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Glucose/potassium ratio as a prognostic marker in the emergency department for multiple trauma patients

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ABSTRACT

Aims: This study aimed to evaluate the prognostic value of the glucose-to-potassium ratio (GPR) measured at emergency department (ED) admission in patients with multiple trauma who required intensive care unit (ICU) follow-up.

Methods: This retrospective study was conducted at a tertiary care center between January 1 and December 31, 2022. Adult patients admitted to the ED with multiple trauma and subsequently transferred to the ICU were included. Demographic characteristics, trauma mechanisms, laboratory values, and ICU outcomes were recorded. The predictive value of GPR for ICU mortality was analyzed using receiver operating characteristic (ROC) curve analysis. Additional comparisons were made with established biomarkers such as lactate and injury severity score (ISS).

Results: A total of 253 patients met the inclusion criteria. The most common trauma mechanisms were falls (45.7%) and traffic accidents (38.9%). Median GPR was significantly higher in non-survivors than in survivors [45.5 (30.5–63.6) vs. 31.6 (25.8–39.5), p=0.001]. ROC analysis yielded an area under the curve (AUC) of 0.712 for GPR. The optimal cut-off value was 66.9, with a sensitivity of 21% and specificity of 95%. In logistic regression analysis, GPR was identified as an independent predictor of mortality (p=0.004, Exp (B): 0.96). While lactate (AUC: 0.775) and ISS (AUC: 0.881) showed stronger predictive power, GPR remains a practical and accessible marker in the ED setting.

Conclusion: GPR is a simple, rapid, and cost-effective biomarker that may contribute to early risk stratification in multiple trauma patients. Although it should not be used in isolation for clinical decision-making, it may serve as a valuable adjunct to established prognostic tools. Further prospective and multicenter studies are warranted to validate its clinical utility.

Keywords: Glucose/potassium ratio, multiple trauma, intensive care unit, prognosis

INTRODUCTION

Trauma remains one of the leading causes of mortality worldwide, particularly affecting younger individuals.[1,2] Despite advances in medical interventions, mortality rates among patients with multiple traumatic injuries still range between 10% and 20%. Multiple trauma cases are frequently encountered in emergency departments (EDs) and require rapid and comprehensive evaluation of different organs and systems. Early diagnosis, timely treatment, and close monitoring play a critical role in reducing mortality in these patients.

Various scoring systems and imaging methods have been developed to assess prognosis in multiple trauma patients.[3,4] One of the most widely used is the injury severity score (ISS), introduced by Baker et al.,[5] which measures the overall severity of multiple injuries in the body. The ISS is calculated by summing the squares of the three highest abbreviated injury scale (AIS) scores from different body regions.[6]

An important component of the response to trauma is activation of the sympathetic nervous system, which leads to excessive release of stress-related hormones and catecholamines such as adrenaline, noradrenaline, and dopamine. Patients with multiple trauma experience this physiological stress response to a significant degree.[7]

This neurohormonal response causes marked changes in glucose and potassium metabolism. During trauma, increased catecholamine and cortisol levels stimulate hepatic gluconeogenesis and glycogenolysis, resulting in hyperglycemia. In addition, increased insulin resistance and decreased peripheral glucose utilization further contribute to this condition. Conversely, catecholamines stimulate the Na^+/K^+-ATPase pump on cell membranes, leading to intracellular potassium shift and hypokalemia.[8]

Therefore, trauma patients may present with both elevated glucose and reduced potassium levels simultaneously. The combined measure, known as the glucose-to-potassium ratio

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(GPR), may reflect the severity of the stress response and the degree of metabolic imbalance. While the prognostic value of GPR has been investigated in isolated trauma settings, its significance in multiple trauma cases has not been adequately evaluated.

Accordingly, the present study aims to investigate whether GPR can serve as a predictor of mortality in multiple trauma patients admitted to the intensive care unit (ICU), in conjunction with other clinical parameters.

METHODS

Ethics

The study has received ethical approval from the Ethics Committee for Non-drug and Non-medical Device Researches at Karatay University (Date: 22.06.2023, Decision No: 2023/003). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Design and Participants

This retrospective study was conducted at Konya City Hospital, a tertiary care center serving approximately 50.000 patients per month, between January 1 and December 31, 2022. Data were obtained through the hospital's electronic medical record system. Clinical characteristics at ED presentation (including ISS), demographic data, ICU follow-up notes, and laboratory results were recorded.

Exclusion criteria included inaccessible medical records, incomplete clinical data, unclear medication history, absence of multiple trauma, history of diabetes, thyroid dysfunction, renal failure, severe malnutrition, extensive burns, liver cirrhosis, hemolyzed blood samples, pregnancy, age under 18 years, and the use of antihypertensive or potassium-regulating medications.

The rationale for applying these exclusion criteria was to eliminate clinical conditions that could directly alter glucose and potassium metabolism (e.g., diabetes, renal failure, thyroid dysfunction, liver cirrhosis, malnutrition, pregnancy), which might otherwise confound the study results. Similarly, medications affecting potassium balance (such as antihypertensives or potassium regulators) and conditions producing exaggerated metabolic responses (e.g., extensive burns) were excluded, since they could independently influence GPR values. This approach was intended to ensure that the findings more accurately reflected the true pathophysiological changes induced by trauma.

During the study period, a total of 724 patients admitted to the ED and subsequently transferred to the ICU were screened. Of these, 471 were excluded due to meeting one or more exclusion criteria. The most common reasons for exclusion were a history of diabetes (n=46), renal failure (n=12), incomplete clinical data (n=327), thyroid dysfunction (n=4), liver cirrhosis (n=3), pregnancy (n=6), extensive burns (n=11), and the use of antihypertensive or potassium-regulating medications (n=62). Ultimately, 253 patients were included in the study cohort.

Laboratory Analysis

Initial blood samples were collected in the ED from patients presenting with multiple trauma. Routine laboratory tests were conducted, and hematologic parameters were analyzed using an automated analyzer (Mindray BC-6000). The neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) were calculated by dividing the absolute counts of neutrophils and platelets by the absolute lymphocyte count, respectively. GPR was obtained by dividing the serum glucose concentration by the serum potassium concentration.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics 23.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean±standard deviation or median (interquartile range), as appropriate. Normality was assessed using the Kolmogorov-Smirnov test.

Comparisons between groups were made using Chi-square tests for categorical variables, and the Mann–Whitney U or Student's t-test for continuous variables. ROC curve analysis was used to assess the predictive value of GPR and other parameters for ICU mortality. Univariate predictors of mortality were further evaluated using logistic regression. Parameters such as Glaskow Coma Scala (GCS) and ISS, which may introduce subjective bias, were excluded from the regression model. Model fit was assessed using the Hosmer–Lemeshow test, and the backward stepwise method was used in logistic regression analysis.

A p-value <0.05 was considered statistically significant.

RESULTS

Throughout 2022, 724 trauma patients were admitted to the ED and subsequently transferred to the ICU for further management. Of these, 253 patients met the study criteria and were included in the analysis. The demographic characteristics of these patients are summarized in **Table 1**. Regarding the mechanism of trauma, the most common cause was falls (n=113, 45.7%), followed by traffic accidents (n=96, 38.9%), occupational injuries (n=32, 13.0%), high-level falls or being pushed (n=5, 2.0%), and physical assault (n=1, 0.4%).

At admission, 189 patients (76.5%) had a GCS score of 15, 25 patients (10.5%) scored 14, and 19 patients (7.7%) scored 3. Intermediate GCS scores were less frequently observed. The ICU distribution was as follows: surgical ICU (n=147, 59.5%), anesthesiology and reanimation ICU (n=61, 24.7%), and emergency ICU (n=33, 13.4%). During follow-up, a total of 24 patients (9.7%) died in the ICU.

Among the 253 patients, 147 sustained thoracic trauma, 106 extremity trauma, 74 head injuries, 34 abdominal trauma, and 15 pelvic trauma. Seventy-five patients (30.4%) had multisystem injuries. The median ISS was 9 (range: 9–18), and the distribution of ISS values is presented in **Table 2**.

The prognostic value of GPR for predicting mortality in ICU-admitted patients was assessed using ROC curve analysis. The analysis identified a cut-off point of 66.9, corresponding to a sensitivity of 0.21 and a 1-specificity of 0.05. Median GPR

Table 1. Demographic and laboratory characteristics of the patients

Parameters*		Survival		Exitus		p	
		n	(%)	n	(%)		
Gender	Male	156	(68.1)	17	(70.8)	p= 0.05	χ2= 0.823
	Female	73	(31.9)	7	(29.2)		
Total		229	(100.0)	24	(100.0)		
			Median (IQR))		Median (IQR)		
Age		26	(36 & 77)	35	(26 & 71)	p=0.053	U=2031.5
NEU (%)		9.88	(7 & 14.78)	14.04	(9.88 & 18.81)	p=0.019	U=1896.5
LEU (%)		1.07	(0.93 & 2.26)	3.32	(1.073 & 5.67)	p=0.013	U=1846
CRP (mg/dl)		1.7	(2.1 & 30.81)	10.6	(1.6725 & 91.54)	p=0.360	U=2371.5
Lactate (mmol/L)		2.5	(1.1 & 2.7)	3.3	(2.5 & 6.7)	p<0.001	U=1206
BE (mmol/L)		-11.0	(-2.6 & 1.1)	-5.7	(-11.0 & 2.6)	p<0.001	U=780
Glucose (mg/dl)		130	(110 & 162)	185.5	(130 & 247)	p<0.001	U=1459
Potasium (mmol/L)		3.6	(3.9 & 4.5)	4.1	(3.6 & 5.1)	p=0.846	U=2611.5
GPR		30.49	(25.75 & 39.51)	45.53	(30.49 & 63.6)	p=0.001	U=1542.5
NEU/LEU		2.14	(3.3594 & 14.28)	6.33	(2.14 & 13.74)	p=0.526	U=2465
PLT/LEU		42.489	(97.446& 242.352)	66.600	(42.489 & 196.936)	p=0.007	U=1777.5
			Mean±SD		Mean±SD		
PLT			244.932±74.367		238.500±70.838	p=0.686	t=-0.404

NEU: Neutrophil, LEU: Lymphocyte, PLT: Platelet, CRP: C-reactive protein, BE: Base exes, GPR: Glucose/potassium ratio, SD: Standard deviation

Table 2. Distribution of patients according to injury severity score (ISS)

ISS	3	4	9	12	13	16	18	22	25	26	27	29	34	43	50	59
n	1	14	131	2	3	2	51	5	4	8	14	1	6	6	4	1
%	0.4	5.7	53	0.8	1.2	0.8	20.6	2	1.6	0.8	5.7	0.4	2.4	2.4	1.6	0.4

ISS: Injury severity score

was 45.5 (30.5–63.6) in non-survivors compared with 31.6 (25.8–39.5) in survivors. ROC analysis yielded an AUC of 0.712, indicating a moderate predictive accuracy for mortality (**Table 3, Figure**).

Table 3. ROC curve data for GPR and other parameters

Parameters	Area under the curve	Standard error	p	95% confidence interval
GPR	0.712	0.057	p=0.001	0.600-0.823
Lactate	0.775	0.055	p<0.001	0.666-0.883
ISS	0.881	0.054	p<0.001	0.775-0.986

ROC: Receiver operating characteristic, GPR: Glucose/potassium ratio, ISS: Injury severity score

In addition, inflammatory biomarkers were evaluated. Both the NLR and the PLR were significantly higher in non-survivors (p<0.05). Serum lactate levels were also strongly associated with mortality, with markedly elevated values in non-survivors (p<0.001). ROC curve analysis demonstrated AUC values of 0.693 for NLR, 0.642 for PLR, and 0.801 for lactate. These findings indicated that lactate was the strongest predictor of mortality; however, GPR also contributed as an independent biomarker of clinical significance.

Logistic regression analysis revealed that each one-unit increase in GPR was associated with a 0.04-fold decrease in the probability of survival (Nagelkerke R^2=0.98). Lactate and

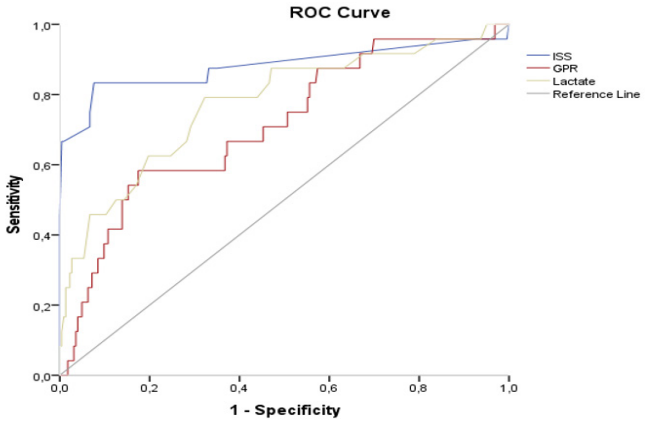

Figure. ROC curve for GPR and other parameters
ROC: Receiver operating characteristic, GPR: Glucose/potassium ratio, ISS: Injury severity score

NLR values were also found to be independently associated with mortality. Detailed results of the model are presented in **Table 4**.

Table 4. Analysis of logistic regression

	B	Sig.	Exp (B)	95% CI for Exp (B)	
				Lower	Upper
GPR	-0.37	p=0.004	0.96	0.939	0.988
BE	0.268	p<0.001	1.30	1.171	1.458

CI: Confidence interval, BE: Base exes, GPR: Glucose/potassium ratio, Hosmer–Lemeshow test: p=0.299

DISCUSSION

Multiple trauma is a severe clinical condition, typically resulting from high-energy injuries, that affects several anatomical regions and requires a multidisciplinary approach. Hemodynamic instability, metabolic stress, and inflammatory responses observed in trauma patients can lead to organ failure and increased mortality.[9-11] Therefore, there is a strong need for simple and reliable biomarkers that can predict prognosis in the early stages.

In this study, falls (45.7%) and traffic accidents (38.9%) were identified as the most common mechanisms of trauma. These findings are consistent with previous studies, such as that by Altuncu et al.,[12] which reported similar distributions. The gender distribution in our study (68.8% male and 31.2% female) also aligns with figures reported in the literature.[4,12]

Our study demonstrated that the GPR may be associated with mortality in multiple trauma patients admitted to the ED and requiring ICU care. Trauma-induced hyperglycemia and hypokalemia result in elevated GPR. These metabolic changes are primarily driven by increased sympathetic activation and catecholamine release following trauma.[7,8] Elevated glucose levels are associated with the stress response, while decreased potassium levels are linked to β-adrenergic stimulation that facilitates intracellular potassium shift.[8]

In our cohort, non-survivors exhibited markedly higher GPR values than survivors. This suggests that GPR may serve as a clinically useful prognostic biomarker in multiple trauma patients. However, our findings also indicate that while elevated GPR reflects increased mortality risk, its predictive value is limited at lower and moderate levels.

Similarly, Turan et al.[4] reported that in patients with isolated thoracoabdominal trauma, GPR was significantly associated with mortality, and its prognostic value increased when combined with the shock index. Katipoğlu et al.[13] also demonstrated a significant association between elevated GPR and mortality in trauma patients. These findings suggest that GPR may be a valid biomarker not only in isolated injuries but also in multiple trauma cases.

The systemic inflammatory response observed after trauma[14,15] may also be reflected in hematological markers such as the NLR and the PLR. However, some studies have reported that NLR tends to rise in the later stages of critical illness, limiting its utility as an early prognostic marker.[16,17] In line with this, our study found no significant association between initial NLR values and mortality. Although PLR showed some prognostic relevance, it did not demonstrate the same specificity as GPR.

On the other hand, commonly used parameters such as lactate and ISS showed stronger predictive power than GPR. Nevertheless, GPR has the advantages of being rapid, inexpensive, and widely available, making it a practical tool in clinical settings. Moreover, logistic regression analysis indicated that GPR was independently associated with mortality, supporting its potential role as a prognostic factor.

In conclusion, GPR may serve as a valuable adjunctive marker for clinicians aiming to perform rapid risk stratification in multiple trauma patients presenting to the ED. However, it should be interpreted alongside other biomarkers and clinical parameters, and not be used as a standalone tool in decision-making.

Limitations

This study has several limitations. First, it was designed as a single-center, retrospective study, which limits the generalizability of the findings. Although glucose and potassium levels were measured at the time of admission to the ED, the exact timing of trauma varied among patients and may have influenced biomarker levels.

Although we proposed that elevated GPR may be associated with increased catecholamine release, catecholamine levels were not directly measured in this study. Therefore, whether GPR truly reflects the sympathoadrenal response could not be confirmed. In addition, some clinical conditions that may affect glucose and potassium levels (such as acute stress hyperglycemia or subclinical endocrine disorders) might not have been fully excluded.

Furthermore, GPR was not directly compared with other established biomarkers, which limits the evaluation of its relative clinical value. Future studies should address these gaps using prospective, multicenter designs with larger patient populations.

CONCLUSION

This study demonstrates that GPR may be associated with mortality in multiple trauma patients. As a parameter that can be easily obtained from routine laboratory tests, it offers the advantages of being rapid, inexpensive, and widely accessible, thereby contributing to risk stratification in clinical practice. However, GPR should not be interpreted in isolation; it must be evaluated in conjunction with other biomarkers and clinical assessments.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study has received ethical approval from the Ethics Committee for Non-drug and Non-medical Device Researches at Karatay University (Date: 22.06.2023, Decision No: 2023/003).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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