Günaydın *et al.*
BMC Musculoskeletal Disorders (2025) 26:22
https://doi.org/10.1186/s12891-024-08207-1

BMC Musculoskeletal Disorders

RESEARCH

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AST/ALT ratio as a potential predictor of 1-year mortality in elderly patients operated for femoral neck fracture

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Abstract

Purpose Hip fractures in elderly individuals are associated with high mortality rates, even with advanced treatment options. Identifying factors correlated with mortality could guide potential preventive strategies. Elevated aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels, as well as the AST/ALT ratio (AAR), have been associated with mortality in various diseases, but their association with hip fracture mortality remains underexplored. This study investigates the correlation between AST, ALT, AAR, and routine laboratory parameters with 1-year mortality in elderly patients undergoing partial hip arthroplasty for femoral neck fractures.

Methods This retrospective cohort study analyzed data from 179 elderly patients (≥60 years) who underwent partial hip replacement for femoral neck fracture between January 2019 and December 2021.

Results Of the 179 patients, 29.6% died within one year of surgery. The deceased patients were older, predominantly male, and had higher rates of postoperative complications and transfusions. Univariate analysis identified age, sex, blood type, comorbidities, postoperative complications, transfusions, and laboratory parameters (including AAR, creatinine, and lymphocyte count) as associated with mortality. Multivariate analysis further highlighted advanced age, male sex, blood group A, postoperative transfusions, elevated creatinine levels, and high AAR (>2.1) as independent predictors of mortality.

Conclusion Our findings suggest that preoperative AAR may serve as an independent predictor of mortality in elderly patients undergoing hip fracture surgery, highlighting its potential utility in preoperative risk stratification.

Keywords AST/ALT ratio, Hip fracture, Laboratory parameters, Mortality prediction, Preoperative predictors

Introduction

Hip fractures in elderly individuals represent a major health burden with substantial mortality rates, despite advancements in surgical and medical management. Thirty-three percent of men and 22% of women who suffer a hip fracture die within one year [1, 2]. Understanding factors associated with mortality may offer insights into potential preventive strategies.

Serum aminotransferase activity, particularly aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels are indicators of liver function and systemic inflammation. Elevated levels of AST and

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ALT, as well as their ratio (AST/ALT ratio or AAR), have been linked to mortality across various diseases, suggesting their potential as biomarkers of systemic health and mortality risk [3].

In recent years, the AST/ALT ratio (AAR) has emerged as an area of growing interest due to its potential as a prognostic biomarker across a range of medical conditions. This ratio has been particularly investigated in relation to its prognostic value in cardiovascular diseases, providing insights into its broader clinical relevance.

A study by Liu et al. investigated the association between an elevated AAR and all-cause mortality in stable CAD patients, providing valuable insights into its predictive potential [4]. Their research identified an optimal threshold for the AAR at 1.4, above which patients demonstrated significantly higher mortality rates. This finding supports the use of the AAR as a low-cost, accessible tool for risk stratification in stable CAD patients, particularly those undergoing percutaneous coronary intervention (PCI). The study further emphasized that an elevated AAR correlates with a higher risk of adverse cardiac events and long-term mortality, suggesting its broader applicability as a prognostic marker in elderly patients and other populations with chronic conditions.

Based on findings from the study by Li et al. [5], the AAR has demonstrated predictive value in the context of mortality and clinical exacerbations among patients with polymyositis/dermatomyositis-associated interstitial lung disease (PM/DM-ILD). In this cohort of 522 patients, a higher AAR (>1.73) was independently associated with a significant increase in 1-year mortality, as well as a greater need for mechanical ventilation and hospital readmission due to disease exacerbations [5].

The AAR has shown significant associations with both all-cause mortality and cancer incidence, making it a valuable biomarker in clinical prognostication. Chen et al. examined a large cohort and found that participants in the highest AAR quartile had a nearly 1.5 times increased risk of all-cause mortality compared to those in the lowest quartile [6]. This elevated ratio was similarly predictive of higher cancer incidence rates, particularly for colorectal cancer, where those with higher AARs demonstrated an increased cancer risk [6].

To our knowledge, no studies have yet examined the association between AST, ALT, and AAR with mortality following hip fracture surgery. This study seeks to fill this gap by investigating these markers in a cohort of elderly patients undergoing partial hip arthroplasty for femoral neck fractures, focusing on their potential predictive value for 1-year mortality.

Methods

Study design

This retrospective observational cohort study was conducted in accordance with the principles of the Declaration of Helsinki. This research was approved by the Mersin University ethics committee (decision date and no: 01.11.2023, 21/740). The study was conducted at the orthopedic surgery department of our regional trauma center. We retrospectively evaluated the data of patients who underwent partial hip replacement for femoral neck fractures in our hospital between January 2019 and December 2021 using the hospital information system. In preparing this report, we adhered to the principles outlined in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Patient selection and data collection

This study evaluated 179 patients who underwent hip fracture surgery at our hospital between January 2019 and December 2021. The inclusion criteria were patients over 60 years of age who underwent partial hip replacement for a femoral neck fracture and who were independently mobile without assistance prior to the fracture. Patients with pathologic fractures, multiple fractures, liver disease, or those who were not independently mobile were excluded from the study. Although the same surgical approach was applied to patients who were not independently mobile, these patients were not included in the study. The flowchart of the study is shown in Figure 1.

To ensure standardization, only patients who were treated using a single wedge tapered stem, manufactured by Tıpsan (Izmir, Turkey), with the same surgical technique were included. All surgeries were performed by the same surgical team using cementless hemiarthroplasty with a bipolar head. All patients received low-molecular-weight heparin for thromboprophylaxis for four weeks. Preoperatively, all patients were reported to be able to walk independently and perform daily activities without the need for assistive devices. Postoperatively, all patients were mobilized with the assistance of healthcare personnel within 48 hours.

In this study, postoperative blood transfusions were administered based on standardized clinical criteria commonly applied in elderly hip fracture patients. The primary indications for transfusion included a hemoglobin level below 8 g/dL, symptomatic anemia (such as shortness of breath, dizziness, tachycardia, or chest pain), significant postoperative blood loss (defined as >500 mL or requiring hemodynamic stabilization), and/or the presence of cardiovascular or pulmonary insufficiency.

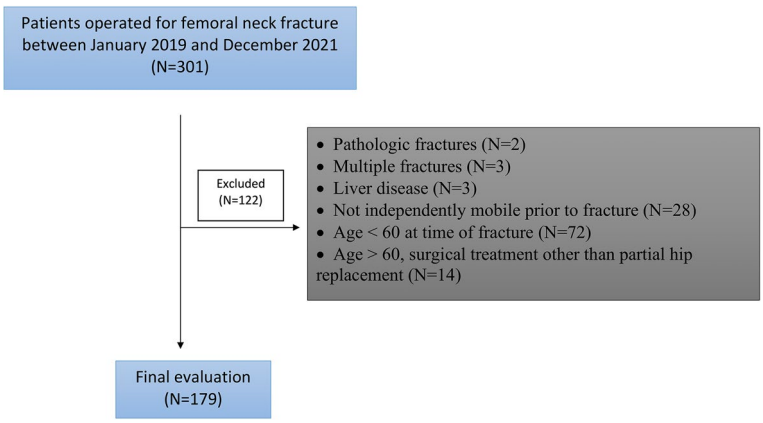

Fig. 1 The flowchart of the study

For patients with a history of cardiovascular disease, a higher transfusion threshold (hemoglobin level below 10 g/dL) was considered. These criteria were implemented to ensure that transfusions were given to optimize oxygen delivery and minimize adverse outcomes in a high-risk elderly population.

Clinical evaluation included various parameters such as age, sex, surgical side, ASA score, anesthesia type, comorbidities, mortality rate, postoperative complications, and the amount of blood transfusion. Postoperative blood transfusions were recorded as separate interventions and were not classified as complications in this study. Complications were defined as adverse events such as infection, periprosthetic fracture, and dislocation.

Laboratory parameters, including AST, AAR, Gamma-Glutamyl Transferase (GGT), total bilirubin, blood urea nitrogen (BUN), creatinine, hematocrit (Htc), platelets, white blood cells (WBCs), lymphocytes (LYMs), and the AB Rh blood group, were obtained from the preoperative laboratory data of the patients. These tests are part of the routine preoperative assessments for trauma patients admitted to the emergency department.

Patient data, including demographic information, comorbidities, laboratory values, and mortality status, were collected retrospectively from the hospital's electronic medical records. Key variables such as age, sex, ASA score, blood type, and comorbidities were extracted directly from these records. Laboratory parameters were gathered from preoperative blood tests.

In our country, there is a national health registry network that provides access to comprehensive health records for patients who have consented to data sharing. For mortality data, a two-step approach was used to ensure completeness. Mortality information for patients who passed away within the hospital was obtained directly from hospital records and the national health registry. For patients whose data were not accessible online through this network, follow-up was conducted by contacting their relatives via telephone to confirm mortality status. This approach ensured that mortality data were successfully obtained for all patients meeting the inclusion criteria, minimizing missing data and providing a reliable dataset for subsequent analysis.

Statistical analysis

Statistical analysis was conducted using the R-based software jamovi (version 2.3) to investigate the relationships between various clinical and surgical factors and one-year mortality in the study cohort. Descriptive statistics were utilized to summarize baseline characteristics, including demographics, comorbidities, and surgical outcomes. Comparative analyses between survivor and deceased groups were conducted using appropriate statistical tests, including Mann–Whitney U tests, independent t tests, chi–square tests, or Fisher's exact tests. Univariate regression analysis was employed to evaluate the association of each variable with mortality, and the hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated. Significant variables (p <0.05) from the univariate analysis were integrated into a multivariate logistic regression model to discern independent predictors of mortality with adjusted HRs, employing backward elimination procedures for model refinement. Additionally, ROC curve analysis was performed for the AAR, categorizing it based on the optimal cutoff (2.1) value with the highest Youden index. Moreover, Kaplan-Meier survival analysis was also conducted to compare survival outcomes between groups. Statistical significance was set at p <0.05 for all analyses.

Results

In this study, 179 patients with a median age of 83 (IQR: 74–87) years were included. The majority were female (58.1%), and most surgeries were performed on the right side (60.9%). The predominant ASA score was 3 (68.7%), and common comorbidities included cardiac disease (75.9%), neurological disease (23.5%), and pulmonary disease (20.7%). Postoperative complications occurred in 6.7% of patients, 27.9% of whom required postoperative transfusion. The overall mortality rate was 29.6% (n=53), with a median time from surgery to death of 3 months (IQR 3–5). Table 1 summarizes the baseline characteristics of the patients.

A comparison of the clinical and surgical characteristics between survivors and deceased patients, as shown in Table 2, revealed significant differences. The deceased patients were older (median age 86.0 vs. 80.0 years, p *<0.001*) and had fewer females (26.4% vs. 71.4%, p *<0.001*). They also had a greater prevalence of blood group A (73.6% vs. 41.3%, p *<0.001*) and experienced more postoperative complications (15.1% vs. 3.2%, p = *0.010*) and transfusions (47.2% vs. 19.8%, p *<0.001*). Additionally, deceased patients had higher urea (p = *0.019*) and creatinine (p = *0.001*) levels and AST/ALT ratios (p = *0.021*), while their lymphocyte counts were lower than those of survivors (1.0 ± 0.4 vs. 1.4 ± 0.6, p *<0.001*). According to the univariate regression analysis, most of these variables were significantly associated with one-year mortality. These included age (HR 1.08, 95% CI 1.04–1.13, p < *0.001*), female sex (HR 0.14, 95% CI 0.07–0.30, p < *0.001*), blood group O (HR 0.18, 95% CI 0.06–0.52, p = *0.002*), blood group A (HR 3.96, 95% CI 1.96–8.03, p < *0.001*), presence of cardiovascular disease (HR 0.28, 95% CI 0.14–0.58, p < *0.001*), postoperative complications (HR 5.42, 95% CI 1.56–18.9, p = *0.008*), postoperative transfusion (HR 3.61, 95% CI 1.80–7.23, p < *0.001*), AAR (HR 2.60, 95% CI 1.31–5.15, p = *0.006*), creatinine levels (HR 10.31, 95% CI 3.57–29.82, p < *0.001*), and WBC count (HR 0.87, 95% CI 0.78–0.97, p = (Table 2).

The multivariate logistic regression model incorporated variables such as age, sex, fracture side, blood group (BG) O and A, the presence of cardiovascular comorbidity (CVD), postoperative complications or transfusions, and laboratory parameters, including the AAR, creatinine level, WBC count, and lymphocyte count ($X^2_{(12)}$ = 150.7, p *<0.001;* Table 3). Backward procedures involving the removal of WBCs, the fracture site, blood type A, and the presence of complications that were not revealed as significant predictors in the first multivariate model did not significantly alter the pseudo R2 values (Nagelkerke's R2: 0.809 to 0.793; McFadden's: 0.692 to 0.671). Additionally, these procedures resulted in a decrease in the Bayesian information criterion (BIC; 134.2 to 118.2) and Akaike information criterion (AIC: 92.8 to 89.5), indicating no substantial difference in predictive ability between the two models. Therefore, the final model included age, sex, AAR, lymphocyte count, creatinine levels, presence of postoperative complications, transfusions, blood group O, and cardiovascular disease. According to the regression analysis, advanced age emerged as a notable risk factor, with each additional year contributing to a 21% increase in the likelihood of mortality (HR 1.21, 95% CI 1.10–1.33). Conversely, female patients demonstrated a substantially reduced risk of mortality compared to male patients, with a hazard ratio of 0.06 (95% CI 0.02–0.23). Interestingly, blood group O had a slight protective effect on mortality, with a hazard ratio of 0.01 (95% CI 0.01–0.39). Furthermore, the presence of cardiovascular disease was associated with a lower mortality risk (HR 0.06, 95% CI 0.01–0.29).

However, postoperative transfusion significantly increased the risk of mortality, with a notably high

Table 1 The baseline characteristics of patients and surgeries

Characteristics, *n*=179	**Value**
Age, median (IQR)	83 (74- 87)
Female, n (%)	104 (58.1)
Right sided, n (%)	109 (60.9)
ASA score, n (%)	
• 2	27 (15.1)
• 3	123 (68.7)
• 4	29 (16.2)
Comorbidities, n (%)	
• Diabetes	23 (12.8)
• Pulmonary disease	37 (20.7)
• Nephrological disease	4 (2.2)
• Neurological disease	42 (23.5)
• Cardiac disease	136 (75.9)
Blood type, n (%)	
• O	44 (24.6)
• A	91 (50.8)
• B	22 (12.3)
• AB	22 (12.3)
• Rh	165 (92.2)
Anesthesia Type, (Spinal), n (%)	167 (93.3)
Postop complications, n (%)	
• Infection	4 (2.2)
• Periprosthetic fracture	4 (2.2)
• Dislocation	4 (2.2)
Postop transfusion, n (%)	50 (27.9)
Mortality, n (%)	53 (29.6)
Surgery to death (month), median (IQR)	3 (3- 5)

IQR Interquartile Range

Table 2 Comparison of clinical and surgical characteristics between survivors and deceased patients

	Alive (*N*=126)	Deceased (*N*=53)	Total (*N*=179)	*P* value
Age, median (IQR)	80.0 (72.2- 86.0)	86.0 (77.0- 92.0)	83.0 (74.0- 87.0)	**<0.001**
Female, n (%)	90 (71.4)	14 (26.4)	104 (58.1)	**<0.001**
Side (right), n (%)	84 (66.7)	25 (47.2)	109 (60.9)	**0.023**
Anesthesia Type, spinal**,** n (%)	114 (90.5)	53 (100.0)	167 (93.3)	**0.046**
Blood Groups, n (%)				
• **O**	40 (31.7)	4 (7.5)	44 (24.6)	**0.001**
• **A**	52 (41.3)	39 (73.6)	91 (50.8)	**<0.001**
• **B**	16 (12.7)	6 (11.3)	22 (12.3)	0.994
• **AB**	18 (14.3)	4 (7.5)	22 (12.3)	0.315
• **Rh**	118 (93.7)	47 (88.7)	165 (92.2)	0.409
ASA score, n (%)				
• **2**	21 (16.7)	6 (11.3)	27 (15.1)	0.659
• **3**	85 (67.5)	38 (71.7)	123 (8.7)	
• **4**	20 (15.9)	9 (17.0)	29 (16.2)	
Comorbidities, n (%)				
• **Diabetes**	0 (0.0)	23 (43.4)	23 (12.8)	**<0.001**
• **Cardiovascular diseases**	105 (83.3)	31 (58.5)	136 (76.0)	**0.001**
• **Respiratory disorders**	23 (18.3)	14 (26.4)	37 (20.7)	0.304
• **Nephrological diseases**	4 (3.2)	0 (0.0)	4 (2.2)	0.448
• **Neurological disorders**	30 (23.8)	12 (22.6)	42 (23.5)	1.000
Postop complication, n (%)	4 (3.2)	8 (15.1)	12 (6.7)	**0.010**
Postop transfusion, n (%)	25 (19.8)	25 (47.2)	50 (27.9)	**<0.001**
Laboratory parameters, n (%)				
• **AST (U/L)** , median (IQR)	26.5 (21.0- 30.2)	23.2 (20.0- 37.8)	25.0 (20.4- 31.0)	0.857
• **ALT (U/L)**, median (IQR)	16.0 (14.0- 20.0)	14.0 (11.0- 27.0)	16.0 (13.0- 20.0)	0.209
• **AAR**, mean (SD)	1.6 (0.4)	1.8 (0.6)	1.7 (0.5)	**0.021***
• **AAR>2.1**, n (%)	8 (6.3)	20 (37.7)	28 (15.6)	**<0.001**
• **GGT (U/L)**, median (IQR)	16.0 (12.0- 24.0)	13.0 (12.0- 32.0)	16.0 (12.0- 26.0)	0.653
• **Total bilirubin (mg/dl)**, median (IQR)	0.5 (0.4- 0.7)	0.6 (0.4- 0.8)	0.5 (0.4- 0.7)	0.344
• **Urea (mg/dl)**, median (IQR)	49.0 (39.0- 59.5)	64.0 (35.0- 79.0)	51.0 (39.0- 64.0)	**0.019**
• **Creatinine (mg/dl)**, median (IQR)	0.9 (0.7- 1.0)	1.2 (0.8- 1.5)	0.9 (0.8- 1.2)	**0.001**
• **PLT (x10^6/uL)**, median (IQR)	209 (164- 255)	186 (156- 257)	207 (157- 257)	0.909
• **Htc (%)**, mean (SD)	38.2 (4.5)	38.6 (4.9)	38.3 (4.6)	0.677**
• **WBC**, mean (SD)	10.2 (3.4)	8.8 (3.2)	9.8 (3.4)	**0.009****
• **Lympocyte (x10^3/uL)**, mean (SD)	1.4 (0.6)	1.0 (0.4)	1.3 (0.6)	**<0.001***

IQR Interquartile Range, *ASA* American Society of Anesthesiologists, *Postop* Postoperative, *AAR* AST/ALT ratio, *SD* standard deviation

* Welch's t Test

** Student's t test

hazard ratio of 37.03 (95% CI 5.25–261.36). An elevated AST/ALT ratio (AAR) was also identified as a significant predictor of mortality, with a hazard ratio of 4.91 (95% CI 1.15–20.88), indicating a 491% increase in the likelihood of mortality. When considering the AAR>2.1 categorized according to the optimal cutoff value determined by ROC (figure 2; with an AUC of 0.586, and according to 2.1 threshold; a specificity of 0.937, 95 %CI: 878 - 972, a sensitivity of 0.377, 95 %CI: 0.248 – 0.521) curve analysis, the adjusted hazard ratio (HR) was 20.87 (95% CI 2.74–158.81), indicating a significant increase in the likelihood of mortality (Table 3). Moreover, we conducted survival analysis with Kaplan-Meier survival curves, as illustrated in Figure 3, to compare survival outcomes between the groups. The restricted mean survival time (RMST) over 12 months was 10.2 ± 0.28 months for the AAR < 2.1

Table 3 Univariate and multivariate analysis of predictors of one-year mortality in elderly patients who underwent hip fracture surgery

	Univariate Analysis		Multivariate model 1		Multivariate model 2	
	Wald test	**HR (95% CI)**	**Wald test**	**HR (95% CI)**	**Wald test**	**HR (95% CI)**
Age	***<0.001***	1.08 (1.04- 1.13)	***0.001***	1.19 (1.07- 1.31)	***<0.001***	***1.21 (1.10- 1.33)***
Female	***<0.001***	0.14 (0.07- 0.30)	***0.002***	0.07 (0.01- 0.38)	***<0.001***	***0.06 (0.02- 0.23)***
Right sided	***0.016***	0.45 (0.23- 0.86)	0.514	0.43 (0.03- 5.42)	removed	
Anesthesia Type	0.988	inf (0.0- inf)	-			
Blood group O	***0.002***	0.18 (0.06- 0.52)	0.187	0.05 (0.00- 4.15)	***0.014***	0.01 (0.01- 0.39)
Blood group A	***<0.001***	3.96 (1.96- 8.03)	0.450	2.97 (0.18- 50.27)	removed	
Cardiovascular disease	***<0.001***	0.28 (0.14–0.58)	***<0.001***	***0.05 (0.01- 0.28)***	***<0.001***	0.06 (0.01- 0.29)
DM	0.986	inf (0.0-inf)	-			
Postop complications	***0.008***	5.42 (1.56- 18.9)	0.502	429.2 (0.01- 998.7)	removed	
Postop transfusion	***<0.001***	3.61 (1.80- 7.23)	***0.001***	25.6 (3.48- 187.57)	***<0.001***	37.03 (5.25- 261.36)
Labaratory parameters						
· AAR (1 unit)	***0.006***	2.60 (1.31- 5.15)	0.092	3.73 (0.80- 17.35)	***0.031***	4.91 (1.15- 20.88)
· Urea	0.246	1.01 (0.99- 1.02)				
· Creatinine	***<0.001***	10.31 (3.57- 29.82)	0.131	6.59 (0.57- 76.09)	***0.037***	17.49 (1.18- 258.90)
· WBC	***0.011***	0.87 (0.78- 0.97)	0.517	1.08 (0.86- 1.35)	removed	
· Lympocyte	***<0.001***	0.21 (0.10- 0.44)	***<0.001***	0.04 (0.01- 0.25)	***<0.001***	0.05 (0.01- 0.24)

IQR Interquartile Range, *ASA* American Society of Anesthesiologists, *Postop* Postoperative, *DM* Diabetes mellitus, *WBC* white blood cell

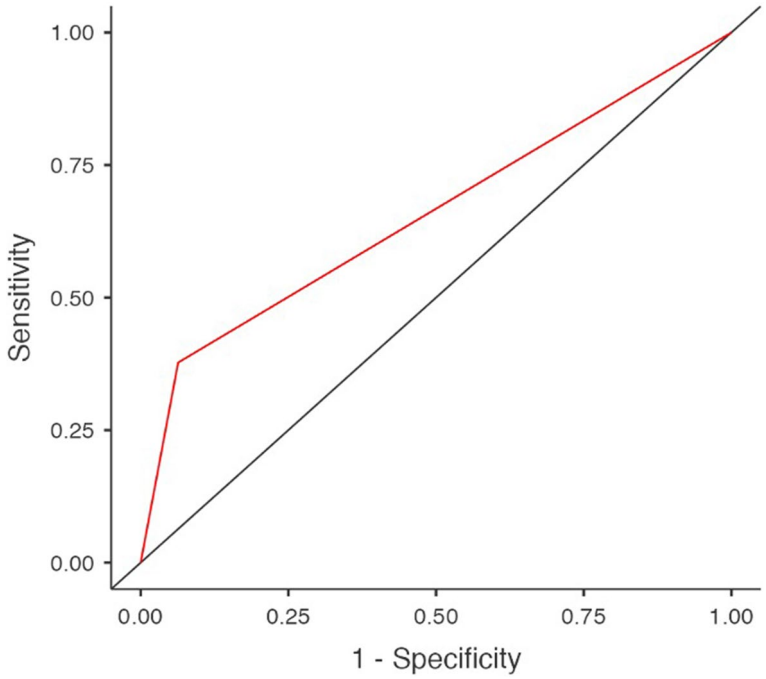

Fig. 2 ROC Curve of AAR for Predicting Mortality Outcomes

group, compared to 7.5 ± 0.87 months for the AAR ≥ 2.1 group, indicating a significant survival disadvantage associated with higher AAR values. At 3 months, survival probabilities were 86.8% (95% CI: 81.5%–92.3%) for the AAR < 2.1 group and 64.3% (95% CI: 48.8%–84.7%) for the AAR ≥ 2.1 group. These probabilities declined to 78.1% (95% CI: 71.8%–85.0%) and 50.0% (95% CI: 34.5%–72.4%) at 6 months, respectively. By 12 months, survival was 78.1% (95% CI: 71.8%–85.0%) for the AAR < 2.1 group and only 28.6% (95% CI: 15.9%–51.3%) for the

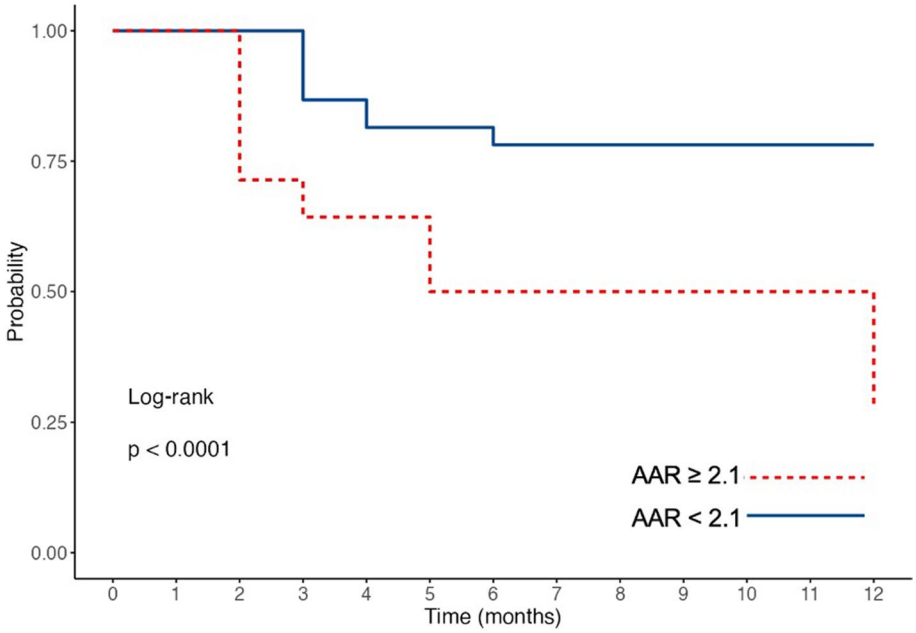

Fig. 3 Kaplan-Meier Survival Curves by AAR Groups (Cutoff: ≥2.1)

AAR ≥ 2.1 group. These results, supported by a significant *p*-value, emphasize the adverse prognostic implications of elevated AAR values.

The final model equation is as follows:

$$P = \frac{1}{1+e(-16.356 + (0.190 \times \text{age}) + (2.862 \times \text{cre}) + (-3.004 \times \text{lymp}) + (1.591 \times \text{AAR}) + (-2.786 \times [1 \text{ if female, or } 0]) + (-2.761 \times [1 \text{ if CVC+, or } 0]) + (3.612 \times [1 \text{ if } \textit{transfused}, \text{ or } 0]) + (-4.681 \times [1 \text{ if Blood group is } 0, \text{ OR } 0])}$$

Discussion

We retrospectively analyzed factors affecting 1-year mortality in elderly patients who underwent partial hip arthroplasty for femoral neck fracture. The most significant finding of the present study was that a high AAR was a significant predictor of mortality. A value of AAR>2.1 significantly increased the risk of mortality. This study also has many other interesting results.

First, advanced age has been identified as a significant risk factor, with each additional year increasing the probability of mortality by 21%. Additionally, female patients were found to have a lower mortality risk than male patients, with female sex having a decreasing effect on mortality risk. Compared with individuals in other blood groups, individuals in blood group O were found to have a protective effect.

The study revealed that the need for postoperative transfusion was associated with a particularly high risk of mortality, underscoring the importance of careful consideration of postoperative transfusion. Finally, the study revealed that high creatinine levels and low white blood cell and lymphocyte counts were associated with an increased risk of mortality according to laboratory parameters.

The associations of advanced age and sex with mortality observed in our study are consistent with those found in many other studies [7–9].

Uzoigwe et al. conducted a study examining the correlation between ABO blood groups and mortality among trauma patients [10]. According to their findings, Group O patients exhibited a decrease in VWF and FVIII levels. However, this decrease did not result in higher transfusion rates or increased mortality within their patient cohort. Unlike in trauma patients, mortality in hip fractures is often attributed to hypercoagulability and microemboli. In our own study, we concluded that individuals with blood type O had a lower risk of 1-year mortality. The laboratory tests conducted by Uzoigwe et al. may explain the protective effect of group O that was observed in our study.

An important finding of our study was the association between postoperative transfusion and high mortality. In their study, Johnston et al. were unable to establish a relationship between postoperative transfusion and

mortality, which differs from our findings [11]. Similarly, Engoren et al. reported increased mortality in patients who received postoperative blood transfusions, suggesting that intraoperative hemorrhage control may be effective in reducing both blood loss and transfusion-related complications [12].

Our study revealed that the correlation of preoperative high urea and creatinine levels and low lymphocyte count with increased mortality seems to be consistent with the literature. This is in line with the results of Laulund et al.'s study [13]. Li et al. also reported that elevated preoperative urea and creatinine levels were associated with increased mortality [14].

As discussed, certain parameters in our study, such as age, are directly associated with an increased risk of mortality and have been widely documented in the literature as independent predictors. Other variables, such as the AAR and hematocrit levels, act as surrogate markers. These biomarkers reflect underlying health conditions and systemic inflammatory responses, which may indirectly contribute to mortality risk. While they do not directly cause mortality, they provide valuable insights into the patient's overall health status and help in identifying those at higher risk.

In the context of systemic inflammation, biomarkers such as the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and lymphocyte-to-monocyte ratio (LMR) have demonstrated prognostic value in surgical and critically ill patients. NLR has been associated with increased mortality risk in conditions like acute coronary syndromes[15], while the systemic immune-inflammation index (SII), which integrates platelet, neutrophil, and lymphocyte counts, has also been linked to poor outcomes in elderly populations [16]. Compared to these markers, the AST/ALT ratio offers unique advantages by combining insights into systemic inflammation and liver function. Elevated AST/ALT ratios have been independently associated with increased mortality risk, particularly in elderly patients with cardiovascular conditions [17]. In the specific context of orthopedic trauma, where inflammation plays a significant role, the AST/ALT ratio represents a practical and accessible biomarker. Its integration into preoperative assessments may improve patient stratification and outcomes, complementing existing inflammatory markers. Further studies are warranted to validate its role and applicability across diverse patient populations.

Our findings indicate that the presence of cardiovascular disease was associated with a lower mortality risk in elderly patients undergoing hip fracture surgery. One potential explanation for this observation could be related to the size of the groups: the AAR $\geq$ 2.1 group included only 28 patients, compared to 151 in the AAR < 2.1 group. This imbalance may have influenced the statistical outcomes and suggests caution in over-interpreting these findings. Additionally, patients with a history of cardiac disease may receive more rigorous monitoring and early interventions, potentially improving their outcomes compared to patients without such a history. This hypothesis aligns with previous evidence suggesting that the presence of comorbidities often leads to closer follow-up and proactive management, which can inadvertently result in better outcomes for specific subgroups [18, 19]. However, this observation warrants further investigation to confirm its validity and explore the underlying mechanisms, particularly in the context of preoperative optimization and post-operative care for patients with cardiovascular disease. Future studies with larger and more balanced sample sizes are necessary to validate these findings and enhance their generalizability.

AAR has been found to be associated with mortality in various clinical conditions in the literature [4–6]. However, there is insufficient research on the effect of this value in orthopedic pathologies. Our study is the first to demonstrate the association between preoperative AAR and increased mortality in patients with hip fractures.

The strengths of our study include its relatively large sample size and comprehensive assessment of clinical and laboratory parameters. However, several limitations should be acknowledged. First, the retrospective nature of the study introduces inherent biases and limits causal inference. Additionally, the study was conducted at a single center, potentially limiting the generalizability of our findings to broader patient populations.

The AST/ALT ratio is a practical and cost-effective biomarker that can enhance preoperative risk assessment. Identifying patients with elevated ratios allows clinicians to stratify surgical risks, optimize perioperative care, and provide targeted interventions for high-risk individuals. Additionally, its prognostic value supports informed discussions with patients and families, aiding in setting realistic expectations and guiding shared decision-making. Integrating the AST/ALT ratio into routine clinical practice represents a step toward more personalized and evidence-based care.

Conclusion

Our study highlights the novel association between elevated preoperative AAR > 2.1 and mortality in hip fractures. Our findings contribute to the understanding of the determinants of mortality in this patient population, offering potential utility in preoperative risk stratification. Further research is needed to confirm these observations and better understand their role in clinical decision-making.

Acknowledgements
None.

Authors' contributions
All authors contributed to the study's conception and design. Material preparation and data collection were performed by Fatih Günaydın, Öner Kılınç, Bülent Sakarya, and İdris Demirtaş. Analysis was performed by Mahmud Aydın and Ali Çelik. The first draft of the manuscript was written by Fatih Günaydın, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. The manuscript was revised collectively by all authors.

Funding
None.

Data availability
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was performed in line with the principles of the Declaration of Helsinki. This research has been approved by the Mersin Üniversitesi Rektörlüğü Klinik Araştırmalar Etik Kurulu (Mersin University Clinical Research Ethics Committee) (Decision date and no: 01/11/2023, 21/740). Informed consent was obtained from all individual participants included in the study as part of a routine process in our hospital for scientific research purposes.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 28 March 2024 Accepted: 17 December 2024
Published online: 06 January 2025

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