

Predictors of In-Hospital Mortality Among Older Adults Presenting to the Emergency Department with Hip Fracture

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Abstract

Objective: This study aimed to identify predictors of in-hospital mortality among geriatric patients presenting with acute hip fracture.

Materials and Methods: This retrospective cohort study included consecutive patients aged ≥ 65 years with radiologically confirmed proximal femoral fractures who presented to a tertiary emergency department between January 2020 and January 2025. Demographic characteristics, comorbidities, functional status, laboratory parameters, trauma characteristics, fracture patterns, and in-hospital complications were recorded. Univariable and multivariable logistic regression analyses were performed to identify independent predictors.

Results: A total of 833 patients were included (mean age 83.6 ± 7.1 years; 64.9% male). The in-hospital mortality rate was 9.1%. Compared with survivors, non-survivors had poorer baseline function (ADL 3 vs. 4; IADL 4 vs. 5), a higher comorbidity burden (CCI 9 vs. 7), and greater physiological instability (NEWS2 4 vs. 3). Laboratory differences were notable, with significantly lower serum sodium levels (134 vs. 138 mmol/L) and higher creatinine levels (1.4 vs. 0.9 mg/dL) among non-survivors. High-energy trauma was more frequent among patients who died (14.5% vs. 6.2%). In the multivariable model, higher BMI (aOR 1.11; 95% CI 1.03–1.20), an increased Charlson Comorbidity Index (aOR 1.22; 95% CI 1.05–1.40), higher NEWS2 scores (aOR 1.51; 95% CI 1.33–1.73), and lower serum sodium levels (aOR 0.76; 95% CI 0.70–0.82) were independently associated with increased mortality, whereas DVT/PE showed a strong but statistically non-significant trend toward higher risk.

Conclusion: Early mortality in geriatric patients with hip fracture presenting to the emergency department is primarily driven by comorbidity burden, physiological derangement, and electrolyte abnormalities. Simple parameters available in the emergency department may facilitate rapid risk stratification and guide early management.

Keywords: Aged, emergency service, hospital, hip fractures, mortality, risk factors

Introduction

Traumatic musculoskeletal injuries are a common reason for emergency department (ED) visits worldwide. In Türkiye alone, there were more than 129 million ED visits in 2021. Nearly 900,000 of these required urgent surgery, and approximately 170,000 were due to fractures or dislocations of the extremities [1,2]. Among these injuries, hip fractures are among the most serious conditions affecting older adults and are associated with long-term disability, loss of independence, and increased mortality.

Despite advances in perioperative and geriatric care, mortality after hip fracture remains high. Studies report that 5–10% of

patients die within 30 days, while 90-day mortality may reach 10–20% [3,4]. Unplanned readmissions are also common and are often related to postoperative complications, frailty, multimorbidity, and inadequate post-discharge support [5,6]. These outcomes place a substantial burden on both patients and healthcare systems.

Several factors associated with poor outcomes after hip fracture have been identified, including advanced age, frailty, multimorbidity, impaired functional status, cognitive decline, and early in-hospital complications [7–9]. However, most previous studies were conducted in inpatient wards or orthopedic units. Prognostic assessment in the ED differs from inpatient evaluation



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because emergency physicians must make early management decisions before definitive surgical treatment, often with limited clinical information and under conditions of acute physiological instability. Unlike inpatient studies, which mainly focus on postoperative outcomes, ED-based assessment may support triage decisions, ICU admission, monitoring intensity, and disposition planning using variables available at presentation [10,11]. Early identification of high-risk patients in the ED may therefore improve initial management and facilitate timely intervention.

Although ED-based care for older trauma patients is becoming increasingly important, real-world data from middle-income countries remain limited. In addition, predictors identifiable at ED presentation that independently influence in-hospital mortality are not fully understood. Therefore, this study aimed to identify predictors of in-hospital mortality in adults aged 65 years and older presenting to the emergency department with acute hip fracture.

Materials and Methods

Study Design and Setting

This single-center, retrospective observational cohort study was conducted in the Emergency Medicine Department of a tertiary academic referral hospital in Türkiye. The ED provides 24/7 care, has an annual census of approximately 400,000 visits, and serves a diverse urban population. The study covered the period from January 1, 2020, to January 1, 2025. The study protocol was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (Date: 23.07.2025, Decision no: 2025-13-28) and was conducted in accordance with the Declaration of Helsinki. All patient data were de-identified prior to analysis to ensure confidentiality.

Study Population

All consecutive adults aged ≥ 65 years who presented to the ED with a diagnosis of acute proximal femoral (hip) fracture were screened. Potential cases were identified through the hospital information management system using ICD-10 codes S72.0–S72.9.

Inclusion Criteria

- Age ≥ 65 years
- Radiologically confirmed acute proximal femoral fracture (X-ray or CT)
- Available demographic, clinical, and radiologic data

Exclusion Criteria

- Age < 65 years
- Periprosthetic, pathological, or metastatic fractures

- History of ipsilateral hip surgery (arthroplasty or internal fixation)
- Incomplete or unverifiable medical records

A STROBE-compliant patient flowchart illustrating the screening, inclusion, and exclusion process is presented in Figure 1.

Data Collection

Electronic health records (EHRs) were independently reviewed by two trained investigators using a standardized protocol. Fracture presence, laterality, and morphology were confirmed through radiology reports and Picture Archiving and Communication System (PACS) imaging, including plain radiographs and computed tomography (CT), when available. Discrepancies were resolved by consensus or, when required, adjudicated by a senior emergency physician.

All variables were extracted into a predefined electronic case report form (eCRF) incorporating internal validation rules. Demographic and baseline characteristics included age, sex, and body mass index (BMI). Pre-fracture functional status was assessed using the Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) scales, ambulation level, and fall history within the preceding year. Frailty was evaluated using the Clinical Frailty Scale (CFS), while cognitive status—including documented dementia type and severity—and sensory impairment, including vision status, were recorded. Comorbidity burden was quantified using the Charlson Comorbidity Index (CCI). Medication exposure before admission included psychoactive agents, antihypertensive drugs, anticoagulant and antiplatelet therapies, and osteoporosis treatments. Admission laboratory parameters, including hemoglobin, sodium, creatinine,

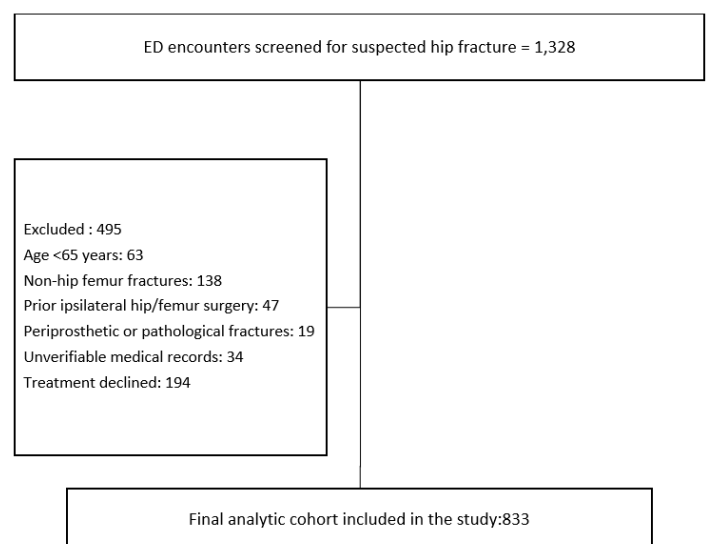


Figure 1. Flow chart of the study

albumin, and C-reactive protein (CRP), were obtained from initial ED testing. Injury-related characteristics included trauma mechanism, location (indoor vs. outdoor), laterality, fracture type (femoral neck, intertrochanteric, or subtrochanteric), AO/OTA 31 classification, displacement, and comminution.

In-hospital complications were defined according to standard diagnostic criteria and included pneumonia, deep vein thrombosis or pulmonary embolism (DVT/PE), myocardial infarction (MI), stroke confirmed by neuroimaging, surgical site infection (SSI), pressure ulcer, reoperation, and delirium. Details of ED disposition and ward or intensive care unit (ICU) admission were documented.

Outcomes

The primary outcome of this study was all-cause in-hospital mortality following the index hip fracture presentation. Secondary outcomes included the development of in-hospital complications and the need for ward or ICU admission.

Statistical Analysis

All statistical analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA) and R version 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria). Normality was assessed using the Kolmogorov–Smirnov test, together with histogram and Q–Q plot inspection. Continuous variables are presented as mean±standard deviation (SD) or median with interquartile range (IQR), as appropriate, while categorical variables are summarized as frequencies and percentages.

Univariable analyses were performed using Pearson's chi-square test or Fisher's exact test for categorical variables and Student's t-test or the Mann–Whitney U test for continuous variables, as appropriate. Variables with clinical relevance or a univariable *p* value <0.10 were entered into multivariable logistic regression analysis to identify independent predictors of in-hospital mortality. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs). A two-sided *p* value <0.05 was considered statistically significant. To reduce overfitting, the events-per-variable (EPV) ratio was calculated; the final model yielded an EPV of 8, which was considered acceptable for logistic regression modeling. Multicollinearity was evaluated using the variance inflation factor (VIF), tolerance statistics, condition indices, and variance decomposition proportions. No evidence of severe multicollinearity was identified, with all VIF values ranging from 1.006 to 1.652. Creatinine was excluded from the final multivariable model because of potential conceptual overlap with age, comorbidity burden, and physiological severity indicators. Model calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test, while discriminative performance was

evaluated using the C-statistic/area under the receiver operating characteristic curve (AUC).

Results

Of the 1,328 patients assessed for eligibility, 833 consecutive individuals who fulfilled the predefined inclusion and exclusion criteria were enrolled and constituted the final analytic cohort (Fig. 1).

Triage categories were distributed as follows: 15 patients (1.8%) were Emergency Severity Index (ESI) level 1, 133 (16.0%) were level 2, and 685 (82.2%) were level 3. A total of 819 patients (98.3%) arrived at the ED via Emergency Medical Services (EMS). Overall, 53.7% of patients presented during daytime and 46.3% during nighttime. Seasonal variation demonstrated a predominance of presentations in spring (*n*=299, 35.9%), followed by winter (*n*=200, 24.0%), summer (*n*=184, 22.1%), and autumn (*n*=150, 18.0%). Of the patients included in the study, 91.6% (*n*=763) were admitted to the hospital from the ED, whereas 8.4% (*n*=70) were discharged directly from the ED. Among hospitalized patients, 160 (19.2%) required intensive care unit (ICU) admission. Among survivors who were discharged following the index hospitalization, 115 (14.8%) were readmitted within 30 days and 317 (40.9%) within 90 days. The in-hospital mortality rate was 9.1% (*n*=76).

In-hospital non-survivors were more likely to be male (47.4% vs. 33.8%, *p*=0.018) and had a higher mean BMI (25.3±4.2 vs. 23.9±3.9 kg/m², *p*=0.009). Age distribution was similar between groups (median 85 vs. 84 years, *p*=0.671). Pre-fracture functional assessments revealed significantly greater impairment among non-survivors. Median ADL (3 vs. 4, *p*=0.006) and IADL scores (4 vs. 5, *p*=0.003) were lower in those who died, indicating reduced baseline independence. Non-survivors had a substantially higher comorbidity burden, reflected in elevated CCI scores (median 9 vs. 7, *p*<0.001). Physiological severity at presentation was also greater, with higher NEWS2 scores (4 vs. 3, *p*=0.041). No significant differences were observed in residential status, fall history, visual impairment, smoking, or alcohol use between groups. Similarly, most medication classes, including psychoactive agents, antihypertensives, diuretics, anticoagulants, and antiplatelets, showed no association with mortality. The only exception was osteoporosis treatment, which was more prevalent among non-survivors (67.1% vs. 54.4%, *p*=0.034). Baseline characteristics of the study cohort are summarized in Table 1.

Non-survivors presented with markedly higher creatinine levels (median 1.4 mg/dL [IQR 1.2–1.7] vs. 0.9 mg/dL [0.6–1.2]) and significantly lower serum sodium levels (median 134 mmol/L [130–136] vs. 138 mmol/L [135–140]) compared with survivors (both *p*<0.001), while hemoglobin and CRP values remained

Table 1. Baseline Characteristics of Patients Stratified by In-Hospital Mortality

Variable	Level	Survivor, n (%)	Non-survivor, n (%)	p
Gender, n (%)	Male	256 (33.8)	36 (47.4)	0.018*
	Female	501 (66.2)	40 (52.6)	
Age (years), median (IQR)	—	84 (78–90)	85 (77–91)	0.671†
BMI (kg/m ²), mean ± SD	—	23.9±3.9	25.3±4.2	0.009&
Residential status, n (%)	Home	674 (89.0)	71 (93.4)	0.492*
	Nursing home	47 (6.2)	3 (3.9)	
	Assisted living	36 (4.8)	2 (2.6)	
Pre-fracture mobility, n (%)	Independent	364 (48.1)	32 (42.1)	0.631*
	With aid	276 (36.5)	29 (38.2)	
	Wheelchair	86 (11.4)	12 (15.8)	
	Bedbound	31 (4.1)	3 (3.9)	
Fall history, n (%)	None	512 (67.6)	54 (9.5)	0.726*
	1 fall	159 (21.0)	13 (17.1)	
	≥2 falls	86 (11.4)	9 (11.8)	
Visual impairment, n (%)	None	172 (22.7)	17 (22.4)	0.492*
	Mild	260 (34.3)	23 (30.3)	
	Moderate	229 (30.3)	29 (38.2)	
	Severe	96 (12.7)	7 (9.2)	
Smoking status	Never	320 (42.3)	27 (35.5)	0.303*
	Former	409 (54.0)	44 (57.9)	
	Current	28 (3.7)	5 (6.6)	
Alcohol use, n (%)	None	714 (94.3)	71 (93.4)	0.749*
	Yes	43 (5.7)	5 (6.6)	
Functional status, median (IQR)	ADL score	4 (2–5)	3 (1–4)	0.006 ^u
	IADL score	5 (3–6)	4 (2–5)	0.003 ^u
	Frailty (CFS)	6 (5–7)	7 (6–8)	0.109 ^u
Comorbidity, median (IQR)	CCI	7 (5–8)	9 (7–10)	<0.001 ^u
Physiology, median (IQR)	NEWS2	3 (2–4)	4 (3–6)	0.041 ^u
Medication Profile, n (%)	Psychoactive medication	302 (39.9)	28 (36.8)	0.604*
	Antihypertensive	519 (68.6)	58 (76.3)	0.205*
	Diuretic	233 (30.8)	24 (31.6)	0.989*
	Anticoagulant	259 (34.2)	32 (42.1)	0.169*
	Antiplatelet	314 (41.5)	34 (44.7)	0.583*
	Osteoporosis Treatment	412 (54.4)	51 (67.1)	0.034*

ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living; CFS: Clinical Frailty Scale; CCI: Charlson Comorbidity Index; NEWS2: National Early Warning Score 2. * Pearson's chi-square test; † Mann–Whitney U test; # Fisher's exact test; & independent samples t-test were used.

similar between groups. Trauma patterns differed substantially by mortality status. High-energy trauma was more common among non-survivors (14.5%, n=11 vs. 6.2%, n=47; p=0.007), and motor vehicle-related injuries demonstrated more than a threefold increase in the mortality group (13.2%, n=10 vs. 3.4%, n=26; p<0.001). In contrast, ground-level falls predominated among survivors (84.1%, n=637 vs. 67.1%, n=51; p<0.001). Among in-

hospital complications, non-survivors experienced substantially higher rates of DVT/PE (7.9%, n=6 vs. 2.6%, n=20; p=0.025), surgical site infection (11.8%, n=9 vs. 3.2%, n=24; p<0.001), and pressure ulcers (21.1%, n=16 vs. 10.6%, n=80; p=0.006) (Table 2).

In univariable analyses, higher BMI, higher CCI, elevated NEWS2 scores, and lower serum sodium levels were significantly associated with in-hospital mortality. In multivariable analysis, BMI

Table 2. Laboratory findings, trauma characteristics, and in-hospital complications according to in-hospital mortality

Variable	Level	Survivor	Non-survivor	p
Laboratory, median (IQR)	Hemoglobin	11.6 (11.4–12.8)	11.3 (10.5–13.2)	0.702 [†]
	Creatinine	0.9 (0.6–1.2)	1.4 (1.2–1.7)	<0.001 [†]
	Sodium	138 (135–140)	134 (130–136)	<0.001 [†]
	CRP	29 (21–39)	33 (24–44)	0.316 [†]
Trauma mechanism, n (%)	Ground-Level Fall	637 (84.1)	51 (67.1)	<0.001 [*]
	High-energy trauma	47 (6.2)	11 (14.5)	0.007 [*]
	MVA	26 (3.4)	10 (13.2)	<0.001 [*]
	Other	47 (6.2)	4 (5.3)	0.743 [*]
Place Of Injury, n (%)	Indoor	531 (70.1)	57 (75.0)	0.376 [*]
	Outdoor	226 (29.9)	19 (25.0)	
Fracture Laterality, n (%)	Left	395 (52.2)	34 (44.7)	0.216 [*]
	Right	356 (47.0)	40 (52.6)	0.351 [*]
	Bilateral	6 (0.8)	2 (2.7)	0.113 [#]
Fracture Location, n (%)	Femoral Neck	378 (49.9)	37 (48.7)	0.670 [*]
	Intertrochanteric	336 (44.4)	37 (48.7)	0.360 [*]
	Subtrochanteric	43 (5.7)	2 (2.6)	0.419 [#]
Fracture Type, n (%)	Closed	752 (99.3)	74 (97.4)	0.128 [#]
	Open	5 (0.7)	2 (2.6)	
Displacement, n (%)		609 (80.4)	64 (84.2)	0.427 [*]
Comminution, n (%)		293 (38.7)	31 (40.8)	0.772 [*]
Complication, n (%)	Pneumonia	161 (21.3)	20 (26.3)	0.309 [*]
	DVT/PE	20 (2.6)	6 (7.9)	0.025 [#]
	MI	41 (5.4)	8 (10.5)	0.076 [#]
	Stroke	15 (2.0)	4 (5.3)	0.086 [#]
	Surgical Site Infection	24 (3.2)	9 (11.8)	<0.001 [#]
	Pressure Ulcer	80 (10.6)	16 (21.1)	0.006 [*]
	Reoperation	27 (3.6)	5 (6.6)	0.203 [#]
	Delirium in Hospital	228 (30.1)	29 (38.2)	0.148 [*]

High-energy trauma includes falls from height and direct high-impact injuries; MVA refers to motor vehicle-related trauma. DVT/PE: deep vein thrombosis or pulmonary embolism; MI: myocardial infarction. * Pearson's chi-square test; † Mann-Whitney U test; # Fisher's exact test; & independent samples t-test were used.

(aOR 1.11; 95% CI 1.03–1.20), CCI (aOR 1.22; 95% CI 1.05–1.40), and NEWS2 score (aOR 1.51; 95% CI 1.33–1.73) remained independent predictors of mortality, whereas higher serum sodium levels were protective (aOR 0.76; 95% CI 0.70–0.82). DVT/PE showed a trend toward increased mortality but did not reach statistical significance (aOR 3.31; $p=0.077$) (Table 3).

The final multivariable model demonstrated acceptable calibration based on the Hosmer–Lemeshow goodness-of-fit test ($\chi^2=5.842$, $df=8$, $p=0.665$). Discriminative performance was excellent, with a C-statistic (AUC) of 0.937 (95% CI 0.912–0.962).

Discussion

In this ED-based cohort of older adults with hip fractures, several clinical, physiological, and biochemical factors independently predicted in-hospital mortality. These findings likely reflect the combined effects of baseline vulnerability, acute physiological deterioration, and early in-hospital complications.

Non-survivors had poorer functional status and greater frailty. However, these measures were not independently significant after multivariable adjustment. This finding is consistent with previous studies showing that frailty-associated functional measures often lose prognostic significance once illness severity and comorbidity burden are included in predictive models [12–14]. Frailty-related parameters, such as ADL, IADL, and the Clinical Frailty Scale, reflect reduced physiological reserve and vulnerability to stressors. In contrast, NEWS2 may capture the acute clinical manifestation of this vulnerability at ED presentation [15,16]. Therefore, the prognostic effects of frailty-related measures may be attenuated because of shared variance with acute physiological instability and multimorbidity. BMI, CCI, and NEWS2 emerged as robust independent predictors. This finding supports previous evidence suggesting that multimorbidity and acute physiological instability may outweigh chronological age in determining short-term prognosis after hip fracture [17,18]. Hyponatremia also showed a strong association with mortality, consistent with studies

Table 3. Univariable and multivariable logistic regression for in-hospital mortality

Variable	Univariable OR (95% CI)	p	Multivariable OR (95% CI)	p
Sex (Male)	1.76 (1.10–2.83)	0.018	1.29 (0.67–2.50)	0.444
Age (per year)	1.00 (0.98–1.03)	0.735	0.98 (0.94–1.02)	0.369
BMI (kg/m ²)	1.08 (1.02–1.15)	0.007	1.11 (1.03–1.20)	0.004
Pre-fracture mobility	1.15 (0.87–1.51)	0.309	1.08 (0.76–1.51)	0.674
ADL score	0.99 (0.87–1.13)	0.824	—	—
IADL score	1.03 (0.93–1.15)	0.584	—	—
Frailty score	0.95 (0.79–1.13)	0.546	—	—
Charlson Comorbidity Index	1.19 (1.07–1.33)	0.001	1.22 (1.05–1.40)	0.007
NEWS2 score	1.60 (1.42–1.81)	<0.001	1.51 (1.33–1.73)	<0.001
Creatinine	1.00 (0.59–1.63)	0.998	—	—
Sodium (mmol/L)	0.75 (0.70–0.80)	<0.001	0.76 (0.70–0.82)	<0.001
Osteoporosis treatment	1.71 (1.05–2.86)	0.036	1.44 (0.79–2.64)	0.236
Ground-Level Fall	1.27 (0.68–2.60)	0.480	—	—
High-energy trauma	1.16 (0.43–2.60)	0.738	—	—
Motor Vehicle Accident	0.90 (0.21–2.59)	0.866	—	—
DVT/PE complication	2.47 (0.80–6.27)	0.078	3.31 (0.81–11.77)	0.077
Myocardial infarction	1.14 (0.39–2.72)	0.787	—	—
Stroke complication	1.18 (0.18–4.21)	0.830	—	—
Surgical site infection	0.63 (0.10–2.15)	0.536	—	—
Pressure ulcer	0.89 (0.39–1.82)	0.775	—	—
Delirium in hospital	1.26 (0.76–2.05)	0.356	—	—

Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index; ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; NEWS2, National Early Warning Score 2; DVT/PE, deep vein thrombosis/pulmonary embolism.

linking sodium imbalance to frailty, malnutrition, and impaired physiological reserve [19,20]. Although creatinine was significant in univariable analysis, it was excluded from the final model because of conceptual overlap with comorbidity burden and physiological derangement. This approach is consistent with parsimonious modeling principles and TRIPOD recommendations [21].

High-energy trauma mechanisms were more common among non-survivors, but their effects diminished after adjustment. This suggests that the physiological consequences of injury may be more important than the trauma mechanism itself in determining mortality risk. Similarly, complications such as DVT/PE, surgical site infection, and pressure ulcers were more frequent among non-survivors, supporting previous evidence on the prognostic importance of early in-hospital complications [22,23]. However, the wide confidence intervals observed for some complications likely reflect limited event numbers and possible rare-event bias [24].

Overall, our findings suggest that simple ED-based parameters, including comorbidity burden, physiological instability, and electrolyte abnormalities, may help identify older hip fracture patients at high risk of in-hospital mortality. Because these variables are readily available at ED presentation, they may support early orthogeriatric involvement, closer monitoring, ICU triage decisions, and timely perioperative optimization. Our results also provide real-world evidence from a high-volume, middle-income ED setting and support further multicenter validation of ED-based prognostic strategies.

This study has several limitations. First, the single-center retrospective design may limit generalizability to other healthcare settings and populations. Second, despite standardized electronic data extraction, some information may have been incomplete or inaccurately documented, particularly regarding pre-fracture functional status and medication history. Therefore, residual misclassification bias may exist. Third, important perioperative variables, such as time to surgery, operative versus conservative management, anesthesia type, and perioperative care factors, were not consistently available and could not be included in the analyses. The absence of these variables may have influenced mortality outcomes and limited interpretation of the independent prognostic associations identified. Fourth, in-hospital mortality was used as the primary outcome, and post-discharge mortality events could not be assessed. Finally, some complications, including DVT/PE and surgical site infection, were relatively infrequent, resulting in wide confidence intervals and reduced precision of effect estimates.

Conclusion

In this ED-based cohort of older adults with hip fractures, mortality was primarily associated with underlying medical vulnerability

rather than fracture characteristics. Comorbidity burden, physiological instability at presentation, and serum sodium levels were the strongest indicators of in-hospital mortality. These findings highlight the importance of early medical risk stratification in the ED and support early multidisciplinary and perioperative management strategies. Larger multicenter studies are needed to further validate these findings.

Ethics

Ethics Committee Approval: This study was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (Date: 23.07.2025, Decision no: 2025-13-28).

Informed Consent: Written informed consent was obtained.

Conflict of Interest: None declared.

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