Obesity Is an Independent Risk Factor of Mortality in Severely Injured Blunt Trauma Patients

Angela L. Neville, MD; Carlos V. R. Brown, MD; Janie Weng, BS; Demetrios Demetriades, MD, PhD; George C. Velmahos, MD, PhD

Hypothesis: Obesity is associated with increased morbidity and mortality in critically injured blunt trauma patients.

Design: Case-control study of all critically injured blunt trauma patients between January 2002 and December 2002.

Setting: Academic level I trauma center at a county referral hospital.

Patients: Two hundred forty-two consecutive patients admitted to the intensive care unit following blunt trauma. Patients were divided into 2 groups by body mass index. The obese group was defined as having a body mass index of 30 kg/m² or higher, and the nonobese group was defined as having a body mass index lower than 30 kg/m².

Main Outcome Measures: Univariate and multivariate analyses were performed to identify risk factors for mortality. Complications and length of stay were also evaluated.

Results: Of the 242 patients, 63 (26%) were obese, and 179 (74%) were nonobese. The obese and nonobese groups were similar with regard to age (mean±SD, 49±18 years vs 45±22 years), male sex (63% vs 72%), Glasgow Coma Scale score (mean±SD, 11±5 vs 11±5), and injury severity score (mean±SD, 21±13 vs 20±14). The obese group had a higher body mass index (mean±SD, 35±7 vs 24±3; P < .001). Mechanisms of injury and injury patterns were similar between groups. The obese group had a higher incidence of multiple organ failure (13% vs 3%; P = .02) and mortality (32% vs 16%; P = .008). Obesity was an independent predictor of mortality with an adjusted odds ratio of 5.7 (95% confidence interval, 1.9-19.6; P = .003).

Conclusions: Critically injured obese trauma patients have similar demographics and injury patterns as nonobese patients. Obesity is an independent predictor of mortality following severe blunt trauma.

Arch Surg. 2004;139:983-987
Obesity imparts a number of anatomical and physiological changes that may impact the body’s response to injury. Our study finds that although obese and nonobese severe blunt trauma patients have similar demograph-

### RESULTS

During the 1-year study period, 242 blunt trauma patients were admitted to the SICU. The population had a mean ± SD age of 45 ± 21 years, was 69% male, and had a mean ± SD ISS of 20 ± 17. Of these patients, 63 (26%) were obese (mean ± SD BMI, 35 ± 7), and 179 (74%) were nonobese (mean ± SD BMI, 24 ± 3). Admission characteristics of the 2 groups are shown in Table 1. Mechanism of injury did not differ between the 2 groups (P = .15). The most frequent mechanisms of injury were motor vehicle accident (37%), pedestrian struck by auto (33%), fall (14%), motorcycle accident (7%), assault (4%), and other (5%). Injury patterns were similar for obese and nonobese patients, with the exception that obese patients had fewer basilar skull fractures (2% vs 13%; P = .01) and more femur fractures (22% vs 10%; P = .01). Mean ± SD ISS were 21 ± 13 for the obese group and 20 ± 14 for the nonobese group (P = .31).

Complications occurred with equal frequency in both the obese and the nonobese groups (35% vs 36%; P = .91). Types of complications and their relative frequencies are depicted in Figure 1. There were no statistically significant differences in the frequency of complications between the groups with one exception. The obese group had a higher rate of MOF than the nonobese group (13% vs 3%; P = .02). Obese and nonobese survivors had the same SICU length of stay (mean ± SD, 10 ± 9 days vs 11 ± 10 days; P = .65) and overall length of stay (mean ± SD, 24 ± 23 days vs 21 ± 17 days; P = .47).

The mortality rate for the entire population was 20% (n = 49), but obese patients had a 2-fold higher mortality rate (32% [n = 20] vs 16% [n = 29]; P = .008). The causes of mortality and the average time to mortality are reported in Table 2. The most common causes of death in both groups were brain injury (67%) and MOF (24%). There was no statistical difference overall in the cause of death between groups (Figure 2). However, MOF as the cause of death was twice as frequent in obese patients (7 of 20 or 35%) than in nonobese patients (3 of 29 or 17%; P = .16). The following were identified as independent risk factors for mortality: obesity, head injury, pulmonary contusion, ISS, and age, as shown in Table 3.

### COMMENT

Obesity imparts a number of anatomical and physiological changes that may impact the body’s response to injury. Our study finds that although obese and nonobese severe blunt trauma patients have similar demograph-

### Table 1. Admission Characteristics*

<table>
<thead>
<tr>
<th></th>
<th>Obese Group (n = 63)</th>
<th>Nonobese Group (n = 179)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>49 ± 18</td>
<td>45 ± 22</td>
<td>.08</td>
</tr>
<tr>
<td>Men, %</td>
<td>63</td>
<td>72</td>
<td>.23</td>
</tr>
<tr>
<td>Heart rate, beats/min</td>
<td>98 ± 35</td>
<td>99 ± 27</td>
<td>.99</td>
</tr>
<tr>
<td>Systolic blood pressure, mm Hg</td>
<td>123 ± 36</td>
<td>130 ± 28</td>
<td>.24</td>
</tr>
<tr>
<td>Glasgow Coma Score</td>
<td>11 ± 5</td>
<td>11 ± 5</td>
<td>.34</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td>35 ± 7</td>
<td>24 ± 3</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Data are presented as mean ± SD unless otherwise indicated.

Figure 1. Types of complications encountered in obese and nonobese patients and their relative frequencies.

a computerized SICU database. Variables analyzed include age, sex, height, weight, mechanism of injury, injuries sustained identified by ICD-9 code, admission heart rate, admission systolic blood pressure, admission Glasgow Coma Scale score, Abbreviated Injury Score for each body region, and Injury Severity Score (ISS).

Height and weight obtained on intake to the SICU were used to calculate the BMI for each patient. Patients were divided into 2 groups by BMI. A BMI of 30 or higher has become the accepted definition of obesity by both the National Institutes of Health and the World Health Organization.6,7 Thus, in our study, the obese group was defined as having a BMI of 30 or higher, and the nonobese group was defined as having a BMI of lower than 30.

The primary outcome measured was mortality, and secondary outcomes were complications, length of SICU stay, and length of hospital stay. Complications included renal failure requiring dialysis, respiratory failure requiring intubation, acute respiratory distress syndrome, pneumonia, sepsis, multiple organ failure (MOF), thromboembolic event, and wound dehiscence. Multiple organ failure was defined as the failure of 2 or more organ systems.

Statistical analysis was performed using the SAS System, version 8.2 (SAS Institute Inc, Cary, NC), and Microsoft Excel 2002 (Microsoft Corp, Redmond, Wash). Values are reported as mean ± SD, odds ratio, and 95% confidence intervals, or as raw percentages where applicable. Categorical variables were compared using chi² or Fisher exact tests, and continuous variables were analyzed using 2-tailed t test. Dichotomous variables were created out of continuous variables at clinically significant cutoff points (eg, age >55 years, BMI ≥ 30, ISS ≥ 20, heart rate > 100 beats/min, and systolic blood pressure < 90 mm Hg). These, along with categorical variables, were entered into univariate analysis. Variables with a difference of P < .20 were included in stepwise logistic regression to identify independent risk factors for mortality. Statistical significance was considered at the level of P < .05 for all comparisons.
Obesity, defined as female body weight of more than 200 pounds or male body weight of more than 250 pounds, was the only dis-

existing illnesses on trauma outcomes. In the early 1990s, 3 retrospective studies, using 3 different definitions of obesity, looked at the effects of obesity on trauma mortality.5,6,10 Using a statewide discharge database from California, Morris et al8 evaluated the effect of preexisting medical conditions on trauma deaths. Secondary diagnoses that were ICD-9 coded on the discharge record made up the preexisting medical conditions. Obesity was one such diagnosis and was not associated with an increased mortality. Limitations of this study include the significant potential for underreporting secondary diagnoses (like obesity) and the probability that there was no uniform definition of obesity among the different hospitals coding the discharge records.

Milzman et al9 looked at prospectively collected trauma registry data to determine the impact of 9 preexisting illnesses on trauma outcomes. Obesity, defined as female body weight of more than 200 pounds or male body weight of more than 250 pounds, was the only disease that was not independently associated with an increased mortality. Their use of an unconventional definition of obesity and the fact that only 2.1% of their population was obese make it difficult to draw conclusions from this study about the effect of obesity on trauma mortality.

A correlation between obesity and trauma mortality was identified by Smith-Choban et al10 in their retrospective review of 351 patients sustaining blunt trauma. Smith-Choban and colleagues found a 42.1% mortality rate in 19 severely overweight patients (BMI >31) compared with a 9% mortality rate in patients with a BMI of lower than 27 (P < .001). Our study's findings complement the results of Smith-Choban and colleagues from 10 years earlier. We also demonstrate a high mortality rate (32%) for the critically injured obese blunt trauma patient.

Our study's overall mortality rate of 20% is in excess of the approximately 10% predicted mortality rate of blunt injured patients with an age of less than 55 years and an ISS in the range of 16 to 24.11 It also exceeds the average mortality rate of 9% found in the Smith-Choban study; their mean ISS was 22.10 This difference between mortality rates may be because our population was slightly older than the Smith-Choban population (mean age, 45 vs 34 years) and more obese (26% with BMI >30 vs 10% with BMI >31), or it may reflect the limitations of the ISS.

We and Smith-Choban and colleagues find increased BMI to be an independent predictor of mortality. The strength of our study lies in the fact that we have a relatively large obese population (n = 63) and that no patients were excluded. Each consecutive admission to our SICU had height and weight measurements taken; thus, BMI was reliably calculated. The Smith-Choban study excluded 177 patients on the basis of incomplete height and weight records; furthermore, they had a relatively small group of patients with a BMI of higher than 31 (n = 19).10 Our study also uses the now widely accepted definition of obesity (BMI ≥30), and thus our con-
cyte-secreted hormone that helps regulate adiposity, has considered the impact of obesity on the inflammatory response. The results of Morris et al and Milzman et al, who found an increased incidence of MOF in the obese group of patients dying from MOF compared with their non-obese counterparts. Furthermore, there was a trend toward obesity patients dying from MOF compared with their non-obese counterparts. In the study by Smith-Choban et al, 7 of the 8 severely overweight trauma patients died from acute respiratory distress syndrome, an inflammatory-mediated event. Finally, an investigation of morbidly obese patients in a medical intensive care unit found the presence of MOF to be the strongest independent predictor of mortality in these patients. One is forced to consider the impact of obesity on the inflammatory response.

There is increasing evidence that leptin, the adipocyte-secreted hormone that helps regulate adiposity, has immunomodulatory actions. Leptin is structurally similar to the interleukin-6 cytokines and has been shown to be important in immunocompetency. In vitro models show that leptin may have a role in increasing phagocytic activity in macrophages, and animal studies reveal that leptin-deficient mice are more prone to lipopolysaccharide-induced lethality. Human studies find survivors of severe sepsis and septic shock to have higher plasma levels of leptin than nonsurvivors. No studies have looked at leptin levels in trauma patients. Interestingly, obese persons have high baseline plasma leptin concentrations. The fact that their high leptin levels do not correlate with the expected feedback responses (to decrease food intake and increase energy expenditure) suggests that obese persons may be resistant to leptin. Could it be possible that leptin resistance in the obese population makes them more prone to inflammatory complications? The role of leptin in the inflammatory cascade is still being evaluated and will need to be studied in the context of obesity. The role of leptin in trauma, a significant but clearly different mediator of the inflammatory response, remains to be seen.

Our study has several limitations. Although we have found an association between obesity and trauma mortality, we can only hypothesize about the reason(s) for this association. Because of the retrospective nature of the study, we were not able to account for other medical conditions that may have confounded our results and led to an increased mortality in this group. Similarly, although we found a trend toward death from MOF in obese patients, we were unable to identify precipitating factors of MOF (such as types of infection or transfusion requirements). Having such information might have helped elucidate the underlying causes of increased death in the obese population. Our study is also limited by the size of the patient population. A larger patient population would have allowed us to stratify levels of BMI to determine any correlation with injury outcome. A larger population also might have identified statistically significant differences in causes of mortality that showed clinically important trends. A study that intends to address these limitations is currently being designed at our institution.

In this retrospective analysis of 242 severely injured blunt trauma patients, we found that obese patients have similar demographics, mechanisms of injury, and injury patterns but higher mortality than their nonobese counterparts. Multiple organ failure occurs more often as a complication in obese patients and is twice as often the cause of death in this population. Obesity, as an independent risk factor, carries a nearly 6-fold increase in mortality rate. This study has important prognostic implications for obese patients, suggesting they be considered a high-risk group for mortality after sustaining severe blunt trauma. Further study to better delineate the relationship between obesity and trauma is warranted.

Accepted for publication May 19, 2004.

This scientific poster was presented at the 75th Annual Meeting of the Pacific Coast Surgical Association; February 16, 2004; Maui, Hawaii.
Correspondence: Angela L. Neville, MD, Los Angeles County and University of Southern California Medical Center, 1200 N State St, Room 9900, Los Angeles, CA 90033 (angelane@usc.edu).

REFERENCES


ARCHIVES OF INTERNAL MEDICINE
The Incidence of Recurrent Venous Thromboembolism After Treatment With Vitamin K Antagonists in Relation to Time Since First Event: A Meta-analysis
Carlo J. J. van Dongen, MSc; Roel Vink, MD; Barbara A. Hutten, PhD; Harry R. Büller, MD, PhD; Martin H. Prins, MD, PhD

Background: After a first episode of venous thromboembolism, patients are treated with vitamin K (phytonadione) antagonists. There are indications that the risk of recurrence after treatment with vitamin K antagonists decreases relative to the time since the first event. The aim of the present meta-analysis is to describe the risk of recurrent venous thromboembolism after treatment with vitamin K antagonist in relation to the time since the index event.

Methods: Computerized searches in MEDLINE and EMBASE databases; reference checks of pertinent articles; personal communication with colleagues to find randomized clinical trials and cohort studies in which patients with venous thromboembolism were treated with vitamin K antagonists. Per treatment arm, 2 reviewers independently extracted data on the number of recurrent events and the duration of follow-up per time period of 3 months.

Results: A total of 135 potentially eligible studies were identified. Of these, 18 studies could be included, comprising 25 treatment arms that could be analyzed. Treatment arms were divided into 3 groups based on treatment duration (short, medium, and long). For all 3 groups, the monthly incidence immediately after discontinuation of treatment was high and declined rapidly thereafter. The monthly incidence after 9 months seemed independent of the treatment duration.

Conclusions: There is a diminishing risk of recurrent venous thromboembolism over time and a stabilization after 9 months independent of the duration of the initial treatment with vitamin K antagonists. These findings have important implications for decision making about the optimal duration of treatment with vitamin K antagonists. (2003;163:1285-1293)

Correspondence: Carlo J. J. van Dongen, MSc, Department of Clinical Epidemiology and Biostatistics, Room J2-204, Academic Medical Center, University of Amsterdam, PO Box 22700, 1100 DE Amsterdam, the Netherlands (c.j.vandongen@amc.uva.nl).