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ORIGINAL ARTICLE

THE EFFECT OF BLOOD PARAMETERS AND SURGICAL TREATMENT METHODS ON MORTALITY IN GERIATRIC HIP FRACTURES: CAN PREOPERATIVE ALBUMIN AND LYMPHOCYTE LEVELS PREDICT MORTALITY

ABSTRACT

Introduction: Geriatric hip fractures are associated with high morbidity and mortality. Identifying reliable preoperative biomarkers may help predict postoperative mortality and improve perioperative management.

Materials and Method: This retrospective study included 913 patients aged 65 years and older who underwent surgery for hip fractures between January 2017 and January 2024. Demographic characteristics, comorbidities, fracture type, surgical and anesthesia methods, ASA score, and preoperative hemoglobin, albumin, and lymphocyte levels were recorded. Mortality status was evaluated, and the diagnostic performance of albumin and lymphocyte levels in predicting mortality was assessed using receiver operating characteristic (ROC) curve analysis.

Results: The mean age of the patients was 79.6 ± 9.7 years, and the postoperative mortality rate was 51.6%. Mortality was significantly associated with lower preoperative albumin and lymphocyte levels ($p < 0.001$). A preoperative albumin level < 3.5 g/dL demonstrated excellent predictive performance for mortality, with a sensitivity of 99.8% and specificity of 99.5% (AUC: 0.997). The predictive accuracy of lymphocyte count was lower (AUC: 0.622). Mortality rates were also significantly higher in patients with an ASA score ≥ 4 and in those who received blood transfusions.

Conclusions: Preoperative serum albumin is a highly accurate biomarker for predicting mortality in geriatric patients undergoing hip fracture surgery. Low albumin levels may reflect malnutrition and reduced physiological reserve, contributing to poorer postoperative outcomes. Routine assessment of albumin may facilitate early identification of high-risk patients and support individualized perioperative management strategies.

Keywords: Geriatrics; Hip Fractures; Albumins; Lymphocytes; Mortality.

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INTRODUCTION

Hip fractures are among the important public health problems worldwide (1). It is the most common type of fracture, especially in osteoporotic elderly individuals, and surgical treatment is generally the standard approach in this patient group and is often applied after hospitalization (2,3). Factors such as age, chronic diseases, cognitive status, and malnutrition play a role in the development of hip fractures (4). Particularly, osteoporosis is one of the most important risk factors for hip fractures in the elderly population (4).

Elderly individuals represent the fastest-growing age group in the global population. Therefore, a substantial rise in the incidence of hip fractures is anticipated in the coming years (5). Approximately 1.5 million people are hospitalized every year due to hip fractures, and this number is predicted to be more than 4.5 million in 2050 (2). It has been reported that more than 80% of patients with hip fractures are aged 65 years or older (6). The risk of mortality increases significantly, especially in the first year following fracture, and increases further with advanced age (5,7). There is strong evidence that performing surgery within 24-48 hours significantly reduces mortality (8).

Among hip fractures, intertrochanteric and femoral neck fractures have distinct etiologies, treatment strategies, and prognoses. Short- and long-term mortality rates of femoral neck fractures are lower compared to intertrochanteric fractures. However, in terms of surgical approach, hip arthroplasty has been reported to be associated with higher mortality rates compared to internal fixation (6). However, certain studies suggest that there is no significant difference in long-term functional outcomes and mortality between the two types of fractures (9).

Serum albumin level is a commonly used marker for assessing malnutrition (10). Preoperative serum albumin levels were significantly associated with mortality and ICU requirement in elderly patients undergoing hip fracture surgery (1). Similarly, studies from developing countries have highlighted

the prognostic value of low preoperative albumin and hematologic parameters. Espinosa et al. reported that reduced preoperative serum markers reflect impaired functional reserve and a higher risk of mortality in elderly populations (2). Within this context, evaluating preoperative albumin and lymphocyte levels may offer practical and effective tools for surgical risk assessment (2).

In addition to albumin, lymphocyte count was evaluated as a potential prognostic parameter because it reflects both nutritional and immunological status. In elderly patients, immune senescence, chronic inflammation, and malnutrition frequently coexist and may negatively influence postoperative recovery (11). Total lymphocyte count has been incorporated into composite prognostic indices such as the Prognostic Nutritional Index (PNI) and the HALP score, which have demonstrated associations with mortality and postoperative complications in geriatric orthopedic populations (12). Furthermore, lymphocyte count is routinely measured, cost-effective, and readily available in daily clinical practice, making it a practical parameter for perioperative risk assessment.

The objective of this study was to evaluate the predictive value of preoperative albumin and lymphocyte levels on postoperative mortality in patients undergoing surgery due to geriatric hip fractures. Moreover, the relationship between mortality and clinical variables such as different surgical techniques, anesthesia methods, ASA score, and blood transfusion was investigated. With the findings of the study, it was aimed to contribute to patient management by identifying biochemical parameters that can predict mortality.

MATERIALS AND METHOD

Study Population

In our study, patients aged 65 years and older who underwent surgical treatment for hip fractures and presented to our clinic between January 2017 and January 2024 were retrospectively included. Patients

under the age of 65, patients with a deteriorated general condition during hospitalization, patients who underwent surgical treatment due to pathological fractures, patients with bilateral hip fractures, patients who had revision surgery for a previous hip fracture on the same side, and patients for whom sufficient data could not be obtained during and after hospitalization were excluded from the study (Figure 1). The study protocol was approved by the Gulhane Clinical Research Ethics Committee of the University of Health Sciences (Decision No: 2024/536, Date: 10/12/2024), and the study was conducted in accordance with the principles of the Helsinki Declaration.

Data Collection

Patients aged 65 years and older who underwent surgical treatment for hip fractures were retrospectively screened through the hospital automation system. Age, gender, and comorbidities (such as coronary artery disease, previous cerebrovascular events, chronic kidney failure, asthma, hypertension, diabetes mellitus, etc.) were

recorded. Patients with clinical conditions known to directly affect serum albumin levels such as chronic liver disease, nephrotic syndrome, active malignancy, or systemic inflammatory disorders were excluded from the study. The type of hip fracture at the time of admission was evaluated by using the PACS system. Hip fractures were classified into three groups: femoral neck fractures, intertrochanteric fractures, and subtrochanteric fractures. Femoral neck fractures were evaluated as fractures occurring within the intracapsular region of the hip joint and the area beneath the fibrous capsule. Intertrochanteric fractures were evaluated as fractures occurring in the region between the femoral neck and the lesser trochanter. The region extending from the lesser trochanter to up to 5 cm distally was evaluated as the subtrochanteric fractures.

Postoperative control X-ray images taken in the operating room following the surgery were evaluated, and the surgical treatments applied to the patients were categorized into three groups: partial hip arthroplasty, proximal femoral nail, and long proximal femoral nail. Operative notes were reviewed to determine the length of the nails used. The nails over 260 mm were evaluated as long proximal femoral nails, and shorter nails were evaluated as proximal femoral nails. The ASA score (I, II, III, IV) routinely recorded in the surgical notes of the patients, the type of anesthesia administered (categorized into general, spinal, and regional), and the duration of surgery were recorded. Preoperative hemoglobin, albumin, and lymphocyte levels were obtained from the initial blood samples collected at the time of hospital admission. Laboratory data of the patients were reviewed, and the most recent preoperative values were recorded, including hemoglobin, albumin, and lymphocyte levels. Preoperative hospital stay duration, the number of erythrocyte and platelet suspensions administered before and after surgery, and the patients who died postoperatively were also recorded. Mortality data were obtained through the hospital information management system (FONET) and the national electronic health record system

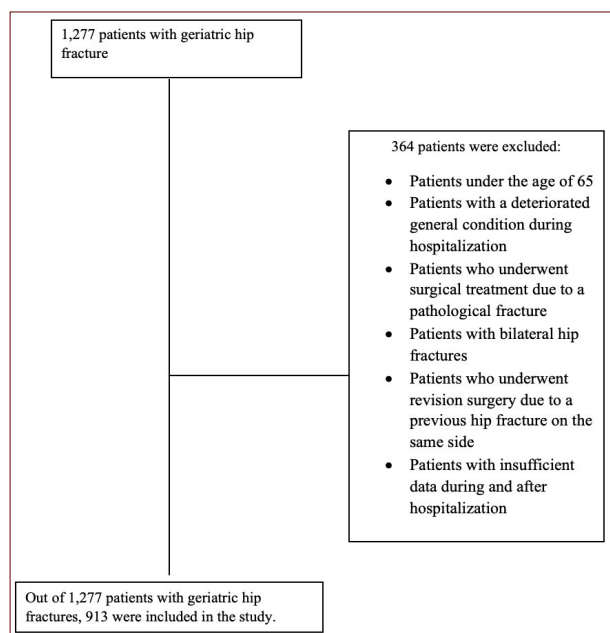


Figure 1. Flow Diagram of the Study



(e-Nabız). Since the exact date or timing of death could not be accessed, mortality was assessed based solely on the presence or absence of a death record. It was not possible to determine whether death occurred during hospitalization or after discharge.

Statistical Analysis

Descriptive statistics for continuous variables were presented as mean, standard deviation, median, minimum, and maximum values, while categorical variables were presented as frequencies and percentages. Power analysis was performed using G*Power (version 3.1.9.7) to assess minimum sample size adequacy for comparing two independent groups. Assuming a medium effect size (Cohen's $d=0.50$), $\alpha=0.05$ and power $(1-\beta)=0.95$, and equal group allocation, the required minimum sample size was 210 patients (105 per group). As our cohort included 913 patients, the available sample size was considered sufficient to detect at least a medium between-group difference in key laboratory parameters. The Shapiro–Wilk test was used to assess the normality of data distribution. The Mann–Whitney U test was used to compare continuous variables between the patients who survived and the patients who died. For comparisons of nominal variables between groups (in cross tables), the Chi-Square test or Fisher's Exact test was used. The diagnostic performance of preoperative albumin and lymphocyte levels in predicting mortality was evaluated by using the area under the ROC curve (AUC). The best cut-off point was calculated by using Youden's Index. Preoperative albumin and preoperative lymphocyte values were evaluated by using diagnostic accuracy criteria (sensitivity, specificity, positive predictive, and negative predictive). In assessments, IBM SPSS for Windows 20.0 (SPSS Inc. Chicago, IL) program was used, and $p<0.05$ was accepted as the statistical significance limit.

RESULTS

913 patients, who were operated on due to hip fracture, were included in the study. The mean age of

the patients was 79.63 ± 9.74 years, with a minimum of 65 and a maximum of 98 years. The mean preoperative hospital stay was 3.65 ± 2.28 days, and the mean duration of surgery was 2.14 ± 0.65 hours. Of the patients, 67% were female and 33% were male. An ASA score of "3" was recorded in 54.8% of the patients, 60.4% had an intertrochanteric fracture (ICF), and spinal anesthesia was administered in 74.5% of the cases. It was determined that 64% of the patients underwent PFN surgery, and 45.8% received blood replacement. It was reported that 51.6% of the patients died.

A difference was found between the ages of the surviving patients and the deceased patients ($p<0.001$). The ages of the deceased patients were found to be higher. There was no difference between the preoperative hospitalization periods of the surviving and the non-surviving patients ($p>0.05$). A difference was found between the operation times of the surviving patients and the deceased patients ($p<0.01$). The operation times of the deceased patients were found to be shorter. There was no difference between the gender distributions of the surviving patients and the deceased patients ($p>0.05$). It was observed that the deceased patients had a higher rate of ASA score of 4. No significant differences were found between surviving and deceased patients in terms of gender distribution, fracture types, or comorbidity rates ($p>0.05$). There was no difference between the anesthesia techniques of the surviving and the deceased patients ($p>0.05$). A difference was found between the blood replacement numbers of the surviving and the deceased patients ($p<0.05$). The blood replacement numbers of the deceased patients were found to be higher. There was no difference between the surgical types of both patient groups ($p>0.05$). A difference was found between the rates of receiving blood replacement in surviving and non-surviving patients ($p<0.05$). The rate of blood replacement was found to be higher in deceased patients (Table 1).

Table 1. Comparison of demographic characteristics and attributes of surviving and deceased patients

	Surviving (n=442,%48.4)		Deceased (n=471,(%51.6)		P
	Mean ± SD Median (Min-Max)		Mean ± SD Median (Min-Max)		
Age (years)	77.08±10.52 79 (65-96)		82.03±8.26 84 (69-98)		<0.001 ^b
Preoperative length of stay (days)	3.57±1.96 3 (0-13)		3.73±2.54 3 (0-29)		0.713 ^b
Operation duration (hours)	2.20±0.61 2 (1-6)		2.09±0.69 2 (0.53-9.0)		0.003 ^b
Blood replacement number (Units)	0.74±1.17 0 (0-8)		0.99±1.55 0 (0-11)		0.019 ^b
	n	%	n	%	
Gender					
Female	294	66.5	318	67.5	0.748 ^c
Male	148	33.5	153	32.5	
ASA					
1/2	130	29.4	82	17.4	<0.001 ^c
3	241	54.5	259	55.0	
4	41	16.1	130	27.6	
Fracture type					
Femoral neck	165	37.3	158	33.5	0.082 ^c
ICF	253	57.2	298	63.3	
Subtrochanteric	24	5.4	15	3.2	
Anesthesia technique					
General	88	20.0	73	15.5	0.349 ^c
Spinal	316	71.7	363	77.1	
Regional	1	0.2	2	0.4	
Spinal+Regional	0	0	1	0.2	
Combined	28	6.3	24	5.1	
LMA	8	1.8	8	1.7	
Comorbidity					
No	66	14.9	70	14.9	0.976 ^c
Yes	376	85.1	401	85.1	
Surgery type					
PFN	271	61.3	313	66.5	0.211 ^c
Long PFN	8	1.8	5	1.1	
PHP	163	36.9	153	32.5	
Blood Replacement					
No	255	57.7	240	51.0	0.041 ^c
Yes	187	42.3	231	49.0	

ASA: American Society of Anesthesiologists, b: Mann-Whitney U Test, c: Chi -Square test/Fisher's Exact test, ICF: Intertrochanteric Fracture, LMA: Laryngeal Mask Airway, PFN: Proximal Femoral Nail, PHP: Partial Hip Prosthesis



Table 2. Comparison of laboratory values of surviving and non-surviving patients

	Surviving (n=442)	Deceased (n=471)	p
	Mean ± SD Median (Min-Max)	Mean ± SD Median (Min-Max)	
Preoperative Hemoglobin	11.75±1.71 11.7 (7.3-18.0)	11.54±1.88 11.3 (6.5-17.9)	0.050 ^b
Preoperative Albumin	4.01±0.29 3.9 (2.9-4.7)	2.59±0.46 2.6 (1.8-7.7)	<0.001 ^b
Preoperative Lymphocyte	1.58±0.81 1.4 (0.3-4.6)	1.24±0.56 1.1 (0.2-4.1)	<0.001 ^b

b: Mann-Whitney U Test

Table 3. Diagnostic performance of Preoperative Albumin and Preoperative Lymphocyte values in distinguishing mortality

	AUC 95% CI	p	Cutoff	Sensitivity 95% CI	Specificity 95% CI	PPV	NPV
Preoperative Albumin	0.997 (0.993-1.000)	<0.001	<3.5	99.8 % (98.8-99.9)	99.5 % (98.4-99.9)	99.6 % (98.8-99.9)	99.8 % (99.1-99.9)
Preoperative Lymphocyte	0.622 0.586-0.659	<0.001	<1.42	79.2 % (75.3-82.6)	47.5 % (42.9-52.1)	61.6 % (58.4-64.8)	68.2 % (65.0-71.2)

AUC: Area Under the Curve , PPV: Positive Predictive Value, NPV: Negative Predictive Value

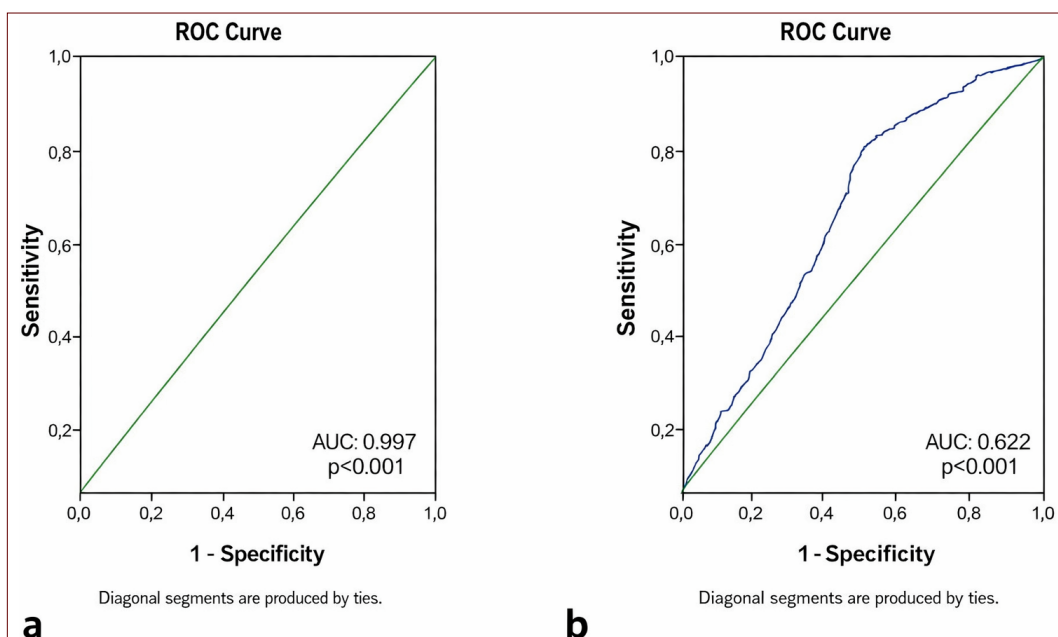


Figure 2. Receiver operating characteristic (ROC) curves showing the predictive value of preoperative laboratory parameters for mortality: (a) albumin and (b) lymphocyte levels.

A significant difference was found between the preoperative hemoglobin values of the surviving and the non-surviving patients ($p=0.05$). The preoperative hemoglobin values of the deceased patients were found to be lower. There was a difference between the preoperative albumin values of the surviving and the non-surviving patients ($p<0.001$). Preoperative albumin values of the deceased patients were found to be lower (Table 2).

AUC calculated for preoperative albumin was found to be significant in predicting mortality in patients with hip fractures ($p<0.001$). The best cut-off point was determined to be <3.5 . AUC calculated for preoperative lymphocyte values was found to be significant in predicting mortality in patients with hip fractures (Table 3).

The best cut-off point was determined to be <1.42 ($p<0.001$). (Figure 2)

DISCUSSION

Mortality rates remain high among geriatric patients with hip fractures, and identifying preventable risk factors through large-scale studies is of great importance. Although surgical techniques have advanced, it is crucial to evaluate the preoperative, intraoperative, and postoperative processes as a whole in order to reduce mortality. Accordingly, a study was designed with the aim of contributing to the existing literature.

Low hemoglobin is a very common condition in patients with hip fractures. In a study conducted by Smeets et al., it was reported that blood transfusion had no effect on mortality (13). In another study, although blood transfusion was found to have no effect on 1-year mortality, it was revealed that there was an increase in mortality as the number of transfusions increased (14). Our study reveals that the low preoperative hemoglobin level and the mortality rate of patients with blood replacement are significantly higher than other patients.

There is no clear consensus regarding the relationship between hip fractures and the type of anesthesia. There is no standardized method among general anesthesia, regional anesthesia, and spinal anesthesia techniques for geriatric hip fracture patients (15). In the study conducted by Kunutsor et al., no relationship was observed between the type of anesthesia and mortality (15). In our study, results similar to the literature were obtained, and no significant relationship was found between the type of anesthesia and mortality. In a meta-analysis including 53 studies, it was reported that the postoperative mortality rate increased with the increase in the ASA score (16). Our study revealed that patients with an ASA score of 4 had a higher mortality rate.

The effects of hip fractures differed between men and women, with male patients having longer surgery durations, higher readmission rates, and higher mortality rates compared to female patients (17). In our study, no significant relationship was found between gender or length of hospital stay and mortality; however, a significant relationship was observed, indicating that patients with shorter operative times had higher mortality rates. ASA scores of these patients were found to be higher compared to other patients.

In a review study including patients over the age of 70 with hip fractures, the relationship between malnutrition and mortality was evaluated (18). Despite advances in treatment methods, mortality rates were reported to remain high, and it was suggested that the prevention of malnutrition might have a significant effect on reducing postoperative mortality (17). In our study, preoperative albumin and lymphocyte levels were evaluated, and the findings suggested that they might serve as predictive risk factors for postoperative mortality.

Albumin and lymphocyte levels were significantly associated with mortality in elderly patients with hip fractures (11). Our study supports these findings and demonstrates particularly high diagnostic accuracy



for albumin levels, with a sensitivity of 99.8% and a specificity of 99.5%. These rates are higher compared to most studies reported in the literature.

Serum albumin levels might be used as a marker to predict postoperative mortality and complication risk in geriatric patients (19). They emphasized that the significantly higher rates of death, sepsis, and intubation in patients with hypoalbuminemia highlighted the importance of albumin as a critical parameter reflecting systemic condition (20). Another study reported that elevated preoperative and postoperative neutrophil-to-lymphocyte ratio (NLR) levels in patients undergoing surgery for geriatric hip fractures were significantly associated with long-term mortality, suggesting that this rate might serve as a prognostic marker (20). This finding highlighted the effect of systemic inflammation on long-term surgical outcomes, and it was suggested that it should be considered in the preoperative assessment (20). However, no significant relationship with short-term mortality was found in their study, and it was suggested that the prognostic value of the parameter might vary depending on timing. In our study, the prognostic value of preoperative albumin and lymphocyte levels in predicting mortality was investigated in patients undergoing surgery for geriatric hip fractures. Our findings indicated that low preoperative albumin levels (<3.5 g/dL) were significantly associated with higher mortality, and that their diagnostic accuracy was remarkably high (AUC: 0.997). Although the lymphocyte level was found to be associated with mortality, it displayed lower diagnostic performance (AUC: 0.622).

The overall mortality rate of 51.6% observed in this study is higher than rates reported in previous literature. However, this finding may be attributed to the advanced mean age of the cohort (79.6 years), the high proportion of patients with ASA scores ≥ 3 (76.8%), and the substantial prevalence of comorbidities (85.1%). Smith et al. demonstrated through a systematic review that advanced age, high ASA scores, and the presence of comorbid

conditions are significantly associated with increased postoperative mortality following hip fracture surgery (16). Similarly, Kannegaard et al. reported a markedly elevated early mortality rate in elderly patients with hip fractures and emphasized that greater comorbidity burden further exacerbates this risk (21).

In previous studies, serum albumin has been identified as a strong predictor of overall mortality in older adults (22). Although this study focused on the prognostic value of individual biomarkers such as albumin and lymphocyte counts, there has been growing interest in composite indices that reflect both nutritional and inflammatory status in geriatric hip fracture patients (12). For instance, the HALP score, which combines hemoglobin, albumin, lymphocyte, and platelet counts, has shown promising results in predicting mortality in elderly populations (12). Inflammation-based prognostic scoring systems have been associated with mortality following hip fractures (23). Future research may explore the applicability of such multidimensional scoring systems to develop more comprehensive risk assessment models.

Although several studies have investigated the association between serum albumin and mortality in geriatric hip fracture patients, the present study contributes to the literature in several aspects. First, it includes a relatively large single-center cohort (n=913), enhancing statistical robustness. Second, it evaluates biochemical parameters alongside surgical and clinical variables within the same population, providing a more comprehensive clinical context. Third, ROC-based cut-off values were determined for albumin and lymphocyte levels, offering practical thresholds for potential risk stratification. Finally, mortality data were obtained from national registry systems, reflecting real-world outcomes in a tertiary referral center population. Geriatric hip fracture is a major public health concern associated with significant morbidity and mortality, yet it is largely preventable. Although surgical

intervention is often inevitable in such cases, the ability to predict postoperative mortality risk during the preoperative period plays a critical role in care planning and clinical decision-making. Low serum albumin levels may reflect not only malnutrition but also underlying inflammatory processes, hepatic dysfunction, and reduced physiological reserve. Similarly, decreased lymphocyte counts may indicate immune suppression and systemic stress. These factors collectively impair the body's ability to tolerate surgical trauma and recover postoperatively. Therefore, biomarkers such as albumin and lymphocyte levels are instrumental in preoperative risk stratification and may also inform preventive strategies. Incorporating such assessments into routine preoperative evaluation allows for tailored interventions based on individualized mortality risk. Mortality in geriatric hip fracture patients is inherently multifactorial and influenced by numerous clinical, functional, and socioeconomic factors. Therefore, it would be inappropriate to attribute mortality solely to a single laboratory parameter such as serum albumin. The present study was designed to evaluate statistical associations and discriminative performance rather than establish causality. Consequently, the findings should be interpreted within a broader clinical context and not as evidence of a direct etiological relationship.

The retrospective and single-center nature of the study are primary factors limiting the generalizability of the results. This situation complicates the assessment of the effect of institutional differences in patient management on the outcomes. Furthermore, the measurement of albumin and lymphocyte levels at different time points may have an effect on the results due to biological variability and differences in laboratory conditions. The lack of assessment of these parameters within a standardized time frame creates limitations in terms of accuracy and comparability. One of the major limitations of the study is the unavailability of specific data regarding

the timing of death. Although death records were accessible via FONET and e-Nabiz systems, it was not possible to determine whether the deaths occurred during hospitalization or after discharge. This limitation may affect the interpretation of the reported mortality rates. Although the AUC value of 0.997 for albumin indicates excellent discriminative performance, such an unusually high value may raise concerns about potential overfitting or imbalance in the data distribution between mortality and albumin levels. Therefore, validation through prospective, multicenter studies is essential to assess the clinical applicability of this finding. Additionally, although several variables were found to be statistically associated with mortality in univariate analyses, multivariable regression modeling was not performed. Therefore, the independent prognostic contribution of albumin and other clinical parameters could not be definitively established. The findings should thus be interpreted as associations rather than independent predictive effects.

CONCLUSIONS

In this large-scale retrospective study, preoperative serum albumin demonstrated very high discriminative performance and was strongly associated with mortality in geriatric patients undergoing hip fracture surgery (AUC: 0.997). While lymphocyte count was also associated with mortality, its diagnostic performance was comparatively limited. These findings suggest that low albumin levels may reflect not only malnutrition but also systemic inflammation and diminished physiological reserve. However, due to the absence of multivariable modeling, the independent prognostic contribution of albumin cannot be definitively established. Therefore, the results should be interpreted cautiously and considered hypothesis-generating. Future prospective, multicenter studies incorporating multivariable analyses are necessary to validate these findings



and to determine the independent clinical utility of albumin in mortality risk stratification.

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