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HALP score can predict the no-reflow phenomenon and in-hospital mortality after saphenous vein graft intervention

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ABSTRACT

Aims: The no-reflow phenomenon (NRP) is one of the most frequently observed complications in saphenous vein graft (SVG) interventions. The aim of this study was to investigate the effect of the hemoglobin, albumin, lymphocyte, and platelet (HALP) score on the development of NRP in patients with acute coronary syndrome (ACS) undergoing percutaneous SVG intervention.

Methods: This retrospective study included 263 patients who applied to our center with the diagnosis of ACS and underwent saphenous vein grafting procedure. The patients were divided into two groups according to whether no-reflow developed or not, and the HALP scores of the groups were compared. In addition, in-hospital mortality was compared between the study groups according to their HALP score values. The predictive ability of the HALP score for no-reflow was evaluated using a receiver operating characteristic curve.

Results: NRP developed in 103 (39.2%) of the patients included in the study patients. HALP score value was found to be significantly lower in the no-reflow group (45.3±20 vs 53.8±18, p:0.001). In the receiver operating characteristic (ROC) analysis, the cutoff value for the HALP score was calculated as 46.5. After multivariable adjustment, the HALP score <46.5 was an independent predictor of no-reflow (OR=4.95, 95% CI:2.48-9.89; p<0.001). Additionally, HALP score was found to be an indicator for in-hospital mortality (0.036).

Conclusion: The HALP score proves to be a valuable predictive tool for NRP and in-hospital mortality in patients with presenting to the emergency department with ACS and undergoing SVG intervention.

Keywords: HALP score, no-reflow phenomenon, saphenous vein graft, percutaneous coronary intervention, acute coronary syndrome

INTRODUCTION

In recent years, significant progress has been made in treating coronary artery disease (CAD) with respect to percutaneous coronary intervention (PCI) and the timing of coronary surgeries.[1] Coronary artery bypass graft (CABG) surgery is often considered the main treatment option for individuals diagnosed with disease in all three major coronary arteries and/or the left main coronary artery. In addition to improving ischaemia, angina, and living conditions, coronary surgery also improves the prognosis in some patients.[2] Despite the worse patency rates of saphenous vein grafts (SVGs) compared to arterial grafts, their easy accessibility plays a role in their more frequent preference in surgeries.[2] During the initial year following CABG surgery, 10-15% of saphenous vein grafts become occluded,[3] and over the first decade, their patency rates decline by 50% as a result of degenerative or obstructive conditions.[4] In procedures involving saphenous vein grafts, various challenges arise, chiefly including flow quantities and distal embolization.[5] The no-reflow phenomenon (NRP) is an adverse event occurring with a frequency of up to 15 percent during SVG interventions.[6,7] NRP deteriotes reverse remodelling of the left ventricle leading to congestive heart failure related topoor prognosis.[8] Although the exact mechanisms behind the development of NRP are not fully understood, capillary bed embolism, endothelial dysfunction, ischemic damage, inflammatory reaction, and stress response are suggested elements in the NRP mechanism.[9] Various comorbid conditions, delayed intervention and excess thrombogenic burden of the vessel are the main factors suggested for the development of NRP.[10] By identifying independent predictors of NRP would be advantageous for managing to limit NRP related clinical adverse events associated with SVG procedures.

Hemoglobin, albumin, lymphocyte and platelet (HALP) score is obtained from four variables that can be easily calculated from blood samples and has been suggested as a biomarker that can express the health prognosis and inflammatory status of some patient groups.[11] Each of these parameters provides important insights into the patient's overall health, and numerous clinical studies have demonstrated their close

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association with the occurrence of no-reflow.[12,13] Because the HALP score indicates conditions like anemia, malnutrition, and proinflammatory states, studies have demonstrated an inverse relationship between cardiovascular mortality risk in the general population and negative clinical outcomes, such as in-hospital death and acute heart failure, within patients experiencing coronary syndrome.[11,14]

The purpose of this research was to explore how the HALP score influences the occurrence of NRP and in-hospital mortality in patients with acute coronary syndrome (ACS) who received SVG intervention. Additionally, the study aimed to assess the independent predictors of NRP occurrence.

METHODS

Ethics

All procedures involving human participants in this study adhered to the ethical standards set by the institutional research committee, as well as the 1964 Declaration of Helsinki and its later amendments or equivalent ethical guidelines. The study did not involve any animal subjects. Approval was obtained from the Clinical Researches Ethics Committee of University of Health Sciences Bursa Higher Specialization Training and Research Hospital (Date: 11.09.2024, Decision No: 2024-TBEK 2024/09-02).

Data Collection and Laboratory Analysis

The study included individuals with previous coronary operation who presented at our hospital with ACS needing SVG intervention. All eligible patients presenting from January 2017 to January 2024 were consecutively enrolled. The study included only those with unstable angina or NSTEMI, while STEMI patients were excluded. The reason for excluding STEMI patients is that in this patient group, optimal conditions cannot be provided in the procedure due to the possibility of hemodynamic deterioration and the possibility of NRP development is higher due to intense thrombus burden. The mentioned situations will reduce the reliability of the HALP score.

The criteria for inclusion were: (1) ages ranging from 20 to 80 years, (2) having undergone CABG more than 6 months prior, and (3) identification of a saphenous vein lesion with a subsequent decision for intervention. Exclusion criteria were: (1) having a prior diagnosis of hemoglobinopathy, (2) existence of mechanical complications, (3) indications of active infection, (4) undergoing active cancer treatment, and (5) having inadequate or missing data. A total of 263 patients meeting these criteria were included. All participants received in-patient care following currrent ACS management guidelines. Demographic information and clinical details, including comorbid status, as well as laboratory and angiographic results, were collected from the hospital's electronic records. Further additional data, such as ritm and vital sign records and previous medications, were gathered through an archive review.

Routine blood tests were conducted at admission. Blood samples taken after an 8-12 hour overnight fast were used for studies on lipid parameters.

Coronary Angiography and Percutaneous Coronary Intervention

All patients underwent evaluation with standard coronary angiography, and a stent with suitable diameter and length was placed in the artery associated with the infarct. An experienced cardiologist, who was not privy to patient details, examined the digital angiographic images and assessed the results before and after the angioplasty. In this study, angiographic NRP was characterized by a thrombolysis in myocardial infarction (TIMI) flow grade below 3, with no signs of coronary spasm or dissection.[15] Thrombus burden was assessed on a scale from 1 to 5, where 1 indicated no thrombus and 5 signified a large thrombus fully obstructing the vessel.[16] After recanalization with a guidewire or small balloon, a grade 5 thrombus was reclassified to between grades 1 and 4. No embolic protection devices were used for any patient, regardless of the thrombus burden in the SVG, because such devices were unavailable at our center.

Definitions

ACS was defined according to the latest universal guidelines for the definition of myocardial infarction.[17] Based on the American diabetes association criteria, patients were defined as diabetic by their first blood sugar measurement at the time of admission and monitoring of fasting blood sugar or use of antidiabetic treatment.[18] Weight (kg)/ height (m^2) was the formula used to determine body-mass index (BMI). The modified Simpson method was preferred to calculate ventricular ejection fraction (LVEF), which was evaluated hours after the procedure. MDRD formula used to calculate eGFR.[19] The HALP score is calculated as follows: HALP score=hemoglobin (g/L)×albumin (g/L)×lymphocyte count (10^9/L)/platelet count (10^9/L).[11]

Statistical Analysis

The statistical software SPSS 26.0 (SPSS Inc., Chicago, IL, U.S.A.) and MedCalc statistical software (trial version 12.7.8, Mariakerke, Belgium) was used to run the analyses. The Kolmogorov–Smirnov or Shapiro–Wilk tests were used to test the normality of quantitative data. Variables were reported as mean±standard deviation (SD) or median and interquartile range values. To analyze categorical data, a $\chi 2$ test was used or Fisher's Exact test if any expected cell count was <5, and descriptive statistics were presented as number (n) and percentage (%). Student's t-test was used to compare normally distributed continuous variables, and the Mann-Whitney U test was used for variables without normal distribution. The Mann-Whitney U test was utilized to analyze two groups, and the subgroup comparisons were described using medians and interquartile ranges. Pairwise comparisons of receiver operating characteristic (ROC) curves were conducted to assess the risk of the NRP and to evaluate the predictive capability by comparing optimal cutoff points of the HALP score along with its components. The optimal cutoff value derived from the ROC analysis for the HALP score was 46.5 and was utilized to categorize groups into low and high HALP score categories. The sensitivity and specificity of these points were identified and the area under the curve (AUC) between the HALP score and its individual components were

compared. When indicated, analyses performed using HALP score as a continuous variable were also reported.

Logistic regression analyses, including both univariate and multivariate approaches, were performed to identify the independent risk factors associated with the NRP. To prevent multicollinearity, the individual components constituting the HALP score were excluded from the regression analysis. Variables found to be significant in the univariate analysis, such as a HALP score below 46.5, age, smoking, stent placement, predilatation, and thrombus grade, were included in a multivariate logistic regression analysis. The impact of each predictor on the NRP was quantified using odds ratios (OR) and 95% confidence intervals (CI). A p-value of less than 0.05 was deemed statistically significant, and all statistical tests were conducted as two-tailed.

RESULTS

An overall number of 263 patients with ACS and a history of CABG surgery were assessed. Among these patients, 211 (80.2%) were male and 52 (19.8%) were female, with an average age of 70±9 years. NRP was observed in 103 (39.2%) of the patients. The number of in-hospital mortality was found to be 13 (4.9%). The average HALP score of the patients included in the study was calculated as 50.5±19.6.

Table 1 presents the comparisons of demographic characteristics, as well as clinical and laboratory findings, between patients who developed NRP and those who did not. The analysis revealed that the average age of patients who did not develop NRP was significantly older than that of those who did (p=0.001). Moreover, there was a significantly higher number of smokers in the group that developed NRP

Table 1. The baseline characteristics and laboratory investigations of all patients

		All patients (n=263)	No-reflow (+) (n=103)	No-reflow (-) (n=160)	p-value
Demographic characteristics					
Age, years		70±9	68±9	72±9	0.001
Male gender, n (%)		211 (80.2)	83 (80.6)	128 (80)	0.908
Body-mass index, kg/m^2		27.6±3.3	27.6±3.5	27.6±3.2	0.916
Comorbidites					
Hypertension, n (%)		224 (85.2)	89 (86.4)	135 (84.4)	0.724
Diabetes mellitus, n (%)		119 (45.2)	40 (38.8)	79 (49.4)	0.126
Hyperlipidemia, n (%)		135 (51.3)	49 (47.6)	86 (53.8)	0.377
Smoking, n (%)		110 (41.8)	53 (51.5)	57 (35.6)	0.015
Chronic kidney disease, n (%)		84 (31.9)	32 (31.1)	52 (32.5)	0.892
On admission					
Systolic blood pressure, mmHg		132±22	131±22	133±22	0.429
Heart rate, beats/min		77±14	77±16	76±13	0.530
Killip class, %	1	201 (76.2)	80 (77.5)	121 (75.4)	0.437
	2	49 (18.8)	16 (15.7)	33 (20.9)	
	3	12 (4.5)	6 (5.6)	6 (3.7)	
	4	1 (0.4)	1 (1.1)	0	
ACE inh use, n (%)		180 (68.4)	69 (67)	111 (69.4)	0.686
Statin use, n (%)		144 (54.8)	54 (52.4)	90 (56.3)	0.612
OAD use, n (%)		78 (29.7)	27 (26.2)	51 (31.9)	0.337
Insulin use, n (%)		20 (7.6)	5 (4.9)	15 (9.4)	0.235
Laboratory assessment					
HbA1c, %		7.16±2.1	7.21±2.5	7.13±1.8	0.790
ABG, mg/dl		175±84	172±72	161±59	0.118
Hemoglobin, g/dl		12.6±1	12.5±0.7	12.7±1.1	0.018
Platelet count, x10^9/L		233.4±43.4	244.3±43.8	226.3±41.8	0.001
Lymphocyte, x10^9/L		2.22±0.8	2.12±0.8	2.29±0.7	0.097
Albumin, g/L		40.8±3.4	40.3±3.8	41.1±3	0.079
Peak troponin I, ng/L		1532 (281-5956)	2322 (437-8700)	945 (220-4523)	0.266
Total cholesterol, mg/dl		183.8±50.7	186.7±50.6	182±50,9	0.463
LDL cholesterol, mg/dl		110.3±43.9	111.3±42.5	109.7±44.9	0.766
eGFR, ml/min/1.73 m^2		70.5±25	72±25.9	69.6±24.4	0.451
HALP score		50.5±19.6	45.3±20.8	53.8±18	0.001
HALP score <46.5		124 (47.1)	62 (60.2)	62 (38.8)	0.001
In-hospital mortality, n (%)		16 (6.1)	12 (11.7)	4 (2.5)	0.003

The data are presented as the median (interquartile range), the mean±SDs or numbers (percentage) of patients. Abbreviations: ABG: Admission blood glucose, ACE: Angiotensin converting enzyme, eGFR: Estimated glomerular filtration rate, HALP: The hemoglobin, albumin, lymphocyte and platelet, IQR: Interquartile range, LDL: Low-density lipoprotein, LVEF: Left ventricular ejection fraction, OAD: Oral antidiabetic

(p=0.015). No notable differences were found regarding other demographic information and comorbid conditions. Both groups had similar mean values for blood pressure, heart rate, killip class and left ventricular ejection fraction at admission. Upon examining laboratory values, it was found that hemoglobin levels (12.5±0.7 vs. 12.7±1.1 mg/dl, p<0.018) and the HALP scores (45.3±20.8 vs. 53.8±18, p=0.001) were significantly lower in patients who developed NRP. Conversely, platelet count values (244.3±43.8 vs. 226.3±41.8, p=0.001) were significantly higher in the same group. There were no statistically significant differences observed in the other laboratory parameters. In the group of patients who developed NRP, the in-hospital mortality rate was found to be significantly higher (p:0.003).

Table 2 illustrates the angiographic parameters based on the presence of NRP. The thrombus burden was found to be significantly greater in patients who developed NRP (p<0.001). The occurrence of NRP was notably lower in patients who received a stent (p=0.002). Conversely, NRP was significantly more common in those who underwent predilatation (p<0.001). There was no significant difference between the groups concerning the length of the stent placed and the occurrence of post-dilatation.

The results of the ROC analysis performed according to the NRP development of the patients are shown in **Figure**. In order to predict the development of NRP in the ROC curve, HALP and its components were compared on the same curve. In this comparison, the ability of the HALP score to predict the development of NRP was found to be superior to its components. As a result of ROC analysis, the optimal cutoff value of the HALP score in predicting the development of NRP was determined to be 46.5 (AUC: 0.645, 95% CI: 0.57-0.71; p<0.001).

According to the results obtained in the ROC analysis, the patient population was divided into 2 groups: those with a HALP score <46.5 and those with a HALP score ≥46.5

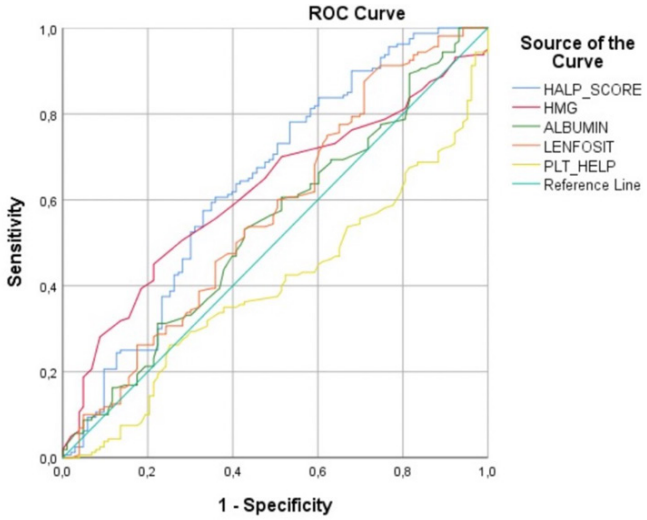

Figure. ROC analysis of the HALP score and the parameters included in this score

(**Table 3**). The prevalence of chronic kidney disease was significantly greater among patients exhibiting a low HALP score (p<0.001). In contrast, no noteworthy disparities were observed in the demographic characteristics of those with low versus high HALP scores. Upon examining laboratory parameters, it was revealed that patients with a HALP score below 46.5 had considerably lower values for hemoglobin (p<0.001), lymphocytes (p<0.001), albumin (p=0.003), and estimated glomerular filtration rate (eGFR) (p=0.001). In the cohort of patients with a HALP score below 46.5, a significantly higher platelet count was observed (p<0.001). However, no statistically significant differences were found in other laboratory parameters. When assessing in-hospital mortality rates, it became evident that patients with a HALP score under 46.5 experienced higher rates of in-hospital mortality (p=0.036). Additionally, the incidence of NRP was notably elevated in this same patient group (p=0.001).

Table 2. Angiographic and procedural status of patients according to NRP

Angiographic parameters		All patients (n=263)	No-reflow (+) (n=103)	No-reflow (-) (n=160)	p-value
Location of the saphenous graft					
LAD, n (%)		16 (6.1)	3 (2.9)	13 (8.1)	0.152
RCA, n (%)		89 (33.8)	32 (31.1)	57 (35.6)	
Cx, n (%)		112 (42.6)	46 (44.7)	66 (41.3)	
Diagonal, n (%)		38 (14.4)	19 (18.4)	19 (11.9)	
OM, n (%)		3 (1.1)	0	3 (1.9)	
IM, n (%)		5 (1.9)	3 (2.9)	2 (1.3)	
Procedural data					
Pre-PCI antiplatelet treatment, n (%)	Clopidogrel	226 (85.9)	83 (80.6)	143 (89.4)	0.068
	Ticagrelor	37 (14.1)	20 (19.4)	17 (10.6)	
Stent implantation, n (%)		251 (95.4)	93 (90.3)	158 (98.8)	0.002
Stent length, (mm)		24 (18-38)	24 (18-42)	24 (20-38)	0.532
Predilatation, n (%)		181 (68.8)	87 (84.3)	94 (58.8)	<0.001
Postdilatation, n (%)		58 (22.1)	22 (21.4)	36 (22.5)	0.880
Thrombus grade, n (%)	1	4 (1.8)	0	4 (1.5)	<0.001
	2	41 (15.6)	0	41 (25,6)	
	3	81 (30.8)	23 (22.3)	58 (36.3)	
	4	88 (33.5)	48 (46.6)	40 (25)	
	5	49 (18.6)	32 (31.1)	17 (10.6)	
Total ischemia time, h		15.6±6.7	14.± 6.9	16.3±6.5	0.051

The data are presented as the median (interquartile range), the mean±SDs or numbers (percentage) of patients. Abbreviations: Cx: Circumflex artery, LAD: Left anterior descending artery, PCI: Percutaneous coronary intervention, RCA: Right coronary artery, TIMI: Thrombolysis in myocardial infarction, NRP: No-reflow phenomenon

Table 3. Basic characteristics and laboratory examinations of all patients according to HALP score

		All patients (n=263)	HALP <46.5 (n=124)	HALP ≥46.5 (n=139)	p-value
Age, years		70± 9	71±10	69±9	0.058
Male gender, n (%)		211 (80.2)	94 (75.8)	117 (84.2)	0.120
Hypertension, n (%)		224 (85.2)	111 (89.5)	113 (81.3)	0.081
Hyperlipidemia, n (%)		135 (51.3)	57 (46)	78 (56.1)	0.109
DM, n (%)		119 (45.2)	58 (46.8)	61 (43.9)	0.586
Chronic kidney disease, n (%)		84 (31.9)	53 (42.7)	31 (22.3)	<0.001
Hemoglobin, g/dl		12.6±1	12.4±0.9	12.9±0.9	<0.001
Lymphocyte, x10^9/L		2.2±0.8	1.71±0.45	2,68±0.74	<0.001
Platelet count, x10^9/L		223±43	248±41	220±41	<0.001
eGFR, ml/min/1.73 m^2		70.5±25	65.2±27	75.3±21.7	0.001
Total cholesterol, mg/dl		183.8±50.7	181.7±56	185.7±45.7	0.518
Albumin, g/L		40.8±3.4	40.1±3.7	41.3±2.9	0.003
LDL cholesterol, mg/dl		110.3±44	110.7±48.8	110±39.3	0.893
LVEF, (%)		41±11	41±12	42±11	0.252
In-hospital mortality, n (%)		16 (6.1)	12 (9.7)	4 (2.9)	0.036
No-reflow, n(%)	(+)	103 (39.2)	62 (50)	41 (29.5)	0,001
	(-)	160 (60.8)	62 (50)	98 (70.5)	

The data are presented as the mean±SDs or numbers (percentage) of patients. Abbreviations: DM: Diabetes mellitus, eGFR: Estimated glomerular filtration rate, HALP: The hemoglobin, albumin, lymphocyte and platelet, LDL: Low-density lipoprotein, LVEF: Left ventricular ejection fraction

The findings from the adjustment analysis are detailed in **Table 4**. In the univariate analysis, several factors, including age, smoking status, hemoglobin levels, platelet counts, stent insertion, predilatation, thrombus grading, and a HALP score of less than 46.5, were identified as significant contributors to the occurrence of NRP in patients undergoing SVG PCI. When these factors were further analyzed through multivariate logistic regression, the HALP score of less than 46.5 was identified as an independent predictor for the development of NRP, regardless of other variables (OR=4.95, 95% CI: 2.48-9.89; p<0.001). Furthermore, a high thrombus burden, the process of predilatation, and stent placement were identified as additional predictors for the development of NRP, independently of other factors (OR=6.77, 95% CI:3.41-13.42; p<0.001, OR=2.43, 95% CI: 1.16-5.10; p:0.019 and OR=0.09, 95% CI: 0.02-0.49; p:0.005). Due to the multicollinearity between the HALP score and the parameters it includes, hemoglobin and platelet counts, hemoglobin and platelet counts were not included in the multivariate analysis.

DISCUSSION

The key finding of this study indicates that the HALP score serves as an important indicator of NRP risk in patients with ACS who receive saphenous graft procedures. Presenting with a low HALP score is independently associated with a heightened risk of NRP, even after accounting for other common factors. Additionally, low HALP score was found to be significantly associated with in-hospital mortality. As far as we are aware, this study is the first to demonstrate a significant link between the HALP score and both the risk of developing NRP and in-hospital mortality in these patients.

The HALP score, primarily evaluated for its efficacy in forecasting the risk of negative clinical outcomes in cancer patients, is a scoring system derived from standard blood parameters, serving as an uncomplicated and readily available biomarker for the overall inflammatory condition.[20,21] Based on these studies, decreased levels of hemoglobin and albumin suggest anemia and malnutrition, whereas a lower lymphocyte count and higher platelet count are linked to inflammation and an impaired immune system. Drawing from this information, the HALP score, which integrates hemoglobin, albumin, lymphocytes, and platelets into one ratio, has been regarded as a novel metric that effectively captures systemic inflammation and nutritional status with a synergistic impact.[22] In STEMI patients, a similar relationship between survival before discharge and the value of the HALP score has been reported in the literature.[14] It has also been demonstrated that the HALP score can forecast the occurrence of NRP and short-term mortality in patients with STEMI who undergo invasive coronary intervention.[23]

Table 4. Analysis of independent predictors of NRP by logistic regression analyses

	Univariate odds ratio (95% CI)	P value	Multivariate odds ratio (95% CI)	p value
Age	1.04 (1.02-1.08)	0.001	1.03 (0.97-1.08)	0.079
Smoking	1.91 (1.16-3.17)	0.011	1.90 (0.90-3.99)	0.089
Hemoglobin**	1.34 (1.03-1.75)	0.030		
Platelet count**	0.99 (0.98-1.00)	0.001		
HALP score <46.5	2.39 (1.44-3.97)	0.001	4.95 (2.48-9.89)	**<0.001**
Stent implantation	0.12 (0.25-0.55)	0.006	0.09 (0.02-0.49)	**0.005**
Predilatation	3.82 (2.06-7.09)	<0.001	2.43 (1.16-5.10)	**0.019**
Thrombus grade *	6.28 (3.57-11.06)	<0.001	6.77 (3.41-13.42)	<0.001

Abbreviations: CI: Confidence interval, HALP: The hemoglobin, albumin, lymphocyte and platelet, NRP: No-reflow phenomenon, * The thrombus grade parameter consists of 5 degrees. Grade 4 and 5 parameters were analyzed according to grade 1-2-3 parameters by binary logistic regression, ** Due to the multicollinearity between the HALP score and its hemoglobin and platelet parameters, hemoglobin and platelet parameters were not included in the multivariate analysis

In our research, we discovered a strong correlation between the HALP score and the development of NRP in patients with ACS whose saphenous grafts treated with percutane invasive way. A low HALP score, potentially linked to oxidative stress and inflammation, has been shown to adversely affect in-hospital survival, correlated with fluctuations in immune function. This relationship might be partially elucidated by the components of the HALP score. Reduced levels of hemoglobin and albumin suggest anemia and malnutrition, which can impair oxygen supply to the heart muscle.[12,13] The occurrence of no-reflow is strongly linked to heightened systemic inflammation and pro-oxidant conditions, while albumin is known for its antioxidant and anti-inflammatory characteristics.[24,25] Thus, reduced albumin levels may contribute to the development of no-reflow through a potential mechanism.[13] Moreover, variability in lymphocyte and platelet numbers may indicate a proinflammatory state that can negatively affect microvascular functions, exacerbating the NRP.[13] In this framework, given its parameters, the HALP score is poised to offer a thorough risk evaluation as a biomarker for predicting the onset of no-reflow. Hence, it can be proposed that these factors together heighten the risk of NRP in patients with a low HALP score who undergo SVG procedures following an ACS diagnosis.

Estimates of how often NRP occurs differ based on the evaluation technique, with literature reports indicating a range between 5% and 60%.[26] For STEMI patients undergoing percutaneous coronary stenting, the occurrence of NRP can be as high as 32%, and it may rise even further, particularly following procedures like degenerate vein graft intervention and rotational atherectomy.[27] ACS and procedures involving the saphenous vein are major risk factors for the onset of NRP.[27] When we evaluated our results in our study, there was a similar NRP development rate as the previously mentioned studies (39.2%). In the present study, the occurrence of NRP was inversely related to age. The average age of patients who developed NRP was 68, whereas it was 72 for those who did not. There was no significant variation in LVEF values between those who developed NRP and those who did not, with values standing at 42 and 41, respectively). Similarly, earlier research in this area has also found no difference in LVEF values relative to the presence or absence of NRP development.[28]

In our research, we identified that the initial thrombus grade and predilatation prior to stent placement are independent predictors of NRP. Our analysis revealed a significantly increased incidence of NRP in patients who had a high thrombus load in the saphenous graft at the onset of the procedure. Previous studies have similarly reported higher rates of NRP in patients undergoing saphenous graft interventions with a high thrombus burden.[29] Furthermore, it was discovered that patients who underwent predilatation experienced a significantly higher incidence of NRP. Earlier studies have indicated that predilatation is associated with increased rates of MACE and mortality during saphenous graft interventions.[30]

Based on these findings, the HALP score can be viewed as a noninvasive indicator for assessing NRP and predicting in-hospital mortality in patients presenting to the emergency department with ACS who undergo SVG intervention. Consequently, for patients deemed at high risk for developing NRP and in-hospital mortality, there is an opportunity to arrange early coronary intervention. Future larger-scale studies are necessary to clarify the mechanism linking the HALP score with the likelihood of NRP development.

Limitations

Some limitations of our study should be noted before interpreting the results. Our study is a single-center retrospective study with a limited sample size. Additionally, since our study is a retrospective study, short and long-term follow-up data of the patients after discharge are not available. While collecting patient data, data about saphenous vein grafts other than the operated saphenous graft (number of saphenous vein grafts, patency status) were not collected. This is because even if there were lesions in other saphenous vein grafts, these lesions did not have an impact on the in-hospital mortality of the patients, as they were not culprit lesions or acute lesions.

CONCLUSION

The HALP score serves as an effective predictor for NRP development and short term mortality in patients with ACS undergoing SVG interventions. Additionally, the presence of a high thrombus burden and predilation prior to stenting were identified as factors that elevate the risk of NRP development. Further research is necessary to confirm and enhance the HALP score's usefulness in larger patient groups and to investigate its potential use in clinical settings.

ETHICAL DECLARATIONS

Ethics Committee Approval

Approval was obtained from the clinical Researches Ethics Committee of University of Health Sciences Bursa Higher Specialization Training and Research Hospital (Date: 11.09.2024, Decision No: 2024-TBEK 2024/09-02).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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