ORIGINAL ARTICLE

Role of glucose/potassium ratio and shock index in predicting mortality in patients with isolated thoracoabdominal blunt trauma

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ABSTRACT

BACKGROUND: The aim of this study, investigate the prognostic value of shock index (SI), which has been accepted for a long time, and glucose-potassium ratio (GPR), which has limited data in patients with trauma and those with isolated blunt thoracoabdominal trauma.

METHODS: This retrospective observational study was conducted at the tertiary reference hospital. Consecutive patients aged 18 years and older treated for blunt thoracoabdominal trauma in the emergency department between August 2020 and February 2022 were included in the study. The ability of GPRs obtained from arterial blood gases and SI levels on admission to predict mortality and indication for surgery was evaluated by calculating areas under receiver operating characteristic curves Area under the curve (AUCs).

RESULTS: A total of 102 patients, of which 91 in the survivor group and 11 in the non-survivor group, were analyzed. The AUCs for estimating mortality with GPR and SI were 0.854 (95% confidence interval [CI], 0.742–0.967) and 0.809 (95%, 0.666–0.952), respectively. The AUCs of GPR and SI to estimate the indication for surgery were 0.761 (95% CI, 0.657–0.864) and 0.582 (95% CI, 0.416–0.747), respectively.

CONCLUSION: This study reported the efficacy of SI and GPR in predicting surgical indication and mortality in patients with isolated blunt thoracoabdominal trauma and the superior predictive role of GPR over SI.

Keywords: Glucose-potassium ratio; mortality; Shock index; thoracoabdominal trauma.

INTRODUCTION

Trauma is one of the most common causes of death worldwide, especially in the young population.[1] The thoracoabdominal area is the most frequently affected in trauma injuries, most of which are blunt trauma.[2,3] The mortality rate in these traumas varies between 10 and 36%, and especially the 1st h is crucial for mortality.[4–8] Therefore, early diagnosis and treatment are critical to reducing the mortality rate. Various imaging methods and algorithms predict prognosis and mortality in patients with trauma. However, some are limited in effectiveness, while others are complex and time-consuming. For this reason, all centers dealing with trauma are working on rapid and effective prognostic markers.[9,10] Shock index (SI) is a scale found by dividing the pulse rate by the systolic blood pressure in patients with trauma, and many studies have proved its effectiveness. It has been shown that mortality increases in patients with SI >1, and this situation is more valuable than that of hypotension and tachycardia.[11,12]

In cases of trauma and stress, glucose level increases and potassium level decreases due to increased catecholamines. In the literature, it has been reported that hyperglycemia or glucose-potassium ratio (GPR) (GPR=glucose/potassium) is fast and effective in predicting morbidity and mortality in patients with subarachnoid hemorrhage, pulmonary embolism, traumatic brain injury, or blunt abdominal trauma. Many publications show that glucose increase correlates with mortality

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and morbidity in critical illnesses and trauma. Isolated GPR has a higher predictive ability for mortality and morbidity than that of glucose and potassium levels.[13–17]

In this study, we aimed to investigate the prognostic value of SI, which has been accepted for a long time, and GPR, which has limited data in patients with trauma and those with isolated blunt thoracoabdominal trauma.

MATERIALS AND METHODS

Trial Design

This retrospective study was conducted at the department of surgery of a tertiary reference hospital. The local ethics committee of the institution approved the study protocol (13.05.2022 date and numbered 22/240), and written informed consent was obtained from all patients or their relatives. The study protocol was devised according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines [1*]. The study was performed in accordance with the ethical standards laid down in the Declaration of Helsinki.

Participants and Eligibility Criteria

Consecutive patients who were 18 years and older treated in the emergency department for blunt thoracoabdominal trauma between August 2020 and February 2022 were considered eligible. Patients with missing data, transferred from another institution, who underwent cardiopulmonary resuscitation before coming to the emergency department, patients with diabetes mellitus or renal failure, and patients taking antihypertensive or potassium-modifying medication were excluded from the study.

A total of 102 patients, of which 91 in the survivor group and 11 in the non-survivor group, were analyzed. The flowchart is shown in Figure 1.

Medical and Demographic History

Age, sex, operation status, systolic blood pressure, heart rate, pneumothorax, hemothorax, intra-abdominal bleeding, blood transfusion status, glucose, potassium, hemoglobin, thrombocyte, and arterial blood gases (ABG) levels on admission were recorded. In addition, SI and GPR were calculated

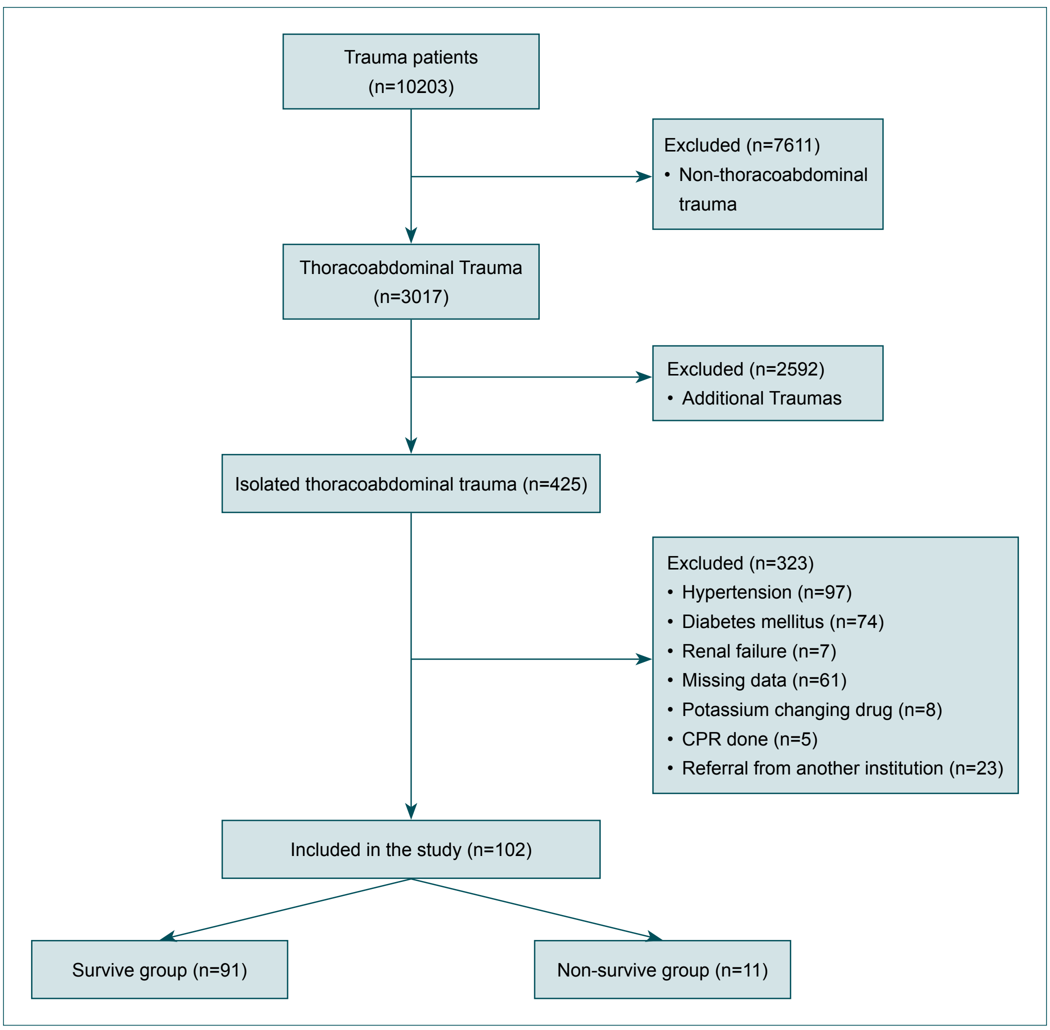

Figure 1. Flowchart diagram.

using the following formulas:

SI = heart rate/systolic blood pressure
Glucose potassium ratio = glucose level/potassium level.

Outcome Measures

The primary outcome was the role of GPR and SI in predicting mortality. The secondary outcome was the role of GPR and SI in predicting surgical indication.

Statistical Analysis

Statistical Package for the Social Sciences for Windows, version 22 (IBM Corp, Armonk, NY) program was used for statistical analysis. Before starting the statistical analysis, Kolmogorov-Smirnov and Shapiro-Wilk normality tests were applied. If the normality assumption could not be achieved even in any group, non-parametric tests were used. The Mann-Whitney U test was used to compare the variables obtained from the measurements. The Chi-square and Fisher's exact tests were used to determine the relationship between categorical variables or analyze differences between the groups. The receiver operating characteristics (ROC) analysis was performed for the role of GPR and SI in predicting mortality. To evaluate the performance of the GPR ratio and SI, the area under the ROC curve Area under the curve (AUC), 95% confidence interval (CI), cutoff values according to the Youden index, sensitivity, and specificity were calculated. Comparative results and other demographic characteristics of the study groups were presented as ratios for qualitative variables and mean and median (minimum-maximum) for quantitative variables. The statistical significance limit was determined as $p<0.05$.

RESULTS

Demographic data (age and sex) and clinical characteristics (e.g., surgery status, systolic blood pressure, heart rate, glucose, and potassium levels) of the 102 patients included in the study are presented in Table 1. There were 91 patients in the survivor group and 11 in the non-survivor group. There was no significant difference in demographic data between the groups. In the non-survivor group, glucose, GPR, heart rate, SI, hemothorax, intra-abdominal bleeding, and blood transfusion rate were significantly higher, while systolic blood pressure, hemoglobin, and platelet levels were significantly lower. The rate of pneumothorax was higher in the non-survivor group, but it was not statistically significant (Table 1). Glucose and GPR were significantly higher in operated patients compared with the non-operated group, but there was no significant difference between heart rate, systolic blood pressure, and SI (Table 2).

The ROC analysis showing the role of GPR and SI in predicting mortality and surgical indication is presented in Table 3.

Table 3 shows the optimal cut-off values for GPR and SI to predict mortality and surgical indication. GPR and SI cutoff values for mortality estimation were 36.8 (sensitivity, 0.82; and specificity, 0.88) and 0.86 (sensitivity, 0.82; and specificity, 0.77), respectively. The AUCs for estimating mortality with GPR and SI were 0.854 (95% CI, 0.742–0.967) and 0.809 (95%, 0.666–0.952), respectively (Fig. 2).

Table 1. Patients' characteristics and laboratory parameters

Items	All patients (n=102)	Survivors (n=91)	Non-survivors (n=11)	p-value
Age	50 (18–80)	49 (18–80)	53 (19–66)	0.69
Sex (male/female)	77/25	72/19	8/3	0.82
Operated patients, n (%)	18 (17.6)	12 (13.2)	6 (54.5)	0.001
Pneumothorax, n (%)	24 (23.5)	20 (22)	4 (36.4)	0.29
Hemothorax, n (%)	27 (26.5)	21 (23.1)	6 (54.5)	0.03
Intra-abdominal bleeding, n (%)	16 (15.7)	8 (8.8)	8 (72.7)	<0.001
Blood transfusion, n (%)	13 (12.7)	4 (4.4)	9 (81.8)	<0.001
Systolic blood pressure	114.3±22.4	116.9±20	92.5±29.5	<0.001
Heart rate (n/min)	92.2±20.6	90.7±19.8	104.5±23.7	0.03
Shock Index	0.85±0.34	0.8±0.3	1.25±0.49	<0.001
Glucose	123.8±35.6	120.4±35.4	151.5±24.6	0.006
Potassium	4.12±0.38	4.17±0.38	3.8±0.26	0.002
Glucose potassium ratio	30.6±7.7	29.5±7	40.11±7.07	<0.001
Hemoglobin	13.7±2.5	14.2±2.15	9.84±2.2	<0.001
Platelet	237.4±75.7	242.7±73.2	193.4±85.3	0.04

Data are presented as mean±standard deviation, median (minimum-maximum), or number (percent). The p value <0.05 was considered significant (survivors vs. non-survivors).

Table 2. Comparison of laboratory parameters and vital signs according to surgical status

İtems	Surgery (n=18)	No-surgery (n=84)	p-value
Systolic blood pressure	104.6±29.5	116.4±21.2	0.09
Heart rate (n/min)	94.8±21.7	91.6±20.4	0.56
Shock Index	0.99±0.41	0.83±0.32	0.28
Glucose	146.3±29.4	118.9±35.1	0.001
Potassium	4.1±0.4	4.13±0.4	0.28
Glucose potassium ratio	36±6.8	29.5±7.4	0.001

Data are presented as mean±standard deviation. P<0.05 was considered significant.

Table 3 also shows the optimal cutoff values of 30.9 (sensitivity, 0.78; and specificity, 0.69) and 0.82 (sensitivity, 0.56; and specificity, 0.73) for GPR and SI to predict the indication for surgery, respectively. The AUCs of GPR and SI to estimate the indication for surgery were 0.761 (95% CI, 0.657–0.864) and 0.582 (95% CI, 0.416–0.747), respectively.

DISCUSSION

Early determination of trauma severity in patients, which is the cause of a significant portion of deaths worldwide, is the most critical point in guiding treatment. This study investigated the predictive role of SI and GPR for mortality and surgical indication in patients with isolated blunt thoracoabdominal trauma. GPR was a stronger predictor of mortality and surgical indication than that of SI in patients with isolated blunt thoracoabdominal trauma.

The mortality rate in thoracoabdominal traumas, which constitute a significant part of blunt traumas, varies from 10 to 36%.[7] The mortality rate was determined by Patel et al.[18]

Table 3. Receiver operating characteristic analysis data for glucose potassium ratio and shock index

Items	Predicting mortality		Predicting surgery indications	
	Glucose potassium ratio	Shock index	Glucose potassium ratio	Shock index
AUC (95% CI)	0.854 [0.742–0.967]	0.809 [0.666–0.952]	0.761 [0.657–0.864]	0.582 [0.416–0.747]
Standard deviation	0.06	0.07	0.05	0.08
Cut-off value	36.8	0.86	30.9	0.82
Youden's index	0.697	0.587	0.468	0.282
Sensitivity	82%	82%	78%	56%
Specificity	88%	77%	69%	73%
P-value	<0.001	0.001	0.01	0.28

AUC: Area under the curve; CI: Confidence interval.

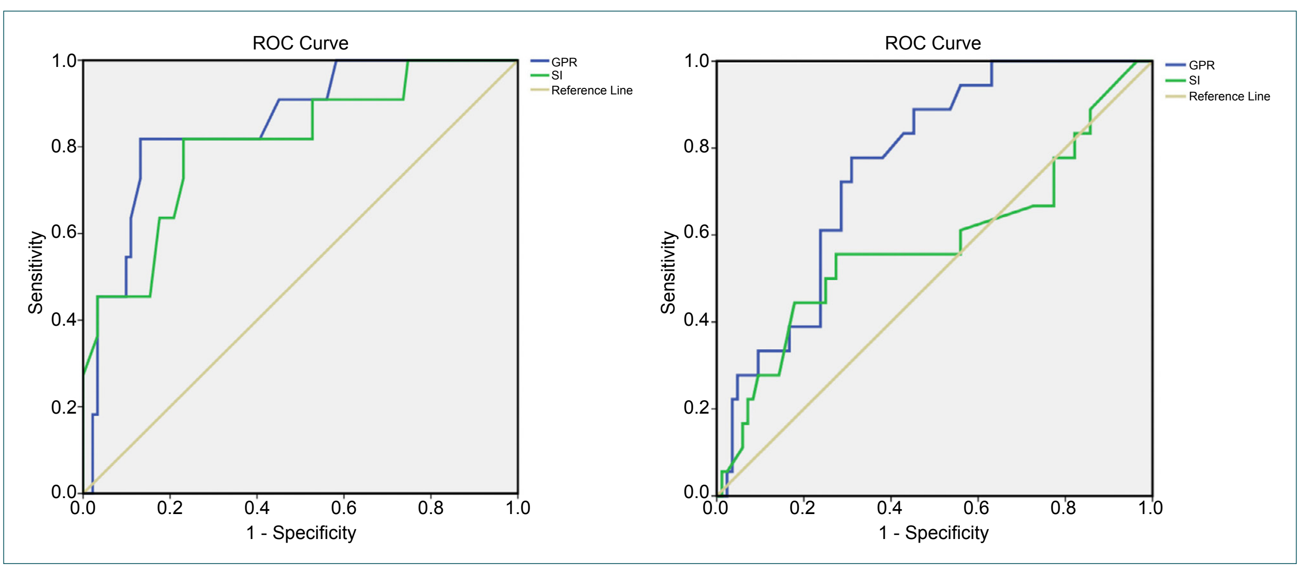

Figure 2. Receiver operating characteristics (ROC) analyzes for glucose potassium ratio and shock index, **(a)** ROC curve analysis of glucose potassium ratio and shock index in predicting mortality. **(b)** ROC curve analysis of glucose potassium ratio and shock index in predicting surgical indication.

and Ciftci et al.[19] reported as 10% and 15.6%, respectively, and this rate was 10.7% in this study. Contrary to expected, patients with thoracoabdominal trauma are operated on at a low rate.[20] In our study, 17.6% of the patients had an operation.

Hypotension and tachycardia are common vital signs in patients with trauma. The previous studies have reported that they can be used to predict mortality.[21] However, these two parameters may be normal due to compensatory mechanisms, especially in patients with severe injury or even shock. For example, hypotension and tachycardia may not be observed in healthy blood donors despite 400–500 cc blood loss.[22] Although systemic blood pressure and pulse rate are easy and quick parameters to detect trauma severity, their reliability is insufficient. Many studies show that the SI obtained by dividing the heart rate by the systemic blood pressure, which Allgower first described in 1976, is more reliable in determining trauma severity than that of hypotension and tachycardia alone.[11,12,23–25] Lammers et al.[26] reported that SI and injury severity score (ISS) were similarly effective in predicting surgical necessity and mortality in patients with trauma. In addition, Inal et al.[27] reported that SI effectively determines prognosis in patients followed up in the intensive care unit after emergency surgery. Richard Crawford et al. reported that SI successfully predicted surgical necessity and mortality.[12] However, Shibahashi et al.[10] found that the efficacy of SI was more limited in older patients and emphasized the SI modified for age. In addition, Il-Jae Wang et al.[28] showed that SI (preSI) evaluated pre-hospital is effective in estimating mortality. This study had a low potential for SI in determining the indication for surgery in patients with blunt thoracoabdominal trauma (cut-off value=0.82, AUC=0.582, and sensitivity and specificity values 56% and 73%, respectively). In addition, the SI cutoff value was 0.86, AUC 0.809, and the sensitivity and specificity values were 82% and 77%, respectively, in estimating mortality in this study. According to these results, although the SI was slightly below the generally accepted cutoff value of 0.9, it effectively estimated mortality in the literature.[11]

Hyperglycemia and hypokalemia are common in patients with trauma due to stress hormone responses.[29] The post-traumatic stress response causes hyperglycemia by increasing catecholamine and glucagon levels. In the literature, articles show a strong relationship between hyperglycemia in patients with trauma and poor prognosis and mortality.[30] In addition, hypokalemia in patients with trauma is due to the effects of catecholamines and glucagon on Na/K adenosine-triphosphatase (ATPase). In this study, a relationship has also been found between hypokalemia and trauma, although not as strong as in previous publications.[31,32] Recently, GPR, which can be calculated quickly and easily and provides reliable information about prognosis, has been increasing in patients with trauma. Jung et al.[16] investigated the relationship between GPR and mortality in patients with subarachnoid hemorrhage and reported that GPR is a safe parameter in estimating mortality, investigated the relationship between GPR and mortality in patients with head trauma and reported that increased GPR could predict mortality for severe head trauma.[33] Recently, Katipoğlu et al. investigated the value of GPR in estimating morbidity and mortality in patients with blunt abdominal trauma and reported that GPR and serum glucose levels were highly effective in predicting surgical necessity and mortality. Our study found that GPR effectively predicted the surgical indication in isolated blunt thoracoabdominal traumas (cutoff value=30.9, AUC=0.761, sensitivity and specificity values 78% and 69%, respectively). We also found that GPR effectively predicted mortality (cutoff value=36.8, AUC=0.854, sensitivity and specificity values 82% and 88%, respectively). According to our results, GPR was powerful and effective in predicting mortality and surgical indication. In addition, we think that the results are more accurate since we did not include patients with diabetes and those using drugs to change their potassium levels. Contrary to previous studies, we avoid time wasting since we obtained the GPR by calculating ABG.

Our study has some limitations. This was a single-center and retrospective study. Another limitation was the absence of other trauma scoring systems (such as ISS and Glasgow coma scale).

Conclusion

Early and rapid intervention is critical in trauma management. SI calculated with the patient's vital signs and GPR obtained from ABG on admission can quickly predict trauma severity, unlike complex algorithms and time-consuming analyses. This study reported the efficacy of SI and GPR in predicting surgical necessity and mortality in patients with trauma and the superior predictive role of GPR over SI.

Ethics Committee Approval: This study was approved by the University of Health Sciences Hamidiye Scientific Research Ethics Committee (Date: 13.05.2022, Decision No: 13/30).

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: E.T., A.Ş.; Design: E.T., A.Ş.; Supervision: E.T., A.Ş.; Resource: E.T., A.Ş.; Materials: E.T., A.Ş.; Data: E.T., A.Ş.; Analysis: E.T., A.Ş.; Literature search: E.T., A.Ş.; Writing: E.T., A.Ş.; Critical revision: E.T., A.Ş.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Glukoz/potasyum oranı ve şok indeksi'nin izole künt torakoabdominal travmalı hastalarda mortalite tahmin etmedeki rolü

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AMAÇ: Bu çalışmanın amacı, uzun süredir kabul gören şok indeksi ve verileri sınırlı olan glukoz/potasyum oranının izole künt torakoabdominal travmalı hastalarda prognostik değerini araştırmaktır.

GEREÇ VE YÖNTEM: Bu geriye dönük gözlemsel çalışma üçüncü basamak bir referans hastanede yürütüldü. Ağustos 2020 ile Şubat 2022 arasında acil serviste künt torakoabdominal travma nedeniyle tedavi edilen 18 yaş ve üstü ardışık hastalar alındı. Girişte arteriyel kan gazlarından elde edilen glukoz/potasyum oranları ve şok indeksi düzeylerinin mortalite ve cerrahi endikasyonu öngörme yeteneği, ROC eğrileri altında kalan alanlar hesaplanarak değerlendirildi.

BULGULAR: Sağ kalan grubunda 91 ve mortalite grubunda 11 olmak üzere toplam 102 hasta analiz edildi. Glikoz/potasyum oranı ve şok indeksi ile mortaliteyi tahmin etmek için ROC eğrileri altında kalan alanlar sırasıyla 0.854 (%95 GA, 0.742–0.967) ve 0.809 (%95, 0.666–0.952) idi. Ameliyat endikasyonunu tahmin etmek için glukoz/potasyum oranı ve şok indeksinin ROC eğrileri altında kalan alanları sırasıyla 0.761 (%95 GA, 0.657–0.864) ve 0.582 (%95 GA, 0.416–0.747) idi.

TARTIŞMA: Bu çalışma, izole künt torakoabdominal travmalı hastalarda cerrahi endikasyonu ve mortalityi öngörmede şok indeksi ve glikoz/potasyum oranının etkinliğini ve glikoz/potasyum oranının şok indeksine göre daha üstün olduğunu bildirmiştir.

Anahtar sözcükler: Glikoz potasyum oranı; mortalite; şok indeksi; torakoabdominal travma.

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