Body Mass Index and Outcomes in Critically Injured Blunt Trauma Patients: Weighing the Impact

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BACKGROUND: The influence of increased body mass index (BMI) on morbidity and mortality in critically injured trauma patients has been studied, with conflicting results. The objective of this study was to investigate the relationship between stratified BMI and outcomes in blunt injured patients.

STUDY DESIGN: Consecutive adult trauma patients from July 2001 to November 2005 with Injury Severity Score (ISS) $\geq$ 16 and blunt mechanism were evaluated using the National Trauma Registry of the American College of Surgeons. Demographics, injury severity, hospital course, complications, and mortality were compared among standard BMI strata. Logistic regression was used to determine odds ratios (OR) with 95% confidence intervals and evaluate BMI as an independent risk factor for morbidity and mortality. Statistical significance was set at $p < 0.05$.

RESULTS: The study group consisted of 1,543 patients. Controlling for age, gender, Injury Severity Score, and Revised Trauma Score, and using BMI 18.5 to 24.9 kg/m^2 as the reference category, morbid obesity (BMI $\geq$ 40 kg/m^2) was associated with acute respiratory distress syndrome (OR 3.675, 95% CI, 1.237 to 10.916), acute respiratory failure (OR 2.793, 95% CI, 1.633 to 4.778), acute renal failure (OR 13.506, 2.388 to 76.385), multisystem organ failure (OR 2.639, 95% CI, 1.085 to 6.421), pneumonia (OR 2.487, 95% CI, 1.483 to 4.302), urinary tract infection (OR 2.332, 95% CI, 1.229 to 4.427), deep venous thrombosis (OR 4.112, 95% CI, 1.253 to 13.496), and decubitus ulcer (OR 2.841, 95% CI, 1.382 to 5.841). Morbid obesity was not associated with increased mortality (OR 0.810, 95% CI, 0.353 to 1.856).

CONCLUSIONS: This is the largest study to date evaluating the relationship between BMI and outcomes in critically injured trauma patients. Increasing BMI increases morbidity while having no proved influence on mortality. (J Am Coll Surg 2007;204:1056–1064. © 2007 by the American College of Surgeons)

Obesity has risen to epidemic proportions in the US. Data from the National Center for Health Statistics reveal a 34% prevalence of obesity, defined as a body mass index (BMI) of 30 kg/m^2 or greater, in American adults 20 years and older.[1] Obese individuals are at increased risk for many diseases including hypertension, diabetes mellitus, dyslipidemia, osteoarthritis, coronary artery disease, stroke, sleep apnea, and cancers of the breast, colon, ovary, and prostate.[1]

Inconsistencies remain in the trauma literature about the influence of obesity in the trauma patient population as it relates to morbidity and mortality.[2-8] Although most studies have demonstrated considerable increases in morbidity,[2-7] there is no agreement about mortality.[2-8] In addition, dissimilar study methodology makes comparisons between analyses extremely difficult. So, given the rising prevalence of obesity and the unique challenges that these patients present when injured, we analyzed the impact of obesity on outcomes in severely injured blunt trauma patients in an effort to answer the question: Does obesity affect complication and death rates in injured patients?

METHODS

Consecutive adult trauma patients admitted to our Level I university trauma center from July 2001 to November 2005, with Injury Severity Score (ISS) $\geq$ 16 and blunt mechanism were identified using the National Trauma Registry of the American College of Surgeons (NTRACS).

Competing Interests Declared: None.

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Abbreviations and Acronyms

BMI	= body mass index
DVT	= deep venous thrombosis
ISS	= Injury Severity Score
MSOF	= multisystem organ failure
NTRACS	= National Trauma Registry of the American College of Surgeons
OR	= odds ratio
PE	= pulmonary embolism
RTS	= Revised Trauma Score
UTI	= urinary tract infection

Admission weight and height were used to calculate BMI, the weight in kilograms divided by the square of the height in meters. Patients were stratified into groups based on BMI using the classification adopted by the National Institutes of Health and the World Health Organization as follows: normal (18.5 to 24.9 kg/m^2), overweight (25 to 29.9 kg/m^2), obese (30 to 39.9 kg/m^2), and morbidly obese ($\geq$ 40.0 kg/m^2). Underweight patients (BMI $<$ 18.5 kg/m^2) were excluded. Demographics, ISS, Revised Trauma Score (RTS), hospital course, complications, and mortality were compared among the BMI strata.

Complications analyzed included the following: acute respiratory distress syndrome (ARDS), acute respiratory failure, acute renal failure, multisystem organ failure (MSOF), pneumonia, urinary tract infection (UTI), sepsis, line infection, wound infection, deep venous thrombosis (DVT), pulmonary embolism (PE), and decubitus ulcer. These complications were defined according to NTRACS.[9]

Values were recorded as mean $\pm$ standard deviation, raw percentages, or as odds ratios with 95% confidence intervals, where applicable. Chi-square analysis was used to assess the association between BMI grouping and categorical variables. Continuous variables were analyzed using the nonparametric Kruskal-Wallis test. Where possible, risk factors for each outcome were identified using univariate analysis. Logistic regression was then applied to study the association of BMI with each of the 12 morbidity outcomes and mortality, with normal BMI (18.5 to 24.9 kg/m^2) used as the reference category for computation of odds ratios with 95% confidence intervals. All analyses were conducted using SPSS for Windows, version 13.0 (SPSS Inc); $p < 0.05$ was used to judge statistical significance.

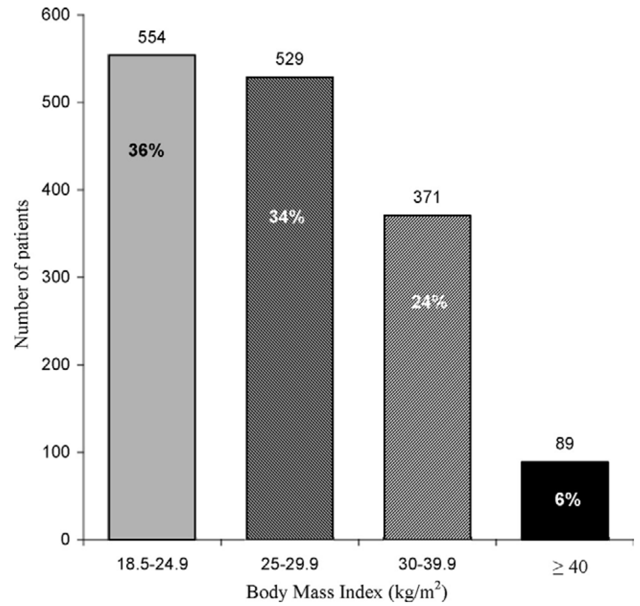

Figure 1. Distribution of patients by body mass index.

RESULTS

During the study period, 2,108 adult patients with ISS $\geq$ 16 were admitted to our trauma center. Of those, 1,751 (83%) had appropriate height and weight data that allowed calculation of BMI. Excluding patients without blunt mechanism and BMI $<$ 18.5 kg/m^2 (n = 61) 1,543 patients made up the study group.

The distribution of patients according to BMI is detailed in Figure 1. Among the 1,543 patients, 36% had a normal BMI, 34% were overweight, 24% were obese, and 6% were morbidly obese. Combining all patients with BMI $\geq$ 30, nearly one-third of the study group was at least obese.

Demographics and clinical characteristics of the study group are shown in Table 1 and Figure 2, with statistical significance being determined by an analysis of variability of the means across BMI strata. There was a statistically

Table 1. Comparison of Demographics and Injury Severity Stratified by Body Mass Index

	Body mass index stratifications, kg/m^2				
Variables	**18.5–24.9**	**25–29.9**	**30–39.9**	**≥ 40**	**p Value***
Age, y	43 ± 21	46 ± 20	47 ± 17	46 ± 17	< 0.001
Gender, % male	71	75	72	53	< 0.001
ISS	24 ± 8	25 ± 10	26 ± 10	27 ± 10	< 0.001
RTS	9.5 ± 3.5	9.6 ± 3.4	9.5 ± 3.4	9.4 ± 3.2	0.426

Means expressed as ± standard deviation.
*p Values reflect tests for significance across the body mass index groups.
ISS, Injury Severity Score; RTS, Revised Trauma Score.

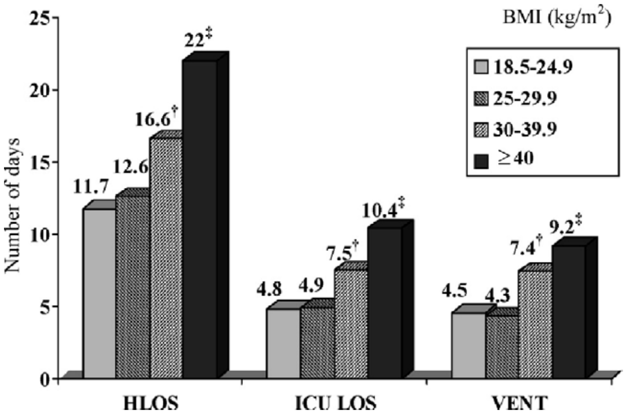

Figure 2. Length of stay and ventilator days stratified by body mass index (BMI). †, $p < 0.0001$ when comparing normal (18.5–24.9 kg/m^2) and obese (30–39.9 kg/m^2) body mass indices; ‡, $p < 0.0001$ when comparing normal (18.5–24.9 kg/m^2) and morbidly obese (≥ 40 kg/m^2) body mass indices. HLOS, hospital length of stay; ICU LOS, intensive care unit length of stay; VENT, ventilator days.

significant difference in age (43 ± 21 years to 46 ± 17 years, $p < 0.001$) and ISS (24 ± 8 to 27 ± 10, $p < 0.001$) among the BMI groups, but these differences were likely not clinically relevant. In addition, there was no difference in RTS, but the percentage of male patients decreased substantially in the BMI ≥ 40 group (71% to 53%, $p < 0.001$, Table 1). There were considerably longer hospital ($p < 0.001$) and ICU ($p < 0.001$) lengths of stay, and longer periods of ventilator support ($p < 0.001$, Fig. 2), as BMI increased.

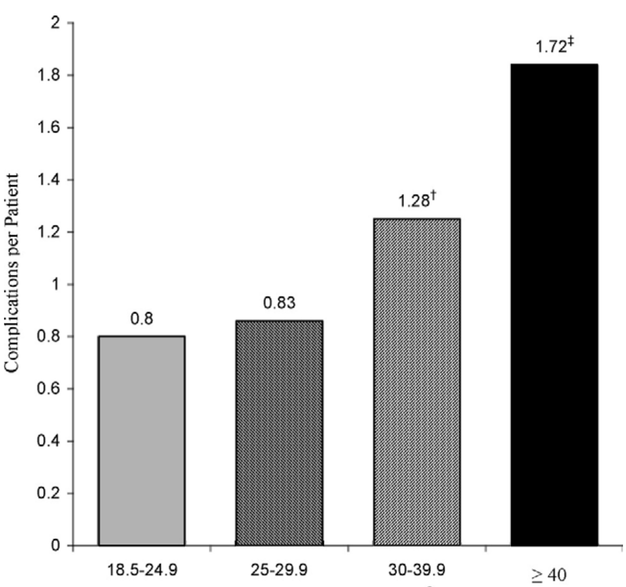

Figure 4. Distribution of complications per patient stratified by body mass index. †, $p < 0.05$ when comparing normal (18.5–24.9 kg/m^2) and obese (30–39.9 kg/m^2) body mass indices; ‡, $p < 0.05$ when comparing normal (18.5–24.9 kg/m^2) and morbidly obese (≥ 40 kg/m^2) body mass indices.

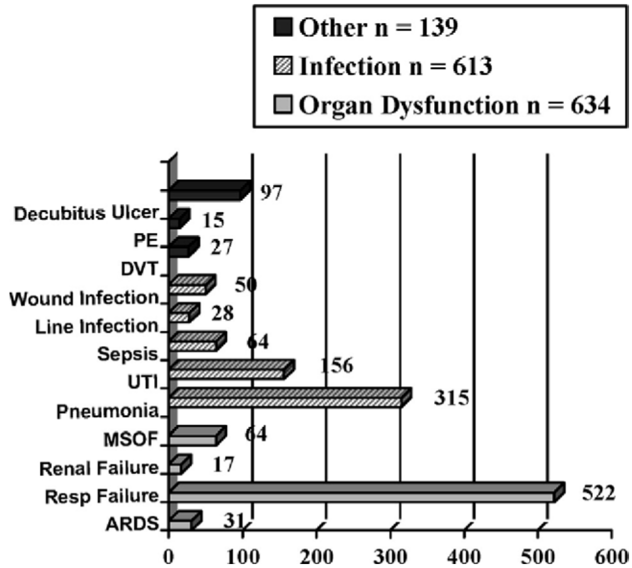

Figure 3. Distribution of complications. ARDS, adult respiratory distress syndrome; DVT, deep venous thrombosis; MSOF, multisystem organ failure; PE, pulmonary embolism; UTI, urinary tract infection.

There were 1,386 episodes of the complications analyzed that occurred in the study group (Fig. 3). The most common were 522 incidences of respiratory failure (37.7%), 315 pneumonias (22.7%), 156 UTIs (11.3%), and 97 decubitus ulcers (7.0%). The mean number of complications per patient increased (Fig. 4) as BMI increased. Patients in the morbidly obese group had twice as many complications from their injuries compared with patients with a normal BMI (1.72 complications versus 0.8 complications, $p < 0.001$).

Using univariate analysis, age, ISS, and RTS were risk factors for morbidity and mortality. Gender also independently affected morbidity. After adjusting for age, gender, ISS, and RTS and using normal BMI as the reference category, morbidly obese patients exhibited notably increased odds of developing ARDS (OR 3.675, 95% CI, 1.237 to 10.916), and respiratory (OR 2.793, 95% CI, 1.633 to 4.778), renal (OR 13.506, 95% CI, 2.388 to 76.385), and MSOF (OR 2.639, 95% CI, 1.085 to 6.421) (Table 2). But obese patients exhibited an increased odds ratio only for respiratory failure (OR 1.763, 95% CI, 1.271 to 2.446). Although a trend toward increasing complications with increasing BMI for all infectious morbidities was apparent, significance was achieved only for pneumonia and UTI in both obese and morbidly obese patients (Table 3). A similar pattern emerged for both venous thrombosis and decubitus ulcer development, but not for pulmonary embolism (Table 4). To summarize, of the 12 complications analyzed across the BMI strata, although overweight patients experienced no notable increase in complications, obesity was associated with 3 complications (acute respiratory failure, pneumonia, and UTI)

Table 2. Odds Ratios with 95% Confidence Intervals for Organ Dysfunction Stratified by Body Mass Index

	Body mass index stratifications, kg/m^2			
Complication	**25–29.9, OR (95% CI)**	**30–39.9, OR (95% CI)**	**≥ 40, OR (95% CI)**	**p Value***
Acute respiratory distress syndrome	0.652 (0.234–1.815)	1.234 (0.477–3.196)	3.675‡ (1.237–10.916)	0.026
Acute respiratory failure	0.941 (0.689–1.286)	1.763† (1.271–2.446)	2.793‡ (1.633–4.778)	<0.001
Acute renal failure	1.755 (0.316–9.752)	4.429 (0.904–21.69)	13.506‡ (2.388–76.385)	0.008
Multisystem organ failure	0.743 (0.370–1.491)	1.448 (0.756–2.776)	2.639‡ (1.085–6.421)	0.032

*p-Values reflect tests for significance across the body mass index groups.
†Significant odds ratio comparing normal (18.5–24.9 kg/m^2) and obese (30–39.9 kg/m^2) body mass indices.
‡Significant odds ratio comparing normal (18.5–24.9 kg/m^2) and morbidly obese (≥ 40 kg/m^2) body mass indices.
OR, odds ratio.

and morbid obesity was associated with 8 complications (ARDS, acute respiratory failure, acute renal failure, MSOF, pneumonia, UTI, DVT, and decubitus ulcer).

The mortality rate for the entire cohort was 10.2%. For the subgroup with BMI ≥ 30, there were 50 deaths in 460 patients (10.9%). There was no difference in the percentage of patients who died across BMI groups ($p = 0.858$, Fig. 5). Using logistic regression and adjusting for age, ISS, and RTS, there was also no corresponding increase in odds ratio of mortality along increasing BMI strata ($p = 0.962$, Fig. 5).

DISCUSSION

The first study to investigate the relationship between trauma and obesity was by Choban and colleagues[2] in 1991 (Table 5). This analysis demonstrated a 42% mortality rate for the obese group compared with 5% in the nonobese group. Thirteen years passed before the study by Neville and associates,[3] but there have been a number of reports[4-7] in recent years because of the obesity epidemic and an increased awareness of its influence in trauma patients. These studies are characterized by different methodologies, including varying definitions for obesity; wide ranges of obese patients (5.3% to 30%), increased morbidity, but no agreement on mortality. Our study has the largest sample size to date and the largest percentage of obese patients within the sample. It is also one of the first to stratify patients using the internationally recognized body mass index groupings, and the first to control for age, gender, ISS, and RTS in assessing outcomes.

Our results suggest that a rising BMI is directly related to increases in hospital and ICU lengths of stay. Morbidly obese patients had a hospital length of stay nearly twice that of patients with a normal BMI, and the ICU length of stay more than doubled. Although there were statistically significant differences in age and ISS among BMI strata, we do not believe that these increases affected outcomes because the differences appeared clinically insignificant. The effect of BMI on length of stay has been previously shown by Byrnes and colleagues.[4] Stratifying their patients into groups with BMI < 35 or ≥ 35, they found an average length of stay of 4.7 versus 7 days, respectively ($p = 0.001$) and an average ICU length of stay of 6.1 versus 8.7 days, respectively ($p = 0.045$). Although we did not include a cost analysis in this study, it is logical to infer that increased lengths of stay led to increased resource allocation in managing this population of patients[7] and, in turn, increased cost.

Obese patients required longer periods of ventilator support than those with a normal BMI, and ARDS, pneumonia, and acute respiratory failure developed more frequently. These results may be attributed to underlying respiratory disorders such as COPD, sleep apnea, and obesity hypoventilation syndrome, all of which produce profound effects on normal respiratory physiology. Obesity causes reductions in lung volume and respiratory compliance, leads to increased work of breathing, and results in a hypoxemic and hypercarbic state.[10,11] These effects are exacerbated in injured, supine, and sedated obese patients.

Table 3. Odds Ratio with 95% Confidence Intervals for Infection Stratified by Body Mass Index

	Body mass index stratifications, kg/m^2			
Complication	**25–29.9, OR (95% CI)**	**30–39.9, OR (95% CI)**	**≥ 40, OR (95% CI)**	**p Value***
Pneumonia	0.977 (0.692–1.379)	1.723† (1.213–2.446)	2.487‡ (1.483–4.302)	<0.001
Urinary tract infection	1.252 (0.799–1.960)	1.823† (1.162–2.860)	2.332‡ (1.229–4.427)	0.013
Sepsis	0.964 (0.500–1.861)	1.314 (0.677–2.551)	1.909 (0.723–5.045)	0.461
Line infection	0.739 (0.268–2.036)	1.211 (0.457–3.213)	2.756 (0.808–9.397)	0.232
Wound infection	1.189 (0.557–2.535)	1.796 (0.848–3.805)	2.829 (1.034–7.739)	0.145

*p-Values reflect tests for significance across the body mass index groups.
†Significant odds ratio comparing normal (18.5–24.9) and obese (30–39.9) body mass indices.
‡Significant odds ratio comparing normal (18.5–24.9) and morbidly obese (≥ 40) body mass indices.
OR, odds ratio.

Table 4. Odds Ratio with 95% Confidence Intervals for Other Complications Stratified by BMI

	Body mass index stratifications, kg/m²			
Complication	**25–29.9, OR (95% CI)**	**30–39.9, OR (95% CI)**	**≥ 40, OR (95% CI)**	**p Value***
Deep venous thrombosis	0.581 (0.168–2.010)	2.210 (0.843–5.795)	4.112† (1.253–13.496)	0.014
Pulmonary embolus	1.019 (0.321–3.227)	0.474 (0.094–2.389)	0.917 (0.107–7.873)	0.808
Decubitus ulcer	0.644 (0.357–1.162)	1.585 (0.937–2.683)	2.841† (1.382–5.841)	<0.001

*p Values reflect tests for significance across the body mass index groups.
†Significant odds ratio comparing normal (18.5–24.9) and morbidly obese (≥ 40) body mass indices.
OR, odds ratio.

Given their compromised respiratory physiology preinjury, the obese have limited ability to compensate when stressed, prolonging the need for ventilator support.

Although other studies have shown increased morbidity in obese patients,[2-7,12] ours is the first to demonstrate an increasing number of complications with increasing BMI. Our results also demonstrate an increased odds ratio of developing organ dysfunction, specific infectious complications, venous thrombosis, and decubitus ulcer formation across established BMI strata. For the morbidly obese, the rate of infectious complications (pneumonia, UTI) was more than twofold greater than that for patients with a normal BMI, and there was a trend toward increased occurrences of sepsis and line and wound infections. It may well be that obese patients are more susceptible to infection because of insulin resistance and hyperglycemia.[13]

The risk of single system organ failure developing was at least 2.5-fold greater for obese patients. In addition, the morbidly obese had a greater than 13-fold odds ratio for renal failure. An increase in postinjury organ failure in obese, injured patients has been demonstrated in other reports.[3-5,7] In the analysis by Ciesla and colleagues,[7] MSOF was 1.81 times more likely to develop in obese patients than in nonobese patients. This compares favorably with the 1.4- and 2.6-times

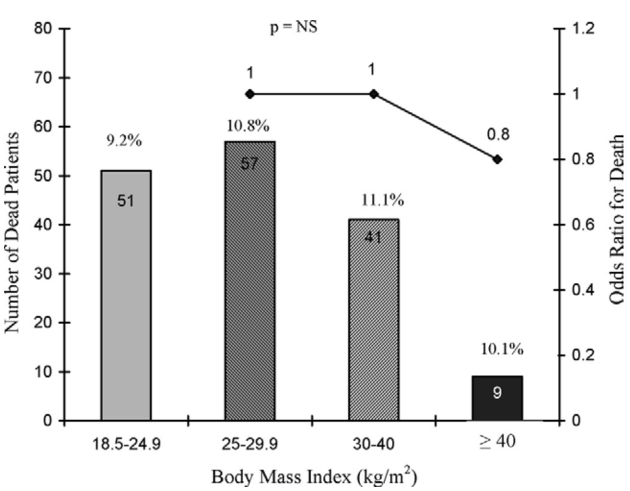

Figure 5. Distribution of dead patients and odds ratio* for death stratified by body mass index. *Odds ratio for death compared with normal (18.5–24.9 kg/m²) body mass index.

likelihoods of MSOF in the obese and morbidly obese populations, respectively, observed in our study.

Ciesla and associates[7] also attributed development of postinjury organ failure to the physiologic consequences of obesity. Adipose tissue serves an important role as an endocrine organ. It has been suggested that adipose tissue, through its secretion of adipokines such as leptin, tumor necrosis factor, interleukin-6, and many others, plays a important role in mediating systemic inflammation and immunity.[14-16] It is hypothesized that excess adiposity may cause a proinflammatory state in obese individuals that leads to organ dysfunction after injury.[3,7,17]

Published reports have not demonstrated a consistent effect of obesity on mortality.[18] Choban and colleagues,[2] Neville and associates,[3] Byrnes and coworkers,[4] Brown and coauthors,[5] and Bochicchio and colleagues[6] demonstrated in their studies increased mortality in obese patients; and Nasraway and associates[13] showed increased mortality in morbidly obese patients. But Ciesla and associates[7] and Duane and coauthors[8] found no relationship between obesity and mortality. Despite the increased morbidity in obese trauma patients found in our study, no correlation between obesity and mortality could be proved. This absence of an association between obesity and mortality is difficult to explain. Because our institution has an active bariatric program in place, perhaps a marked increase in mortality in the obese population was not appreciated because of the expertise in managing this difficult population. A multidisciplinary approach, including hospital beds to accommodate the body habitus of the obese, transfer equipment for placing patients in chairs, dietary consultants for nutritional management, and pharmacists who assist with medication dosing may lead to better outcomes. Additionally, because it has been shown that obese patients require increased amounts of staff to care for them, attention to optimal nurse staffing requirements may have had an impact on patient outcomes as they pertain to mortality.[19]

This study does have limitations. Our analysis was limited by the retrospective design and the need to exclude patients because of a lack of height and weight data. This was a similar shortcoming of other studies.[2,4] Despite the exclusion of some patients, though, our study had the largest number of obese trauma patients to date. In addition,

Table 5. Cumulative Review

First author, year	Number obese pts/total pts (%)	Mechanism of injury		Overall mortality, %	Obese mortality, %	Odds ratio for mortality (p value)
		Blunt	Penetrating			
Choban,[2] 1991	~19*/184 (10.3)	184	—	9	42.1	—
Neville,[3] 2004	63/242 (26.0)	242	—	20	32	5.7 (0.003)
Byrnes,[4] 2005	122†/1,179 (10.3)	1,102	77	4.8	10.7	—
Brown,[5] 2005	283/1,153 (25)	1,153	—	18.2	22	1.6 (0.03)
Bochicchio,[6] 2006	62/1,167 (5.3)	829	338	15.3	21	4.2‡/8.8§ (<0.01‡/<0.001§)
Ciesla,[7] 2006	152/716 (21)	594	122	8	7	0.79 (0.499)
Duane,[8] 2006	115/453 (25)	453	—	6	4	—
Newell, 2007	460/1,543 (30)	1,543	—	10.2	10.9	0.810 (0.962)

*Obese = BMI > 31.
†Obese = BMI ≥ 35.
‡BMI 30–49.
§BMI ≥ 49.
BMI, body mass index; Pts, patients.

we did not take into consideration the influence of comorbidities that may affect outcomes. Although our study results suggested increased morbidity with increasing BMI, we are unable to ascertain whether this was solely the effect of obesity or the result of preexisting medical comorbidities.

In conclusion, our results demonstrated that increasing BMI extends ICU and hospital lengths of stay, increases ventilator days, and augments risk of specific complications. Although obese patients are affected, the morbidly obese are most notably affected. Our findings also suggested that morbid obesity does not increase the risk of mortality when controlled for age, ISS, and RTS. Given the complexity and high resource use of this unique patient population, future studies examining obese trauma patients are needed to help define the physiologic consequences of obesity that influence outcomes and target measures that improve management of this challenging group.

Author Contributions

Study conception and design: Newell, Bard, Goettler, Rotondo
Acquisition of data: Newell, Bard, Goettler, Toschlog, Schenarts, Sagraves
Analysis and interpretation of data: Newell, Bard, Goettler, Toschlog, Schenarts, Sagraves, Holbert, Pories, Rotondo
Drafting of manuscript: Newell, Holbert, Rotondo
Critical revision: Newell, Bard, Goettler, Toschlog, Schenarts, Sagraves, Holbert, Pories, Rotondo

REFERENCES

1. National Center for Health Statistics Health, United States, 2006; with chartbook on trends in the health of Americans. Hyattsville, MD: US Department of Health and Human Services, 2006.
2. Choban P, Weireter LJ, Maynes C. Obesity and increased mortality in blunt trauma. J Trauma 1991;31:1253–1257.
3. Neville AL, Brown CVR, Weng J, et al. Obesity is an independent risk factor of mortality in severely injured blunt trauma patients. Arch Surg 2004;139:983–987.
4. Byrnes MC, McDaniel MD, Moore MB, et al. The effect of obesity on outcomes among injured patients. J Trauma 2005;58:232–237.
5. Brown CVR, Neville AL, Rhee P, et al. The impact of obesity on the outcomes of 1153 critically injured blunt trauma patients. J Trauma 2005;59:1048–1051.
6. Bochicchio GV, Joshi M, Bochicchio K, et al. Impact of obesity in the critically ill trauma patient: A prospective study. J Am Coll Surg 2006;203:533–538.
7. Ciesla DJ, Moore EE, Johnson JL, et al. Obesity increases risk of organ failure after severe trauma. J Am Coll Surg 2006;203:539–545.
8. Duane TM, Dechert T, Aboutanos MB, et al. Obesity and outcomes after blunt trauma. J Trauma 2006;61:1218–1221.
9. American College of Surgeons Committee on Trauma. Resources for optimal care of the injured patient. Chicago: American College of Surgeons; 1999.
10. Varon J, Marik P. Management of the obese critically ill patient. Crit Care Clin 2001;17:187–200.
11. Brunette DD. Resuscitation of the morbidly obese patient. Am J Emerg Med 2004;22:40–47.
12. Bercault N, Boulain T, Kuteifan K, et al. Obesity-related mortality rate in an adult intensive care: A risk-adjusted matched cohort study. Crit Care Med 2004;32:998–1003.
13. Nasraway SA, Albert M, Donnelly AM, et al. Morbid obesity is an independent determinant of death among surgical critically ill patients. Crit Care Med 2006;34:964–970.
14. Axelsson J, Heimburger O, Lindholm B, et al. Adipose tissue and its relation to inflammation: the role of adipokines. J Ren Nutr 2005;15:131–136.
15. Tilg H, Moschen AR. Adipocytokines: mediators linking adipose tissue, inflammation and immunity. Nat Rev Immunol 2006;10:772–783.
16. Rondinone CM. Adipocyte-derived hormones, cytokines, and mediators. Endocrine 2006;29:81–90.
17. Brown CVR, Rhee P, Neville AL, et al. Obesity and traumatic brain injury. J Trauma 2006;61:572–576.
18. O'Brien JM, Phillips GS, Ali NA, et al. Body mass index is independently associated with hospital mortality in mechanically ventilated adults with acute lung injury. Crit Care Med 2006;34:738–744.
19. Rose MA, Baker G, Drake DJ, et al. Nurse staffing requirements for care of morbidly obese patients in the acute care setting. Bariatr Nurs Surg Patient Care 2006;1:115–121.