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ORIGINAL ARTICLE

The Glucose/Potassium Ratio Exhibits a Predictive Role That is Both Earlier and More Efficacious Compared to the Inflammatory Response in the Context of Isolated Thoracic Trauma

İzole Torasik Travmalarında; Glukoz/Potasyum Oranı, İnflamatuar Yanıta Kıyasla Hem Daha Erken Hem de Daha Etkili Bir Öngörücü Rol Sergiler

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ABSTRACT

Background/Aim: This study was designed to elucidate the relationship between the AIS 90 thoracic score, which is commonly used to assess the severity of trauma in trauma patients, and the relatively limited studies and data available on the Glucose Potassium Ratio (GPR). Additionally, the study aims to highlight the superiority, if any, of GPR in terms of trauma severity and prognosis, along with the Neutrophil Lymphocyte Ratio (NLR), which plays an important role in trauma severity and prognosis.
Material-Methods: Between June 2020 and June 2022, individuals aged 18 and older admitted to the emergency department with isolated thoracic trauma were included in the study. Data pertaining to these patients were retrospectively analyzed with the AIS 90 thoracic score serving as the reference point. The retrospective screening data of the patients enrolled in the study facilitated the categorization of individuals into three groups based on criteria delineating outpatient treatment, hospitalization and admission to the intensive care unit. The mean values of the GPR and the NLR across these three groups were assessed utilizing Analysis of Variance (ANOVA). Tukey tests were used for homogeneous groups and Tamhane tests were used for non-homogeneous groups to determine specific groups that caused significant differences. ANOVA homogeneity was checked by the Levene test and if homogeneity could not be achieved, the Welch test was used.
Results: The analysis of 89 patients with isolated thoracic trauma revealed no statistically significant difference in the GPR values between the three groups (Levene $p < 0.05$, ANOVA $p=0.025$). However, further exploration through Tukey multiple comparisons indicated that the observed significant difference was attributable to patients admitted to the intensive care unit. Likewise, a statistically significant difference was observed between the three groups in the analysis of NLR values. (Levene $p=0.252$, Welch $p=0.028$). Following Tukey's multiple comparisons, it was determined that the significant difference could be attributed to patients hospitalized in the intensive care unit.
Conclusion: The findings of the study support the conclusion that individuals with an AIS 90 thoracic score above 3 and who need to be admitted to intensive care show higher GPR values than other groups. The association between high GPR values and heightened lung parenchymal injury was evident. Consequently, it can be inferred that a high GPR value may serve as an indicator of lung parenchymal damage, suggesting a greater need for intensive care unit admission in such patients.

Keywords: Thoracic trauma, Glucose Potassium Ratio (GPR), İntensive care unit hospitalization, Abbreviated Injury Scale(AIS 90)

ÖZ

Giriş: Bu çalışma, travma hastalarında travmanın şiddetini değerlendirmede yaygın olarak kullanılan AIS 90 torasik skoru ile Glukoz Potasyum Oranı (GPR) arasındaki ilişkiyi aydınlatmayı amaçlayan, bu konuda sınırlı sayıda mevcut çalışma ve veri ışığında tasarlanmıştır. Ek olarak, çalışma, travma şiddeti ve prognozunda önemli rol oynayan Nötrofil Lenfosit Oranı (NLO) ile birlikte travma şiddeti ve prognoz açısından GPR'nin (varsa) üstünlüğünü vurgulamayı amaçlamaktadır.
Gereç ve Yöntemler: Haziran 2020-Haziran 2022 tarihleri arasında acil servise izole toraks travması ile başvuran 18 yaş ve üzeri bireyler çalışmaya dahil edildi. Bu hastalara ait veriler retrospektif olarak incelendi ve AIS 90 torasik skoru referans noktası olarak kullanıldı. Çalışmaya dahil edilen hastaların retrospektif tarama verileri, bireylerin ayaktan tedavi, hastaneye yatış ve yoğun bakım ünitesine yatış kriterlerine göre üç gruba ayrılmasını kolaylaştırdı. Bu üç gruptaki Glukoz Potasyum Oranı (GPR) ve Nötrofil Lenfosit Oranı (NLO) ortalama değerleri, Varyans Analizi (ANOVA) kullanılarak değerlendirildi.
Homojen gruplar için Tukey testleri, homojen olmayan gruplar için Tamhane testleri kullanılarak anlamlı farklılıklara neden olan spesifik gruplar belirlendi. ANOVA homojenliği Levene testi ile kontrol edilmiş, homojenlik sağlanamazsa Welch testi kullanılmıştır.
Bulgular: İzole toraks travması geçiren 89 hastanın analizinde, GPR değerleri açısından üç grup arasında istatistiksel olarak anlamlı bir fark saptanmadı (Levene $p < 0.05$, ANOVA $p = 0.025$). Bununla birlikte, Tukey çoklu karşılaştırmaları yoluyla yapılan daha ayrıntılı analiz, gözlenen anlamlı farkın yoğun bakım ünitesine kabul edilen hastalara atfedilebileceğini göstermiştir.
Benzer şekilde, NLO değerlerinin analizinde üç grup arasında istatistiksel olarak anlamlı bir fark gözlendi. (Levene $p=0.252$, Welch $p=0.028$). Türkiye'nin çoklu karşılaştırmalarını takiben, anlamlı farkın yoğun bakım ünitesinde yatan hastalara atfedilebileceği belirlendi.
Sonuç: Çalışmanın bulguları, AIS 90 torasik skoru 3'ün üzerinde olan ve yoğun bakım ünitesine yatış gerektiren bireylerin diğer gruplara göre yüksek GPR değerleri gösterdiği sonucunu desteklemektedir. Yüksek GPR değerleri ile artmış akciğer parankimal hasarı arasındaki ilişki belirgindi. Sonuç olarak, yüksek bir GPR değerinin akciğer parankimal hasarının bir göstergesi olabileceği sonucuna varılabilir, bu da bu tür hastalarda yoğun bakım ünitesine yatış ihtiyacının daha fazla olduğunu düşündürür.

Anahtar Kelimeler: Toraks Travması, Glukoz Potasyum Oranı (GPR), Yoğun Bakım Ünitesinde Yatış, Kısaltılmış Yaralanma Skalası (AIS 90)

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Introduction

The prevalence of thoracic traumas is particularly notable in individuals within the first four decades of life. These injuries are associated with a considerable mortality rate, which can vary widely, ranging from 1% to 36%, contingent on factors such as the severity of the trauma (1-3). Blunt thoracic traumas may give rise to a spectrum of injuries, encompassing, yet not confined to, rib fractures, pulmonary contusions, and cardiac injuries. The timely identification and precise management of such traumas assume paramount significance in the preservation of lives, particularly considering their heightened rates of mortality and morbidity (4).

The laboratory markers, with their rapidity, effectiveness and robust prognostic value, provide valuable insights. Integrating them into decision-making processes can significantly enhance thoracic trauma management. The surgeon in the Neutrophil-to-Lymphocyte Ratio (NLR) in response to post-traumatic stress and hypoxia holds significance comparable to alterations in electrolyte balance. This phenomenon is integral to both local and systemic inflammatory responses (5). Decreases in serum potassium (K) levels due to intracellular entry and concurrent elevation in glucose levels represent the most notable changes in electrolyte balance in response to stress and hypoxia (6,7). Alteration in electrolyte balance, especially the Glucose Potassium Ratio (GPR), is a prognostic marker that is activated earlier than inflammatory responses. This ratio has been found useful in the evaluation of mortality and morbidity in various medical conditions such as head traumas, cerebrovascular diseases, myocardial infarction, pulmonary embolism and abdominal traumas in the literature (8-11).

Trauma scoring systems offer a standardized method for quantifying the severity of trauma, assisting healthcare professionals in making informed decisions regarding the optimal level of care and necessary interventions for patients with thoracic trauma. Among these scoring systems, the Abbreviated Injury Scale (AIS), particularly the latest revised AIS 90 Scoring system, holds considerable significance. (12,13).

This study aimed to clarify the correlation and clinical significance between the AIS 90 thoracic score, the NLR score and the GPR score.

Methods

Ethical considerations were prioritized, and approval was secured from the local ethics committee for our study (Protocol number 05-28, dated 04.05.2023). The study involved the inclusion of patients with isolated thoracic trauma who were admitted to the emergency department.

In the retrospective screening of patient data, individuals with incomplete information, concomitant trauma other than thoracic trauma, a medical history of hypertension, diabetes, renal failure, and potential drug use known to interfere with electrolyte balance were systematically excluded from the study. The analysis focused on the data of a total of 89 patients aged 18 years and older who sought medical attention at the emergency department between June 2020 and June 2022, as illustrated in Figure 1.

The retrospective data of the patients were categorized based on the AIS 90 thoracic scoring system. Variables such as age, gender and trauma-related pathologies were considered for grading. . Trauma-related pathologies were further detailed, including simple single rib/sternal fracture, multiple rib fractures (more than three), lung contusion, hemothorax, pneumothorax, vascular injury, and multiple rib fractures exceeding three. Utilizing the AIS 90 scoring table developed by Grevitt MP et al., the elucidation of trauma-related pathologies, such as simple single rib/sternum fracture, multiple rib fractures (exceeding three), lung contusion, hemothorax, pneumothorax, vascular injury, and multiple rib fractures exceeding three, was conducted in greater detail (Table 1) (14).

The demographic information, including age and gender of the study participants was systematically analyzed. Subsequently, based on the hospitalization records, the patients were stratified into three distinct groups: 1) individuals subjected to outpatient treatment (Out-Patients), 2) those admitted to general ward facilities (Hospitalized), and 3) those requiring intensive care unit admission (Admitted to Intensive care). Gross Patient Revenue (GPR) and Net Length of Stay (NLO) metrics were computed for each respective group.

Statistical Analysis

ANOVA was employed to assess the equality of the GPR and NLR averages between the groups. In determining the specific groups contributing to the observed differences in those with significant distinctions in ANOVA, Tukey tests were utilized for homogeneous groups, while Tamhane multiple comparison tests were applied for non-homogeneous groups. The Levene test was conducted to evaluate the homogeneity assumption of ANOVA, and in cases where homogeneity was not met, the Welch test was performed for groups that did not conform to the homogeneity assumption. An independent two-sample t-test was employed to assess the equality of the GPR and NLR averages between the two groups.

If the significance levels for Levene (p-value), ANOVA (p-value), and Welch (p-value) tests are all greater than 0.05, it suggests that there is no significant difference in the variances between the groups Levene, no significant difference in means among the groups ANOVA, and no violation of the homogeneity of variance assumption Welch.

Results

The study encompassed data from 89 participants, comprising 47 males and 42 females. The average age of the patients was determined as 34.41 years. Statistical analysis revealed no noteworthy distinctions between the groups concerning age and gender.

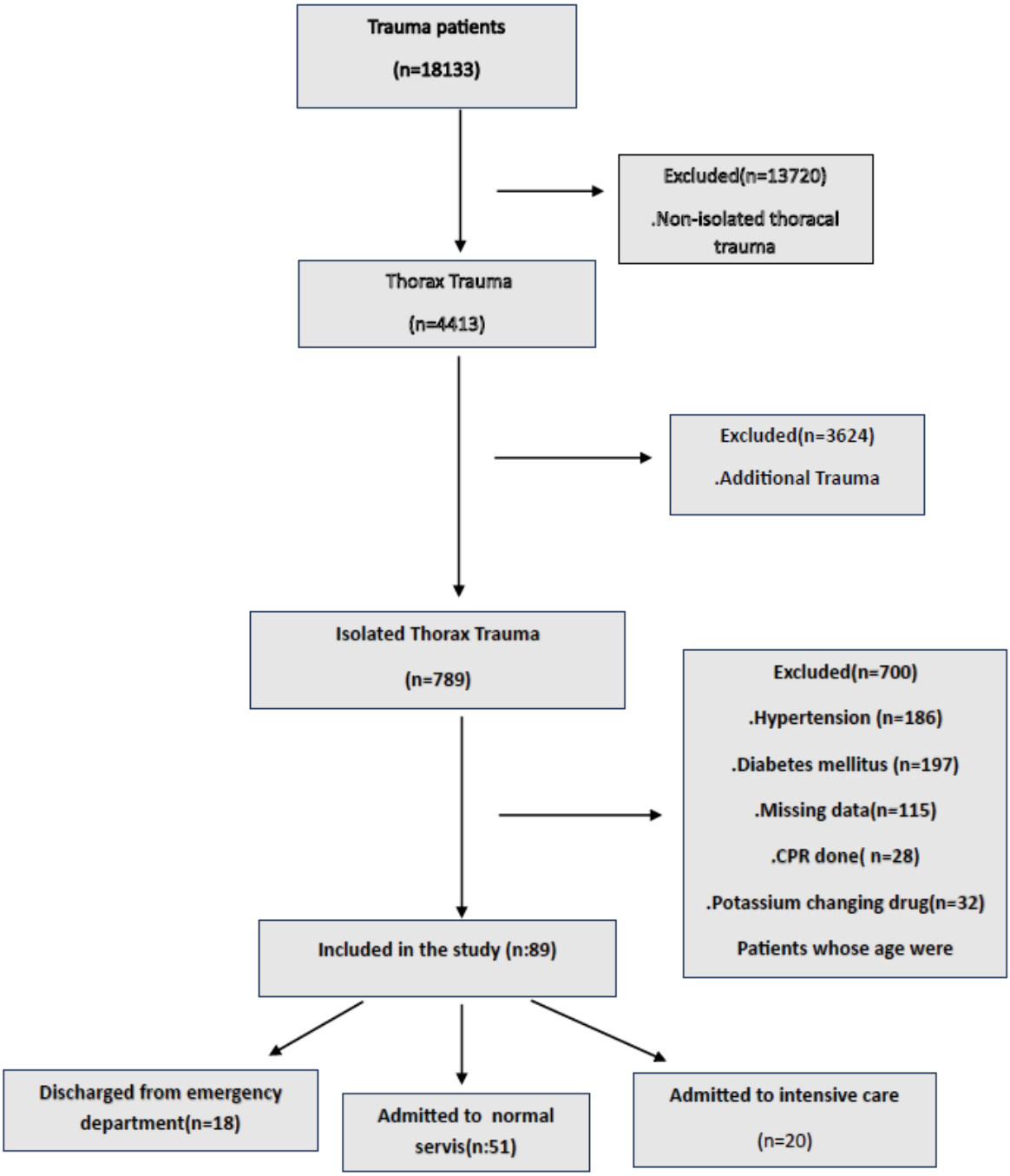

Figure1: Flowchart diagram

Out of the entire cohort of 89 patients, 18 individuals underwent follow-up in the emergency department due to trauma and were subsequently discharged. Moreover, 51 patients were admitted to the thoracic surgery service while an additional 20 patients received ongoing monitoring and care within the intensive care unit. The difference in GPR values between the groups was statistically significant (Levene p-value=0.252>0.05, ANOVA p-value=0.025<0.05) (Table 2). Tukey's multiple comparisons revealed that the difference was attributable to patients hospitalized in intensive care (Table 3). The difference between the GPR values between the groups was statistically significant (Levene p-value=0.252>0.05, ANOVA p-value=0.025<0.05) (Table 2). Similarly, the difference in NLR values between groups was statistically significant (Levene p-value=0.000<0.05, Welch p-value=0.028<0.05) (Table 2). Tukey's multiple comparisons identified that the difference was due to patients hospitalized in intensive care. The homogeneous subset obtained from pairwise comparison is detailed in Table 4. For patients with a single simple rib/sternal fracture or fewer than 3 rib fractures and an AIS 90 score <3, no significant difference was found in GPR values for the

three groups (Levene p-value=0.620>0.05, ANOVA p-value=0.566>0.05) (Table 5). Similarly, for patients with a single simple rib/sternal fracture or fewer than 3 rib fractures and an AIS 90 score <3, the difference in NLR values among the three groups is not statistically significant (Levene p-value=0.260>0.05, ANOVA p-value=0.547>0.05) (Table 5).

Similarly, the difference in NLR values between groups was statistically significant (Levene p-value=0.000<0.05, Welch p-value=0.028<0.05) (Table 2). Tukey's multiple comparisons identified that the difference was due to patients hospitalized in intensive care. The homogeneous subset obtained from pairwise comparison is shown in Table 4. For the patients with a single simple rib/sternal fracture or fewer than 3 rib fractures and an AIS 90 score <3, there was no significant difference in GPR values for the three groups (Levene p-value=0.620>0.05, ANOVA p-value=0.566>0.05) (Table 5). Similarly, for patients with a single simple rib/sternal fracture or fewer than 3 rib fractures and an AIS 90 score <3, the difference in NLR values between the three groups was not statistically significant (Levene p-value=0.260>0.05, ANOVA p-value=0.547>0.05) (Table 5).

On examining the GPR values for two groups with and without lung parenchymal damage (hemothorax, pneumothorax, lung contusion, 3 or more multiple rib fractures, vascular injury) and AIS 90 Score > 3, a statistically significant difference was observed (Levene p-value=0.000<0.05, t-test p-value=0.004<0.05). However, the difference in NLR values between these two groups was not statistically significant (Levene p-value=0.805>0.05, t-test p-value=0.597>0.05) (Table 6).

The Pearson correlation coefficient between GPR and NLR rates is 0.138 (p-value=0.198), and this correlation was statistically insignificant.

Table 1: Thoracic section of the Abbreviated Injury Scale (AIS). Uploaded by Grevitt MP, Muhivdeen HA, Griffiths C.Trauma care in a military hospital, JR Army Med. Corps. 1991. Oct;137(3):131-5. Doi:10.1136/jramc-137-03-06

AIS	Severity	Injury Description
1	Minor	Rib contusion/fracture* Sternal contusion
2	Moderate	2-3 rib fractures, stable chest* Multiple fractures of a single rib sternal fracture
3	Severe, not life-threatening	Rib fractures open/displaced/ communicated >3 rib fractures, stable chest*
4	Severe, life-threatening	Flail chest(unstable chest wall)
5	Critical, survival uncertain	Severe flail (usually requires ventilatory support
*Add AIS for the presence of haemothorax, pneumothorax,haemo-or pneu-momediastium.		

Table 2: Descriptive Statistics

		Number of Patients	Mean	Standard Deviation	Standard Error	Confidence İntervals (%95) for the mean	
						Lower Limit	Upper Limit
GPR	Hospitalized	51	32,83	15,53	2,17	28,47	37,20
	Admitted to İntensive care	20	42,35	16,09	3,6	34,82	49,88
	Out-Patients	18	30,57	9,07	2,14	26,06	35,08
	Total	89	34,51	15,09	1,6	31,34	37,69
NLR Hospitalized 51			1,78	,68	,10	1,59	1,97
	Admitted to İntensive care	20	4,75	4,74	1,06	2,53	6,97
	Out-Patients	18	1,68	,69	,16	1,34	2,03
	Total	89	2,43	2,61	,28	1,88	2,98

Tablo 3: GPR Tukey Pairwise Comparison Results

	Hospitalization Status	Number of Patients	Lower clusters for alpha= 0.05	
			1	2
Tukey HSDab	Out-patient	18	30,57	
	Hospitalized	51	32,83	32,83
	Intensive care	20		42,35
	P value		,85	,068

Tablo 4: NLR Tamhane Comparison Test Results

Hospitalization (I)	Hospitalization (J)	Mean Differences (I-J)	Standard Error	P Value	Confidence interval (%95) for the mean	
					Lower Limit	Upper Limit
Hospitalized	Intensive care	-2,97*	1,06	,03	-5,75	-,19
	Out-patient	,10	,19	,94	-,38	,58
Intensive care	Hospitalized	2,97*	1,06	,03	,19	5,75
	Out-patient	3,07*	1,07	,03	,27	5,86
Out-patient	Hospitalized	-,10	,19	,94	-,58	,38
	Intensive care	-3,07*	1,07	,03	-5,86	-,27

Table 5: Descriptive Statistics

		Number of Patients	Mean	Standard Deviation	Standard Error	Confidence İntervals (%95) for the mean	
						Lower Limit	Upper Limit
GPR	Hospitalized	51	32,83	15,53	2,17	28,47	37,20
	Admitted to İntensive care	20	42,35	16,09	3,6	34,82	49,88
	Out-Patients	18	30,57	9,07	2,14	26,06	35,08
	Total	89	34,51	15,09	1,6	31,34	37,69
NLR	Hospitalized	51	1,78	,68	,10	1,59	1,97
	Admitted to İntensive care	20	4,75	4,74	1,06	2,53	6,97
	Out-Patients	18	1,68	,69	,16	1,34	2,03
	Total	89	2,43	2,61	,28	1,88	2,98

Tablo 6: GPR and NLR Values for Two Groups with and without Lung Parenchymal Damage

Lung Parenchymal damage (hemothorax, pneumothorax, multiple rib fractures (>3)		Number of patients	Mean	Standard Deviation	Standard Error
GPR	Yes	47	38,75	17,97	2,62
	No	42	29,77	9,08	1,40
NLR	Yes	47	2,57	1,88	,27
	No	42	2,27	3,25	,50

Discussion

In accordance with the AIS 90 Thoracic scoring system, patients with thoracic trauma whose scores surpassed 3 within the initial 6 hours following emergency admission demonstrated elevated Gross Patient Revenue (GPR) compared to patients with an AIS 90 score below 3. Consequently, individuals presenting with isolated thoracic trauma and exhibiting heightened GPR values are recommended for referral to the intensive care unit to ensure comprehensive monitoring and appropriate medical intervention.

The absence of statistical significance in GPR and NLR values concerning outpatient treatment, hospitalization or intensive care unit admissions in patients with a single simple rib/sternal fracture or an AIS score of 90<3, and in those with fewer than <3 rib fractures, suggests that GPR is comparably effective as NLR in assessing trauma severity. This observation underscores the potential utility of GPR as a valuable and equivalent marker in gauging the severity of trauma.

In cases of thoracic trauma associated with lung parenchymal injury, the significance of the GPR value was noteworthy when the AIS exceeded 3, whereas the NLR did not exhibit statistical significance within the same patient cohort. This implies that considering the maximum length of stay in the emergency department is 24 hours, GPR can be regarded as an early predictive marker within the initial 24 hours post-trauma, potentially indicating a correlation with the severity of trauma experienced. The observed difference between GPR and NLR values in the context of thoracic traumas with lung parenchymal injury can be elucidated by acknowledging that NLR is inherently correlated with trauma severity and tends to function as a late predictive marker for both mortality and morbidity (15). The distinct temporal dynamics and sensitivity of these biomarkers contribute to their varied roles in reflecting trauma-related outcomes.

In conclusion, the GPR emerges as a promising biomarker for swiftly and effectively assessing the prognosis of emergency department admissions. The observed correlations between GPR values and various trauma-related outcomes, particularly in the context of thoracic traumas with lung parenchymal injury, suggest its potential utility as an early predictive marker for patient prognosis in the acute setting. Further research and validation may solidify its role in clinical practice. In the light of the dynamics observed with the NLR, which tends to enhance its effectiveness within the hospital or on the days following hospitalization, the practice of keeping patients with predictive significance in terms of mortality and morbidity for a maximum of 24 hours seems appropriate for the diagnostic window. Contrastingly, in the context of emergency departments, GPR emerges as a notably more suitable predictive marker. It helps to ensure that patients are promptly referred to the appropriate care units, facilitating timely and accurate treatment decisions, as supported by relevant references (16,17).

Based on the findings of this study in isolated thoracic traumas, there is a basis for further investigations examining the impact of GPR on prognosis within emergency departments. Subsequent studies with larger patient cohorts and exploration across diverse pathologies could provide additional insights into the utility and generalizability of GPR as a prognostic marker. Such research endeavors would contribute to a more comprehensive understanding of the role of GPR in emergency medicine and its potential implications for patient outcomes.

Acknowledging the novelty and limited extant research on GPR as a rapid and effective biomarker, it is crucial to recognize the principal limitations of our study. Notably, the study was conducted with a relatively restricted patient sample. Additionally, the exclusion of patients with known comorbidities and drug usage implemented to minimize potential influences on electrolyte balance and hyperglycemia, may impact the generalizability of the findings. Furthermore, the choice of trauma scores utilized in different studies can introduce variability and should be considered in the context of the broader research landscape. Future

studies with more extensive and diverse participant groups may help address these limitations and provide a more nuanced understanding of GPR's applicability as a biomarker.

The meticulous understanding of the profound impact of trauma, coupled with the implementation of judicious follow-up and treatment protocols, stands as a pivotal determinant in mitigating both mortality and morbidity rates within the demographic of trauma patients, as corroborated by existing literature (1,3). To assess the gravity of trauma in emergency departments, numerous trauma severity scores have been delineated in the literature, encompassing parameters such as patients' clinical profiles, vital signs, laboratory results and imaging findings. The utilization of scoring systems is designed to expedite an early assessment of trauma severity. In our investigation, we employed the AIS 90 trauma severity scoring system to assess patients who presented with isolated thoracic trauma (18,19).

Irrespective of the trauma's mechanism or the body region it impacts, trauma serves as a physiological stressor prompting various metabolic responses. One well-recognized metabolic response to stress is the initiation of an inflammatory reaction. In recent years, the literature has underscored the significance of NLR as a paramount biomarker of the inflammatory response. Notably, it has gained recognition as a predictive indicator for mortality and morbidity in various medical conditions including sepsis, infections, cerebrovascular diseases among patients in intensive care settings (20,21).

The study aimed to assess the predictive capacity of mortality and morbidity in trauma patients. However, existing research suggests that the rise in NLR values in response to stress tends to occur relatively late, typically manifesting around 5-7 days. This delayed increase in NLR underscores its significance as a late predictor in determining mortality and morbidity outcomes for patients within hospital or intensive care settings, as well as for postoperative patients (22-24).

Hence, there is a pressing need for swifter and more efficacious markers in diagnosing, appropriately monitoring and treating patients in the emergency department.

In instances of trauma-related stress exposure, the GPR exhibits an increase concomitant with heightened catecholaminergic discharge in metabolism. This is facilitated by the extrusion of intracellular glucose from cells and the reduction in serum potassium attributable to hyperglycemia, with a concurrent influx of potassium into cells through the same mechanism.

The outcomes of the study, strategically designed to anticipate that the body's reaction to stress could be as potent as, if not faster, the inflammatory response, are poised to significantly enhance hospitalization planning for individuals presenting to the emergency department with isolated thoracic trauma. It is anticipated that the findings will make a significant contribution to this issue by providing appropriate timing, meticulous follow-up and personalized treatment strategies. (25-28).

Conclusion

In conclusion, GPR values can be used as faster and more effective predictive markers compared to NLR in assessing trauma severity and determining patient prognosis in emergency department trauma management.

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Ethical considerations: This study was carried out after the approval of the local institutional review board (Konya City Hospital Ethical Committee, 04.05.2023, 05-28)

Data Sharing Statement: The entire deidentified dataset, data dictionary, and analytic code for this investigation are available upon request, from the date of article publication by contacting Demet Doctor, MD, at email dr_demetacar@hotmail.com

Author contributions: Demet Acar conceived the study and designed the trial. Demet Acar and Emine Kadıoğlu supervised the conduct of the trial and data collection. Demet Acar and Nazlı Karakuş Kenan undertook the recruitment of participating centers and patients and managed the data, including quality control. Asiye Müminat Çap provided statistical advice on study design and analyzed the data; Emine Doğan chaired the data oversight committee. Demet Acar drafted the manuscript, and all authors contributed substantially to its revision. Demet Acar and Yavuz Yılmaz take responsibility for the paper as a whole.

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