Research Article / Araştırma Makalesi
doi: 10.18678/dtfd.1549923

Duzce Med J, 2025;X(X):X-X
Düzce Tıp Fak Derg, 2025;X(X):X-X

Prognostic Value of Geriatric Nutritional Risk Index and Prognostic Nutritional Index in Geriatric Orthopedic Trauma Patients in the Surgical Intensive Care Unit

Cerrahi Yoğun Bakım Ünitesindeki Geriatrik Ortopedik Travma Hastalarında Geriatrik Nutrisyonel Risk İndeksi ile Prognostik Nutrisyonel İndeksin Prognostik Değeri

Kadir ARSLAN
0000-0003-4061-0746
Ayça Sultan ŞAHİN
0000-0002-7765-5297

Department of Anesthesiology and Reanimation, University of Health Sciences Kanuni Sultan Süleyman Training and Research Hospital, İstanbul, Türkiye

Corresponding Author
Sorumlu Yazar
Kadir ARSLAN
kadir.arslan@sbu.edu.tr

Received / Geliş Tarihi : 14.09.2024
Accepted / Kabul Tarihi : 04.01.2025
Available Online /
Çevrimiçi Yayın Tarihi : 31.01.2025

ABSTRACT

Aim: Malnutrition is associated with postoperative morbidity and mortality in geriatric patients. This study investigated the prognostic value of geriatric nutritional risk index (GNRI) and prognostic nutritional index (PNI) in geriatric orthopedic trauma patients.
Material and Methods: Geriatric (≥65 years old) patients followed in the surgical intensive care unit after orthopedic trauma surgery between June 2019 and June 2022 were evaluated retrospectively. Patients were classified into mortality and survivor groups. GNRI was calculated according to the ratio of serum albumin level and actual body weight to ideal body weight. PNI was obtained from serum albumin level and blood lymphocyte count.
Results: The study included 371 patients. American Society of Anesthesiologists (ASA) IV status was significantly higher in the mortality group (p<0.001). Mean BMI, albumin, lymphocyte levels, PNI, and GNRI were significantly lower in the mortality group (p=0.009, p=0.008, p=0.030, p=0.001, and p=0.003, respectively). While the median Glasgow coma scale (GCS) score was significantly lower, the median acute physiology and chronic health evaluation (APACHE)-II score and median injury severity score (ISS) were significantly higher in the mortality group (p<0.001 for all). Regression analysis revealed that ASA IV status, APACHE-II score, and ISS were independent predictors of mortality. In ROC curve analysis, the area under the curve (AUC) for GNRI was 0.660 (95% CI, 0.553-0.768), and the AUC for PNI was 0.654 (95% CI, 0.566-0.743).
Conclusion: In geriatric orthopedic trauma patients, nutritional scores GNRI and PNI help predict in-hospital mortality. Although their prognostic values are not high, they are similar.
Keywords: Trauma; malnutrition; geriatric nutritional risk index; prognostic nutritional index; mortality.

ÖZ

Amaç: Malnutrisyon, geriatrik hastalarda postoperatif morbidite ve mortalite ile ilişkilidir. Bu çalışmada, geriatrik ortopedik travmalı hastalarda geriatrik nutrisyonel risk indeksi (GNRI) ve prognostik nutrisyonel indeksin (PNI) prognostik değeri araştırılmıştır.
Gereç ve Yöntemler: Haziran 2019 ile Haziran 2022 tarihleri arasında ortopedik travma cerrahisi sonrasında cerrahi yoğun bakım ünitesinde takip edilen geriatrik (≥65 yaş) hastalar retrospektif olarak değerlendirildi. Hastalar mortalite ve yaşayan grupları olarak sınıflandırıldı. GNRI, serum albümin düzeyi ile gerçek vücut ağırlığının ideal vücut ağırlığına oranına göre hesaplandı. PNI ise serum albumin düzeyi ve kan lenfosit sayısından elde edildi.
Bulgular: Çalışmaya 371 hasta dahil edildi. Mortalite grubunda Amerikan Anestezistler Derneği (American Society of Anesthesiologists, ASA) IV statüsü anlamlı olarak daha yüksekti (p<0,001). Mortalite grubunda ortalama BMI, albumin, lenfosit düzeyleri ile PNI ve GNRI anlamlı şekilde daha düşüktü (sırasıyla p=0,009, p=0,008, p=0,030, p=0,001 ve p=0,003). Mortalite grubunda ortanca Glasgow koma skalası (GKS) skoru anlamlı şekilde daha düşükken, ortanca akut fizyoloji ve kronik sağlık değerlendirmesi (acute physiology and chronic health evaluation, APACHE)-II skoru ve ortanca yaralanma şiddet skoru (injury severity score, ISS) anlamlı olarak daha yüksekti (hepsi için p<0,001). Regresyon analizinde ASA IV statüsü, APACHE-II skoru ve ISS'nin mortalitenin bağımsız prediktörleri olduğu belirlendi. ROC eğrisi analizinde, eğri altında kalan alan (area under the curve, AUC), GNRI için 0,660 (%95 GA, 0,553-0,768) ve PNI için 0,654 (%95 GA, 0,566-0,743) saptandı.
Sonuç: Geriatrik ortopedik travmalı hastalarda, nutrisyonel skorlardan GNRI ve PNI, hastane içi mortalitenin öngörülmesinde faydalıdır. Prognostik değerleri yüksek olmamakla birlikte benzer saptanmıştır.
Anahtar kelimeler: Travma; malnütrisyon; geriatrik nutrisyonel risk indeks; prognostik nutrisyonel indeks; mortalite.

INTRODUCTION

Trauma is on the rise in the geriatric population, leading to functional limitations, morbidity, and mortality (1,2). Visual impairments, musculoskeletal problems, comorbidities, and polypharmacy are contributing factors to this trend (3). Low-energy traumas, such as hip fractures, are a common consequence of osteoporosis in geriatric patients, while craniofacial traumas carry the highest mortality rates (4). There is an increased risk of complications in patients with geriatric trauma. These patients require intensive care unit (ICU) care and may have long lengths of stay (5). The treatment and care process in critical geriatric trauma patients negatively affects the patient and their relatives physically, psychologically, and socially.

Malnutrition in geriatric patients occurs due to inadequate or excessive energy consumption or imbalance in food consumption. It can cause physical and cognitive dysfunction, decreased quality of life, postoperative complications, and increased mortality in elderly individuals (6). Malnutrition is also associated with higher levels of frailty. Nutritional deficiencies in functionally limited geriatric patients with comorbidities should be prevented. In addition to body mass index, anthropometric measurements, and biochemical markers, various nutritional screening tests are used to assess malnutrition. However, there is yet to be an ideal method on which there is a consensus to assess malnutrition in geriatric patients. The lack of consensus on this issue is a significant challenge that needs to be addressed. The geriatric nutritional risk index (GNRI) and prognostic nutritional index (PNI) are associated with poor prognosis in both trauma patients and critically ill patients, followed by non-traumatic reasons, and are predictors of mortality (7,8). PNI helps evaluate preoperative nutritional status and may help determine the geriatric population's postoperative delirium and ICU requirements (9,10). However, there are not enough studies comparing the prognostic value of GNRI and PNI in geriatric trauma patients in the postoperative period, further highlighting the need for more research in this area.

This study aimed to compare the prognostic value of GNRI and PNI on mortality in critically ill geriatric trauma patients followed in the surgical ICU (SICU) during the postoperative period.

MATERIAL AND METHODS

This retrospective observational study complied with the principles of the Declaration of Helsinki. It was initiated after the approval of the scientific research ethics committee of İstanbul Kanuni Sultan Süleyman Training and Research Hospital (27.03.2024, 55). Patients who underwent surgery due to geriatric trauma at the University of Health Sciences, İstanbul Kanuni Sultan Süleyman Training and Research Hospital between June 2019 and June 2022 and whose postoperative follow-up and treatment were performed in the SICU were included in the study. Study data were obtained from the hospital information system and patient follow-up forms.

Inclusion criteria were: 1) ≥65 years of age, 2) orthopedic trauma patients undergoing surgery. Exclusion criteria included: 1) preoperative albumin transfusion, 2) undergoing major surgery within the last month, 3) chronic renal failure, 4) severe liver dysfunction, 5) not checking albumin level during SICU admission, 6) viral and bacterial infection within the last month, and 7) missing data.

Along with demographic data, comorbidities, American Society of Anesthesiologists (ASA) status, Glasgow coma scale (GCS) score, acute physiology and chronic health evaluation (APACHE)-II score, injury severity score (ISS), hemoglobin, albumin, and lymphocyte levels on admission to SICU and in-hospital mortality of geriatric patients who underwent surgery after trauma and were followed in SICU were recorded. GNRI and PNI were calculated from the patient's blood results at admission to the SICU. The patients were classified as survivor and mortality groups, and the data were compared.

Prognostic Nutritional Index (PNI)

A PNI based on serum albumin and lymphocyte concentrations is a new inflammation-based risk score that predicts prognosis in various patient populations. PNI has also been reported to predict postoperative morbidity and mortality in geriatric trauma patients (8-10). It is calculated from the formula PNI = (10 × serum albumin (g/dL) + 0.005 × total lymphocyte count).

Geriatric Nutritional Risk Index (GNRI)

The GNRI, a practical and effective tool, is used to identify patients at risk of morbidity and mortality due to malnutrition. Calculated using albumin and ideal body weight (IBW), this score can be readily applied in daily practice, providing a valuable tool for patient care. GNRI= [1.489 × albumin (g/L)] + [41.7 × (weight/IBW)]. GNRI has been shown to have prognostic value in geriatric trauma patients and patients with malignancy (6,7,11,12). IBW was calculated using the following formula in male and female, widely accepted and used in the literature due to its accuracy and simplicity (7). IBW male= (height-80) × 0.7, IBW female= (height-70) × 0.6

This was a retrospective observational study aimed to compare the effectiveness of the GNRI and the PNI in predicting in-hospital mortality among elderly patients with orthopedic trauma, and all patients who met the inclusion and exclusion criteria during three years between June 2019 and June 2022 were included.

Statistical Analysis

The statistical analyses were performed using IBM SPSS Statistics, Version 27.0 (IBM Corp., Armonk, NY). The Kolmogorov-Smirnov test, histogram, skewness, and kurtosis values assessed the conformity of the data to normal distribution. Descriptive statistics of the data according to normality were expressed as mean±standard deviation, and median (interquartile range) [min-max]. The independent samples t-test was used to analyze quantitative data showing a normal distribution, and the Mann-Whitney U test was used to analyze data not showing a normal distribution. Qualitative data were expressed as the number of patients, and percentage, and analyzed using the Pearson chi-square test and Fisher's exact test. Multivariate logistic regression analysis was performed to evaluate independent factors of mortality. Receiver operating characteristics (ROC) curve analysis was performed to determine the prognostic value of GNRI and PNI. Youden index was used to determine the cut-off values of GNRI and PNI. The statistical significance level for all analyses was set at $p<0.05$.

RESULTS

Between June 2019 and June 2022, 371 patients who underwent surgery for geriatric orthopedic trauma and were followed up in the SICU postoperatively were included in the study (Figure 1). The mean age of the patients was 78.5±8.4 years, and 61.7% (n=229) were female. Age and gender did not differ significantly between the groups (p=0.229 and p=0.607, respectively). Median BMI was significantly lower in the mortality group (24.1 vs. 25.7 kg/m^2, p=0.009). ASA IV status was significantly higher in the mortality group than in the survivor group (18.2% vs. 2.7%, p<0.001). In the mortality group, median GCS score were significantly lower, while APACHE-II score and ISS at admission were significantly higher (p<0.001 for all). While hemoglobin levels at SICU admission did not differ significantly (p=0.857) between the groups, albumin (2.8±0.6 vs. 3.1±0.5 g/dL, p=0.008) and lymphocyte (1.4±0.6 vs. 1.7±0.6 x10^9/L, p=0.030) levels were significantly lower in the mortality group. In the mortality group, median PNI (27.9 vs. 31.2, p=0.001) and median GNRI (51.2 vs. 54.4, p=0.003) were found significantly lower (Table 1).

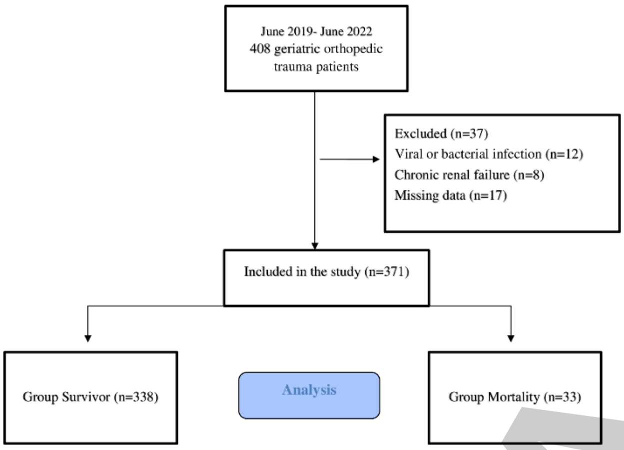

Figure 1. Flow chart of the study

Hypertension was found in 67.9% (n=252) of the patients, diabetes mellitus in 34% (n=126), coronary artery disease/heart failure in 31.5% (n=117), asthma/chronic obstructive pulmonary disease in 12.9% (n=48), hemorrhagic and ischemic stroke in 9.7% (n=36), and chronic renal failure in 7.3% (n=27). No significant difference was found between the groups regarding comorbidities (Table 2).

Multivariate regression analysis was performed for ASA status, GCS, APACHE-II score, and ISS, which are prognostic scoring systems in trauma patients and show significant differences in mortality in patients followed in SICU, and nutritional scores GNRI and PNI. The enter method was used in regression analysis. ASA IV status, APACHE-II score, and ISS were found as independent predictors of mortality (p=0.038, p=0.004, and p<0.001, respectively). Multicollinearity between GNRI and PNI was evaluated using the Pearson correlation analysis. A weak correlation coefficient (r=0.15) was detected between

Table 1. Clinical characteristics of the patients and comparison of groups

	Survivor Group (n=338)	**Mortality Group (n=33)**	**p**	**Overall (n=371)**
Age (year)	78.3±8.3	80.1±8.8	0.229	78.5±8.4
Gender, n (%)				
Female	210 (62.1)	19 (57.6)	0.607	229 (61.7)
Male	128 (37.9)	14 (42.4)		142 (38.3)
BMI (kg/m^2)	25.7 (23-28) [16-44]	24.1 (22-24) [21-34]	**0.009**	25.5 (23-27) [16-44]
Weight (kg)	69.5±12.7	66.1±10.5	0.090	69.2±12.6
IBW (kg)	56.7±5.0	57.6±5.3	0.403	56.8±5.0
ASA Status, n (%)				
I	4 (1.2)	0 (0.0)		4 (1.1)
II	65 (19.2)	2 (6.1)	**<0.001**	67 (18.1)
III	260 (76.9)	25 (75.7)		285 (76.8)
IV	9 (2.7)	6 (18.2)		15 (4.0)
GCS	15 (12-15) [3-15]	12 (3-12) [3-15]	**<0.001**	15 (12-15) [3-15]
APACHE-II	13 (9-18) [6-37]	29 (22-32) [11-46]	**<0.001**	14 (10-19) [6-46]
ISS	9 (9-9) [4-25]	25 (25-25) [9-25]	**<0.001**	9 (9-9) [4-25]
ISS, n (%)				
1-15	292 (86.4)	1 (3.0)		293 (79.0)
16-24	44 (13.0)	7 (21.2)	**<0.001**	51 (13.7)
≥25	2 (0.6)	25 (75.8)		27 (7.3)
Duration of ICU (days)	3 (1-8) [1-81]	12 (5-17) [2-82]	**<0.001**	3 (2-9) [1-82]
Hemoglobin (g/dL)	10.9±1.7	10.8±1.9	0.857	10.9±1.7
Albumin (g/dL)	3.1±0.5	2.8±0.6	**0.008**	3.1±0.5
Lymphocyte (x10^9/L)	1.7±0.6	1.4±0.6	**0.030**	1.7±0.6
PNI	31.2 (28-35) [14-45]	27.9 (23-32) [16-42]	**0.001**	30.9 (28-35) [14-45]
GNRI	54.4 (50-59) [33-94]	51.2 (47-53) [45-72]	**0.003**	54.2 (50-59) [33-94]

BMI: body mass index, IBW: ideal body weight, ASA: American Society of Anesthesiologists, GCS: Glasgow coma scale, APACHE-II: acute physiology and chronic health evaluation-II, ISS: injury severity score, ICU: intensive care unit, PNI: prognostic nutritional index, GNRI: geriatric nutritional risk index, data were expressed as number of patients (percentage), mean±standard deviation, and median (interquartile range) [min-max]

Table 2. Comparison of comorbid diseases between the groups

Comorbidity	Survivor Group (n=338)	Mortality Group (n=33)	p	Overall (n=371)
Hypertension, n (%)	231 (68.3)	21 (63.6)	0.580	252 (67.9)
Diabetes, n (%)	112 (33.1)	14 (42.4)	0.282	126 (34.0)
CAD/HF, n (%)	109 (32.2)	8 (24.2)	0.345	117 (31.5)
Asthma/COPD, n (%)	47 (13.9)	1 (3.0)	0.076	48 (12.9)
Stroke, n (%)	34 (10.1)	2 (6.1)	0.459	36 (9.7)
Chronic renal failure, n (%)	24 (7.1)	3 (9.1)	0.674	27 (7.3)

CVD/HF: coronary artery disease/heart failure, COPD: chronic obstructive pulmonary disease

the two. PNI and GNRI were not independent predictors of mortality (Table 3). The regression analysis determined that -2 Log likelihood= 28.992, Nagelkerke R square= 0.901. For the Hosmer and Lemeshow test, p=1.000.

The PNI and GNRI prognostic values used to predict mortality were evaluated with ROC curve analysis. The optimal cut-off value for PNI was 26, and the area under the curve (AUC) was 0.660 (95% CI, 0.553-0.768). The AUC was 0.654 (95% CI, 0.566-0.743) and the cut-off value was 53.1 for GNRI (Table 4, Figure 2). PNI and GNRI help predict mortality in geriatric orthopedic patients. Although their prognostic values are not high, they are close to each other.

Table 3. Regression analysis for mortality

	OR	95% CI	p
ASA IV	4.621	1.311-12.188	**0.038**
GCS	0.951	0.727-1.243	0.713
APACHE-II	1.365	1.103-1.690	**0.004**
ISS	1.978	1.463-2.673	**<0.001**
PNI	0.888	0.722-1.093	0.263
GNRI	0.890	0.763-1.039	0.141

OR: odds ratio, CI: confidence interval, ASA: American Society of Anesthesiologists, GCS: Glasgow coma scale, APACHE-II: acute physiology and chronic health evaluation-II, ISS: injury severity score, PNI: prognostic nutritional index, GNRI: geriatric nutritional risk index

Table 4. Mortality prediction performance of PNI and GNRI

	Cut-off	AUC (95% CI)	Sensitivity	Specificity
PNI	26.0	0.660 (0.553-0.768)	45.5	85.5
GNRI	53.1	0.654 (0.566-0.743)	75.8	59.5

PNI: prognostic nutritional index, GNRI: geriatric nutritional risk index, AUC: area under the curve, CI: confidence interval

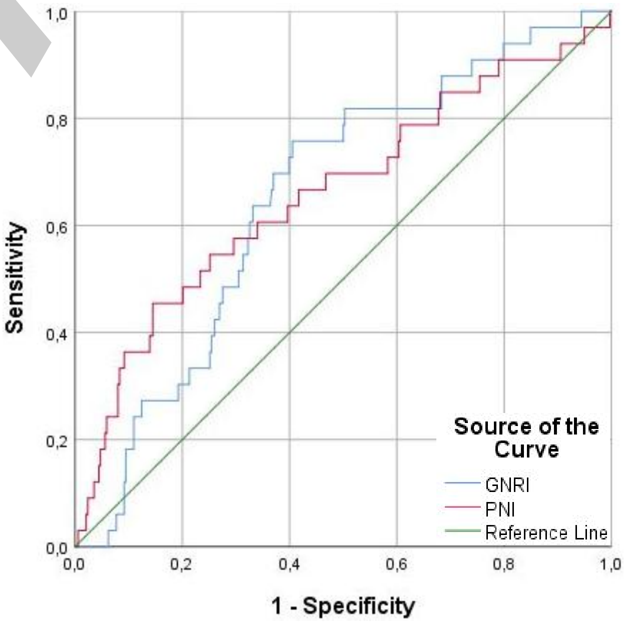

Figure 2. ROC curve analysis of PNI and GNRI

ROC: receiver operating characteristic, PNI: prognostic nutritional index, GNRI: geriatric nutritional risk index

DISCUSSION

In this study conducted in a tertiary center, ASA IV status, GCS, APACHE-II score, and ISS at admission to SICU, albumin, lymphocyte levels, and PNI and GNRI helped predict mortality in geriatric trauma patients. ASA IV status, APACHE-II score, and ISS were independent predictors of mortality, while PNI and GNRI were not independent predictors of mortality. At the same time, GNRI and PNI were found to have similar prognostic values in predicting mortality.

The elderly population is increasing worldwide in parallel with the increase in average life expectancy, improvement in quality of life due to significant medical developments, and the decrease in population growth rate. Falls and fall-related injuries are common in the elderly geriatric population. Falls are seen in approximately 30% of adults aged 60 and over every year (13). It has been reported that geriatric trauma patients have orthopedic trauma most frequently and are primarily patients with hip (proximal femur) fractures (10,14). It has been stated that geriatric traumas are more common in females, and 60% occur due to falls (14). The present study included patients with orthopedic trauma. In line with the literature, the female gender ratio (61.7%) was found to be higher, but gender did not show a significant effect on mortality. Hip fractures affect more than 1 million people annually globally, with the highest mortality occurring within the first 30 days (15). Geriatric patients are at high risk for nutritional deficiencies and malnutrition due to their low functional capacity, multiple comorbidities, polypharmacy, inadequate nutrition, and dysphagia (16). Malnutrition is a serum albumin level of <3.5 g/dL or a peripheral blood lymphocyte count of <1500 cells per mm^3 (17). Malnutrition is associated with increased risk of complications, increased length of hospital stay, readmission to the ICU, increased infection rates, and higher mortality rates in hospitalized patients (18-20). While mortality rate is around 13% in patients with hip fractures within the first month, this rate can increase to 25% in geriatric hip fracture patients with malnutrition (21,22). Low albumin and lymphocyte levels, essential markers in evaluating malnutrition in patients with geriatric hip fractures, are prognostic factors in determining 1-year mortality (23). In the present study, the in-hospital mortality rate in geriatric orthopedic trauma patients was found to be 8.9%. In line with the literature, albumin, and lymphocyte levels at admission to the SICU were significantly low in the mortality group. However, their prognostic value is limited due to many factors that can affect albumin and lymphocyte levels. Although the patients had various comorbidities, they did not show a significant effect on mortality.

Prognostic scoring systems are used to plan treatment and improve patient care in non-traumatic or trauma patients monitored in the ICU. In addition to non-trauma-specific scores (GCS, APACHE-II), various trauma-specific scores (ISS and revised trauma score) are used to predict mortality (2,3,10,24). In addition to these scores, nutritional scores such as PNI and GNRI have recently been reported to have prognostic value in various clinical situations in the geriatric population, where malnutrition is frequently seen (6-10). PNI is a simple measurement used to assess the patient's nutritional status. It can be easily calculated using serum albumin and lymphocyte count. Low PNI values have been reported to be an independent predictor of 6-month mortality after cancer surgery (8). It has also been reported that the preoperative PNI value, which can be easily calculated in geriatric hip fracture patients, is valid in predicting postoperative ICU requirements and mortality (10). In another study, low preoperative PNI values in geriatric hip fracture patients were associated with increased hospital stay, postoperative delirium, and increased mortality (25). Another nutritional indicator with prognostic value in geriatric patients is the GNRI, calculated using serum albumin level, body weight, and IBW. It has been reported that GNRI has prognostic value in heart failure (26), chronic obstructive pulmonary disease (27), some malignancies (11,28), and trauma patients (7,29). Su et al. (30) reported that in geriatric patients with femoral fractures, GNRI helps to classify malnourished patients and that low GNRI scores lead to a significant increase in mortality. Kregel et al. (31) reported that infectious complications are higher, hospital stays are more extended, and mortality is higher in geriatric trauma patients with low GNRI scores. To our knowledge, the prognostic value of GNRI and PNI has not been compared in geriatric trauma patients. Our study found that GNRI and PNI calculated at the time of admission to SICU were helpful in predicting in-hospital mortality, and their prognostic values were similar. However, it was determined that both GNRI and GNRI have lower prognostic value than the APACHE-II and ISS scores currently used to determine prognosis in the ICU.

The main limitation of the study is that it is retrospective and single-center design. Secondly, in-hospital mortality was evaluated to determine the prognosis in the study, and data over 28 days were not recorded. Thirdly, patients other than orthopedic trauma patients (such as intracranial trauma patients) were not included in the study. Fourthly, serum albumin levels of some patients were not measured during admission to the SICU. Excluding these patients may have affected the study results.

CONCLUSION

Orthopedic traumas, especially hip fractures, are primarily seen in geriatric trauma patients due to falls. Malnutrition is frequently seen in geriatric patients who undergo surgery due to orthopedic trauma and is associated with postoperative complications and mortality. In orthopedic trauma patients followed in the postoperative SICU, GNRI, and PNI at admission help predict in-hospital mortality and have similar predictive values. It should be remembered that the detection and treatment of nutritional deficiencies in the geriatric population is not just effective, but also brings hope and optimism for the patient's prognosis.

Ethics Committee Approval: The study was approved by the Ethics Committee of İstanbul Kanuni Sultan Süleyman Training and Research Hospital (27.03.2024, 55).

Conflict of Interest: None declared by the authors.

Financial Disclosure: None declared by the authors.

Acknowledgments: None declared by the authors.

Author Contributions: Idea/Concept: KA; Design: KA, ASŞ; Data Collection/Processing: KA; Analysis/Interpretation: KA; Literature Review: KA, ASŞ; Drafting/Writing: KA; Critical Review: KA, ASŞ.

REFERENCES

1. Clare D, Zink KL. Geriatric trauma. Emerg Med Clin North Am. 2021;39(2):257-71.
2. Arslan K, Sahin AS, Yalcın N, Kaya E. Evaluation of trauma patients followed up and treated in intensive care unit: the sample of İstanbul province training and research hospital. Turk J Intensive Care. 2023;21(1):41-7.
3. Kirshenbom D, Ben-Zaken Z, Albilya N, Niyibizi E, Bala M. Older age, comorbid illnesses, and injury severity affect immediate outcome in elderly trauma patients. J Emerg Trauma Shock. 2017;10(3):146-50.
4. Gioffre-Florio M, Murabito LM, Visalli C, Pergolizzi FP, Fama F. Trauma in elderly patients: a study of prevalence, comorbidities and gender differences. G Chir. 2018;39(1):35-40.
5. Arslan K, Kaya E, Şahin AS. Classical blind percutaneous dilatational tracheostomy vs fiberoptic bronchoscopy guided percutaneous dilatational tracheostomy in the intensive care unit: Complications, mortality, and outcomes. Duzce Med J. 2023;25(3):273-8.
6. Phan K, Ranson W, White SJW, Cheung ZB, Kim J, Shin JI, et al. Thirty-day perioperative complications, prolonged length of stay, and readmission following elective posterior lumbar fusion associated with poor nutritional status. Global Spine J. 2019;9(4):417-23.

7. Rau CS, Tsai CH, Chou SE, Su WT, Hsu SY, Hsieh CH. The addition of the geriatric nutritional risk index to the prognostic scoring systems did not improve mortality prediction in trauma patients in the intensive care unit. Emerg Med Int. 2023;2023:3768646.
8. Cadwell JB, Afonso AM, Shahrokni A. Prognostic nutritional index (PNI), independent of frailty is associated with six-month postoperative mortality. J Geriatr Oncol. 2020;11(5):880-4.
9. Xing H, Xiang D, Li Y, Ji X, Xie G. Preoperative prognostic nutritional index predicts postoperative delirium in elderly patients after hip fracture surgery. Psychogeriatrics. 2020;20(4):487-94.
10. Arslan K, Celik S, Arslan HC, Sahin AS, Genc Y, Erturk C. Predictive value of prognostic nutritional index on postoperative intensive care requirement and mortality in geriatric hip fracture patients. North Clin Istanb. 2024;11(3):249-57.
11. Ozturk E, Elibol T, Kilicaslan E, Kabayuka B, Erdogan Ozunal I. Prognostic nutritional index predicts early mortality in diffuse large B-cell lymphoma. Medeni Med J. 2022;37(1):85-91.
12. Hanada M, Yamauchi K, Miyazaki S, Hirasawa J, Oyama Y, Yanagita Y, et al. Geriatric nutritional risk index, a predictive assessment tool, for postoperative complications after abdominal surgery: A prospective multicenter cohort study. Geriatr Gerontol Int. 2019;19(9):924-9.
13. Montero-Odasso MM, Kamkar N, Pieruccini-Faria F, Osman A, Sarquis-Adamson Y, Close J, et al. Evaluation of clinical practice guidelines on fall prevention and management for older adults: A systematic review. JAMA Netw Open. 2021;4(12):e2138911. Erratum in: JAMA Netw Open. 2023;6(8):e2332257.
14. Baykan N, Durukan P, Salt O, Yakar S, Kantar Y, Kaymaz ND, et al. Examination of geriatric trauma patients presenting to the emergency department. Phnx Med J. 2022;4(1):22-6.
15. Abrahamsen B, van Staa T, Ariely R, Olson M, Cooper C. Excess mortality following hip fracture: a systematic epidemiological review. Osteoporos Int. 2009;20(10):1633-50.
16. Bouillanne O, Morineau G, Dupant C, Coulombel I, Vincent JP, Nicolis I, et al. Geriatric nutritional risk index: A new index for evaluating at-risk elderly medical patients. Am J Clin Nutr. 2005;82(4):777-83.
17. Morey VM, Song YD, Whang JS, Kang YG, Kim TK. Can serum albumin level and total lymphocyte count be surrogates for malnutrition to predict wound complications after total knee arthroplasty? J. Arthroplasty. 2016;31(6):1317-21.
18. Dudrick SJ. Nutrition management of geriatric surgical patients. Surg Clin North Am. 2011;91(4):877-96.
19. Lew CCH, Yandell R, Fraser RJL, Chua AP, Chong MFF, Miller M. Association between malnutrition and clinical outcomes in the intensive care unit: A systematic review. J Parenter Enteral Nutr. 2017;41(5):744-58.
20. Inciong JFB, Chaudhary A, Hsu HS, Joshi R, Seo JM, Trung LV, et al. Hospital malnutrition in northeast and southeast Asia: A systematic literature review. Clin Nutr ESPEN. 2020;39:30-45.
21. Hu F, Jiang C, Shen J, Tang P, Wang Y. Preoperative predictors for mortality following hip fracture surgery: a systematic review and meta-analysis. Injury. 2012;43(6):676-85.
22. Wilson JM, Boissonneault AR, Schwartz AM, Staley CA, Schenker ML. Frailty and malnutrition are associated with inpatient postoperative complications and mortality in hip fracture patients. J Orthop Trauma. 2019;33(3):143-8.
23. Lu J, Chen YY, Zhang L, Li YG, Wang C. Laboratory nutritional parameters predict one-year mortality in elderly patients with intertrochanteric fracture. Asia Pac J Clin Nutr. 2016;25(3):457-63.
24. Arslan K, Arslan HC, Sahin AS. Evaluation of critically ill obstetric patients treated in an intensive care unit during the COVID-19 pandemic. Ann Saudi Med. 2023;43(1):10-6.
25. Canbolat N, Büyük D, Sulejmani İ, Sağlam Y, Altun D, Durmaz H, et al. The relationship between preoperative prognostic nutritional index and postoperative mortality in patients with hip fracture. Turk J Intensive Care. 2022;20(Suppl 1):7-13.
26. Nishi I, Seo Y, Hamada-Harimura Y, Yamamoto M, Ishizu T, Sugano A, et al. Geriatric nutritional risk index predicts all-cause deaths in heart failure with preserved ejection fraction. ESC Heart Fail. 2019;6(2):396-405.
27. Matsumura T, Mitani Y, Oki Y, Fujimoto Y, Ohira M, Kaneko H, et al. Comparison of geriatric nutritional risk index scores on physical performance among elderly patients with chronic obstructive pulmonary disease. Heart Lung. 2015;44(6):534-8.
28. Lidoriki I, Schizas D, Frountzas M, Machairas N, Prodromidou A, Kapelouzou A, et al. GNRI as a prognostic factor for outcomes in cancer patients: A systematic review of the literature. Nutr Cancer. 2021;73(3):391-403.
29. Liu HT, Wu SC, Tsai CH, Li C, Chou SE, Su WT, et al. Association between geriatric nutritional risk index and mortality in older trauma patients in the intensive care unit. Nutrients. 2020;12(12):3861.
30. Su WT, Wu SC, Huang CY, Chou SE, Tsai CH, Li C, et al. Geriatric nutritional risk index as a screening tool to identify patients with malnutrition at a high risk of in-hospital mortality among elderly patients with femoral fractures-A retrospective study in a level I trauma center. Int J Environ Res Public Health. 2020;17(23):8920.
31. Kregel HR, Murphy PB, Attia M, Meyer DE, Morris RS, Onyema EC, et al. The Geriatric Nutritional Risk Index as a predictor of complications in geriatric trauma patients. J Trauma Acute Care Surg. 2022;93(2):195-9.