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Admission hyperglycemia is associated with different outcomes after blunt versus penetrating trauma



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ABSTRACT

Background: Stress-induced hyperglycemia is associated with worse outcomes after trauma; however, the effect of mechanism of injury has not been studied. To fill this gap, we tested the hypothesis that blunt and penetrating trauma evoke different glycemc responses which are associated with different outcomes.

Materials and methods: A retrospective cohort study comparing adults with blunt ($n = 835$) or penetrating trauma ($n = 858$) and admission glucose levels ≥ 106 mg/dL, ≥ 150 mg/dL, and ≥ 200 mg/dL at a level 1 trauma center from 02, 2011 to 08, 2013. Primary outcomes were mortality and infectious complications.

Results: For all patients, mean Injury Severity Score was 14 ± 12 , with 10% ($n = 162$) infections and 6% ($n = 102$) mortality. Median admission glucose was 122 mg/dL (102–154 mg/dL). Hyperglycemia was associated with infections, length of stay, and mortality (all $P < 0.01$). Ten percent had an admission glucose ≥ 200 mg/dL, which was associated with infections after blunt trauma (odds ratio [OR], 2.28; 95% CI, 1.16–4.47; $P = 0.017$) but not penetrating trauma. Hyperglycemia was not an independent predictor of mortality in blunt trauma. In contrast, glucose ≥ 150 mg/dL (OR, 2.58; 95% CI, 1.13–5.89; $P = 0.025$) and ≥ 200 mg/dL (OR, 2.98; 95% CI, 1.27–6.98; $P = 0.012$) both predicted mortality in penetrating trauma patients.

Conclusions: This is the first study to show that hyperglycemia is associated with fundamentally different outcomes after blunt versus penetrating trauma. Patients who died were 4–8 times more likely to have hyperglycemia and penetrating, not blunt, trauma. Incorporation of hyperglycemia in injury scoring systems might improve outcome predictions after trauma.

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Introduction

Injured patients are broadly classified according to several factors, including age, gender, mechanism of injury, and injury severity. Several scoring systems based on one or more of these factors are correlated with patient outcomes.¹⁻⁴ Blunt or penetrating mechanism of injury is another potential factor affecting patient outcomes,⁵⁻¹⁰ but few studies have determined whether the type of trauma influences the compensatory metabolic response.

Stress-induced hyperglycemia is an integral part of the compensatory response to trauma and is attributed to the release of neurohumoral mediators.¹¹ Rapid glycogenolysis and gluconeogenesis provide metabolic substrate and are associated with insulin resistance, persistent endoplasmic and sarcoplasmic reticulum stress, and unfolded protein response activation.^{12,13} McNamara *et al.*¹⁴ were among the first to report stress-induced hyperglycemia after combat trauma. The phenomenon has subsequently been correlated to injury severity, morbidity, and mortality in civilian trauma, both at admission and perioperatively.¹⁵⁻¹⁸

Despite the large body of evidence regarding hyperglycemia and critical illness, no prior studies have compared outcomes as a function of the two mechanisms of injury. To fill this gap, we tested the hypothesis that hyperglycemia is associated with different outcomes in blunt *versus* penetrating trauma patients.

Methods

Study setting

The study was conducted at the Ryder Trauma Center in the University of Miami/Jackson Memorial Medical Center. Ryder Trauma Center is a level I trauma center and has been verified by the American College of Surgeons. This study was approved by the institutional review board with waiver of informed consent.

Study design and population

A retrospective cohort study was performed using the trauma registry and detailed chart review at the Ryder Trauma Center. To obtain equal samples of blunt and penetrating adult trauma patients (18 years or older), approximately 1000 consecutive blunt and 1000 consecutive penetrating admissions from February 2011 to August 2013 were reviewed. Exclusion criteria were known diagnosis of diabetes mellitus ($n = 81$), isolated orthopedic trauma ($n = 19$), isolated neurotrauma ($n = 9$), transfers from outside institutions ($n = 22$), pregnancy ($n = 2$), incarceration ($n = 11$), aged < 18 y ($n = 91$), or missing data ($n = 65$). Blunt patients were more likely to be excluded for isolated neurotrauma, diabetes mellitus, and transfer status. Penetrating patients were more likely to be excluded for missing data and aged < 18 y. Diabetic patients were identified by meticulous review of history and physical examination reports,

admission notes, consultation notes, and discharge summaries. Hemoglobin A1C values are not routinely drawn at our institution and, therefore, were not used to identify diabetic patients. Patients with isolated orthopedic and neurologic trauma were excluded because these patients are not managed by the trauma service.

Groups were stratified based on mechanism of injury and plasma glucose. Admission glucose was chosen for analysis as this initial value has been shown to reliably correlate with outcomes in trauma patients.^{15-17,19-24} Separate analyses were conducted for admission glucose levels ≥ 106 , 150, or 200 mg/dL, as defined by prior studies.¹⁶ Outcomes were in-hospital mortality and infection, which was defined as bacteremia, urinary tract infection, or quantitative bronchoalveolar lavage-proven pneumonia.

Statistical analysis

Continuous variables are reported as mean \pm standard deviation if parametric or as median [interquartile range] if nonparametric. Normally distributed continuous variables were compared using Student's *t*-test. Nonparametric variables were compared using the Mann–Whitney *U* test. Categorical variables are presented as frequency (%) and were compared using χ^2 or Fisher's exact test, as appropriate. Multiple logistic regression was used to control for confounders and obtain adjusted odds ratios and 95% confidence intervals. Normoglycemia was used as the reference point for all comparisons in the logistic regression models. Results were considered statistically significant if $P \leq 0.05$. All tests were two-tailed. Analyses were performed using SPSS version 22.0 (IBM Corporation, Armonk, NY).

Results

General description

The overall study population was comprised of 1693 patients. Patient characteristics are listed in [Table 1](#). The sample consisted of mostly young, male patients with approximately even cohorts of blunt and penetrating trauma (49% *versus* 51%). The mean Injury Severity Score (ISS) was 14 ± 12 . The median admission glucose was 122 mg/dL [102-154 mg/dL]. Seventy-one percent of patients had an admission glucose ≥ 106 mg/dL, 27% had an admission glucose ≥ 150 mg/dL, and 10% had an admission glucose ≥ 200 mg/dL.

[Table 2](#) shows several differences between the 835 blunt trauma patients (49%) and 858 penetrating trauma patients (51%). Within blunt trauma, the following mechanisms were observed: motor vehicle collisions (36%), pedestrian *versus* car (18%), fall (16%), motorcycle collisions (15%), assault (5%), bicyclist *versus* car (4%), personal watercraft (2%), crush (1%), helicopter crash ($< 1\%$), and other (2%). Within penetrating trauma, the following mechanisms were observed: gunshot (56%), stab (35%), bite (2%), propeller (1%), impalement ($< 1\%$), and other (6%). Penetrating trauma patients tended to be

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