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ORIGINAL ARTICLE ANESTHESIOLOGY & REANIMATION

NORTH CLIN ISTANB 2024;11(3):249–257
doi: 10.14744/nci.2024.60430

Predictive value of prognostic nutritional index on postoperative intensive care requirement and mortality in geriatric hip fracture patients

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ABSTRACT

OBJECTIVE: The incidence of postoperative morbidity and mortality in hip fracture patients is high and is associated with nutritional deficiencies. This study investigated the predictive value of preoperative prognostic nutritional index (PNI) on postoperative intensive care unit (ICU) requirement and mortality in geriatric hip fracture patients.

METHODS: Geriatric (≥65 years old) hip fracture patients who underwent surgery between January 2021 and September 2023 were evaluated retrospectively. Patients were classified according to the unit followed in the postoperative period (service group and ICU group) and 28-day mortality (mortality group and survivor group). The predictive value of PNI for ICU requirement and mortality and the factors affecting ICU requirement and mortality were investigated.

RESULTS: The study included two hundred twenty-two patients, and 66.2% (n=147) were women. In the postoperative period, 47.7% (n=106) of the patients were followed in the ICU and 52.3% (n=116) in the inpatient service. The 28-day mortality of the patients was 6.8% (n=15). PNI was found to be significantly lower in patients followed in the ICU (group ICU) than in those followed in the service (group S) and in patients who died (group mortality) compared to those who lived (group survivor) (p<0.001 and p=0.029, respectively). In multivariate regression analysis, high American Society of Anesthesiologists (ASA) status and low PNI were determined to be independent risk factors for ICU requirement. Acute Physiology and Chronic Health Assessment II score was an independent predictor of mortality. In ROC curve analysis, the cut-off value of PNI in predicting mortality was 32.5, and the area under the curve was 0.660 (95% CI, 0.516–0.803).

CONCLUSION: In geriatric hip fracture patients, preoperative PNI value can be used, like ASA status, in determining postoperative ICU requirements. Nutritional deficiencies are associated with adverse postoperative outcomes in this patient group, and low PNI values (<32.5) help predict in-hospital mortality.

Keywords: Geriatrics; hip fractures; malnutrition; mortality; prognostic nutrition index.

Cite this article as: *Arslan K, Celik S, Cetin Arslan H, 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):249–257.*

Received: January 08, 2024 *Revised:* March 02, 2024 *Accepted:* March 18, 2024 *Online:* June 26, 2024

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Provincial Directorate of Health - Available online at www.northclinist.com

Hip fractures (proximal femur fractures) are a global public health problem, with more than 10 million cases occurring annually worldwide [1]. Hip fractures, an essential consequence of osteoporosis, occur due to low-energy traumas with advancing age. It is associated with increased mortality rates, increased risk of postoperative complications, need for intensive care unit (ICU), long-term hospital stay, and decreased quality of life [2]. The 1-year mortality rate after hip fracture surgery is reported to be between 15.7 and 34.5% [3, 4]. In addition, the treatment and care process negatively affects patients and their relatives physically, psychologically, and socially and also creates a severe economic burden on the healthcare system.

It has been reported that perioperative malnutrition is an independent risk factor for postoperative complications in patients undergoing orthopedic surgery and that adequate nutritional support can prevent postoperative complications [5]. The nutrition of patients, especially the geriatric population, should be closely monitored and evaluated for nutritional deficiency. Although various serological tests, anthropometric measurements, and screening tools are used for this purpose, there has yet to be a consensus on a method. It has been reported in the literature that the prognostic nutritional index [PNI=10 x serum albumin (g/dl) + 0.005 x total lymphocyte count (mm^3)] is associated with poor prognosis in various clinical conditions and malignancies and is a significant predictor of mortality [6, 7]. It has been stated that PNI can be a comprehensive marker in evaluating the nutritional status of patients undergoing surgery and is also helpful in detecting postoperative delirium in geriatric hip fracture patients [8]. However, there are no sufficient studies in the literature on the predictive value of PNI in postoperative intensive care unit requirements and mortality in geriatric trauma patients.

The primary aim of this study is to investigate the predictive value of PNI on postoperative ICU requirement and in-hospital mortality in geriatric hip fracture patients in a tertiary center. The secondary aims of the study are to determine the factors affecting ICU requirement and mortality in geriatric hip patients.

Highlight key points

- Prognostic nutritional index was significantly lower in geriatric hip fracture patients in the ICU and mortality groups.
- Prognostic nutritional index and high ASA status were independent predictors of ICU requirement in geriatric hip fracture patients.
- ASA status, GCS and APACHE-II scores, albumin, lactate, PNI, and LAR were influential factors in mortality in geriatric hip fracture patients. However, only the APACHE-II score was an independent predictor of mortality.

MATERIALS AND METHODS

This retrospective observational study was started after the approval of the Kanuni Sultan Suleyman Training and Research Hospital Clinical Research Ethics Committee (date: 27.12.2023, number: KAEK/2023.12.180). The principles of the Declaration of Helsinki were used to conduct the study. The data of patients who underwent surgery due to hip fracture at the University of Health Sciences Kanuni Sultan Suleyman Training and Research Hospital between January 2021 and September 2023 were evaluated retrospectively through the hospital information system and patient files.

Inclusion criteria:

- Patients with isolated hip fractures aged 65 and over,

Exclusion criteria:

- Chronic renal failure and severe liver dysfunction,
- Malignancy,
- Use of medications that can cause bone marrow depression,
- Having major surgery within the last month,
- Performing preoperative albumin transfusion,
- Recent viral or bacterial infections, including COVID-19,
- Absence of albumin, lymphocyte count, and other data.

In our hospital, patients with low albumin levels can be transfused when the serum level is <2.5 g/dL.

Demographic data, postoperative ICU requirements, ASA status, Glasgow coma scale (GCS) and APACHE II scores, anesthesia types, comorbid diseases, ICU and hospital stay times, and 28- and 90-day mortality of geriatric patients with hip fracture were recorded. Preoperative hemoglobin, albumin, lymphocyte, lactate levels, PNI, and lactate/albumin ratio (LAR) values were calculated and analyzed.

The patients were evaluated by an anesthesiologist after the operation and were followed up in the inpatient service or ICU in the postoperative period. Patients were classified as those in the inpatient service (group S) and those in the ICU (group ICU). Additionally, patients

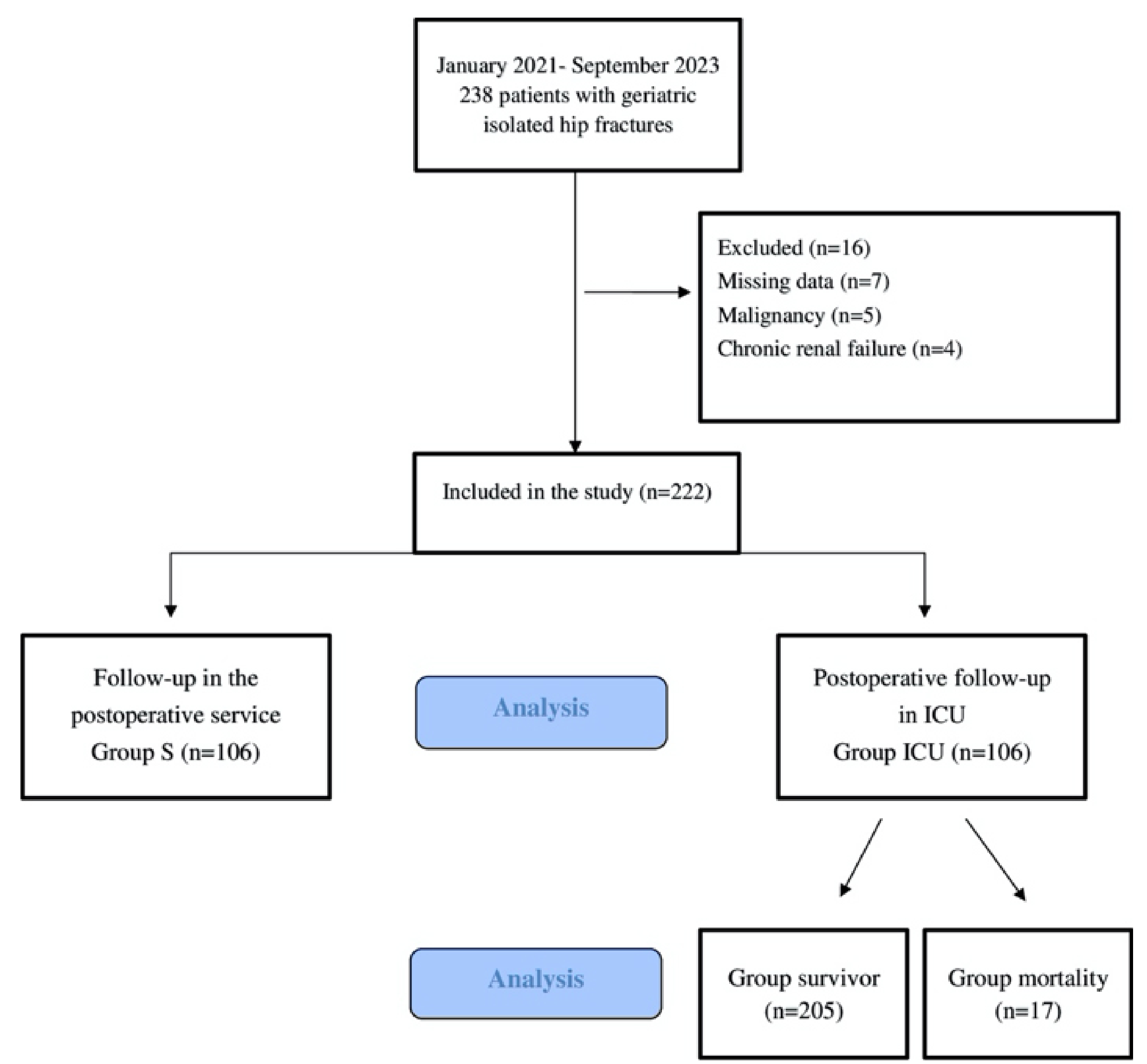

FIGURE 1. Flow chart of the study.

were classified as survivor group and mortality group according to in-hospital mortality status in the postoperative period.

The study's primary purpose is to analyze the predictive value of preoperatively calculated PNI value for ICU requirement and in-hospital mortality in geriatric patients scheduled for surgery due to hip fracture. G*Power 3.1 program was used to determine the sample size. It was determined that 105 patients needed to be included in the study to obtain $p<0.05$ and 90% power for chi-square tests.

Statistical Analysis

SPSS Inc., Chicago, USA (SPSS v26.0) program was used to analyze the data. Whether the data showed a normal distribution was evaluated analytically (Shapiro-Wilks test) and visually (histogram). Descriptive statistics were expressed as number of patients, percentage, mean, standard deviation, and range. In analyzing quantitative variables between two independent groups, the independent sample t-test was used for normally distributed data, and the Mann-Whitney U test was used for non-normally distributed data. Pearson chi-square test and Fisher exact test were used to evaluate qualitative data. Multivariate logistic regression analysis was performed to determine whether PNI and other parameters that showed significant differences between the groups were independent predictors of ICU requirement and mortality. Logistic regression analysis results are presented as odds ratio (OR) and 95% confidence interval (CI). ROC curve analysis was performed to determine the prognostic value of PNI on mortality. The significance level for all results was accepted as p<0.05.

RESULTS

The study included two hundred twenty-two patients who underwent surgery for geriatric hip fractures between January 2021 and September 2023 (Fig. 1). The average age of the patients was 80.6±7.4 (65–99) years, and 66.2% (n=147) were women. Most geriatric hip fracture patients (65.8%, n=146) were in ASA III-IV status. Spinal anesthesia was applied to 82.4% of the patients (n=183). The most common comorbid diseases in the patients were hypertension (74.3%) and diabetes mellitus (39.1%). Postoperative ICU was required in 47.7% (n=106) of the patients. The average length of stay in the ICU was 12.1±6.3 days. The mean preoperative albumin levels of the patients were 3.38±0.4 g/dL, and the mean PNI values were 33.8±4.4. 28-day mortality was 6.8% (n=15) (Table 1).

In the postoperative period, 52.2% of the patients were followed in the inpatient service (Group S, n=116) and 47.8% in the ICU (Group ICU, n=106). The mean age of the patients in the Group ICU was significantly higher (83.2±7.4 vs. 78.2 ±6.7 years, p<0.001). Similarly, ASA III-IV status, preoperative APACHE II scores, and LAR values were significantly higher in ICU patients (p<0.001, p<0.001, and p=0.004, respectively). Preoperative mean albumin levels were found to be significantly lower in patients in the ICU group (3.16±0.3 vs. 3.58±0.4 g/dL, p<0.001). Mean PNI values were also significantly lower in patients in the ICU group (31.7±3.6 vs. 35.8±4.2, p<0.001) (Table 2).

Demographic data were similar between patients in the mortality and survivor groups. In the mortality group, preoperative GCS scores were significantly lower (12.5±1 vs. 14±1.1, p<0.001) and APACHE II scores were significantly higher (29.6±7.9 vs. 15.2±3.7, p<0.001). Mean PNI values in patients in the mortality group were significantly lower than in the survivor

TABLE 1. Demographic data and some clinical features of geriatric hip fracture patients

Variable	Overall (n=222)
Age (years)	80.6±7.4 (65–99)
Gender, %	
Female	66.2
Male	33.8
BMI (kg/m^2)	25.9±4.7 (16.3–38.5)
ASA status, %	
I	6.8
II	27.5
III	61.3
IV	4.5
Anesthesia type, %	
Spinal	82.4
General	16.7
Spinal+epidural	0.9
Comorbid disease, %	
None	8.1
Hypertension	74.3
Diabetes mellitus	39.1
CAD/HF	17.5
Alzheimer/Parkinson	13.1
Asthma/COPD	11.7
Cerebrovascular disease	8.5
Others*	7.6
Ejection fraction, %	
<40	6.6
40–60	86.9
>60	9.9
Length of hospital stay (day)	11.6±7.4 (3–55)
ICU requirement, %	47.7
Length of stay in ICU (day)	12.1±6.3 (3–35)
GCS score	13.9±1.1 (10–15)
Hemoglobin (g/dL)	11±1.5 (7.7–15.7)
Albumin (g/dL)	3.38±0.4 (2.16–4.44)
Lymphocyte (mm^3)	1.39±1.1 (0.2–16.2)
Prognostic Nutritional Index	33.8±4.4 (21.6–44.4)
Lactate	1.66±0.6 (0.4–3.9)
Lactate/albumin ratio	0.49±0.1 (0.13–1.28)
Mortality (28-day)	6.8
Mortality (90-day)	7.7

Values are the percentage, mean±standard deviation (range). BMI: Body Mass Index; ASA: American Society of Anesthesiologists; ICU: Intensive care unit; GCS: Glasgow Coma Scale; CAD/HF: Coronary artery disease/heart failure; COPD: Chronic obstructive pulmonary disease. *: Epilepsy, acute or chronic renal failure, multiple sclerosis, hypothyroidism.

TABLE 2. Clinical characteristics of patients in the service and ICU groups

	Group S (n=116)	Group ICU (n=106)	p
Age (years)	78.2±6.7 (65–92)	83.2±7.4 (65–99)	**<0.001**
Gender, %			0.818
Female	65.5	67	
Male	34.5	33	
BMI (kg/m²)	27±5 (18–38.5)	24.8±4.2 (16.3–38)	**0.002**
ASA status, %			**<0.001**
I	11.2	1.9	
II	47.4	5.7	
III	41.4	83	
IV	0	9.4	
Anesthesia type, %			0.220
Spinal	85.3	79.2	
General	14.7	18.9	
Spinal+epidural	0	1.9	
GCS score	14.4±0.7 (12–15)	13.4±1.3 (10–15)	**<0.001**
Hemoglobin (g/dL)	11.3±1.6 (7.7–15.7)	10.7±1.4 (8.2–15.7)	**0.005**
Albumin (g/dL)	3.58±0.4 (2.1–4.4)	3.16±0.3 (2.4–4.1)	**<0.001**
Lymphocyte (mm³)	1.4±1.5 (0.2–16.2)	1.2±0.6 (0.4–3)	0.398
Prognostic Nutritional Index	35.8±4.2 (21.6–44.4)	31.7±3.6 (24.2–41.5)	**<0.001**
Lactate	1.64±0.6 (0.5–3.9)	1.69±0.6 (0.4–3)	0.412
Lactate/albumin ratio	0.46±0.1 (0.1–1.2)	0.53±0.2 (0.1–1)	**0.004**

Values are the percentage, mean±standard deviation (range). BMI: Body Mass Index; ASA: American Society of Anesthesiologists; ICU: Intensive care unit; GCS: Glasgow Coma Scale.

group (31±4.9 vs. 34±4.3, p=0.029). Similarly, while mean albumin levels were significantly lower in the mortality group, lactate levels and LAR values were significantly higher than those in the survivor group (p=0.027, p=0.008, and p=0.002, respectively) (Table 3).

In the multivariate regression analysis of the parameters that showed significant differences between the ICU and service groups, high ASA status and low PNI were found to be independent risk factors for ICU requirement (p=0.003 and p<0.001, respectively) (Table 4).

The multivariate regression analysis of the values that showed a significant difference between the mortality and survivor groups determined that only the APACHE II score was an independent predictor of mortality (Table 5).

In ROC curve analysis, the cut-off value of PNI in predicting mortality was 32.5, the area under the curve (AUC)=0.660 (95% CI, 0.516–0.803), sensitivity 0.647 and specificity 0.620 (p<0.001) (Fig. 2).

DISCUSSION

In this study conducted in a tertiary center, it was determined that the preoperative PNI value was valid both in determining the ICU requirement and in predicting mortality in patients with geriatric hip fractures. We determined that the preoperatively calculated PNI value can be used as an independent evaluation criterion, such as ASA status, in determining the need for ICU. In addition, we found that GCS and APACHE II scores and the LAR ratio, which have recently been used to determine prognosis in various diseases and conditions, can also be used to predict mortality. APACHE II score was found to be an independent predictor of mortality.

Many factors, such as age, ASA status, comorbid diseases, functional capacity, preoperative hemodynamic measurements, operation and procedure time, amount of fluid given, anesthesia preference, and perioperative events, effectively determine the postoperative ICU requirement [9]. Celik and Dagli [10] reported that 32.5% of geriatric

Table 3. Clinical characteristics of the survivor and mortality group

	Group survivor (n=205)	Group mortality (n=17)	p
Age (years)	80.3±7.4 (65–99)	83.6±7.3 (70–98)	0.082
Gender, %			0.891
Female	66.3	64.7	
Male	33.7	35.3	
BMI (kg/m²)	25.8±4.7 (16.3–38.5)	26.9±4.8 (21–38)	0.380
ASA status, %			**0.014**
I	7.3	0	
II	29.8	0	
III	59	88.2	
IV	3.9	11.8	
Anesthesia type, %			0.321
Spinal	83.4	70.6	
General	15.6	29.4	
Spinal+epidural	1	0	
GCS score	14±1.1 (10–15)	12.5±1 (11–15)	<**0.001**
APACHE II score	15.2±3.7 (8–31)	29.6±7.9 (13–46)	<**0.001**
Hemoglobin (g/dL)	11±1.5 (7.7–15.7)	11.5±2 (8.2–15.7)	0.331
Albumin (g/dL)	3.40±0.4 (2.1–4.4)	3.12±0.5 (2.4–4.1)	**0.027**
Lymphocyte (mm³)	1.4±1.2 (0.2–16.2)	1.3±0.7 (0.4–3)	0.661
Prognostic Nutritional Index	34±4.3 (21.6–44.4)	31±4.9 (24.2–41.5)	**0.029**
Lactate	1.63±0.6 (0.4–3.9)	2±0.6 (0.4–3)	**0.008**
Lactate/albumin ratio	0.48±0.1 (0.1–1.2)	0.64±0.2 (0.1–0.9)	**0.002**

BMI: Body Mass Index; ASA: American Society of Anesthesiologists; ICU: Intensive care unit; GCS: Glasgow Coma Scale; APACHE II: Acute Physiology and Chronic Health Assessment II.

Table 4. Multivariate logistic regression analysis in predicting ICU requirement

Variables	OR	95% CI (min–max)	p
Age	1.057	0.972–1.149	0.194
BMI	1.090	0.984–1.208	0.100
ASA status	9.347	1.880–42.158	**0.003**
GCS	1.314	0.775–2.228	0.310
Hemoglobin	0.896	0.655–1.226	0.492
PNI	1.356	1.174–1.565	<**0.001**
LAR	1.236	0.102–15.030	0.868
Constant	0.000		0.998

BMI: Body Mass Index; OR: Odds ratio; CI: Confidence interval (minimum–maximum); PNI: Prognostik Nutrisyonel Indeks; LAR: Laktat/albumin ratio; GCS: Glasgow Coma Scale.

Table 5. Multivariate logistic regression analysis in predicting in-hospital mortality

Variables	OR	95% CI (min–max)	p
ASA status	6.571	0.581–74.369	0.510
GCS	1.575	0.633–3.117	0.403
APACHE II	0.695	0.589–0.820	<**0.001**
PNI	1.159	0.932–1.442	0.184
LAR	0.192	0.003–14.242	0.453
Constant	1.425		0.964

BMI: Body Mass Index; OR: Odds ratio; CI: Confidence interval (minimum–maximum); PNI: Prognostik Nutrisyonel Indeks; LAR: Laktat/albumin ratio; GCS: Glasgow Coma Scale; APACHE II: Acute Physiology and Chronic Health Assessment II.

hip fracture patients were followed up in the ICU in the postoperative period and that advanced age, high ASA status, and hypoalbuminemia were independent risk factors for admission to the ICU in these patients. The authors also stated that the age of patients admitted to the ICU was significantly higher, and their hemoglobin levels were

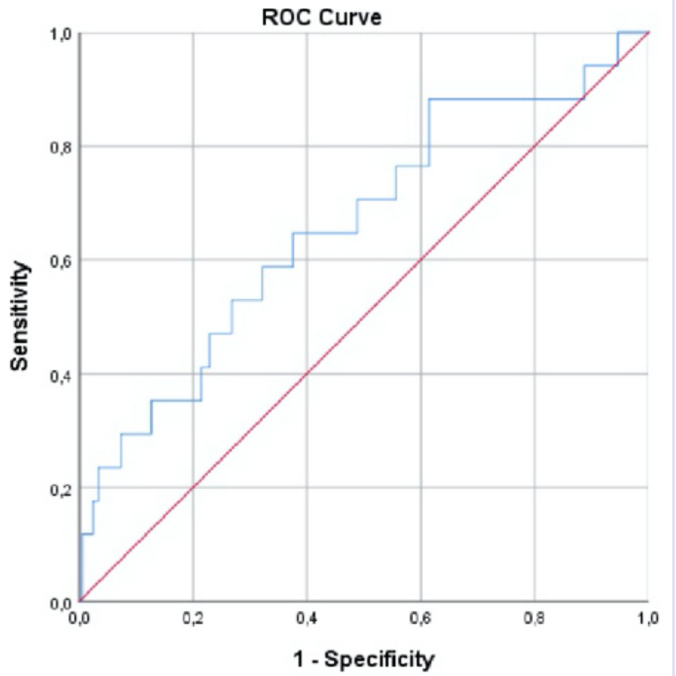

FIGURE 2. ROC curve for mortality prediction of PNI. Receiver operating characteristics curve analyses of the PNI predicting in-hospital mortality in geriatric hip fracture patients. The AUCs of PNI for mortality was 0.660 (95% CI, 0.516–0.803), p<0.001.

PNI: Prognostic Nutritional Index; AUC: Area under the curve; CI: Confidence intervals.

significantly lower than those admitted to the inpatient service. In another study, it was reported that 52% of geriatric hip fracture patients were followed up in the postoperative ICU; the average age of the patients was 80.4±7 years, and 64% were women [11]. Consistent with the literature, in our study, 47.7% (106/222) of geriatric hip fracture patients required postoperative ICU, while the average age of the patients was 80.6±7 years, and 66% were female. While age, ASA status, APACHE II score, and LAR values were significantly higher in patients in the ICU group, BMI, GCS, hemoglobin, albumin, and PNI values were significantly lower. In this study, we contributed to the literature and determined that the preoperative PNI value is an independent predictor of the need for ICU.

As a result of the increase in average life expectancy, the number of patients with osteoporotic hip fractures (proximal femur fractures) has increased. Hip fractures affect 1.5 million people globally annually, predicted to increase to 2.6 million in 2025 [12]. In patients with hip fractures, most mortality occurs within the first 30 days. Hu et al. [13] reported the 30-day mortality rate after hip fracture surgery as 13.3%. Poor preoperative functional capacity, comorbid diseases, surgical processes, accompanying traumas, nutritional deficiencies, and malnutrition increase mortality rates [14]. Wilson et al. [15] reported that the mortality rate in hip fractures with malnutrition was approximately 25%. Malnutrition is defined as albumin level <3.5 g/dL or lymphocyte count <1500 cells (per mm^3) [16]. Low albumin and lymphocyte levels are prognostic factors in determining 1-year mortality in older patients with hip fractures [17]. Decreases in serum albumin levels are observed in hepatocellular dysfunctions, protein synthesis disorders, renal losses such as nephrotic syndrome, gastrointestinal losses such as protein-losing enteropathy, and cases where catabolism increases, such as sepsis [18]. Lymphopenia can occur in viral infections, autoimmune and inflammatory system activations, gastrointestinal cancers, malnutrition, and immunosuppression. PNI, which can be easily calculated from serum albumin and lymphocyte levels, has prognostic importance as it reflects the balance between inflammation and nutrition.

PNI, when used as a preoperative pretest, can help predict postoperative mortality as a tool for evaluating nutrition. Taskin et al. [19] reported that in geriatric femur fractures, preoperative albumin, prealbumin, and PNI values were found to be significantly lower in patients who developed mortality compared to those who survived. The authors stated that the cut-off PNI value for predicting mortality in patients with femur fractures was 29, and the 6-month mortality rate was 22.4%. In another study, it was reported that low preoperative PNI values in geriatric hip fracture patients led to increased hospital stay, increased postoperative delirium rate, and increased 3-month mortality [20]. In our study, consistent with the literature, the preoperative PNI value (cut-off value 32.5) was significantly lower in the mortality group, but no independent predictor of mortality was detected. Consistent with the literature, the 28- and 90-day mortality of hip fracture patients was 6.8% and 7.7%, respectively.

In addition to trauma-specific scoring systems such as GCS, non-specific scoring systems such as APACHE II are used to determine the prognosis and predict mortality in critically ill patients followed in the ICU [21, 22]. It has been stated in the literature that low GCS, high APACHE II scores, and high serum lactate levels can predict mortality in trauma patients [22]. Arslan et al. [22] reported that serum lactate level is an indicator of tissue perfusion disorder and that high lactate levels are an independent predictor of mortality in trauma patients. However, serum lactate levels can be affected by many conditions, such as decreased hepatic lactate clearance, sepsis, chronic diseases, decreased kidney function, and thiamine deficiency. This situation may limit its prognostic use. For this reason, recent studies have stated that the LAR ratio helps predict mortality in trauma patients [23]. In our study, although lactate level and LAR were significantly higher in the mortality group, they were not independent predictors of mortality. In trauma patients, early hemodynamic resuscitation and provision of adequate oxygen to tissues and organs are essential in preventing death. Lactate and LAR values were not detected as independent predictors of mortality due to the limited amount of blood and fluid loss in the hip fracture patients in the current study.

The study has some limitations. The first is that it is retrospective and single-centered. Secondly, since the trauma time of hip fracture patients could not be determined, the effect of trauma time on mortality was not evaluated. Thirdly, albumin and lymphocyte levels were checked during preoperative anesthetic evaluation. The period between preoperative evaluation and operation time is not standardized.

Conclusion

In conclusion, the PNI value, which can be easily calculated preoperatively in geriatric hip fracture patients, can be used as an independent parameter, such as ASA status, in determining postoperative ICU requirements. Considering that nutritional and protein deficiencies are practical in early mortality in patients with hip fracture, determination and treatment of preoperative nutritional level in this patient group will contribute to recovery.

Ethics Committee Approval: The Kanuni Sultan Suleyman Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 27.12.2023, number: KAEK/2023.12.180).

Authorship Contributions: Concept – KA, SC, HCA, CE; Design – KA, SC, HCA, ASS, CE; Supervision – KA, HCA, ASS, YG, CE; Fundings – KA, SC, HCA; Data collection and/or processing – KA, SC; Analysis and/or interpretation – KA, ASS, YG, CE; Literature review – KA, HCA, YG, CE; Writing – KA, HCA; Critical review – KA, HCA, ASS, YG, CE.

Conflict of Interest: No conflict of interest was declared by the authors.

Use of AI for Writing Assistance: Artificial intelligence-supported technologies were not used in writing the article.

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

Peer-review: Externally peer-reviewed.

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