

HALP Score as a Prognostic Biomarker in Tricuspid Valve Surgery: Association with in-Hospital and Long-Term Mortality

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Purpose: Tricuspid valve surgery is associated with significant perioperative and long-term risks. The Hemoglobin, Albumin, Lymphocyte, and Platelet (HALP) score is an integrated biomarker reflecting nutritional, inflammatory, and hematologic status. HALP score has proven prognostic utility, yet its relevance in tricuspid valve surgery is not well established. This study aimed to evaluate the association between preoperative HALP score and both in-hospital and long-term mortality in patients undergoing tricuspid valve surgery.

Patients and Methods: This retrospective study included adult patients (≥ 18 years) who underwent isolated or combined tricuspid valve surgery between 2014 and 2021. The HALP score was calculated as platelet count $\times$ hemoglobin $\times$ albumin / lymphocyte count. Patients were grouped into low and high HALP score categories based on the mean HALP score. Laboratory parameters, echocardiographic findings, and mortality rates were compared. Laboratory and echocardiographic data, as well as mortality outcomes, were compared. Logistic regression was used to identify independent predictors of in-hospital mortality, while Cox proportional hazards and Kaplan–Meier analyses assessed long-term mortality. ROC curve analysis was performed to determine the optimal HALP cutoff.

Results: Among 277 patients, 28 (10.1%) experienced in-hospital mortality and 45 (16.1%) died during follow-up. Patients who died had significantly lower HALP scores ($p < 0.001$). Univariate analysis showed that age, atrial fibrillation, EuroSCORE, low hemoglobin, low albumin, lymphopenia, low HALP score, chronic kidney disease, and perioperative complications were associated with in-hospital mortality. However, only advanced CKD and perioperative complications remained significant in multivariate analysis. HALP score was independently associated with long-term mortality ($p < 0.001$). The optimal HALP cutoff was 0.2998 (sensitivity 73.3%, specificity 73.7%; AUC = 0.817).

Conclusion: Lower preoperative HALP scores are associated with increased long-term mortality after tricuspid valve surgery. Although not predictive of in-hospital mortality, the HALP score may help identify high-risk patients using routine laboratory values.

Keywords: tricuspid valve surgery, HALP score, in-hospital mortality, prognostic biomarker, risk stratification

Introduction

Heart valve diseases are often progressive, with surgery being the primary treatment option for cases that are severe or symptomatic.¹ Due to the higher mortality risk, tricuspid valve surgery is performed less frequently than other valve surgeries, such as aortic or mitral valve surgery. Mortality rates in patients undergoing tricuspid valve surgery are influenced by factors such as general health, comorbidities, surgical risk scores, and the complexity of the procedure. Overall, in-hospital mortality for tricuspid valve surgery has been reported at around 10–15%.^{2,3}

Perioperative risk assessment is critical for predicting surgical outcomes and planning patient treatment. Traditional risk scores, such as the Society of Thoracic Surgeons (STS) Predicted Risk of Mortality (PROM) score and the European System

for Cardiac Operative Risk Evaluation II (EuroSCORE II) are widely used tools in valvular Surgery to estimate postoperative risks.⁴ Recently, the TRI-SCORE was explicitly developed to predict mortality for tricuspid valve surgery.⁵ While these traditional and procedure-specific risk scores provide valuable prognostic information, they often require complex calculations. They may not fully capture the patient's systemic or immune nutritional status. In contrast, laboratory-based scores offer significant advantages, as they rely on readily available laboratory parameters, making them not only more accessible and less time-consuming but also capable of providing deeper insights into the patient's overall perioperative risk.

The Hemoglobin, Albumin, Lymphocyte, Platelet (HALP) score has recently emerged as a valuable prognostic biomarker. Reflecting a patient's immune nutritional status has been studied as a predictor of various clinical outcomes across a wide range of conditions.⁶ In cardiovascular settings, the HALP score has shown significant prognostic value. For instance, higher HALP scores have been associated with a lower risk of 1-month and 1-year mortality in patients with heart failure.⁷ Additionally, the HALP score has demonstrated its ability to predict in-hospital mortality in patients with ST-elevation myocardial infarction undergoing primary percutaneous coronary intervention.⁸ Furthermore, studies have shown that preoperative HALP scores are reliable predictors of 1-month mortality in patients undergoing coronary artery bypass grafting.⁹ Despite these findings, the prognostic role of the HALP score in valvular heart surgery—particularly in the setting of tricuspid valve procedures—remains unclear. Its potential relevance to tricuspid valve surgery is especially compelling given the unique pathophysiological profile of these patients. Tricuspid regurgitation is commonly associated with advanced right ventricular dysfunction, venous congestion, and hepatic impairment—all of which can lead to hypoalbuminemia, anemia, and lymphopenia.^{1–3,10} These changes are reflected in the components of the HALP score, providing a strong biological rationale for its investigation in this setting.

Previous studies have evaluated several inflammatory and nutritional markers in cardiac surgery settings. Notably, the Controlling Nutritional Status (CONUT) score and Prognostic Nutritional Index (PNI) have demonstrated significant associations with adverse outcomes in patients undergoing coronary artery bypass graft (CABG) surgery, including increased postoperative complications, prolonged intensive care unit stay, and higher mortality rates.^{11,12} The neutrophil-to-lymphocyte ratio (NLR) has similarly been linked to adverse outcomes in cardiac surgery patients.¹³ In contrast, the HALP score has primarily been studied in oncologic and general cardiology populations, including patients with heart failure or myocardial infarction. Notably, these studies have not included patients undergoing tricuspid valve surgery—a population often characterized by systemic congestion, hepatic dysfunction, and right ventricular failure, all of which may significantly affect immune and nutritional status. To our knowledge, this is the first study to evaluate the prognostic significance of the HALP score specifically in tricuspid valve surgery.

Therefore, this retrospective study aims to evaluate the association between preoperative HALP score and in-hospital and long-term mortality in patients undergoing tricuspid valve surgery. By addressing this gap, we hope to highlight the potential utility of the HALP score as a cost-effective and accessible tool for perioperative risk stratification.

Material and Methods

This retrospective observational study included adult patients (aged ≥ 18 years) who underwent isolated or combined tricuspid valve surgery at Istanbul S.B.U. Mehmet Akif Ersoy Thoracic, Cardiovascular Surgery Training and Research Hospital between 2014 and 2021. This retrospective study was conducted using data obtained from hospital medical records, the national electronic health system, and the official death notification registry. Patients with missing outcome data were excluded from the final analysis. To minimize potential confounding factors, individuals with acute or chronic liver disease, hepatitis B or C infection, acute infection, acute heart failure, morbid obesity, asthma or chronic obstructive pulmonary disease, endocrine disorders, or alcohol/substance abuse were not included in the study cohort.

Demographic characteristics, laboratory test results (hemoglobin, albumin, lymphocyte count, platelet count, hepatitis markers, and infection parameters), and echocardiographic findings were recorded. Patients who died during or after Surgery (in-hospital mortality) were identified from the hospital records. The HALP score was calculated for all patients using the following formula:

$$\text{HALP Score} = \text{Platelet Count (}/\text{L)} \times \text{Hemoglobin (g/L)} \times \text{Albumin (g/L)} \times \text{Lymphocyte Count (}/\text{L)}$$

Patients were divided into two groups based on the mean HALP score: low HALP score group and high HALP score group, and laboratory parameters, echocardiographic parameters, and mortality rates were compared between these two groups.

Statistical Analysis

Categorical variables are presented as frequencies and percentages. Continuous variables are presented as mean $\pm$ standard deviation for normally distributed data and median (interquartile range [IQR]) for non-normally distributed data. The Mann–Whitney *U*-test and independent sample *t* test were used to compare continuous variables between the dead and alive groups. Chi-square test of Fischer’s exact test was used to compare categorical variables between dead and alive groups. Univariate logistic regression analysis was performed to identify potential predictors of in-hospital mortality. Subsequently, a multivariate logistic regression model was constructed to explore independent predictors of in-hospital mortality, including potentially significant variables in the univariate analysis. Cox proportional hazards regression analysis with a forward likelihood ratio selection method was used to assess long-term mortality. Receiver operating characteristic (ROC) curve analysis was performed to determine the optimal cut-off value of the HALP score for predicting in-hospital and long-term mortality. The study population was divided into two groups as low HALP score and high HALP score groups according to the cut off value. Kaplan Meier curves were constructed to exhibit the survival plots in lower and higher HALP score groups. Statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 25.0 (Armonk, NY: IBM Corp). A p-value of <0.05 was considered statistically significant.

Results

A total of 277 patients who underwent tricuspid valve surgery were included in the study. Of these patients, only 4 (1.4%) underwent isolated tricuspid valve surgery. One patient underwent mass excision and tricuspidoplasty due to tricuspid valve fibroelastoma, and three patients underwent isolated tricuspid valve replacement (TVR) due to primary tricuspid valve insufficiency. A total of 27 patients underwent TVR, and 250 patients underwent tricuspid valve repair, all of which were performed using tricuspid ring annuloplasty as the surgical technique. Forty-eight patients (17.3%) underwent CABG, 30 underwent left atrial appendage ligation, and 8 underwent a maze procedure. One patient underwent a Bentall operation. Patient demographic characteristics and laboratory findings are given in Table 1. Demographic features, clinical and laboratory parameters between dead and alive patients are given in Table 2.

Table 1 Baseline Characteristics

Age	59 $\pm$ 11
Sex (Male), n (%)	107(38.6)
BMI	28.3 $\pm$ 5.9
BSA	1.8 $\pm$ 0.2
Hypertension, n (%)	146(52.7)
Diabetes, n (%)	191(36.5)
COPD, n (%)	50(18.1)
Smoking, n (%)	30(10.8)
AF, n (%)	214(77.3)
CAD, n (%)	112(40.4)

(Continued)

Table 1 (Continued).

Surgical Intervention, n (%)	
Isolated Tricuspid	4(1.4)
2 Valves	171(61.7)
3 Valves	54(19.5)
2 Valves + CABG	41(14.8)
3 Valves + CABG	7(2.5)
Tricuspid Valve Intervention Type, n (%)	
Annuloplasty	250(90.3)
TVR	27(9.7)
Emergent Surgery, n (%)	3(1.1)
EF (%)	55(50–60)
sPAP, mmHg	50(41–60)
EuroSCORE	2.8(1.8–4.8)
Hemoglobin, gr/dl	12.6(10.9–14.0)
Platelet count, *10 ³	238 (186–295)
WBC, *10 ³	7.5(6.2–8.8)
Lymphocyte count *10 ³	1.8(1.3–2.4)
Creatinine, mg/dl	0.9(0.7–1.1)
AST, IU/L	20(16–25)
ALT IU/L	16(12–24)
Albumin gr/dl	4.2(3.7–4.4)
HALP Score	0.38(0.26–0.57)

Abbreviations: BMI, body mass index; BSA, body surface area; COPD, chronic obstructive pulmonary disease; AF, atrial fibrillation; CAD, coronary artery disease; CABG, coronary artery bypass grafting; TVR, tricuspid valve replacement; EF, ejection fraction; sPAP, systolic pulmonary artery pressure; EuroSCORE, European System for Cardiac Operative Risk Evaluation; WBC, white blood cell count; AST, aspartate aminotransferase; ALT, alanine aminotransferase; HALP, hemoglobin, albumin, lymphocyte, and platelet-based score.

Table 2 Demographic Features, Clinical and Laboratory Parameters Between Dead and Alive Patients

	Alive	Dead	p
Age	59±11	64±10	0.003
Sex (Male), n (%)	89(38.4)	18(40.0)	0.836
BMI	28.4±5.8	27.6±6.4	0.408
BSA	1.8±0.2	1.8±0.2	0.246

(Continued)

Table 2 (Continued).

	Alive	Dead	p
Hypertension, n (%)	123(53.0)	23(51.1)	0.815
Diabetes, n (%)	79(34.1)	22(48.9)	0.058
COPD, n (%)	39(16.8)	11(24.4)	0.223
Smoking, n (%)	22(9.5)	8(17.8)	0.101
AF, n (%)	185(79.7)	29(64.4)	0.025
CAD, n (%)	97(41.5)	15(33.3)	0.289
Surgical Intervention, n (%)			0.563
Isolated Tricuspid	3(1.3)	1(2.1)	
2 Valves	148(63.8)	23(51.1)	
3 Valves	42(18.1)	12(26.7)	
2 Valves + CABG	33(14.2)	8(17.8)	
3 Valves + CABG	6(2.6)	1(2.2)	
Tricuspid Valve Intervention Type, n (%)			0.409
Annuloplasty	211(90.9)	39(86.7)	
EF (%)	54±9	51±9	0.067
sPAP, mmHg	51±14	57±16	0.019
EuroSCORE	2.5(1.7–4.1)	6.0(3.0–10.0)	<0.001
Hemoglobin, gr/dl	12.8±1.8	10.8±2.1	<0.001
Platelet count, *10 ³	240(190–292)	220(169–321)	0.626
WBC, *10 ³	7.5(6.1–8.7)	7.4(6.1–9.8)	0.686
Lymphocyte count *10 ³	1.9(1.5–2.4)	1.1(0.9–1.55)	<0.001
Creatinine, mg/dl	0.87(0.71–1.04)	1.02(0.76–1.52)	0.004
AST, IU/L	19(16–24)	22(16–28)	0.206
ALT IU/L	16(12–23)	13(10–34)	0.398
Albumin gr/dl	4.0±0.5	3.6±0.6	<0.001
HALP Score	0.41(0.29–0.62)	0.22(0.12–0.30)	<0.001
CKD Grade, n (%)			<0.001
>90	120(51.7)	6(13.3)	
60-90	85(36.6)	9(20.0)	
30-60	24(10.3)	18(40.0)	
<30	3(1.3)	12(26.7)	

(Continued)

Table 2 (Continued).

	Alive	Dead	p
Cerebrovascular Disease, n (%)	2(0.9)	3(6.7)	0.032
Surgery Time, min	129±32	131±32	0.628
Perioperative Complication, n (%)	31(13.4)	33(73.3)	<0.001

Notes: Bold values indicate statistical significance ($p < 0.05$).

Abbreviations: BMI, body mass index; BSA, body surface area; COPD, chronic obstructive pulmonary disease; AF, atrial fibrillation; CAD, coronary artery disease; CABG, coronary artery bypass grafting; EF, ejection fraction; sPAP, systolic pulmonary artery pressure; EuroSCORE, European System for Cardiac Operative Risk Evaluation; WBC, white blood cell count; AST, aspartate aminotransferase; ALT, alanine aminotransferase; HALP, hemoglobin, albumin, lymphocyte, and platelet-based score; CKD, chronic kidney disease.

In-hospital mortality was observed in 28 patients (10.1%). The overall mortality rate during follow-up was 16.1% (45 patients). The HALP score of patients who experienced in-hospital mortality and died during long-term follow-up was found to be significantly lower compared to surviving patients (Figures 1 and 2). In univariate logistic regression analyses, age, atrial fibrillation (AF), high EuroSCORE, low albumin, hemoglobin, lymphocyte, HALP score, chronic kidney disease, history of cerebrovascular disease and complicated perioperative course were found to be associated with in-hospital mortality, while in multivariate analyses chronic kidney disease grade and complicated peri-operative process were found to be independent predictors of in-hospital mortality (Table 3).

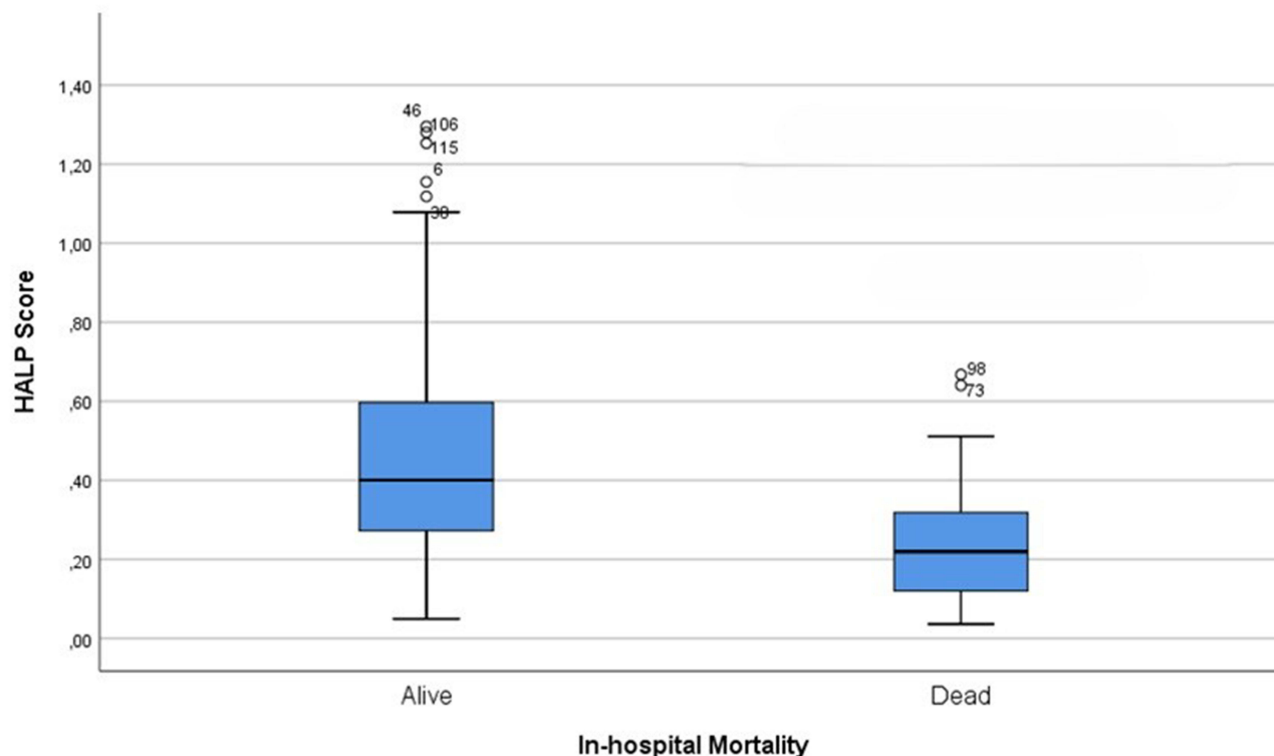


Figure 1 Box plot graph for in-hospital mortality. Median HALP score is significantly higher in alive group than in dead group.

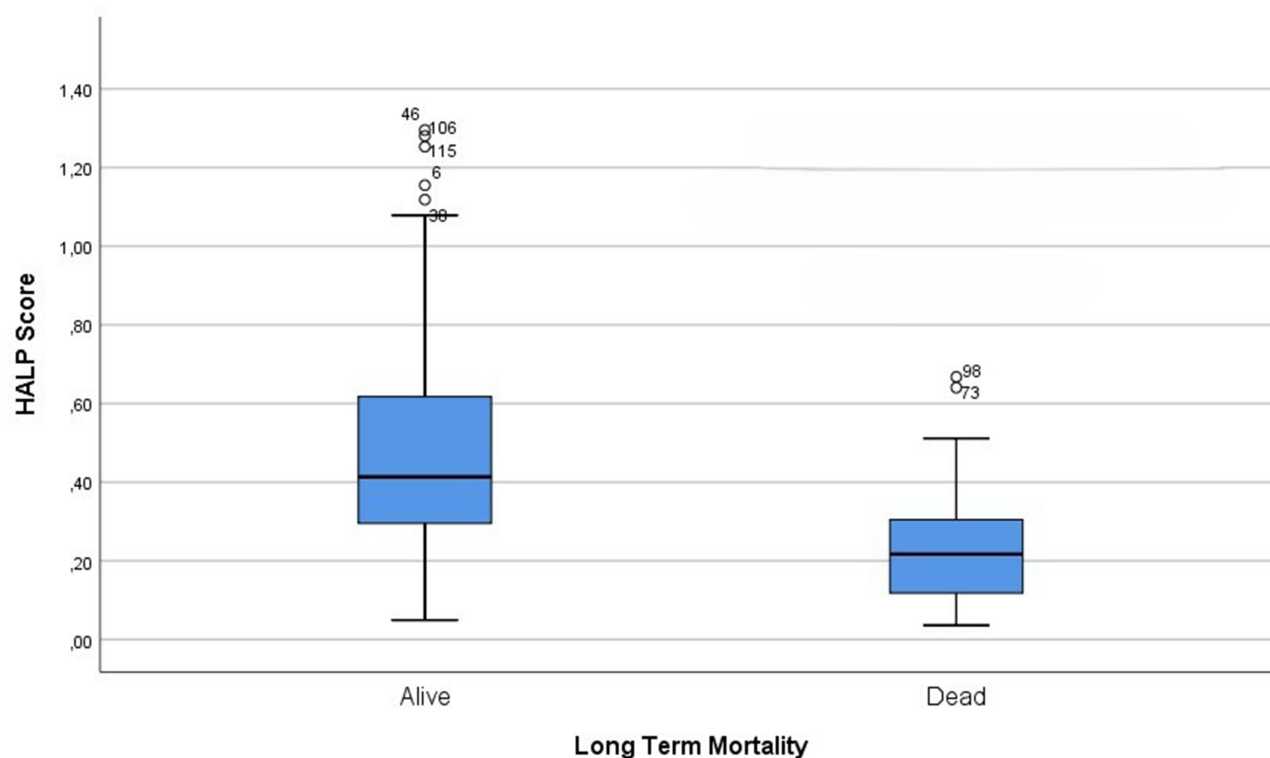


Figure 2 Box plot graph for long term mortality. Median HALP score is significantly higher in alive group than in dead group.

Cox regression analysis revealed that the HALP score was an independent predictor of long-term mortality (Table 4). Age, presence of AF, chronic kidney disease grade and presence of perioperative complications were the other independent predictors of long-term mortality. In the ROC curve analysis, a HALP score cutoff value of 0.2998 predicted long-term mortality with 73.3% sensitivity and 73.7% specificity (Figure 3). The area under the curve (AUC) was 0.817 (95% CI: 0.748–0.886). Kaplan Meier survival plots were created to exhibit the survival difference between lower and higher HALP score groups (Figure 4).

Table 3 Logistic Regression Analyses Showing in-Hospital Mortality

Variable	Univariate				Multivariate			
	Exp(B)	95% CI		p	Beta	95% CI		p
		Lower	Upper			Lower	Upper	
Age	1.048	1.006	1.093	0.027	1.033	0.965	1.106	0.351
Sex	0.730	0.317	1.670	0.459				
Diabetes	1.348	0.611	2.977	0.460				
Hypertension	1.039	0.475	2.275	0.923				
CAD	1.489	0.648	3.423	0.348				
COPD	1.271	0.487	3.317	0.625				
Smoking	1.948	0.680	5.576	0.214				
AF	0.343	0.153	0.771	0.010	0.299	0.077	1.151	0.079

(Continued)

Table 3 (Continued).

Variable	Univariate				Multivariate			
	Exp(B)	95% CI		p	Beta	95% CI		p
		Lower	Upper			Lower	Upper	
BMI	0.996	0.932	1.064	0.896				
EF	0.974	0.936	1.015	0.213				
sPAP	1.023	0.999	1.048	0.064	0.995	0.956	1.035	0.796
Surgical Intervention				0.880				
2 valves vs Isolated Tricuspid	0.310	0.030	3.154	0.322				
3 valves vs Isolated Tricuspid	0.375	0.035	4.205	0.426				
2 valves+CABG vs Isolated Tricuspid	0.324	0.027	3.901	0.375				
3 valves+CABG vs Isolated Tricuspid	0.500	0.023	11.088	0.661				
Euroscore	1.107	1.030	1.189	0.005	0.931	0.830	1.045	0.227
Albumin	0.882	0.829	0.938	<0.001	0.946	0.859	1.042	0.259
Hemoglobin	0.677	0.549	0.834	<0.001				
Platelet	0.996	0.990	1.001	0.117				
Lymphocyte	0.101	0.041	0.247	<0.001				
HALP Score	0.002	<0.001	0.037	<0.001	0.146	0.005	4.447	0.270
CKD Grade				<0.001				0.017
GFR 60–90 vs >90	4.227	0.834	21.435	0.082	2.890	0.374	22.345	0.309
GFR 30–60 vs >90	22.000	4.636	104.401	<0.001	8.409	1.072	65.947	0.043
GFR <30 vs >90	93.000	16.365	528.511	<0.001	33.143	3.289	333.938	0.003
Cerebrovascular Disease	14.820	2.363	92.930	0.004	3.983	0.370	42.936	0.255
Surgery Time	0.998	0.986	1.010	0.773				
Perioperative Complication	31.350	10.319	95.245	<0.001	10.900	2.990	39.738	<0.001

Notes: Bold values indicate statistical significance ($p < 0.05$).

Abbreviations: AF, atrial fibrillation; BMI, body mass index; CAD, coronary artery disease; CABG, coronary artery bypass grafting; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; EF, ejection fraction; EuroSCORE, European System for Cardiac Operative Risk Evaluation; GFR, glomerular filtration rate; HALP, hemoglobin, albumin, lymphocyte, and platelet-based score; sPAP, systolic pulmonary artery pressure.

Table 4 Cox Regression Model for Long-Term Mortality

Variable	Exp(B)	95% CI		p
		Lower	Upper	
Age	1.040	1.001	1.080	0.046
AF	0.355	0.171	0.738	0.006
HALP Score	0.012	0.001	0.143	<0.001
CKD Grade				0.001

(Continued)

Table 4 (Continued).

Variable	Exp(B)	95% CI		p
		Lower	Upper	
GFR 60–90 vs >90	1.234	0.403	3.777	0.712
GFR 30–60 vs >90	2.917	1.068	7.964	0.037
GFR <30 vs > 90	7.716	2.517	23.657	<0.001
Perioperative Complication	5.528	2.538	12.036	<0.001

Notes: Bold values indicate statistical significance ($p < 0.05$).

Abbreviations: AF, atrial fibrillation; HALP, hemoglobin, albumin, lymphocyte, and platelet-based score; CKD, chronic kidney disease; GFR, glomerular filtration rate.

Finally, it was found that the HALP score was negatively correlated with both length of hospital stay, and intensive care unit stay in our study population, although the correlation was weak but statistically significant (correlation coefficient for intensive care unit stay = -0.318 ; $p = <0.001$; correlation coefficient for length of hospital stay = -0.196 ; $p = 0.001$).

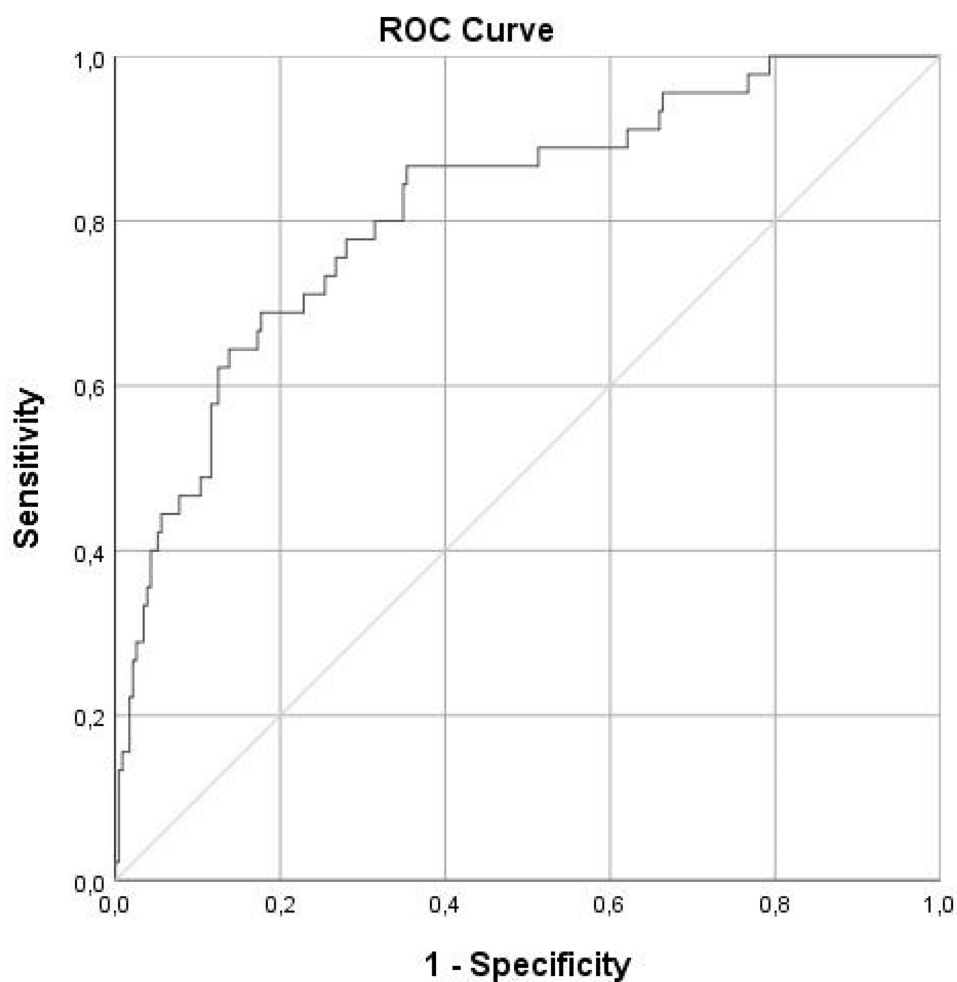


Figure 3 ROC curve analysis of HALP Score to predict long term mortality. The cutoff value 0.2998 is capable to predict long term mortality with %73.3 sensitivity and % 73.7 specificity. AUC: 0.817 (95% CI= 0.748–0.886).

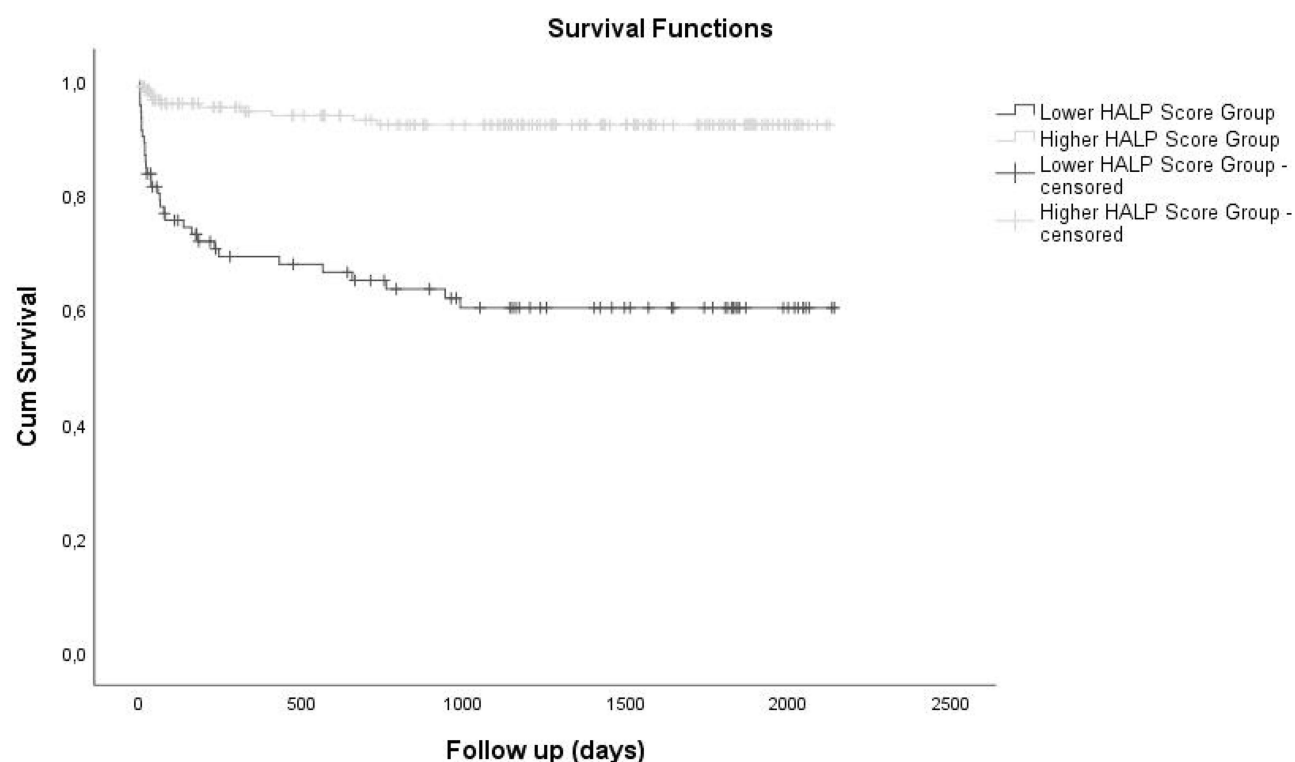


Figure 4 Kaplan Meier survival curves according to the lower and higher HALP score grades (Log rank p value <0.001).

Discussion

The study found a significant association between preoperative HALP scores and in-hospital mortality in patients undergoing tricuspid valve surgery; patients with lower HALP scores were more likely to experience adverse perioperative events. However, although the HALP score was associated with in-hospital mortality in univariate analysis, it did not remain an independent predictor in multivariate analysis. In contrast, the HALP score was identified as an independent predictor of long-term mortality. Moreover, lower HALP scores were significantly associated with prolonged hospital and intensive care unit stays, although these correlations were modest.

The HALP score is a composite measure combining four distinct indices -hemoglobin, albumin, lymphocyte count, and platelet count- to assess nutritional and immune status. Originally developed and studied in oncologic patients, it has gained attention as a prognostic tool.⁶ Its advantage is integrating important hematological and biochemical markers, comprehensively reflecting the patient's overall physiological status. For instance, a meta-analysis demonstrated that a low pre-treatment HALP score is a reliable negative biomarker for predicting survival outcomes in cancer patients, underscoring its relevance in oncologic prognosis.¹⁴ Beyond oncology, the HALP score has been associated with neurological outcomes, particularly in stroke patients. Studies have shown that a low HALP score is linked to an increased risk of post-stroke cognitive impairment.¹⁵ Furthermore, an elevated HALP score has been correlated with a reduced risk of recurrent stroke and mortality within both the acute phase (90 days) and the long-term phase (1 year) following stroke onset.¹⁶

The HALP score has also been studied in cardiac patients, demonstrating its prognostic utility in various cardiovascular conditions. A low HALP score has been shown to predict both in-hospital and 1-year mortality in patients hospitalized with a diagnosis of non-ST-segment elevation myocardial infarction.¹⁷ Similarly, Zheng et al reported a negative association between the HALP score and all-cause mortality in patients with coronary artery disease, highlighting its potential prognostic value in this population.¹⁸ However, despite its demonstrated utility in these cardiac populations, its role in patients undergoing heart valve Surgery, particularly tricuspid valve surgery, had not been previously investigated. Our study addresses this gap by demonstrating that the HALP score is significantly associated

with both in-hospital and long-term mortality in patients undergoing tricuspid valve surgery, suggesting its potential as a valuable prognostic marker in this population. In our analysis, a HALP score cutoff value of 0.2998 predicted long-term mortality with 73.3% sensitivity and 73.7% specificity (AUC = 0.817, 95% CI: 0.748–0.886).

Previous studies have highlighted the prognostic relevance of nutritional markers in cardiac surgery. Lower Prognostic Nutritional Index (PNI) levels have been shown to be significantly associated with increased in-hospital mortality in patients undergoing CABG and left-sided valve surgeries.^{19,20} The HALP score, like the PNI, provides insight into both nutritional and immune status, but it also includes hemoglobin and platelet levels—two additional components that may improve its prognostic strength. In addition to the PNI, other nutritional scoring systems such as the Controlling Nutritional Status (CONUT) score have also been shown to predict mortality in cardiac surgery populations. In a prospective observational study of 252 patients undergoing elective cardiac surgery, lower preoperative nutritional status—as assessed by higher CONUT scores—was independently associated with increased long-term mortality, even after adjusting for established surgical risk scores and postoperative complications.²¹ Alongside nutritional indices, inflammatory markers such as the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) have also gained attention.²² In a recent study involving 179 patients, both NLR and PLR measured during the early postoperative period were found to be strong predictors of 90-day mortality and length of hospital stay following cardiac surgery.²³ These findings support the importance of immune-inflammatory dynamics in the early postoperative period. What sets the HALP score apart is its ability to combine nutritional (albumin, hemoglobin) and inflammatory (lymphocyte, platelet) components in a single, easily obtainable index, offering a broader view of the patient's overall physiological state.

The HALP score is derived from hemoglobin, albumin, lymphocyte, and platelet levels, reflecting the essential clinical condition. Each component of the HALP score contributes to adverse surgical outcomes in patients with tricuspid valve disease through distinct but interrelated physiologic mechanisms. Anemia, one of the key components of the HALP score, is a well-established independent risk factor for increased perioperative and postoperative mortality in cardiac surgery patients.^{24,25} In patients with severe tricuspid valve disease, several mechanisms have been proposed to explain the development of anemia, including low renal perfusion, intestinal malabsorption, nutritional deficiencies, and hemodilution—mechanisms that have also been implicated in left-sided heart failure.²⁶ In addition, hypersplenism due to long-term systemic venous congestion extending to the portal and splenic venous systems as a consequence of chronic volume overload in the right ventricle and right atrium is increasingly recognized as an important factor.²⁶ This mechanism is further supported by the frequent coexistence of thrombocytopenia and hypoalbuminemia in patients with advanced tricuspid regurgitation, indicating the presence of portal hypertension and hepatic dysfunction.²⁶ Anemia has several consequences, including reduced oxygen-carrying capacity, decreased tissue oxygenation, and an increased risk of complications like infection and organ failure, leading to poor surgical outcomes. Similarly, hypoalbuminemia, another component of the HALP score, reflects both poor nutritional status and increased systemic inflammation, making it an important predictor of perioperative complications and mortality.^{27,28} Lymphopenia has been linked to ultrasound findings of portal congestion and right ventricular dysfunction; however, whether these associations indicate a direct pathophysiologic mechanism or merely reflect advanced disease remains unclear.²⁹ Preoperative lymphopenia has also been associated with higher postoperative mortality and complications, including infections, cardiac dysfunction, and renal failure, highlighting the role of immune status in surgical outcomes.³⁰ Platelets, the fourth component of the HALP score, play a dual role in coagulation and inflammation. Elevated platelet levels may reflect a proinflammatory or hypercoagulable state and may contribute to tissue damage and increased risk of thrombotic complications after cardiac surgery.^{31,32}

This study has several limitations that should be acknowledged. First, its retrospective and single-center design may limit the generalizability of the findings. Second, the patient cohort was heterogeneous, including both isolated and combined tricuspid valve surgeries, which may have introduced variability in postoperative outcomes. Additionally, certain important clinical variables were not consistently available in the dataset and could not be incorporated into the analysis. Furthermore, some echocardiographic parameters, including right ventricular function, were missing or not uniformly recorded, limiting a more detailed assessment of cardiac function. Furthermore, as a retrospective study, our findings are limited by the inability to control for all potential confounding variables. Factors such as baseline frailty, chronic inflammatory conditions—which may influence both HALP components and mortality—were not systematically assessed. Although long-term mortality was evaluated, detailed survival

analyses such as Kaplan–Meier curves and cause-specific mortality data were not included, which might have offered further prognostic insights. Additionally, the HALP score's prognostic performance in this surgical population has not yet been externally validated, and no direct comparisons were made with established cardiac surgical risk models such as the EuroSCORE II or STS score, which limits the broader applicability of our conclusions.

Conclusion

Lower preoperative HALP scores were associated with both in-hospital and long-term mortality in patients undergoing tricuspid valve surgery. Although the HALP score was not an independent predictor of in-hospital outcomes after adjusting for clinical factors, it remained a significant and independent marker for long-term mortality. The score, which combines common laboratory parameters reflecting nutritional, inflammatory, and hematologic status, may offer practical value in identifying patients at higher long-term risk. Its ease of calculation and low cost make it a potentially useful addition to existing preoperative assessment tools. Still, these findings should be confirmed in prospective, multicenter cohorts before broader clinical application.

Ethics Statement

This study was reviewed and approved by the İstanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee (Ethics Committee Approval Number: 2025.01.-07, Date: 14.01.2025). Written informed consent was obtained from all study participants before enrollment. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Disclosure

The authors report no conflicts of interest in this work.

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