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Original Contribution

The association between seatbelt use and trauma outcomes: Does body mass index matter?

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ABSTRACT

Background: National Highway Traffic Safety Administration (NHTSA) reports that seat belt use results in a significant decrease in MVC mortality. The rate of obesity is currently extensive. There is limited data on the impact of seat belt use and body mass index (BMI) on mortality and trauma outcomes following MVCs. This study aimed to evaluate the impact of seat belt use and BMI on outcomes in adult trauma patients.
Methods: A four-year review using our Level I Trauma Center registry. Patients were divided by BMI into normal weight BMI < 25 (NL-BMI), overweight BMI 25–29.9, and obese BMI ≥ 30. Groupings were subdivided by seat belt use into patients wearing a seat belt at the time of injury (seatbeltPOS) and those who were not (seatbeltNEG).
Results: 11,792 patients involved in MVCs were included in our study. 4515 (38.3%) were NL-BMI, 4583 (38.9%) were overweight, and 2694 (22.8%) were obese. SeatbeltPOS patients had significantly lower mortality compared to seatbeltNEG, regardless of BMI, with 12/1394 (0.86%) in seatbeltPOS compared to 274/10,398 (2.64%) deaths in seatbeltNEG patients ($p \ll 0.001$). Evaluated by BMI, overweight and obese seatbeltPOS patients had significantly less deaths 7/900 (0.78%) vs overweight and obese seatbeltNEG patients 179/6377 (2.81%) ($p = 0.0004$). NL-BMI seatbeltPOS patients also had significantly lower mortality 5/494 (1.01%) compared to NL-BMI seatbeltNEG patients 95/4021 (2.36%), ($p = 0.048$).
Conclusion: Use of a seat belt reduced Trauma Center mortality regardless of BMI. Seat belts should be used by all patients as a mechanism to significantly reduce mortality.

1. Background

Fatalities due to motor vehicle collisions (MVCs) are one of the most prevalent causes of avoidable morbidity and mortality in the United States. Seat belts have been proven to be one of the most effective risk-reducing safety measures in MVCs, reducing the incidence of crash-related morbidity and mortality by >50% [1]. The increased use of seat belts over the last two decades has resulted in a significant decrease in both adult as well as pediatric MVC associated mortality. The importance of using a seat belt to prevent serious and even fatal outcomes resulting from collisions is common knowledge, but the exact reduction in risk of mortality needs to be further explored.

The seminal paper on the exact mechanisms of safety restraints and seat belts in morbidly obese individuals was published by the Association for the Advancement of Automotive Medicine in 2009 [2]. In this explicative study the authors elegantly described the kinematics of blunt trauma and biomechanics of restraints as they impact endomorphic somatotypes. Extrapolating data from post-mortem human surrogates i.e. obese crash test subjects with a control group of normal weight crash test subjects, they were able to detail the exact impact of seat belt restraint system pressure applied to different parts of the torso and the resulting contour deformities, which would lead to internal organ damage. In their study, they found that although the results were not uniformly consistent, there was a tendency for greater injury risk with higher weight body habitus, even with proper seat belt use. This concept of greater bodily injury in obese occupants wearing a seat belt was confirmed by Reed et al. who demonstrated that an increase in body mass index (BMI) of 10 kg/m^2 more than normal was associated with seat belt position issues [3]. In this group, the lap belt positioned further forward and higher relative to the anterior-superior iliac spine leading. Obesity was also associated with restricted foot positioning and closer proximity of the knees to the dashboard as well as greater inboard shoulder belt webbing and more slack in the belt system, leading to greater excursion and a less effective restraint system [3]. The general consensus is that as BMI increases, the routing of the seat belt away from the skeleton increases, allowing for an increased likelihood of injuries and increased severity of injuries [2,3].

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Cummins et al. 2011 collected data from the National Trauma Database (NTDB) to determine if seat belts reduce mortality and injury severity after car accidents. Compared with a no safety restraint device group, passengers using a seat belt had a 51% reduction in risk of mortality. The seat belt plus airbag group had a 67% reduction in risk of mortality [4]. Use of restraints prevents passengers from being ejected from the car during a crash, while those who do not wear a seat belt are more likely to be ejected. While improvements in vehicles and seat belts have minimized the amount of MVC related mortalities, they have not eliminated this issue. While the total number of fatalities and vehicles associated with MVCs was undergoing a downward trend, this changed in 2012 when fatalities and vehicles involved began increasing; reaching a peak in 2016 [5,6]. Aside from poorer health and increased risk of diseases, there is question as to whether obesity is a major risk factor for mortality resulting from MVCs. Desapriya et al. 2011 completed further exploration into the effect of a driver's obesity and risk of mortality, which supports the association of obesity with higher fatality and increased risk of injuries related to MVCs in the adult population [7].

There is limited and inconclusive data on the effect of BMI on mortality and trauma outcomes following MVC. This study aimed to evaluate the use of seat belts in the adult population and to evaluate whether the use of seat belts in normal BMI, overweight, and obese patients has an impact on outcomes in adult trauma patients.

2. Study design and methods

This study is a four-year review of prospectively collected data utilizing our Level I Trauma Center registry for trauma patients admitted from January 2014 through December 2017 presenting after MVCs. Adult patients were defined per Florida Department of Health (FL-DOH) guidelines as age ≥ 16 years. Within the adult population presenting following MVC, seat belt use was evaluated by EMS, Fire Rescue, patient or family interview. If presented with conflicting information, the final analysis was done by the admitting trauma surgeon. Patients were further divided based on BMI and characterized as either normal weight, with BMI < 25 (NL-BMI), overweight, with BMI 25–29.9, or obese, with BMI ≥ 30. Groupings were further subdivided based on seat belt use into patients wearing a seat belt at the time of injury (seatbeltPOS) and those not utilizing a seat belt (seatbeltNeg). Demographics such as age, gender, race, and Injury Severity Score (ISS) were also evaluated. The primary outcome considered in this analysis was inpatient mortality. The secondary outcome was ICU length of stay (ICU-LOS). For the study population, descriptive statistical analysis was used. Values were reported as mean ± standard deviation (SD) for continuous variables with normal distribution and as frequencies for categorical variables. Means were compared using the Student *t*-test, and differences between categorical variables was assessed using the Fisher exact test for pair-wise comparisons and chi squared analysis for comparisons among multiple groups, with significance defined as $p < 0.05$. Logistic regression was performed to determine the association between adult seat belt use, BMI, and trauma outcomes. Statistics were performed using SPSS statistics software version 25.

3. Results

There were 11,792 adult patients involved in MVCs included in our study. In this group 4515 (38.3%) were normal BMI, 4583 (38.9%) were overweight, and 2694 (22.8%) were obese. Average ISS was similar between all groups ($p > 0.05$) including normal BMI seatbeltPOS and seatbeltNEG (9.13 vs 8.14), overweight seatbeltPOS and seatbeltNEG (9.23 vs 8.07), and obese seatbeltPOS and seatbeltNEG (9.41 vs 7.75) patients.

Patients wearing seat belts at the time of impact had significantly lower mortality compared to those who did not, regardless of BMI, with 12/1394 (0.86%) deaths among restrained passengers compared to 274/10,398 (2.64%) deaths in unrestrained passengers ($p < 0.01$, χ^2). Evaluated by BMI, overweight and obese restrained car occupants had significantly fewer deaths, 7/900 (0.78%), versus unrestrained patients in the same BMI group, 179/6377 (2.81%, $p = 0.0004$, χ^2). Restrained patients with normal BMI also had significantly lower mortality, 5/494 (1.01%), compared to unrestrained patients, 95/4021 (2.36%, $p = 0.048$, χ^2).

There was no significant difference in length of stay in the ICU (ICU-LOS) between all groups ($p > 0.05$) including normal BMI seatbeltPOS and seatbeltNEG (1.93 vs 2.01), overweight seatbeltPOS and seatbeltNEG (2.75 vs 2.22), and obese seatbeltPOS and seatbeltNEG (2.67 vs 2.47) patients as shown in Table 1.

4. Discussion

In our study, seat belt use was predictably associated with a significant decrease in Trauma Center mortality regardless of BMI. As a recent epidemic, it has been previously clear that obesity is a major health risk factor. Our study is one of the first to examine the association between BMI and use of car restraints, as well as association with increased mortality and injury severity. We found no association between BMI and Trauma Center mortality in patients who survived to hospital, and contrary to prior studies, there was no significant decrease in seat belt use among patients with BMI > 25 who had injuries severe enough to go to the hospital.

Of note, the population of patients in this study includes people involved in MVCs who sustained or were suspected to sustain injuries severe enough to warrant hospital admittance. It is likely that seat belt use decreases the likelihood that a patient involved in MVC would be injured severely enough to require hospitalization. This may explain why the vast majority of patients in this study were without seat belts at the time of injury, in contrast to the majority of the overall population reporting seat belt usage. This subset of patients involved in MVCs indicates that all results are representative of patients with injuries severe enough to require hospitalization.

While this study's population is different from the entire population of people exposed to MVCs, the results of this study are nonetheless noteworthy and demonstrate valuable trends. The outcomes of this study indicate that seat belts reduce the risk of injury overall which is the general consensus and is supported by the extensive majority of literature. Furthermore, and most remarkably, seat belts were found to reduce the risk of a severe injury turning fatal. That is, a patient wearing a seat belt at the time of collision and sustaining injuries requiring hospitalization will have a lower risk of mortality than a patient not wearing restraints.

By contrast, in 2007, Schlundt et al. examined the association between obesity and seat belt use [9]. For participants with a BMI < 25 (non-overweight) seat belt use was reported as 82.6%, for BMI 25.0–29.9 (overweight) seat belt use was reported as 80.1%, for BMI 30.0–39.9 (obese) seat belt use was reported as 76.6%, and for BMI > 40.0 (extremely obese) seat belt use was reported as 69.8% [9]. These findings indicate that as BMI increases, seat belt use decreases; however, this study may have selection bias as participants may have declined to participate and reporting bias as data was self-reported and thus may not have accurately reflected the participants' true weight or seat belt use. Likewise, examination of the connection between BMI and seat belt use by Lichtenstein et al. 1989 supports the association between obesity and decreased seat belt usage [10]. Nonetheless, in comparison, our study found no significant decrease in seat belt use among patients who were overweight or obese and required hospital admittance after their MVC.

Further, our study found no association between BMI and Trauma Center mortality after MVC. This finding is consistent with Zarzaur et al. 2008, which reported that neither mortality nor intra-abdominal injury was increased in obese patients wearing a seat belt as compared to non-obese patients wearing a seat belt [11]. This demonstrates that BMI may not be associated with increased risk of death in patients who survived to hospitalization following an MVC. Contrarily, exploration into the effect

Table 1
Adult patient characteristics and incidence of injuries by BMI and use of car restraints.

	Normal BMI < 25 (4515 patients, 38.3% of total population)		p	Overweight BMI 25–29.9: 4583 patients (38.9% of total population)		p	Obese BMI ≥ 30: 2694 patients (22.8% of total population)		p
	Seatbelt (+)	Seatbelt (−)		Seatbelt (+)	Seatbelt (−)		Seatbelt (+)	Seatbelt (−)	
Total # of patients	494 (11%)	4021 (89.0%)		536 (12%)	4047 (88%)		364 (14%)	2330 (86%)	
Gender									
Male	223 (45.1%)	2156 (53.6%)	0.04	287 (54%)	2655 (66%)	≪0.004	196 (54%)	1437 (62%)	0.004
Female	271 (54.9%)	1865 (46.4%)		249 (46%)	1392 (34%)		168 (46%)	894 (38%)	
Average age (years)	40.7	56.1	ns	47.3	54.3	ns	59.8	53.1	ns
Average BMI	22.18	21.94	ns	27.1	27.2	ns	35.0	34.4	ns
Average ISS	9.13	8.14	ns	9.2	8.1	ns	9.4	7.8	ns
ICU-LOS (days)	1.93	2.01	ns	2.75	2.22	ns	2.67	2.47	ns
Discharge status									
Alive	489 (99%)	3926 (97.6%)	0.048	532 (99%)	3933 (97%)	0.01	361 (99%)	2265 (97%)	0.01
Dead	5 (1.01%)	95 (2.36%)		5 (1%)	114 (3%)		2 (1%)	65 (3%)	

*ns = not significant.

of a driver's obesity and risk of mortality by Desapriya et al. 2011 supports the association of obesity with higher Trauma Center fatality and increased risk of fractures of the lower extremities [7].

Nationwide seat belt laws are lacking and lawmaking regarding car restraints are left up to individual states. A national study by the Center for Disease Control and Prevention determined that 85% of adults in the United States reported that they always used seat belts [12]. In Florida, it is required for adults to wear seat belts when they are front seat passengers or the driver [13]. This is a primary law, meaning authorities can stop a vehicle based on this offense alone. Nonetheless, not every state requires seat belts for adults and certainly not every state has primary seat belt laws. The seat belt laws being primary or secondary may have an effect on the number of adults wearing seat belts, but in our study where the seat belt law is primary; there was no significant decrease in seat belt use among overweight and obese patients.

Our study was limited by a relatively small sample size involving only our Trauma Center's registry for trauma patients, which are representative of demographic population of our service catchment area. Further, the study excluded anyone who was involved in MVCs that did not sustain injuries, which require hospital intervention. This study also excludes on-scene fatalities. Future studies should include a larger sample size and analyze a multi-institutional registry or the NTDB to reveal a more precise impact on trauma outcomes. Obesity is increasing at an alarming rate in the US [14].

5. Conclusion

Use of a seat belt was found to be associated with significantly reduced mortality in normal weight, overweight and obese patients who were involved in an MVC and required Trauma Center admission. Seat belts should be used in normal weight, overweight and obese patients as a mechanism to significantly reduce mortality. Future research efforts should focus on not just identifying but also alleviating the effect of BMI on MVC injury and further explicate the attributable risk of BMI on MVC mortality.

Abbreviations

NHTSA National Highway Traffic Safety Administration
MVC Motor Vehicle Collision
BMI body mass index
ns not significant
NL-BMI Normal body mass index
SeatbeltPOS Seat belt positive
SeatbeltNEG Seat belt negative
FL-DOH Florida Department of Health
ISS Injury Severity Score
ICU-LOS Intensive care unit length of stay
SD Standard deviation

Competing interests

Authors declare that they have no competing interests.

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Authors' contributions

Study design and conception: Adel Elkbuli
Data collection, interpretation and analysis: Adel Elkbuli, Paul J Spano II, Brianna Dowd, Mark McKenney
Manuscript preparation: Adel Elkbuli, Brianna Dowd, Paul J Spano II, Dessy Boneva, Shaikh Hai
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All authors read and approved the final manuscript.

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This research is conducted in compliance with institutional ethical standards.

Availability of data and material

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