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Original Article

Association Between Admission Glucose-to-Potassium Ratio and 30-Day Mortality in Elderly Patients With Hip Fractures

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ABSTRACT

Objective: Hip fractures in the elderly represent a major public health concern, associated with significant short-term mortality and functional decline. Early risk stratification upon admission is essential to guide clinical management. The stress index (SI), defined as the glucose-to-potassium ratio, has emerged as a potential prognostic biomarker in various acute medical conditions. However, its role in predicting mortality in patients with traumatic hip fractures remains underexplored.

Methods: This retrospective study included patients aged ≥18 years who presented to the emergency department of a teratiary care hospital with traumatic hip fractures between January 1, 2022, and January 1, 2024. Data were obtained from electronic health records, including demographic information, laboratory values at admission, vital signs, comorbidities, and 30-day mortality outcomes. The SI was calculated as the glucose-to-potassium ratio. The primary outcome was 30-day all-cause mortality. Predictive performance was assessed using receiver operating characteristic (ROC) analysis, and model calibration was evaluated using the Hosmer–Lemeshow test and Brier score.

Results: A total of 440 patients were included, with a 30-day mortality rate of 9.3% (n=41). The stress index was significantly higher among non-survivors (40.5 [IQR 33.6–47.5]) compared to survivors (32.4 [IQR 27.2–37.2], p<0.001). ROC analysis yielded an area under the curve of 0.794 (95% CI 0.726–0.860). The optimal cutoff value (Youden index) was 35.9, with 73.2% sensitivity and 76.4% specificity. Calibration metrics indicated good model fit and prediction accuracy.

Conclusion: The admission SI is independently associated with 30-day mortality in elderly patients with traumatic hip fractures. As a rapid and accessible marker, it may enhance early risk stratification and inform clinical decision-making in emergency care settings.

INTRODUCTION

Hip fractures represent a significant cause of morbidity and mortality among the elderly population.[1-3] Globally, the incidence of hip fractures is increasing due to aging demographics, with individuals aged 65 years and older constituting the majority of cases.[4,5] These injuries often result from low-energy falls and are associated with substantial functional decline, loss of independence, and increased healthcare utilization. Despite advances in surgical techniques and postoperative care, the 30-day mortality rate following hip fracture remains high, ranging from 5% to 10%, and can exceed 30% in certain populations.[6,7] Early identification of patients at increased risk of adverse outcomes is crucial for optimizing management strategies and improving survival rates.

The stress index (SI), defined as the ratio of serum glucose to potassium levels upon admission, has emerged as a potential prognostic marker in various acute medical conditions.[8-10] This index reflects the physiological stress response, where elevated glucose levels and decreased potassium levels are common findings.[11] In trauma patients, a higher SI has been associated with increased mortality and poorer outcomes.[12] Its utility lies in its simplicity and the rapid availability of its components, making it an attractive tool for risk stratification in emergency settings.

This study aims to evaluate the association between the admission glucose-to-potassium ratio and 30-day mortality in elderly patients presenting with hip fractures.

MATERIALS AND METHODS

This retrospective observational study was conducted at the emergency department of Kartal Dr. Lütfi Kırdar City Hospital. The study included patients who presented to the emergency department with a preliminary diagnosis of traumatic femur fracture between January 1, 2022 and January 1, 2024. Ethical approval was obtained from the local ethics committee of Kartal Dr. Lütfi Kırdar City Hospital (Approval No: 2024/010.99/11/35, Date: 25.12.2024). The principles outlined in the Declaration of Helsinki have been followed.

Patients aged 65 years and older who presented with traumatic femur fractures and had available data on admission laboratory parameters were included in the analysis. Patients were excluded if data regarding age, sex, comorbidities, medication use, admission laboratory findings (including serum glucose and potassium levels), or 30-day mortality status were incomplete or missing.

Data were obtained retrospectively from the hospital's electronic health records (Hospital-Based Information Management System, HBYS). A standardized digital data collection form in Excel format was used for data extraction. Variables collected included demographic characteristics, comorbidities, chronic medication use, initial laboratory results such as serum glucose, potassium, albumin, hemoglobin, creatinine, blood urea nitrogen (BUN), and C-reactive protein (CRP), as well as vital signs at admission and intensive care unit (ICU) admission status. The SI was calculated as the ratio of serum glucose (mg/dL) to potassium (mmol/L) upon presentation to the emergency department.

The primary outcome of this study was 30-day all-cause mortality following emergency department admission due to traumatic femur fracture.

Descriptive statistics were calculated for all variables and stratified by 30-day mortality status. Continuous variables were assessed for normality using histograms and Q–Q plots. Normally distributed variables were summarized as mean ± standard deviation and compared using Student's t-test; non-normally distributed variables were summarized as median [interquartile range (IQR)] and compared using the Wilcoxon rank-sum test. Categorical variables were presented as counts and percentages and compared using Pearson's chi-squared test or Fisher's exact test, as appropriate.

The predictive performance of the SI was evaluated using receiver operating characteristic (ROC) analysis. The optimal cutoff was determined using Youden's index. Area under the curve (AUC) with 95% confidence intervals (CI), sensitivity, specificity, positive and negative predictive values, and likelihood ratios were reported for this threshold.

Calibration of the logistic regression model incorporating the SI was assessed using a calibration plot, the Hosmer–Lemeshow test, and the Brier score. Model discrimination was further explored through fixed-sensitivity threshold analysis. For predefined sensitivity levels (97%, 95%, 90%, 80%, and 70%), the corresponding thresholds were identified, and diagnostic performance metrics were calculated at each point, including 95% CI via stratified bootstrap (2000 replicates). All analyses were performed using R version 4.4.2 (R Foundation for Statistical Computing).

RESULTS

A total of 440 elderly patients with hip fractures were included, of whom 41 (9.3%) died within 30 days. Table 1 presents the baseline characteristics of survivors and deceased patients. The deceased group was older (85.9±4.5 vs. 78.7±8.0 years, p<0.001; Δ –7.18 [95% CI –8.80 to –5.56]), had lower hemoglobin (10.4±2.0 vs. 11.8±1.6 g/dL, p<0.001), lower albumin (3.1±0.6 vs. 3.6±0.5 g/dL, p<0.001), and higher blood urea nitrogen (30.8±8.8 vs. 19.7±6.0 mg/dL, p<0.001; Δ –11.05 [95% CI –13.90 to –8.21]). The stress index (glucose-to-potassium ratio) was significantly higher in the deceased group (40.5 [IQR 33.6–47.5] vs. 32.4 [IQR 27.2–37.2], p<0.001). The deceased group also had lower mean arterial pressure (83.4±9.5 vs. 89.6±8.0 mmHg, p<0.001; Δ 6.22 [95% CI 3.12 to 9.32]) and a higher incidence of intensive care unit (ICU) admission (48.8% vs. 15.5%, p<0.001).

The discriminative ability of the stress index for predicting 30-day mortality was evaluated using ROC analysis (Fig. 1). The AUC was 0.794 (95% CI 0.726–0.860). The optimal cutoff determined by Youden's index was 35.9, corresponding to a sensitivity of 73.2% (95% CI 59.6–86.7) and a specificity of 76.4% (95% CI 72.3–80.6) (Table 2). The positive likelihood ratio at this threshold was 3.10 (95% CI 2.27–4.13), and the negative likelihood ratio was 0.35 (95% CI 0.21–0.55).

Calibration was assessed using a calibration plot, the

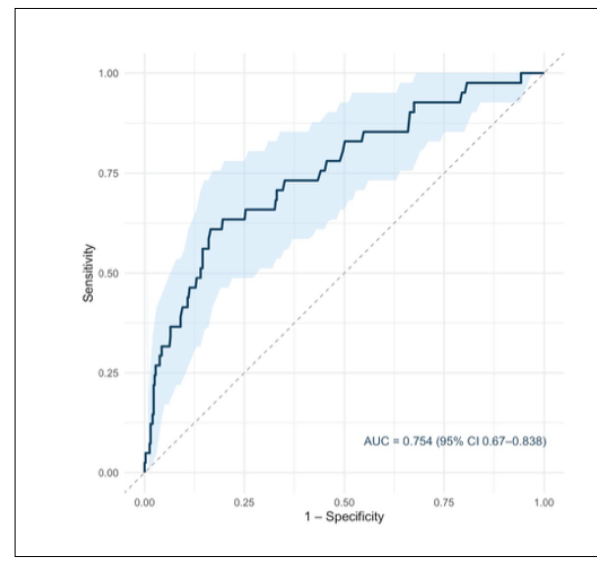

Figure 1. Receiver operating characteristic (ROC) curve for the stress index (glucose-to-potassium ratio) in predicting 30-day mortality among elderly hip fracture patients.

Table 1. Demographic and characteristic features of the patients

Variable	Survivors (n=399)	Deceased (n=41)	p	Mean difference (95% CI)
Demographics & Function				
Age (years)	78.7±8.0	85.9±4.5	<0.001	–7.18 (–8.80 to –5.56)
Male sex	286 (71.7%)	23 (56.1%)	0.048	
Dependent mobility	247 (61.9%)	12 (29.3%)	<0.001	
Comorbidities				
Modified Frailty Index	2.8 [1.9–3.8]	4.5 [3.5–5.0]	<0.001	
Ortho-MPI Score	4.7 [3.7–5.9]	6.2 [5.1–8.7]	<0.001	
Dementia	95 (23.8%)	18 (43.9%)	0.339	
Diabetes mellitus	112 (28.1%)	14 (34.1%)	0.002	
Hypertension	110 (27.6%)	15 (36.6%)	0.019	
CAD	102 (25.6%)	14 (34.1%)	0.037	
Chronic kidney disease	71 (17.8%)	12 (29.3%)	0.014	
Malignancy	51 (12.8%)	9 (22%)	0.031	
Chronic lung disease	50 (12.5%)	10 (24.4%)	0.021	
Perioperative Characteristics				
ASA score	2.8 [2.5–3.2]	3.7 [3.1–4.0]	<0.001	
Surgery delay >48 h	112 (28.1%)	18 (43.9%)	0.047	
Femoral neck fracture	198 (49.6%)	27 (65.9%)	0.051	
Intertrochanteric fracture	201 (50.4%)	14 (34.1%)	0.051	
ICU admission	62 (15.5%)	20 (48.8%)	<0.001	
Laboratory Parameters				
Hemoglobin (g/dL)	11.8±1.6	10.4±2.0	<0.001	1.32 (0.68 to 1.95)
Albumin (g/dL)	3.6±0.5	3.1±0.6	<0.001	0.52 (0.33 to 0.71)
Creatinine (mg/dL)	1.0 [0.7–1.3]	1.5 [1.0–1.8]	<0.001	
BUN (mg/dL)	19.7±6.0	30.8±8.8	<0.001	–11.05 (–13.90 to –8.21)
CRP (mg/L)	47.9 [32.0–65.8]	79.5 [60.9–118.1]	<0.001	
Glucose (mg/dL)	134.1 [111.7–151.2]	162.3 [131.4–177.0]	<0.001	
Potassium (mmol/L)	4.1 [3.9–4.3]	3.9 [3.5–4.2]	0.005	
Stress index (Glucose / K)	32.4 [27.2–37.2]	40.5 [33.6–47.5]	<0.001	
Vital Signs				
SBP (mmHg)	124.0 [115.0–136.0]	121.0 [112.0–133.0]	0.072	
DBP (mmHg)	71.0 [66.0–78.0]	66.0 [56.0–74.0]	<0.001	
MAP (mmHg)	89.6±8.0	83.4±9.5	<0.001	6.22 (3.12 to 9.32)
Shock Index	0.7 [0.6–0.7]	0.7 [0.6–0.7]	0.080	
Hospital Course				
Length of stay (days)	8.0 [6.0–10.0]	6.0 [5.0–8.0]	<0.001	
Any complication	277 (69.4%)	16 (39.0%)	<0.001	
Major complication	338 (84.7%)	27 (65.9%)	0.004	

ASA, American Society of Anesthesiologists; BUN, blood urea nitrogen; CAD, coronary artery disease; CAR, C-reactive protein–to–albumin ratio; CCI, Charlson Comorbidity Index; CKD, chronic kidney disease; CRP, C-reactive protein; DBP, diastolic blood pressure; GCS, Glasgow Coma Scale; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; MAP, mean arterial pressure; MFI, Modified Frailty Index; MPI, Multidimensional Prognostic Index; SBP, systolic blood pressure; SI, stress index.

Hosmer–Lemeshow test, and the Brier score. The model showed excellent agreement between predicted and observed mortality probabilities across deciles of risk (Fig. 2), with a mean absolute error of 0.014 and a 90th percentile absolute error of 0.024. The Hosmer–Lemeshow test was not significant (χ^2=5.01, degrees of freedom =8, p=0.76), suggesting good model fit. The Brier score was 0.076, indicating good overall prediction accuracy.

To aid clinical interpretation, post-test probabilities were visualized using Fagan nomograms. For a pretest mortality probability of 10.3%, a stress index above 35.9 increased the post-test probability to 26.2%, while a value below the threshold reduced it to 3.9% (Fig. 3).

Finally, the diagnostic performance of the stress index was evaluated at fixed sensitivity thresholds (Table 3). At 90% sensitivity, the corresponding threshold was 28.65, yielding

Table 2. Performance metrics of the Stress Index (Glucose/Potassium) for predicting 30-day mortality

Metric	Value	95% CI
Cutoff value (Youden index)	35.9	—
Area under the curve	0.794	0.726–0.860
Sensitivity (%)	73.2	59.6–86.7
Specificity (%)	76.4	72.3–80.6
Positive predictive value (%)	24.2	16.5–33.3
Negative predictive value (%)	96.5	94.1–98.0
Positive likelihood ratio	3.10	2.27–4.13
Negative likelihood ratio	0.35	0.21–0.55

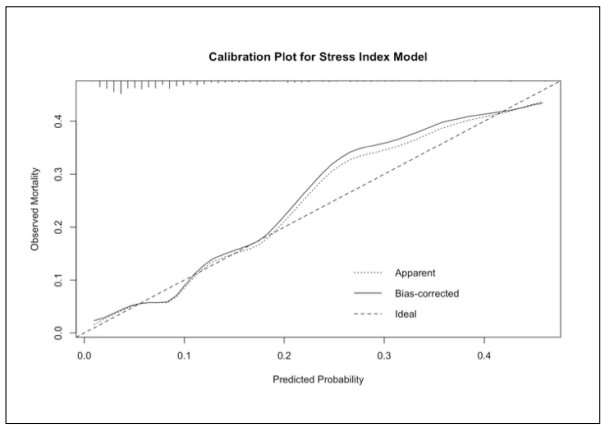

Figure 2. Calibration plot of the Stress Index (Glucose-to-potassium ratio) model for 30-day mortality.

a specificity of 32.6% (95% CI 28.3–37.1) and a negative predictive value of 97.0% (95% CI 94.2–99.3). Across all sensitivity levels examined (70% to 97%), negative likelihood ratios remained consistently low (range 0.11–0.45), highlighting the utility of the SI as a rule-out tool in this population.

DISCUSSION

This study demonstrated that a higher admission SI was significantly associated with increased 30-day mortality in elderly patients with traumatic femur fractures. The SI showed good predictive performance and may serve as a simple, rapid, and clinically applicable marker for early mortality risk assessment in this vulnerable population.

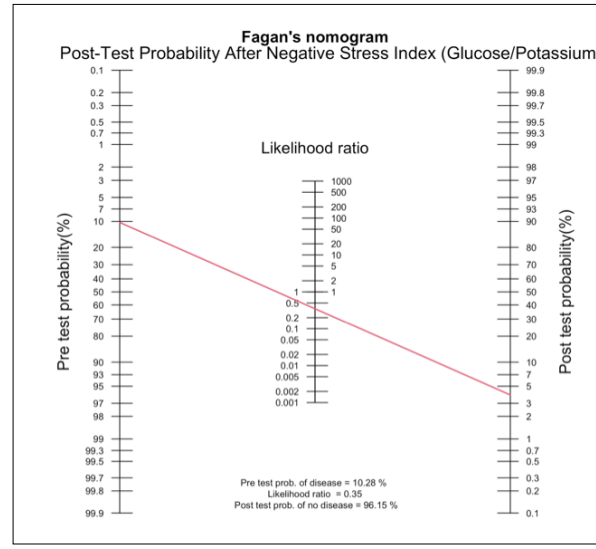

Figure 3. Fagan nomogram showing the impact of a negative Stress Index on post-test probability of 30-day mortality.

Hip fractures in elderly patients often trigger a significant physiological stress response. This response involves the activation of the hypothalamic-pituitary-adrenal axis, leading to increased cortisol secretion, which in turn promotes gluconeogenesis and insulin resistance, resulting in hyperglycemia.[13] Concurrently, stress-induced catecholamine release and cellular shifts can cause hypokalemia. The SI, calculated as the glucose-to-potassium ratio, encapsulates these metabolic changes and serves as a surrogate marker for the severity of the physiological stress response. Elevated SI values have been associated with adverse outcomes in various acute medical conditions, including trauma and critical illness.[14-16]

Hip fractures are a significant cause of morbidity and mortality among the elderly. These injuries often result in prolonged hospitalization, reduced mobility, and increased dependency.[17,18] Complications such as infections, thromboembolic events, and cardiovascular issues are common and contribute to the high mortality rates observed in this population.[19] Early identification of patients at higher risk of adverse outcomes is crucial for implementing targeted

Table 3. Estimated diagnostic performance of the Stress Index (Glucose/Potassium) at fixed sensitivity thresholds

Fixed Sensitivity	Threshold	Specificity	PPV	NPV	+LR	–LR
97%	24.85	22.1 [17.8–27.2]	10.2 [8.6–11.8]	98.6 [96.4–99.8]	1.25 [1.02–1.53]	0.11 [0.03–0.35]
95%	25.90	25.1 [20.8–30.5]	10.7 [9.0–12.2]	97.8 [95.3–99.4]	1.27 [1.06–1.52]	0.20 [0.08–0.44]
90%	28.65	32.6 [28.3–37.1]	12.1 [10.7–13.3]	97.0 [94.2–99.3]	1.34 [1.15–1.56]	0.30 [0.13–0.60]
80%	32.45	52.7 [47.9–58.4]	15.3 [12.5–18.2]	95.1 [92.3–96.9]	1.70 [1.43–2.02]	0.37 [0.22–0.58]
70%	34.70	65.0 [59.6–69.9]	17.9 [14.2–21.4]	93.2 [89.5–95.8]	2.02 [1.64–2.50]	0.45 [0.30–0.68]

NPV, negative predictive value; PPV, positive predictive value; +LR, positive likelihood ratio; –LR, negative likelihood ratio.

interventions. The SI, being a readily available and cost-effective biomarker, could aid clinicians in stratifying risk and optimizing management strategies for elderly patients with hip fractures.

Previous studies have explored various biomarkers for predicting mortality in elderly patients with hip fractures.[20-22] For instance, elevated blood glucose levels and low serum potassium have individually been linked to poor outcomes.[13] However, the combined assessment of these parameters through the SI offers a more comprehensive evaluation of the patient's physiological stress response.

Our findings are consistent with prior research indicating that the SI may serve as a clinically relevant marker in trauma care. In a recent retrospective study involving patients with traumatic femoral fractures, Huang et al.[13] observed that higher SI values on arrival were associated with greater in-hospital mortality and longer hospital stays. Notably, this association remained significant after accounting for comorbidities and injury severity. In our study, we similarly observed that non-survivors had significantly elevated SI values, and the index demonstrated good predictive performance for 30-day mortality. These parallel observations, drawn from distinct populations and healthcare systems, support the use of the SI as a simple, accessible measure to aid early risk stratification in emergency settings.

The present study is subject to certain methodological constraints that should be acknowledged. Its retrospective design inherently carries the risk of selection bias and limits the ability to establish causality. The single-center setting may restrict the external validity of the findings, as patient characteristics and management strategies may vary across institutions. Additionally, the reliance on admission glucose and potassium values precludes assessment of temporal fluctuations, which may offer further prognostic insight. Lastly, although multiple relevant clinical parameters were considered, the influence of unmeasured confounders cannot be entirely excluded.

Conclusion

This study provides evidence that the SI, calculated as the glucose-to-potassium ratio at the time of emergency department admission, is independently associated with short-term mortality in elderly patients with traumatic femur fractures. The index demonstrated a reliable predictive performance and offers a practical, readily obtainable biomarker for early mortality risk assessment. Its implementation in routine clinical evaluation may support timely decision-making and the allocation of critical care resources.

Ethics Committee Approval

The study was approved by the Kartal DR. Lütfi Kırdar City Hospital Ethics Committee Hospital Ethics Committee (Date: 25.12.2025, Decision No: 2024/010.99/11/35).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: E.Y.; Design: E.Y.; Supervision: A.U.S.; Fundings: E.Y.; Materials: E.Y.; Data: E.Y.; Analysis: E.Y.; Literature search: E.Y., A.U.S.; Writing: E.Y., A.U.S.; Critical revision: A.U.S.

Conflict of Interest

None declared.

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Yaşlı Hastalarda Kalça Kırığına Bağlı 30 Günlük Mortalite ile Başvuru Glukoz/Potasyum Oranı Arasındaki İlişki

Amaç: Yaşlı bireylerde görülen kalça kırıkları, önemli bir halk sağlığı sorunu olup kısa vadeli mortalite ve fonksiyonel kayıplarla ilişkilidir. Acil servise başvuruda erken risk sınıflaması, klinik yönetimin yönlendirilmesi açısından kritik öneme sahiptir. Glukoz/potasyum oranı olarak tanımlanan stres indeksi (SI), çeşitli akut tıbbi durumlarda potansiyel bir prognostik biyobelirteç olarak ortaya çıkmıştır. Ancak travmatik kalça kırığı olan hastalarda mortalite öngörüsündeki rolü yeterince araştırılmamıştır.

Gereç ve Yöntem: Bu retrospektif çalışmaya, 1 Ocak 2022 ile 1 Ocak 2024 tarihleri arasında bir üçüncü basamak hastanesinin acil servisine travmatik kalça kırığı nedeniyle başvuran ve yaşı ≥18 olan hastalar dahil edilmiştir. Veriler, demografik bilgiler, başvuru anındaki laboratuvar değerleri, hayati bulgular, eşlik eden hastalıklar ve 30 günlük mortalite verilerini içerecek şekilde elektronik sağlık kayıtlarından elde edilmiştir. SI, glukoz/potasyum oranı olarak hesaplanmıştır. Birincil sonuç, 30 günlük tüm nedenlere bağlı mortalitedir. Öngörü performansı, ROC (receiver operating characteristic) analizi ile değerlendirilmiş, model kalibrasyonu Hosmer–Lemeshow testi ve Brier skoru ile incelenmiştir.

Bulgular: Toplam 440 hasta çalışmaya dahil edilmiş olup, 30 günlük mortalite oranı %9.3 (n=41) olarak saptanmıştır. Stres indeksi, yaşamını yitiren hastalarda (40.5 [IQR 33.6–47.5]) sağ kalanlara göre (32.4 [IQR 27.2–37.2]) anlamlı olarak daha yüksek bulunmuştur (p<0.001). ROC analizi sonucunda eğri altındaki alan (AUC) 0.794 (%95 GA 0.726–0.860) olarak hesaplanmıştır. Youden indeksine göre en uygun eşik değeri 35.9 olup, bu noktada duyarlılık %73.2 ve özgüllük %76.4 olarak belirlenmiştir. Kalibrasyon ölçütleri, model uyumunun ve öngörü doğruluğunun iyi olduğunu göstermiştir.

Sonuç: Acil serviste başvuru sırasında ölçülen stres indeksi, yaşlı hastalarda travmatik kalça kırığına bağlı 30 günlük mortalite ile bağımsız olarak ilişkilidir. Hızlı ve kolay erişilebilir bir belirteç olarak SI, erken risk sınıflaması süreçlerine katkı sağlayarak acil bakım kararlarını destekleyebilir.

Anahtar Sözcükler: Glukoz; kalça kırığı; stres indeksi; potasyum; yaşlı.