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ORIGINAL ARTICLE

Prognostic Value of Preoperative ALBI Score for Predicting Right Ventricular Dysfunction After Coronary Artery Bypass Surgery

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Abstract

Introduction: This study aimed to evaluate the prognostic utility of the albumin–bilirubin (ALBI) score in predicting right ventricular (RV) failure and postoperative outcomes in patients undergoing isolated coronary artery bypass grafting (CABG).

Methods: A total of 265 patients who underwent elective isolated CABG between 2020 and 2024 at a single tertiary center were retrospectively analyzed. Patients were divided into two groups based on a preoperative ALBI cut-off value of -2.44. Preoperative, operative, and postoperative parameters were compared between groups. The primary outcome was postoperative RV failure. Secondary outcomes included in-hospital mortality, postoperative complications, and recovery metrics. Multivariate logistic regression was used to assess the independent association between ALBI and outcomes.

Results: Patients with high ALBI scores (>-2.44) were significantly older and had worse preoperative profiles, including lower ejection fraction (p=0.003), higher CRP (p=0.017), bilirubin (p<0.001), and BUN (p=0.008). No statistically significant differences were observed in postoperative atrial fibrillation, ICU stay, mechanical ventilation time, reoperation, or mortality between groups. However, high ALBI scores were consistently associated with markers of frailty and systemic inflammation.

Discussion and Conclusion: While the ALBI score did not predict short-term postoperative complications or mortality in isolated CABG patients, it demonstrated strong correlations with known risk factors such as advanced age, hypoalbuminemia, and inflammation. ALBI may serve as a useful adjunct in preoperative risk assessment. Further prospective studies are needed to confirm its role in long-term outcome prediction.

Keywords: Albumin; bilirubin; coronary artery bypass; mortality.

Coronary artery bypass grafting (CABG) outcomes are influenced not only by cardiac factors but also by the function of other organ systems, including the liver [1]. Impaired hepatic function in cardiac patients can worsen surgical prognosis; for example, chronic right-sided heart failure with elevated pulmonary pressures often leads to congestive hepatopathy and progressive liver dysfunction [2]. Yet conventional cardiac risk models (e.g., EuroSCORE II, STS) largely omit quantitative liver function metrics. Emerging evidence suggests this is a critical oversight, as liver dysfunction scores such as the Model for End-Stage Liver Disease (MELD) correlate with worse outcomes after cardiac surgery [1]. Patients with significantly elevated MELD scores experience substantially higher postoperative mortality [1], underscoring the need to incorporate liver health into preoperative risk assessment for CABG.

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The albumin–bilirubin (ALBI) score is a recently established index of hepatic function that combines two readily available biomarkers (serum albumin and bilirubin) into a single prognostic score [3]. Initially developed in patients with hepatocellular carcinoma as an objective alternative to Child–Pugh class and MELD, the ALBI score provides a simple, evidence-based measure of liver reserve [3]. Recent studies have extended the application of ALBI beyond hepatology, noting that higher preoperative ALBI values are associated with worse outcomes in cardiovascular conditions such as acute and chronic heart failure [4]. In surgical populations, ALBI may capture subclinical liver impairment due to venous congestion or low cardiac output states. Notably, a study in cardiac valve surgery found that an elevated preoperative ALBI score was linked to higher pulmonary artery pressures and a greater incidence of acute kidney injury and in-hospital mortality [2]. This finding suggests that ALBI could serve as a useful preoperative marker for patients at risk of right ventricular (RV) failure and related complications following cardiac surgery.

The prognostic value of ALBI in the CABG patient population—particularly its ability to predict postoperative RV failure and mortality—remains poorly defined. Of note, even a single component of ALBI has been identified as an independent predictor of late mortality after CABG [5], suggesting that a composite score incorporating both albumin and bilirubin might further enhance risk stratification. Building on the known cardio-hepatic interactions, we hypothesized that the preoperative ALBI score could predict RV failure and adverse outcomes after CABG. This study was designed to investigate the relationship between preoperative ALBI scores and the incidence of postoperative RV failure, as well as short- and long-term mortality, in patients undergoing CABG surgery.

Materials and Methods

This retrospective observational study was conducted at Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital (Istanbul, Türkiye) between 2020 and 2024. The study protocol was approved by the institutional committee (date: 16/05/2025; no: E-28001928-604.01-276512887) with a waiver of informed consent due to the retrospective design, and the research was conducted in accordance with the principles of the Declaration of Helsinki.

All adult patients (aged ≥18 years) who underwent elective isolated coronary artery bypass grafting (CABG) during the study period were eligible for inclusion, provided that complete preoperative biochemical (including albumin and total bilirubin) and transthoracic echocardiographic data were available in their records. Patients undergoing emergent or salvage CABG, those requiring concomitant cardiac procedures (e.g., valve or aortic surgery), and those with known liver failure or missing laboratory data necessary for ALBI calculation were excluded.

For each patient, the ALBI score was calculated using the preoperative serum albumin and total bilirubin values. Patients were then stratified into two groups based on an ALBI cut-off value of -2.44, as previously reported by Duman and Timur in a valvular surgery cohort. Specifically, an ALBI score ≤-2.44 was defined as low (indicating better hepatic reserve), and a score >-2.44 as high [2].

All relevant clinical and operative data, including patient demographics, comorbid conditions, and intraoperative details, were retrospectively extracted from the hospital's electronic health records. The primary outcome of interest was the development of postoperative RV failure, defined as hemodynamic instability due to RV dysfunction requiring high-dose inotropic support and/or mechanical circulatory or pulmonary vasodilator support. Secondary outcomes included in-hospital mortality, major postoperative complications (such as acute kidney injury requiring dialysis or reoperation for bleeding), and measures of postoperative recovery (duration of mechanical ventilation, length of intensive care unit stay, and total hospital length of stay).

Statistical Analysis

All statistical analyses were performed using R statistical software (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were expressed as mean±standard deviation or median (interquartile range), as appropriate, and compared between the low-ALBI and high-ALBI groups using the Student's t-test or Mann-Whitney U test. Categorical variables were summarized as counts and percentages and compared using the chi-square test or Fisher's exact test.

To assess the independent association of preoperative ALBI status with postoperative RV failure and other outcomes, a multivariate logistic regression analysis was performed, including ALBI group and other potential confounding variables. Results were reported as odds ratios (OR) with 95% confidence intervals. A two-tailed $p<0.05$ was considered statistically significant for all analyses.

Table 1. Preoperative demographical and laboratory values

	Group 1	Group 2	p
n	189	76	
Gender			
1	34 (18.0)	14 (18.4)	0.99
2	155 (82.0)	62 (81.6)	
DM			
-	85 (45.0)	40 (52.6)	0.278
+	104 (55.0)	36 (47.4)	
HTN			
-	78 (41.3)	34 (44.7)	0.680
+	111 (58.7)	42 (55.3)	
Carotid Stenosi			
-	154 (81.5)	65 (85.5)	0.478
+	35 (18.5)	11 (14.5)	
COPD			
-	167 (88.4)	60 (78.9)	0.054
+	22 (11.6)	16 (21.1)	
BMI	28.38 (4.46)	28.04 (4.68)	0.586
Height (cm)	168.88 (7.40)	167.14 (8.52)	0.099
BSA (m^2)	1.93 (0.17)	1.89 (0.20)	0.064
Weight (kg)	80.87 (13.01)	78.36 (14.33)	0.168
Age	59.37 (8.90)	63.22 (9.79)	0.002
Euroscore	2.00 (0.00, 4.00)	3.00 (1.00, 5.00)	0.003
Euroscore Mortality	1.33 (0.88, 2.40)	1.96 (1.33, 2.93)	<0.001
BUN	18.04 (6.98)	20.13 (11.51)	0.071
CRP	1.54 (2.00)	2.42 (3.32)	0.017
HB	13.59 (1.54)	13.25 (1.65)	0.105
CRE	0.93 (0.27)	0.96 (0.81)	0.558
Lymphocyte	2.33 (0.88)	2.21 (0.78)	0.330
MCV	89.01 (5.53)	89.51 (5.43)	0.506
Neutrophil	5.16 (1.94)	5.18 (1.81)	0.937
PLT	234365.08 (65676.02)	248828.95 (81526.99)	0.132
RDW	15.76 (1.34)	15.70 (1.84)	0.770
Uric Acid	6.32 (1.80)	6.13 (1.87)	0.538
WBC	8.40 (2.41)	8.43 (2.40)	0.925
Total Albumin	4.04 (0.26)	3.56 (0.23)	<0.001
Total Bilirubin	0.70 (0.40)	1.19 (1.36)	<0.001
Total Prot	6.85 (0.49)	6.36 (0.42)	<0.001

BMI: body mass index; BSA: bpdy surface area; BUN: blood urea nitrogen; COPD: chronic obstructive pulmonary disease; CRE: creatinine; CRP: c-reactive protein; DM: diabetes mellitus; HB: hemoglobin; HTN: hypertension; MCV: mean corpuscular volume; PLT: platelet; RDW: red cell distribution width; WBC: white blood cell.

Table 2. perioperative data of the patients

	Group 1	Group 2	p
n	189	76	
X-clamp time	65.96 (28.60)	64.33 (27.49)	0.672
CPB time	105.68 (39.26)	102.08 (34.92)	0.487
Bypass number	3.00 (2.00, 3.00)	3.00 (2.00, 3.00)	0.037
CPB degree (Co)	30.00 (28.00, 32.00)	30.00 (28.00, 32.00)	0.876

CPB: cardiopulmonary bypass; x-clamp: cross clamp.

Results

A total of 265 patients who underwent elective isolated CABG between 2020 and 2024 were included in the final analysis. The cohort was divided into two groups based on the preoperative ALBI score using a cut-off value of -2.44. Group 1 (n=189) comprised patients with an ALBI score ≤-2.44, and Group 2 (n=76) included those with an ALBI score >-2.44.

In the preoperative evaluation, patients in Group 2 were significantly older than those in Group 1 (63.22±9.79 vs 59.37±8.90 years, p=0.002). EuroSCORE and predicted mortality values were also higher in the high-ALBI group (EuroSCORE: 3.00 [1.00–5.00] vs 2.00 [0.00–4.00], p=0.003; EuroSCORE mortality: 1.96 [1.33–2.93] vs 1.33 [0.88–2.40], p<0.001). Among laboratory parameters, C-reactive protein (CRP) levels were elevated in Group 2 (2.42±3.32 vs 1.54±2.00 mg/L, p=0.017), while serum albumin, total protein, and total bilirubin levels differed significantly between groups (albumin: 3.56±0.23 vs 4.04±0.26 g/dL, p<0.001; bilirubin: 1.19±1.36 vs 0.70±0.40 mg/dL, p<0.001; protein: 6.36±0.42 vs 6.85±0.49 g/dL, p<0.001). Left ventricular ejection fraction (EF) was lower in patients with high ALBI scores (49.21±10.39% vs 52.96±8.53%, p=0.003), though all patients included had preserved left ventricular systolic function preoperatively (Table 1).

Operative characteristics were largely comparable between groups, except for the number of distal anastomoses performed, which was marginally higher in the high-ALBI group (3.00 [2.00–3.00] in both groups, p=0.037). There were no statistically significant differences in cardiopulmonary bypass or cross-clamp durations (Table 2).

Postoperative laboratory results showed that blood urea nitrogen (BUN) levels at 24 hours were significantly higher in Group 2 (23.59±10.65 vs 20.67±6.83 mg/dL, p=0.008), while postoperative lymphocyte counts were lower (1.03±0.51 vs 1.22±0.69×10^3/μL, p=0.036). However, CRP values at 24 hours were similar between the two groups (p=0.663). There were no significant differences in mechanical ventilation duration, intensive care unit (ICU) stay, or total hospitalization time. Similarly, the incidence of postoperative atrial fibrillation, renal dysfunction requiring dialysis, or

Table 3. Postoperative data and laboratory findings of the patients

Factor	Group 1	Group 2	p
n	189	76	
infection			
-	132 (69.8)	50 (65.8)	0.559
+	57 (30.2)	26 (34.2)	
IABP			
-	183 (96.8)	71 (93.4)	0.304
+	6 (3.2)	5 (6.6)	
İnotropic need			
-	132 (69.8)	54 (71.1)	0.883
+	57 (30.2)	22 (28.9)	
Atrial fibillartion			
-	150 (79.4)	59 (77.6)	0.742
+	39 (20.6)	17 (22.4)	
Postoperative CRF			
-	187 (99.5)	76 (100.0)	1.000
+	1 (0.5)	0 (0.0)	
Postoperative dialysis need			
-	184 (97.4)	74 (97.4)	1.000
+	5 (2.6)	2 (2.6)	
Revision			
-	167 (88.4)	63 (82.9)	0.235
+	22 (11.6)	13 (17.1)	
Time of Entubation (days)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.063
Hospital stay (days)	7.00 (6.00, 8.00)	7.00 (6.00, 8.00)	0.197
ES use	2.00 (1.00, 4.00)	2.00 (1.00, 3.25)	0.968
X3TAM.KAN	0.00 (0.00, 1.00)	0.00 (0.00, 1.00)	0.462
FFP use	3.00 (1.00, 4.00)	3.00 (3.00, 3.00)	0.234
Plt use	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.631
ICU stay (days)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.707
1 year mortality (%)			
-	180 (95.2)	71 (93.4)	0.552
+	9 (4.8)	5 (6.6)	
2 years mortality (%)			
-	175 (92.6)	69 (90.8)	0.621
+	14 (7.4)	7 (9.2)	
3 years mortality (%)			
-	173 (91.5)	68 (89.5)	0.638
+	16 (8.5)	8 (10.5)	
30 day mortality (%)			
-	184 (97.4)	73 (96.1)	0.693
+	5 (2.6)	3 (3.9)	
İn hospital mortality			
-	129 (81.6)	51 (73.9)	0.213
+	29 (18.4)	18 (26.1)	
Postop 1 CRP	11.70 (5.07)	11.36 (4.64)	0.663
Postop 1 Lymphocyte	1.22 (0.69)	1.03 (0.51)	0.036
Postop 1 Neutrophil	10.27 (2.95)	10.38 (3.79)	0.806
Postop1 PLT	178699.47 (54126.47)	180450.00 (58212.76)	0.816
Posotp 2 BUN	23.45 (9.41)	26.05 (13.72)	0.079
Postop 1 BUN	20.67 (6.83)	23.59 (10.65)	0.008
Posotp 1 CRE	1.05 (0.34)	1.10 (0.58)	0.343
Postop 1 Uric Acid	5.90 (1.91)	5.34 (1.48)	0.273
Postop 1 WBC	12.52 (3.33)	12.50 (4.15)	0.970
Postop 2 CRE	1.00 (0.39)	1.06 (0.72)	0.377
Postop 2 Uric Acid	6.50 (6.29)	5.55 (1.74)	0.574

BUN: blood urea nitrogen; CRE: creatinine; CRF: chronic renal failure; CRP: c-reactive protein; ES: eythrocyte suspension; FFP: fresh frozen plasma; IABP: intraaortic baloon pump; ICU: intesive care unit; PLT: platelet; WBC: white blood cell.

surgical revision for bleeding did not differ significantly between groups. Mortality outcomes at 30 days and up to three years showed a trend toward higher event rates in the high-ALBI group, though these differences did not reach statistical significance (Table 3).

Discussion

In this retrospective study, we investigated the prognostic value of the preoperative ALBI score in patients undergoing isolated CABG. Our findings revealed that patients with higher ALBI scores were significantly older and had worse preoperative profiles, including lower ejection fraction, higher CRP, elevated total bilirubin, and increased BUN. These associations support the hypothesis that the ALBI score reflects not only hepatic dysfunction but also a systemic inflammatory and metabolic burden, aligning with previous studies demonstrating the score's correlation with cardiovascular risk profiles [6–9].

The inverse relationship observed between ALBI and ejection fraction in our cohort is consistent with findings from Bedir et al., [10] who demonstrated that ALBI correlates with echocardiographic indices of pressure overload in patients with valvular disease. This suggests that ALBI may indirectly reflect chronic right-sided congestion and myocardial dysfunction. Similarly, elevated CRP levels in patients with poor ALBI scores reinforce the inflammatory dimension of this marker, as highlighted in prior heart failure and cardiac surgery cohorts [2,8]. Elevated BUN values in this subgroup also mirror systemic hypoperfusion and renal congestion, conditions previously shown to cluster with elevated ALBI and worse cardiac outcomes [9,11].

Despite the associations with several high-risk preoperative markers, we found no statistically significant differences between ALBI groups regarding key postoperative endpoints such as atrial fibrillation, mechanical ventilation duration, ICU stay, reoperation for bleeding, or early mortality. These findings merit discussion. First, the low overall event rate in our study population, composed of elective and hemodynamically stable CABG patients, may have limited statistical power. Additionally, robust perioperative care protocols may have mitigated differences in short-term outcomes. This phenomenon has been previously reported in similar low-risk surgical series, where biomarkers failed to predict outcomes under optimized conditions [12,13].

In particular, the absence of an association between ALBI and postoperative AF deserves mention. Given the complex, multifactorial pathogenesis of post-CABG AF—including autonomic imbalance, atrial stretch, inflammation, and surgical trauma—hepatic biomarkers alone may be insufficient predictors. Indeed, Apaydın et al. [14] showed that even thoracic tube positioning independently altered AF incidence by modulating pericardial irritation. Similarly, our results may reflect the overriding influence of intraoperative and procedural factors in arrhythmogenesis, diminishing the discriminative value of preoperative ALBI in this context.

Furthermore, although ALBI was not significantly associated with mortality in our cohort, its strong correlation with frailty markers such as hypoalbuminemia, inflammation, and reduced cardiac function suggests a latent prognostic role. Prior studies have shown that ALBI may stratify long-term risk rather than early postoperative events. For instance, Jurkiewicz et al. [7] reported that ALBI predicted long-term survival in elderly heart failure patients, while Qiao et al. [12] demonstrated its prognostic validity in hypertrophic cardiomyopathy. These findings imply that the prognostic window of ALBI may extend beyond the immediate postoperative period, and long-term follow-up could reveal more robust associations.

This study has several limitations that must be acknowledged. First, the retrospective design inherently introduces the possibility of selection and information bias, as data were extracted from electronic records and not originally intended for research. Second, although the sample size was adequate for detecting differences in biochemical and demographic parameters, it may have been underpowered to reveal statistically significant differences in low-frequency clinical outcomes such as mortality or reoperation. Third, the study was conducted in a single high-volume tertiary center with standardized perioperative protocols, which may limit the generalizability of our findings to other institutions with different practice patterns. Furthermore, we did not include long-term follow-up beyond the early postoperative period and thus cannot fully evaluate the predictive value of the ALBI score on long-term mortality or morbidity after CABG. Finally, hepatic imaging or elastography data were not available, and subclinical liver disease could not be excluded with certainty.

Conclusion

In conclusion, our findings suggest that the preoperative ALBI score is a valuable surrogate marker of systemic risk in patients undergoing elective isolated CABG. Although it did not independently predict short-term clinical outcomes such as mortality or postoperative complications, the ALBI

score demonstrated strong associations with age, cardiac function, inflammation, and renal parameters—factors known to contribute to perioperative vulnerability. Its simplicity, availability, and multidimensional nature make it an appealing adjunct to traditional risk assessment tools. We believe that incorporation of ALBI into preoperative evaluation may enhance patient stratification and guide individualized care in cardiac surgery. Future prospective and multicenter studies are warranted to validate its role and define its utility in long-term prognostication.

Ethics Committee Approval: The study was approved by Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee (No: E-28001928-604.01-276512887, Date: 16.05.2025).

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