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Obesity in trauma: outcomes and disposition trends

Zachary Osborne, M.D.^{a,b,*}, Blair Rowitz, M.D.^{a,b}, Henry Moore, M.D.^{a,b},
Uretz Oliphant, M.D.^{a,b}, JoAnn Butler^{a,b}, Michelle Olson, M.D.^{a,b}, John Aucar, M.D.^b

^aCarle Foundation Hospital; ^bUniversity of Illinois at Urbana Champaign, IL, USA

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Abstract

BACKGROUND: Obesity's effect on the outcomes of trauma patients remains inconclusive.

METHODS: A retrospective review of all falls, motor vehicle collisions (MVCs), and penetrating trauma patients admitted from January 2008 to December 2012 was performed. The outcomes evaluated included mortality, length of stay at hospital, and discharge disposition. Patients were grouped according to the body mass index (BMI) and stratified by injury severity scores.

RESULTS: Two thousand one hundred ninety six patients were analyzed; 132 penetrating, 913 falls, and 1,151 MVCs. Penetrating traumas had no significant difference in outcomes. In falls, obese patients had a lower mortality ($P = .035$). In MVCs, obese patients had longer hospitalizations ($P = .02$), and mild and moderate MVC injuries were less likely to be discharged home ($P = .032$ and $.003$). Obese patients sustained fewer head injuries in falls and MVCs ($P = .005$ and $.043$, respectively).

CONCLUSIONS: In falls, a higher BMI may benefit patients. However, an increasing BMI is associated with a longer length of stay at hospital, and decreased likelihood of discharge to home.

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The increasing prevalence of obesity in modern society poses special problems in trauma. Much of the literature suggests an increase in mortality and morbidity among hospitalized obese patients.^{1,2} This difference is attributed to impaired mobility, longer hospitalizations, higher incidence of respiratory complications, higher venous thromboembolic events, and higher nosocomial infection rates.^{1,2} The risk of poorer outcomes may be aggravated by the need for special equipments and technical difficulties in performing procedures related to body habitus.¹ However, the current literature on the effect of obesity on trauma population remains inconclusive, with some articles showing that obese patients have a higher mortality,^{3–6} while others

found no difference in mortality.^{7–9} In one study on high-energy blunt trauma comparison, the obese patients were found to have a lower mortality.¹⁰

Although the effect of obesity on mortality remains inconclusive, there seems to be relatively consistent differences in the injury patterns affecting the obese patients compared to nonobese patients. Obese trauma patients sustain fewer liver injuries, mandibular fractures, and cerebral injuries, but more pelvic fractures, rib fractures, and lower extremity fractures.⁸ Others have demonstrated a similar pattern, of fewer head injuries, but more chest injuries, and lower extremity injuries.⁷

It is difficult to interpret the body of literature on the interaction between obesity and trauma, in which articles vary widely in patient selection, stratification, and definition of outcomes. In an effort to perform a systematic review (unpublished), we note that some articles report the injury severity score (ISS) as patient characteristic, to assess whether clinical outcomes are different for matched injuries. However, if obesity is to be assessed as a risk factor for specific injuries, the ISS should more

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* Corresponding author. Tel.: +1-217-383-3311; fax: +1-217-326-1300.

E-mail address: Zachary.Osborne@carle.com

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appropriately be treated as an outcome measure. Some studies focus on specific injury mechanisms, such as penetrating, or blunt trauma and some further specify subsets of blunt mechanisms according to the energy of impact, while others fail to distinguish the mechanism of injury into separate analyses. Articles that focus on intensive care unit (ICU) patients tend to have rigorously documented clinical data, while most other articles exclude a large portion of their trauma patients because there is not enough information available to calculate the BMI. Additionally, much of the contemporary literature varies in the method of stratifying obesity into consistently defined cohorts according to body mass index (BMI). The National Institute of Health (NIH) defines the BMI according to the following scheme: BMI 18.5 to 24.9 = Normal weight; 25.0 to 29.9 = Overweight; 30.0 to 39.9 = Obese; and 40.0 and above = Extreme obesity.¹¹ Some articles utilize a BMI above 27 to identify obesity and most fail to distinguish underweight patients from normal patients, which might obscure findings when comparing rates of adverse outcomes.^{1,3–6}

The purpose of this article is to examine original data from the trauma registry of a state-designated Level I trauma center to compare the outcomes and injury patterns in patients stratified by mechanism of injury, body mass index, and ISS.

Methods

A retrospective review of our prospective trauma registry at a state-designated, micro urban, Level I trauma center was used as the primary data source, on the basis of an institutional review board approved protocol. All trauma patients admitted between January 2008 and December 2012 were screened. Patients were excluded if they were under the age of 18 years, pregnant, or sustained burns. All patients who did not have a height, weight, and ISS documented in the registry were also excluded. Three groups were defined according to the mechanism of injury: penetrating trauma, blunt trauma secondary to motor vehicle collision (MVC), and blunt trauma secondary to falls. Patients injured by fall were confined to those who fell from a height of <1 story and included falls from standing, falls from sitting, and fall down <1 flight of stairs. Patients included in the motor vehicle collision (MVC) category included automobiles, motorcycle collisions, snowmobiles, and all-terrain vehicles. These were grouped as high-energy injuries. Patients were then stratified by BMI according to the NIH classification system. Additionally, patients whose BMI was <18.5 were extracted into a separate group for comparison. Data extracted included the following: age, sex, ISS, mechanism of injury, list of injuries (injury pattern), length of stay (LOS), discharge disposition, complications, and mortality.

Patients in each mechanism group were initially stratified as obese or nonobese based on a BMI of <30 versus ≥30 and were compared for injury patterns, complications, LOS, discharge disposition, and mortality rates. The same outcomes

were then analyzed in blunt trauma patients, distinguishing between those injured by MVC or falls, after further stratification into the 4 BMI groups defined by NIH. Subsequently, patients with MVC or fall mechanisms were stratified into a matrix by BMI and ISS to analyze LOS, disposition, and mortality. Injury severity was stratified by the ISS as follows: Mild <9; Moderate 9 to 14; Severe 15 to 25; and Critical >25.

Categorical variables were compared using a chi-square analysis and the Cochran–Armitage trend test. Continuous variables were compared using the independent *t* test and Pearson correlation test. Multivariate regression analysis of the mortality rate with respect to age, ISS, Glasgow coma scale (GCS), and BMI was also performed. All statistical comparisons were performed with SAS 9.2 (SAS Institute, Inc, Cary, NC), Microsoft Excel 2011 (Microsoft Corporation, Redmond, Washington), and with consultation with an academic statistician.

Results

The trauma registry contained 3,768 patients for the time period reviewed. Of these, 1,572 required exclusion by age, pregnancy, burn, or incomplete specification of height, weight, and ISS. The remaining 2,196 (58.3%) patients constitute the subjects of this analysis. Of the 1,151 patients injured by MVC, 381 (33.1%) were obese. Of the 913 patients injured by fall, 233 (25.4%) were obese. Of the 132 patients with penetrating injuries, 42 (31.8%) were obese (Fig. 1).

Effect of obesity in patients with penetrating injury

In the penetrating injury group, chi-square analysis of obese versus nonobese patients demonstrated no difference in the mortality rate, LOS, or rate of discharge to home. Patients were subsequently stratified into 5 groups of BMI as follows: Underweight <18.5, Normal 18.5 to <25, Overweight ≥25 to 29.9, Obese ≥30 to 39.9, Morbidly obese ≥40; and into 4 groups by ISS as follows: Mild <9, Moderate 9 to 14, Severe 15 to 25, and Critical >25. The Cochran–Armitage trend test confirmed that no difference in the mortality rate, LOS, or rate of discharge to home was found in the penetrating trauma group at any level of stratification. There was no difference in the injury pattern or complications based on BMI in the penetrating trauma patients. Because of the relatively few obese patients with penetrating injury, the subsequent focus of this analysis is on the group of patients who sustained blunt trauma.

Effect of obesity in patients with blunt trauma from motor vehicle crash

Among the 1,151 patients injured by MVC, there was no difference in age or gender distribution between those with a BMI <30 or the obese patients. There was no difference in the overall mortality between the obese and nonobese

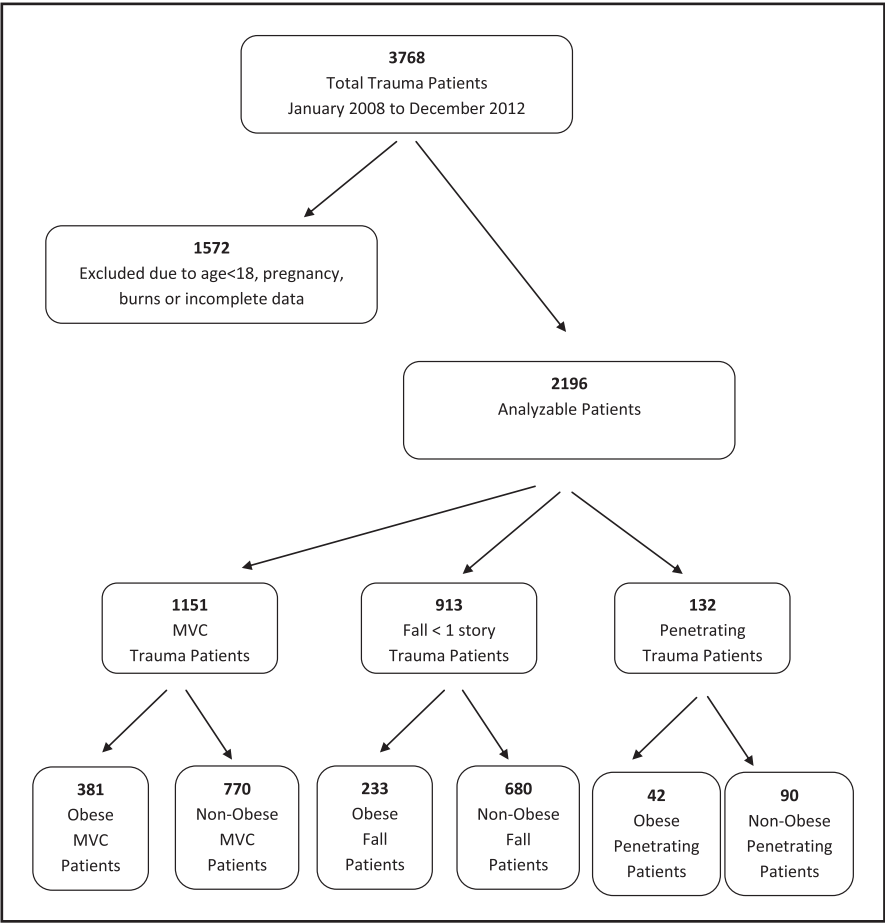


Figure 1 Study population.

patients in this group using chi-square analysis ($P = .87$). A multivariate analysis comparing the initial GCS, ISS, age, mortality rate, and BMI confirmed that BMI was not an independent predictor of mortality for the MVC group. However, obese patients were noted to have a longer overall hospitalization than nonobese patients (7 ± 11 vs 6 ± 6 days, $P = .02$). Of the 199 patients in this group who were admitted to the ICU, the 75 obese patients had significantly longer ICU stays than the 124 nonobese patients (10 ± 12 vs 6 ± 6 days, $P = .002$). Of the 135 patients requiring intubation, the 47 obese patients required significantly greater ventilator support days than the 88 nonobese patients (10 ± 13 vs 6 ± 6 days, $P = .009$). When stratified into 5 BMI groups and 4 ISS groups, the Cochrane–Armitage test showed that there was no significant difference in mortality based on BMI. However, the LOS increased as BMI increased for moderately injured patients ($P = .027$), and patients with higher BMIs were less likely to be discharged home for mild and moderate ISS groups ($P = .032$ and $.003$, respectively).

Effect of obesity in patients with blunt trauma from falls

Among the 913 patients injured by fall of <1 story, there was a significant difference in the “age of falling” between

the obese and nonobese (65 ± 17 vs 69 ± 19 , $P = .003$) patients. There was no difference in the gender or LOS of those who fell. There was a lower mortality rate for the obese patients when compared to nonobese patients (3.00% vs 6.73%, $P = .035$). In a multivariate analysis, as the BMI increased, the mortality decreased, even when accounting for the difference in the age ($P = .0039$). When fall patients were stratified into the 5 BMI and 4 ISS groups, higher BMI was associated with decreased mortality in the moderate and severe ISS cohorts ($P = .016$ and $.018$), while LOS increased with increasing BMI for the moderately injured ($P = .038$) patients, using the Cochrane–Armitage test.

The incidence of specific system injuries and complications between the obese and nonobese patients injured with blunt traumatic mechanisms is summarized in Table 1. The data show that the incidence of head injury is lower in the obese population, for both MVC and fall patients. We found a statistically significant higher incidence of spine injury among the obese patients injured by fall. There was a trend toward a higher incidence of lower extremity fracture among obese fall patients, but this did not reach statistical significance. Obese patients had a statistically higher incidence of cardiac, gastrointestinal, and hematological complications in the fall group and higher urinary and gastrointestinal complications in the MVC group.

Table 1 Injury patterns and complications of nonobese versus obese patients

	MVC			Falls		
	Nonobese	Obese	<i>P</i> value	Nonobese	Obese	<i>P</i> value
Injuries	<i>n</i> = 787	<i>n</i> = 391		<i>n</i> = 744	<i>n</i> = 255	
Head	66%	58%	.004*	72%	65%	.043*
Spine	43%	40%	.318	18%	26%	.006†
Chest	42%	44%	.475	13%	12%	.492
Abdomen	15%	12%	.106‡	3%	3%	.868
Pelvis	11%	11%	.867	4%	4%	.654
Upper extremity	29%	30%	.77	10%	11%	.342
Lower extremity	24%	22%	.442	8%	11%	.08‡
Vascular	4%	2%	.129‡	1%	0.3%	.618
Minor	60%	55%	.078‡	38%	35%	.392
Complications	<i>n</i> = 77	<i>n</i> = 70		<i>n</i> = 70	<i>n</i> = 37	
Resp	43%	43%	1	34%	20%	.096
CVS	7%	1%	.121	14%	38%	.005†
Urinary	12%	36%	.0005†	29%	30%	.9
Neuro	12%	9%	.533	26%	11%	.069
GI	3%	16%	.005*	11%	27%	.04†
Heme	26%	37%	.144‡	11%	27%	.04†
Infectious	17%	20%	.483	1%	3%	.643
Sho	7%	6%	.844	6%	0.00%	.138‡
Decubitus ulcer	4%	7%	.38	9%	3%	.242

CVS = cardiovascular system (atrial fibrillation, myocardial infarction, ST-segment elevation or depression, pericarditis); GI = gastrointestinal; Heme = hematological system (disseminated intravascular coagulopathy, venous thromboembolism, heparin-induced thrombocytopenia, anemia, acute blood loss); Infectious = wound infection, bacteremia, cellulitis, abscess; Neuro = neurological system (drug and alcohol withdrawal, cerebral vascular accident, cerebrospinal fluid leak, vocal cord paralysis, DTs, seizures); Resp = respiratory (aspiration pneumonia, acute respiratory distress syndrome, pleural effusion, pneumonia, empyema); Shock = hemodynamic shock and systemic inflammatory response syndrome; Urinary = urinary tract infection, pyelonephritis, acute renal failure, urinary retention.

*Statistically significant at <5%, *P* = .05.

†Obese patients noted to have a higher rate compared to nonobese patients.

‡Trend toward statistically significant.

Comments

This study further highlights the complex problems in determining the effects of obesity on patterns of injury and outcomes in obese patients. This study is only descriptive and therefore unable to assess the effects of any particular treatment intervention. It relies on the assumption that injury mechanisms, evaluation, and management techniques are uniform between obese and nonobese populations. The formula for kinetic energy, $k = (1/2) mv^2$, implies that velocity has a much greater effect on energy transfer than mass. However, mass might still have a prominent effect at lower velocities. It is reasonable to expect that increased mass may be associated with more frequent or more severe injuries at equal velocity. There is a counter theory proposed by Arbabi³ that some level adiposity maybe protective, by imparting a “cushion” effect. This work focused on severe blunt injury demonstrated a lower ISS in overweight patients who sustain MVCs; nevertheless, obese patients had a higher mortality. Furthermore, it has been traditionally thought that obesity leads to an increased bone density and therefore resilience to fractures. However, this explanation has been challenged in recent studies demonstrating that

increased fat deposits in the bone related to obesity may actually weaken the bone.¹²

The effects of associated comorbidities, nutritional impairment or increased nutritional reserve, mobility impairment, and other factors remain controversial with regard to the effects of trauma outcomes in this special population. This study failed to identify any relation between BMI and mortality, LOS, or discharge disposition among penetrating trauma patients. However, this could represent a Type II statistical error, based on insufficient size of the cohort. In the blunt MVC population, obese patients were noted to have increased overall hospitalization and ICU LOS, even if no difference in mortality. Our findings are similar to other reports, which demonstrate no difference in mortality, but a higher complication rate in obese patients.^{7,10} Byrnes et al⁵ also stratified patients using ISS, demonstrated that obese patients were 2.8 times more likely to die from their traumatic injuries compared to their normal weight counterparts and suffered worse respiratory and renal complications. In contrast, a study focused on severe blunt trauma demonstrated that as the BMI increased there was a decrease in mortality.¹⁰ It was noted in our study that obese patients tend to fall at a younger age and had a lower mortality. The higher

mortality in the nonobese patients in this group may reflect the presence of associated comorbidities or the higher age. It is also possible that the increase in obesity makes it harder to balance, leading to increase in falls at a younger age – these are areas for further research.

This study suffers from similar limitations affecting other articles on the subject. We included only 58% of eligible patients, due largely to missing the height and weight information needed to calculate BMI. We discovered that the state trauma registry does not require routine inclusion of these measurements. Some of the trends noted in injury and complication rates may have reached statistical significance with larger cohorts. Less than 20% of our study population was ICU patients, while a significant portion of the literature specifically focuses on ICU patients.^{6,7,9} The retrospective, descriptive methodology is subject to selection bias, incomplete data, and unmeasured variables. We were unable to specifically extract the extent of comorbidities present in the obese or nonobese cohorts, which could significantly impact both risk for injury and outcomes.

Factors that would likely increase the practical usefulness of future studies include the following: the use of a standardized classification of body mass, such as that proposed by the NIH; rigorous recording and reporting of patient height and weight, even if this means modifying current trauma registry practices; distinction of patient cohorts by mechanism of injury; and, the careful distinction of the ISS as an outcome measure to assess the risk of injury versus a stratification variable to assess the outcome from injury and treatment.

Conclusions

This study demonstrates that the patterns of injury and outcomes for obese trauma patients may be distinct for different mechanisms of injury. We failed to demonstrate significant differences in mortality, LOS, or disposition for victims of penetrating trauma. However, despite similar mortality, obese patients injured by MVC suffered longer hospital stays, longer ICU stays, and more ventilator days than nonobese patients. We unexpectedly found that obese patients injured by a fall of <1 story had a lower mortality than their nonobese counterparts, but remain hard pressed to identify a reliable theory to explain this finding. The impact of obesity on trauma patients remains a complex subject that deserves further study.

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Discussion

Roxie M. Albrecht (Oklahoma City, OK): This paper on obesity and trauma adds to the literature on what a huge issue, or I should say significant issue or problem that this disease in our society. It increases health care costs and increases ICU stay and hospital length of stay. Did you tease out potential reasons for these increased lengths of stay, such as pulmonary issues requiring additional non-invasive ventilatory support or more frequent therapies why the patients were in the ICU and could not be offered on the floor? Or if mobilization was an issue, requiring those patients to remain in the hospital or be transferred to rehab facilities? I saw in the paper you analyzed infections such as wound infections, bacteremia and abscesses but added UTI's, as well as pneumonias to the organ specific categories. Did you separately evaluate nosocomial infections, such as nosocomial pneumonias, catheter related UTI's or bloodstream infections separate from the respiratory and GU complications. And then finally, in the MVC category, were these just MVC's or were they falls greater than one story? ATV crashes or recreational vehicles, auto versus pedestrian and motorcycle crashes, were those included in this study. Thank you, again, for allowing me to discuss this paper.

Osborne: With regards to the first question, increased length of stay in both the ICU and general population, we didn't specifically go back and look at the characteristics of that hospitalization, as this was a trauma database registry and some of that was a little bit more difficult but certainly an area for us to improve and move forward with the study. With regards to the exclusion criteria, the patients usually had one of the two data points for BMI. They either had a height and a weight or they had a weight

but no height. So we were able to kind of eyeball it. No, we didn't go back and directly focus on that. With regards to the motor vehicle collision category, we did include motorcycle collisions and ATV's in this. Motor vehicle collision was a broad definition. We used falls less than one story.

James G. Tyburski (Detroit, MI): Two questions. The first one is, the length of stay, a lot of trauma patients, especially blunt trauma, can shorten length of stay. Obese patients, it can be extremely hard to get a satisfactory FAST exam. You will watch the patient for overnight or a day,

or a day and a half if they have. Is there any way you can factor that into your length of stay differences?

Osborne: With regards to the clinical assessment, when we started this out, we had that intuition that obese patients are just harder to immobilize. We can't get up to speak to what you are actually talking about. If the assessment of this patient is mobile enough to go home, and that was kind of a clinical aspect. With regards to our data supporting that, we did just look at the actual total length of stay. It wasn't a way for us to go back and assess the assessment on a daily aspect.