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Original Article

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

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ABSTRACT

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 injures 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.

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 injures 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%) drivers, 5854 (20.43%) front passengers and 5382 (18.79%) rear passengers. There were 2605 children aged 0–14 years (9.09%), certainly none of them are drivers. In this pediatric population there were 2300 (88.29%) back passengers and 305 (11.71%) front passengers. There were 2050 (7.15%) senior citizens aged 65 years and older, 1249 (60. 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
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 front and rear seat passengers ($p = 0.3062$).

Relating to chest injuries, comparison between any two seat locations shows that front seat passengers are at greater risk for serious chest injuries than rear seat passengers ($p < 0.0001$) and drivers ($p < 0.0001$). 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.[3] Brockamp et al.[4] 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[5] in a study on 25,230 vehicle passengers involved in accidents demonstrated that rear seat passenger position mortality rate was 39% less compared with front seat passengers. Similar findings were reported by Mayrose and Priya.[6] In their study on 27,098 occupants of

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)	0.5220

Data were presented as n (%) or p value. AIS: abbreviated injury severity score; TBI: traumatic brain injury.

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	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)	99 (14.35)	164 (4.29)	49 (4.43)	51 (5.67)	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.

motor vehicles involved in fatal crashes, significantly lower mortality was found in rear seat passengers than in front seat passengers. Conversely, Brown and Bilston[7] found significantly higher mortality rates among rear seat passengers than among drivers and front seat passengers. Bliston et al.,[8] investigated a pediatric population in another study, found that for children 9–15 years old, the rear seat carried a lower risk for severe injuries while for older teenagers and adults, 16 years and older, front seat passengers are at lower risk for severe injury. The finding of the protective nature of rear seat position for children is consistent with the existing evidence in pediatric populations.[9,10] Our study was focused on trauma victims who survived MVA and were hospitalized to the trauma center due to severe injuries. In general, all people involved in road traffic accidents are divided into the three categories. The first group includes those, who unfortunately died on scene, mostly resulting from unpreventable death causes. The decrease of such mortality mostly depends on improving of the road infrastructures, quality of cars and development of more sophisticated protective devices. The second group consists of the slightly injured patients who are not in need of hospitalization. The major medical resources and health system costs invested in the third group – hospitalized patients. In our opinion, awareness to the existing differences in the severe injury patterns depending on seat position may help improve current therapeutic policies. For example, in this study front seat passengers' mortality rate was higher than drivers'. Differences in mortality rate between rear seat passengers and front seat passengers and between rear seat passengers and drivers were not statistically significant.

The relevant literature often refers to road fatalities and injuries without precisely identifying the injuries responsible. Ndiaye et al.,[11] who studied the cause of death in 287 drivers, found that in all AIS ≥ 4 injuries chest trauma were the most common cause of death, followed by head and abdominal injuries. On the contrary, Madjan et al.[12] demonstrated that significant head injury was the most prevalent injury among casualties of motor vehicle accidents.

Several studies evaluated and compared the incidence of different types of injury related to seat location. In the study conducted by Brown and Blistion[7] mentioned earlier, rear seat passengers had more head and abdominal injuries than front seat passengers. Pedley and Thakore,[13] in a study on 5138 motor vehicle victims, showed that mortality rates did not differ significantly between front seat passengers and drivers. There was a significantly higher incidence of severe thoracic injury in front seat passengers than in drivers. Likewise, in a study by Negard et al.[14] on 42,860 drivers and front seat passengers involved in car accidents, severe thoracic injuries were found in 1.27% of drivers and 1.36% of front seat passengers and 0.38% of drivers and 0.43% of front seat passengers suffered severe abdominal injuries.

In our study, serious chest injury was the most prevalent injury, followed by head and abdominal injury. Rear seat passengers were found at higher risk for serious head injury that probably due to limited use of seat belts. This information may lend a hand in more liberal use of brain computed tomography scan in these occupants. Passengers were found to be at higher risk for serious abdominal injury than drivers regardless of their location. Such greater probability of intraperitoneal injury should be taken to the account and use of abdominal computed tomography should be strongly considered in this particular population. Front seat passengers were at greater risk for serious chest injuries than rear passengers and drivers. The risk for serious pelvic injury was similar in all groups, which may be attributed to the scarcity of this injury.

The results of the studies mentioned above seem to differ significantly one from another. This inconsistency may be attributed to factors related to the study design. Factors such as methodology (sampling alone and not including the all population), definitions of severe injuries and inclusion of children in the study may influence the results. Furthermore, some of the differences may be related to the environment in which the MVA occurred. Urban versus rural roads, use of restraint devices, legal speed limits and enforcement, technological advances in the car industry through the past years, increasing use of cellphones and other elements may impact considerably on injury patterns.

Limitations of this study include the lack of information regarding seat belt use, child restraint seats and the presence of airbags. The inclusion of children in this study may influence the results due to different injury patterns in this population. In addition, children probably represent a significant proportion of those seated in the rear seats. The distribution of seating positions in rear seat passengers, center seat versus outboard seat, influence the risk for injuries among children and adults as well.[6,15] These data were not available in this study. In addition our national trauma registry does not include information regarding different vehicle types, its weight and speed which may give another bias to this study. Our study included only private cars road accidents victims, but we have no information according different types of the vehicles. In addition, there is no data how many drivers and passengers were thrown outside from vehicles, as well as their location in front or opposite side. It may have influence on injury patterns. However we believe that this impact may be minimalized due to large numbers provided by our study.

The data in this study were derived from the National Trauma Registry, a comprehensive and up to date database that includes information regarding most of the hospitalized MVAs casualties in Israel in recent years, which enhances the power of this study. In addition, we could only carefully assume that differences in the serious injury patterns found in different seat position participants may be similar in the “died on the scene” trauma victims.

To the best of our knowledge, no study comparing incidence of serious injuries between hospitalized drivers, front seat passengers and rear seat passengers has been carried out. Elucidation of injury patterns in relation to car seat position may help to develop “customized” therapeutic and diagnostic management policy for different locations of car passengers. Further study to characterize injury patterns will help attain this goal.

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