ORIGINAL RESEARCH

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Predictors of ED Outcomes and 30-Day Mortality in Oldest Olds Presenting with Trauma

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Abstract

Objective: Trauma-related emergency department (ED) admissions among older adults are increasing with population aging. The oldest-old, defined as patients aged ≥85 years, are particularly vulnerable, as even low-energy mechanisms may result in clinically important morbidity and mortality. This study aimed to evaluate the epidemiological, clinical, and prognostic features of trauma presentations among the oldest-old and to identify factors associated with ED outcomes and 30-day mortality.

Materials and Methods: This single-center retrospective observational study included trauma patients aged ≥85 years who presented to the ED between May 1, 2020, and August 1, 2023. Demographic characteristics, mechanisms of injury, frailty levels, clinical and laboratory parameters, injury severity scores, ED outcomes, and 30-day mortality were recorded. Frailty was assessed using the Clinical Frailty Scale. Univariate and multivariate logistic regression analyses were performed to identify independent predictors of 30-day mortality.

Results: A total of 467 patients were included. The median age was 88 years, and 70.2% were female. Falls were the predominant mechanism of injury (91.9%). Overall, 47.8% were discharged, 48.8% were admitted to hospital wards, 2.8% required ICU admission, and 0.6% died in the ED. The 30-day mortality rate was 8.1%. In multivariate logistic regression analysis, the shock index, Geriatric Trauma Outcome Score, and frailty level were identified as independent predictors of 30-day mortality.

Conclusion: Trauma among the oldest-old was predominantly related to low-energy mechanisms, particularly falls, yet was associated with clinically important morbidity and mortality. Injury severity scoring, early physiological assessment, and frailty evaluation may improve ED risk stratification. Further prospective studies are required to validate these findings.

Keywords: Emergency; frailty; geriatrics; oldest old; trauma.

Introduction

Trauma-related emergency department (ED) admissions among older adults have increased in recent years, largely reflecting population aging, improved health services, longer life expectancy, increased mobility, and the growing vulnerability of geriatric patients to injury [1-3]. Even low-energy mechanisms may lead to clinically significant morbidity in this population because of age-related physiological changes, reduced functional reserve, osteoporosis, comorbidities, and the frequent use of antithrombotic medications [4,5]. Therefore, trauma in older adults represents an important challenge for emergency physicians, not only because of injury management itself but also because adverse outcomes may occur despite apparently minor mechanisms of trauma.

The oldest-old population, generally defined as individuals aged 85 years and older, warrants particular attention, as this rapidly growing demographic group is expected to double in size by 2050 [6,7]. Ground-level falls are the predominant mechanism of injury in this age group, and these low-energy events may result in serious injury patterns, including hip fractures, intracranial hemorrhage, and rib fractures [8]. However, the literature focusing specifically on trauma presentations among patients aged ≥85 years remains limited, and reported admission rates, mechanisms of trauma, and clinical outcomes vary substantially across countries, healthcare systems, and hospital settings.

Early identification of oldest-old trauma patients at high risk for poor outcomes is essential for appropriate triage, resource

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allocation, and clinical decision-making in the emergency department. Traditional injury severity metrics, such as the Injury Severity Score (ISS) and Geriatric Trauma Outcome Score (GTOS), have been widely used to estimate trauma severity and mortality risk in older adults [9,10]. In addition, physiological markers such as the Glasgow Coma Scale, shock index, renal function, albumin level, and inflammatory parameters, including the neutrophil-to-lymphocyte ratio, may provide important information regarding acute physiological derangement. Nevertheless, the predictive value of these parameters in the oldest-old trauma population remains incompletely defined, particularly in cohorts with predominantly low-energy mechanisms and low injury severity.

Frailty has increasingly been recognized as a clinically meaningful predictor of adverse outcomes in geriatric trauma, independent of chronological age and injury severity [11]. Because frailty reflects reduced physiological reserve and vulnerability to stressors, its assessment may improve risk stratification beyond conventional trauma scoring systems. Therefore, this study aimed to characterize the epidemiological, clinical, and prognostic features of trauma presentations among patients aged ≥85 years and to identify factors associated with ED outcomes and 30-day mortality. In particular, we sought to evaluate the prognostic contributions of injury severity metrics, physiological parameters, laboratory markers, and frailty level in this oldest-old trauma cohort.

Materials and Methods

Study Setting and Population

This single-center retrospective observational study was conducted at one of the largest tertiary care centers in the country, with more than 900,000 annual ED visits and a total hospital capacity of 2,682 beds. Trauma patients aged ≥85 years who presented to the ED during the 3-year and 3-month study period between May 1, 2020, and August 1, 2023, were included in the study.

Patients who were directly transferred to hospital wards or the intensive care unit (ICU) without ED evaluation; experienced trauma secondary to underlying medical conditions such as cerebrovascular events, cardiac syncope, pulmonary embolism, or sepsis; had pathological fractures; voluntarily discontinued treatment; or had missing or incomplete study data were excluded.

Data Collection

The study was approved by the Ethics Committee of Basaksehir Cam and Sakura City Hospital on November 6, 2023, with protocol number KAEK/25.10.2023.520. Following approval by the institutional review board, eligible patients were identified through the hospital information system by screening trauma-related ICD-10 diagnostic codes (S00-S99 and T00-T14), codes related to traffic accidents (V00-V99), burns (T20-T32), and falls (W00-W19).

All study variables were recorded using a standardized data collection form by the investigating physicians. Collected variables included age, sex, type of admission (walk-in or ambulance), time of admission, chief complaint, chronic medical conditions, antithrombotic medications, mechanism of injury, injury-to-ED time, frailty level, GCS, and vital parameters on admission. In addition, the shock index (SI), Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), and Geriatric Trauma Outcome Score (GTOS) were calculated and recorded on the form.

Frailty status was retrospectively assessed using the Clinical Frailty Scale (CFS), a 9-point clinical tool used to grade frailty based on baseline functional status, independence in daily activities, comorbidity burden, mobility, and need for assistance. Frailty status was retrospectively assigned based on information available in the electronic medical records, including pre-injury functional status, mobility, dependency in activities of daily living, comorbidities, cognitive impairment, and nursing and physician notes at admission.

SI was calculated as the ratio of heart rate to systolic blood pressure. The AIS was determined by assigning each injury to an anatomical region and grading its severity on a 6-point ordinal scale ranging from minor (1) to unsurvivable (6). The ISS was calculated as the sum of the squares of the highest AIS scores from the three most severely injured body regions. The GTOS was calculated using the following formula: GTOS=Age+(2.5×ISS)+22 (if RBC transfusion was administered).

Laboratory parameters were recorded at the initial ED presentation and included hemoglobin, hematocrit, platelet count, red cell distribution width (RDW-CV), international normalized ratio (INR), activated partial thromboplastin time (aPTT), neutrophil-to-lymphocyte ratio (NLR), C-reactive protein (CRP), creatinine, GFR, and albumin. NLR was defined as the neutrophil count (10^9/L) divided by the lymphocyte count (10^9/L).

The study was conducted in accordance with the principles of the Declaration of Helsinki. The ethics committee waived the requirement for individual patient consent because of the retrospective observational nature of the study and the use of anonymized data.

Definition of Outcomes

The primary clinical outcome of the study was 30-day mortality, defined as death from any cause within 30 days after the index ED admission for trauma. Secondary outcomes included ED disposition (discharge, ward admission, ICU admission, or death in the ED). Outcomes were assessed based on in-hospital medical records, electronic hospital information system data, and the e-Nabız system.

Data Analysis

Statistical analyses were performed using IBM SPSS Statistics (SPSS Inc., Chicago, IL, USA). Categorical variables were presented as frequencies and percentages, whereas continuous variables were expressed as medians and interquartile ranges (IQRs) because the data were non-normally distributed. Normality was assessed using the Shapiro–Wilk test. Comparisons between categorical variables were performed using the chi-square test or Fisher's exact test, as appropriate. Continuous variables were compared using the Mann–Whitney U test for two-group analyses and the Kruskal–Wallis test for comparisons involving more than two groups.

Univariate logistic regression analyses were initially performed to evaluate the associations between clinical variables and 30-day mortality. Variables with $p<0.10$ in the univariate analyses were included in the multivariable logistic regression model to identify independent predictors of 30-day mortality. Odds ratios (ORs) with 95% confidence intervals (95% CIs) were reported. Receiver operating characteristic (ROC) curve analyses were performed to evaluate the predictive performance of the ISS and GTOS for 30-day mortality. A two-tailed $p<0.05$ was considered statistically significant.

Results

A total of 15,150 patients aged ≥85 years were admitted to the ED during the 3-year and 3-month study period. Among them, 672 patients primarily presented with trauma. After meticulous evaluation, 205 patients were excluded for the following reasons: direct transfer to hospital wards without proper ED evaluation (n=20), pathological fractures (n=3), missing data (n=87), discontinuation of treatment (n=30), and trauma secondary to syncope/presyncope caused by cardiac conditions (n=21), cerebrovascular events (n=33), pulmonary embolism (n=2), or sepsis (n=9). Ultimately, 467 patients were included in the final analysis.

Trauma admissions most commonly occurred during the afternoon hours (12:00–17:59) (37.3%), in the summer months (28.9%), and on weekdays (74.4%). The majority of patients arrived by ambulance rather than as walk-in admissions (66.4% vs. 33.6%). Blunt trauma accounted for the vast majority of cases (n=457, 97.9%), whereas penetrating trauma was uncommon (n=10, 2.1%). Falls were the predominant mechanism of injury (n=429, 91.9%), followed by simple hitting/bumping injuries (n=14, 2.9%), traffic accidents (n=10, 2.1%), and burns (n=7, 1.5%). Among fall-related injuries, same-level falls were the most common mechanism (n=374, 87.2%), followed by falls from bed (n=36, 8.4%), falls down stairs (n=12, 2.8%), and falls from a toilet seat or chair (n=7, 1.6%). The most common chief complaints were hip pain (n=215, 46.0%), headache (n=56, 12.0%), and back pain (n=49, 10.5%). The most frequently affected anatomical regions were the lower extremities (n=266, 57.0%), followed by the head and face region (n=62, 13.3%) and the upper extremities (n=58, 12.4%). Hip fractures were detected in 200 patients.

The study cohort comprised 139 males (29.8%) and 328 females (70.2%). Patient age ranged from 85 to 108 years, with a median age of 88 years (IQR, 86–91). Most patients (n=411, 88%) had at least one chronic medical condition. The most common comorbidity was hypertension (n=334, 71.5%), followed by diabetes mellitus (n=95, 20.3%), Alzheimer's disease (n=81, 17.3%), and coronary artery disease (n=66, 14.1%). Patient demographics are presented in detail in Table 1.

Median time from injury to ED admission was 6 hours (IQR, 3–24). There was a moderate positive correlation between frailty level and time to ED admission (Spearman's $\rho=0.34$, $p<0.001$). Additionally, a significant association was observed between frailty status and mode of admission, with frail patients more frequently arriving by ambulance than non-frail patients ($p<0.001$).

Among the 467 patients, 223 (47.8%) were discharged directly from the ED, 228 (48.8%) were admitted to hospital wards, 13 (2.8%) required ICU admission, and 3 (0.6%) died in the ED. During hospitalization, 195 patients (41.8%) underwent surgical intervention for their injuries. The 24-hour mortality rate was 1.2% (n=6/467), whereas the 30-day mortality rate was 8.1% (n=38/467).

The Kruskal–Wallis analysis for ED outcomes is shown in Table 2. In addition, frailty level was significantly associated with severe ED outcomes ($\chi^2=33.3$, $p<0.001$); the proportion of frail patients increased progressively from the discharged group to the deceased group.

In univariate logistic regression analysis, age, GCS, shock index, ISS, GTOS, NLR, CRP, GFR, albumin, and frailty level were identified as significant predictors of 30-day mortality. In contrast, INR, aPTT, RDW-CV, creatinine, male sex, and antithrombotic medication use were not associated with 30-day mortality.

Among the individual predictors, GTOS demonstrated the highest discriminative ability (AUC=0.831), followed by ISS (AUC=0.789),

Table 1. Baseline demographic and clinical characteristics of patients aged ≥85 years with trauma

Variable	N	Min- Max	Median (IQR) or n (%)
Continuous Variables			
Age, years	467	85-108	88 (86-91)
SBP (mmHg)	467	60-200	140 (130-160)
DBP (mmHg)	467	37-140	80 (72-90)
HR (bpm)	467	47-155	88 (78-98)
RR (/min)	467	12-40	19 (18-22)
GCS	467	6-15	15 (15-15)
Shock Index	467	0.31-2.58	0.61 (0.55-0.68)
ISS	467	0-34	9 (3-9)
GTOS	467	87-175	107.5 (96-112)
HGB (g/dL)	371	4.4-17	11.20 (10.30 - 12.80)
HCT (%)	371	12.1-55	34.90 (31.00-38.70)
PLT (10^9/L)	371	1.50-875	226 (176-287)
RDW-CV	371	11.7-23.6	14.20 (13.30-15.20)
NLR	371	0.5-50.7	5.15 (2.99-8.73)
INR	363	0.80-6.56	1.05 (1.00-1.10)
APTT (seconds)	363	14-58	28 (24.20-32.00)
CRP (mg/L)	363	0.10-289	20 (4.90-51.45)
Creatinine (mg/dL)	363	0.46-75	1.02 (0.81-1.28)
GFR (mL/min/1.73m^2)	363	6-92	52.50 (39-70)
Albumin (g/L)	336	23-46	35 (33-38)
Categorical Variables			
Sex	467	Male:139 (29.8%) | Female:328 (70.2%)	
Comorbidities	467	None:56 (12%) | One:163 (34.9%) | 2 or more:248 (53.1%)	
Antithrombotic Use	467	None:286 (61.2%) | Single:157 (33.6%) | Dual:24 (5.1%)	
Frailty	467	Non-Frail:83(17.8%) | Pre-frail:232(49.7%) | Frail:152(32.5%)	
Injury to ED admission	467	Immediate (≤1 hour):12 (2.6%) | Early (1-6 hours):307 (65.7%) | Delayed (6-24 hours): 84 (18%) |Very delayed (>24 hours):64 (13.7%)	
Severity of Injury (ISS)	467	No injury (0): 4 (0.9%) | Minor (1-8): 227 (48.6%)| Moderate (9-15): 217 (46.5%) | severe (16-24): 15 (3.2%) | Very severe (>25): 4 (0.9%)	

APTT: Activated partial thromboplastin time; CRP: C-reactive protein; DBP: Diastolic blood pressure. ED: Emergency department; GCS: Glasgow Coma Scale; GFR: Glomerular filtration rate; GTOS: Geriatric Trauma Outcome Score; HCT: Hematocrit; HGB: Hemoglobin; HR: Heart rate; INR: International normalized ratio; IQR: Interquartile range; ISS: Injury Severity Score; NLR: Neutrophil-to-lymphocyte ratio; PLT: Platelet count; RBC: Red blood cell; RDW-C: Red cell distribution width–coefficient of variation; RR: Respiratory rate; SBP: Systolic blood pressure.

shock index (AUC=0.738), and frailty (AUC=0.738) (Figure 1). Optimal cutoff values determined by the Youden index were GTOS>112.50 (sensitivity, 71.1%; specificity, 79.5%), ISS>8.00 (sensitivity, 97.4%; specificity, 53.1%), shock index>0.71 (sensitivity, 55.3%; specificity, 86.5%), and frailty=3 (sensitivity, 71.1%; specificity, 70.9%).

Prior to multivariate modeling, collinearity was assessed among candidate variables. ISS and GTOS demonstrated severe collinearity (r=0.941); accordingly, ISS was excluded from the multivariate model, and GTOS was retained given its superior discriminative ability in univariate analysis (AUC=0.831 vs. 0.789). Complete-case analysis was also performed, yielding a final analytic sample of n=333 patients (36 events; event rate, 10.8%).

Table 2. Kruskal-Wallis Analysis —emergency department outcome					
Variable	**Discharged (n=223) Median [IQR]**	**Ward (n=228) Median [IQR]**	**ICU (n=13) Median [IQR]**	**Deceased (n=3) Median [IQR]**	**p**
Age (years)	88.00 [86.00-91.00]	89.00 [86.75-91.00]	89.00 [87.00-90.00]	90.00 [88.00-91.00]	0.5964
GCS	15.00 [15.00-15.00]	15.00 [15.00-15.00]	13.00 [12.00-14.00]	13.00 [12.50-14.00]	**<0.001**
Shock Index	0.59 [0.55-0.65]	0.62 [0.55-0.70]	0.64 [0.55-0.82]	1.18 [1.06-1.22]	**0.0007**
ISS	2.00 [1.00-4.00]	9.00 [9.00-9.00]	10.00 [9.00-18.00]	27.00 [18.50-30.50]	**<0.001**
GTOS	96.00 [91.00-100.00]	111.50 [108.5-114.5]	115.50 [112.0-133.0]	153.50 [135.25-164.25]	**<0.001**
NLR	3.83 [2.51-7.01]	5.79 [3.55-9.22]	5.98 [4.49-20.16]	11.86 [6.90-13.27]	**<0.001**
INR	1.06 [1.00-1.10]	1.03 [0.99-1.10]	1.10 [1.00-1.20]	1.20 [1.10-1.34]	0.3952
APTT (sec)	28.25 [25.57-32.00]	27.50 [24.00-32.00]	30.00 [25.90-39.00]	29.80 [26.55-30.40]	0.5285
RDW-CV	13.90 [13.30-14.70]	14.40 [13.30-15.53]	14.40 [13.40-14.80]	16.90 [14.80-17.45]	0.0616
CRP (mg/L)	20.00 [4.75-27.05]	20.00 [5.03-57.60]	51.50 [3.40-157.00]	45.70 [24.00-82.85]	0.1157
Creatinine (mg/dL)	0.99 [0.81-1.22]	1.01 [0.81-1.29]	1.72 [1.04-2.34]	1.36 [1.19-1.87]	**0.0036**
GFR (mL/min/1.73m^2)	54.00 [42.00-69.50]	53.00 [39.00-72.00]	35.00 [23.00-47.00]	45.00 [31.00-47.50]	**0.0072**
Albumin (g/L)	35.50 [35.00-39.00]	35.00 [32.00-38.00]	32.00 [29.00-35.00]	31.50 [29.75-33.25]	**0.0017**

APTT: Activated partial thromboplastin time; CRP: C-reactive protein; GCS: Glasgow Coma Scale; GFR: Glomerular filtration rate; GTOS: Geriatric Trauma Outcome Score; ICU: Intensive care unit; INR: International normalized ratio; IQR: Interquartile range; ISS: Injury Severity Score; NLR: Neutrophil-to-lymphocyte ratio; RDW-C: Red cell distribution width–coefficient of variation

Multivariate logistic regression analysis is shown in Table 3. Our multivariate model demonstrated excellent discriminative ability, with an AUC (C-statistic) of 0.879 (95% CI, approximately 0.82–0.94).

Discussion

In this study, we characterized the epidemiological, clinical, and prognostic features of trauma presentations among patients aged ≥85 years and identified independent predictors of 30-day mortality. Frailty emerged as a clinically meaningful variable across multiple dimensions; frail patients experienced longer delays to ED presentation, were more likely to arrive by ambulance, and were associated with worse ED outcomes. Patients who experienced more serious ED outcomes demonstrated significantly higher ISS, GTOS, shock index, NLR, and creatinine values, whereas GCS, GFR, and albumin levels were significantly lower than those of patients discharged from the ED or admitted to the ward. In multivariate logistic regression analysis, SI, GTOS, and frailty level were identified as independent predictors of 30-day mortality (model AUC=0.879). Our findings underscore the importance of incorporating injury severity metrics and frailty assessment into the risk stratification of oldest-old patients presenting with trauma.

Trauma-related emergency admissions among geriatric patients have increased in recent years [12–14]. Previous studies have reported that trauma accounts for 18–36.7% of emergency department presentations among patients aged ≥65 years [12,15,16]. However, the literature on the oldest-old population (aged ≥85 years) remains limited and inconsistent. A study from the United Kingdom reported that injuries and falls constituted approximately 31% of all emergency admissions among patients

Table 3. Multivariate logistic regression- independent predictors of 30-day mortality (n=333, events=36)						
Variable	**Adjusted OR**	**95% CI Lower**	**95% CI Upper**	**p**	**Model AUC**	**95% CI of AUC**
Age (years)	1.059	0.950	1.181	0.297	0.879	0.82-0.94
GCS	1.060	0.626	1.794	0.830	0.879	0.82-0.94
Shock Index	**1.656**	**1.265**	**2.167**	**<0.001**	0.879	0.82-0.94
GTOS	**1.048**	**1.002**	**1.096**	**0.039**	0.879	0.82-0.94
NLR	1.022	0.964	1.084	0.465	0.879	0.82-0.94
CRP (mg//L)	1.052	0.978	1.130	0.172	0.879	0.82-0.94
GFR (mL/min/1.73m^2)	1.002	1.000	1.004	0.057	0.879	0.82-0.94
Albumin	1.061	0.954	1.179	0.273	0.879	0.82-0.94
Frailty	**2.780**	**1.263**	**6.122**	**0.011**	0.879	0.82-0.94

Data are presented as adjusted odds ratios with 95% confidence intervals. The model AUC represents the discriminative performance of the multivariable logistic regression model for predicting 30-day mortality. Abbreviations: AUC: Area under the receiver operating characteristic curve; CI: Confidence interval; CRP: C-reactive protein; GCS: Glasgow Coma Scale; GFR: Glomerular filtration rate; GTOS: Geriatric Trauma Outcome Score; NLR: Neutrophil-to-lymphocyte ratio; OR: Odds ratio.

aged ≥85 years (3,991/12,883) [17]. In contrast, a Turkish study reported a trauma-related admission rate of 1.7% among patients aged ≥80 years (361/21,850), while another study reported that soft tissue injuries, traffic accidents, and falls together accounted for 18% (142/780) of presentations among patients aged ≥85 years [18,19]. Similarly, a study from India reported that trauma accounted for only 6% of all emergency department admissions among patients aged >80 years (53/8,563) [20]. In the present study, trauma-related admissions accounted for 4.4% of all emergency admissions among patients aged ≥85 years (672/15,150). These variations may be attributed to differences in healthcare systems, health policies, hospital settings, patient populations, and cultural factors.

Trauma may result in more serious outcomes in geriatric patients because of diminished physiological reserve, characteristic injury patterns, pre-existing comorbidities, and medications such as anticoagulants [21-23]. Early recognition of factors associated with worse outcomes is therefore essential. ISS and GTOS are among the most widely studied scoring systems for trauma severity and outcome prediction in this population, and both have been validated as strong predictors of mortality in geriatric trauma patients [24-26,9]. However, the predictive adequacy of ISS alone has been questioned; Kim et al. [27] argued that ISS may be insufficient for the comprehensive assessment of geriatric trauma because it does not incorporate physiological parameters or patient-specific factors such as age and transfusion requirements. Indeed, several studies have reported superior predictive performance of GTOS compared with ISS for mortality in this population [24-26,9]. Consistent with these findings, in our oldest-old cohort, GTOS demonstrated a higher AUC than ISS (0.831 vs. 0.789), and in multivariate analysis, GTOS emerged as one of the strongest independent predictors of 30-day mortality.

Physiological instability at presentation, as reflected by GCS and shock index in our cohort, is well supported by the existing literature. Moradi et al. [28] demonstrated that elderly trauma

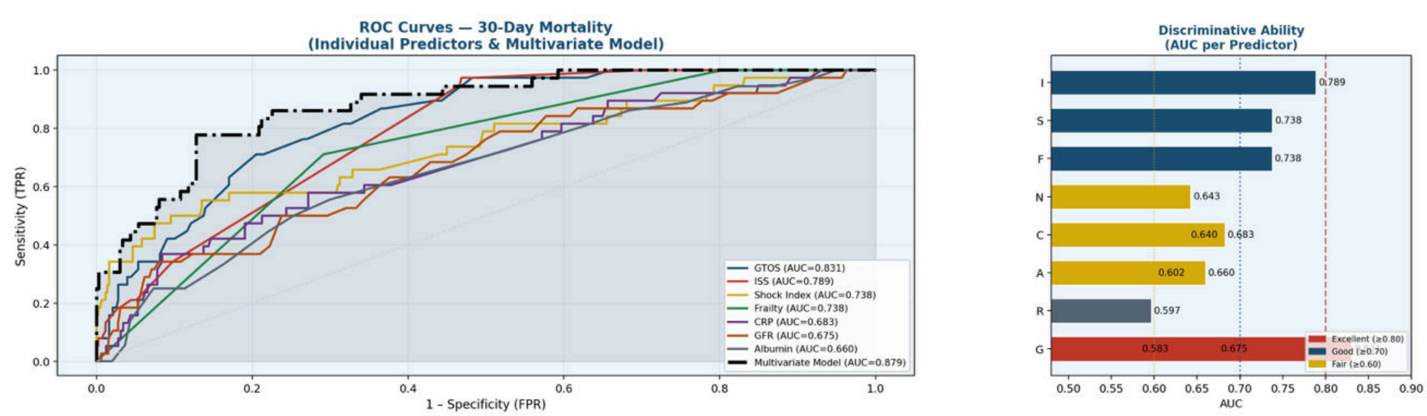

Figure 1. ROC curves-30-Day Mortality (Individual Predictors and Multivariate Model)

patients who died during hospitalization presented with significantly lower GCS scores and systolic blood pressure than survivors, consistent with our findings. The predictive value of the shock index in geriatric trauma, however, remains a subject of debate. Physiological aging and the widespread use of antihypertensive medications may alter baseline vital signs, potentially obscuring traditional hemodynamic markers of shock. Autonomic dysfunction has been shown to blunt the expected tachycardic response to physiological stress in elderly patients, meaning that SI values may appear falsely reassuring despite significant underlying hemodynamic instability [29-31]. Consistent with this, Vandrajabpour et al. [32] reported SI to be an unreliable predictor of mortality in an elderly cohort, with a sensitivity of only 48.48% and an AUC of 0.339 at a cutoff of 0.9. Nevertheless, several studies have demonstrated the utility of SI in predicting adverse outcomes in geriatric trauma patients [33,34], and our findings align with this evidence; shock index was associated with both ICU admission and in-ED death and emerged as an independent predictor of 30-day mortality in multivariate analysis. The variability in reported predictive performance across studies likely reflects differences in threshold selection, patient populations, and injury profiles, reinforcing the need for age-specific validation of SI cutoff values in geriatric trauma.

Elevated NLR, reflecting systemic inflammation, was also associated with ICU admission and in-ED death in our oldest-old cohort. Although immune responses may be attenuated in older adults because of immunosenescence, aging is paradoxically characterized by chronic low-grade inflammation and impaired regulation of the inflammatory response, a phenomenon often referred to as "inflammaging" [35]. This underlying dysregulation may partly explain why higher NLR at presentation was associated with ICU admission and in-ED death in our cohort. However, NLR did not emerge as an independent predictor of 30-day mortality in multivariate analysis. This may suggest that although NLR captures the overall inflammatory and physiological stress burden following trauma, its prognostic signal is not independent; rather, it is likely mediated or confounded by closely related factors such as injury severity, hemodynamic instability, renal dysfunction, frailty, or nutritional compromise [36]. In this context, NLR may be better understood as a marker of overall physiological derangement than as a standalone predictor of mortality in this population.

Notably, age and coagulation parameters were not associated with ICU admission, in-ED death, or 30-day mortality in our cohort. The lack of an association with age is consistent with the broader literature, which suggests that ICU admission decisions are primarily driven by injury severity, physiological instability, and pre-existing medical conditions rather than chronological age alone [37]. Regarding coagulation parameters, although trauma-induced coagulopathy is well recognized as a contributor to adverse outcomes, its prognostic impact may be more pronounced in higher-acuity trauma populations; the predominantly low-severity injury profile of our cohort may have limited its discriminatory value. These findings should nonetheless be interpreted with caution. The majority of our patients sustained low-severity injuries (ISS 1–2), and the cohort included only 13 ICU admissions and 3 in-ED deaths, resulting in limited statistical power to detect associations with less common outcomes. Larger prospective studies with more balanced severity distributions are needed to draw more definitive conclusions regarding the prognostic role of age and coagulation parameters in oldest-old trauma patients.

Frailty has been shown to predict in-hospital complications, longer hospital and ICU lengths of stay, and mortality in geriatric trauma patients, independent of injury severity [38]. In our multivariate analysis, frailty emerged as an independent predictor of 30-day mortality, reinforcing its prognostic value beyond traditional trauma scoring systems. These findings highlight the importance of routine frailty assessment at the time of ED presentation, as early identification of frail patients may guide triage decisions, inform goals-of-care discussions, and facilitate the timely mobilization of geriatric-specific resources.

The clinical implications of our multivariate analysis are particularly relevant to emergency department triage and early risk stratification. Current triage systems, such as the Emergency Severity Index and the Canadian Triage and Acuity Scale, rely primarily on presenting acuity, vital sign thresholds, and anticipated resource needs, without formally incorporating frailty or trauma-specific severity indices. This may result in miscalibrated triage decisions in oldest-old trauma patients, whose physiological reserve and injury tolerance may differ substantially from those of younger patients. In light of our findings, a combined approach integrating acute hemodynamic status (shock index), age-adjusted injury severity (GTOS), and baseline vulnerability (frailty level) may provide a more comprehensive framework for risk stratification, resource allocation, and goals-of-care discussions than any single score in isolation.

This study has several limitations. First, it was conducted retrospectively at a single tertiary ED, which may limit the generalizability of the findings to other healthcare systems, hospital settings, and trauma populations. Second, although the overall sample size was acceptable, the number of severe outcomes was limited, particularly ICU admissions, in-ED deaths, and 30-day mortality events. This may have reduced the statistical power for some comparisons and increased the risk of model instability or overfitting in the multivariate analysis. Third, the study population predominantly consisted of patients with low-energy trauma and relatively low injury severity; therefore, the prognostic performance of the identified predictors may differ in cohorts with higher-acuity trauma or more balanced injury severity distributions. Finally, this study evaluated 30-day mortality but did not assess longer-term outcomes such as functional decline, institutionalization, quality of life, or delayed complications. Prospective multicenter studies with standardized frailty assessment and longer follow-up are needed to validate these findings and clarify their role in clinical decision-making.

Conclusion

Trauma in the oldest-old population was predominantly related to low-energy mechanisms, particularly falls. However, even these low-energy injuries may be associated with clinically important morbidity and mortality. Among the evaluated clinical, physiological, and prognostic variables, shock index, GTOS, and frailty level were identified as independent predictors of 30-day mortality. Further prospective studies are required to validate these findings and clarify their applicability across different emergency care settings.

Abbreviations

AIS: Abbreviated Injury Scale
aPTT/APTT: Activated Partial Thromboplastin Time
AUC: Area Under the Curve
CFS: Clinical Frailty Scale
CI: Confidence Interval
CRP: C-Reactive Protein
DBP: Diastolic Blood Pressure
ED: Emergency Department
GCS: Glasgow Coma Scale
GFR: Glomerular Filtration Rate
GTOS: Geriatric Trauma Outcome Score
HCT: Hematocrit
HGB: Hemoglobin
HR: Heart Rate
ICD-10: International Classification of Diseases, 10th Revision
ICU: Intensive Care Unit
INR: International Normalized Ratio
IQR: Interquartile Range
ISS: Injury Severity Score
NLR: Neutrophil-to-Lymphocyte Ratio
OR: Odds Ratio
PLT: Platelet Count
RBC: Red Blood Cell
RDW-CV: Red Cell Distribution Width–Coefficient of Variation
ROC: Receiver Operating Characteristic
RR: Respiratory Rate
SBP: Systolic Blood Pressure
SI: Shock Index
SPSS: Statistical Package for the Social Sciences

Ethics Committee Approval: This study was approved by The Basaksehir Cam and Sakura City Hospital on 06.11.2023 with protocol number of KAEK/25.10.2023.520.

Informed Consent: Written informed consents were obtained from patients who participated in this study.

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References

1. Santing JAL, Brand CLVD, Panneman MJM, Asscheman JS, van der Naalt J, Jellema K. Increasing incidence of ED-visits and admissions due to traumatic brain injury among elderly patients in the Netherlands, 2011-2020. Injury. 2023;54:110902.
2. Vaupel JW, Villavicencio F, Bergeron-Boucher MP. Demographic perspectives on the rise of longevity. Proc Natl Acad Sci U S A. 2021;118:e2019536118.
3. Orces CH. Trends in hospitalization for fall-related injuries in US older adults, 2001-2021. ScientificWorldJournal. 2025;2025:8340466.
4. Shanahan TAG, Tonkins M, Bouamra O, Surendra Kumar D, Edwards A, White L, et al. Comparative analysis of the characteristics, care pathways, and outcomes of English and Welsh major trauma patients injured by high versus low energy transfer mechanisms in 2019. PLoS One. 2026;21:e0344392.
5. Kerschbaum M, Lang S, Henssler L, Ernstberger A, Alt V, Pfeifer C, et al. Influence of oral anticoagulation and antiplatelet drugs on outcome of elderly severely injured patients. J Clin Med. 2021;10:1649.
6. Lund BD, Wang T. A bibliometric study of research pertaining to the oldest-old (age eighty-five and older). J Med Libr Assoc. 2020;108:59–66.
7. US Department of Commerce, Economics and Statistics Administration, US Census Bureau. Vincent GK, Velkoff VA. The next four decades: the older population in the United States: 2010 to 2050 (no. 1138); 2010. Available at: https://www.census.gov/prod/2010pubs/p25-1138.pdf Accessed May 21, 2019.

8. Bhattacharya B, Maung A, Schuster K, Davis KA. The older they are the harder they fall: Injury patterns and outcomes by age after ground level falls. Injury. 2016;47:1955–9.
9. Bozorgi F, Assadi T, Sazgar M, Jahanian F, Abdollahifar M, Aminiahidashti H. Trauma outcomes in elderly patients referring to the emergency department via the rapid emergency medicine score, injury severity score, and geriatric trauma outcome score indices. Int J Emerg Med. 2025;18:223.
10. Cook AC, Joseph B, Inaba K, Nakonezny PA, Bruns BR, Kerby JD, et al. Multicenter external validation of the Geriatric Trauma Outcome Score: A study by the Prognostic Assessment of Life and Limitations After Trauma in the Elderly (PALLIATE) consortium. J Trauma Acute Care Surg. 2016;80:204–9.
11. Alqarni AG, Gladman JRF, Obasi AA, Ollivere B. Does frailty status predict outcome in major trauma in older people? A systematic review and meta-analysis. Age Ageing. 2023;52:afad073.
12. Jiang L, Zheng Z, Zhang M. The incidence of geriatric trauma is increasing and comparison of different scoring tools for the prediction of in-hospital mortality in geriatric trauma patients. World J Emerg Surg. 2020;15:59.
13. Bindrich S, Mittlmeier T, Falk SSI. In the last 10 years, have our polytrauma patients become geriatric? The emergency trauma bay in the context of demographic change. Eur J Trauma Emerg Surg. 2025;51:61.
14. Dinh MM, Roncal S, Byrne CM, Petchell J. Growing trend in older patients with severe injuries: mortality and mechanisms of injury between 1991 and 2010 at an inner city major trauma centre. ANZ J Surg. 2013;83:65–9.
15. Zafar SN, Obirieze A, Schneider EB, Hashmi ZG, Scott VK, Greene WR, et al. Outcomes of trauma care at centers treating a higher proportion of older patients: the case for geriatric trauma centers. J Trauma Acute Care Surg. 2015;78:852–9.
16. Haines M, Measey MM, Whitty A, McCabe A. Outcomes in older patients presenting with major trauma to an Irish university hospital emergency department: a five-year review. Ann Emerg Med. 2023;82(4 Suppl):S25–6.
17. Ogliari G, Coffey F, Keillor L, Aw D, Azad MY, Allaboudy M, et al. Emergency department use and length of stay by younger and older adults: Nottingham cohort study in the emergency department (NOCED). Aging Clin Exp Res. 2022;34:2873–85.
18. Söz G, Karakaya Z. The evaluation of geriatric patients who presented with trauma to the emergency department. Arch Med Sci. 2019;15:1261–8.
19. Demircan A, Aygencel Bıkmaz ŞG, Kadı G, Keleş A, Bildik F, Öktem B, et al. Evaluation of the general characteristics of patients aged 85 years and above admitted to a university hospital emergency department. Turk J Med Sci. 2017;47:1393–402.
20. Abhilash KPP, Tephilah R, Pradeeptha S, Gunasekaran K, Chandy GM. Injury patterns and outcomes of trauma in the geriatric population presenting to the emergency department in a tertiary care hospital of South India. J Emerg Trauma Shock. 2019;12:198–202.
21. Brown CV, Rix K, Klein AL, Ford B, Teixeira PG, Aydelotte J, et al. A comprehensive investigation of comorbidities, mechanisms, injury patterns, and outcomes in geriatric blunt trauma patients. Am Surg. 2016;82:1055–62.
22. Calvo RY, Lindsay SP, Edland SD, Macera CA, Wingard DL, Ohno-Machado L, et al. The differential associations of preexisting conditions with trauma-related outcomes in the presence of competing risks. Injury. 2016;47:677–84.
23. Wong H, Lovett N, Curry N, Shah K, Stanworth SJ. Antithrombotics in trauma: management strategies in the older patients. J Blood Med. 2017;8:165–74.
24. Liu XY, Qin YM, Tian SF, Zhou JH, Wu Q, Gao W, et al. Performance of trauma scoring systems in predicting mortality in geriatric trauma patients: comparison of the ISS, TRISS, and GTOS based on a systemic review and meta-analysis. Eur J Trauma Emerg Surg. 2024;50:1453–65.
25. Ravindranath S, Ho KM, Rao S, Nasim S, Burrell M. Validation of the geriatric trauma outcome scores in predicting outcomes of elderly trauma patients. Injury. 2021;52:154–9.
26. Chow J, Kuza CM. Predicting mortality in elderly trauma patients: a review of the current literature. Curr Opin Anaesthesiol. 2022;35:160–5.
27. Kim JG, Choi HY, Kang GH, Jang YS, Kim W, Lee Y, et al. Prognostic association between injury severity score and the outcomes of elderly patients with trauma in South Korea. J Pers Med. 2024;14:674.
28. Moradi EV, Sadrzadeh SM, Zakeri H, Rezvani B, Azari M, Ghorbannezhad G. Evaluating trauma severity scores: predicting mortality in patients with geriatric trauma. Hong Kong J Emerg Med. 2025;32:e70015.
29. Choudhary MK, Holmström K, Bouquin H, Saarinen TP, Koskela JK, Pietilä E, et al. Impact of aging on cardiovascular dynamics and heart rate variability during passive head-up tilt. Physiol Rep. 2025;13:e70477.
30. Chester JG, Rudolph JL. Vital signs in older patients: age-related changes. J Am Med Dir Assoc. 2011;12:337–43.
31. Madden KM, Feldman B, Meneilly GS. Baseline shock index and baroreflex function in older adults. Aging Health Res. 2025;5:100220.
32. Vandrajabpour Z, Paknezhad S, Ghaffarzad A, Parsian Z, Mortezabagi H, Akhgari A. Determining the predictive value of shock index, reverse shock index, and modified shock index in hospital outcome of gastrointestinal bleeding in elderly patients. Int J Aging. 2024;2:e25.
33. Pandit V, Rhee P, Hashmi A, Kulvatunyou N, Tang A, Khalil M, et al. Shock index predicts mortality in geriatric trauma patients: an analysis of the National Trauma Data Bank. J Trauma Acute Care Surg. 2014;76:1111–5.
34. Rafieezadeh A, Prabhakaran K, Kirsch J, Klein J, Shnaydman I, Bronstein M, et al. Shock index is a stronger predictor of outcomes in older compared to younger patients. J Surg Res. 2024;300:8–14.
35. Müller L, Di Benedetto S. Immunosenescence and inflammaging: Mechanisms and modulation through diet and lifestyle. Front Immunol. 2025;16:1708280.
36. Hosseini M, Fazeli P, Hajivalili M, Paydar S. The prognostic values of neutrophil to lymphocyte ratio in traumatically injured patients upon admission: a mini-review. Eur J Inflamm. 2023;21.
37. Kirshenbom D, Ben-Zaken Z, Albilya N, Niyibizi E, Bala M. Older age, comorbid illnesses, and injury severity affect immediate outcome in elderly trauma patients. J Emerg Trauma Shock. 2017;10:146–50.
38. Abdelrahman H, El-Menyar A, Consunji R, Khan NA, Asim M, Mustafa F, et al. Predictors of prolonged hospitalization among geriatric trauma patients using the modified 5-Item Frailty index in a Middle Eastern trauma center: an 11-year retrospective study. Eur J Trauma Emerg Surg. 2025;51:82.