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Body mass index in blunt trauma patients with hemorrhagic shock: opposite ends of the body mass index spectrum portend poor outcome

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Abstract

BACKGROUND: There are controversial data on the relationship between trauma and body mass index. We investigated this relationship in traumatic hemorrhagic shock.

METHODS: The "Glue Grant" database was analyzed, stratifying patients into underweight, normal weight (NW), overweight, Class I obesity, Class II obesity, and Class III obesity. Predictors of mortality and surgical interventions were statistically determined.

RESULTS: One thousand nine hundred seventy-six patients were included with no difference in injury severity between groups. Marshall's score was elevated in overweight (5.3 ± 2.7, $P = .016$), Class I obesity (5.8 ± 2.7, $P < .001$), Class II obesity (5.9 ± 2.8, $P < .001$), and Class III obesity (6.3 ± 3.0, $P < .001$) compared with NW (4.8 ± 2.6). Underweight had higher lactate (4.8 ± 4.2 vs 3.3 ± 2.5, $P = .04$), were 4 times more likely to die (odds ratio 3.87, confidence interval 2.22 to 6.72), and were more likely to undergo a laparotomy (odds ratio 2.06, confidence interval 1.31 to 3.26) than NW.

CONCLUSION: Early assessment of body mass index, with active management of complications in each class, may reduce mortality in traumatic hemorrhagic shock.

Trauma and obesity are 2 important problems with significant clinical, public health, and financial implications for the American healthcare system. Among individuals aged 1 to 44 years, trauma is the leading cause of death, and is also the third leading cause of death among individuals of all age groups.[1] As a result of injuries, about 41 million US residents visit the emergency department every year, with 2.3 million hospitalized.[2] Approximately 180,181 US residents die annually from trauma,[2] with hemorrhage,

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traumatic brain injury, and sepsis being the leading causes of treatable trauma deaths.[3–5] The annual lifetime costs of trauma, including direct healthcare costs and indirect costs from lost economic productivity, amount to $406 billion.[6]

In addition, obesity has reached epidemic proportions in the United States. The Centers for Disease Control and Prevention estimates that 35.1% of adults aged 20 years and older are obese, while 69% of adults of the same age are overweight (OW) or obese.[7] The medical complications of obesity are one of the most diverse of any clinical condition, including hypertension, diabetes mellitus, dyslipidemia, coronary artery disease, cerebrovascular disease, osteoarthritis, obstructive sleep apnea, and gastroesophageal reflux disease and account for about 112,000 deaths annually in the United States.[8] The direct health cost of obesity in 2008 US dollars was $147 billion and on the average, the medical costs of obese individuals were $1,429 higher than NW individuals.[9]

Despite these disconcerting statistics, there is very sparse data on the relationship between trauma and obesity. The few available studies provide conflicting results. Diaz et al[10] retrospectively examined 1,334 critically ill trauma patients seen at a Level I trauma center and stratified them into nonmorbidly obese with a body mass index (BMI) less than 40 kg/m^2 and morbidly obese with BMI greater than or equal to 40 kg/m^2. They concluded that morbid obesity was not a risk factor for mortality in critically ill trauma patients. Newell et al[11] analyzed data on 1,543 trauma patients stratifying them by BMI into NW (18.5 to 24.9 kg/m^2), OW (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 (UW) patients (BMI $<$ 18.5 kg/m^2) were excluded from this analysis. They found an association among morbid obesity and acute respiratory distress syndrome (ARDS), acute respiratory failure, acute renal failure, multisystem organ failure, pneumonia, urinary tract infection, deep venous thrombosis, and decubitus ulcer. No association between morbid obesity and increased mortality was demonstrated. On the other hand, Neville et al,[12] in their analysis of 242 trauma patients divided into obese (BMI $\geq$ 30 kg/m^2) and nonobese (BMI $<$ 30 kg/m^2), showed that despite critically injured obese trauma patients having similar demographics and injury patterns as the nonobese patients, obesity was an independent predictor of mortality after severe blunt trauma. Similarly, Brown et al[13] studied 1,153 critically injured blunt trauma patients and showed that obesity (BMI $\geq$ 30 kg/m^2) was independently associated with mortality. With these conflicting results, the development of robust clinical management guidelines based on body weight is difficult.

In the majority of these studies on trauma outcomes and body weight, the UW population is almost always neglected.[11] In one of the few available studies on the subject, Evans et al[14] analyzed data on 461 trauma patients older than 45 years and concluded that while UW trauma patients had a lower 90-day survival, BMI was not a predictor of morbidity or mortality. In a study of 5,766 patients based on the Trauma Registry of the German Society for Trauma Surgery, Hoffmann et al[15] found that UW and obesity in polytraumatized patients were associated with significantly increased mortality.

We investigated the relationships between trauma outcomes and the entire spectrum of BMI in blunt trauma patients with hemorrhagic shock, representing one of the sickest and most physiologically deranged cohorts. We hypothesize that blunt trauma patients in hemorrhagic shock on both ends of the BMI spectrum have the following: (1) increased postinjury complications and mortality rates; (2) the highest odds of requiring a surgical intervention; and (3) significantly worse quality indicators—increased hospital length of stay (LOS), increased intensive care unit (ICU) LOS, and increased ICU ventilation days.

Patients and Methods

Study design and patient population

This is a retrospective analysis of the "Inflammation and the Host Response to Injury" trauma relational database, also known as the Glue Grant database. The Inflammation and the Host Response to Injury program is a large-scale collaborative program funded by the National Institute of Medical Sciences in which basic science and clinical data were prospectively collected from trauma and burns patients in 8 Level I trauma or burn centers in the United States.

Patients included in the database met the set criteria for hemorrhagic shock and had high chances of survival before the blunt traumatic event. Specifically, the inclusion criteria were as follows: blunt trauma patients without isolated head injury; absence of severe traumatic brain injury, defined as Abbreviated Injury Scale (AIS) of head less than 4 or Glasgow Coma Score motor greater than 3 within 24 hours; emergency department arrival less than or equal to 6 hours from the time of injury; blood transfusion within 12 hours of injury; base deficit greater than or equal to 6 or systolic blood pressure less than 90 mmHg within 60 minutes of emergency department arrival; and fully or partially intact cervical spinal cord. Therefore, these patients met the definition of hemorrhagic shock following blunt trauma. Patients with any of the following characteristics were excluded: age less than 16; anticipated survival of less than 24 hours from injury; anticipated survival less than 28 days because of pre-existing medical condition; inability to obtain first blood draw within first 12 hours after injury; severe traumatic brain injury, that is, Glasgow Coma Score less than or equal to 8 after ICU admission and brain computerized tomography scan abnormality within first 12 hours after injury; inability to obtain informed consent; pre-existing, ongoing immunosuppression (eg, transplant recipient, chronic high-dose corticosteroids [$>$20 mg/prednisone-equivalents/day], oncolytic drug(s) therapy within the past 14 days, HIV positive, and CD4