



## Assessing the correlation of trauma severity, blood sugar level, and neurologic outcomes in traumatic spinal cord injury patients

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### Article info

#### Article History:

Received: 29 Dec. 2014

Accepted: 28 Feb. 2015

ePublished: 09 June. 2015

#### Keywords:

Trauma,  
Spinal Cord Injury,  
Blood Sugar Level,  
Insulin

### Abstract

**Introduction:** Trauma, due to stimulating stress responses like hormones, leads to increased blood sugar level (BS level), which worsens cerebrospinal and renal damages. Admission hyperglycemia associated with poor outcomes in severe traumatic injuries, therefore glucose control leads to improved outcomes and better prognosis of these patients. This study aims to analyze the impact of severity of spinal cord injury (SCI) (based on Frankel classification) on BS level in these patients. Furthermore, the effect of controlling the BS level in a normal range on improving the neurological outcomes [muscular force (MF)] was examined.

**Methods:** This is a cross-sectional study in which admission BS level of all SCI patient, were measured, and regular treatments were applied based on standard protocols. The recovery process of motor and sensory disorders was also examined in discharge and was evaluated with the primarily measured BS level. Besides, patients with high BS level (more than 200 mg/dl) underwent the insulin protocol, and the effects of glucose level control on the final outcome of SCI patients were evaluated.

**Results:** Among the 380 patients enrolled in this study, 266 were male (70%) and 114 were female (30%). The mean age of patients was  $35.84 \pm 18$ -65 years old. The mean hospital length of stay was 5.98 days (from 3 to 14 days). The mean BS level in patients with MF of 0/5, 1/5, 2/5, 3/5, 4/5 and 5/5 were 169.8, 185.9, 177.3, 172.8, 117.5 and 118.0 mg/dl, respectively. The rate of MF changes was measured in hyperglycemic patients who underwent an insulin protocol.

**Conclusion:** As the SCI trauma becomes more severe, the BS level increases with a higher rate. Besides, there was a significant difference ( $P = 0.001$ ) in MF of patients before and after the insulin protocol prescription.

**Citation:** Torbati M, Meshkini A, Abri-Aghdam B, Amirfarhangi S. Assessing the correlation of trauma severity, blood sugar level, and neurologic outcomes in traumatic spinal cord injury patients. *J Anal Res Clin Med* 2015; 3(2): 107-11.

### Introduction

Trauma, due to stimulating stress responses like hormones, increases the blood sugar level (BS level)<sup>1</sup> by inducing neurohormonal reactions, acute trauma leads to changes in carbohydrate, protein, and fat metabolism. As it was said, by releasing special cytokines and body defense regulating hormones, trauma results in increased BS level (hyperglycemia),

which significantly affects body function and treatment process. In fact, hyperglycemia is a compensatory response of the body against trauma and stress. We are aware of multifactorial etiology of hyperglycemia in trauma patients. Though it seems that activation of the sympathoadrenal system (by hypothalamus and pituitary) is the major factor of increased BS level.

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Jeremitsky et al. study showed that early hyperglycemia in severe trauma patients' associated with poor outcomes and tight glucose control is needed to achieve better outcomes and prognosis.<sup>2</sup> Hyperglycemia worsens cerebrospinal and renal damages since it cause ischemia (insufficient blood supply), hypophosphatemia (serum phosphate reduction), gastro paresis (delayed gastric emptying), delayed wound healing, and white blood cells dysfunctions.<sup>3,4</sup>

Most of the trauma patients (with different levels of hyperglycemia) are in urgent need of immediate surgery, which requires exact BS level control. Disregarding this intervention causes early outcomes, including diabetic ketoacidosis, hyperosmolar coma, increased risk of infections, and wound healing disorders. Therefore, there is a significant relation between admission BS level and severity of trauma.<sup>5</sup>

As the results of a study indicated a correlation between mild hyperglycemia (115-145 mg/dl) and mortality rate in severely injured patients, which could be prevented by the tight BS level control.<sup>6</sup> Gore et al. showed that children with a more severe head trauma had a higher BS level compared to those with a mild injury.<sup>7</sup> A similar study was conducted including 60 participants (with traumatic brain injury) in two groups: Their BS level and consciousness were randomly determined and the impact of BS control on improving the consciousness state was assessed. The results of conducted survey showed that controlling BS level in traumatic brain injury patients leads to faster restoration of consciousness and better outcomes.<sup>2</sup>

Porhomayon et al. examined 96 patients with moderate to severe head trauma admitted at intensive care unit (ICU) of neurosurgery.<sup>8</sup> BS level was higher in patients with severe head trauma resulting in a poor outcome. Besides, insulin therapy did not improve the clinical outcome of patients with BS level > 200 mg/dl, which claims that extreme BS level control had no effect on improving the neurological outcome of patients.<sup>8</sup>

Conducted studies have confirmed the impact of severity of trauma on hyperglycemia and outcome of traumatic patients (especially traumatic brain injuries). Though, regarding the controversial blood glucose levels which are claimed to improve the outcome and fasten the recovery process, scientists and doctors are encouraged to carry out more researches in this field.<sup>9</sup>

In a study performed at New York University from 1995 to 1996, the impact of increased BS level on trauma severity was assessed in a model consisted of 47 spinal cord injury (SCI) rats. The subjects were assigned in three groups based on trauma level: A. Mild SCI, B. Severe SCI and C. Control group.<sup>10</sup>

All the subjects underwent routine glucose control consisting of serial blood glucose checks during the initial 24 h after the injury, comparing the recorded results showed a direct relation between BS level and severity of trauma outcomes, besides, examining the arterial blood pH and blood gas saturation level, and also evaluating the impact of insulin therapy on the mortality rate, demonstrated the little neuroprotective effect of low blood acidosis rate. It also showed that insulin-induced reduction of BS level had no effect on the clinical outcome but further studies are recommended to examine the correlation of hyperglycemia and SCI.<sup>10</sup>

SCI, proceeding from accidents and falling, etc. as other type of trauma is influenced by the sympathoadrenal system, leading to increased BS level. As related studies claim, hyperglycemia increases the production of metabolites such as lactic acid, and free radicals. This study aims to assess the correlation of the severity of traumatic SCI and BS level in humans.

## Methods

This is a cross-sectional study which involves all SCI patients presenting to (neurosurgery) emergency and trauma section of Imam Reza Hospital, Tabriz, Iran, from March 2013 through September 2014. Considering certain statically indexes ( $\alpha = 5\%$ , statically power = 90%, mean BS change = 10%), sample

size of 380 was calculated. Exclusion criteria: Very young and old (< 18 and > 65 years) patients and patients with diabetes, multiple trauma, traumatic brain injury were excluded from the study.

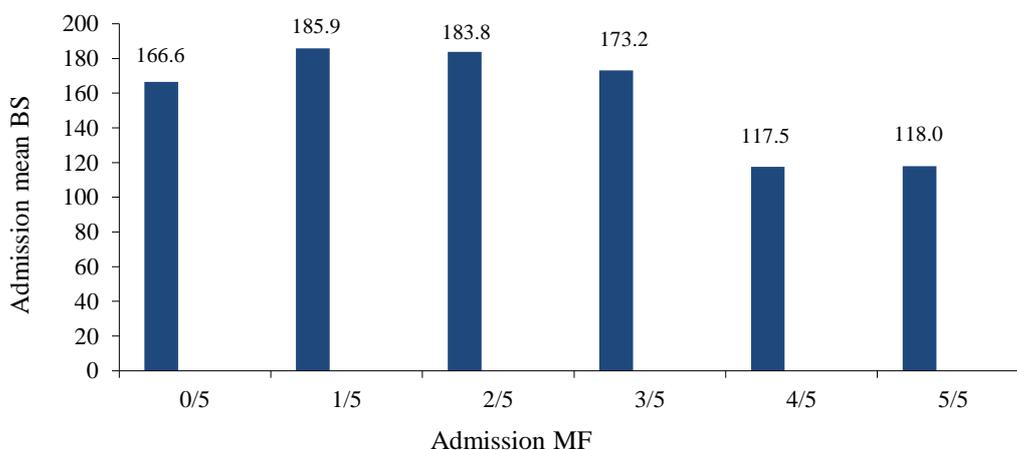
Admission BS level of all SCI patients were measured, and regular treatments were applied based on standard trauma protocols. The recovery process of motor and sensory disorders was also examined in discharge and evaluated with the primarily measured BS level. Besides, patients with high BS level underwent the insulin protocol due to endocrine consultation. Then, the final outcome of patients was assessed. A paired t-test is used to analyze the results. Statistical procedures were conducted within SPSS software (version 16, SPSS Inc., Chicago, IL, USA). The mean rates reported based on mean ± standard deviation (SD) and statistical results with  $P < 0.050$  are considered significant.

### Results

Among the 380 patients enrolled in this study, 266 were male (70%) and 114 female (30%). The mean age of patients was  $35.84 \pm 18-65$  years old. The mean admission BS level was 142.64 (76-362 mg/dl).

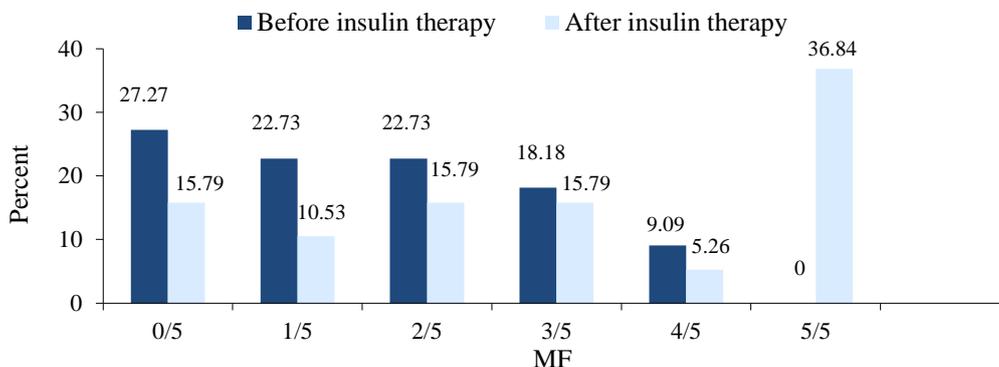
The mean BS levels in patients with muscular force (MF) of 0/5, 1/5, 2/5, 3/5, 4/5, and 5/5 were 169.8, 185.9, 177.3, 172.8, 117.5 and 118.0 mg/dl, respectively. The result of Tukey test showed higher BS level in weaker MF levels (1/5, 2/5) than higher MF levels (4/5, 5/5) (Figure 1).

The prevalence rate of hyperglycemic patients was 11.6%. Patients with an admission glucose concentration > 200 mg/dl underwent insulin protocol. Comparing the prevalence of a certain MF level before and after the insulin therapy (in both upper and lower limbs), a significant change was observed ( $P = 0.001$ ) (Figure 2).



**Figure 1. Correlation of admission mean BS and MF in spinal cord injury patients**

MF: Muscular force; BS: Blood sugar



**Figure 2. MF in hyperglycemic SCI patients before and after insulin therapy**

MF: Muscular force; SCI: Spinal cord injury

## Discussion

Based on the findings of this study, more severe injuries (based on Frankel classification) leading to weaker MF, significantly associate with higher BS level ( $P = 0.001$ ), which is in concordance with previous studies in this field.

Miller et al. showed the direct impact of severity of brain trauma on BS increasing rate,<sup>4</sup> a similar study also confirmed this result.<sup>11</sup> Another study showed that blood hyperglycemia in admission to emergency unit was in correlation with severity of trauma and leads to increased mortality and hospital length of stay.<sup>12</sup>

BS level in first 24 h after admission can be influenced by taken drugs or type of fluid therapy. Thus, in trauma patients, BS level should be measured first they are admitted to emergency department to eliminate such effects.

In the current study, the mean admission BS was 142.64 mg/dl (between 76 and 362 mg/dl) while in Jabalameli et al.<sup>5</sup> research the maximum rate of BS within the subjects was 140 mg/dl, which also confirmed the correlation between trauma severity and BS raise, but no significant relation was seen between trauma score and BS level.<sup>5</sup> In conducted studies, e.g. Desai et al., most of the trauma patients were young, usually between 20-40 years old.<sup>12</sup> Likewise, in Iran traumatic injuries mainly occur in young men, consequently, 70% of the patients in our survey were male, most of them between 20-40 years old.

A study was conducted by Amini et al.<sup>13</sup> to assess the impact of special factors, including age, gender and accident mechanism, on the admission hyperglycemia occurrence in multiple trauma patients. No significant relation was recognized. The mean  $\pm$  SD BS was  $128.38 \pm 25.47$  mg/dl, the survey also indicated 21.6% of the patients to have an admission glucose level above 140 mg/dl<sup>13</sup> similarly in our study, no significant result was found to approve the impact of age and gender on BS and MF of the subjects. A related research showed that insulin secretion

of pancreas is suppressed in trauma patients, which is believed to be caused by increased glucagon or catecholamine serum concentration.<sup>14</sup>

Therefore, an induced systemic stress response occur, usually leading to severe brain injuries.<sup>15</sup> In current research, all patients with a serum glucose concentration above 200 mg/dl underwent an insulin protocol. A significant improvement of MF was observed after insulin therapy in comparison to primary MF ( $P = 0.001$ ). In most of the studies conducted on the treatment of trauma-induced hyperglycemia, a reduction in the complications and mortality rate was seen in patients who underwent the insulin protocol.<sup>9,16,17</sup>

A number of studies have shown that exogenous insulin in severely injured patients lead to decreased mortality rate and ICU length of stay.<sup>18</sup> Furthermore, insulin causes the vasodilatation of vessels and anti-inflammatory effects since it reduces the local inflammatory cytokines.<sup>19,20</sup> Both of these impacts potentially decrease the neuronal damage, while in a study conducted by Porhomayon et al.<sup>8</sup> in Iran no significant result was found to approve the impact of insulin therapy on improved prognosis in head trauma patients.

In this study, it was determined that an increased BS response, influenced by trauma severity, occur in non-diabetic brain injured patients, leading to poor outcomes in these patients. It clarified the reverse impact of hyperglycemia on the recovery of the neurologic system since it causes local ischemia. It was also shown that insulin leads to a moderate reduction of mortality and neurologic outcome Glasgow outcome score (GOS), but it has no effect on patients with normal serum glucose concentration. It means that insulin influences the neurons by affecting the serum glucose concentration.<sup>8</sup> Sala et al. claimed that insulin has no effect on final outcome of trauma patients.<sup>10</sup>

## Limitation

It is not ethically acceptable to prevent insulin therapy in some of the hyperglycemic

patients. Therefore this research could not use a control group to compare the results.

### Conclusion

Considering the effect of increased BS on intensifying the neurologic lesions, it is necessary to control the BS to help faster recovery and prevent probable complications in trauma patients, further studies are recommended to assess the impact of insulin

therapy on hospital length of stay.

### Conflict of Interests

Authors have no conflict of interest.

### Acknowledgments

We would like to thank Miss Tahmineh Maanavi, head Nurse of the Trauma Ward of Imam Reza Medical Center, for helping in data collection from patients' files.

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