Multivariate analysis of blood parameters for predicting mortality in patients with hip fractures

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Abstract. The present retrospective cross-sectional study aimed to evaluate the predictive value of blood parameters and ratios for predicting mortality in patients with hip fractures. In total, 758 patients with hip fractures attending the Department of Orthopedics and Traumatology, Kütahya Health Sciences University Faculty of Medicine (Kütahya, Turkey) between January 2016 and January 2023 were included in the present study. Patients were then divided into two groups, namely the mortality (n=464; 61.2%) and survivor (n=294; 38.8%) groups. Patients in the mortality group were further sub-divided into the following three subgroups: i) Those who succumbed in <1 month (n=117; 25.2%); ii) those who succumbed between 1 and 12 months (n=185; 39.9%); and iii) those who succumbed >12 months later (n=162; 34.9%). In addition, the RDW coefficient of variation, mean platelet volume (MPV), MPV/platelet ratio, neutrophil-to-lymphocyte ratio, monocyte-to-lymphocyte ratio, platelet-to-lymphocyte ratio (PLR), mean platelet volume-to-lymphocyte ratio and monocyte-to-eosinophil ratio means were all found to be significantly higher in the mortality group (P<0.05). MPV (P<0.01), HGB (P<0.05), eosinophil, EOS (P<0.01), HRR (P<0.01), and PLR (P<0.05) were all revealed to exert significant effects on mortality. An age cut-off of 74.50 years had a sensitivity of 81.5% and specificity of 37.1%, whereas an MPV cut-off of 8.85 yielded a sensitivity of 73.5% and specificity of 36.1%. By contrast, an HGB cutoff of 11.05 had a sensitivity of 55.6% and specificity of 35.7%, an eosinophil cut-off of 0.065 had a sensitivity of 47.6% and specificity of 35.4%, whilst a HRR cut-off of 0.7587 had a sensitivity of 55.2% and specificity of 30.3%. Furthermore, a PLR cut-off of 152.620 had a sensitivity of 67.2% and specificity of 41.8% for hip fracture-associated mortality. An age cut-off of 79.50 years had a sensitivity of 70.9% and specificity of 41.5%, while an age cut-off of 83.50 years had a sensitivity of 46.2% and specificity of 64.0% for mortality occurring <1 month after hip fractures. To conclude, results from the present study suggested that HRR has potential predictive value for hip fracture-associated mortality and 30-day mortality, whereas the PLR could only predict hip fracture-associated mortality.

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Abbreviations: AUC, area under the curve; ELR, eosinophil-to-lymphocyte ratio; HRR, hemoglobin-to-red cell distribution width ratio; MER, monocyte-to-eosinophil ratio; MLR, monocyte-to-lymphocyte ratio; MPV/PLT, mean platelet volume-to-platelet ratio; MPVLR, mean platelet volume-to-lymphocyte ratio; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; RDW, red cell distribution width; RDW-CV, red cell distribution width coefficient of variation

Key words: hip fracture, mortality, blood parameters, predictive value

Introduction

Hip fractures pose a significant risk of morbidity and mortality to patients, resulting in high public health costs. A previous provisional study predicted that the frequency of hip fractures will rise exponentially with aging populations, with 4.5-6.3 million being reported annually worldwide by 2050 (1). Elderly individuals tend to suffer from severe health complaints more frequently, particularly hip fractures (2-4). Hip fractures in older individuals can incur not only medical problems but can also limit their self-care abilities whilst preventing their daily activities, because hip fractures in older adults will most probably limit their physical activity. In addition, aging can directly or indirectly affect the health of older individuals and is associated with high-mortality diseases.

Mortality is one of the most important outcomes of hip fractures. Previous studies on hip fractures have focused on causes, risk factors and predictors of mortality (5-8). In an observational study, Pollmann *et al* (5) reported that age, sex, cognitive impairment and the American Society of Anesthesiologists score are risk factors of mortality in patients with hip fractures (5). In another study, Garre-Fivelsdal *et al* (6) reported that a standardized clinical pathway significantly reduced the 30-day mortality in patients with hip fractures (6). Holvik *et al* (8) also reported that traumatic hip fractures have

Table I. Baseline and clinical parameters of mortality groups and difference analysis results.

Parameter	No (n=294)	Yes (n=464)	P-value
Sex, n (%)			<0.001[a]
Female	208 (70.7)	264 (56.9)	
Male	86 (29.3)	200 (43.1)	
Age, years	77.21±7.69	80.84±7.03	<0.001[b]
Monocytes, n (x10^9/l)	0.59±0.23	0.60±0.27	0.498[b]
RDW-CV	14.33±2.32	14.89±2.20	<0.001[b]
Neutrophil	8.33±3.52	8.51±4.00	0.925[b]
PLT, g/l	225.49±75.98	221.41±81.12	0.398[b]
MPV, g/l	9.13±0.81	9.56±1.04	<0.001[b]
HGB, g/l	11.67±1.78	11.32±1.75	0.007[c]
Eosinophils, n (x10^9/l)	0.14±0.14	0.09±0.12	<0.001[b]
Lymphocytes, n (x10^9/l)	1.41±0.71	1.18±0.64	<0.001[b]
EOS, %	0.14±0.14	0.09±0.12	<0.001[b]
Follow-up, days	37.62±14.39	12.00±14.52	<0.001[b]
ELR	0.11±0.10	0.08±0.10	<0.001[b]
HRR	0.83±0.17	0.78±0.17	<0.001[c]
MPV/PLT	0.04±0.02	0.05±0.03	0.011[b]
NLR	7.59±5.14	9.50±6.49	<0.001[b]
MLR	0.50±0.28	0.64±0.38	<0.001[b]
PLR	191.82±94.27	238.07±148.53	<0.001[b]
MPVLR	8.10±4.04	10.56±5.72	<0.001[b]
MER	13.25±18.29	24.89±29.08	<0.001[b]
NMR	15.44±7.40	15.89±9.21	0.741[b]

[a]Fisher's Exact Test, [b]U-Mann Whitney Test and [c]unpaired t-test. RDW-CV, RDW-CV, red cell distribution width coefficient of variation; PLR, platelet-to-lymphocyte ratio; MPV, mean platelet volume; HGB, hemoglobin; EOS, eosinophil; ELR, eosinophil-to-lymphocyte ratio; HRR, hemoglobin/red cell distribution width ratio; MPV/PLT, mean platelet volume-to-platelet; NLR, neutrophil-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MPVLR, mean platelet volume-to-lymphocyte ratio; MER, monocyte-to-eosinophil ratio; NMR, neutrophil-to-monocyte ratio.

higher mortality rates, with trauma being the most important risk factor.

Effective mortality prediction is therefore crucial for reducing the risk of such an event, by allowing for the prompt management of risk factors and vital functions. Therefore, clinical research and meta-analysis studies have previously examined the role of neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), eosinophil-to-lymphocyte ratio (ELR), hemoglobin-to-red cell distribution width (RDW) ratio (HRR), mean platelet volume-to-platelet (MPV/PLT) ratio and monocyte-to-lymphocyte ratio (MLR), in patients with orthopedic problems (9-14). The main objective of these ratios is to identify indicators that could predict mortality and disease-related mortality accurately.

It may be suggested that in order to reduce the mortality rate and increase the quality of life after hip fracture, indicators that can predict mortality and are more easily obtained in the clinic are needed. Despite the existence of studies on risk factors and mortality in patients with hip fractures, detailed studies on the association between mortality and blood parameters remain scarce. Therefore, the present study aimed to evaluate the predictive value of blood parameters and ratios for predicting mortality in patients with hip fractures.

Patients and methods

Study design. The present study was conducted in descriptive cross-sectional and retrospective study pattern. Patient data were retrospectively taken from patient files according to the ethical approval frame. Ethical approval was obtained from Kütahya Health Sciences University Non-Invasive Clinical Research Ethics Committee (approval no. E-41997688-050.99-77929).

The present study included 758 patients with hip fractures attempting to Department of Orthopedics and Traumatology, Kütahya Health Sciences University Faculty of Medicine (Kütahya, Turkey) between January 2016 and January 2023. Patient files were accessed after ethical approval was received, between January 2023 to June 2023. Yao *et al* (15) reported the NLR as 6.38±4.74 for a hip fracture population. According to this previous study, power analysis was calculated from 10% deviation and 90% Confidence and effect size of 0.250 was found. According to this effect size, the minimum sample size was calculated as 175 using the G*Power 3.1.9.2 program (Heinrich-Heine-Universität Düsseldorf). In the present study, >175, which was the calculated minimum required sample size, was reached. The patients were divided into two groups, namely mortality (n=464; 61.2%) and survivor (n=294; 38.8%).

Table II. Spearman's rank correlation analysis between mortality and parameters of patients.

Parameter	r_s	P-value
RDW-CV	0.189	<0.001
MPV, g/l	0.190	<0.001
HGB, g/l	-0.102	0.005
Eosinophils, n (x10^9/l)	-0.227	<0.001
Lymphocytes, n (x10^9/l)	-0.181	<0.001
EOS, %	-0.218	<0.001
Follow-up, days	-0.653	<0.001
ELR	-0.163	<0.001
HRR	-0.169	<0.001
MPV/PLT	0.092	0.011
NLR	0.135	<0.001
MLR	0.170	<0.001
PLR	0.148	<0.001
MPVLR	0.221	<0.001
MER	0.216	<0.001

RDW-CV, RDW-CV, red cell distribution width coefficient of variation; MPV, mean platelet volume; HGB, hemoglobin; EOS, eosinophile percentage; ELR, eosinophil-to-lymphocyte ratio; HRR, hemoglobin-to-red cell distribution width ratio; MPV/PLT, mean platelet volume-to-platelet ratio; NLR, neutrophil-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MPVLR, mean platelet volume-to-lymphocyte ratio; MER, monocyte-to-eosinophil ratio.

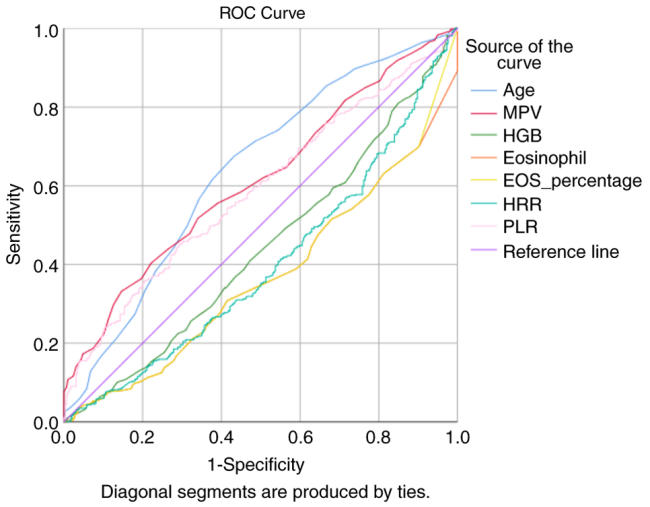

Figure 1. ROC curve results for parameters that significantly regressed following Cox regression. ROC, receiver operating characteristic; MPV, mean platelet volume; HGB, hemoglobin; EOS, eosinophil (%); HRR, hemoglobin-to-red cell distribution width ratio; PLR, platelet-to-lymphocyte ratio.

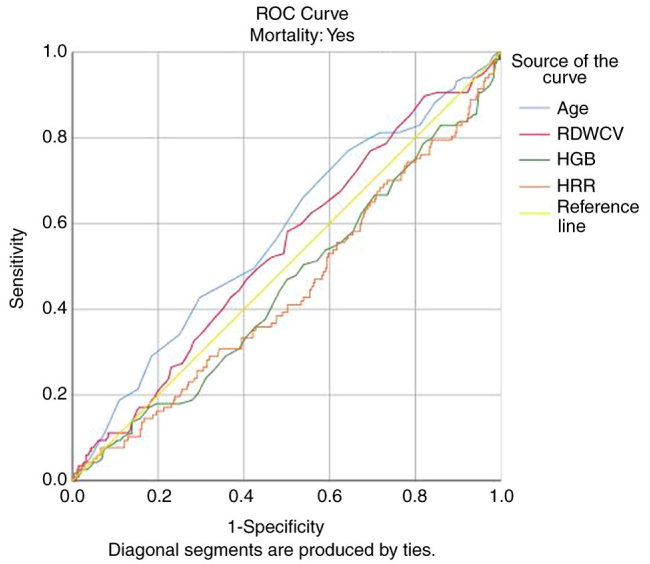

Figure 2. ROC curve analysis results for mortality occurring <1 month. ROC, receiver operating characteristic; RDW-CV, red cell distribution width coefficient of variation; HGB, hemoglobin; HRR, hemoglobin-to-red cell distribution width ratio.

In addition, patients in the mortality group were divided into the following three subgroups: i) Those who succumbed in <1 month (n=117; 25.2%); ii) those who succumbed between 1 and 12 months (n=185; 39.9%); and iii) those who succumbed in >12 months (n=162; 34.9%). In the present study, inclusion criteria were: i) Patients having hip fractures; ii) patient files having follow up data for research duration; and iii) patients aged ≥18 (not pediatric samples). Exclusion criteria were: i) Patient files not having required data for the research; ii) patients having chronic health problems affecting results; iii) patients having malign diseases; iv) patients having comorbidities may affect results; v) patients having pre-existing conditions which may affect mortality or blood parameters; and vi) infection reported patient files which may affect blood parameters.

Data collection process. The hospital automation system and patient files provided information on blood parameters, postoperative mortality status, demographics and the number of surgeries performed. However, the content of indications, information regarding epicrisis and details on which indication was followed at which center were unclear because the study was retrospective. Due to this, indication-associated mortalities that were explicitly stated as study criteria were disregarded.

Statistical analysis. Frequency analysis was used to generate descriptive statistics for nominal and ordinal parameters, whereas means ± standard deviations were used to describe scale parameters. Kolmogorov-Smirnov test was used to examine the normality of scale parameters. Fisher's exact test was used to analyze differences between sex distributions. The U-Mann Whitney test was used for comparing non-parametric differences, whereas the unpaired t-test was used to analyze any parametric differences. Since there may be regression deviations in field difference (16), Cox regression was used for mortality prediction. Spearman's rank correlation, Cox regression and receiver operating characteristic (ROC) analysis were used for relationship analysis. SPSS Statistics for Windows version 25.0 (IBM Corp.) was used for analysis at 95% CI. P<0.05 was considered to indicate a statistically significant difference.

Table III. Cox regression at multivariate level for mortality and significantly associated parameters at univariate level.

						95.0% CI for OR	
Parameter	B	Standard error	Wald	P-value	OR	Lower	Upper
Sex	-0.438	0.098	20.086	<0.001	0.645	0.533	0.781
Age, years	0.040	0.007	33.482	<0.001	1.040	1.027	1.054
RDW-CV	-0.101	0.056	3.174	0.075	0.904	.809	1.010
MPV, g/l	0.257	0.055	21.811	<0.001	1.293	1.161	1.440
HGB, g/l	0.238	0.108	4.816	0.028	1.268	1.026	1.568
Eosinophil	-65.350	18.069	13.081	<0.001	0.000	0.000	0.000
Lymphocytes, n ($x10^9$/l)	-0.109	0.148	0.543	0.461	0.897	.671	1.198
EOS (%)	65.546	18.012	13.242	<0.001	$2.92x10^{28}$	$1.36x10^{13}$	$6.28x10^{43}$
ELR	-1.233	1.260	0.957	0.328	0.291	0.025	3.445
HRR	-4.515	1.483	9.265	0.002	0.011	0.001	0.200
MPV/PLT	3.432	2.949	1.354	0.245	30.942	0.096	10023.797
NLR	-0.006	0.013	0.241	0.624	0.994	0.969	1.019
MLR	0.013	0.213	0.004	0.950	1.013	0.667	1.539
PLR	0.001	0.001	5.044	0.025	1.001	1.000	1.003
MPVLR	-0.018	0.019	0.874	0.350	0.982	0.945	1.020
MER	0.005	0.003	3.041	0.081	1.005	0.999	1.010

OR, odds ratio; CI, Confidence interval; RDW-CV, red cell distribution width coefficient of variation; MPV, mean platelet volume; HGB, hemoglobin; EOS, eosinophile percentage; ELR, eosinophil-to-lymphocyte ratio; HRR, hemoglobin-to-red cell distribution width ratio; MPV/PLT, mean platelet volume-to-platelet ratio; NLR, neutrophil-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MPVLR, mean platelet volume-to-lymphocyte ratio; MER, monocyte-to-eosinophil ratio.

Table IV. Receiver operating curve results for significantly regressed parameters following Cox regression.

				Asymptotic 95% CI	
Variables	Area under the curve	Standard error	P-value	Lower bound	Upper bound
Age	0.638	0.021	<0.001	0.597	0.679
MPV, g/l	0.612	0.020	<0.001	0.572	0.652
HGB, g/l	0.560	0.021	0.005	0.398	0.482
Eosinophils, n ($x10^9$/l)	0.634	0.020	<0.001	0.327	0.405
EOS (%)	0.628	0.020	<0.001	0.332	0.411
HRR	0.600	0.021	<0.001	0.359	0.441
PLR	0.587	0.021	<0.001	0.547	0.628

MPV, mean platelet volume; HGB, hemoglobin; EOS, eosinophile percentage; HRR, hemoglobin-to-red cell distribution width ratio; PLR, platelet-to-lymphocyte ratio.

Results

Baseline characteristics. In total, 70.7% of the surviving patients and 56.9% of the mortality group were women. The mean age was found to be 80.84±7.03 years in the mortality group and 77.21±7.69 years in the non-mortality group. Age was ranged between 61-96 years. Comorbidity were exclusion criteria. Female percentage, hemoglobin (HGB), eosinophil, lymphocyte, EOS (%), follow-up, ELR and HRR means were found to be significantly higher in the survivor group (P<0.05). By contrast, age, RDW coefficient of variation (CV), MPV, MPV/PLT, NLR, MLR, PLR, mean platelet volume-to-lymphocyte ratio (MPVLR) and monocyte-to-eosinophil ratio (MER) means were found to be significantly higher in the mortality group (P<0.05). The differences between monocytes, neutrophils, PLTs, and neutrophil-to-monocyte ratios were not significant between the two groups (Table I).

Mortality (Table II) was found to be correlated with RDW-CV (r_s=0.189; P<0.01), MPV (r_s=0.190; P<0.01), HGB (r_s=-0.102; P<0.01), eosinophil (r_s=-0.227; P<0.01), lymphocyte (r_s=-0.181; P<0.01), EOS % (r_s=-0.218; P<0.01),

Table V. Spearman's rank correlation analysis between 30-day mortality and parameters of patients.

Mortality after <1 month	r_s	P-values
RDW-CV	-0.091	0.050
MPV, g/l	-0.024	0.610
HGB, g/l	0.136	0.003
Eosinophil, n ($x10^9$/l)	0.010	0.832
Lymphocyte, n ($x10^9$/l)	0.019	0.690
EOS (%)	0.002	0.972
ELR	-0.009	0.848
HRR	0.155	0.001
MPV_PLT	-0.070	0.134
NLR	-0.008	0.868
MLR	-0.053	0.254
PLR	0.007	0.873
MPVLR	-0.022	0.644
MER	-0.016	0.734

RDW-CV, red cell distribution width coefficient of variation; MPV, mean platelet volume; HGB, hemoglobin; EOS, eosinophile percentage; ELR, eosinophil-to-lymphocyte ratio; HRR, hemoglobin-to-red cell distribution width ratio; MPV/PLT, mean platelet volume-to-platelet ratio; NLR, neutrophil-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MPVLR, mean platelet volume-to-lymphocyte ratio; MER, monocyte-to-eosinophil ratio.

Table VI. Receiver operating characteristic curve analysis results for mortality at <1 month.

				Asymptotic 95% CI	
Variables	Area under the curve	Standard error	P-value	Lower bound	Upper bound
Age	0.574	0.031	0.016	0.514	0.634
RDW-CV	0.539	0.030	0.211	0.479	0.598
HGB, g/l	0.453	0.031	0.126	0.392	0.514
HRR	0.445	0.031	0.074	0.384	0.506

RDW-CV, red cell distribution width coefficient of variation; HGB, hemoglobin; HRR, hemoglobin-to-red cell distribution width ratio.

Table VII. Test results for cut off values for HLR and PLR for mortality using Fisher's exact test.

	Mortality		
Variables	No	Yes	P-value
HRR <0.7587	89 (30.3)	208 (44.8)	<0.001
HRR >0.7587	205 (69.7)	256 (55.2)	
PLR <152.6198	123 (41.8)	152 (32.8)	0.007
PLR >152.6198	171 (58.2)	312 (67.2)	

HRR, hemoglobin/red cell distribution width ratio; PLR, platelet-to-lymphocyte ratio.

follow-up (r_s=-0.653; P<0.01), ELR (r_s=-0.163; P<0.01), HRR (r_s=-0.169; P<0.01), MPV/PLT (r_s=0.092; P<0.01), NLR (r_s=0.135; P<0.01), MLR (r_s=0.170; P<0.01), PLR (r=0.148; P<0.01), MPVLR (r_s=0.221; P<0.01) and MER (r_s=0.216; P<0.01).

Cox regression analysis results. Cox regression analysis results showed that sex (B=-0.438; P<0.01), age (B=0.040; P<0.01), MPV (B=0.257; P<0.01), HGB (B=0.238; P<0.01), eosinophil, EOS % (B=-0.65.30; P<0.01), HRR (B=-4.515; P<0.01) and PLR (B=0.001; P<0.01) can significantly affect mortality (Table III).

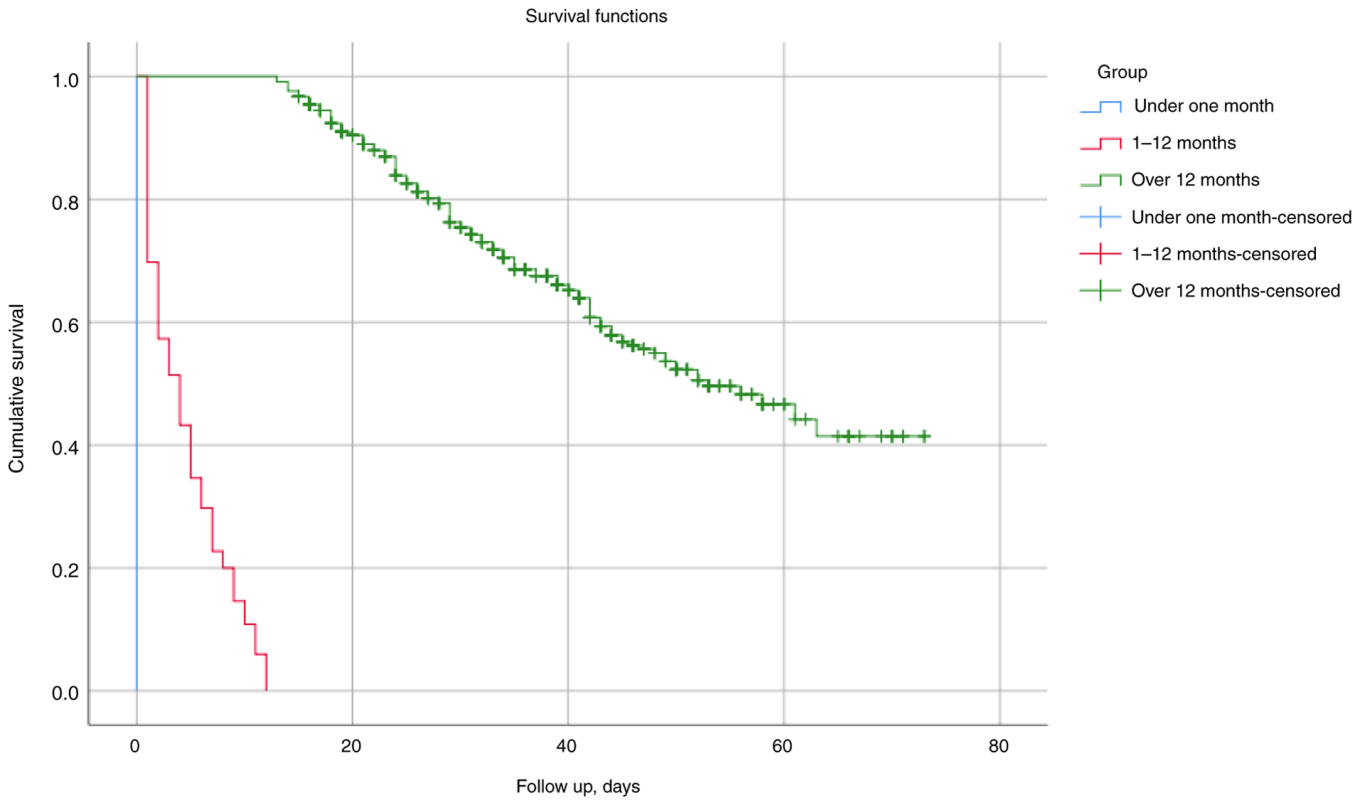

Figure 3. Kaplan-Meier analysis for 30-day mortality and 1-year mortality.

ROC analysis results. Although the predictive value of all regression parameters following Cox regression were significant (P<0.05), their area under the curve (AUC) values were found to be closer, where age had the highest predictive value, followed by eosinophil, EOS (%), MPV, HRR, PLR and HGB (Table IV).

An age cut-off of 74.50 years had a sensitivity of 81.5% and specificity of 37.1%, an MPV cut-off of 8.85 had a sensitivity of 73.5% and specificity of 36.1%, an HGB cut-off of 11.05 had a sensitivity of 55.6% and specificity of 35.7%, an EOS cut-off of 0.065 had a sensitivity of 47.6% and specificity of 35.4%, an HRR cut-off of 0.7587 had a sensitivity of 55.2% and specificity of 30.3%, whilst a PLR cut-off of 152.6198 had a sensitivity of 67.2% and specificity of 41.8%, for hip fracture-related mortality (Fig. 1).

Spearman's rank correlation analysis showed that patient parameters, namely, age (B=-0.168; P<0.01), RDW-CV (B=-0.091; P<0.05), HGB (B=0.136; P<0.01) and HRR (B=0.155; P<0.01), significantly correlated with mortality occurring in <1 month (Table V).

The results of the ROC curve analysis showed that age had a predictive value for mortality occurring <1 month after hip fractures (AUC=0.574; P<0.05; Table VI).

An age cut-off of 79.50 years had a sensitivity of 70.9% and specificity of 41.5%, whereas an age cut-off of 83.50 years had a sensitivity of 46.2% and specificity of 64.0% for mortality occurring in <1 month (Fig. 2). Kaplan-Meier Analysis for 30-day mortality and 1-year mortality was also shown in Fig. 3.

The sample was grouped according to the cut-off points obtained, and these were also displayed with a cross table. Test results for cut-off values for HLR and PLR for mortality showed that HRR cut-off of 0.7587 had a sensitivity of 55.2% and specificity of 30.3%, whereas a PLR cutoff of 152.6198 had a sensitivity of 67.2% and specificity of 41.8% for hip fracture-related mortality (Table VII).

Discussion

In the present study, blood parameters that can affect hip fracture-related mortality were examined in a multivariate analysis. Specifically, medical records of 294 and 464 patients who survived or succumbed following hip fracture surgery were retrospectively reviewed. Blood parameter ratios and basic blood parameters of the patients were then used to analyze indicator rates in the literature.

Despite advancements in its diagnosis and treatment, hip fracture-associated mortality remain a significant public health problem (17-20). Kjærvik *et al* (7) previously reported that patients with hip fractures have a cumulative mortality rate of 16% within the first 12 months and 41% within 6 years (7). In another study, Holvik *et al* (8) reported a 30-day mortality of 24.3% after hip fractures (8). By contrast, Meyer *et al* (3) reported a 30-day mortality rate of 4.5-6.4% in women and 9.5-11.8% in men following hip fracture. In the present study, the 30-day mortality rate was reported to be 15.4%, where the 1-year mortality rate was 24.4% in the entire sample. The rates obtained in the present study are consistent with those of previous studies, presenting high mortality rates following hip fracture.

Although currently no data support a specific demographic structure for hip fractures, it may be argued that it is more

common in older, female individuals (21-23). In a previous study by Wang *et al* (12), the mean age of patients with hip fractures was 79.31 years and 66.96% of the patients were female. In the study by Garre-Fivelsdal *et al* (6), the mean age of the patients was between 80.0 and 79.7 years and the proportion of female patients was between 66.7-65.9%. However, Pollmann *et al* (5) previously reported that 67.9-69.2% patients with hip fractures were female, with a mean age of 79.6-79.7 years (5). In the present study, the mean age of the patients was 80.84 years in the mortality group and 77.21 years in the survivor group, of which 56.9% of the patients in the mortality group and 70.7% in the survivor group were female. This suggests that the present results are consistent with those of previous studies.

Previous studies have examined the prospect of using blood parameters to estimate hip fracture-related mortality. However, only a few variables were included in these studies (24-26). Wang *et al* (12) reported that older patients with PLR of ≥189 are at risk of mortality within 1 year. In the present study, the predictive value of HRR and PLR on hip fracture-related mortality was statistically significant. HRR had a predictive value over 30-day mortality.

Research gives important clues for hip fractures and mortality; there are a number of confounder factors such as blood disorders, immunological diseases and immunodeficiency disorders, medications (especially corticosteroids) and infections. Although an area affected by such a number of factors may seem ineffective in terms of generalization at first glance, the large number of cases where these factors are excluded demonstrates the clinical value of the research results. In addition, although the research excludes confounders, it will form a basis for gradually studying the effects of these confounders in further research.

In the present study, changes in blood values over time were not analyzed because of the predictive importance of blood values at the first application. In addition, once the patient comes to the clinic and starts receiving intervention, there will be medications given for the determination of blood values, follow-up period and a number of confounders; therefore, since invasive procedures are involved, the predictive value in blood parameters will not be reliable. Hence, blood values at the time of application were examined predictively and cross-sectionally.

The retrospective study design was the primary limitation of the present study. It is difficult to follow-up patients because of various reasons, such as difficulty in following up hip fracture-related mortality and patients in time-based studies frequently change healthcare institutions. However, in prospective studies, obtaining a large sample size and following up with patients pose significant challenges. In addition, the present study was conducted in a single center (Department of Orthopedics and Traumatology, Kütahya Health Sciences University Faculty of Medicine). Within society within a certain hospital, district and demographic structure, the lifestyle of individuals and their health levels can show similarities. Therefore, multicenter studies are required to take into account the possible effects of demographic variables and different regions. However, multicenter studies can also pose serious problems regarding permission, procedure, data integrity and continuity. Therefore, as in other studies, the present study employed a single-center research design. It is also noteworthy that the use of public hospital data in the present study is an important limitation. Data records are not kept regularly in public hospitals in the region and patients changing addresses or health institutions can also be considered as a limitation.

The fact that public hospital data was used in the research is an important limitation. Data records are not kept regularly in public hospitals in the region and patients changing addresses or health institutions can also be considered as a limitation. Although in the past, only forensic cases were recorded with regard to fractures, when clinical observations and patient age ranges are taken into account, it may be stated that the majority of fractures are mainly caused by falls and have high severity.

The most notable contribution of the present study to the field is the evaluation of indicators that may be predictive of hip fracture-related mortality. Accordingly, the present study aimed to predict and reduce mortality in patients with hip fractures. This structure gives it a pragmatic feature in research and clinical applications. In addition, the present study examined variables that may have different abilities to predict mortality of patients with hip fractures. To the best of the authors' knowledge, the present study can be considered the first in the field. Previous studies on mortality following hip fracture diagnosis have generally focused on a few biomarkers. Finding variables and novel indicators associated with mortality can make a positive contribution to the field in fighting the disease and improving the quality of life of individuals during the treatment process. Hip fracture cases are important both because they reduce the daily life quality of individuals and because they create a public health burden economically. Blood parameters are routinely checked and relatively easily obtained values. Even if there is no definitive diagnosis regarding mortality by looking at these, giving an idea can provide significant clinical benefit in terms of closer follow-up of patients. In different areas, multivariate evaluation of blood parameters, as in the present study, can provide clinical benefit. In this respect, the research can also be a guide for further literature studies.

To conclude, the HRR was found to have a predictive value for hip fracture-related mortality and 30-day mortality, whereas the PLR could only predict hip fracture-related mortality. Predicting the risk of hip fracture-associated mortality is crucial, particularly in older, female patients, which can possibly be estimated with HRR and PLR. They can be readily measured in a time efficient manner in clinical settings. By considering the effect of other mortality-related parameters, the life expectancy and quality of patients can be increased.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

Statistical analysis was performed by TCD and MK. Data collection was by TCD and MK. Literature review was by AOÜ, SY and FK. TCD and MK confirm the authenticity of all the raw data. TCD and MK wrote the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Ethical approval was obtained from Kütahya Health Sciences University Non-Invasive Clinical Research Ethics Committee, Kütahya, Turkey (approval no. E-41997688-050.99-74729). According to research design and ethical approval, patient consent was not required for the present retrospective study.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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