The “cushion effect” revisited:

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Abstract

Background: It is known the pattern and severity of injuries sustained during a motor vehicle accident depend on many variables. An interesting avenue for research is obesity as a positive or negative modifier for injury distribution patterns in MVA. We hypothesize that body mass index (BMI) will influence MVC related injury patterns.

Methods: We queried STRAC data for DHR - Edinburg for the years 2014 to 2018 using CPT codes for MVC/MVA, IS > 8, age 15 - 64. Interactions between injury location, BMI, seatbelt and gender were analyzed.

Results: We had 191 detailed crashes, we found increasing age to be protective for abdomen and pelvis (OR .94), increasing BMI to be predisposing for extremity injuries (OR 1.06) and increasing BMI and female gender together to be protecting for head and neck injury (OR .98). Patient without abdominal injuries were younger with lower BMI. However sample size small (46).

Conclusion: BMI seems to have an exacerbating effect on extremity injuries and a protective effect for head and neck injuries driven predominantly by females. We believe this likely due to an increase in momentum effect of each appendage and a decrease in torque of the neck. Age seems to be protective and we believe this is primarily due to hormonal deposition of adipose

tissue. Overall it remains important to maintain a high index of suspicion when dealing with MVC triage patients and treat each individually.

INTRODUCTION:

Motor vehicle accidents continue to be a large source of morbidity and the leading cause of mortality in the 25 to 35 male and female age group. It is estimated that 90 people die each day from MVC and 18,000 lives could be saved yearly if USA rates equaled that of other industrialized nations. (1) At the same time the United States ranks 12th in the world for obesity and first among industrialized nations (2). However few research has been done about the interplay between both epidemics.

We know from previous literature obesity alone can be a risk factor for being involved in an MVC. A large meta-analysis done by (3) found that among commercial truck drivers, those having OSA were up to 4 times more likely to experience a motor vehicle crash as non-OSA drivers. While OSA can occur in the non-obese population it is highly related to obesity and many studies have demonstrated a direct relationship between obesity and disease severity of OSA and up to 80 percent of obese patient have some degree of sleep apnea (4).

One less studied avenue is how obesity alone can influence the severity and distribution of injury patterns. Perhaps the most famous paper on the matter “ The Cushion Effect” in 2003 from the University of Michigan found a predisposing and exacerbating effect of obesity specifically on lower extremity injuries and an overall increase with mortality and overall ISS but not ISS at presentation. (17) A large recent review of literature on the relationship between obesity and MVC out of the University of British Columbia included over 800 studies and concluded that overall there was a trend towards increased all cause mortality with increasing obesity, however no real reduction in intra abdominal and pelvic injuries despite there being a protective effect on severity and prevalence of head and neck injuries.(5) Other papers have found a protective effect on intra abdominal injuries with increasing obesity in children (6) however research remains scant.

Texas Trauma Tract Five composed of (Cameron, Hidalgo, Starr, Willacy) is one of the most obese regions in the nation. With its exploding population and designation as a medically underserved area, DHR as an emerging level 1 trauma center is uniquely equipped to study how obesity affects injury patterns in MVC.

PATIENTS AND METHODS

Methods
Setting and Study Design

Patient data was collected from their electronic medical records and local trauma data bank of a single Level 2 Trauma Center in South Texas was used in the study. Data was obtained from the presentation of injury at the emergency room. The Hospital is located approximately 10 miles north of the southernmost border of the United States and has a demographic population of approximately 70% Hispanics. The study was submitted and approved by the Institutional Review Board conforming to the Declaration of Helsinki and the U.S. Federal Policy for the Protection of Humans Subjects. The study team submitted a full waiver of authorization under the Health Insurance

Portability and Accountability Act (HIPAA, 1996) and was approved by the Institutional Review Board to conduct this retrospective study. The retrospective period of chart review was set from January 1st, 2015 to December 31st, 2019.

Inclusion and exclusion criteria

Male and female subjects 15 to 64 years, inclusive, presented to the emergency room, regardless of transportation method and with an ISS above 8 were included in the study. The patient must have had a documented motor vehicle accident at the time of injury. Accidents in motorcycles and all-terrain vehicles were excluded from the study. Pregnant women were also excluded from the cohort. Diabetic patients were also excluded. Reasons for exclusion were for diabetes diabetes predisposition for fractures and in pregnancy the change in body morphology would both confound distribution of injuries only due to blunt trauma.

Data source and Variables

Patients meeting inclusion criteria were identified via an electronic report from the hospital trauma data bank. Once the list of patients and the corresponding medical record number were obtained, the same variables for all patients were extracted. All the presented information was part of the subject's documented standard of care, as extracted from both the electronic medical record and the trauma data bank. The demographic variables collected were age, sex, ethnicity, body mass index, presentation site of injury, use of seatbelt or restrain, injury severity score, and speed of the vehicle at the moment of the accident (when available). To maintain consistency in the data extraction process, the individuals reviewing the charts for injuries were supervised and followed specific instructions for the classification of injuries. Two general surgeons provided oversight of the whole data collection process and a clinical scientist designed the group comparisons, under the request of the study principal investigator.

The location of the injuries were divided in four anatomical regions: Head and Neck, Chest, Abdomen and Pelvis, and Extremities (appendicular skeleton), consistent with the anatomical regions collected for the National Trauma Data Bank. The data was collected using a binomial variable for which one (1) was assigned if the injury was present in the region, and zero (0) for no injury.

Head and neck injuries included any face fractures or soft tissues disruptions of face requiring operative management or admission, body or spinous process fractures of cervical vertebrae, skull fractures, hematomas, symptomatic contusions, intracranial hemorrhages, vascular injuries at level and above C7 and diffuse axonal injuries documented by radiological exams.

Chest injuries included fractures of the scapula and the clavicles, rib fractures, symptomatic lung contusions requiring monitoring and supportive measures, any penetrating injuries and severe blunt soft tissue injury with concomitant lung contusion, any body or lamina fractures C 7 to T8 and spinous process fractures with concomitant soft tissue injury.

Abdominal and pelvic injuries included solid organ lacerations, hematomas, ruptures, abdominal wall herniations likely exacerbated by blunt force, perforations of hollow viscus including pelvic rectus, mesenteric disruptions of any kind, any penetrating injuries including pre fascial soft tissue injuries that required operative exploration, peritoneal/retroperitoneal hematomas, any spine fractures of body or spinous process extending from T 8 to sacrum were also considered intra abdominal injuries if concomitant with bowel or mesenteric injury and abdominal pain was a symptoms.

Extremity Injuries included all bones of the extremities, excluding pelvic girdle fractures but including hip fractures after the level of the anatomic neck of femur, injuries above this were counted in abdomen and pelvis. Clavicular and scapular fractures through the body of the bones were counted as chest injuries, disruptions to the shoulder girdle including distal clavicular fractures and dislocations were counted as long bone injuries, soft tissues and vascular disruptions without concomitant bone injuries by requiring admission or ISS greater than 8 were counted in this category as well

Statistical Methods

To summarize major findings we used descriptive statistics (mean, standard deviation, frequencies percentages) as appropriate for the continuous or categorical variable. When appropriate, the normal distribution of variables was measured using the Shapiro-Wilk goodness-of-fit test. Non-normally distributed variables were analyzed using the Wilcoxon test, and normally distributed variables were analyzed using the Student t-test for independent samples. Categorical variables were analyzed using the Chi-square or Fisher exact tests. Linear regressions were used to explore the relationships between variables and illustrated using their corresponding 95% confidence intervals. Variance in the presence or absence of injury across different BMIs was done using an F-test ANOVA. The statistical analyses were two-sided and conducted using JMP 15.0 (SAS Institute, Inc, Carry, NC, USA). The significance was set at $p < 0.05$.

RESULTS

During the 4 year study period, 191 patients were identified from our trauma database; the mean age of patients was The mean BMI was 29. The mean ISS was 18. We had about twice as many males (137) than females (71). Our all cause mortality after admission was 7 percent.

Overall we categorized 312 individual injuries. The greatest total number of injuries occurred in the chest (100), followed closely by the appendicular/soft tissue injuries (98), head and and neck (90) and lastly abdomen and pelvis (50). Males had a higher odds ratio (1.35 (0.74-2.48) of chest injuries and lower odds ratio for head and neck (.50 (0.27-0.94) and appendicular/soft tissue injuries (.49 (0.25-0.93). Males were slightly more likely to have a single injury (1.2 (.068-2.16) and females more likely to suffer multiple with an males to females odds ratio of (0.84 (.0.47-1.48). About half of accidents were restrained 127 out of 208 and males were more likely to be unrestrained (1.2 (0.47-1.48).

Overall there appears to be no relationship between BMI and total ISS of injuries on presentation. (Figure 1). However there was a protective effect of BMI at very high speeds mediated mostly by reduction in ISS of head injuries. (Figure 4). However with increasing BMI there was a significant reduction in the odds of receiving an abdominal and pelvic injury (p= 0.0081) and a strong trend towards increasing odds of appendicular skeleton/soft tissue injuries (p=0.0802) (Figure 2). No definite correlation or strong trend was noted for head and neck injuries or chest injuries However when split by gender it seems the statistical difference in decreasing abdominal injuries was driven primarily by females. (Section C. Figure 2)

When BMI over ISS was subcategorized as speed, you can see a very strong protective effect of BMI at very high speeds however small sample size. (Figure 3) When further subdivided by types of injury and ISS at different speeds it seems BMIs protective effect at high speeds is mostly attributable to reduction of head and neck injuries. (Figure 4)

Discussion:

In the present study we had some results that were concordant and discordant with the current literature. Most of the literature does not always show a protective effect of BMI on intra abdominal injuries, usually only a strong trend (8)(13). In fact some of the research shows that there may even be a predisposing factor for thorax (9) and even abdominal injuries (10). There does always seem to be a protective effect for head and neck injuries often seen and sometimes statistically significant. (8) (7).

In our study there was a protective effect for abdomen and pelvis injuries with increasing BMI and a strong trend towards increased prevalence of appendicular skeletal and soft tissue injuries. Overall in our study there wasn't a protective or exacerbating effect for head and neck injuries or chest injuries, but there does appear to be a head and neck protective effect at high speeds, consistent with most of the literature. However when we split data up by gender we can see remarkable differences between males and females prevalence for injury. With increasing BMI females have a risk of injury to abdomen(**numbers) compared to males at (numbers)** creating an almost 2 or 3 to 1 protective effect.

With increasing BMI females actually did not have a statistically significant increase in appendicular and soft tissue injury but only a strong trend. This is consistent with the current literature.

As far as we know only a couple studies have studied injury distribution patterns associated with MVC injury split by gender and most only focused on overall mortality with a trend towards reduced mortality in obese women as well as an opposite effect as obesity increased mortality in men (11, 12).

We theorize that this protective effect is actually real and is due to gendered distribution of fat. It is well known that females tend to store fat subcutaneously compared to male visceral deposition of fat. New research is also showing that adipose tissue differs in hormone receptor composition in males and females and that this is one of the primary reasons driving gendered fat deposition.(13) We hypothesize that the reason for the exaggerated protective effect of obesity on intra abdominal injuries in our review was partially driven by our hispanic population. It is well studied that hispanics in general either due to childhood obesity or genetics tends to undergo puberty at younger ages (14) and tend to have more circulating sex hormones and lower SHBG (15). This could lead to an exaggerated subcutaneous deposition of fat in females protecting them from intra abdominal injuries and visceral deposition of fat in males possibly increasing risk of abdominal injury in MVC specifically seen in heavily hispanic areas. This could lead to a new avenue of research as to how traumatology is affected by racial and gender differences.

Conclusion:

In our study we found obesity to have a correlative possibly causative effect on obtaining intra abdominal injuries during MVC of all types. Specifically with the strongest reduction in women. We believe our effect was more pronounced that other studies due to our heavily hispanic, young and obese population. We believe our study can be used to frame arguments for reduction in overall costs of heal index of suspicion. Not all patients are the same and need to be treated as individuals. We believe that DHR an emerging Level 1 Trauma institution is uniquely suited for studying effect of obesity on general traumatology further. th care as imaging obtained after trauma is heavily influenced by clinical exam and

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