

## Sex-Based Abdominal Injury Disparities in Motor Vehicle Crash Injuries: A Clinical Review

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### I. Introduction

Innovation in vehicle safety design has contributed to a significant reduction in motor vehicle crash (MVC)-associated injuries and fatalities. Several studies have examined the relative risk or odds of injury and fatality between females and males involved in MVCs [1-6]. Most of them indicate that females often face a higher relative risk of injury compared to males. Compared to the past decade, occupant protection systems from more recent model year vehicles have reduced injury risk in both sexes, but there are still disparities between sexes [7]. Among all MVC-associated injuries, there is almost a paucity of data regarding the characterization of abdominal injuries. The objective of this study is to evaluate the disparities in male/female abdominal injury patterns by evaluating the National Trauma Data Bank (NTDB) of the USA. The assessment factors include vehicle type, occupant position and demographic variables. Additionally, the effect of MVC-associated injury on physiological variables was evaluated by examining the trend between Injury Severity Score (ISS) and Shock Index (SI). The former scoring technique is used to assess the injury and its severity, while the latter clinical metric is a ratio of heart rate to systolic blood pressure, commonly used to evaluate trauma patients in clinical settings [8-9]. An  $SI > 1$  is an early indication for a patient undergoing a state of shock.

### II. Methods

#### **Data source**

Data from the NTDB from 2018 to 2021 for patients 15 years and older were considered for analysis. This timeframe was selected to incorporate the most recent data available, capturing advancements in modern automobile safety features. Only patients in vehicle crashes who were wearing lap and shoulder belts were extracted, defined using International Classification of Disease (ICD) external cause codes (N=125,642). The initial query included age, primary external cause codes specific to traffic-related vehicle crash (V43 to V57), and Abbreviated Injury Scale (AIS) injury diagnosis codes related to abdomen injuries (S35.0 to S36.1). The crash type was grouped based on the vehicle involved and occupant position during the event. Injuries were grouped based on 15 key anatomies in the abdomen (i.e. adrenal gland, kidney, liver, pancreas, spleen, large intestine, small intestine, stomach, retroperitoneum, mesentery, duodenum, omentum, rectus abdominus, gallbladder) and assessed by sex, age group, BMI group, and shock index (SI). A waiver from the Institutional Review Board of the author's institute was obtained to review the clinical database for this study.

#### **Analysis technique**

Weighted frequency analysis was performed on the extracted data to assess the contribution of each injury type to the total MVC-associated abdominal injury. Followed by Z test, proportion analysis was performed to evaluate the effect of sex on injury occurrence. The influence of variables such as age, stature and BMI was assessed by conducting logistic regression. Finally, ISS vs. SI linear regression was examined to assess the trend for males and females.

### III. Initial findings

Following data assessment and cleanup procedures, a total of N=106,759 cases were deemed suitable for the present study. Among these, 52,853 (49.5%) were male patients, while 53,906 (50.5%) were female patients. Of these, MVC-associated abdominal injuries accounted for 15,740 (29.3%) in males and 15,041 (27.5%) in females. The contribution of abdominal injury among the driver of a passenger car [group1] was 11,435 (28.8%) in males and 9,590 (26.3%) in females. For passengers of a passenger car [group2], the abdominal injuries were 2,459 (33.2%) in males and 4,435 (30%) in females. For the driver of a truck/van [group3], the abdominal injuries were 1,580 (28.2%) in males and 584 (25.1%) in females. For passengers of a truck/van [group3], the abdominal injuries were 266 (29.9%) in males and 432 (28.9%) in females. Of the

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considered 15 injury types, injuries to the liver, kidney, spleen and mesentery contributed >10% to the overall abdominal injury among both sexes. Figure 1 provides the weighted frequency, linear fit trend associated with variables (i.e. age, stature, BMI) summarized in Figure 2 and Table I lists the Odds ratio, implying the effect of sex. An exemplar linear regression plot showcasing the ISS vs. SI trend for patient cases with AIS2 liver injury is provided in Figure 3.

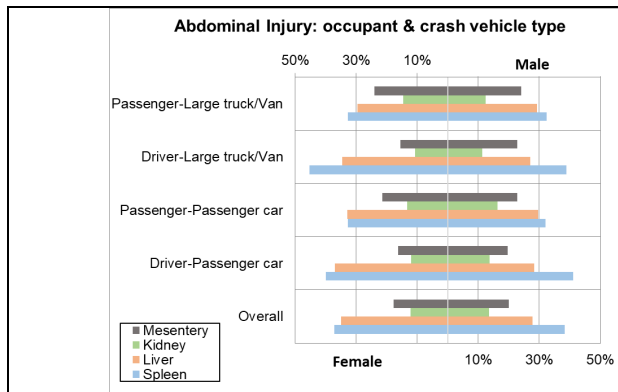


Fig. 1. Prominent abdominal injuries grouped by vehicle type, occupant position and sex.

TABLE I  
ODDS RATIO FOR PROMINENT ABDOMINAL INJURIES

Prominent Abdominal Injury	All crashes	Sedan-Driver	Sedan-Passenger	Truck-Driver	Truck-Passenger
Kidney	0.88**	0.86**	0.93	0.78**	1.21
Liver	1.39**	1.48**	1.42*	1.16*	1.02
Spleen	0.95*	0.96	1.3*	1.04	1.01
Mesentery	0.86*	0.80**	0.62**	0.93	0.98

\*  $p < 0.05$ ; \*\*  $p < 0.01$

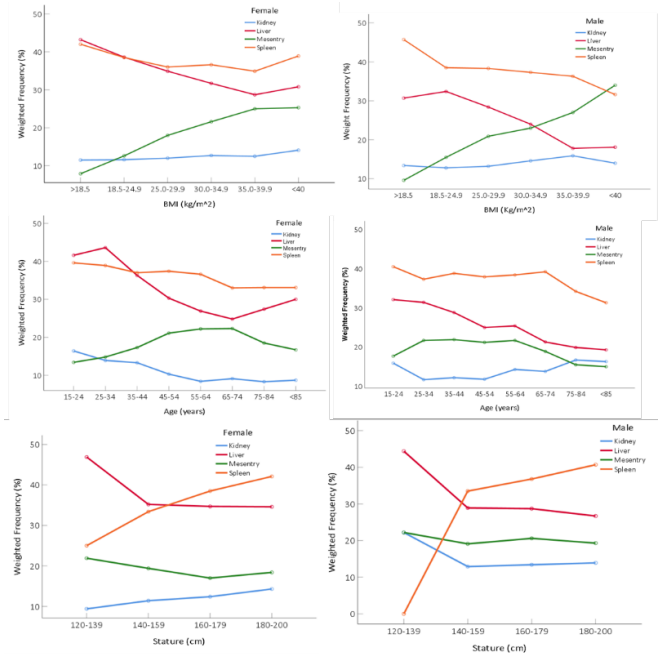


Fig. 2. Linear trend fit for prominent abdominal injuries separated by female in left and male in right.

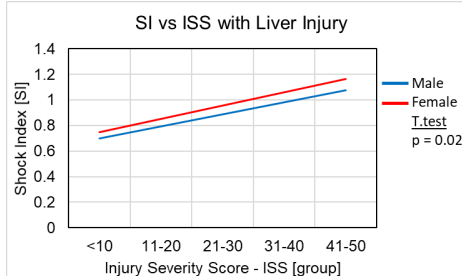


Fig. 3. Trend analysis for shock index [SI] vs. injury severity score [ISS]. Injury considered was AIS2 and the patient case included age < 34 years, BMI < 24.9 and Stature < 179 cm. Trend significant for  $p < 0.05$ .

## IV. Discussion

Four years of MVC-associated abdominal injury data from NTDB were analyzed to assess the impact of sex on injury occurrence, revealing liver, spleen, kidney, and mesentery injuries as significant contributors. While sex emerged as a significant factor for these injuries overall, variations were noted across vehicle types and occupant positions. Females exhibited increased vulnerability to liver injuries, whereas males were more susceptible to spleen, kidney and mesenteric injuries. Occupant demographics played a role in injury occurrence, varying with vehicle and occupant type. Exemplar trend analysis showed that females, with similar injury severity (AIS2), tended to reach a state of shock at lower injury severity scores compared to males.

This study provided a preliminary understanding of the differential impact of sex on MVC-associated abdominal injuries. Recognizing these disparities, coupled with physiological response, may inform future safety design development to enhance protection for both male and female occupants in MVCs.

## V. References

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