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

U NINTENTIONAL INJURY REMAINS the fifth leading cause of death in the United States. Meanwhile, the number of overweight individuals climbs at an alarming rate. Recent estimates from an epidemiological review found 18.9% of the US population to be obese, defined by a body mass index (BMI) of 30 or higher. (BMI is the weight in kilograms divided by the height in meters squared.) An understanding of the interplay between these 2 health care epidemics is paramount.

Obesity imparts anatomical and physiological changes that may interfere with the body’s response to injury. Obese patients have a compromised pulmonary status characterized by reduced lung volumes and compliance, as well as increased ventilation/perfusion mismatching. Obesity is an independent risk factor for cardiovascular disease, which can complicate any hospitalization. Higher incidences of deep venous thrombosis, gastroesophageal reflux, and insulin resistance also afflict obese patients.

The obese habitus additionally affects our ability to care for such patients. Obesity makes airway management more challenging, surgical exposures more difficult, and radiographic imaging less reliable. For these reasons, we hypothesized that obesity would be associated with increased morbidity and mortality in critically injured trauma patients. The objective of this study was to characterize the relationship between obesity and blunt trauma outcomes.

METHODS

We evaluated all blunt trauma admissions to the surgical intensive care unit (SICU) at our academic level I trauma center from January 2002 to December 2002. Data on each patient was extracted from both a trauma registry and...
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 χ² 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 cut-off 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.

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±5). 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 (3%). Injury patterns were similar for obese and nonobese patients, with the exception that obese patients 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 (5 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.
ics, injury patterns, and complication rates, obese patients are more than 5 times more likely to die from their injury than their nonobese counterparts.

Our study adds to a somewhat controversial body of literature that has failed to find a clear association between obesity and 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 patients were 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-

<table>
<thead>
<tr>
<th>Cause of Mortality</th>
<th>Obese Group, No.</th>
<th>Nonobese Group, No.</th>
<th>Mean ± SD Time to Mortality (Obese vs Nonobese), d</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed head injury</td>
<td>12</td>
<td>21</td>
<td>8 ± 8 vs 6 ± 7</td>
<td>.7</td>
</tr>
<tr>
<td>Multiple organ failure</td>
<td>7</td>
<td>5</td>
<td>27 ± 32 vs 8 ± 5</td>
<td>.2</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>1</td>
<td>0</td>
<td>5†</td>
<td>NA</td>
</tr>
<tr>
<td>Exsanguination</td>
<td>0</td>
<td>3</td>
<td>2 ± 1‡</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>29</td>
<td>15 ± 25 vs 6 ± 7</td>
<td>.1</td>
</tr>
</tbody>
</table>

Abbreviation: NA, not available.
*P value reflects comparison between the mean times to mortality in obese and nonobese groups.
†Obese group only.
‡Nonobese group only.

Table 2. Causes of Mortality and Length of Time to Death

Figure 2. Causes of mortality and their relative percentages in obese and nonobese subgroups.

<table>
<thead>
<tr>
<th></th>
<th>Adjusted Odds Ratio (95% Confidence Interval)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe head injury</td>
<td>34.8 (8.9-165.9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pulmonary contusion</td>
<td>10.4 (2.9-41.8)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Body mass index ≥30</td>
<td>5.7 (1.9-19.6)</td>
<td>.003</td>
</tr>
<tr>
<td>Injury Severity Score ≥20</td>
<td>4.6 (1.4-17.5)</td>
<td>.01</td>
</tr>
<tr>
<td>Age &gt;55 y</td>
<td>1.6 (1.3-2.2)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Table 3. Independent Risk Factors of Mortality
The results of Morris et al and Milzman et al, who found an increased incidence of MOF in the obese group, provided evidence that obesity leads to an increased mortality rate. This study has important prognostic implications for obese patients, suggesting that they should 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.
The Incidence of Recurrent Venous Thromboembolism After Treatment With Vitamin K Antagonists in Relation to Time Since First Event: A Meta-analysis

Carlo 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 index 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 duration of follow-up per time period of 3 months.

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.

Correspondence: Carlo 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).