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The HALP Score's Prognostic Value for the Elderly Patients (≥ 75 years) Patients Following Percutaneous Coronary Intervention for Acute Myocardial Infarction

Akut Miyokard Enfarktüsü Nedeniyle Perkütan Koroner Girişim Uygulanan Yaşlı (≥ 75 yaş) Hastalarda HALP Skorunun Prognostik Değeri

ABSTRACT

Objective: Despite the reality that percutaneous coronary intervention (PCI) lowers mortality following acute myocardial infarction (AMI), older patients (≥ 75 years) are still at high risk of mortality. The purpose of this study was to evaluate the prognostic significance of the HALP score, which reflects the inflammatory and nutritional status, in this population.

Method: We retrospectively included 128 elderly patients who underwent PCI at our institution, between 2019 and 2022. The primary endpoint of the study was long-term, all-cause mortality. The study population was categorized into two distinct groups based on survival status: survivors and non-survivors. A multivariable Cox regression analysis was conducted to identify independent predictors of long-term all-cause mortality.

Results: The median follow-up time was 49.9 (35.6–62.74) months. In multivariable analysis, the HALP score and CRP independently predicted all-cause mortality at long-term follow-up (hazard ratio (HR): 0.96, 95% confidence interval (CI): 0.94–0.99, P = 0.003; HR: 1.04, 95% CI: 1.01–1.07, P = 0.020; respectively). Receiver operating characteristic curve analysis identified 26.252 as the optimal HALP score cut-off for predicting mortality (area under the curve (AUC): 0.764; 95% CI: 0.672–0.855; P < 0.001), with 73% sensitivity and 70.3% specificity. The HALP score demonstrated a higher AUC value, indicating better discriminative power compared to its individual components. In Kaplan–Meier analysis, patients with HALP score< 26.252 had a higher mortality during follow-up (log rank P < 0.0001).

Conclusion: The HALP score is an independent predictor of long-term all-cause mortality in older AMI patients following PCI.

Keywords: Coronary artery disease, elderly patient, HALP score, inflammation, malnutrition, mortality

ÖZET

Amaç: Perkütan koroner girişimin (PKG) akut miyokard infarktüsü (AMİ) sonrası mortaliteyi azaltmasına rağmen, yaşlı hastalar (≥75 yaş) hâlâ yüksek mortalite riski altındadır. Bu çalışmanın amacı, enflamatuvar ve beslenme durumunu yansıtan HALP skorunun bu popülasyondaki prognostik önemini değerlendirmektir.

Yöntem: 2019-2022 yılları arasında kurumumuzda PKG yapılan 128 yaşlı hastayı retrospektif olarak çalışmaya dâhil ettik. Çalışmanın birincil son noktası, uzun vadeli tüm nedenlere bağlı ölüm oranıydı. Çalışma popülasyonu, sağ kalım durumuna göre iki ayrı gruba ayrıldı: sağ kalanlar ve sağ kalamayanlar. Uzun vadeli tüm nedenlere bağlı mortalitenin bağımsız belirleyicilerini bulmak için çok değişkenli bir Cox regresyon modeli oluşturuldu.

Bulgular: Ortanca takip süresi 49,9 (35,6-62,74) aydı. Çok değişkenli analizde HALP skoru ve CRP, uzun dönem takipte tüm nedenlere bağlı mortaliteyi bağımsız olarak öngörmüştür (sırasıyla hazard ratio (HR): 0,96, %95 confidence interval (CI): 0,94-0,99, P = 0,003; HR: 1,04, %95 CI: 1,01-1,07, P = 0,020). Receiver operating characteristic (ROC) eğrisi analizi, 26,252 değerini %73 duyarlılık ve %70,3 özgüllük ile mortaliteyi öngörmek için en uygun kesme değeri olarak belirlemiştir (eğri altındaki alan (AUC): 0,764; %95 CI: 0,672-0,855, P < 0,001). ROC analizinde HALP skoru, daha yüksek bir AUC değeri göstererek kendi bileşenlerine kıyasla daha iyi ayırt edici güce sahip olduğunu ortaya koydu. Kaplan-Meier analizinde, HALP skoru <26,252 olan hastalarda takipte ölüm oranı daha yüksekti (log-rank P < 0,0001).

Sonuç: HALP skoru, yaşlı AMİ hastalarında PKG sonrası uzun dönem tüm nedenlere bağlı ölümün bağımsız bir öngördürücüsüdür.

Anahtar Kelimeler: Koroner arter hastalığı, yaşlı hasta, HALP skoru, inflamasyon, mortalite, malnütrisyon

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As the quality and accessibility of healthcare continue to improve worldwide, life expectancy is increasing. However, the prevalence of coronary artery disease (CAD) is likewise increasing as the population ages.[1] In older adults, CAD, particularly acute myocardial infarction (AMI), is a leading cause of morbidity and mortality. Elderly patients with AMI face a significantly higher risk of complications before, during, and after percutaneous coronary intervention (PCI) compared to younger populations. Their frailty, polypharmacy, reduced medication adherence, impaired renal function, increased stroke risk and dementia, negatively impacts their prognosis, leading to a higher mortality risk. Therefore, identifying prognostic markers to predict mortality in elderly patients undergoing PCI is crucial for improving patient management. Although some biomarkers have been associated with poor outcomes in AMI patients, specific markers that can reliably predict prognosis in high-risk elderly patients are still needed.

One of the main processes behind the development of atherosclerosis is inflammation.[2] Additionally, malnutrition is a fundamental indicator of frailty in elderly patients and serves as a predictor of worse outcomes in individuals with cardiovascular disease.[3] A new measure called the HALP score uses hemoglobin (Hb), lymphocyte (Lym), platelet (Plt), and albumin levels to assess a patient's nutritional and inflammatory conditions. Initially, the HALP score's potential predictive significance was examined in cancer patients.[4–6] Recent studies have demonstrated its prognostic significance in CAD, heart failure, and pulmonary thromboembolism.[7–13] Nevertheless, no prior assessment has been conducted on its prognostic importance, particularly in older individuals suffering from AMI. Thus, our goal was to find out how useful the HALP score was for predicting outcomes in older AMI patients undergoing PCI.

Materials and Methods

Study Design and Population

In this retrospective study, 1,863 consecutive patients who underwent PCI for AMI (including ST-elevation myocardial infarction (STEMI) and non-STEMI) at our hospital, between January 2019 and December 2022, were initially screened. Patients aged 75 years and older with technically successful procedures were examined. Based on the 2023 European Society of Cardiology Guidelines for the treatment of acute coronary syndromes, AMI diagnostic criteria were established.[14] Exclusion criteria were as follows: history of coronary artery bypass graft surgery, presentation with Killip class 4, failed PCI, hematologic and rheumatologic diseases, malignancy, insufficient or lost follow-up data, severe infection prior to admission, advanced hepatic or renal disease (glomerular filtration rate (GFR) < 15 mL/min/1.73 m^2 or receiving hemodialysis), including nephrotic syndrome, a history of blood transfusion prior to admission and in-hospital mortality. Ethics committee approval was obtained from Yalova University Health Sciences Non-Interventional Clinical Research Ethics Committee (Approval Number: 2025/81, Date: 05.02.2025), and the study was conducted in accordance with the Declaration of Helsinki's tenets. The study's retrospective methodology and the use of de-identified medical record data eliminated the need to obtain participants' formal informed consent.

ABBREVIATIONS

AMI	Acute myocardial infarction
AUC	Area under the curve
CAD	Coronary artery disease
CKD	Chronic kidney disease
CRP	C-reactive protein
DM	Diabetes mellitus
GFR	Glomerular filtration rate
Hb	Hemoglobin
HR	Hazard ratios
IQR	Interquartile range
Lym	Lymphocyte
MACE	Major adverse cardiac events
PCI	Percutaneous coronary interventions
Plt	Platelet
ROC	Receiver operating characteristic
STEMI	ST-elevation myocardial infarction
TIMI	Thrombolysis in myocardial ınfarction

Data Collection and Measurement of the HALP Score

The demographic and clinical data of the patients, along with laboratory results such as complete blood count and blood biochemistry, were obtained from the hospital database and electronic health records. Prior to the PCI surgery, blood samples were obtained from the antecubital vein and recorded in the medical records. Biochemical measurements were performed using a molecular analysis device (Roche Diagnostics, Mannheim, Germany). The following formula, which takes into account the levels of Hb, Lym, Plt and serum albumin, was used to determine the HALP score: Lym count (109/L) × albumin (g/L) × Hb (g/L)/Plt count (109/L).[15]

Outcomes and Definitions

At long-term follow-up (> 30 days following the index procedure), all-cause death was the main outcome; all-cause mortality refers to death resulting from any cause.[16] The date of death was obtained from the Provincial Health Directorate's Public Health Department, but the inability to determine the specific causes of death limited our ability to assess secondary endpoints. This represents one of the main limitations of our study.

The Thrombolysis in Myocardial Infarction (TIMI) criteria were used to categorize antegrade coronary flow following PCI (TIMI 0: no antegrade flow, TIMI I: penetration without perfusion, TIMI II: partial perfusion and TIMI III: full perfusion).[17] Pre-procedural TIMI flow was defined as pre-TIMI flow.[18] Technical success was characterized by achieving TIMI grade 3 flow in the target vessel with residual stenosis below 30%, whereas failure to meet these criteria was defined as failed PCI.[19]

In the present study, the thrombus burden assessed via coronary angiography was stratified into six categories. Grade 0 represented the absence of angiographic thrombus. Grade 1 indicated a possible presence of thrombus, suggested by findings such as decreased contrast density, haziness or an irregular lesion contour. Grade 2 was defined as a definite thrombus with its largest dimension measuring less than 50% of the vessel's

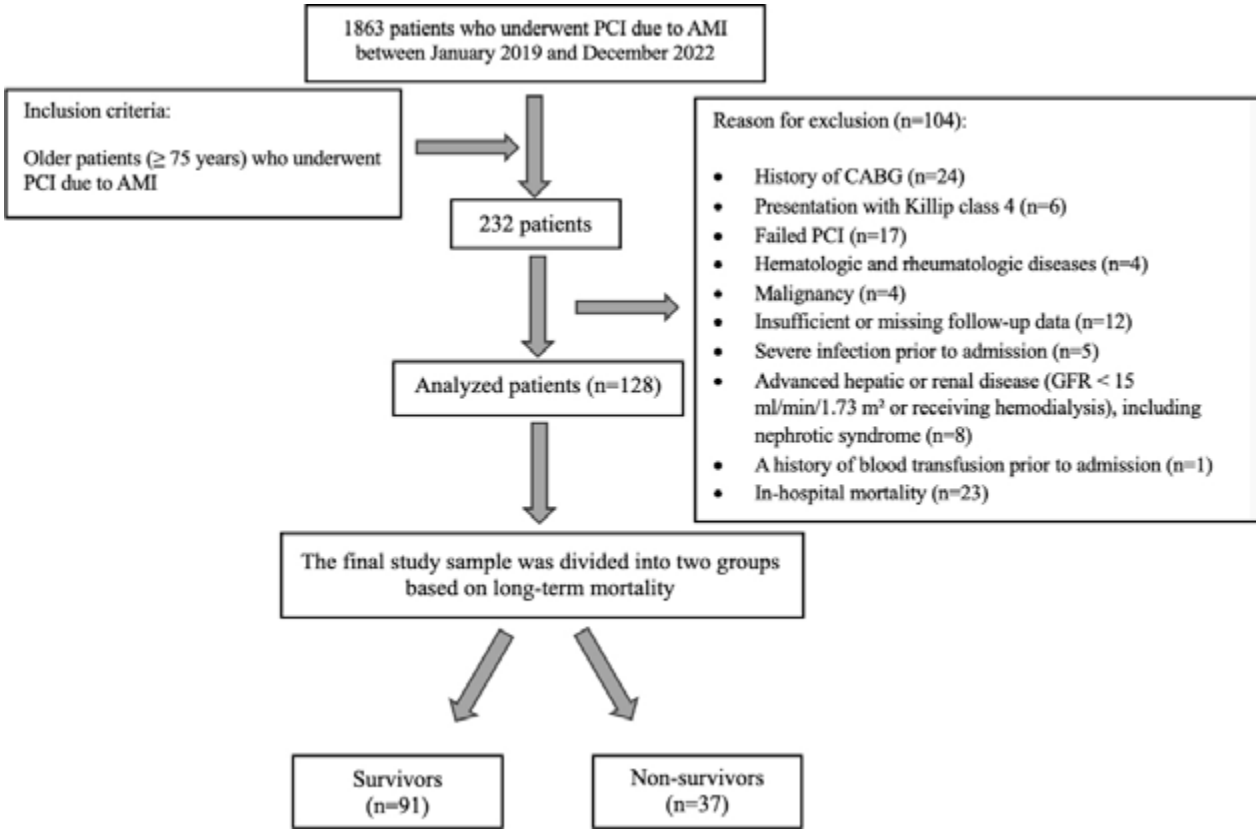

Figure 1. Flowchart of study population.

AMI, Acute myocardial infarction; CABG, Coronary artery by-pass grafting; PCI, Percutaneous coronary interventions; GFR, Glomerular filtration rate.

diameter. Grade 3 included thrombi whose largest dimension exceeded 50% but remained below two vessel diameters. Grade 4 referred to thrombi measuring more than two vessel diameters in size. Lastly, Grade 5 represented a thrombus causing complete occlusion of the affected vessel.[20] Following the restoration of antegrade flow using a guidewire or balloon dilatation, grade 5 angiographic thrombus load was reclassified. Based on the final thrombus burden, patients with grade 1–3 thrombus load were classified as having a moderate thrombus burden, whereas those with grade 4–5 thrombus burden were classified as having a severe thrombus burden.[20,21]

Statistical Analysis

The Jamovi version 2.6.2 (The Jamovi project, Sydney, Australia) with the "ggplot," "Hmisc," and "rms" packages were used for all statistical methods. Depending on the distribution, continuous variables were presented as median and interquartile range (IQR) or mean and standard deviation. The Kolmogorov-Smirnov test was employed to determine normalcy. Counts and percentages were used to display categorical variables. The Mann-Whitney U test and the independent samples t-test were used to compare independent continuous variables, while Fisher's exact test or Pearson's chi-squared test were used to analyze categorical data. To find independent predictors of mortality, a multivariable Cox regression analysis was used. Clinical relevance served as the foundation for the development of statistical models. Hazard ratios (HR) and 95% confidence intervals (CI) were used to express the findings. The predictive power of the HALP score, Hb, Lym count and albumin levels for mortality was evaluated using the area under the curve (AUC) values, obtained from receiver operating characteristic (ROC) analysis. The Kaplan–Meier technique was used to examine survival times after the follow-up period. From the date of diagnosis until the date of death or final follow-up, the overall survival was computed. Using the log-rank test, group differences were evaluated. For all analyses, a p-value of less than 0.05 was deemed statistically significant.

Results

The median follow-up duration was 49.9 (35.6–62.74) months in this study. A total of 23 patients experienced in-hospital mortality. After applying the inclusion and exclusion criteria, the final analysis included 128 patients over the age of 75 who underwent PCI with technical success (Figure 1). Of these, 76 (59%) were male and the median age was 79 (77–83). Two groups were created from the research population according to their mortality status: 37 patients (29%) were in the non-survivor group, while 91 patients (71%) were in the survivor group. Table 1 displays the research population's demographics and clinical results. Patients' median length of stay in the hospital was three (3–4) days. The female gender was more prevalent in the non-survivor group, and both the mean age and length of hospital stay were higher in this group (P <0.05 for all).

Table 1. Baseline characteristics of the study population according to mortality status

Variables	All patients (n = 128)	Survivors (n = 91, 71%)	Non-survivors (n = 37, 29%)	P
Demographic features and risk factors				
Gender (male), n (%)	76 (59)	59 (65)	17 (46)	**0.049**
Age (years)	79 (77–83)	78 (76–82)	81 (79–85)	**0.002**
DM, n (%)	47 (37)	33 (36)	14 (38)	0.867
HT, n (%)	63 (49)	42 (46)	21 (57)	0.277
HL, n (%)	29 (23)	18 (20)	11 (30)	0.248
PCI history, n (%)	26 (20)	18 (20)	8 (22)	0.814
CKD, n (%)	61 (48)	39 (43)	22 (59)	0.088
CVD, n (%)	5 (4)	3 (3)	2 (5)	0.577
AF	13 (10)	9 (10)	4 (11)	0.876
EF (%)	55 (48–60)	55 (45–60)	55 (50–60)	0.663
CA-AKI	23 (18)	16 (18)	7 (19)	0.858
Smoking, n (%)	11 (9)	10 (11)	1 (3)	0.129
STEMI/non-STEMI, n (%)	74 (59)	50 (57)	24 (65)	0.403
Length of hospital stay (day)	3 (3-4)	3 (3-4)	3 (3-5)	**0.049**
Follow-up time (month)	49.88 (35.6–62.74)	54.17 (42.37–66.6)	33 (10.83–48.73)	**<0.001**

The data are presented as percentages and median (interquartile range). Statistical significance was defined as P < 0.05 and indicated in bold. AF, Atrial fibrillation; CA-AKI, Contrast-associated acute kidney injury; CKD, Chronic kidney disease; CVD, Cerebrovascular disease; DM, Diabetes mellitus; EF, Ejection fraction; HL, Hyperlipidemia; HT, Hypertension; PCI, Percutaneous coronary intervention; STEMI, ST Elevation myocardial infarction.

Table 2 displays the research population's laboratory results. The non-survivor group had considerably lower levels of Hb, albumin, Lym counts, and HALP score than the survivors group (P <0.001, and P <0.001, respectively). On the other hand, the non-survivor group's C-reactive protein (CRP) levels were substantially greater than those of the survivors group (P <0.001). A comparison of HALP scores between the survivor and non-survivor groups using a box plot is shown in Figure 2. Periprocedural features of PCI in the study population were comparable between the groups (Table 3).

A multivariable Cox proportional hazards regression model was constructed to identify potential factors associated with all-cause mortality. The development of the model was guided by clinical relevance and variables that may influence mortality, including age, sex, diabetes mellitus (DM), chronic kidney disease (CKD), ejection fraction, CRP and the HALP score, were included in the model. In this model, the HALP score and CRP independently predicted all-cause mortality at long-term follow-up (HR: 0.96, 95% CI: 0.94–0.99, P = 0.003; HR: 1.04, 95% CI: 1.01–1.07, P = 0.020; respectively). Figure 3 depicts a forest plot for multivariable analysis showing variables linked to all-cause mortality. In addition, Figure 4 illustrates the estimated effect of HALP score on the HR for mortality based on a multivariable Cox proportional hazards model. A lower HALP score is associated with a higher risk of mortality, suggesting that HALP may serve as an independent prognostic marker (Table 4).

According to the ROC curve analysis, the ideal cut-off value of the HALP score for forecasting all-cause death was 26.252 (Figure 5). At this threshold, the AUC was 0.764 (95% CI: 0.672–0.855; P <0.001), with a sensitivity of 73% and a specificity of 70.3%. The HALP score demonstrated a higher AUC value, indicating better discriminative power compared to each of its individual components (Hb, albumin, Plt and Lym count).

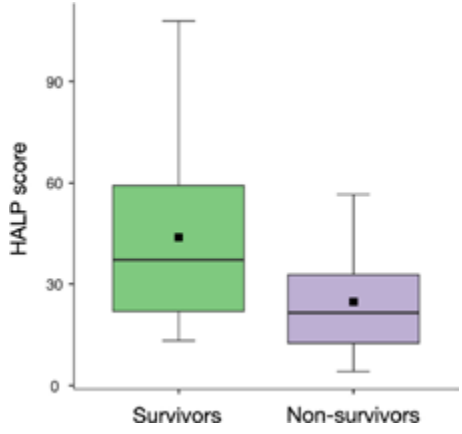

Figure 2. Comparison of HALP scores between the survivors and non-survivors group using a box plot.

A single-arm Kaplan–Meier analysis revealed that the overall 60-month survival rate after PCI in elderly patients was 69.1%. (Figure 6A). The cumulative all-cause mortality rates at 1, 3 and 5 years were 8.6% (n = 11), 15.8% (n = 20), and 30.9% (n = 33), respectively. When stratified by the HALP score cut-off value derived from the ROC analysis, patients with a low HALP score (47.2%) had a considerably lower 60-month survival rate than those with a high HALP score (85.9%) (log-rank test, P < 0.0001) (Figure 6B).

Table 2. Baseline laboratory findings of the study population according to mortality status

Variables	All patients (n = 128)	Survivors (n = 91, 71%)	Non-survivors (n = 37, 29%)	P
HbA1c (%), n (%)	5.9 (5.5–6.7)	5.8 (5.5–6.65)	6.15 (5.7–6.85)	0.182
Urea (mg/dL)	43 (34–50.15)	42.9 (34–48.9)	45 (33.95–52.25)	0.533
Creatinine (mg/dL)	1.08 (0.88–1.33)	1.08 (0.86–1.3)	1.01 (0.90–1.35)	0.584
GFR	59.1 ± 17.4	59.81 ± 16.29	57.3 ± 20.1	0.484
Sodium (mEq/L)	139 (137–140)	139 (137–140)	139 (138–140)	0.681
Potassium (mmol/L)	4.25 (4.07–4.6)	4.23 (4.0–4.5)	4.26 (4.1–4.7)	0.827
Total-C (mg/dL)	189.6 ± 41.5	190.5 ± 40.33	187.35 ± 44.77	0.698
HDL-C (mg/dL)	43 (38.5–51)	42.5 (37.25–50)	44 (40–53)	0.344
TG (mg/dL)	120 (92–167)	123.5 (95–191)	110 (84–140)	0.096
LDL-C (mg/dL)	120.72 ± 33.3	121.09 ± 31.27	119.8 ± 38.2	0.845
CRP (mg/L)	2 (0.84–4)	2 (0.5–3)	4 (3–7.40)	**<0.001**
Albumin (g/L)	4 (3.7–4.1)	4 (3.8–4.1)	3.9 (3.6–4)	**0.046**
Peak troponin	13.4 (4–25)	16 (5.15–25)	9.30 (2.5–25)	0.222
WBC (10^3/μL)	9.7 ± 3.2	9.75 ± 3.18	9.56 ± 3.25	0.757
Neu (10^3/μL)	6.75 (4.7–9.3)	6.4 (4.29–8.7)	7.7 (5.3–9.7)	0.10
Lym (10^3/μL)	1.6 (1.1–2.14)	1.7 (1.29–2.30)	1.1 (0.97–1.60)	**<0.001**
Mon (10^3/μL)	0.55 (0.40–0.70)	0.60 (0.41–0.70)	0.50 (0.40–0.60)	0.109
Hb (g/dL)	12.6 ± 1.8	12.87 ± 1.68	12.06 ± 1.95	**0.020**
Plt (10^3/μL)	241 (198.7–306.2)	239 (198–280)	243 (200–357)	0.140
Glucose	118.5 (101–157)	117 (99.5–146)	137 (107–180)	0.064
AST	20 (16.65–31)	20 (16.07–28)	22 (17–40)	0.251
ALT	15 (12–21)	15 (12–20.75)	15 (11–21)	0.949
HALP score	30.76 (19.97–50)	37.09 (22–59.2)	22 (12.53–28.1)	**<0.001**

The data are presented as percentages, mean ± standard deviation, or median (interquartile range). Statistical significance was defined as P < 0.05 and indicated in bold. ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; CRP, C reactive protein; GFR, Glomerular filtration rate; Hb, Hemoglobin; HbA1c, Glycated hemoglobin; HDL-C, High-density lipoprotein cholesterol; LDL-C, Low-density lipoprotein; Lym, Lymphocyte; Mon, Monocyte; Neu, Neutrophil; Plt, Platelet; TG, Triglyceride; Total-C, Total cholesterol; WBC, White blood cell.

Discussion

The predictive importance of the HALP score in elderly AMI patients undergoing PCI was examined in this investigation. According to our research, the HALP score and CRP are both reliable indicators of long-term mortality following PCI. The HALP score has the potential to be a useful tool for risk stratification in this patient group, as evidenced by the fact that patients with low scores had much greater mortality rates during long-term follow-up than patients with high scores. This is the only study that we are aware of that shows the HALP score has prognostic significance for long-term all-cause mortality in elderly (≥ 75 years) AMI patients after PCI.

Due to population aging, the number of patients over 75 is continuously rising and CAD, particularly AMI, continues to be the leading cause of mortality among elderly patients. These patients undergoing PCI had a much higher risk of major adverse cardiac events (MACE) and death both in-hospital and during follow-up.[22] It has been demonstrated that older patients have more complicated lesions, left main lesions and severe coronary disease; as a result, they constitute a group with greater risk features.[23] However, this increased risk should not imply that PCI should be avoided in elderly patients. The decision to perform PCI should be individualized, and identifying high-risk patients during long-term follow-up may help improve clinical outcomes. To enable the early identification of older individuals at greater risk of death, a straightforward and easily accessible risk score is therefore required.

A novel metric derived from basic laboratory data is the HALP score, which represents the nutritional and systemic inflammatory condition of patients.[24] Each one of the score's components is essential to determining a patient's overall health.[25] Anemia and malnutrition are indicated by lower Hb and albumin levels, while inflammation and a compromised immune system are associated with elevated Plt and decreased Lym counts.[10] The HALP score's predictive power was first investigated in patients with gastric cancer.[26] Furthermore, in a meta-analysis including 13,038 cancer patients with solid tumors, a low HALP score was associated with decreased overall survival.[6] Current studies focus on the predictive value of the HALP score in cardiovascular diseases.[7–9,10–13,24,27] Karakayali et al.[10] showed that in patients with STEMI undergoing primary PCI, the HALP score was an independent predictor of in-hospital death. Similarly, Toprak et al.[12] found that the HALP score was a reliable indicator of short-term prognosis and

Table 3. Comparison of angiographic and periprocedural features of patients in the study population according to mortality status

Variables	All patients (n = 128)	Survivors (n = 91, 71%)	Non-survivors (n = 37, 29%)	P
Angiographic features				
Femoral vs radial access, n (%)	53 (41)	33 (36)	20 (54)	0.064
Culprit lesion, n (%)				0.337
LMCA	1 (1)	0 (0)	1 (3)	
LAD	49 (38)	37 (41)	12 (32)	
CX	28 (22)	19 (21)	9 (24)	
RCA	50 (39)	35 (38)	15 (41)	
Pre-TIMI flow, n (%)				0.591
0	64 (50)	49 (54)	15 (41)	
1	8 (6)	5 (5)	3 (8)	
2	21 (16)	14 (15)	7 (19)	
3	35 (27)	23 (25)	12 (32)	
Thrombus TIMI grade, n (%)				0.073
0	5 (4)	5 (5)	0 (0)	
1	24 (19)	20 (22)	4 (11)	
2	50 (39)	37 (41)	13 (35)	
3	30 (23)	18 (20)	12 (32)	
4	15 (12)	10 (11)	5 (14)	
5	4 (3)	1 (1)	3 (8)	
High grade thrombus	19 (15)	11 (12)	8 (22)	0.169
CTO	8 (6)	5 (5)	3 (8)	0.580
Coronary ectasia	22 (17)	16 (18)	6 (16)	0.853
Presence of severe lesion, n (%)				
LMCA	5 (4)	2 (2)	3 (8)	0.118
LAD	79 (62)	22 (59)	22 (59)	0.737
CX	45 (35)	29 (32)	16 (43)	0.222
RCA	69 (54)	46 (51)	23 (62)	0.232
Peri-procedural features				
No-reflow, n (%)	8 (6)	6 (7)	2 (5)	0.801
Amount of contrast media	204.1 ± 72.9	198.2 ± 66.6	218.6 ± 85.6	0.152

The data are presented as percentages, mean ± standard deviation. Statistical significance was defined as P < 0.05 and indicated in bold. CTO, Chronic total occlusion; CX, Circumflex artery; LAD, Left anterior descending artery; LMCA, Left main coronary artery; RCA, Right coronary artery; TIMI, Thrombolysis in myocardial infarction.

no-reflow in STEMI patients. The HALP score was associated with both no-reflow and long-term MACE in STEMI patients after primary PCI, according to Liu et al.[24] Furthermore, Kılıç et al.[27] showed that a low HALP score was associated with both in-hospital and one-year mortality in non-STEMI patients.

In this study, we found that the HALP score was an independent predictor of long-term mortality in older AMI patients after PCI. There are a number of reasons why a low HALP score is linked to long-term mortality. First off, the Hb, albumin, Lym and Plt counts that make up the HALP score are all significant biomarkers that affect prognosis in the elderly. Low Plt counts indicate systemic inflammation, low Lym numbers indicate immunological dysfunction, and anemia and hypoalbuminemia represent dietary inadequacy as well as general weakness. A decline in immunological and nutritional health may be indicated by the combination of these measures, which might have an adverse effect on cardiovascular healing processes. Furthermore, these characteristics are frequently linked to comorbid illnesses that might raise the risk of death, such as CKD, cancer or chronic inflammatory disorders. In order to predict long-term outcomes for older patients with AMI, a straightforward instrument like the HALP score—which is based on regular laboratory data—may be clinically useful.

Additionally, long-term mortality has been linked to increased CRP levels in several research publications in the literature. For instance, Kinjo et al.[28] discovered that in patients with AMI, CRP concentration was an independent predictor of long-term cardiovascular and all-cause mortality. Similarly, Xia et al.[29] reported

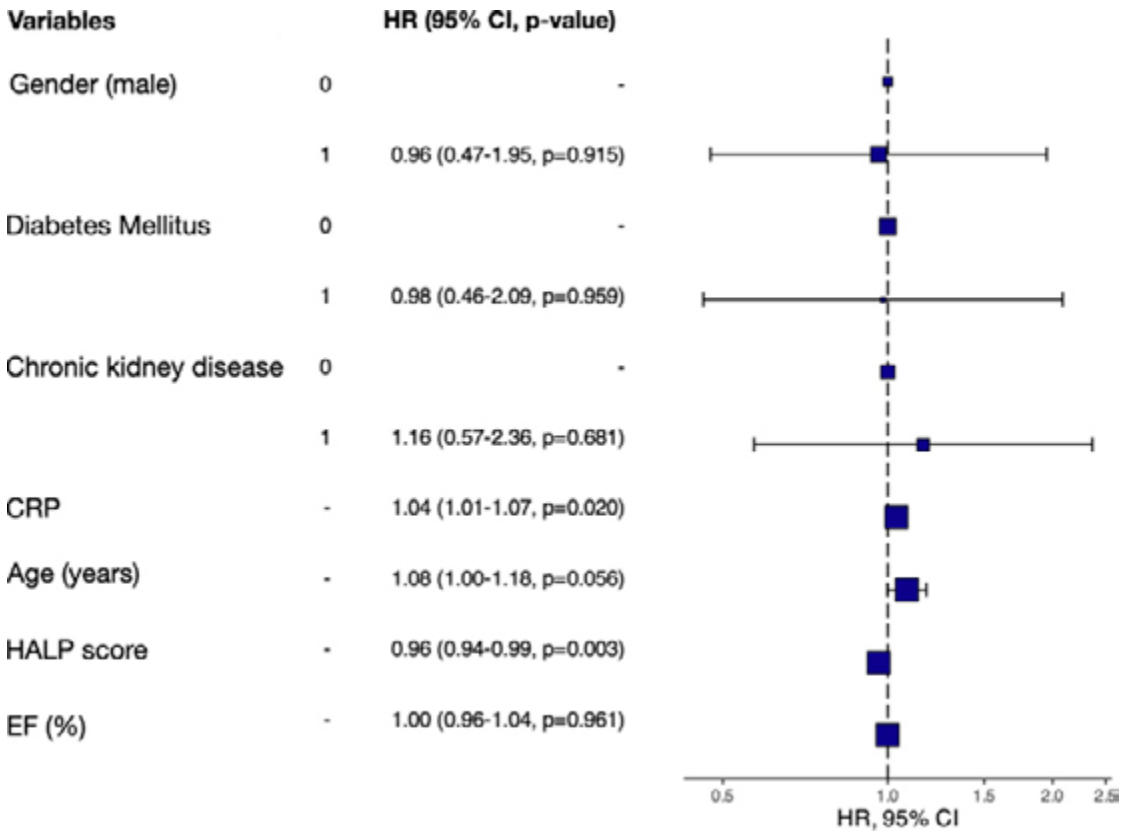

Figure 3. Predictors associated with all-cause mortality in elderly patients who underwent percutaneous coronary intervention.

HR, Hazard ratio; CI, Confidence interval; CRP, C-reactive protein; HALP, Hemoglobin, albumin, lymphocyte, and platelet; EF, Ejection fraction.

that CRP was an independent predictor of long-term all-cause, cardiovascular and cardiac mortality following AMI, regardless of DM status. Our research also shows that high CRP levels are an independent predictor of higher long-term mortality in older AMI patients, which is in line with previous findings. These findings emphasize the importance of systemic inflammation in predicting outcomes for patients with AMI and the potential use of CRP as a straightforward yet effective biomarker for risk assessment.

Our study concludes by highlighting the HALP score's potential as a helpful indicator of long-term mortality in older AMI patients after PCI. By closely monitoring this group, HALP score evaluation might be included in standard clinical practice to assist in identifying high-risk patients and enhance outcomes. The usefulness of the HALP score in forecasting morbidity and death in elderly AMI patients after PCI, however, requires more research with long-term follow-up.

Table 4. Multivariable logistic Cox regression analysis for prediction of mortality

	Multivariable Cox Regression Analysis	
Variables	**HR (95%, CI)**	**P**
Age (years)	1.08 (1.00–1.18)	0.056
Gender (male)	0.96 (0.47–1.95)	0.915
DM	0.98 (0.46–2.09)	0.959
CKD	1.16 (0.57–2.36)	0.681
EF	1.00 (0.96–1.04)	0.961
CRP (mg/L)	1.04 (1.01–1.07)	**0.020**
HALP score	0.96 (0.94–0.99)	**0.003**

Statistical significance was defined as P < 0.05 and indicated in bold. CKD, Chronic kidney disease; CRP, C-reactive protein; DM, Diabetes mellitus; EF, Ejection fraction.

Limitations

The association between HALP score and mortality in older patients who underwent PCI may be further supported by these findings. However, our study has a number of limitations. It was retrospective in design and based on data obtained from medical records, which may lead to selection and information bias. Despite the limited sample size, the study reflected a specific patient group. Due to the lack of access of the National Death Notification System database, the causes of death could not be determined. Therefore, we reported the primary endpoint as overall mortality and were unable to assess the secondary outcome. Furthermore, our study did not assess frailty, nor did it compare the HALP score to established cardiovascular risk assessment tools. Data regarding the rates of optimal medical therapy and specific drug usage among patients following acute myocardial infarction were also not available in this study. This limitation may affect the comprehensive assessment of determinants of long-term survival and should be considered when interpreting the results.

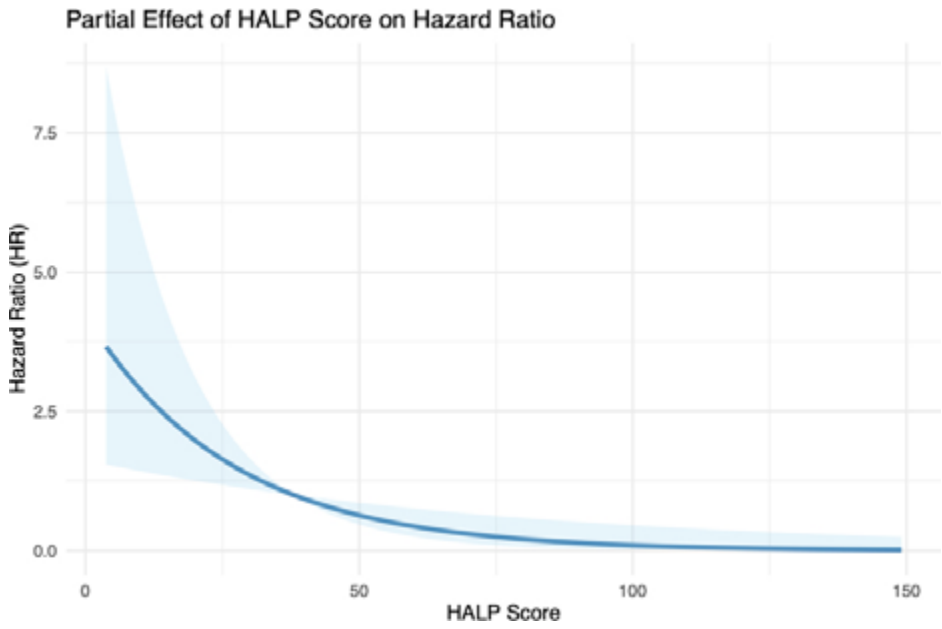

Figure 4. Partial effect plot of HALP score on hazard ratio for mortality. The plot illustrates the estimated effect of HALP score on the hazard ratio for mortality based on a multivariable Cox proportional hazards model. The blue line represents the predicted hazard ratio across the range of HALP scores, adjusted for age, gender, chronic kidney disease, CRP, ejection fraction, and diabetes mellitus. The shaded area indicates the 95% confidence interval.

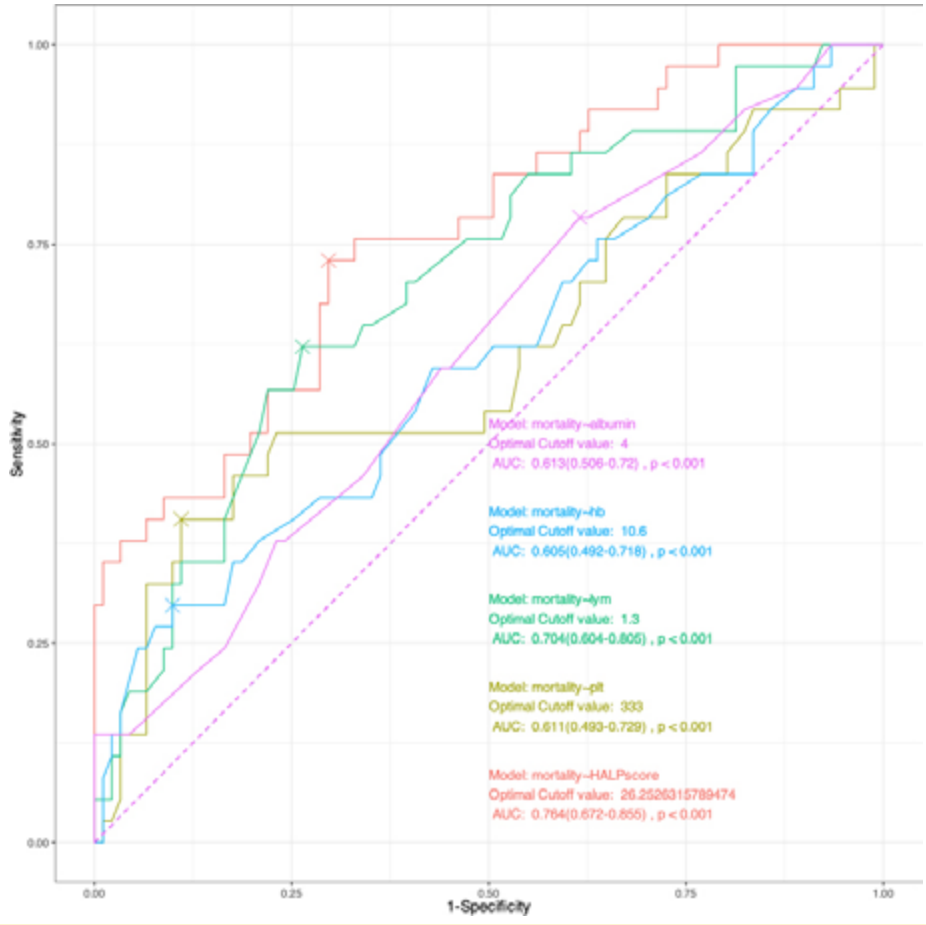

Figure 5. ROC curve analysis of the HALP score and its individual components in predicting mortality among elderly patients with acute myocardial infarction.

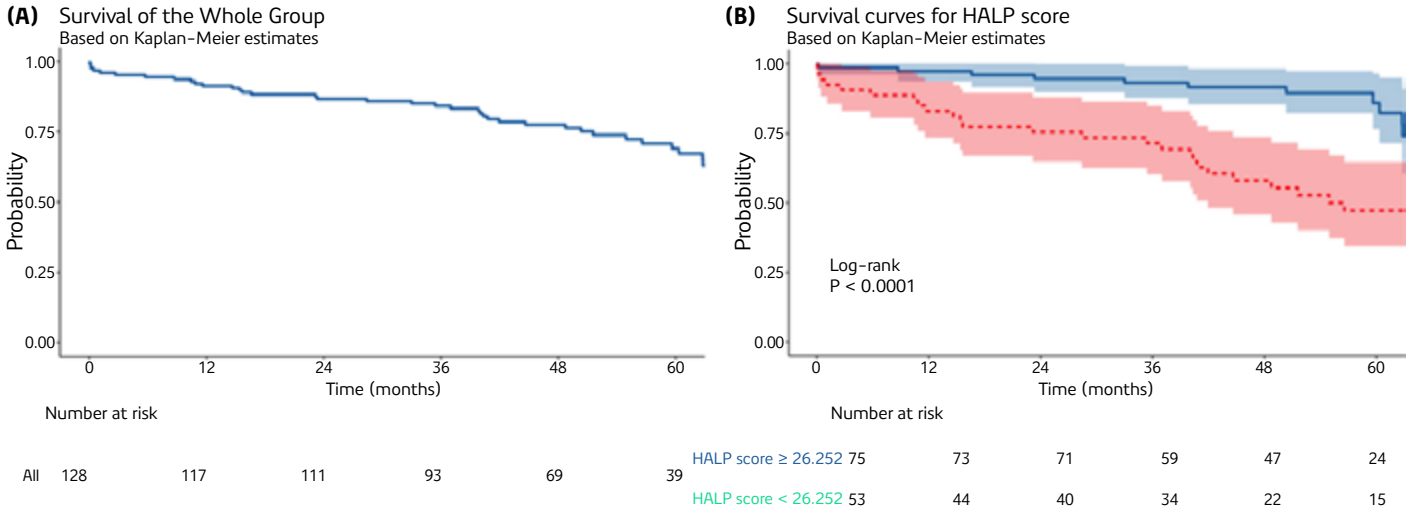

Figure 6. (A) A single-arm Kaplan–Meier analysis. (B) Kaplan–Meier survival curves for all-cause mortality, according to the HALP score.

Conclusion

Elderly patients represent a high-risk cohort with elevated long-term overall mortality rates. In this population, the HALP score may serve as a potential prognostic marker for survival. Despite their increased risk, revascularization should not be deferred solely due to age in these patients. The HALP score may be a valuable tool to support personalized clinical decision-making regarding PCI in elderly individuals.

Ethics Committee Approval: Ethics committee approval was obtained from Yalova University Health Sciences Non-Interventional Clinical Research Ethics Committee (Approval Number: 2025/81, Date: 05.02.2025).

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