THE ANATOLIAN JOURNAL OF CARDIOLOGY

Official journal of the TURKISH SOCIETY OF CARDIOLOGY

The HALP Score and Its Association with Respiratory and Intensive Care Outcomes After Minimally Invasive Valve Surgery: The MINI-HALP Study

ABSTRACT

Background: The hemoglobin–albumin–lymphocyte–platelet (HALP) score is an emerging nutritional inflammatory biomarker. Although minimally invasive valve surgery (MIVS) offers advantages over sternotomy, current prediction models such as EuroSCORE II and STS-PROM may not fully capture perioperative vulnerability. Evidence evaluating whether HALP predicts early postoperative recovery in MIVS remains limited.

Methods: This single-center retrospective study included 139 adults undergoing MIVS between January 2020 and June 2025. Patients were stratified based on the median HALP value (≤42.2 vs. >42.2). Baseline characteristics, operative data, and postoperative outcomes were compared. Correlations between HALP and operative risk indices (STS and EuroSCORE II), ventilation duration, intensive care unit (ICU) stay, and hospitalization length were assessed using Spearman's analysis. Receiver-operating characteristic curves evaluated the ability of HALP to predict prolonged intubation and ICU stay.

Results: Higher HALP scores were associated with younger age, better functional status, and lower STS and EuroSCORE II values. Patients with HALP >42.2 had shorter intubation time (9.7 ± 13.3 vs. 16.6 ± 27.2 hours, P=.013) and ICU stay (2.3 ± 2.7 vs. 3.1 ± 3.0 days, P=.021). All in-hospital deaths occurred in the low-HALP group. The HALP score showed inverse correlations with STS (r=−0.351), EuroSCORE II (r=−0.296), intubation time (r=−0.236), and ICU duration (r=−0.231) (all P < .01). No significant association was observed with hospitalization time.

Conclusions: A low preoperative HALP score was associated with prolonged ventilation, extended ICU stay, and increased early mortality after MIVS. The HALP reflects biological resilience beyond conventional risk models and may serve as an accessible adjunct for risk stratification. Prospective multicenter studies are needed to confirm these findings and support its incorporation into clinical decision-making.

Keywords: HALP score, ICU stay, minimally invasive valve surgery, risk stratification

ORIGINAL INVESTIGATION

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Received: November 20, 2025
Accepted: January 7, 2026
Available Online Date: March 13, 2026

Cite this article as: Zengin H, Akman C, Akkaya BB, Yılmaz M, Demir ZA, Mavioğlu HL. The HALP score and its association with respiratory and intensive care outcomes after minimally invasive valve surgery: the MINI-HALP study. *Anatol J Cardiol.* 2026;XX(X):1-8.

DOI: 10.14744/AnatolJCardiol.2026.6036

INTRODUCTION

The HALP score, first proposed by Chen et al in 2015, integrates hemoglobin, albumin, lymphocyte, and platelet counts into a single index reflecting both nutritional and immune status.[1] This score quantifies the balance between hematologic and metabolic components of systemic health, offering a simple composite indicator derived from routine laboratory parameters.[1] Since its introduction, HALP has been recognized as a composite biomarker linking systemic inflammation, nutritional reserve, and long-term outcomes across various clinical settings.[1] Although the European System for Cardiac Operative Risk Evaluation II (EuroSCORE II) and Society of Thoracic Surgeons Predicted Risk of Mortality (STS-PROM) models remain standard tools for surgical risk estimation, both were originally developed in large sternotomy populations and perform inconsistently in minimally invasive valve surgery (MIVS) cohorts.[2-4]

Recent validation studies have shown that, despite reasonable discrimination, these models frequently overpredict operative mortality and show poor calibration for the patient selection and procedural characteristics of MIVS.[2,3] Consequently, growing evidence supports the need for procedure-specific or recalibrated risk algorithms better aligned with outcomes in minimally invasive valve surgery.[3,4] In parallel, MIVS has gained widespread adoption as a less invasive alternative to conventional sternotomy; however, evidence regarding its impact on postoperative respiratory and intensive care outcomes remains heterogeneous.[5-9] Several meta-analyses and cohort studies have reported shorter mechanical ventilation times and reduced intensive care unit (ICU) length of stay after MIVS, yet these benefits are not uniformly demonstrated across all surgical subtypes or institutional protocols.[5,6,8] Recent investigations suggest that the observed improvements may be driven more by enhanced perioperative pathways and early extubation protocols than by the surgical access itself.[7,9] Collectively, these findings underscore the heterogeneity of existing evidence and highlight the need for procedure-specific evaluation of postoperative recovery metrics in the minimally invasive era.[5-9]

Despite growing interest in composite nutritional and inflammatory indices, evidence linking the HALP score to postoperative respiratory outcomes and intensive care trajectories remains extremely limited, particularly in the context of minimally invasive valve surgery. Furthermore, established risk prediction systems such as EuroSCORE II and STS-PROM, which were calibrated in full-sternotomy cohorts, often fail to accurately reflect perioperative risk in this surgical subset. Therefore, the present study aimed to evaluate the association between preoperative HALP score and prolonged mechanical ventilation and ICU stay following minimally invasive valve surgery, and to determine whether this hematologic–nutritional index could provide incremental prognostic insight beyond traditional surgical risk models.

HIGHLIGHTS

- This study is the first to evaluate the prognostic value of the hemoglobin–albumin–lymphocyte–platelet (HALP) score in minimally invasive valve surgery (MIVS).
- Patients with low preoperative HALP scores (≤42.2) experienced significantly longer intubation times, extended intensive care unit stays, and all in-hospital deaths occurred exclusively in this group.
- The HALP score showed a significant inverse correlation with established surgical risk indices, including STS and EuroSCORE II, indicating that lower HALP reflects higher predicted operative risk.
- Hemoglobin–albumin–lymphocyte–platele provides additional prognostic insight beyond conventional risk models by capturing nutritional–inflammatory status and biological resilience, which directly influence perioperative recovery.
- Given its simplicity, accessibility, and strong association with postoperative outcomes, HALP may serve as a useful adjunct for preoperative risk stratification in MIVS.

METHODS

Study Design

This single-center, observational, retrospective cohort study was conducted between June 2021 and April 2025 at a tertiary cardiovascular surgery center. A total of 139 consecutive patients who underwent minimally invasive valve surgery during the study period were included in the analysis. The hemoglobin, albumin, lymphocyte, and latelet (HALP) score, a composite nutritional and inflammatory index, was calculated using the following formula: hemoglobin (g/L) × albumin (g/L) × lymphocyte count (/L) ÷ platelet count (/L)[1]. The study population was divided into 2 groups according to the median HALP score (≤42.2 vs. >42.2) to investigate the association between preoperative nutritional-inflammatory status and perioperative outcomes.

All adult patients (≥18 years) who underwent elective minimally invasive aortic, mitral, or tricuspid valve surgery via thoracotomy or mini-sternotomy were eligible for inclusion. Demographic, clinical, laboratory, echocardiographic, and procedural variables were retrieved from institutional electronic medical records and operative reports. Patients were excluded if they had active infective endocarditis, urgent surgery, concomitant coronary artery bypass grafting (CABG) or aortic surgery, emergency procedures for acute aortic dissection or rupture, prior valve surgery within 6 months, hematologic malignancies, chronic inflammatory or autoimmune diseases, severe hepatic dysfunction, chronic renal failure requiring dialysis, or incomplete preoperative laboratory data. The study was approved by the institutional ethics committee (Ethics Committee Approval no: TABED-1/1688/2025-24/09/2025) and conducted in accordance with the Declaration of Helsinki.

Definitions and Outcomes

All perioperative and postoperative variables were defined according to established international consensus guidelines. Postoperative acute kidney injury (AKI) was defined as an increase in serum creatinine by ≥0.3 mg/dL within 48 hours or ≥1.5 times baseline within 7 days, in accordance with the Kidney Disease: Improving Global Outcomes (KDIGO) criteria.[10] Postoperative stroke was defined as a new focal neurological deficit lasting more than 24 hours and confirmed by imaging and classified as disabling or non-disabling based on residual neurological impairment.[11]

Re-exploration was defined as reopening of the surgical site for causes such as bleeding, tamponade, or prosthetic valve dysfunction, whereas reoperation or reintervention denoted any subsequent valve surgery or catheter-based procedure performed after the index operation.[12] Infective endocarditis was diagnosed using the modified Duke criteria.[13]

Prolonged intubation was defined as mechanical ventilation lasting ≥24 hours, and prolonged ICU stay as ICU duration ≥2 days following surgery.[14] Prolonged hospitalization was defined as total postoperative length of stay >7 days.[15] Mortality included both cardiac and non-cardiac deaths occurring during the index hospitalization; cardiovascular mortality referred specifically to death due to myocardial infarction, heart failure, fatal arrhythmia, or valve-related complications.[16]

All outcome data, including mortality and postoperative complications, were obtained from institutional electronic records and cross-checked against national healthcare databases.

Statistical Analysis

The normality of distribution for continuous variables was assessed using both graphical methods and the Shapiro–Wilk test. Continuous variables are expressed as mean ± standard deviation (SD) or median (minimum–maximum), as appropriate, whereas categorical variables are presented as frequencies and percentages. Comparisons between groups classified according to the HALP score (≤42.2 vs. >42.2) were performed using the independent samples *t*-test for normally distributed variables and the Mann–Whitney *U*-test for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Because no universally accepted cut-off value for the HALP score exists in cardiac or minimally invasive valve surgery populations, the median HALP value of the cohort (42.2) was used to provide an unbiased, data-driven stratification. This approach ensured balanced group sizes and minimized the risk of misclassification or selection bias associated with externally derived thresholds. In addition, receiver operating characteristic (ROC) curve analyses were conducted to further evaluate the predictive ability of the HALP score for prolonged intubation time, ICU stay, and total hospitalization duration. The area under the curve (AUC) with corresponding 95% CIs was calculated, and the optimal discriminatory threshold of the HALP score was identified using Youden's index.

The relationships between the HALP score and perioperative parameters, including STS, EuroSCORE II, intubation time, ICU stay, and hospitalization duration, were assessed using Spearman's rank correlation coefficient. All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA) and Microsoft Excel 2024 software. A 2-tailed *P*-value <.05 was considered statistically significant.

RESULTS

This single-center study included 139 consecutive patients who underwent minimally invasive valve surgery and were categorized according to the median HALP score (≤42.2 vs. >42.2). Baseline demographic, clinical, and echocardiographic characteristics are summarized in Table 1. The mean age was significantly lower in the high-HALP group than in the low-HALP group (50.28 ± 14.58 vs. 56.16 ± 12.01 years, *P* = .033). Body surface area was higher among patients with HALP >42.2 (1.93 ± 0.18 vs. 1.85 ± 0.20 m^2, *P* = .015). The proportion of male patients was greater in the high-HALP group (62.3% vs. 42.9%, *P* = .022). NYHA class I-II was more frequent among those with HALP >42.2 (91.3% vs. 75.7%, *P* = .013), whereas preoperative atrial fibrillation was more common in the low-HALP group (35.7% vs. 20.3%, *P* = .043). Other baseline variables were comparable between the groups (Table 1).

Preoperative laboratory and surgical characteristics of the study cohort are presented in Table 2. Hemoglobin (14.08 ± 1.33 vs. 12.40 ± 1.59 g/dL, *P* < .001), platelet (229.65 ± 70.23 vs. 291.94 ± 66.53 $\times 10^3$/μL, *P* < .001), and albumin (43.84 ± 3.41 vs. 41.80 ± 3.69 g/L, *P* = .001) values significantly differed across the groups. STS (1.24 ± 1.13 vs. 1.90 ± 1.37, *P* < .001) and EuroSCORE II (0.91 ± 0.52 vs. 1.31 ± 1.08, *P* = .002) were lower in patients with higher HALP scores. The rates of aortic valve replacement (49.3% vs. 30.0%, *P* = .020) and right anterior thoracotomy (34.8% vs. 18.6%, *P* = .031) were higher in the high-HALP group, while conventional right thoracotomy was more frequent in the low-HALP group (68.6% vs. 50.7%, *P* = .032). Other procedural parameters were similar between the 2 groups (Table 2).

Postoperative outcomes according to HALP categories are summarized in Table 3. Postoperative sinus rhythm was observed more frequently in the high-HALP group (98.6% vs. 90.0%, *P* = .033), whereas pacemaker implantation was required more often among patients with low HALP (10.0% vs. 1.4%, *P* = .033). Intubation time (9.70 ± 13.34 vs. 16.59 ± 27.16 hours, *P* = .013) and ICU stay (2.30 ± 2.69 vs. 3.06 ± 2.99 days, *P* = .021) were shorter in the high-HALP group. All-cause in-hospital mortality occurred exclusively in patients with HALP ≤42.2 (8.6% vs. 0%, *P* = .015). The remaining postoperative complications were comparable between the 2 groups (Table 3).

Correlation analyses between HALP and perioperative parameters are presented in Table 4. The HALP score showed a significant inverse correlation with both STS (*r* = −0.351, *P* < .001) and EuroSCORE II (*r* = −0.296, *P* < .001). Figure 1 illustrates these relationships between HALP score and operative risk indices. The HALP was also inversely correlated with intubation time (*r* = −0.236, *P* = .005) and ICU stay (*r* = −0.231, *P* = .006), while no significant correlation was found with total hospitalization duration (*r* = −0.113, *P* = .187) (Figure 2).

Subgroup analysis revealed that patients with prolonged intubation (≥24 hours), extended ICU stay (≥2 days), or hospitalization ≥7 days had lower HALP scores, although these differences did not reach statistical significance (Table 5).

DISCUSSION

This study is the first to investigate the prognostic significance of the HALP score in patients undergoing MIVS. The major findings of the present study are summarized as follows: (1) patients with lower preoperative HALP scores (≤42.2) exhibited significantly longer intubation time and ICU stay compared with those with higher HALP scores (>42.2); (2) all in-hospital deaths occurred exclusively in the low-HALP group, suggesting a potential link between impaired nutritional–inflammatory status and early postoperative mortality; (3) the HALP score demonstrated a significant inverse correlation with both established surgical risk indices, namely the STS and EuroSCORE II, indicating that lower HALP values parallel higher predicted surgical risk; and (4) the HALP score was inversely associated with perioperative recovery parameters, including ventilation and intensive care duration, whereas no significant relationship was

Table 1. Comparison of Demographic, Clinical, and Echocardiographic Characteristics by HALP Score Groups

Variables	HALP Score ≤42.2 (n = 70)	HALP Score >42.2 (n = 69)	*P*
Age (years)	56.16 ± 12.01	50.28 ± 14.58	**.033**
Body surface area (m^2)	1.85 ± 0.20	1.93 ± 0.18	**.015**
Sex (Male), n (%)	30 (42.9)	43 (62.3)	.022
Smoking, n (%)	20 (28.6)	24 (34.8)	.431
Hypertension, n (%)	27 (38.6)	23 (33.3)	.520
Hyperlipidemia, n (%)	11 (15.7)	14 (20.3)	.483
Diabetes mellitus, n (%)	8 (11.4)	13 (18.8)	.222
COPD, n (%)	10 (14.3)	7 (10.1)	.456
ASCV), n (%)	6 (8.6)	6 (8.7)	.979
Chronic kidney disease (CKD), n (%)	1 (1.4)	0 (0.0)	.504
Heart failure (HF), n (%)	4 (5.7)	1 (1.4)	.187
Previous cardiac surgery, n (%)	11 (15.7)	8 (11.6)	.480
Previous MVR, n (%)	4 (5.7)	4 (5.8)	.633
Previous AVR, n (%)	1 (1.4)	0 (0.0)	.504
Previous AVR + MVR, n (%)	2 (2.9)	1 (1.4)	.505
Other previous surgery, n (%)	2 (2.9)	1 (1.4)	.505
History of MI, n (%)	1 (1.4)	1 (1.4)	.748
History of PCI, n (%)	3 (4.3)	4 (5.8)	.492
History of TIA or stroke, n (%)	3 (4.3)	2 (2.9)	.507
History of IE, n (%)	1 (1.4)	1 (1.4)	.999
NYHA functional class, n (%)			
I–II	53 (75.7)	63 (91.3)	**.013**
III–IV	17 (24.3)	6 (8.7)	
Left ventricular ejection fraction (LVEF, %)	57.03 ± 7.15	58.32 ± 6.66	.235
LVEDD, mm	5.03 ± 0.73	5.19 ± 0.73	.157
LVESD, mm	3.37 ± 0.72	3.46 ± 0.69	.385
IVS, mm	1.11 ± 0.25	1.15 ± 0.25	.355
Preoperative sinus rhythm, n (%)	45 (64.3)	55 (79.7)	**.043**
Preoperative atrial fibrillation, n (%)	25 (35.7)	14 (20.3)	**.043**

Values are expressed as mean ± standard deviation (SD) or median (minimum–maximum), as appropriate. Bold values indicate statistically significant differences ($P < .05$).
ASCVD, atherosclerotic cardiovascular disease; AVR, aortic valve replacement; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; HF, heart failure; IE, infective endocarditis; IVS, interventricular septum; LVEF, left ventricular ejection fraction; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; MI, myocardial infarction; MVR, mitral valve replacement; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; TIA, transient ischemic attack.

observed with total hospitalization time. Collectively, these findings suggest that the HALP score, an easily obtainable preoperative biomarker, may provide complementary prognostic insight beyond conventional risk prediction models in patients undergoing MIVS.

The relationship between systemic inflammatory burden and postoperative recovery has been consistently demonstrated across different cardiac populations. For example, cohorts with active infective endocarditis—characterized by heightened inflammatory activity—exhibit significantly longer ICU stays and higher early mortality.[17] These observations highlight that biological vulnerability plays a key role in early postoperative trajectories, independent of procedural complexity. The HALP score integrates hematologic, nutritional, and inflammatory domains that together influence perioperative resilience and postoperative recovery. Malnutrition and hypoalbuminemia impair wound healing and reduce oncotic pressure, while anemia and lymphopenia limit oxygen delivery and immune response. These factors collectively weaken physiologic reserve, leading to delayed recovery and prolonged ventilation and ICU stay.[18,19] Thus, HALP provides a comprehensive reflection of the host's biologic fitness, independent of procedural complexity.

Mechanistically, each HALP component has a biologically plausible role in postoperative outcomes. Anemia and hypoalbuminemia reduce tissue oxygenation and protein synthesis, lymphopenia reflects immune exhaustion, and platelet activation contributes to thrombo-inflammatory injury.[20] These mechanisms explain the observed association between low HALP and prolonged mechanical ventilation or ICU stay: patients entering surgery with a diminished nutritional–inflammatory reserve exhibit impaired cardiopulmonary adaptation and slower recovery following anesthesia and cardiopulmonary bypass.

Table 2. Comparison of Preoperative Laboratory and Surgical Characteristics by HALP Score Groups

Variables	HALP Score ≤42.2 (n = 70)	HALP Score >42.2 (n = 69)	*P*
Hemoglobin (g/dL)	12.40 ± 1.59	14.08 ± 1.33	**<.001**
Neutrophil count (×10³/μL)	4.69 ± 1.62	4.48 ± 1.35	.561
Platelet count (×10³/μL)	291.94 ± 66.53	229.65 ± 70.23	**<.001**
Monocyte count (×10³/μL)	0.44 ± 0.14	0.45 ± 0.13	.515
Total cholesterol (mg/dL)	177.76 ± 35.76	174.22 ± 46.42	.317
Albumin (g/L)	41.80 ± 3.69	43.84 ± 3.41	**.001**
Creatinine (mg/dL)	0.87 ± 0.24	0.88 ± 0.17	.390
Aortic valve replacement (AVR), n (%)	21 (30.0)	34 (49.3)	**.020**
Mitral valve replacement (MVR), n (%)	33 (47.1)	29 (42.0)	.544
Tricuspid valve replacement (TVR), n (%)	10 (14.3)	4 (5.8)	.096
MVR + TVR, n (%)	2 (2.9)	0 (0.0)	.252
AVR + MVR, n (%)	2 (2.9)	1 (1.4)	.505
Right anterior thoracotomy (RAT), n (%)	13 (18.6)	24 (34.8)	.031
Infra-axillary approach, n (%)	1 (1.4)	2 (2.9)	.495
J-shaped sternotomy, n (%)	8 (11.4)	8 (11.6)	.592
Right thoracotomy, n (%)	48 (68.6)	35 (50.7)	.032
STS score	1.90 ± 1.37	1.24 ± 1.13	**<.001**
EuroSCORE II	1.31 ± 1.08	0.91 ± 0.52	**.002**
Cardiopulmonary bypass time (min)	153.97 ± 59.14	146.81 ± 44.94	.487
Aortic cross-clamp time (min)	104.16 ± 37.94	104.01 ± 30.88	.642

Values are expressed as mean ± standard deviation (SD) or median (minimum–maximum), as appropriate. Bold values indicate statistically significant differences ($P < .05$).
CPB, cardiopulmonary bypass; EuroSCORE II, European System for Cardiac Operative Risk Evaluation II; HGB, hemoglobin; PLT, platelet count; RAT, right anterior thoracotomy; STS, Society of Thoracic Surgeons; TVR, tricuspid valve replacement; Xcl, aortic cross-clamp; AVR, aortic valve replacement; MVR, mitral valve replacement.

Table 3. Comparison of Postoperative Outcomes by HALP Score Groups

Variables	HALP Score ≤42.2 (n = 70)	HALP Score >42.2 (n = 69)	*P*
Postoperative sinus rhythm, n (%)	63 (90.0)	68 (98.6)	**.033**
Postoperative atrial fibrillation, n (%)	13 (18.6)	8 (11.6)	.251
Postoperative pacemaker requirement, n (%)	7 (10.0)	1 (1.4)	**.033**
Intubation time (hours)	16.59 ± 27.16	9.70 ± 13.34	**.013**
ICU stay (days)	3.06 ± 2.99	2.30 ± 2.69	**.021**
Hospital stay (days)	8.43 ± 5.46	8.06 ± 7.60	.183
Re-exploration, n (%)	8 (11.6)	4 (5.8)	.227
Postoperative bleeding, n (%)	6 (8.6)	1 (1.4)	.060
Postoperative stroke, n (%)	1 (1.4)	0 (0.0)	.504
Postoperative disabling stroke, n (%)	0 (0.0)	0 (0.0)	-
Paravalvular leak, n (%)	1 (1.4)	1 (1.4)	.748
Myocardial infarction (MI), n (%)	0 (0.0)	0 (0.0)	-
Vascular complication, n (%)	2 (2.9)	0 (0.0)	.252
Postoperative acute kidney injury (AKI), n (%)	3 (4.3)	3 (4.3)	.999
Infective endocarditis, n (%)	1 (1.4)	1 (1.4)	.999
Reintervention/Reoperation, n (%)	10 (14.3)	4 (5.8)	.096
Rehospitalization, n (%)	19 (27.9)	20 (29.4)	.850
All-cause mortality, n (%)	6 (8.6)	0 (0.0)	**.015**
Cardiovascular mortality, n (%)	3 (4.3)	0 (0.0)	.125

Values are expressed as mean ± standard deviation (SD) or median (minimum–maximum). Bold values indicate statistically significant differences ($P < .05$).
AKI, acute kidney injury; ICU, intensive care unit; MI, myocardial infarction.

Table 4. Correlation Between HALP Score and STS, ESII, Intubation Time, ICU Stay, and Hospitalization Duration

Variables	*r*	*P*
STS	−0.351	**<.001**
EuroSCORE II	−0.296	**<.001**
Intubation time (hours)	−0.236	**.005**
ICU stay (days)	−0.231	**.006**
Hospitalization duration (days)	−0.113	.187

r; Spearman's correlation coefficient. Bold values indicate statistically significant differences ($P < .05$).
HALP, hemoglobin, albumin, lymphocyte, and platelet; STS, Society of Thoracic Surgeons; EuroSCORE II, European System for Cardiac Operative Risk Evaluation II; ICU, intensive care unit.

In line with Demir et al[21] who demonstrated that lower preoperative HALP scores were strongly associated with in-hospital and long-term mortality after tricuspid valve surgery, the results extend the prognostic value of HALP to the minimally invasive valve surgery setting. Although Demir et al did not examine respiratory parameters or perioperative recovery indices such as intubation duration, ICU stay, or hospital length of stay, the study demonstrates that reduced HALP scores are closely linked to prolonged intubation and extended ICU stay in the early postoperative period. This novel observation suggests that impaired nutritional–inflammatory reserve may hinder postoperative respiratory recovery, supporting the broader concept that HALP reflects systemic vulnerability rather than operative complexity. The consistent association between lower HALP values and adverse early recovery metrics in the cohort therefore complements prior evidence linking HALP to increased postoperative risk in other cardiac surgery populations.

Similarly, Koyuncu and Koyun[22] showed that reduced HALP scores strongly predicted 30-day mortality after CABG, a setting characterized by greater ischemic and inflammatory

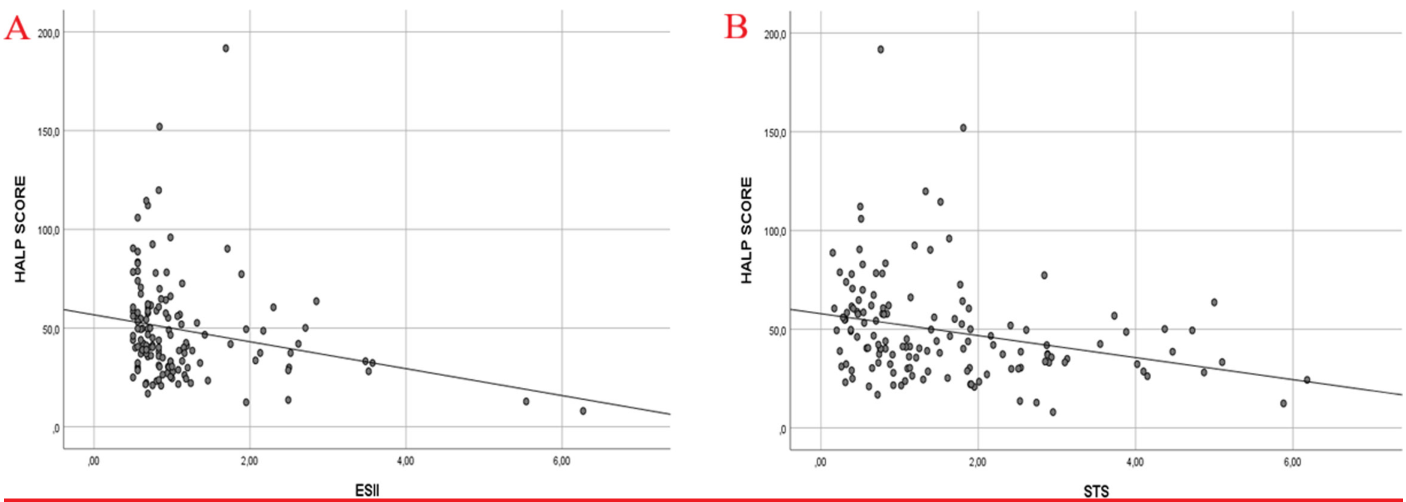

Figure 1. Preoperative HALP score distribution in the study cohort. HALP, Hemoglobin, Albumin, Lymphocyte, Platelet; ESII, EuroSCORE II; STS, Society of Thoracic Surgeons Score.

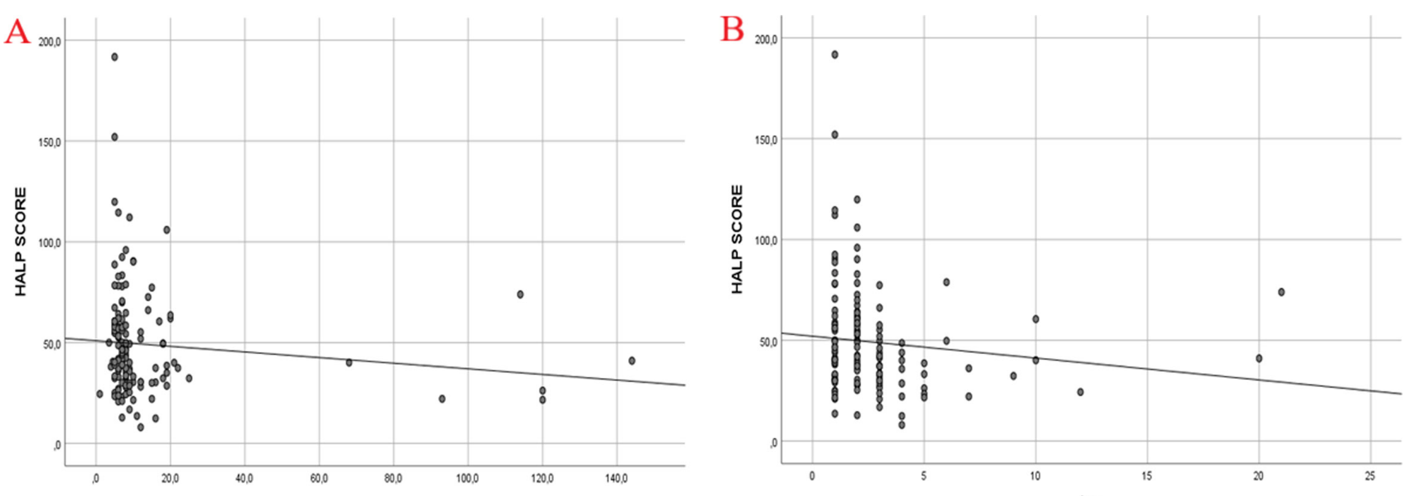

Figure 2. Association between preoperative HALP score and postoperative outcomes. HALP, Hemoglobin, Albumin, Lymphocyte, Platelet; ESII, EuroSCORE II; STS, Society of Thoracic Surgeons score.

Table 5. Comparison of HALP Scores According to Intubation Time, ICU Stay, and Hospitalization Duration Classifications

Variables	Classification	Mean ± SD	Median (Min-Max)	*P*
Intubation time	<24 hours	49.76 ± 26.60	43.8 (8.0-191.7)	.105
	≥24 hours	36.74 ± 18.19	32.3 (21.6-73.9)	
ICU stay	<2 days	54.64 ± 33.94	45.0 (13.6-191.7)	.314
	≥2 days	46.09 ± 20.72	41.9 (8.0-119.8)	
Hospitalization duration	<7 days	52.07 ± 28.25	46.6 (16.8-191.7)	.184
	≥7 days	45.41 ± 23.48	40.5 (8.0-152.0)	

HALP, hemoglobin, albumin, lymphocyte, and platelet; ICU, intensive care unit; SD, standard deviation.

burden. Their findings align with the results and are biologically supported by prior studies demonstrating that malnutrition, anemia, and inflammation impair oxygen transport and delay wound healing.[23,24]

Altunova et al[25] further expanded this relationship by reporting that low HALP values were associated with higher mortality following endovascular aortic repair (EVAR). The findings complement these observations by demonstrating that HALP deterioration manifests early as impaired respiratory recovery—prolonged intubation and extended ICU stay—potentially preceding late adverse outcomes.

Traditional surgical risk models such as EuroSCORE II and STS remain valuable tools for mortality prediction but perform inconsistently in minimally invasive cardiac surgery. In a large minimally invasive mitral valve surgery (MIMVS) cohort, Moscarelli et al[2] reported that EuroSCORE II achieved good discrimination yet consistently overpredicted mortality in low-risk patients. More recently, Berretta et al[26] showed that both STS and EuroSCORE II preserved discriminative capacity but lacked calibration in MIMVS. The findings are consistent with these observations: patients with lower HALP values had both higher predicted surgical risk and worse early recovery metrics, suggesting that HALP provides non-redundant, patient-centered information that captures biological dimensions absent from anatomy-based risk models.

Integrating HALP into preoperative evaluation may enhance risk stratification and help identify patients who could benefit from nutritional or anti-inflammatory optimization before surgery. Such tailored strategies may improve early postoperative recovery without adding procedural risk.

Study Strengths and Limitations

The main strength of the study is its first-in-field evaluation of the HALP score as a preoperative prognostic biomarker, uniquely focused on early respiratory recovery and ICU outcomes in a MIVS population. This study has several limitations that should be acknowledged. First, it was a single-center, retrospective analysis with a relatively limited sample size, which may restrict the generalizability of the findings. Second, the HALP score was calculated from baseline preoperative laboratory data; although this approach reflects real-world clinical practice, future prospective studies with serial perioperative measurements could provide deeper insight into the temporal dynamics of nutritional and inflammatory status. Third, long-term follow-up data were not available, preventing evaluation of the prognostic value of HALP for late morbidity and survival after valve surgery. Finally, the study cohort included patients undergoing different minimally invasive approaches and valve types, which may introduce heterogeneity in operative complexity and recovery time. Although all procedures were performed by the same surgical team using standardized protocols, minimizing inter-operator variability.

CONCLUSION AND RECOMMENDATIONS

In conclusion, a low preoperative HALP score—indicating impaired nutritional and inflammatory status—was independently associated with prolonged mechanical ventilation and ICU stay in patients undergoing minimally invasive valve surgery. The HALP integrates hemoglobin, albumin, lymphocyte, and platelet levels into a single, objective index that reflects biological resilience beyond anatomical or procedural risk factors. Unlike traditional models such as STS and EuroSCORE II, which emphasize surgical complexity, HALP captures host-related vulnerability that directly influences perioperative outcomes. Its simplicity and accessibility support its use as a complementary biomarker for preoperative risk stratification, warranting further validation in larger, multicenter cohorts.

Ethics Committee Approval: The study was approved by the Ankara Bilkent City Hospital Ethics Committee (Ethics Committee Approval No: TABED-1/1688/2025; Date: 24/09/2025) and was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – C.A., H.Z.; Design – H.Z.; Supervision – Z.D, H.M.; Resources – B.A., H.Z.; Materials – B.A, H.M.; Data Collection and/or Processing – M.Y., B.A.; Analysis and/or Interpretation – C.A., H.Z.; Literature Search – C.A.; Writing – H.Z., C.A.; Critical Review – Z.D., H.M.

Declaration of Interests: The authors have no conflicts of interest to declare.

Funding: The authors declare that this study received no financial support.

AI-Assisted Tools Statement: No artificial intelligence (AI)–assisted technologies—including large language models (LLMs), chatbots, or image-generation tools—were used in the conception, design, data collection, analysis, or writing of this manuscript.

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