Original Research

Prehospital Blood Glucose Testing as a Predictor of Impending Hypotension in Adult Trauma Patients

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ABSTRACT

Objective: Stress-induced hyperglycemia has been found to increase hemorrhagic shock, morbidity, and mortality in the trauma patient. The purpose of this study is to evaluate whether prehospital point-of-care glucose is an independent predictor of hypotension in the adult trauma patient transported by air ambulance to the receiving trauma center.

Methods: This retrospective chart review evaluated adult, nondiabetic trauma patients transported by air ambulance at 3 programs in the Midwest for the calendar year 2018. A total of 107 patients met the inclusion criteria. The primary analysis was the determination of an optimal cutoff for the blood glucose diagnostic for predicting a hypotensive outcome followed by chi-square incidence comparison.

Results: The optimal diagnostic cutoff point using Youden’s index (J) was determined to be a blood glucose value of 220 mg/dL or greater. Initial glucose values were associated with an increased relative risk of a hypotension outcome (P = .040). Glucose dichotomy was also associated with a mean decrease in systolic blood pressure during transport (P = .016).

Conclusion: The findings in this study indicate a point-of-care glucose measurement greater than 220 mg/dL should prompt prehospital clinicians to initiate aggressive balanced resuscitation before arrival at the receiving trauma center in order to prevent worsening hypotension and hemorrhagic shock.

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Hyperglycemia appears secondary to a hypermetabolic state that occurs in patients suffering critical illness, stress, or injury. This state is characterized by excessive gluconeogenesis, glycogenolysis, and insulin resistance. The neuroendocrine response to this stress causes increased activation of the adrenal gland. Because of this activation and release of a multitude of proinflammatory markers, there is an excess of counter-regulatory hormones such as glucagon, cortisol, and catecholamines. Insulin is found in lower concentrations in plasma, indicating a relative deficiency. The insulin that is present in the plasma fails to suppress gluconeogenesis from the liver despite elevated plasma glucose levels. In addition, there is impaired glucose uptake into the skeletal muscle. The result is an elevated blood glucose level, and this phenomenon has been studied under various names including stress-induced hyperglycemia (SIH), stress hyperglycemia, acute glucose elevation, or early hyperglycemia. For this study, we have elected to use SIH.

Studies have shown that SIH is a predictor of morbidity and mortality in the critically ill and injured patient. Specifically, trauma patients appear to be more prone to poor outcomes with an elevated admission blood glucose compared with other critically ill patients. Laird et al showed a significant relationship between the Injury Severity Score, Glasgow Coma Scale (GCS), and mortality with an admission plasma glucose ≥ 150. Two studies also found that patients with severe injury and a plasma glucose > 200 mg/dL were associated with higher rates of infection and mortality. This finding was found to be independent of the severity of injury or the associated shock. Kreutziger et al described that patients who died in hemorrhagic shock had the highest blood glucose levels on hospital admission compared with other critically ill patients. A systematic review concluded after reviewing 17 articles

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that met the inclusion criteria that there is strong evidence that early hyperglycemia is correlated with a worse prognosis in trauma patients.\textsuperscript{16} Despite this growing body of literature, there are no published studies evaluating prehospital blood glucose as a predictor of hypotension before arrival at the receiving trauma center. Prehospital emergency clinicians provide an important role in trauma care by initiating and continuing lifesaving stabilization and resuscitation. Because trauma is the fourth leading cause of death overall for all ages in the United States, prehospital providers commonly encounter these patients, and early prediction of hypotension has the potential to impact resuscitation.\textsuperscript{24} The purpose of this proposed retrospective chart review is to evaluate whether prehospital point-of-care glucose is an independent predictor of hypotension in the adult trauma patient transported by air ambulance to the receiving trauma center. Identifying a rapid, point-of-care parameter that indicates impending hypotension would allow for optimization of prehospital care of trauma patients. Prehospital point-of-care glucose may provide valuable information to the prehospital provider and the receiving trauma center in the evaluation and treatment of these trauma patients.

Methods

This retrospective chart review was conducted in air medical programs within the United States. This study was approved by the institutional review board with exempt status because of its retrospective design.

A detailed chart review was performed using the data of trauma patients that were transported by air ambulance from the selected programs. All trauma transports were collected for the year 2018, which totaled 1,623 patients. Each patient contact was reviewed by the authors. Patients were manually excluded if they were diabetic (n = 103), were less than 18 years of age (n = 184), were pregnant (n = 3), patient contact was made but patient was not transported (n = 13), no point-of-care glucose was documented (n = 210), or they had a point-of-care blood glucose less than 200 mg/dL. The point-of-care glucose measurement or GCS was documented, the initial value was documented at scene or hospital before departure. The third describes the time from dispatch to the arrival of the air ambulance clinicians at the bedside. The second describes the time the clinicians were with the patient at the scene or hospital before departure. The third describes the time from departure to the arrival at the trauma center, which reflects the actual air ambulance transport time. These data indicate that the glucose values were obtained between 26.9 minutes and 69 minutes from dispatch to on-scene arrival, the average time at scene from arrival to departure, and the average transport time to medical facility. The primary analysis determined the maximum Youden’s J index value to define an optimal glucose cutoff score for predicting hypotensive outcome. Relative risk was calculated along with a Pearson chi-square test to determine both the significance of the relationship and the strength of the effect. Finally, the diagnostic cutoff was evaluated for predictive significance for the change in systolic blood pressure during transport via the Student t-test.

Results

A total of 107 patients met the inclusion criteria. The demographic data including the mean and standard deviation are included in Table 1.

The primary outcome variable was the systolic blood pressure measurement on arrival at the receiving trauma center. The final mean for the systolic blood pressure for our population was 122.5 mm Hg with a standard deviation of 35.4 mm Hg. The sample yielded 22 (20.6%) patients who had a final systolic blood pressure below 90 mm Hg. The blood pressure cutoff is an objectively measured outcome and is not subject to any interpretative bias because this criterion is a physiologic parameter. Table 2 provides the individual variables that were evaluated for their ability to predict hypotension.

The area under the receiver operating characteristic curve for a hypotensive outcome based on blood glucose was 0.581 with a standard error of 0.068 corresponding to a P value of .243 for a test of equivalence to 0.5. The optimal diagnostic cutoff point using Youden’s index (J) was determined to be a glucose blood value of 220 mg/dL or greater corresponding to a sensitivity of 0.864 with a 1-specificity value of 0.635. Nineteen of the 22 hypotensive patients (86%) were found to be hypertensive with a point-of-care glucose of 220 mg/dL. There were 3 (14%) who were hypotensive with a point-of-care glucose below the cutoff of 220 mg/dL.

Table 3 illustrates that patients with initial glucose values of 220 mg/dL and above had significantly greater mean decreases in systolic blood pressure (SBP) (P = .016). Patients with glucose below the 220 mg/dL threshold experienced no significant changes in SBP. Post hoc testing revealed that GCS was not associated with any significant changes in SBP either (P > .05).

Table 4 provides the mean for 3 segmented times from dispatch to arrival at the medical facility. The first describes the mean time from dispatch to the arrival of the air ambulance clinicians at the bedside. The second describes the time the clinicians were with the patient at the scene or hospital before departure. The third describes the time from departure to the arrival at the trauma center, which reflects the actual air ambulance transport time. These data indicate that the glucose values were obtained between 26.9 minutes and 69 minutes postdispatch on average.

Discussion

Previous studies have shown that admission plasma blood glucose levels were strongly associated with increased mortality, increased length of stay, hemorrhagic shock, and increased infection rates.\textsuperscript{3,13,14,16,17,19,20,22,23} Kreutziger et al\textsuperscript{20,22} showed that admission blood glucose indicated the presence or development of hemorrhagic shock during the initial hospitalization more precisely than other

<table>
<thead>
<tr>
<th>Variable/Statistic</th>
<th>Study Cohort (N = 107) Mean (SD)</th>
</tr>
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<tbody>
<tr>
<td>Age (years)</td>
<td>52.3 (22.61)</td>
</tr>
<tr>
<td>GCS score</td>
<td>9.6 (5.23)</td>
</tr>
<tr>
<td>Initial systolic BP (mm Hg)</td>
<td>131.6 (39.02)</td>
</tr>
<tr>
<td>Initial diastolic BP (mm Hg)</td>
<td>77.1 (22.06)</td>
</tr>
<tr>
<td>Initial heart rate</td>
<td>103.3 (22.22)</td>
</tr>
<tr>
<td>Male</td>
<td>66 (62%)</td>
</tr>
<tr>
<td>Female</td>
<td>41 (38%)</td>
</tr>
</tbody>
</table>

BP = blood pressure; GCS = Glasgow Coma Scale; SD = standard deviation.
The 2 most common reasons for lack of transport were patient decision. The 2 most common reasons for lack of transport were patient refusal and the patient died secondary to their traumatic condition. These 2 conditions also confer bias. We included transports for both scene and interfacility air ambulance transports. Because of variation in the time and duration of the initial resuscitation at the sending centers, this could impact the results. The point-of-care glucose may have been completed at any time during the transport, and this could affect the findings because of this variance. Finally, because of this study being confined to the prehospital transport of these patients, there is no hospital laboratory or outcomes data including morbidity, mortality, and length of hospital stay. Correlation with these variables would also be of benefit in future studies and would allow for comparison with other studies that did evaluate these variables. In order to determine if a more aggressive resuscitation strategy is beneficial in patients with elevated prehospital glucose measurements, it will be important to evaluate all of these elements in future studies. This may include a more robust retrospective prehospital study limiting the transport to scene transports, including a larger geographic area, and/or a prospective design evaluating outcomes.

This retrospective chart review study showed that point-of-care glucose measured in the prehospital air ambulance environment predicted the development of hypotension before arrival to the receiving trauma center. The relative risk of the development of hypotension was 2.95 times greater with a point-of-care glucose measurement of ≥ 220. This inexpensive, rapid, and reliable measurement is an indicator of hypotension in the trauma patients meeting the inclusion criteria reviewed in this study. This finding is consistent with the previous studies that evaluated admission glucose measurements in the prediction of hemorrhagic shock. Based on these findings, a point-of-care glucose measurement greater than 220 mg/dL should prompt prehospital clinicians to initiate aggressive balanced resuscitation before arrival at the receiving trauma center in order to prevent worsening hypotension and hemorrhagic shock.

Acknowledgment

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References