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The Relationship Between Preoperative Hemoglobin, Albumin, Lymphocyte, and Platelet Score and Postoperative Outcomes in Patients with Type 2 Diabetes Mellitus Undergoing Coronary Artery Bypass Surgery

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ABSTRACT

Introduction: Type 2 diabetes mellitus (T2DM) significantly increases the risk of morbidity and mortality following coronary artery bypass grafting (CABG). Identifying preoperative prognostic indicators is critical for improving postoperative outcomes in this patient population.
Methods: This study aimed to investigate the relationship between the preoperative Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) score and postoperative complications and mortality in T2DM patients undergoing isolated CABG surgery. A total of 675 T2DM patients who underwent isolated CABG surgery between 2018 and 2024 were retrospectively analyzed. Patients were grouped according to their preoperative HALP scores. Demographic characteristics, postoperative complications, intensive care and hospital stay durations, revascularization needs, and one-year mortality rates were compared between groups.
Results: Patients with lower HALP scores experienced significantly higher rates of postoperative infections, pneumonia, renal dysfunction, longer intensive care unit/hospital stays, and increased one-year mortality ($P < 0.001$). These findings indicate a strong correlation between nutritional/immune status and surgical outcomes in diabetic patients.
Conclusion: Preoperative HALP score may serve as a reliable, cost-effective associated factor of postoperative complications and mortality in T2DM patients undergoing CABG. Incorporating HALP scoring into routine preoperative assessment could enhance risk stratification and perioperative management strategies
Keywords: HALP Score. Coronary Artery Disease. Diabetes Mellitus. CABG.

Abbreviations, Acronyms & Symbols			
AF	= Atrial fibrillation	HALP	= Hemoglobin, Albumin, Lymphocyte, and Platelet
AUC	= Area under the curve	HD	= Hemodialysis
BMI	= Body mass index	ICU	= Intensive care unit
CABG	= Coronary artery bypass grafting	LoS	= Length of stay
CAD	= Coronary artery disease	LVEF	= Left ventricular ejection fraction
CI	= Confidence interval	OR	= Odds ratio
COPD	= Chronic obstructive pulmonary disease	MACE	= Major adverse cardiovascular events

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CRP	= C-reactive protein	PCI	= Percutaneous coronary intervention
CVA	= Cerebrovascular accident	ROC	= Receiver operating characteristic
DM	= Diabetes mellitus	T2DM	= Type 2 diabetes mellitus
EuroSCORE	= European System for Cardiac Operative Risk Evaluation		

INTRODUCTION

Although all complications of diabetes mellitus (DM) are clinically important, it remains one of the leading causes of morbidity and mortality in patients with coronary artery disease (CAD)[1]. Moreover, approximately 80% of patients with DM eventually die due to CAD-related complications[2]. In patients with DM, coronary revascularization is often necessary due to the severity and extent of the disease[3]. Alongside percutaneous interventions, coronary artery bypass grafting (CABG) has become increasingly common. Large-scale studies have reported an overall mortality rate of 1 – 4% for CABG procedures[4]. However, it is well known that CABG carries a significantly higher mortality risk in patients with DM compared to non-diabetic individuals[5]. The ability to associate mortality and morbidity in advance is crucial for improving the quality of healthcare delivery in these patients.

In recent years, the Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) index — calculated using the formula hemoglobin (g/dL) × albumin (g/dL) × lymphocyte count (10^3/μL) / platelet count (10^3/μL) — has emerged as a marker of nutritional status and systemic inflammation, particularly in cancer surgery[6,7]. Similarly, the Controlling Nutritional Status (or CONUT) score, which includes serum albumin, lymphocyte count, and total cholesterol level, has also been associated with prognosis in patients with cancer and stroke[8,9]. These malnutrition-based scores have also shown prognostic value in patients with heart failure[10]. Recent studies have started to explore the relationship between nutritional status scores and clinical outcomes in CAD as well[11].

Although HALP has been evaluated in general cardiac cohorts, evidence in a strictly defined type 2 diabetic population undergoing isolated CABG remains scarce. This study addresses that gap by investigating HALP in a large, homogeneous diabetic cohort.

There is limited evidence specifically investigating the association between malnutrition scores and mortality following CABG[12]. Evaluating the relationship between the preoperative HALP score and postoperative outcomes may help cardiac surgeons to better manage postoperative complications. In this study, we aimed to assess the association between preoperative HALP scores and postoperative outcomes in patients with type 2 DM undergoing isolated CABG.

METHODS

This retrospective observational study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the relevant health authorities and institutional review board (Prof. Dr. Cemil Tascioglu City Hospital Local Ethics Committee; date: 14.04.2025; decision no: E-48670771-514.99-273681564). All procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all individual participants included in the study. Clinical trial number was not applicable.

A total of 675 patients with type 2 DM who underwent isolated CABG between 2018 and 2024 were included in the study. All consecutive eligible elective isolated CABG patients with type 2 DM operated between 2018 and 2024 were included to minimize selection bias.

Patients with end-stage renal failure, hepatic failure, additional cardiac pathologies, malignancies, active infections, or those who underwent emergency surgery were excluded. The exclusion of emergency surgeries and end-stage organ failure was intended to reduce the impact of acute metabolic or hemodynamic instability on perioperative inflammatory parameters.

All CABG procedures were performed by the same core surgical and anesthesiology team during the study period to reduce operator-dependent variability.

All patients underwent surgery with median sternotomy. The procedures were performed under cardiopulmonary bypass, using the left internal mammary artery and saphenous vein grafts.

Patients were divided into two groups based on their preoperative HALP scores. Demographic data, postoperative laboratory markers (C-reactive protein [CRP], procalcitonin), postoperative complications (cerebrovascular events, atrial fibrillation, pneumonia, sternal wound infection, saphenous site infection, sternal dehiscence), duration of intensive care unit (ICU) and hospital stay, need for repeat coronary revascularization, and one-year mortality were compared between the groups.

HALP Score Assessment

Fasting blood samples, including measurements of serum albumin, hemoglobin, lymphocyte count, and platelet count, were obtained one day before surgery. The HALP score was calculated using the following formula:

$$\text{HALP} = \text{Hemoglobin (g/L)} \times \text{Albumin (g/L)} \times \text{Lymphocyte count } (10^9\text{/L}) / \text{Platelet count } (10^9\text{/L})$$

The optimal cutoff value of 0.46 was determined by receiver operating characteristic (ROC) analysis using the Youden index to predict one-year mortality.

Statistical Analysis

All statistical analyses were performed using the IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, N.Y., USA). Continuous variables were assessed for normality using the Kolm-

ogorov–Smirnov and Shapiro–Wilk tests. Variables with a normal distribution were expressed as mean ± standard deviation, while non-normally distributed variables were presented as median with interquartile ranges (25th – 75th percentile). Categorical variables were expressed as counts and percentages (%). Comparisons between two independent groups were conducted using the independent samples *t*-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed continuous variables. The chi-square test or Fisher's exact test was used for comparison of categorical variables, as appropriate. To evaluate the association between HALP score and adverse postoperative outcomes, a binary logistic regression analysis was conducted. Variables with clinical relevance or a *P*-value < 0.10 in univariate comparisons were included in the multivariable model. Odds ratios (OR) (Exp(B)) and 95% confidence intervals (CIs) were reported to quantify the strength of associations. The associate performance of the HALP score for postoperative complications and one-year mortality was further assessed using ROC curve analysis. The area under the curve (AUC), along with sensitivity, specificity, and 95% CI, was calculated. A two-tailed *P*-value < 0.05 was considered statistically significant throughout the analysis.

RESULTS

A total of 675 patients who underwent CABG were analyzed and categorized into two groups based on their HALP scores, using a cutoff value of 0.46. Among them, 337 patients were classified as having a low HALP score (< 0.46), and 338 patients had a high HALP score (> 0.46). There were no significant differences in baseline characteristics such as age, sex distribution, body mass index (BMI), presence of hypertension, DM, hyperlipidemia, current smoking status, or history of cerebrovascular accidents between the groups. However, chronic obstructive pulmonary disease was more prevalent in the low HALP group compared to the high HALP group (32.0% *vs.* 21.6%, $P = 0.002$). Preoperative left ventricular ejection fraction and HbA1c levels were similar between groups. In contrast, patients with higher HALP scores demonstrated significantly greater values of hemoglobin, platelet count, lymphocyte count, and albumin (all $P < 0.001$). The mean HALP score was markedly higher in the high HALP group (0.72 ± 0.34 *vs.* 0.30 ± 0.10, $P < 0.001$) (Table 1).

The frequency of postoperative atrial fibrillation did not differ significantly between the groups (30.3% *vs.* 27.8%, $P = 0.482$). Notably, patients in the low HALP group had significantly prolonged ICU stay (6.45 ± 6.97 *vs.* 4.79 ± 1.88 days, $P < 0.001$) and total hospital stay (13.11 ± 9.21 *vs.* 10.23 ± 3.71 days, $P < 0.001$) (Figures 1, 2). Preoperative levels of inflammatory biomarkers, including CRP and procalcitonin, were also significantly elevated in the low HALP group, consistent with a heightened baseline inflammatory state (Table 2).

Postoperative outcomes revealed that patients with lower HALP scores experienced significantly higher rates of complications. Specifically, the low HALP group had increased incidences of sternal wound dehiscence (11.6% *vs.* 3.8%, $P < 0.001$), postoperative cerebrovascular accidents (10.1% *vs.* 5.0%, $P = 0.027$), pneumonia (33.8% *vs.* 6.8%, $P < 0.001$), sternal (14.5% *vs.* 4.4%, $P < 0.001$) and saphenous wound infections (23.1% *vs.* 7.45%, $P < 0.001$), as well as need for re-catheterization (8.6% *vs.* 3.8%, $P = 0.010$). Furthermore, one-year mortality was significantly higher in the low HALP group (13.6% *vs.* 1.5%, $P < 0.001$), alongside greater rates of postoperative renal dysfunction (10.7% *vs.* 3.8%, $P < 0.001$) and need for renal replacement therapy (7.4% *vs.* 2.4%, $P = 0.002$) (Figure 3).

In the multivariable logistic regression analysis, only the HALP score emerged as an independent associated factor of adverse postoperative outcomes (OR = 0.007, 95% CI: 0.001 – 0.069, $P < 0.001$), whereas albumin, hemoglobin, and platelet levels were not statistically significant (Table 3).

ROC curve analysis demonstrated that the HALP score had a strong associate capacity for adverse outcomes, with an AUC of 0.240 (95% CI: 0.18 – 0.29, $P < 0.001$), sensitivity of 92%, and specificity of 64% (Figure 4).

DISCUSSION

In this study, we examined the relationship between preoperative HALP score and postoperative outcomes in patients with type 2 DM undergoing CABG. It is well-established that CABG is associated with higher rates of morbidity and mortality in patients with diabetes compared to the general population[10]. Consistent with this, our findings demonstrate that patients with lower preoperative HALP scores had significantly higher rates of postoperative complications — particularly sternal wound infections, saphenous site infections, pneumonia — and higher mortality rates.

The HALP score is a composite index that combines indicators of nutritional status (hemoglobin and albumin) with markers of immune function (lymphocyte and platelet counts). Inflammation is known to play a key role in the pathogenesis of both DM and atherosclerosis[13]. While type 1 DM is characterized by insulin deficiency, type 2 DM is primarily associated with insulin resistance, metabolic dysfunction, and nutritional disturbances[14]. Therefore, a scoring system that reflects both inflammatory status and nutritional condition, such as HALP, may have clinical value in assessing prognosis in patients with CAD and type 2 DM[7].

In a meta-analysis conducted by Chen et al.[15], which included 33 studies, patients who experienced major adverse cardiovascular events (MACE) after percutaneous coronary intervention (PCI) were found to have significantly higher mean platelet volume compared to those without events. Albumin is widely recognized as a marker of nutritional status and has been studied as a prognostic factor in CAD. Inflammatory processes reduce albumin levels by decreasing hepatic synthesis. A study by H. Wada et al.[16] involving 1,316 patients demonstrated that low preprocedural serum albumin levels were associated with increased risk of MACE in patients undergoing PCI. Moreover, higher albumin levels are thought to mitigate oxidative stress, inflammatory response, and thrombosis[17].

Lymphocytes play a crucial role in tissue repair and regulation of inflammatory responses. Elevated lymphocyte counts have been associated with better outcomes in chronic ischemic heart disease by limiting infarct size[18]. Anemia, malnutrition, and inflammation are interrelated may influence the prognosis of the disease[19]. During systemic inflammation, increased cytokine production inhibits iron absorption, leading to reduced hemoglobin synthesis and resulting in anemia[20]. In addition, nutritional deficiencies frequently seen in CAD patients may also contribute to anemia. Low hemoglobin levels have been identified as independent associated factors of cardiovascular events and mortality in patients with stable CAD[21]. Thus, reduced hemoglobin and hematocrit values can significantly contribute to poor prognosis and mortality in chronic ischemic heart disease.

Table 1. Demographic and clinical characteristics by HALP score group.

Variables	Low HALP Score < 0.46 (n = 337)	High HALP Score > 0.46 (n = 338)	*P*-value
Age, years	64.42 ± 9.38	64.82 ± 10.03	0.594
Sex, male	84 (284)	84 (283)	0.987
BMI	31.45 ± 8.55	31.34 ± 8.13	0.862
Patients with hypertension, % (n)	57.3 (193)	59.2 (200)	0.616
Previous CVA, % (n)	15.4 (52)	18 (61)	0.363
Patients with COPD, % (n)	32 (108)	21.6 (73)	0.002
Patients with hyperlipidemia, % (n)	43.9 (148)	47.3 (160)	0.419
Current smoker, % (n)	70.3 (237)	70.1 (237)	0.953
Family history of CAD	61.7 (208)	63.3 (214)	0.669
Preoperative LVEF, %	54.11 ± 7.07	53.50 ± 7.47	0.273
Hba1c, %	7.57 ± 1.94	7.61 ± 1.79	0.788
Preoperative creatine, mg/dl	0.91 [0.76 - 1.13]	0.89 [0.77 – 1.05]	0.118
T-cholesterol	174 [145 - 204]	187 [145 - 218]	0.036
Hemoglobin, g/L	12.20 [11.05 – 13.40]	14[13.10 – 15.00]	< 0.001
Platelet count, 103/ml	224.84 ± 58.74	266.19 ± 75.05	< 0.001
Lymphocyte count,	2.57 ± 0.75	1.66 ± 0.58	< 0.001
Albumin level	3.92 [3.54 – 4.21]	4.19 [3.90 – 4.45]	< 0.001
HALP score	0.30±0.10	0.72 ± 0.34	< 0.001
LoS in ICU, days	6.45 ± 6.97	4.79 ± 1.88	< 0.001
LoS in hospital, days	13.11 ± 9.21	10.23 ± 3.71	< 0.001
Preoperative CRP	11.99 ± 20.56	19.55 ± 30.54	< 0.001
Postoperative 1 CRP	79.27 ± 57.29	81.79 ± 56.44	0.565
Postoperative 3 CRP	249.18 ± 183.49	234.82 ± 132.38	0.244
Procalcitonin	0.04 [0.02 - 0.11]	0.03 [0.01 - 0.09]	0.016
Postoperative 1 procalcitonin	0.62 [0.16 - 1.34]	0.56 [0.16 - 1.20]	0.383
Postoperative 3 calcitonin	1.06 [0.40 - 2.65]	1.03 [0.40 - 2.17]	0.237

BMI=body mass index; CAD=coronary artery disease; COPD=chronic obstructive pulmonary disease; CRP=C-reactive protein; CVA=cerebrovascular accident; HALP=Hemoglobin, Albumin, Lymphocyte, and Platelet; ICU=intensive care unit; LoS=length of stay; LVEF=left ventricular ejection fraction

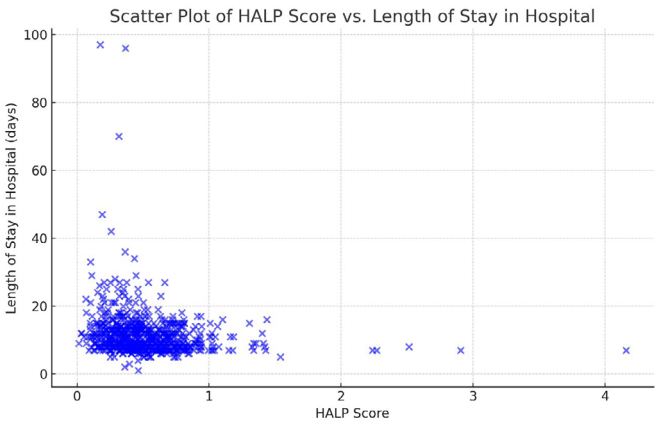

Fig. 1 - *Scatter plot of Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) Score vs. length of stay in hospital.*

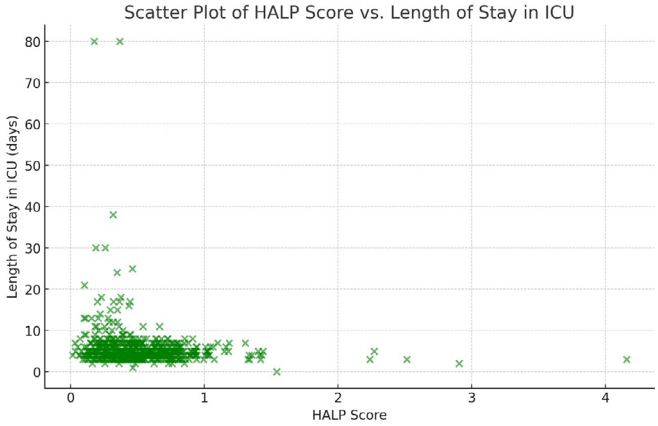

Fig. 2 - *Scatter plot of Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) score vs. length of stay intensive care unit (ICU).*

Table 2. Postoperative complications by HALP score group.

Variables	Low HALP Score < 0.46	High HALP Score > 0.46	*P*-value
Revision sternal dehiscence, % (n)	11.6 (39)	3.8 (13)	< 0.001
Postoperative CVA, % (n)	10.1 (34)	5 (17)	0.027
Postoperative pneumonia	33.8 (114)	6.8 (23)	< 0.001
Sternal wound	14.5 (49)	4.4 (15)	< 0.001
Saphenous wound	23.1 (78)	7.45 (25)	< 0.001
Catheterization	8.6 (29)	3.8 (13)	0.010
Mortality (one year)	13.6 (46)	1.5 (5)	< 0.001
Postoperative renal dysfunction	10.7 (36)	3.8 (13)	< 0.001
Renal replacement treatment (HD)	7.4 (25)	2.4 (8)	0.002
Postoperative AF	30.3 (102)	27.8 (94)	0.482

AF=atrial fibrillation; CVA=cerebrovascular accident; HALP=Hemoglobin, Albumin, Lymphocyte, and Platelet; HD=hemodialysis

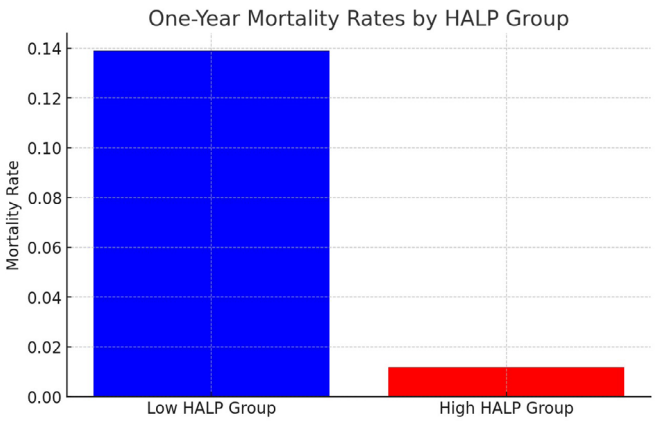

Fig. 3 - *One-year mortality rates by Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) group.*

Similar with other major surgical procedures, nutritional and inflammatory disturbances are also observed in patients following CABG[10]. These changes often manifest as alterations in BMI, which is associated with cardiac metabolism and function in patients with CAD and heart failure[11].

Type 2 DM has previously been identified as an independent risk factor for complications following CABG[1]. A study by John E. Brush et al.[22] reported that insulin-treated patients had a higher risk of postoperative stroke, whereas non–insulin-treated patients exhibited higher rates of surgical site infections and new-onset renal failure. Consistent with this, our study found that patients with lower HALP scores experienced more frequent surgical site infections (sternal and saphenous wounds). Moreover, literature suggests that patients with Type 2 DM have higher rates of postoperative mortality and coronary revascularization compared to non-diabetic patients[1]. Our results align with these findings, as we also observed increased rates of mortality and repeat revascularization in the lower HALP score group.

Risk scoring systems in CABG, such as the European System for Cardiac Operative Risk Evaluation (EuroSCORE) and the Society of Thoracic Surgeons risk score, are used to assess preoperative risk and guide clinical decision-making[23]. Given the elevated surgical risk in patients with type 2 DM, accurate associate of postoperative complications through scoring systems is quite important. Early identification of high-risk patients may allow for more effective preventive strategies, which can ultimately improve patient outcomes and reduce healthcare costs.

The HALP score has been used in a variety of chronic conditions — including malignancies and cerebrovascular diseases — as an associated factor of inflammation, nutritional status, and clinical outcomes[6]. A 2022 meta-analysis including 13,110 cancer patients found that those with lower HALP scores had poorer overall survival[7]. Another study demonstrated that lower HALP scores were associated with increased 90-day and one-year mortality in patients with acute ischemic stroke[12]. Although studies examining HALP in chronic cardiac conditions remain limited, a study in 1,307 STEMI patients showed that those with lower HALP scores after primary PCI had higher in-hospital mortality[24]. Similarly, another study involving 239 CABG patients found a correlation between lower HALP scores and postoperative mortality[12]. Our study supports these previous findings by showing that low HALP scores are associated with increased mortality. Furthermore, consistent with existing literature, we observed higher rates of sternal infections in diabetic patients with lower HALP scores[1].

In this study, we found a significant association between the HALP score and several postoperative outcomes, including surgical site infection, sternal dehiscence, pneumonia, and mortality following CABG. Patients with lower HALP scores were at greater risk for these complications, as well as for postoperative stroke, need for coronary reintervention within one year, and overall mortality. A HALP score < 0.46 was found to be significantly associated with all these adverse outcomes.

Although HALP remained independently associated with postoperative outcomes across multiple analytical models, the possibility of residual confounding and model overfitting cannot be completely excluded due to the retrospective design. Therefore, HALP should be considered a complementary risk indicator, and further prospective multicenter validation is warranted.

Table 3. Binary logistic regression analysis of factors influencing postoperative outcomes.

Variables	Exp B	95% CI	*P*-value
HALP score	0.007	0.001 – 0.069	< 0.001
Albumin	0.792	0.517 – 1.213	0.284
Hemoglobin	1.023	0.898 – 1.166	0.734
Platelet	1.000	0.997 – 1.004	0.826

CI=confidence interval; HALP=Hemoglobin, Albumin, Lymphocyte, and Platelet

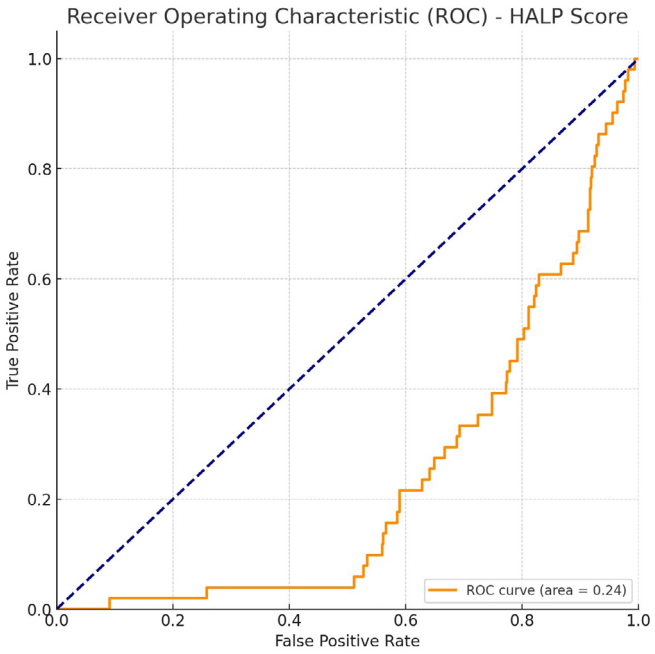

Fig. 4 - *Receiver operating characteristic – Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) score. Area under the curve 0.240, 95% confidence interval 0.18 and 0.29, P-value < 0.001. Sensitivity 92% and specificity 64%.*

Limitations

This study has several limitations. First, it is a retrospective, single-center analysis, which may limit the generalizability of the findings. Second, the exclusion of emergency surgeries and patients with end-stage organ failure, although necessary to avoid acute metabolic and inflammatory confounding, may introduce selection bias and restrict applicability to more heterogeneous clinical populations. Third, the HALP cutoff value (0.46) was derived from this specific cohort using ROC-Youden analysis and therefore requires external validation in independent and multi-center cohorts. Fourth, despite multivariable adjustments and assessment for collinearity, residual confounding cannot be fully excluded, which is an inherent limitation of observational analyses. Fifth, EuroSCORE II data were not uniformly available for this retrospective cohort and, therefore, could not be incorporated for direct comparison with established surgical risk models; future prospective studies including standardized risk scoring systems may help validate the incremental prognostic value of HALP. Finally, this study demonstrates association rather than causation, and prospective research is required to clarify temporal relationships and predictive utility. Additionally, hemoglobin levels differ physiologically between men and women, and sex-specific HALP thresholds have not yet been standardized in the literature. Although a uniform scoring approach was applied in this study, future work should consider sex-adjusted HALP thresholds to potentially enhance discriminative performance and clinical relevance.

CONCLUSION

In conclusion, the preoperative HALP score shows a significant association with postoperative complications and mortality in patients with type 2 DM undergoing CABG. A lower HALP score may indicate impaired immune function and poor nutritional status, both of which increase susceptibility to infections and delay surgical recovery. Although the HALP score demonstrates strong associate value as a practical, low-cost biomarker for perioperative risk assessment, its causal relationship without comes cannot be established due to the retrospective nature of this study.

Data Availability

The authors declare that the data supporting the findings of this study are available within the article.

Artificial Intelligence Usage

The authors declare use of ChatGPT, OpenAI for language editing and clarity improvement. The content produced by the artificial intelligence tool was revised and edited by the authors as necessary, and they take full responsibility for all scientific content to be published.

Potential Conflict of Interest

The authors declare that there is no conflict of interest in this study.

Sources of Funding

The authors declare no external funding to this study.

Authors' Roles & Responsibilities

CY Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved; final approval of the version to be published

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