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ORIGINAL ARTICLE

# Relationship between mortality and HALP score in femoral neck fractures treated with hemiarthroplasty

Fatih Tahak, MD[1], Haluk Yaka, MD[2], Alper Kırılmaz, MD[3], Ahmet Fevzi Kekeç, MD[2], Tahsin Sami Çolak, MD[2], Mustafa Özer, MD[2]

[1]Department of Orthopedics and Traumatology, Karapınar State Hospital, Konya, Türkiye
[2]Department of Orthopedics and Traumatology, Necmettin Erbakan University Faculty of Medicine, Konya, Türkiye
[3]Department of Orthopedics and Traumatology, Konya City Hospital, Konya, Türkiye

## ABSTRACT

**Objectives:** This study aims to investigate the predictive value of the Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) score for six-month mortality in patients undergoing hemiarthroplasty for femoral neck fractures (FNFs).

**Patients and methods:** Between March 2019 and March 2022, a total of 60 patients (32 males, 28 females; mean age: 83.2±6.3 years; range, 67 to 95 years) who underwent hemiarthroplasty for FNFs were retrospectively analyzed. Complete blood count and albumin levels were analyzed in venous blood samples at the time of hospital admission. The neutrophil/lymphocyte ratio (NLR), monocyte/lymphocyte ratio (MLR), platelet/lymphocyte ratio (PLR), prognostic nutritional index (PNI), systemic immune-inflammation index (SII), and HALP scores were calculated. The six-month mortality rates of the patients were recorded.

**Results:** At six-month follow-up, 22 (36.6%) patients died and 38 (63.4%) survived. In logistic regression analysis, only HALP score was found to be associated with six-month mortality independently of other parameters (p=0.001 odds ratio [OR]=1.09, 95% confidence interval [CI]: 1.06-1.13). The six-month survival increased 1.09-fold for each unit increase in HALP score. In the receiver operating characteristics (ROC) curve analysis, the HALP score showed 71.1% sensitivity and 72.7% specificity using a cut-off value of 19.95 (area under the curve [AUC]: 0.804, 95% CI: 0.687-0.921).

**Conclusion:** Our study results show that low HALP score is associated with six-month mortality in this patient group. Based on these findings, we suggest that the clinical use of the HALP score as a prognostic marker in hip fracture patients.

***Keywords:*** Femoral neck fracture, HALP score, hip fracture, immune biomarkers mortality, nutritional biomarkers, prognostic scores.

Hip fractures continue to be an important public health problem in the world affecting the elderly population. The average age of patients with hip fractures increases by approximately one year every five years. The average patient age, which was 73 years in the 1960s, increased to 81 years in the 2000s and 82 years in 2010.[1] The World Health Organization (WHO) reports that the number of patients over the age of 65 would increase by approximately 88% in the next 25 years.[2] Hip fractures constitute the majority of fractures due to osteoporosis with the ageing population.[3] In Türkiye, nearly 255,000 osteoporosis-related fractures occurred in 2019, of which 24,000 were hip fractures.[4] The one-year mortality rate for osteoporotic hip fracture is 33%.[5] According to the sex distribution of hip fractures, the one-year mortality rate is approximately 33% in men and 22% in women.[6,7] A systematic analysis showed that, between 2000 and 2018, one-year mortality was 17.47% after femoral intertrochanteric fractures and 9.83% after femoral neck fractures (FNFs).[8]

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**Correspondence**: Fatih Tahak, MD. Karapınar Devlet Hastanesi, Ortopedi ve Travmatoloji Kliniği, 42400 Karapınar, Konya, Türkiye.

E-mail: dr.fth.th@gmail.com

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In the literature, studies have been conducted using neutrophil/lymphocyte ratio (NLR), monocyte/lymphocyte ratio (MLR), platelet/lymphocyte ratio (PLR), prognostic nutritional index (PNI) and systemic immune-inflammation index (SII) on blood values to predict mortality after hip fracture. The Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) score has been the subject of research mostly in cancer patients and it can be used as a mortality predictor.[9-11] The HALP score includes each of the nutritional, inflammation and immune markers to interpret the general prognosis of elderly patients.[12] As HALP only requires a complete blood count (CBC) and albumin, it seems to be a cost-effective biomarker to assist clinicians in improving outcomes for patients with immuno-nutritional deficiencies. It may also have high reliability to provide more detailed risk stratification.

Considering the clinical significance of the HALP score components, hemoglobin level is an important indicator of anemia, which increases the patient's comorbidities and mortality risk.[13] Albumin levels are influenced by the patient's nutritional status and metabolic demands and are the best known serum marker of malnutrition.[14] Lymphocytes are anti-inflammatory immune cells and low total lymphocyte counts have been associated with increased mortality in hip fractures.[15] High platelet levels may indicate an impaired immune system and increased risk of infection.[16]

Due to the increasing number of hip fractures, mortality should be addressed meticulously. In the literature, mortality prediction has been focused on mortality prediction and low-cost mortality predictors have been attempted to be determined. To the best of our knowledge, there is no study on the HALP score in predicting mortality after hip fracture. In the present study, we aimed to investigate the predictive value of the HALP score for six-month mortality in patients undergoing hemiarthroplasty for FNFs.

## PATIENTS AND METHODS

This single-center, retrospective study was conducted at Necmettin Erbakan University Faculty of Medicine, Department of Emergency Medicine between March 2019 and March 2022. Patients who underwent hemiarthroplasty in the Department of Orthopedics and Traumatology for 31B1, 31B2, and 31B3 FNFs according to the AO/OTA classification on direct radiography were screened. The patients received antibiotic at a dose of 2 g preoperatively, 15 mg/kg of tranexamic acid before incision, and cementless hemiarthroplasty under spinal anesthesia as standard. Of a total of 173 patients who underwent hemiarthroplasty, patients over 65 years of age, those who underwent hemiarthroplasty for FNF and had an American Society of Anesthesiologists (ASA) Class 3 were included in the study. Those with multiple traumas (n=2), open fracture (n=1) and pathological fracture (n=13), patients with ASA Class 2 (n=8) and ASA Class 4 (n=19), patients with periprosthetic fracture (n=4), patients whose surgery was delayed due to the novel coronavirus disease 2019 (COVID-19) pandemic (n=22) or whose cause of death was COVID-19 infection (n=20), and patients whose preoperative albumin value was not analyzed (n=24) were excluded. Finally, a total of 60 patients (32 males, 28 females; mean age: 83.2±6.3 years; range, 67 to 95 years) who met the inclusion criteria were recruited. The study flowchart is shown in Figure 1. Written informed consent was obtained from all patients and from first-degree relatives of deceased patients. The study protocol was approved by the Necmettin Erbakan University Meram Faculty of Medicine Pharmaceutical and Non-Medical Research Ethics Committee (date: 20/09/2024, no: 2024/5190). The study was conducted in accordance with the principles of the Declaration of Helsinki.

### Data collection

Demographic data, time from admission to surgical treatment, preoperative blood values, ASA class, and time to death were obtained from the hospital automated record system. Venous blood samples obtained from each patient at the time of admission and CBC were analyzed. The NLR, MLR and PLR ratios were obtained by dividing the first number of neutrophils, lymphocytes, monocytes and platelets by the second number in the routinely measured CBC. The PNI was calculated by the formula [PNI= 10 × serum albumin (g/dL)] + 0.005 × lymphocyte count (×$10^3$/μL)] as defined by Onodera et al.[17] Hu et al.[18] defined SII as follows: platelet (1,000 cells/μL) × neutrophil (1,000 cells/μL)/lymphocyte (1,000 cells/μL). As described by Chen et al.,[12] the HALP score was as follows: [hemoglobin (g/L) × albumin (g/L) × lymphocytes (/L)]/platelets (/L).

### Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was used to check the normality of the distribution. Continuous data

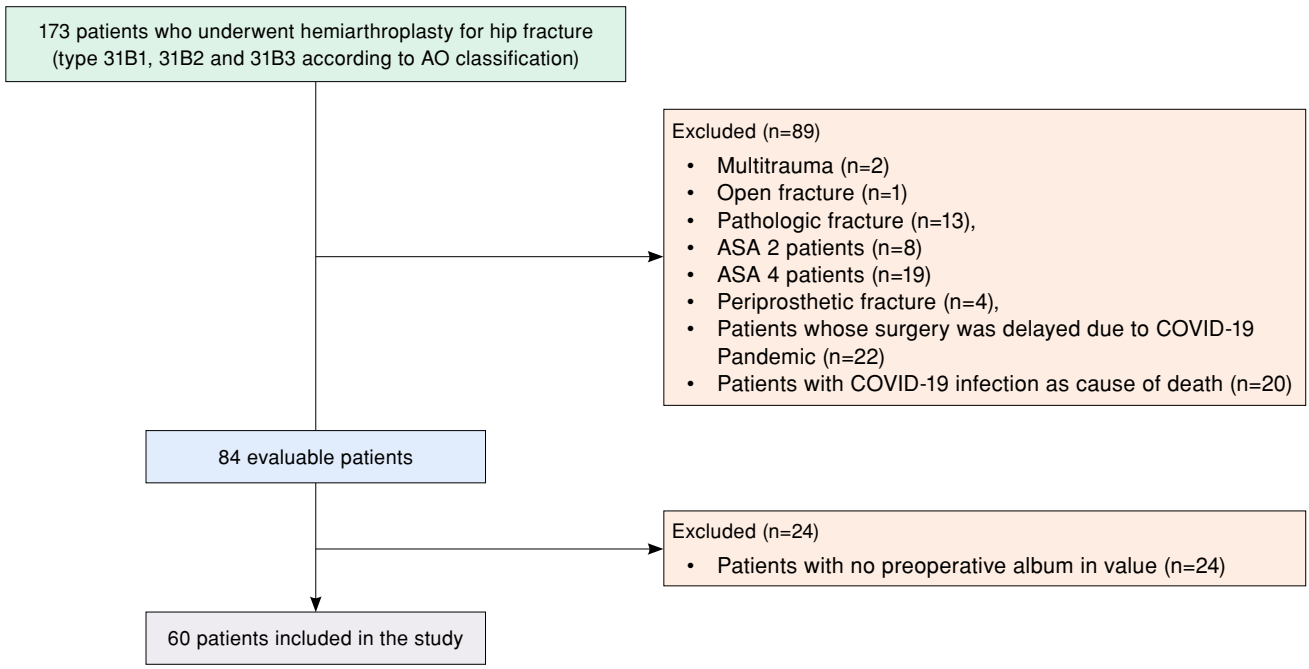


**FIGURE 1.** Study flowchart.
ASA: American Society of Anesthesiologists; COVID-19: Coronavirus disease 2019.

**TABLE I**
Demographic and baseline characteristics of patients

| | Total | | | Survivors | | | Non-survivors | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | Mean±SD | Min-Max | n | Mean±SD | Min-Max | n | Mean±SD | Min-Max | *p* value<br>Power<br>Effect size d |
| Mean (year) | | 83.2±6.3 | 67-95 | | 82.9±7.1 | | | 83.6±7.6 | | 0.139 |
| Sex | | | | | | | | | | 0.023 |
| Male | 32 | | | 21 | | | 11 | | | |
| Female | 28 | | | 17 | | | 11 | | | |
| Side | | | | | | | | | | 0.783 |
| Right | 33 | | | 21 | | | 12 | | | |
| Left | 27 | | | 17 | | | 10 | | | |
| NLR | | 9±6.3 | 0.4-33 | | 8.3±5.1 | 1.5-24.2 | | 10.3±8.1 | 0.4-33 | 0.285<br><0.80<br>0.4 |
| MLR | | 0.7±0.9 | 0.1-7.2 | | 0.5±0.2 | 0.1-1.2 | | 0.9±1.4 | 0.1-7.2 | 0.169<br>0.99<br>2.0 |
| PLR | | 218.4±110.8 | 44-534.9 | | 199.1±92.3 | 66.5-534.8 | | 251.5±132.9 | 44-525.4 | 0.112<br><0.80<br>0.55 |
| SII | | 1979.5±1594.1 | 8.8-8557.5 | | 1738.9±1483.5 | 332.8-8557.5 | | 2395±1725.3 | 8.8-5996.1 | 0.144<br><0.80<br>0.44 |
| PNI | | 32.9±5.3 | 21.2-43.4 | | 33.5±4.7 | 21.7-42.6 | | 31.9±6.2 | 21.2-43.4 | 0.307<br><0.80<br>0.45 |
| HALP | | 27.5±19.3 | 4-97.5 | | 33.5±20.9 | 13.1-97.5 | | 17.1±9.6 | 4-43.8 | **0.001***<br>0.84<br>0.8 |

SD: Standard deviation; NLR: Neutrophil/lymphocyte ratio; MLR: Monocyte/lymphocyte ratio; PLR: Platelet/lymphocyte ratio; SII: Systemic immune-inflammation index; PNI: Prognostic nutritional index; HALP: Hemoglobin, albumin, lymphocyte, and platelet; * p<0.05 indicates statistical significance.

were expressed in mean ± standard deviation (SD) or median (min-max), while categorical data were expressed in number and frequency. The Mann-Whitney U test and Pearson chi-square test were used to analyze the groups that did not conform to normal distribution. Independent sample t-test was used to determine whether NLR, MLR, PLR, PNI, SII and HALP score could be used as a marker for mortality. Since there may be many parameters affecting the relationship between hip fractures and mortality and there may be a relationship between these parameters, logistic regression analysis was performed to identify the parameters that were related independently of other parameters by including the age, sex, NLR, MLR, PLR, PNI, SII and HALP score parameters of the patients. The receiver operating characteristics (ROC) curve analysis with area under the curve (AUC) calculation was performed to estimate the sensitivity and specificity of the HALP score. The post-hoc power calculations were carried out using the G*Power version 3.1.9.4 software (Heinrich Heine University, Düsseldorf, Düsseldorf, Germany). A two-tailed $p$ value of <0.05 was considered statistically significant.

## RESULTS

At six-month follow-up, 22 (36.6%) patients died and 38 (63.4%) survived. The mean values of NLR, PLR, MLR, PNI, SII and HALP scores are given in Table I.

According to the logistic regression analysis, only HALP score was found to be associated with mortality independently of other parameters (p=0.001 odds ratio [OR]=1.09, 95% confidence interval [CI]: 1.06-1.13). These results showed that the six-month survival increased 1.09-fold for each unit increase in HALP score (Table II).

**TABLE II**
Logistic regression analysis results of the evaluated parameters

| Variables | *p* | Odds ratio | 95% CI |
|---|---|---|---|
| HALP | **0.001*** | 1.09 | 1.06-1.13 |
| NLR | 0.285 | | |
| MLR | 0.068 | | |
| PLR | 0.112 | | |
| PNI | 0.144 | | |
| SII | 0.144 | | |

CI: Confidence interval; HALP: Hemoglobin, Albumin, Lymphocyte, and Platelet; NLR: Neutrophil/lymphocyte ratio; MLR: Monocyte/lymphocyte ratio; PLR: Platelet/lymphocyte ratio; PNI: Prognostic nutritional index; SII: Systemic immune-inflammation index; * p<0.05 indicates statistical significance.

The ROC curve analysis revealed that the HALP score had a sensitivity of 71.1% and specificity of 72.7% using a cut-off value of 19.95 (likelihood ratio [LR]=3.6, AUC: 0.804, 95% CI: 0.687-0.921) (Figure 2).

## DISCUSSION

In the present study, we investigated the predictive value of the HALP score for six-month mortality in patients undergoing hemiarthroplasty for FNF. The main finding of this study was that a low HALP score, calculated using hemoglobin, albumin, lymphocyte and platelet parameters in preoperative blood tests, was associated with six-month mortality in patients undergoing hemiarthroplasty for FNF. The HALP score showed 71.1% sensitivity and 72.7% specificity for mortality at values below a cut-off value of 19.95, and each unit increase in HALP score resulted in a 1.09-fold increase in six-month survival.

In a study by Çeliksöz et al.[11] involving 522 patients who underwent hemiarthroplasty, the 30-day mortality rate was 5.24% and the one-year mortality rate was 21.2%. Similarly, Fu et al.[19] reported a one-year mortality rate of 23.4% in a study of 702 patients with FNFs. Şener et al.[20] found the one-year mortality rate to be 27.9% in 280 patients who underwent hemiarthroplasty for FNFs.

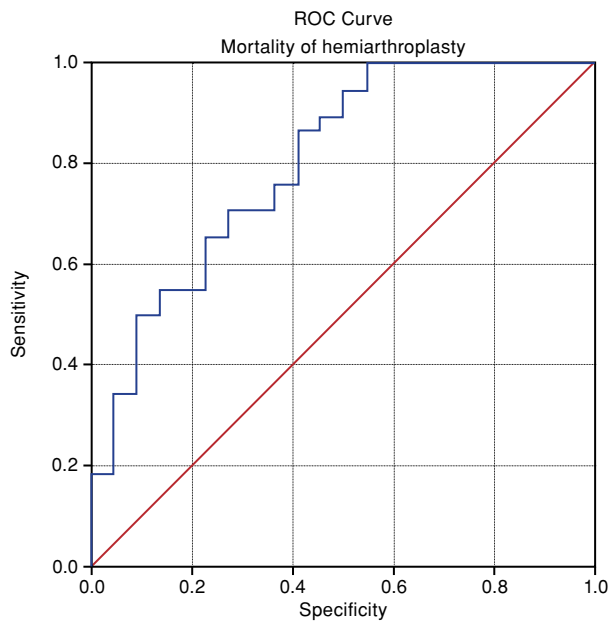


**FIGURE 2.** ROC curve of HALP score for mortality in patients undergoing hemiarthroplasty.
ROC: Receiver operating characteristic; HALP: Hemoglobin, Albumin, Lymphocyte, and Platelet.

Revieving the eight-year mortality associated with hip fracture in the geriatric population, Johnston et al.[21] found the mortality rate to be 30.7% in a series of 27,475 participants. In our study, the six-month mortality rate was 36.6%, which is consistent with the literature.

In their study, Tekin et al.[22] evaluated 124 patients with hip fractures treated with proximal femoral nailing and found that NLR, PLR, and MLR were associated with mortality. Long et al.[23] also reported that preoperative NLR could be used to predict mortality in elderly hip fracture patients and MLR was significant only in the univariate analysis. However, Karadeniz et al.[24] in a study of 190 patients who underwent hemiarthroplasty for FNF found that NLR at the time of hospitalization was not associated with one-year mortality, but was associated with NLR on Day 5. Wang et al.[10] emphasized that preoperative PLR in elderly hip fracture patients was associated with increased one-year all-cause mortality. Emektar et al.[25] showed that preoperative NLR and PLR were closely correlated with one-year postoperative mortality in a study of patients with peri-hip fractures, but they considered that these results did not make a significant contribution to clinical practice. In the current study, the NLR, PLR and MLR were not found to be associated with mortality. In our study, the same surgical technique was applied as in Karadeniz and Yurtbay.[24] and, similarly, NLR values at the time of hospitalization were not found to be associated with mortality. Karadeniz and Yurtbay.[24] found that postoperative Day 5 NLR values were associated with one-year mortality, but since Day 5, the NLR value was not calculated in our study, and its relationship with mortality could not be evaluated. The reason for the contradiction with other studies may be due to the difference in the types of fractures included in the study. While only FNF patients were included in our study, Tekin et al.[22] included only intertrochanteric fracture, Long et al.[23] and Wang et al.[10] included femoral neck and intertrochanteric fracture, and Emektar et al.[25] included FNF, pertrochanteric and subtrochanteric fracture patients. In this respect, immune markers such as NLR, PLR and MLR were not found to be associated with preoperative mortality in FNF patients, but may predict mortality in relation to intertrochanteric, subtrochanteric and pertrochanteric fracture types.

In diseases with poor prognosis and high mortality risk, particularly among cancer patients, predictive factors for mortality have increasingly been investigated and utilized in recent years. One of the main predictors is the SII-based on systemic immune inflammation.[26] Wang et al.[26] showed that SII was significantly associated with poor all-cause mortality in older adults with hip fractures undergoing surgery and might be a good index to predict prognosis. Celiksoz et al.[11] found a significant correlation between preoperative SII in patients who survived and those who died within one year. They found no significant correlation between postoperative first-day and third-day SIIs. Although there is a significant correlation between SII and one-year mortality in hip fractures, Celiksoz et al.[11] found no significant correlation on postoperative Days 1 and 3, whereas Wang et al.[26] obtained significant results on postoperative Day 30. Taken together, the data on SII in the early postoperative period (first 30 days) vary. In our study, no significant correlation was found between the SII and six-month mortality.

Furthermore, Wang et al.[27] reported that PNI was an independent predictor of postoperative complications and two-year all-cause mortality in hip fracture patients in their cohort study. Similarly, Chen et al.[28] reported that PNI value had a significant predictive value for three-year mortality rate among patients after hip fracture surgery. However, in a meta-analysis study by Liu et al.[29] examining the relationship between nutritional indices and mortality after hip fracture, PNI was not associated with mortality. In our study, similar to Liu et al.,[29] no significant correlation was found between PNI and six-month mortality. In the study of Wang et al.[27] the age limit was 45 years and the fracture types and treatments varied. In this case, we believe that both the younger age group and different treatment applications may have affected the results. Also, in the study of Chen et al.,[28] osteosynthesis and arthroplasty were used as surgical treatment, total hip arthroplasty was included in the arthroplasty group, and the number of patients who underwent osteosynthesis was higher, suggesting that the effect of the procedure on mortality predictor parameters may increase as the invasiveness of the procedure decreases.

In the literature, the prognostic and predictive value of HALP score for mortality among cancer patients has been extensively investigated. Farag et al.[30] showed that HALP score was a good prognostic biomarker in gastrointestinal, lung, urinary system, gynecological, ear, nose and throat cancers. Also, Xu et al.[31] examined the prognostic value of HALP score in patients with solid tumors and concluded

that low HALP score was associated with decreased survival.

Although this study is advantageous to have a single type of fracture patients and to evaluate patients undergoing a single type of surgical treatment in terms of homogeneity, it has certain limitations. First, it has a single-center, retrospective design with a relatively small sample size. Second, albumin value was not measured in many patients during preoperative preparation and, therefore, the HALP score could not be calculated. In future prospective and multi-center studies, different fracture types and different surgical techniques can be evaluated with a larger number of patients and the predictive value of the HALP score can be examined in more detail. In addition, only the relationship between the HALP score and six-month mortality was examined in our study, and further studies are needed to investigate this relationship in the long term.

In conclusion, to the best of our knowledge, there is no study in the literature investigating the predictive value of preoperative HALP score for mortality in patients with FNFs. Our study results show that low HALP score is associated with six-month mortality in this patient group. Based on these findings, we suggest that the clinical use of the HALP score as a prognostic marker in hip fracture patients.

**Data Sharing Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Author Contributions:** Idea/Concept: F.T., A.F.K., H.Y.; Design: M.Ö., T.S.Ç.; Control/supervision, critical review: M.Ö., H.Y.; Data collection and/or interpretation: H.Y., A.F.K.; Literature review, writing the article, references and fundings: F.T., H.Y.; Materials: F.T., A.K.; Other: M.Ö., T.S.Ç.

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