ORIGINAL ARTICLE

Assessment of serum glucose potassium ratio as a predictor for morbidity and mortality of blunt abdominal trauma

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ABSTRACT

BACKGROUND: Our hypothesis is that glucose-potassium (GLU/K) ratio can be used to predict morbidity and mortality in the evaluation of patients with blunt abdominal trauma in emergency departments. The aim of the study is to demonstrate the effect of changes in serum GLU/K ratio on morbidity and mortality and to ensure that patient management is performed more quickly and effectively.

METHODS: The hemogram and biochemical parameters of 99 patients with isolated blunt abdominal trauma, applied to our hospital between January 2016 and January 2020, have been retrospectively reviewed. Patients were divided into two groups as non-survivors and survivors. The GLU/K ratio was calculated, and their ability to predict mortality and morbidity was statistically evaluated between the groups.

RESULTS: In the non-survivor (mortal) group; blood urea nitrogen, serum creatinine, serum GLU and GLU/K ratio were statistically higher than the living group ($p<0.005$). Moreover, the sensitivity and specificity of the serum GLU/K ratio were found 72.7% and 84.1% respectively.

CONCLUSION: We think that serum GLU/K ratio can have an important role in the follow-up and management of patients using it as a simple, quickly accessible, and easy predictor in evaluating patients with blunt abdominal trauma.

Keywords: Blood glucose/potassium ratio; blunt abdominal trauma; emergency room.

INTRODUCTION

Background

Blunt abdominal traumas, which account for the majority of abdominal injuries recorded in Emergency Departments, are a major cause of morbidity and mortality.[1] Among the causes, there are vehicle accidents, falls and non-vehicle traffic accidents constitute the top three. The most frequent injuries are detected in the spleen and the liver, pancreas bowel diaphragm, and retroperitoneal injuries are also observed.[2,3]

In blunt abdominal traumas, damage can occur in the intra-abdominal organs with various mechanisms. Intra-abdominal pressure increase can cause that the blunt trauma applied to the anterior abdominal wall applies friction to the intra-abdominal organs and posterior thorax wall and vertebrae causing organ lacerations and perforations. Furthermore, tears may occur in vascular structures.[2] Bleeding in the organs, contusion, and injuries may be seen in the intra-abdominal organs as a result of serious traumas in the intestines and liver-spleen injuries.[4]

Serum glucose and potassium (GLU/K) are well-known serum markers, and their peripheral analysis is simple, cost-effective, and rapid. Especially after trauma, serum GLU concentrations rise significantly and serum K concentrations decrease significantly.[5] The reason for this situation is sympathetic system activation due to neuroendocrine response to hemorrhagic shock that may develop after injuries.[6] With the activation of the sympathetic system, an increase in blood GLU levels and a

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decrease in K levels are expected due to the increase in catecholamines.[7,8] In addition, it has been reported that post-traumatic hyperglycemia and insulin resistance often accompany more severe clinical conditions and increase mortality.[9]

GLU/K ratio was previously evaluated on diseases such as traumatic brain injury, subarachnoid hemorrhage, delayed neuropsychiatric syndrome (DNS), and it has been shown that this parameter affects morbidity and mortality in all these traumatic and systemic stress accompanied situations.[10–12] Rapid identification of blunt abdominal traumas in Emergency Departments is important in terms of rapid identification of intraabdominal injuries of patients. A wide range of imaging methods, laparotomy, and clinical biomarkers can be employed when evaluating patients with blunt abdominal traumas.[13,14]

GLU/K ratio, a marker that may affect post-traumatic mortality, has not been studied before in abdominal trauma, and this study will be the first report in this area. In this study, the adequacy of the GLU/K ratio, which is an easy and simple parameter that can be used in the clinic in predicting the mortality and severity of patients with blunt abdominal trauma was evaluated.

MATERIALS AND METHODS

Study Design and Setting

A total of 99 patients with isolated blunt abdominal trauma who applied to our hospital between January 2016 and January 2020 were included in the present study. Those who had pregnancy, Diabetes Mellitus, blood GLU over 200 at the time of admission, hyperkalemia, drug use history causing hypokalemia, chronic disease history, acute renal failure, chronic renal failure, nephrological pathology, malignancy history were not included in the study.

The patients included in the study were examined in groups that were admitted and followed-up after blunt abdominal trauma and underwent surgical intervention. In addition, the patients were also grouped as those who died and who did not. On hospital admission, laboratory parameters were recorded: complete blood count (hemoglobin, red blood cell, platelet count, white blood cell, mean corpuscular volume [MCV]), biochemistry (Alanine aminotransferase, aspartate aminotransferase, gamma-glutamyl transferase, blood urea nitrogen [BUN], serum creatinine, sodium, K, calcium, GLU, GLU/K) levels.

The study protocol was approved by the institutional ethics committee of the Sivas Cumhuriyet University (2020-08/07). Informed consent was received from the patients or their legal representatives.

Statistical Analyses

All statistical analyses were performed using the IBM Statistical Package for the Social Sciences Statistics for Windows version 23.0 software (IBM, Armonk, NY, USA). Continuous data are reported as mean±standard deviation. The comparison of quantitative variables between the two groups was performed using the Mann–Whitney U test. Correlations between categorical variables were evaluated using the Chi-square test. Receiver operating characteristics (ROC) analysis was performed for the GLU/K ratio and GLU for predicting DNS. The area under the ROC curve (AUC), cut-off values, sensitivity, specificity, positive predictive value, and negative predictive values were calculated in order to evaluate the performance of the GLU/K ratio and GLU. The level of statistical significance was set at $p<0.05$.

RESULTS

A total of 11 of the 99 patients included in the study died (11.1%). Surgery was performed in 43 (46.5%) of the cases included in the study. The average age was 58±27 in the group that died, and 48±20 in the group that survived. When gender distribution was examined, there were 3 females (27.8%) 8 males (72.7) in the group that died, and there were 25 females (28.4%), 63 males (71.6%) in the surviving group. No statistically significant differences were detected between the groups in terms of age and gender ($p>0.05$). Table 1 shows

Table 1. Comparison of laboratory parameters according to the mortality status

Variables	Mortality		p-value
	Survivor	Non survivor	
ALT (U/L)	21 (IQR:29.00)	30 (109.00)	0.199
AST (U/L)	27 (22.00)	55 (162.00)	0.062
BUN (mg/dL)	15.8 (5.60)	26.3 (11.72)	0.001
GGT (U/L)	20 (12.50)	38 (8.22)	0.432
Hematocrit, %	40.54±5.84	38.27±8.22	0.250
Hemoglobin (g/dL)	13.66±2.10	12.34±2.89	0.061
Calcium, mmol/L	8.82±0.57	8.46±0.88	0.063
Creatinine (mg/dL)	0.79 (0.27)	1.0 (0.99)	0.006
MCV, fL	87.85 (5.65)	83.4 (7.50)	0.004
Platelet (x10^3/mm^3)	226 (98.50)	268 (214.0)	0.052
Potassium (mmol/L)	4.21 (0.56)	4.09 (0.86)	0.303
RBC (x10^4/mm^3)	4.67 (0.73)	4.27 (1.83)	0.759
Sodium (mmol/L)	138 (3.55)	136 (8.00)	0.258
Glucose (mg/dL)	111 (34.00)	168 (81.00)	0.007
WBC (x10^3/mm^3)	12.32 (7.87)	14.61 (12.74)	0.322
GLU/K ratio	26 (7.88)	43 (19.91)	0.004

RBC: Red blood cell; WBC: White blood cell; BUN: Blood urea nitrogen; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; GGT: Gamma-glutamyl transferase; MCV: Mean corpuscular volume. Mean±SD and non normal distrubition median (IQR) (Student t-test was used for normally distributed data; Mann-Whitney U used for non-normally distributed data).

Table 2. Comparison of laboratory parameters according to the surgery status

Variables	Non-surgery	Surgery	p-value
GLU/K ratio	24.17 (4.14)	30.82 (10.52)	<0.001
Glucose (mg/dL)	103 (27)	127 (40)	<0.001
Potassium (mmol/L)	4.18 (0.56)	4.13 (0.55)	0.623

Mean±SD and non normal distrubition median (IQR).

Table 3. ROC curve analysis of glucose/potassium ratio (GLU/K), glucose, and potassium in predicting mortality

Variables	Potassium	Glucose	GLU/K ratio
AUC	0.404	0.752	0.771
Standard Error	0.100	0.109	0.106
p	0.303	0.007	0.004
Sensitivity	–	0.636	0.727
Specificity	–	0.977	0.841
Cutoff	–	165.000	33.950
Asymptotic 95% CI			
Upper Bound	0.601	0.966	0.979
Lower Bound	0.208	0.537	0.562
PPV	–	97.72	84.09
NPV	–	63.64	72.73

ROC: Receiver operating characteristics; GLU/K: Glucose potassium ratio; AUC: Area under curve; PPV: Positive predictive value; NPV: Negative predictive value; CI: Confidence interval.

Table 4. ROC curve analysis of glucose/potassium ratio (GLU/K), glucose, and potassium in predicting surgery indications

Variables	Potassium	Glucose	GLU/K ratio
AUC	0.471	0.726	0.709
Standard Error	0.058	0.052	0.053
p	0.623	<0.001	<0.001
Sensitivity	–	0.642	0.736
Specificity	–	0.783	0.739
Cutoff	–	118.500	26.150
Asymptotic 95% CI			
Upper Bound	0.586	0.828	0.814
Lower Bound	0.357	0.624	0.604
PPV	–	78.26	73.91
NPV	–	64.15	71.70

ROC: Receiver operating characteristics; GLU/K: Glucose potassium ratio; AUC: Area under curve; PPV: Positive predictive value; NPV: Negative predictive value; CI: Confidence interval.

an analysis of laboratory parameters between survivor and non-survivor group. The BUN, Creatinine, GLU, and GLU/K ratios of the non-survivor group were found to be statistically and significantly higher than the survivor group. MCV was statistically and significantly higher in the survivor group. No statistical differences were detected between other parameters. The comparison of GLU, GLU/K, K values in non-surgery and surgery group is given in Table 2. GLU/K and GLU values were found to be statistically significant in the surgery group. The ROC analysis in terms of GLU/K, GLU, and K mortality is seen in Table 3. K was statistically insignificant. GLU cut-off value for 165 AUC 752, sensitivity was 63.6%, specificity was 97.7%; GLU/K ratio cut-off value for 33.95 AUC: 0.771, Sensitivity: 72.7% and specificity 84.1%. ROC analysis, GLU, GLU/K ratio, and K are seen in Table 4 for patients who would undergo surgery. K was statistically insignificant. GLU cut of value for 118.5 AUC: 0.726 sensitivity was found to be 64.2% and specificity was 78.2%; GLU/K ratio cut-off value for 26.1 AUC: 0.709, sensitivity was found to be 73.6% and specificity was 73.9%. ROC analysis charts are seen in Figure 1.

DISCUSSION

Mortality because of blunt abdominal trauma in Emergency Departments is the most feared complication. In this study, we examined GLU/K ratio and GLU's adequacy in predicting mortality in blunt abdominal traumas and in predicting surgical indications. Serum GLU/K values are parameters that can be measured quickly and metabolism is well known. Although it varies according to the laboratories, these parameters are studied in a maximum of 1 h in the laboratory of our hospital.

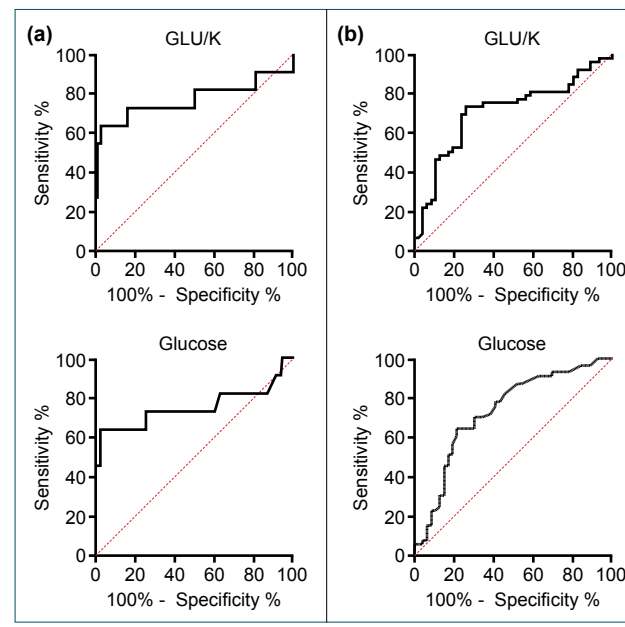

Figure 1. Receiver operating characteristics (ROC) analyses of glucose/potassium (GLU/K) ratio and glucose, **(a)** ROC curve analysis of GLU/K, and glucose in predicting mortality. **(b)** ROC curve analysis of GLU/K, and glucose in predicting surgery indications.

These parameters, which can be studied quickly in this way, show changeability after injuries.

In post-traumatic cases, the sympathetic system is activated, resulting in excessive catecholamine production such as adrenaline, noradrenaline, and dopamine. Along with glucagon and corticosteroids, catecholamines are the primary GLU regulating hormones involved in the hyperglycemic response. Catecholamines are of great importance after injury and stress because they increase glucagon secretion and thus increase blood GLU concentrations. In addition, especially serum K is important because it ensures the continuity of many cellular functions.

K, most of which is stored inside the cells, is transported via active cellular uptake via the cell membrane and adenosine triphosphatase sodium /K pump (Na +/K + -ATPase). Na +/K + -ATPase; it is regulated by catecholamines, B2 adrenergic hormones and insulin, which can result in a decrease in peripheral blood K concentrations.[8,15]

Also, epinephrine can cause hypokalemia because the membrane bounded Na/K ATPase is stimulated by a β - adrenoceptor, thus causing K influx.[7] In addition, the rise in serum GLU concentrations caused by excessive catecholamine secretion also induces insulin secretion and subsequently leads to serum K entry into cells.[16] Therefore, it is theoretically possible that elevated serum GLU concentrations may be highly correlated with trauma severity and post-traumatic prognosis, which has been confirmed in several previous traumatic brain trauma studies.[10,17] Meanwhile, it is possible that the increase in serum GLU and the decrease in K concentration are associated with a poor post-traumatic prognosis.[10,18,19]

Hyperglycemia is an expected metabolic response in trauma patients.[19] However, hyperglycemia is a poor prognosis indicator in many diseases.[20,21] Vogelzang et al.[22] examined the relations between hyperglycemia and mortality and found that hyperglycemia was more significant in patients who were hospitalized with trauma in intensive care. In another study, hyperglycemia in the first week of trauma was associated with prolonged hospitalization and longer hospital stay in intensive care.[23]

In the study of Leto et al.,[24] which examined the relations between mortality and blood GLU levels at the time of admission for hip fractures, it was found that the mortality of patients with blood sugar 140 and above was statistically significant compared to those under 140. They argued that blood GLU levels could be a prognostic indicator in hip fracture patients. In the study conducted by Yendamuri et al.,[25] they found that the rate of blood sugar in the group that was mortal among general trauma patients was 34.1% in those with >200 mg/dl. Kreutziger et al.[26] examined whether blood GLU levels at the time of application were a predicament factor for mortality in multi-trauma patients, and found the blood GLU in the mortal group as 11.8±4.08 mmol/L (212±80 mg/dl). They argued that the blood GLU level at the time of admission was an independent predictor for hospital mortality in multi-trauma patients. In our study, blood GLU levels (168±81mg/ dl) were found to be high in the mortal group at the time of admission in isolated blunt abdominal trauma patients. This result is similar to the above studies. Furthermore, blood GLU levels were high when compared to patients who did not require operation after being referred from the Emergency Department.

Zhou et al.[10] examined the benefit of serum GLU/K ratio as a 30-day mortality predictor in patients with severe head traumas. According to the results of the study, they reported that the serum GLU/K ratio had a potential value for mortality in patients with severe head traumas. Fujiki et al.[11] examined serum GLU/K ratio as clinical risk factors in patients with aneurysmal subarachnoid hemorrhage. According to the results of the study, it was found that the serum GLU/K ratio was statistically and significantly high in the serious group (63.9 [23.1] vs. 63.9 [23.1]; p<0.001). In our study, it was found that the mortality rate in the mortal group was statistically significant compared to the group that was not mortal. It was also found that GLU/K ratio in the group requiring surgical indications was statistically and significantly higher than the non-surgical group. These results were similar to the above studies.

In the study in which blood GLU levels, serum lactate levels, and base deficit were examined as mortality predictors in multitrauma patients, it was found that the GLU cut-off value for 140 had 89% sensitivity and 49% specificity, base deficit cut-off value for -5.6% had 64% sensitivity and 93% specificity, and lactate cut-off value for 2.6 had 92% sensitivity and 42% specificity.[27] Ahmad Fawzy et al.[28] examined the mortality predictivity of coagulopathy parameters in adult trauma patients. According to the results of the study, the AUC 0.650 sensitivity was 50% specificity was 66.7% for platelet 173,000 cut-off value, for AUC 0.793 sensitivity was 86.4% specificity was 64% for PT 18.7 cut-off value, for APTT cut-off value 31, AUC 0.913 sensitivity was 81.8% specificity was 87%. In a study that was conducted as a mortality predictor of trauma score systems, Yousefzadeh-Chabok et al.[29] compared trauma scores as mortality predictors in elderly trauma patients, and found the best cut-off points for predicting mortality in revised trauma score, injury severity score (ISS), and (Trauma and ISS) systems were ≤6, ≥13.5, and ≤2, with sensitivity of 99%, 84%, and 95% and specificity of 62%, 62%, and 72%, respectively. In our study, it was found that GLU/K ratio for cut off value was 33.9, AUC 0.771 sensitivity 72.7% specificity 84.1% as a mortality predictor in blunt abdominal trauma patients. Again, for patients with surgical indications, the AUC 0.709 had 73.6% specificity and 73.9% sensitivity for 26.2% cut-off value. These values were low compared to trauma scores but had high sensitivity and specificity values compared to other laboratory values. As the result, we found

that GLU/K and GLU values were statistically significant in patients with mortal blunt abdominal traumas and surgical indications.

Strengths and Limitations

The glucagon, corticosteroid, and catecholamine hormones levels were not analyzed at the time of presentation. The presence of unknown neuroendocrine factors that may affect GLU and K measurements in trauma patients is also a limitation of the study. In addition, the causes for hyperkalemia or hypokalemia were identified by evaluating the background of the patient from the charts.

Conclusion

It is vital to evaluate the blunt abdominal trauma patients accurately in Emergency Departments. Mortality predictors are needed especially in 1st and 2nd stage Emergency Departments that do not have adequate evaluation tools. We recommend that the GLU/K ratio has a high potential as an easy and fast predictor in evaluating patients with blunt abdominal traumas.

Ethics Committee Approval: This study was approved by the Sivas Cumhuriyet University Faculty of Medicine Non-interventional Clinical Researches Ethics Committee (Date: 12.08.2020, Decision No: 2020/08/07).

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: B.K., E.D.; Design: B.K., E.D.; Supervision: B.K., E.D.; Resource: B.K., E.D.; Materials: B.K., E.D.; Data: B.K., E.D.; Analysis: B.K., E.D.; Literature search: B.K., E.D.; Writing: B.K., E.D.; Critical revision: B.K., E.D.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Künt abdominal travma hastalarında serum glikoz potasyum oranının morbidite ve mortalite için bir öngörücü olarak değerlendirilmesi

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AMAÇ: Hipotezimiz acil servislerde künt abdominal travmalı hastaların değerlendirilmesinde glukoz potasyum oranın morbidite ve mortaliteyi tahmin etmede kullanılabileceğidir. Çalışmanın amacı, serum glukoz/potasyum oranındaki değişikliklerin morbidite ve mortalite üzerindeki etkisinin gösterilerek hasta yönetiminin daha seri ve yeterli yapılmasını sağlamaktır.
GEREÇ VE YÖNTEM: Hastanemize Ocak 2016–Ocak 2020 yılları arasında başvuran izole künt karın travması olan 99 hastanın başvuru anındaki hemogram parametreleri ve biyokimsayal parametreleri geriye dönük olarak incelendi. Hastalar mortal seyreden ve sağ kalanlar olarak iki gruba ayrıldı, glukoz potasyum oranı hesaplandı ve mortalite ve morbiteyi öngörmedeki yeterliliği istatiksel olarak değerlendirildi.
BULGULAR: Mortal seyreden grupta, yaşayan gruba göre kan üre azotu, serum kreatinin, serum glukoz ve glukoz potasyum oranı istatistiksel olarak anlamlı olacak şekilde yüksekti ($p<0.005$). Ayrıca serum glukoz potasyum oranın mortaliteyi ön görmede %72.7 sensitiviteye, %84.1 spesifiteye sahip olarak bulundu.
TARTIŞMA: Sonuçta, serum glukoz potasyum oranın künt karın travmalı hastaları değerlendirmede basit, hızlı ulaşılabilen kolay bir önbelirteç olarak kullanılarak hastaların takip ve yönetiminde önemli role sahip olabileceğini düşünmekteyiz.
Anahtar sözcükler: Acil servis; künt abdominal travma; serum glukoz/potasyum oranı.

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