11%), side center (4%) and side front (3%). 204 (87.2%) collisions occurred during the day, 19 (8.1%) at night and 11 (4.7%) at twilight. Speed was similar in crashes involving pedestrians, bicyclists and motorcyclists, being as high as 7.0 ± 3.6, 7.0 ± 4.0 and 7.9 ± 4.2 km/h respectively.
Conclusions: This is the first study that analyzes injury severity among these vulnerable road users following collisions with reversing vehicles. The majority of collisions occur at low impact speed during the day. Most injuries resulting from these collisions are not serious, however pedestrians are at greatest risk of severe injury to any body region. The lower extremities suffer the most serious and frequent injuries within this cohort.

1. Introduction

Numerous factors influence the injury severity attributed to motor vehicle crashes including those involving non-passengers. Previous studies involving pedestrians struck by vehicles for example have demonstrated an association between high-energy collisions and risk of death as well as the correlation between impact speed and injury severity. (Rosen et al., 2011; Tefft, 2013). In a 2013 study by Matsui et al., authors demonstrated that an impact speed of less than 30 km/h resulted in serious injury in less than 27% of collisions with pedestrians and fatalities in less than 5% (Matsui et al., 2013a,b). In addition to factors related to impact, vehicle type has also been shown to influence injury severity. The risk of pedestrian fatality for example, is greater in collisions involving vans or sport utility vehicles (SUVs) compared with passenger vehicles (Desapriya et al., 2010; Lefler and Gabler, 2004). Meanwhile, vehicle safety features such as passenger detection systems

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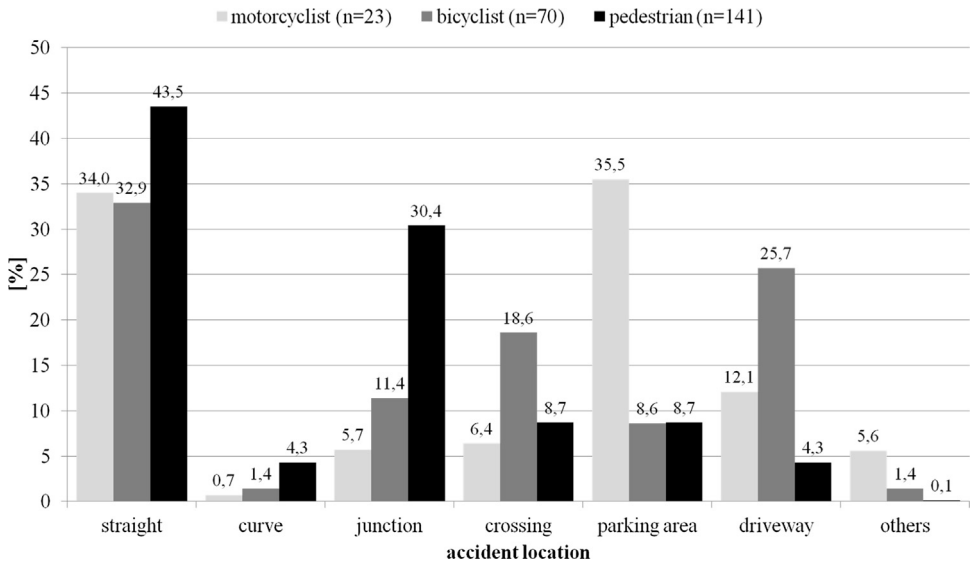

Fig. 1. Collision location type, frequency given vulnerable road users.

including automatic braking strongly influence pedestrian safety. (Matsui et al., 2013a,b).

Like pedestrians, bicyclists as well as motorcyclists are vulnerable road users with high risk of severe injury following collisions with vehicles. In a study by Räsänen and Summala, of 188 motor vehicle collisions involving bicyclists, 21 were seriously injured while an additional 13 resulted in fatality. Similar to previous studies involving collisions with pedestrians, lack of attention was attributed to the majority of these collisions with cyclists (Rasanen and Summala, 1998). Furthermore, complementary studies assessing risk of severe injury within this cohort have predictably demonstrated a positive correlation between impact speed and injury severity. (Stone and Broughton 2003; Haleem et al., 2015). When comparing a speed of 80 km/h to 32 km/h for example, risk of death increases 16 times amongst bicyclists involved in collisions with motor vehicles.

Due to a wide range in collision variables and circumstances, numerous studies have investigated injury severity amongst pedestrians, bicyclists and motorcyclists however few studies analyze injury severity attributed to collisions with reversing vehicles. In a 2001 retrospective analysis by Mayr et al., authors identified 32 children whom were hit by reversing cars. This analysis demonstrated that the most common injuries included contusions of the head, face or extremities (n = 12) and long bone fractures (n = 7). Of note, authors even found two children suffering from pelvic fractures. While this study illustrates the potential for serious injuries resulting from collisions with reversing cars, the study cohort was limited to those patients admitted to the department of pediatric surgery and therefore prevents the extrapolation of these findings to the general population. (Mayr et al., 2001)

With a better understanding of injury patterns resulting from collisions with reversing vehicles and their severity, clinicians including rescue workers and emergency department personnel will be better prepared to quickly triage patients without underestimation of injuries, ultimately improving care (Davidson et al., 2014; Mckay, 2005; Stefanopoulos et al., 2003).

Previous studies have demonstrated patterns of injury and severity amongst this vulnerable cohort, including pedestrians, bicyclists and motorcyclists, however no studies to our knowledge examine these adult patients in the setting of collisions with reversing vehicles. In a retrospective analysis of a prospectively maintained database, the goals of this study were therefore to 1) examine the incidence of reversing motor vehicle crashes involving pedestrians, bicyclists and motorcyclists and 2) examine the patterns and severity of those collisions.

2. Material and Methods

Our local accident research unit prospectively maintains the German In-Depth Accident Study (GIDAS) registry including technical investigations of motor vehicle collisions combined with medical data relevant to crash victims. The registry includes a cohort collected from both urban and suburban communities and is representative of national motor vehicle collision statistics in Germany. GIDAS was established in 1999 for the detailed analysis of crashes in Germany (Otte et al., 2012) and is supported by BASt (Bundesanstalt für Straßenwesen) and FAT (Forschungsvereinigung für Automobiltechnik).

The accident research unit is staffed with personnel highly trained to investigate and document circumstances of automobile crashes. These staff members are notified by police radio immediately after a crash and arrive at the scene with or shortly after police and rescue personnel. Details of the collision are collected at the scene (including measurements by photography, stereo photography, three dimensional-laser technique, etc.), as well as clinical information regarding those involved. Clinical information is additionally collected at the treating hospital including demographic data, x-ray examination, injury type and severity. (Brand et al., 2012; Richter et al., 2007). Of note, patients are not followed beyond admission or thereafter. Impact speed is reconstructed using the software PC-Crash (MEA Forensic).

A retrospective query of the GIDAS database was performed for collisions involving reversing cars as well as pedestrians, bicyclists or motorcyclists. All crashes that did not involve pedestrians, bicyclists or motorcyclists were excluded from this study.

Injury severity was documented using the abbreviated injury scale 2005 (AIS) (Haasper et al., 2010). Briefly, AIS is a scoring system that classifies injury severity according to body region (i.e. head, abdomen, upper and lower extremities, etc.) and involved structures. Severity ranges from 1 to 6 including minor, moderate, serious, severe, critical and fatal respectively with a score of 9 describing an injury for which insufficient information is available. For standardization, detailed lists are available which classify severity for various injuries. A femur fracture for example, is an AIS 3 according to AIS 2005. In addition to the documentation of AIS, the maximum abbreviated injury scale (MAIS) was determined as well.