Journal of Anesthesia (2025) 39:205–214
https://doi.org/10.1007/s00540-024-03444-z

ORIGINAL ARTICLE

Correlation of preoperative fibrinogen/albumin ratio with morbidity following advanced-age hip fractures: an observational study

Emine Dizem Sunal Altın[1] · Nur Canbolat[1] · Mehmet I. Buget[1] · Yekta Furkan Altın[2] · Serkan Bayram[2] · Kemalettin Koltka[1]

Received: 16 September 2023 / Accepted: 2 December 2024 / Published online: 15 December 2024

Abstract

Purpose Given the occurrence of comorbidities in geriatric patients, the postoperative period of hip fractures may progress with high morbidity and mortality. Recently, several inflammatory markers have been used to evaluate the treatment course. Herein, we prospectively followed-up and examined the relationship between preoperative fibrinogen/albumin ratio(FAR) and morbidity/mortality in elderly patients with hip fracture.

Methods Patients aged ≥ 85 years who underwent hip fracture surgery under unilateral spinal anesthesia were included in this prospective observational study. The patients' preoperative FAR, age-adjusted Charlson comorbidity index(AACCI) score, Nottingham Hip Fracture Score, and Clinical Frailty Scale score were calculated. In addition, data on patients' morbidity, 3-month mortality, and lengths of intensive care unit (ICU) and hospital stay were recorded. The patients were categorized into two groups based on the FAR cutoff value of 0.102. A total of 108 patients participated in the study, with 43 assigned to Group 1(FAR < 0.102) and 65 to Group 2(FAR ≥ 0.102).

Results A significant difference was found in the risk of death within 3-months between patients with high and low FAR scores($p = 0.018$). Patients with higher FAR scores were more likely to die within 3 months. A significantly positive association was observed between the FAR and AACCI score, with the AACCI score of Group2 being significantly higher than that of Group 1($p = 0.029$). The lengths of hospital($p = 0.044$) and ICU($p = 0.013$) stay were significantly higher in Group2 than in Group1.

Conclusion Preoperative FAR, which is an inexpensive and readily available test, is a promising index for predicting mortality and complications in patients with hip fracture.

Keywords Fibrinogen/albumin ratio · Hip fracture · Charlson comorbidity index

Introduction

The World Health Organization defines aging as a decrease in the ability to adapt to the environment. Senility can be categorized into three stages: young-old age (65–74 years), middle-old age (75–84 years), and advanced-old age (≥ 85 years) [1]. Geriatric patients constitute a candidate population for various orthopedic operations [2]. Hip fractures, the frequency of which increases with the aging of societies and which pose significant risks, especially to the geriatric population, are becoming a serious problem, resulting in high mortality and morbidity rates and placing financial burdens globally [3]. The associated 1-year postoperative mortality rate in patients with hip fracture has been reported to be 15–30% [4].

To date, various scoring systems have been used for estimating the prognosis of hip fractures. Planning perioperative treatment management by determining the preoperative risk in patients with hip fracture can facilitate improvement in their prognosis and reduce mortality and morbidity rates [5]. Currently, three scoring systems are used for estimating mortality and morbidity rates in patients with hip fracture: the age-adjusted Charlson comorbidity index (AACCI), Nottingham Hip Fracture Score (NHFS), and Clinical Frailty

✉ Nur Canbolat
drnurekiz@gmail.com

1 Department of Anesthesiology and Reanimation, Istanbul Faculty of Medicine, Istanbul University, Turgut Ozal Millet Cd, 34093 Istanbul, Turkey

2 Department of Orthopedics and Traumatology, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey

Scale (CFS) [6–8]. These scoring systems can be used for calculations relevant to the preoperative period. The AACCI is an age-adjusted modification of the Charlson comorbidity index, a comorbidity scale widely used in the field of medicine worldwide [6]. The validity of this scale has been demonstrated by estimating 1-, 5-, and 10-year mortality rates in different patient groups, including patients with hip fracture [6]. It is also used to evaluate patients' preoperative additional morbidity factors by questioning them through interviews and to perform risk estimations in terms of morbidity and mortality [9]. The NHFS is a scoring system created specifically for patients with hip fracture and is used to predict 30 day and 1 year mortality, length of hospital stay, and complications after hip fracture surgery [8]. The CFS was developed to predict geriatric patients' prognosis and outcomes after hospitalization for acute illness [10].

The Fibrinogen/Albumin Ratio (FAR) is a novel and inexpensive inflammatory marker that can be easily applied in clinical settings. FAR is used to determine patients' systemic inflammatory response and nutritional status. It is also used to predict disease severity, response to surgical and medical treatment, prognosis, and mortality in cancer cases, cardiovascular diseases, and several other diseases [11, 12]. The relationship between FAR and postoperative complications regarding revision hip and knee arthroplasties has been previously demonstrated [13].

The primary aim of this study is to investigate the relationship between preoperative FAR and AACCI and morbidity in patients with advanced-age hip fractures. Our secondary aim is to investigate the relationship between preoperative FAR and mortality, NHFS, CFS, length of stay in ICU and hospital, usage of blood products and other postoperative complications.

Methods

This prospective observational study was conducted from March 2022 to February 2023. It was approved by the Istanbul University's Istanbul Medical Faculty Clinical Studies Ethics Committee (file no: 2021/196), and the study protocol was registered at clinicaltrials.gov (NCT05272072). All enrolled patients were informed about the surgery, anesthesia, and intensive care procedures to be undertaken in the study, and written informed consent was obtained from the patients and first-degree relatives.

The inclusion criteria were as follows: age ≥ 85 years, Body Mass Index (BMI) < 40 kg/m^2, and American Society of Anesthesiologists physical status (ASA-PS) class I–IV patients who underwent hip fracture surgery under unilateral spinal anesthesia. The exclusion criteria were contraindication to regional anesthesia, known allergy to local anesthetics, central nervous system infection, coagulopathy, severe liver failure, and hematological, rheumatological, or autoimmune diseases. Patients who were administered general and regional anesthesia concomitantly or those with incomplete medical records were excluded from the study.

During the preoperative evaluation, patients' demographic data (i.e., age, sex, height, weight, and BMI); hemoglobin, platelet, fibrinogen, albumin, and C-Reactive Protein (CRP) levels in peripheral blood sampled within 48 h preoperatively; and FAR were recorded.

AACCI

For calculating the AACCI score, data including the patient's age and 19 comorbidity factors were collected. A weighted score was established for each comorbidity while considering the relative risk of mortality [9]. These comorbidities included heart attack, heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic respiratory diseases, connective tissue diseases, peptic ulcer, benign liver diseases, uncomplicated diabetes, hemiplegia, moderate or advanced renal failure, complicated diabetes, cancer, leukemia, lymphoma, moderate or severe liver diseases, metastatic malignancy, and acquired immunodeficiency syndrome. The AACCI score was calculated by adding 1 point for patients aged 40–49 years, 2 points for those aged 50–59 years, 3 points for those aged 60–69 years, and 4 points for those aged ≥ 70 years to the total score recorded from the patient's comorbidities.

NHFS

This objective scoring system comprises seven parameters: age, sex, presence of ≥ 2 comorbidities, Abbreviated Mental Test (AMT) score [14], hemoglobin level during admission, presence of malignancy, and living in a nursing home. An AMT score of < 7 points was reflected as 1 point in the NHFS. The sum of the scores obtained from the seven parameters was calculated as the final score, with the lowest score being 0 and the highest score being 10 [15].

CFS

For calculating the CFS score, patients' comorbidities, cognition status, and functional status were evaluated using clinical descriptors and illustrated graphics to generate a frailty score ranging from 1 (very fit) to 9 (terminally ill). The CFS score was determined by evaluating patients' self-sufficiency or the level of help needed for performing daily activities such as bathing, dressing, house chores, climbing stairs, cooking, taking medication, going out of the house, shopping, and monitoring the financial situation [16].

Preoperative comorbidities; the NHFS; and ASA-PS, AACCI, AMT, and CFS scores of all patients were recorded for further analyses.

Standard monitoring was performed for the patients in the operating room. Electrocardiography, invasive arterial monitoring, and peripheral oxygen saturation measurement were performed for all patients. Midazolam (1 mg, intravenous) and fentanyl (50 mcg, intravenous) were administered under 4–6 L/min mask oxygen. The patients were placed in the lateral decubitus position and subjected to unilateral spinal anesthesia after infiltration of the skin with 2-mL lidocaine 2%. Subsequently, spinal puncture was performed at the L3–4 or L4–5 intervertebral space level using a 22G atraumatic spinal needle by injecting 10 mg hyperbaric bupivacaine into the intrathecal space via a midline approach under strict adherence to the rules of asepsis and antisepsis. The patients were instructed to remain in the lateral decubitus position for 10 min after the end of spinal injection. Loss of motor function was assessed using the Bromage score. Surgery was started with complete block. Then, cefazolin (2 g, intravenous) and pantoprazole (40 mg, intravenous), as a proton pump inhibitor, were administered for prophylaxis. The amount of blood product and transfusion employed in the intraoperative period was then recorded.

The patients were then transferred to the ICU for follow-up monitoring for 3-month postoperatively. The date of death of the patients was enquired from the national death notification system. Pulmonary, cardiovascular, neurologic, renal-urinary, hematological, surgical, and other complications were registered as postoperative complications. The lengths of ICU and hospital stay and the occurrence of any postoperative complications within 3 months were recorded.

Statistical analysis

The Number Cruncher Statistical System (NCSS) 2020 Statistical Software (NCSS LLC, Kaysville, Utah, USA) program was used for statistical analysis. Quantitative variables were expressed as mean, standard deviation, median, and min and max values, while qualitative variables were expressed as descriptive statistics such as frequency and percentage. The Shapiro–Wilk test and box plot charts were used to evaluate the conformity of the data to normal distribution.

Student's *t* test was used for the quantitative evaluation of two normally distributed groups, whereas Mann–Whitney *U*-test was used for the evaluation of non-normally distributed variables according to two groups. Spearman's correlation analysis was used to evaluate relationships between variables. Chi-square test, Fisher Exact test, and Fisher Freeman Halton test were used to compare qualitative data. The results were evaluated at the 95% confidence interval, and the level of significance was set to $p < 0.05$.

We performed sample size analysis using the Power and Sample Size Program (PS version 3.1.2). The study was planned based on the continuous response variable of two paired samples. A previous study reported that the difference in response was normally distributed for albumin/fibrinogen ratio with a standard deviation of 3.27; if the true difference in the mean response is 1.27, it is necessary to study 108 patients to reject the null hypothesis that this response difference is 0 with a probability of 0.8 [13]. Considering a potential dropout rate of 20%, a total of 131 patients were planned for inclusion in this study.

Results

A total of 113 patients who underwent hip fracture surgery under unilateral spinal anesthesia were included in the study. A total of 108 patients completed the study (Fig. 1). Of these patients, 73.1% ($n = 79$) were women and 26.9% ($n = 29$) were men. The mean FAR of the patients was 0.16 ± 0.15. The demographic data of the patients are shown in Table 1.

Old age ($p = 0.002$), high CRP levels ($p = 0.001$), low albumin levels ($p = 0.001$), high NHFS ($p = 0.001$), and high FAR ($p = 0.018$) were found to be associated with 3-month mortality (Table 2). The lengths of ICU stay ($p = 0.0014$), and hospital stay ($p = 0.039$) of the patients who died were higher than those of patients who survived (Table 1).

According to the 3-month mortality, no difference in sex, BMI, and ASA-PS score ($p > 0.05$) was noted between the patients who died and those who survived; however, the FAR of the patients who died was higher than that of patients who survived (Table 2). The value of the area under the receiver operative characteristic curve for FAR was determined to be 0.697 (95% confidence interval: 0.558–0.835), with a standard error of 7.1%. The preoperative FAR cutoff value of 0.102 was found to be a predictor of mortality. The sensitivity of FAR in detecting mortality was 92.86%, its specificity was 44.68%, and its negative predictive value was 97.67% (Table 3; Fig. 2). Based on the calculated FAR cutoff value of 0.102, the patients were categorized into Group 1 (FAR < 0.102) and Group 2 (FAR ≥ 0.102).

No difference was observed between the groups in terms of their ASA-PS score, NHFS, and CFS score and comorbidities including diabetes mellitus, coronary artery disease, pulmonary arterial hypertension, congestive heart failure, dementia, left ventricular hypertrophy, acute renal failure, and chronic obstructive pulmonary disease ($p > 0.05$; Table 4). The AACCI score was significantly higher in Group 2 than in Group 1 ($p = 0.029$; Table 4). The rate of having hypertension (HT) ($p = 0.022$) or chronic renal failure (CRF) ($p = 0.013$) was higher in Group 2 than in Group 1 (Table 4). The lengths of hospital stay ($p = 0.044$) and ICU

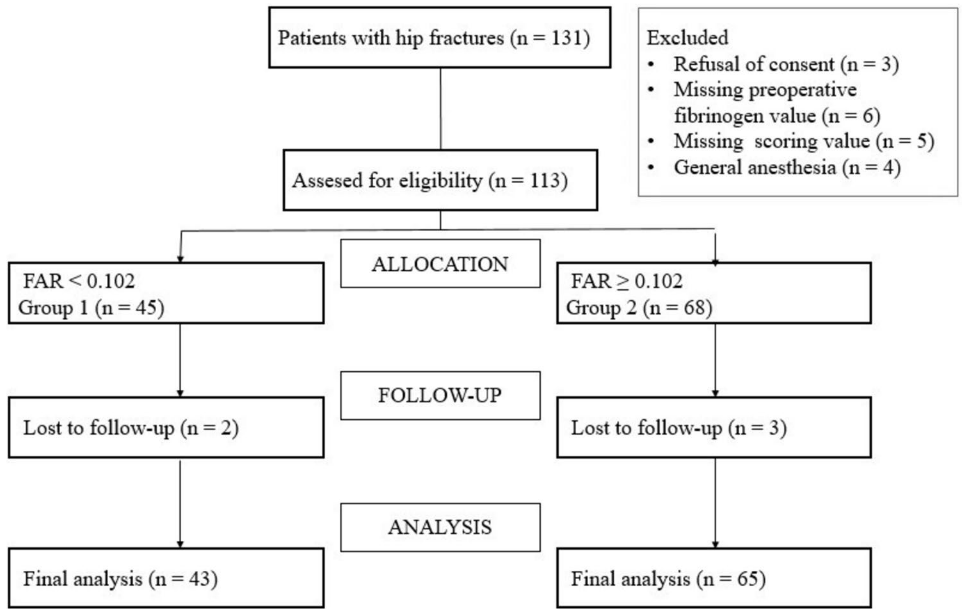

Fig. 1 Flowchart depicting the scheme of the study. *FAR* Fibrinogen/Albumin Ratio

stay ($p = 0.013$) were longer in Group 2 than in Group 1 (Table 4).

The FAR ≥ 0.102 rate ($p = 0.031$), age ($p = 0.021$), AACCI scores ($p = 0.046$), CFS scores ($p = 0.034$), and lengths of ICU stay ($p = 0.001$) and hospital stay ($p = 0.001$) were greater in patients with pulmonary complications than in those without pulmonary complications (Table 5).

Discussion

In this study, a high FAR in patients who underwent hip fracture surgery under unilateral spinal anesthesia was found to be associated with a high AACCI score, lengthy ICU and hospital stays, increased 3-month mortality rate, HT and CRF comorbidities, and postoperative pulmonary complications.

Hip fractures represent a medical emergency with high morbidity and mortality rates. These surgeries are generally performed within 48–72 h, leaving little time for thorough preoperative assessment and patient optimization [4]. This urgency highlights the value of quickly obtained and easily interpreted quantitative measures, such as FAR, for immediate risk assessment. To the best of our knowledge, this is the first study to evaluate the relationship of preoperative FAR with the AACCI score in patients undergoing primary hip fracture surgery.

Albumin, which is a negative acute-phase reactant associated with multiple functions in the body, is a recognized marker of nutrition and mortality [17, 18]. In our study, a relationship was observed between low albumin levels and high mortality rates. We believe that a low preoperative albumin level acts as a simple and early indicator for determining the increased risk in patients with hip fracture, the majority of whom are geriatric patients. However, as the operation is generally urgent for patients with hip fracture, it seems unlikely that nutrition can be restored during the preoperative period.

In a retrospective analysis of 466 patients who underwent revision total knee or revision total hip arthroplasty, decreased albumin/fibrinogen ratio and low serum albumin levels acted as independent risk factors for undergoing revision surgery for septic reasons within 90 days. In addition, an inverse correlation was observed between the patients' albumin/fibrinogen ratios and Charlson comorbidity index scores [13]. In our study, the FARs of patients who died within 3 months postoperatively were higher than those of patients who survived, demonstrating a positive association between the preoperative FAR and AACCI score ($p = 0.029$). Some propositions regarding the AACCI score are subjective. Owing to the urgency of the operation, in operations wherein advanced examinations are performed only in some special cases during the preoperative period, the AACCI score calculated based on the anamnesis and preoperative examination data collected from the patients and their relatives may be miscalculated because of the presence of certain undiagnosed comorbidities. Accordingly, the results may be incorrect, especially for advanced-age patients, who often have multiple comorbidities. As the AACCI is a qualitative measurement, this approach can be useful in estimating the risk of morbidity and mortality.

NHFS is a specific scoring system for patients with hip fracture that does not require surgical data for calculation, thus allowing the calculation to be performed in the preoperative period. The validity of the NHFS has been recognized in predicting early discharge from the hospital and 30 day

Table 1 Demographic characteristics of the study patients

Variables		*n* (%)
Sex	Female	79 (73.1)
	Male	29 (26.9)
Age	Mean ± SD	87.20 ± 3.43
	Median (Min–Max)	85 (85–104)
BMI (kg/m^2)	Mean ± SD	26.69 ± 5.05
	Median (Min–Max)	26.5 (13.6–39.5)
ASA-PS score	II	32 (29.6)
	III	72 (66.7)
	IV	4 (3.7)
AACCI score	Mean ± SD	6.03 ± 1.79
	Median (Min–Max)	6 (4–11)
NHFS	Mean ± SD	5.69 ± 1.25
	Median (Min–Max)	6 (3–9)
CFS score	Mean ± SD	4.90 ± 1.36
	Median (Min–Max)	5 (2–8)
Hemoglobin level (g/dL)	Mean ± SD	10.34 ± 1.81
	Median (Min–Max)	10.4 (3.7–14.1)
Platelet level (10^3/mm^3)	Mean ± SD	228.10 ± 84.50
	Median (Min–Max)	213.5 (63–503)
CRP level (mg/L)	Mean ± SD	46.93 ± 55.24
	Median (Min–Max)	24.4 (0.3–244.2)
Fibrinogen level (mg/dL)	Mean ± SD	408.27 ± 131.36
	Median (Min–Max)	393 (163.4–746)
Albumin level (g/dL)	Mean ± SD	3.58 ± 0.52
	Median (Min–Max)	3.6 (2.2–4.6)
FAR	Mean ± SD	0.16 ± 0.15
	Median (Min–Max)	0.1 (0–0.8)
Erythrocyte suspension transfusion (units)	Mean ± SD	1.56 ± 1.23
	Median (Min–Max)	2 (0–6)
Duration of anesthesia (minutes)	Mean ± SD	112.03 ± 21.16
	Median (Min–Max)	110 (60–160)
Length of ICU stay (day)	Mean ± SD	2.99 ± 5.28
	Median (Min–Max)	2 (1–48)
Length of hospital stay (day)	Mean ± SD	11.36 ± 8.61
	Median (Min–Max)	9 (3–65)
Comorbidity	Mean ± SD	3.84 ± 3.75
	Median (Min–Max)	3 (0–22)
Mortality (3 months)	Alive	94 (87.0)
	Deceased	14 (13.0)

BMI body mass index, *ICU* intensive care unit, *ASA-PS* american society of anesthesiologists physical status, *AACCI* age-adjusted charlson comorbidity index, *NHFS* nottingham hip fracture score, *CFS* clinical frailty scale, *CRP* C-reactive protein, *FAR* fibrinogen/albumin ratio

and 1 year mortality rates [19, 20]. In our study, patients who died had higher NHFS scores than those who survived. We believe that the NHFS, which is specific to patients with hip fracture, can help clinicians predict and plan the perioperative process.

More than 50 years ago, it was reported that inflammatory mechanisms play a role in the pathogenesis of HT [21]. It was also shown that the levels of inflammatory markers such as fibrinogen and CRP increase in HT patients [22], whereas those of albumin decrease [23]. In some studies, hypoalbuminemia and hyperfibrinogenemia developed in cases of cardiovascular comorbidities associated with CRF, and these cases were associated with poor prognosis [12]. In a study of 249 patients newly diagnosed with HT who visited the

Table 2 Comparison of the Study Variables Based on 3-month Mortality

Variables		3-Month Mortality		*p*
		Alive (*n* = 94)	Deceased (*n* = 14)	
Age	Mean ± SD	87.06 ± 3.35	90.20 ± 4.21	***a*0.002****
	Median (Min–Max)	85 (85–104)	89 (85–95)	
Sex	Female	72 (76.6)	7 (50.0)	***b*0.052**
	Male	22 (23.4)	7 (50.0)	
BMI (kg/m^2)	Mean ± SD	26.73 ± 4.91	25.74 ± 8.14	***a*0.745**
	Median (Min–Max)	26.3 (16.8–39.5)	27.3(13.6–35.5)	
ASA-PS score	I	31 (33.0)	1 (7.1)	***b*0.081**
	II	60 (63.8)	12 (85.7)	
	III	3 (3.2)	1 (7.1)	
Length of ICU (day)	Mean ± SD	2.00 ± 2.00	8.00 ± 13.00	***a*0.014***
	Median (Min–Max)	1 (1–17)	3 (1–48)	
Length of hospital stay (day)	Mean ± SD	10.00 ± 6.00	18.00 ± 16.00	***a*0.039***
	Median (Min–Max)	9 (3–41)	14 (3–65)	
CRP level (mg/L)	Mean ± SD	40.50 ± 51.21	90.10 ± 63.67	***a*0.001****
	Median (Min–Max)	13 (0.3–219.2)	80.6 (18–244.2)	
Fibrinogen level (mg/dL)	Mean ± SD	400.61 ± 124.92	459.70 ± 164.71	***a*0.182**
	Median (Min–Max)	383.7 (163.4–746)	450.2 (185–722.3)	
Albumin level (g/dL)	Mean ± SD	3.65 ± 0.51	3.14 ± 0.35	***a*0.001****
	Median (Min–Max)	3.8 (2.2–4.6)	3.2 (2.6–3.6)	
AACCI score	Mean ± SD	6.00 ± 2.00	7.00 ± 2.00	***a*0.011***
	Median (Min–Max)	5 (4–11)	7 (4–10)	
NFHS	Mean ± SD	6.00 ± 1.00	7.00 ± 1.00	***a*0.001****
	Median (Min–Max)	5 (3–9)	7 (5–8)	
CFS score	Mean ± SD	5.00 ± 1.00	5.00 ± 1.00	***a*0.409**
	Median (Min–Max)	5 (2–8)	5 (4–7)	
FAR	Mean ± SD	0.148 ± 0.149	0.192 ± 0.150	***a*0.018***
	Median (Min–Max)	0.11 (0.0–0.8)	0.16 (0.10–0.68)	

BMI body mass index, *ICU* intensive care unit, *ASA-PS* american society of anesthesiologists physical status, *CRP* C-reactive protein, *AACCI* age-adjusted charlson comorbidity index, *NHFS* nottingham hip fracture score, *CFS* clinical frailty scale, *FAR* fibrinogen/albumin ratio

[a]Mann–Whitney *U*-Test

[b]Fisher Freeman Halton Test

*$p < 0.05$, **$p < 0.01$

Table 3 Diagnostic Screening Tests and ROC Curve Results for FAR

	Diagnostic scan					ROC curve		
	Cut off	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Area	95% Confidence interval	*p*
FAR	≥ 0.102	92.86	44.68	20.00	97.67	0.697	0.558–0.835	***0.024****

ROC receiver operating characteristic, *FAR* fibrinogen/albumin ratio

*$p < 0.05$

cardiology outpatient clinic of a hospital, the patients who responded to treatment had a high FAR, suggesting that it is a strong marker for predicting high morning blood pressure, which is associated with cardiovascular diseases such as atherosclerosis [24]. This study is important considering that a high FAR indicates that patients are prone to cardiovascular risks. In our study, the rate of having HT and/or CRF in Group 2 was higher than that in Group 1. One of the most important pathologies underlying CRF is HT, and these two often occur as comorbidities. We believe that FAR can help identify geriatric patients prone to cardiovascular risks as well as determine the prognosis of patients with HT or CRF.

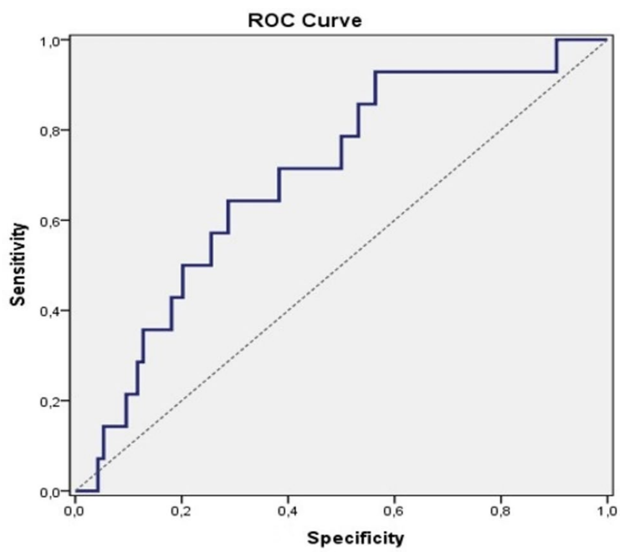

Fig. 2 ROC Curve for FAR based on 3-month mortality. *ROC* Receiver Operating Characteristic

Although general anesthesia was not applied in the present study, postoperative pulmonary complications developed in the study patients. With advanced age, respiratory muscles weaken and closing capacity increases, the risk of aspiration increases accompanied by dysphagia, and the response of the respiratory center to hypoxia and hypercapnia decreases. Postoperative mobilization of patients with hip fracture may be delayed because of osteoporosis, comorbidities, and some other treatments. All these factors may predispose this population to postoperative pulmonary complications. In our study, an increased FAR was associated with postoperative pulmonary complications, implying that FAR can be used in clinical practice to predict pulmonary complications that can aggravate and become fatal at an advanced age.

Recent studies highlight the relationship between fibrinogen levels and bone health, indicating that inflammation may increase fracture risk through mechanisms that trigger bone resorption [25, 26]. An inverse association has been observed between fibrinogen levels and bone mineral density, suggesting that FAR could serve as an indicator of both bone health and the risk of surgical complications. It takes 5–10 days for fibrinogen levels to peak after acute inflammation (such as trauma or operation) [27]. Fibrinogen, which is a positive acute-phase reactant, also plays a role in coagulation, and its level may decrease in major traumas [28]. Hip fracture is an emergency, and it is recommended that patients be operated within 48–72 h [4]. Therefore, fibrinogen levels measured preoperatively in such patients may not be sufficiently high. These reasons may explain why we did not observe any relationship between fibrinogen and mortality and morbidity in our study.

FAR has been shown to be a predictor of disease severity in patients with acute coronary syndrome, stroke, chronic venous insufficiency and hypertension [12, 29]. Given the association of elevated fibrinogen and decreased albumin levels with a prothrombotic and proinflammatory state, we propose a multidisciplinary approach that includes early identification and communication with patients and their families about potential risks. Timely surgical intervention is crucial, as delays can exacerbate patient outcomes. Intraoperative monitoring should focus on complications related to thrombotic and inflammatory processes. It is essential to inform the surgical team about potential risks, such as fracture recurrence and prosthetic failure due to the inverse association between fibrinogen and bone health and to carefully evaluate antibiotic use to minimize surgical site infection risks [25, 26]. Postoperatively, implementing respiratory physiotherapy, initiating anticoagulation promptly, encouraging early mobilization, and providing comprehensive care instructions to family members will be vital in ensuring optimal recovery and reducing complications in this vulnerable population.

The limitations of this study are that the study design was observational in nature, it was a single-center study, the operations were performed by different surgeons, and the number of patients was limited.

In this study, a significant association was found between the NHFS and 3-month mortality; however, no correlation was observed between FAR and NHFS. We noted a significantly positive association between the AACCI score and preoperative FAR in patients with hip fracture. We believe that preoperative FAR, which is an inexpensive and readily available test, may be a promising marker for predicting mortality and complications in patients with hip fracture, and related randomized controlled trials with a larger sample size may further clarify our findings.

Table 4 FAR vs. variables

Variables		FAR		*p*
		< 0.102 (*n* = 43)	≥ 0.102 (*n* = 65)	
ASA-PS	*II*	13 (30.2)	19 (29.2)	***b*0.817**
	III	29 (67.5)	43 (667.2)	
	IV	1 (2.3)	3 (4.6)	
Diabetes mellitus	−	31 (72.1)	41 (63.1)	***e*0.331**
	+	12 (27.9)	24 (36.9)	
Hypertension	−	10 (23.3)	5 (7.7)	***e*0.022***
	+	33 (76.7)	60 (92.3)	
Coronary artery disease	−	35 (81.4)	42 (64.6)	***e*0.059**
	+	8 (18.6)	23 (35.4)	
Peripheral artery disease	−	41 (95.3)	63 (96.9)	***c*1.000**
	+	2 (4.7)	2 (3.1)	
Congestive heart failure	−	36 (83.7)	55 (84.6)	***e*0.901**
	+	7 (16.3)	10 (15.4)	
Dementia	−	31 (72.1)	49 (75.4)	***e*0.702**
	+	12 (27.9)	16 (24.6)	
Cerebrovascular disease	−	35 (81.4)	52 (80.0)	***c*1.000**
	+	8 (18.6)	13 (20.0)	
Chronic renal failure	−	39 (90.7)	46 (70.8)	***e*0.013***
	+	4 (9.3)	19 (29.2)	
Acute renal failure	−	41 (95.3)	58 (89.2)	***c*0.312**
	+	2 (4.7)	7 (10.8)	
Chronic obstructive pulmonary disease	−	40 (93.0)	62 (95.4)	***c*0.681**
	+	3 (7.0)	3 (4.6)	
Length of hospital stay (day)	Mean ± SD	9.37 ± 5.89	12.68 ± 9.34	***a*0.044***
	Median (Min–Max)	9 (3–41)	10 (5–65)	
Length of ICU (day)	Mean ± SD	1.74 ± 1.21	3.82 ± 6.63	***a*0.013***
	Median (Min–Max)	1 (1–7)	2 (1–48)	
AACCI score	Mean ± SD	5.58 ± 1.65	6.32 ± 1.82	***a*0.029***
	Median (Min–Max)	5 (4–11)	6 (4–10)	
NHFS	Mean ± SD	5.60 ± 1.16	5.75 ± 1.31	***a*0.569**
	Median (Min–Max)	6 (3–8)	6 (3–9)	
CFS score	Mean ± SD	4.84 ± 1.43	4.94 ± 1.032	***a*0.721**
	Median (Min–Max)	5 (2–8)	5 (2–7)	

FAR fibrinogen/albumin ratio, *ASA-PS* american society of anesthesiologists physical Status, *ICU* intensive care unit, *AACCI* age-adjusted charlson comorbidity index, *NHFS* Nottingham Hip Fracture Score, *CFS* clinical frailty scale

[a]Mann–Whitney *U*-Test

[b]Fisher Freeman Halton Test

[c]Fisher Exact Test

[e]Pearson Chi-Square

*$p < 0.05$

Table 5 Comparison of study Vvariables based on pulmonary complications

Variables		Pulmonary complication		*p*
		Did not occur ($n=84$)	Occured ($n=24$)	
CRP level (mg/L)	Mean ± SD	45.28 ± 55.51	52.7 ± 55.07	***a*0.412**
	Median (Min–Max)	22.3 (0.3–244.2)	38.2 (0.5–219.2)	
Fibrinogen level (mg/dL)	Mean ± SD	404.36 ± 133.79	421.97 ± 124.22	***d*0.565**
	Median (Min–Max)	384.1(163.4–746)	427.4(185–722.3)	
Albumin (g/dL)	Mean ± SD	3.62 ± 0.47	3.43 ± 0.64	***d*0.111**
	Median (Min–Max)	3.7 (2.6–4.6)	3.4 (2.2–4.6)	
FAR (Cutoff)	< 0.102	38 (45.2)	5 (20.8)	***e*0.031***
	≥ 0.102	46 (54.8)	19 (79.2)	
Age	Mean ± SD	86.85 ± 3.16	88.46 ± 4.12	***a*0.021***
	Median (Min–Max)	85 (85–104)	87 (85–97)	
Sex	Female	60 (71.4)	19 (79.2)	***e*0.451**
	Male	24 (28.6)	5 (20.8)	
BMI (kg/m^2)	Mean ± SD	26.91 ± 5.02	25.90 ± 5.20	***d*0.462**
	Median (Min–Max)	26.5 (16.8–39.5)	25.4 (13.6–35.5)	
ASA-PS score	II	27 (32.1)	5 (20.8)	***b*0.517**
	III	54 (64.3)	18 (75)	
	IV	3 (3.6)	1 (4.2)	
Length of ICU stay (day)	Mean ± SD	2.00 ± 2.00	6.00 ± 10.00	***a*0.001****
	Median (Min–Max)	1 (1–19)	3 (1–48)	
Length of hospital stay (day)	Mean ± SD	9.00 ± 5.00	19.00 ± 13.00	***a*0.001****
	Median (Min–Max)	8 (3–40)	14 (5–65)	
AACCI score	Mean ± SD	6.00 ± 2.00	7.00 ± 2.00	***a*0.046***
	Median (Min–Max)	5 (4–11)	7 (4–10)	
NHFS	Mean ± SD	6.00 ± 1.00	6.00 ± 1.00	***d*0.242**
	Median (Min–Max)	6 (3–9)	6 (3–8)	
CFS score	Mean ± SD	5.00 ± 1.00	5.00 ± 1.00	***d*0.034***
	Median (Min–Max)	5 (2–8)	6 (3–7)	

CRP C-reactive protein, *FAR* fibrinogen/albumin ratio, *BMI* body mass index, *ASA-PS* american society of anesthesiologists physical status, *ICU* Intensive Care unit, *AACCI* age -adjusted charlson comorbidity index, *NHFS*: nottingham hip fracture score, *CFS* clinical Frailty Scale

[a]Mann–Whitney-*U* Test

[b]Fisher Freeman Halton Test

[d]Student's t test

[e]Pearson's Chi-Square

*$p<0.05$, **$p<0.0$

Data availability The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors declare no conflicts of interest.

References

1. Alterovitz SS, Mendelsohn GA. Relationship goals of middle-aged, young-old, and old-old internet daters: an analysis of online personal ads. J Aging Stud. 2013;27:159–65.
2. Bhushan S, Huang X, Duan Y, Xiao Z. The impact of regional versus general anesthesia on postoperative neurocognitive outcomes in elderly patients undergoing hip fracture surgery: a systematic review and meta-analysis. Int J Surg. 2022;105: 106854.
3. Haleem S, Choudri MJ, Kainth GS, Parker MJ. Mortality following hip fracture: trends and geographical variations over the last SIXTY years. Injury. 2023;54:620–9.
4. Seong YJ, Shin WC, Moon NH, Suh KT. Timing of hip-fracture surgery in elderly patients: literature review and recommendations. Hip Pelvis. 2020;32:11–6.
5. Di Martino G, Di Giovanni P, Cedrone F, D'Addezio M, Meo F, Scampoli P, Romano F, Staniscia T. Development and validation of a new tool in predicting in-hospital mortality for hip-fractured patients: the PRIMOF score. Medicina (Kaunas). 2022;58:1082.

6. Charlson ME, Carrozzino D, Guidi J, Patierno C. Charlson comorbidity index: a critical review of clinimetric properties. Psychother Psychosom. 2022;91:8–35.
7. Thorne G, Hodgson L. Performance of the nottingham hip fracture score and clinical frailty scale as predictors of short and long-term outcomes: a dual-centre 3-year observational study of hip fracture patients. J Bone Miner Metab. 2021;39:494–500.
8. Doherty WJ, Stubbs TA, Chaplin A, Reed MR, Sayer AA, Witham MD, Sorial AK. Prediction of postoperative outcomes following hip fracture surgery: independent validation and recalibration of the nottingham hip fracture score. J Am Med Dir Assoc. 2021;22:663–9.
9. Suidan RS, Leitao MM Jr, Zivanovic O, Gardner GJ, Long Roche KC, Sonoda Y, Levine DA, Jewell EL, Brown CL, Abu-Rustum NR, Charlson ME, Chi DS. Predictive value of the age-adjusted charlson comorbidity index on perioperative complications and survival in patients undergoing primary debulking surgery for advanced epithelial ovarian cancer. Gynecol Oncol. 2015;138:246–51.
10. Basic D, Shanley C. Frailty in an older inpatient population: using the clinical frailty scale to predict patient outcomes. J Aging Health. 2015;27:670–85.
11. Huang L, Mo Z, Zhang L, Qin S, Qin S, Li S. Diagnostic value of albumin to fibrinogen ratio in cervical cancer. Int J Biol Markers. 2020;35:66–73.
12. Lin L-H, Liu H, Jin D-H, Zou J, Xie Y-X, Qiu H, Jia M, Li D-M, Liu B-C. Fibrinogen-to-albumin ratio is related to the severity of coronary artery disease in chronic kidney disease patients undergoing coronary angiography. Nefrologia. 2022;42:696–703.
13. Maimaiti Z, Xu C, Fu J, Tianyu Li W, Chai W, Zhou Y, Chen J. A novel biomarker to screen for malnutrition: albumin/fibrinogen ratio predicts septic failure and acute infection in patients who underwent revision total joint arthroplasty. J Arthroplasty. 2021;36:3282–8.
14. Jitapunkul S, Pillay I, Ebrahim S. The abbreviated mental test: its use and validity. Age Ageing. 1991;20:332–6.
15. Kapur B, Shumon S, Platt S. A worsening trend - possum and nhfs in patients with a fractured neck of femur. J Ortho Bone Disord. 2017;1: 000105.
16. Mendiratta P, Schoo C, Latif R. Clinical Frailty Scale. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK559009/
17. Zhang Z, Pereira SL, Luo M, Matheson EM. Evaluation of blood biomarkers associated with risk of malnutrition in older adults: a systematic review and meta-analysis. Nutrients. 2017;9:829.
18. Malafarina V, Reginster JY, Cabrerizo S, Bruyere O, Kanis JA, Martinez JA, Zulet MA. Nutritional status and nutritional treatment are related to outcomes and mortality in older adults with hip fracture. Nutrients. 2018;10:555.
19. Moppett IK, Wiles MD, Moran CG, Sahota O. The nottingham hip fracture score as a predictor of early discharge following fractured neck of femur. Age ageing. 2012;41:322–6.
20. Wiles M, Moran C, Sahota O, Moppett I. Nottingham hip fracture score as a predictor of one year mortality in patients undergoing surgical repair of fractured neck of femur. Br J Anaesth. 2011;106:501–4.
21. Xiao L, Harrison DG. Inflammation in hypertension. Can J Cardiol. 2020;36:635–47.
22. Jae SY, Kurl S, Laukkanen JA, Lee CD, Choi YH, Fernhall B, Franklin BA. Relation of C-reactive protein, fibrinogen, and cardiorespiratory fitness to risk of systemic hypertension in men. Am J Cardiol. 2015;115:1714–9.
23. Ahbap E, Sakaci T, Kara E, Sahutoglu T, Koc Y, Basturk T, Sevinc M, Akgol C, Kayalar AO, Ucar ZA. The relationship between serum albumin levels and 24 h ambulatory blood pressure monitoring recordings in non-diabetic essential hypertensive patients. Clinics (Sao Paulo). 2016;71:257–63.
24. Özdemir M, Yurtdaş M, Asoğlu R, Yildirim T, Aladağ N, Asoğlu E. Fibrinogen to albumin ratio as a powerful predictor of the exaggerated morning blood pressure surge in newly diagnosed treatment-naive hypertensive patients. Clin Exp Hypertens. 2020;42:692–9.
25. Chen YJ, Wang X, Zhang HY, Du YN, Jin XJ, Zhang ZF. Inverse association between bone mineral density and fibrinogen in menopausal women. Climacteric. 2021;24:146–50.
26. Du W, Wang Z, Dong Y, Hu J, Chan X. Association between fibrinogen and bone mineral density postmenopausal women. J Orthop Surg Res. 2023;18:376.
27. Gabay C, Kushner I. Acute-phase proteins and other systemic responses to inflammation. N Engl J Med. 1999;340:448–54.
28. Winearls J, Reade MC, McQuilten Z, Curry N. Fibrinogen in traumatic haemorrhage. Curr Opin Anaesthesiol. 2021;34:514–20.
29. Acharya P, Jakobleff WA, Forest SJ, Chinnaduria T, Mellas N, Patel SR, Kizer JR, Billett HH, Goldstein DJ, Jorde UP, Saeed O. Fibrinogen albumin ratio and ischemic stroke during venoarterial extracorporeal membrane oxygenation. ASAIO J. 2020;66:277–82.