Original Article

Evaluation of differences in injury patterns according to seat position in trauma victims survived traffic accidents

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Purpose: Investigation of injury patterns epidemiology among car occupants may help to develop different therapeutic approach according to the seat position. The aim of the study was to evaluate and compare differences in the incidence of serious injuries, between occupants in different locations in private cars.

Methods: A retrospective study including trauma patients who were involved in motor vehicle accidents and admitted alive to 20 hospitals (6 level I trauma centers and 14 level II trauma centers). We examined the incidence of injuries with abbreviated injury score 3 and more, and compared their occurrence between seat locations.

Results: The study included 28,653 trauma patients, drivers account for 60.8% (17,417). Front passenger mortality was 0.47% higher than in drivers. Rear seat passengers were at greater risk (10.26%) for traumatic brain injuries than front seat passengers (7.48%) and drivers (7.01%). Drivers are less likely to suffer from serious abdominal injuries (3.84%) compared to the passengers (front passengers - 5.91%, rear passengers - 5.46%).

Conclusion: Out of victims who arrived alive to the hospital, highest mortality was found in front seat passengers. The rate of serious chest injuries was higher as well. Rear seat passengers are at greater risk for serious traumatic brain injuries. All passengers have a greater incidence of abdominal injuries. These findings need to be addressed in order to develop "customized" therapeutic policy in trauma victims.

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Introduction

Road traffic accident has been one of the leading causes of death since last century. Despite enormous efforts on improving the road infrastructures, advances in development of protective technologies and implementation of educational programs, motor vehicle accidents (MVA) remain a leading cause of severe morbidity and death in young people.1 Incorporation of anti-lock braking, airbags, seat belts and other safety accessories have made vehicles safer.2 However, the differences in trauma patterns and, especially of severe injuries sustained depending on where the occupant was sitting, are still not described enough. Such knowledge may help the trauma teams in decision making.

As well, data on patterns of injury sustained in the various locations of seats in a car can highlight special protective needs and suggest additional improvements in safety accessories in these specific locations in the vehicle.

The aim of this study was to evaluate differences in the incidence and severity of injuries in motor vehicle accidents victims. The patterns of injuries associated with high morbidity and mortality were compared between occupants in different locations in private cars.

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Methods

We performed a retrospective cohort study involving trauma patients who were hospitalized due to involved in private car MVA from 2001 to 2013. The data was obtained from the records of the National Trauma Registry maintained by Israel’s National Center for Trauma and Emergency Medicine Research, in the Gertner Institute for Epidemiology and Health Policy Research. This registry records information concerning all trauma patients hospitalized in 20 hospitals of which six are considered level I trauma centers (all level I centers in the country) and fourteen are considered level II trauma centers. Data collected in registry includes: age, gender, seat location, injury severity score (ISS), mortality, abbreviated injury severity score (AIS) of traumatic brain injury (TBI), AIS of thoracic and abdominal injuries, and AIS of pelvic fractures as well. TBI was defined as the presence of any kind of intracranial bleeding (epidural, subdural, subarachnoid or parenchymal hemorrhage). We examined the incidence and severity of these types of injuries and compared their occurrence between seat locations in the car. We also evaluated the incidence of the serious (AIS $\geq$ 3) head, chest, abdomen and pelvis injuries according to different mechanisms of MVA: front to front, front to back, front to side and crashing with objects.

Statistical analysis was performed using SAS statistical software Version 9.2 (SAS, Cary, NC). Statistical tests performed included Chi-square tests. A $p$-value of less than 0.05 was considered statistically significant.

Results

The registry included 28,653 trauma patients involved in MVA where only private cars were involved. There were 17,417 (60.78%) front seat passengers and 258 (12.59%) were back passengers. There were 2050 (7.15%) senior citizens aged 65 years and older, 1249 (40.93%) of them were drivers, 543 (26.49%) were front seat passengers and 258 (12.59%) were back passengers.

In all the patients, 20,240 (70.64%) patients of them identified with ISS from 1 to 8, 4143 (14.46%) patients with ISS 9–14 and 4270 (14.9%) patients with ISS 16 and more. Table 1 shows distribution of injury severity by seat location. Detailed comparison of the ISS $\geq$ 16 group shows that drivers are less likely to be injured severely than front seat passengers ($p < 0.0001$) and passengers sitting in the rear ($p = 0.0001$). The mortality of all the patient involved in MVA was 1.62% (465 patients). Table 2 shows mortality rates in the various seat locations. The mortality in front passengers is higher than in drivers ($p = 0.0120$). There was no statistically significant difference between front and back passengers ($p = 0.2801$) and between drivers and back passengers ($p = 0.2879$). We decided to concentrate our analysis on serious trauma victims with AIS $\geq$ 3, in selected injuries.

| Table 1 | ISS distribution according to seat location. |
|---------|---------------------------------------------|
| ISS    | Passenger Front | Passenger Back | Driver |
| 1–8    | 4024 (68.74)    | 3640 (67.63)   | 12,576 (72.21) |
| 9–14   | 867 (14.81)     | 875 (16.26)    | 2401 (13.79)   |
| ISS $\geq$ 16 | 963 (16.45)    | 867 (16.11)    | 2440 (14.01)   |

Data were presented as n (%). ISS: Injury severity score. ($p < 0.001$).

Table 2 shows mortality rates according to different seat locations.

| Table 2 | Comparison of mortality rates according to different seat locations. |
|---------|------------------------------------------------|----------------|----------------|----------------|----------------|
| Mortality | Passenger Front | Passenger Back | Driver |
| Alive    | 5739 (98.04)    | 5291 (98.31)   | 17,158 (98.51) |
| Dead     | 115 (1.96)      | 91 (1.69)      | 259 (1.49)     |

Data were presented as n (%). ($p = 0.0398$).

With 2211 (7.72%) patients in all trauma victims suffered serious TBI, defined by AIS $\geq$ 3. There were 1308 (4.56%) patients suffered serious abdominal injury, 3901 (13.61%) patients suffered serious chest injury and 533 (1.86%) patients suffered serious pelvis injury.

Distribution of brain, abdomen, chest and pelvic injuries with AIS $\geq$ 3 by seat location is shown in Table 3.

A detailed comparison between any two seat locations shows that rear seat passengers are at greater risk for TBI than front seat passengers ($p < 0.0001$) and drivers ($p < 0.0001$). No significant difference was found between front seat passengers and drivers ($p = 0.2250$).

With regard to serious abdominal injuries, drivers are less likely to suffer from serious injuries compared to front seat passengers ($p < 0.0001$) and rear seat passengers ($p < 0.0001$).

No significant difference was found between rear seat passengers and drivers ($p = 0.6245$). There were no significant differences in the incidence of pelvic injuries between groups.

In addition, we analyzed the incidence of serious injuries in four most common mechanisms of MVA: front to front, front to back, front to side and crash to object. These account for 61.4% of trauma victims involved in private MVA (see Table 4).

Discussion

Road traffic accidents are a worldwide problem resulting in high morbidity and mortality, mostly in the young population. In his study on 24,373 road accidents trauma victims registered in German trauma registry found that younger population had significantly more severe life threatening injuries and lower Glasgow coma scale. Over the world, multiple efforts have been made in order to reduce the insult of road traffic accidents. The possible ways are including improvement of infrastructure, development of various protective car accessories, drivers' education and undoubtedly advancement in national trauma systems.

Several studies investigated the correlation between injuries and seat position in the car. For example, Smith and Cummings in a study on 25,230 vehicle passengers involved in accidents demonstrated that rear seat passenger position mortality rate was 39% less significantly more severe life threatening injuries and lower Glasgow coma scale. Over the world, multiple efforts have been made in order to reduce the insult of road traffic accidents. The possible ways are including improvement of infrastructure, development of various protective car accessories, drivers' education and undoubtedly advancement in national trauma systems.

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Table 3 shows distribution of injuries with AIS $\geq$ 3 according to seat locations.

| Table 3 | Distribution of injuries with AIS $\geq$ 3 according to seat locations. |
|---------|------------------------------------------------|----------------|----------------|----------------|----------------|
| AIS $\geq$ 3 | Passenger Front | Passenger Back | Driver | $p$ value |
| TBI     | 438 (7.48)      | 552 (10.26)    | 1221 (7.01)   | <0.0001       |
| Abdominal Injury | 346 (5.91) | 294 (5.46)    | 668 (3.84)    | <0.0001       |
| Chest Injuries | 912 (15.58) | 695 (12.91) | 2294 (13.17) | <0.0001       |
| Pelvic Injuries | 119 (2.03) | 95 (1.77)    | 319 (1.83)    | 0.5200        |

Data were presented as n (%) or $p$ value. AIS: abbreviated injury severity score; TBI: traumatic brain injury.
motor vehicles involved in fatal crashes, significantly lower mortality was found in rear seat passengers than in front seat passengers. Conversely, Brown and Bilston investigated a greater mortality rate among rear seat passengers than among drivers and front seat passengers. Bilston et al., investigated a significant positive correlation between rear seat passengers and drivers. There was a significantly higher incidence of severe thoracic injury in front seat passengers compared to rear seat passengers. Pedley and Thakore, in a study on 5138 motor vehicle crash victims, showed that mortality rates did not differ significantly between front seat passengers and drivers. These data were presented as a percentage. TBI: traumatic brain injury; D: Driver; FP: Front passenger; RP: Rear passenger.

### Table 4
Distribution of injuries with AIS ≥ 3 according to seat locations, in impact configurations of MVA.

| Characteristics | Impact configurations | Front to Front | Front to Side | Front to Back | Crash with Object |
|-----------------|-----------------------|---------------|--------------|--------------|------------------|
|                 |                       | D             | FP           | RP           | D               | FP           | RP           |
| TBI             | 280 (10.29)           | 120 (11.26)   | 137 (14.01)  | 126 (5.78)   | 55 (6.21)       | 81 (11.74)   | 100 (2.62)   | 28 (2.53)    | 70 (7.78)    | 189 (8.54)   | 52 (8.64)    | 49 (11.32)   |
| Abdomen         | 226 (8.31)            | 129 (12.10)   | 110 (11.25)  | 85 (3.90)    | 53 (5.98)       | 41 (5.94)    | 42 (1.10)    | 13 (1.17)    | 29 (3.22)    | 115 (5.20)   | 50 (8.31)    | 25 (5.77)    |
| Chest           | 616 (22.65)           | 270 (25.33)   | 212 (21.68)  | 291 (13.34)  | 156 (17.61)     | 95 (14.35)   | 164 (4.29)   | 49 (4.43)    | 31 (3.87)    | 330 (14.92)  | 113 (18.77)  | 75 (17.32)   |
| Pelvis          | 122 (4.49)            | 33 (3.10)     | 23 (2.35)    | 56 (2.57)    | 34 (3.84)       | 26 (3.77)    | 18 (0.47)    | 4 (0.36)     | 12 (1.33)    | 41 (1.85)    | 13 (2.16)    | 11 (2.54)    |
|                 |                       |               |              |              |                 |              |              |              |              |                 |              |              |

Data were presented as n (%). TBI: traumatic brain injury; D: Driver; FP: Front passenger; RP: Rear passenger.
References

1. Ramage-Morin PL. Motor vehicle accident deaths, 1979 to 2004. Health Rep. 2008;19:45–51.

2. Curry P, Ramaiah R, Vavilala MS. Current trends and update on injury prevention. Int J Crit Illn Inj Sci. 2011;1:57–65. https://doi.org/10.4103/2229-5151.79283.

3. National Center for Health Statistics (US). Health, United States, 2010: With Special Feature on Death and Dying. Hyattsville (MD): National Center for Health Statistics (US); 2011.

4. Brockamp T, Schmucker U, Lefering R, et al, Working Group Injury Prevention of the German Trauma Society (DGU); Committee on Emergency Medicine, Intensive Care and Trauma Management of the German Trauma Society (Section NIS); TraumaRegister DGU®. Comparison of transportation related injury mechanisms and outcome of young road users and adult road users, a retrospective analysis on 24,373 patients derived from the TraumaRegister DGU®. Scand J Trauma Resusc Emerg Med. 2017;25:57. https://doi.org/10.1186/s13049-017-0401-1.

5. Smith KM, Cummings P. Passenger seating position and the risk of passenger death or injury in traffic crashes. Accid Anal Prev. 2004;36:257–260.

6. Mayrose J, Priya A. The safest seat: effect of seating position on occupant mortality. J Saf Res. 2008;9:433–436. https://doi.org/10.1016/j.jsr.2008.06.003.

7. Brown J, Bilston LE. The scope and nature of injuries to rear seat passengers in NSW using linked hospital admission and police data. Traffic Inj Prev. 2014;15:462–469. https://doi.org/10.1080/15389588.2013.833692.

8. Bilston LE, Du W, Brown J. A matched-cohort analysis of belted front and rear seat occupants in newer and older model vehicles shows that gains in front occupant safety have outpaced gains for rear seat occupants. Accid Anal Prev. 2010;42:1974–1977. https://doi.org/10.1016/j.aap.2010.06.002.

9. Howard AW. Automobile restraints for children: a review for clinicians. CMAJ. 2002;167:769–773.

10. Durbin DR, Chen J, Smith R, Elliott MR, Winston FK. Effects of seating position and appropriate restraint use on the risk of injury to children in motor vehicle crashes. Pediatrics. 2005;115:e305–e309.

11. Ndiaye A, Chambois M, Chiron M. The fatal injuries of car drivers. Forensic Sci Int. 2009;184:21–27. https://doi.org/10.1016/j.forsciint.2008.11.007.

12. Majdan M, Rusnak M, Rehorcikova V, Brazinova A, Leitgeb J, Mauritz W. Epidemiology and patterns of transport-related fatalities in Austria 1980-2012. Traffic Inj Prev. 2015;16:450–455. https://doi.org/10.1080/15389588.2014.962133.

13. Pedley DK, Thakore S. Difference in injury pattern between drivers and front seat passengers involved in road traffic accidents in Scotland. Emerg Med J. 2004;21:197–198.

14. Newgard CD, Lewis RJ, Kraus JF. Steering wheel deformity and serious thoracic or abdominal injury among drivers and passengers involved in motor vehicle crashes. Ann Emerg Med. 2005;45:43–50.

15. Kallan MJ, Durbin DR, Arbogast KB. Seating patterns and corresponding risk of injury among 0- to 3-year-old children in child safety seats. Pediatrics. 2008;121:e1342–e1347. https://doi.org/10.1542/peds.2007-1512.