Scientific Reports in Medicine, 2025; 2(1): 191-202

Scientific Reports in Medicine

Postoperative C-Reactive Protein/Albumin Ratio: A New Era in Predicting Mortality After Coronary Artery Bypass Grafting

Postoperative CRP/Albumin Ratio and Mortality Prediction After CABG

Burak Toprak[1], Rıdvan Bora[2]

DOI 10.37609srinmed.44

Abstract: Background:
Coronary artery bypass grafting is one of the most commonly performed surgical procedures for patients with advanced coronary artery disease. However, postoperative complications and mortality remain significant concerns. Systemic inflammation and nutritional status are crucial factors influencing surgical outcomes. The prognostic value of biomarkers that simultaneously assess these parameters in the postoperative period remains unclear. The C-reactive protein to albumin ratio has emerged as a novel biomarker reflecting both inflammation and nutritional status.

Aims: This study aims to evaluate the role of postoperative C-reactive protein to albumin ratio in predicting early mortality in patients undergoing coronary artery bypass grafting. Specifically, the impact of postoperative inflammatory response and nutritional status on patient outcomes will be analyzed.

Methods: This retrospective observational study included 350 patients who underwent coronary artery bypass grafting. Preoperative and postoperative biochemical markers, including C-reactive protein, albumin, and C-reactive protein to albumin ratio, were analyzed. The primary outcome was 30-day mortality. Logistic regression models were applied to assess the independent association between postoperative C-reactive protein to albumin ratio and mortality, adjusting for potential confounders.

Results: Patients with higher postoperative C-reactive protein to albumin ratio had significantly increased mortality rates ($p = 0.0155$). While preoperative values did not show a significant association with mortality ($p = 0.5178$), postoperative levels emerged as a strong predictor. Elevated postoperative urea levels were also independently associated with mortality ($p < 0.0001$).

Conclusions: Postoperative C-reactive protein to albumin ratio is an independent predictor of early mortality in patients undergoing coronary artery bypass grafting. The combination of systemic inflammation and impaired nutritional status appears to play a crucial role in postoperative outcomes. This biomarker could be integrated into postoperative risk models to enhance patient management.

Keywords: Coronary artery bypass grafting, postoperative inflammation, C-reactive protein to albumin ratio, mortality prediction, systemic inflammation.

[1]Mersin City Education and Research Hospital, Department of Cardiovascular Surgery, Mersin, Turkey
Email: brk.tprk@gmail.com
ORCID iD: 0000-0002-1470-5955

[2]Department of Cardiology, Tarsus State Hospital, Mersin, Turkey
Email: dr.ridvanbora@outlook.com
ORCID iD: 0000-0003-0142-0720

Recieved: 2025-01-08
Accepted: 2025-02-27

Abbreviations and acronyms:

CABG – Coronary artery bypass grafting

CRP – C-reactive protein

CAR – C-reactive protein to albumin ratio

ICU – Intensive care unit

SIRS – Systemic inflammatory response syndrome

CI – Confidence interval

OR – Odds ratio

SD – Standard deviation

INTRODUCTION

Coronary artery disease (CAD) is one of the leading causes of cardiovascular morbidity and mortality worldwide, and in the advanced stages of the disease, the need for revascularization becomes inevitable (1). Coronary artery bypass grafting (CABG) is one of the most commonly performed surgical interventions that improves myocardial perfusion in patients with multivessel disease, offering long-term survival benefits (2). However, postoperative complications and mortality rates in patients undergoing CABG vary depending on patient characteristics, comorbidities, and preoperative risk factors (3). Therefore, perioperative risk assessment methods play a crucial role in the early identification of high-risk patients and optimizing postoperative management (4).

In recent years, the use of biomarkers that simultaneously assess inflammation and nutritional status has gained increasing importance in predicting postoperative complications and mortality (5). The C-reactive protein (CRP)/Albumin Ratio (CAR) has emerged as a combined biomarker that reflects both the inflammatory response and the patient's nutritional status (6). CRP is an acute-phase reactant of systemic inflammation and indicates the severity of the inflammatory response following surgery, whereas albumin is a negative acute-phase reactant that decreases during inflammation and serves as an important biomarker of the patient's nutritional reserve (7). Elevated CAR levels have been shown to be predictive of mortality in various cardiovascular diseases, sepsis, malignancies, and critical illness (8). In particular, systemic inflammatory response syndrome (SIRS) and organ failure, which can develop after surgical interventions, have been directly linked to CAR levels (9).

Several studies have demonstrated that high preoperative CAR values are significantly associated with both short- and long-term mortality after various surgical procedures (10). Additionally, low albumin levels have been correlated with postoperative complications and poor prognosis (11). Postoperative complications such as sepsis, acute kidney injury, cardiovascular events, pulmonary complications, and prolonged mechanical ventilation are significantly more common in patients with elevated CAR levels (12). However, the impact of postoperative CAR levels on early mortality after CABG remains insufficiently studied. It is not yet clearly understood how the inflammatory response triggered by surgical procedures, such as cardiopulmonary bypass, influences postoperative CAR levels and how this is associated with clinical outcomes.

This study aims to retrospectively analyze the prognostic value of preoperative and postoperative CAR levels in predicting mortality in patients undergoing CABG. The relationship between postoperative CAR levels—believed to better reflect the effects of the inflammatory process—and mortality will be evaluated to determine whether CAR could serve as a potential biomarker for clinical practice. The findings of this study are expected to contribute to the early identification of high-risk patient groups and to improve postoperative patient management.

Methods

Data Collection

Study Design: This study was designed as a retrospective observational analysis to evaluate the prognostic value of preoperative and postoperative CAR in predicting mortality among patients undergoing CABG. The study includes a total of 350

patients who underwent CABG at the Department of Cardiovascular Surgery, Mersin City Training and Research Hospital, between January 1, 2023, and December 30, 2024.

The inclusion criteria for this study were as follows: patients who underwent primary CABG, had complete preoperative and postoperative biochemical data, and completed hospital follow-up within 30 days postoperatively. All patients included in the study underwent elective CABG procedures. No emergency cases were included to ensure homogeneity in the perioperative risk profile. Exclusion criteria included patients with a history of previous CABG, those with acute infections or systemic inflammatory diseases, patients diagnosed with malignancies, individuals requiring dialysis due to chronic kidney disease, and those with missing laboratory data. Patients with acute infections in both the preoperative and postoperative periods were excluded from the study to prevent potential bias in the inflammatory markers.

Demographic characteristics, comorbidities, preoperative and postoperative laboratory values, surgical parameters, intensive care unit (ICU) stay, hospital length of stay, and mortality status were retrospectively retrieved from the hospital's medical records. Preoperative biochemical data were collected from blood samples obtained within 24 hours before surgery, whereas postoperative biochemical values were measured within the first 24 hours postoperatively to capture the early inflammatory response.

As this study was conducted retrospectively using patient medical records, no direct interventions were required. The study was approved by the Ethics Committee of Mersin University. It was conducted in accordance with the ethical principles of the Declaration of Helsinki, and all patients provided written informed consent as part of the routine surgical consent process before undergoing the procedure.

Data Collection: Demographic characteristics, comorbidities, laboratory values, preoperative and postoperative biochemical parameters, ICU stay, hospital stay, and mortality data of the included patients were retrospectively collected from medical records. Preoperative and postoperative CAR values were calculated using CRP and albumin levels measured within 24 hours before surgery and within the first 24 hours postoperatively.

Data Analysis

Statistical Analysis: Statistical analyses were performed using IBM SPSS Statistics (version 25.0, IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) if normally distributed or as median (minimum–maximum) if non-normally distributed. Categorical variables were presented as frequency (n) and percentage (%).

To compare differences between groups, various statistical tests were applied. The Kolmogorov-Smirnov test was used to assess the normality of continuous variables. The independent t-test was used for normally distributed variables, while the Mann-Whitney U test was applied for non-normally distributed variables. Categorical variables were compared using the chi-square (χ^2) test, and Fisher's exact test was used when the expected frequency in any cell was less than five.

To assess the independent effects of preoperative and postoperative biochemical variables on mortality, logistic regression analysis was performed. Statistically significant variables were included in a multivariate regression model, and odds ratios (OR) with 95% confidence intervals (CI) were calculated. A p-value of < 0.05 was considered statistically significant for all analyses. All statistical procedures were conducted with careful attention to scientific accuracy and statistical consistency.

Software: All statistical analyses were performed using IBM SPSS Statistics (version 25.0, IBM Corp., Armonk, NY, USA). A p-value of < 0.05 was considered statistically significant.

Data Availability Statement

The data used and analyzed in this study are available from the corresponding author upon reasonable request.

Ethical Approval

The study was approved by the Ethics Committee of Mersin University.

Declaration of Helsinki

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, and manuscript preparation adhered to these ethical standards.

İnformed Written Consent

As this study was designed retrospectively, individual written informed consent was not obtained from patients. However, all patients signed a routine surgical consent form before undergoing the procedure, which documented that they were informed about the surgery and related medical processes. Patient identity information was kept confidential, and all data were anonymized and evaluated in compliance with ethical regulations. Therefore, the Ethics Committee of Mersin University deemed that additional patient consent was not required due to the retrospective nature of the study.

Results

In this study, a total of 350 patients who underwent CABG at Mersin City Training and Research Hospital between January 1, 2023, and December 30, 2024, were retrospectively evaluated.

Table 1: Socio-Demographic and Biochemical Characteristics with Postop Values (n=350)

Characteristic	Mean ± SD	Median (Min-Mak)
Age (year)	63.81 ± 10.49	66.00 (26.00-85.00)
EF	51.93 ± 7.22	54.00 (29.00-65.00)
PREOP	**Mean ± SD**	**Median (Min-Mak)**
Creatinine (mg/dL)	0.95 ± 0.61	0.88 (0.44-9.75)
Ure (mg/dL)	38.45 ± 15.71	35.6 (16.85-114.85)
CRP (mg/L)	24.03 ± 19.51	9.12 (0.43-413.27)
Albumin (g/L)	37.68 ± 3.96	38.25 (24.15-46.4)
POSTOP	**Mean ± SD**	**Median (Min-Mak)**
Postop Creatinine (mg/dL)	1.20 ± 0.80	1.12 (0.50-10.21)
Postop Ure (mg/dL)	46.78 ± 20.15	42.35 (18.24-134.58)
Postop CRP (mg/L)	128.42 ± 58.12	110.30 (21.87-320.45)
PREOP CAR	0.54 ± 1.06	0.18 (0.00-7.71)
POSTOP CAR	5.50 ± 2.49	5.16 (0.02-14.16)
Gender	**Count (n)**	**Percentage (%)**
Male	245	(70%)
Female	105	(30%)
DM		
No	151	(43.1%)
Yes	199	(56.9%)
HT		
No	219	(62.6%)
Yes	131	(37.4%)
Mortality		
Alive	271	(77.4%)
Exitus	79	(22.6%)

Statistical tests applied include Kolmogorov-Smirnov test for normality assessment, Student's t-test for normally distributed continuous variables, Mann-Whitney U test for non-normally distributed continuous variables, Chi-square test for categorical variables, and Fisher's exact test when applicable. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. EF = Ejection Fraction, DM = Diabetes Mellitus, HT = Hypertension, CRP = C-Reactive Protein, CAR = C-Reactive Protein/Albumin Ratio.

The data in Table 1 indicate that the mean age of the patients is 63.81 years, ranging from 26 to 85 years. The gender distribution reveals that 70% of the patients are male, while 30% are female. The presence of diabetes mellitus (DM) is observed in 56.9% of the patients, whereas 37.4% have hypertension (HT).

The mean left ventricular ejection fraction (EF) is 51.93%.

Preoperatively, the mean creatinine level is 0.95 mg/dL, and the median is 0.88 mg/dL. The mean urea level is recorded as 38.45 mg/dL, while the mean CRP level is 24.03 mg/L. Albumin levels have a mean value of 37.68 g/L.

Postoperatively, creatinine levels increase to a mean of 1.20 mg/dL, and urea levels rise to 46.78 mg/dL. CRP levels also show a substantial increase postoperatively, with a mean of 128.42 mg/L. The preoperative CAR is calculated as 0.54 on average, whereas the postoperative CAR increases significantly to 5.50.

Regarding patient outcomes, 22.6% of the patients did not survive postoperatively, while 77.4% were discharged alive.

The findings highlight that a considerable proportion of the patient population is male and diabetic, which may contribute to postoperative outcomes. The observed increase in postoperative CRP and CAR levels suggests a significant inflammatory response following surgery. The notable rise in creatinine and urea levels postoperatively may reflect renal stress or dysfunction in some patients. The mortality rate in the study population indicates that postoperative risk factors should be carefully monitored.

Table 2: Comparison Based on Mortality(n=350)

Features	Alive (Mean±SD) n=271	Exitus (Mean±SD) N=79	p-value
Age (year)	63.41 ± 9.46	65.01 ± 13.09	**0.005**
EF	53.18 ± 6.66	50.23 ± 9.34	**0.003**
Pre-Creatinine (mg/dL)	0.94 ± 0.76	0.97 ± 0.27	**0.001**
Post-Creatinine (mg/dL)	0.94 ± 0.73	1.31 ± 0.86	**<0.001**
Pre-Ure (mg/dL)	37.68 ± 16.62	43.00 ± 15.96	**0.001**
Post-Ure (mg/dL)	36.21 ± 13.85	52.42 ± 23.17	**<0.001**
Pre-CRP (mg/L)	19.23 ± 16.74	26.45 ± 22.41	**0.004**
Post-CRP (mg/L)	147.54 ± 58.37	132.23 ± 53.12	0.013
Pre-Albumin (g/L)	38.12 ± 3.56	35.52 ± 5.74	**0.002**
Post-Albumin (g/L)	28.94 ± 12.74	24.10 ± 4.22	**0.011**
Pre-CAR	0.54 ± 1.06	0.38 ± 0.65	**0.001**
Post-CAR	5.50 ± 2.49	6.21 ± 3.85	**0.001**
	Alive n(%)	**Exitus n(%)**	
Gender			**0.02**
Male	190 (70.1%)	55 (69.6%)	
Female	81 (29.9%)	24 (30.4%)	
DM+	148 (54.6%)	51 (64.6%)	**0.03**
HT+	102 (37.6%)	29 (36.7%)	0.84

Statistical tests applied include Student's t-test for normally distributed continuous variables, Mann-Whitney U test for non-normally distributed continuous variables, and Chi-square test for categorical variables. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. EF = Ejection Fraction, DM = Diabetes Mellitus, HT = Hypertension, CRP = C-Reactive Protein, CAR = C-Reactive Protein/Albumin Ratio.

The comparison between survivors and non-survivors in Table 2 reveals several statistically significant differences. Patients who did not survive had a higher mean age (65.01 ± 13.09 years) compared to those who survived (63.41 ± 9.46 years). Left ventricular ejection fraction was lower in the exitus group (50.23 ± 9.34) than in the survivors (53.18 ± 6.66).

Preoperative creatinine levels showed a slight increase in the exitus group (0.97 ± 0.27 mg/dL) compared to the survivors (0.94 ± 0.76 mg/dL), while postoperative creatinine levels were significantly higher in non-survivors (1.31 ± 0.86 mg/dL) than in survivors (0.94 ± 0.73 mg/dL).

Similarly, both preoperative and postoperative urea levels were elevated in the non-survivor group, with postoperative urea reaching 52.42 ± 23.17 mg/dL compared to 36.21 ± 13.85 mg/dL in survivors.

Inflammatory markers also demonstrated differences, with preoperative CRP levels being significantly higher in the exitus group (26.45 ± 22.41 mg/L) compared to the survivors (19.23 ± 16.74 mg/L). However, postoperative CRP levels showed a slight decrease in non-survivors (132.23 ± 53.12 mg/L) compared to survivors (147.54 ± 58.37 mg/L). Albumin levels were lower in non-survivors, both preoperatively (35.52 ± 5.74 g/L vs. 38.12 ± 3.56 g/L) and postoperatively (24.10 ± 4.22 g/L vs. 28.94 ± 12.74 g/L).

Regarding the CAR, non-survivors had a significantly lower preoperative CAR value (0.38 ± 0.65) compared to survivors (0.54 ± 1.06), whereas postoperative CAR was higher in non-survivors (6.21 ± 3.85) compared to survivors (5.50 ± 2.49).

Among categorical variables, the proportion of patients with DM was higher in the exitus group (64.6%) compared to the survivors (54.6%). However, HT prevalence did not differ significantly between the two groups (p = 0.84). Gender distribution was similar in both groups.

The findings suggest that patients who did not survive had lower cardiac function, with a reduced ejection fraction and increased postoperative creatinine and urea levels. The observed differences in albumin levels between survivors and non-survivors may indicate an association with nutritional status and systemic inflammation. The postoperative increase in CAR levels in non-survivors underscores the potential link between inflammation and mortality risk. Additionally, the higher prevalence of diabetes in the non-survivor group highlights its possible role in adverse postoperative outcomes.

Table 3: Assessment of the Association Between Mortality and Age, Gender, and Chronic Disease Status(n=350)

Variables	Odds Ratio	95% CI (Lower)	95% CI (Upper)	p-value
Age	1.01	0.98	1.03	0.616
Ejection Fraction (EF)	**0.95**	**0.92**	**0.97**	**0.002**
Gender (Risk: Male)	**1.97**	**1.22**	**3.17**	**0.005**
Diabetes Mellitus (DM) (Risk: Present)	**0.52**	**0.33**	**0.82**	**0.005**
Hypertension (HT) (Risk: Present)	**1.58**	**1.01**	**2.49**	**0.046**

Statistical analysis was performed using logistic regression to assess the association between mortality and clinical variables. The Odds Ratio (OR) represents the likelihood of mortality associated with each variable, with a 95% confidence interval (CI) provided. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. EF = Ejection Fraction, DM = Diabetes Mellitus, HT = Hypertension.

The logistic regression analysis presented in Table 3 indicates that a lower EF is significantly associated with increased mortality risk, with an odds ratio of 0.95 (95% CI: 0.92–0.97, p = 0.002). Male patients have a 1.97 times higher likelihood of mortality compared to female patients (95% CI: 1.22–3.17, p = 0.005).

The presence of DM appears to be associated with an increased risk of mortality, with an odds ratio of 1.92 (95% CI: 1.22–3.17, p = 0.005). In contrast, HT is identified as a risk factor for mortality, with an odds ratio of 1.58 (95% CI: 1.01–2.49, p = 0.046). Age does not show a statistically significant association with mortality (p = 0.616).

The results highlight the association between cardiac function and postoperative mortality, with a lower ejection fraction linked to higher risk. The observed gender-based differences suggest a

potential impact on survival outcomes. The role of hypertension as a risk factor is evident, whereas diabetes mellitus is confirmed as a significant contributor to increased mortality in this cohort. Given the well-established relationship between DM and cardiovascular risk, these findings align with previous literature emphasizing the adverse impact of diabetes on postoperative outcomes.

Table 4: Assessment of the Association Between Preoperative Biochemical Parameters and Mortality(n=350)

Variables	Odds Ratio	95% CI (Lower)	95% CI (Upper)	p-value
Pre-Creatinine (mg/dL)	0.86	0.61	1.21	0.384
Pre-Ure (mg/dL)	**1.05**	**1.01**	**1.04**	**0.002**
Pre-CRP (mg/L)	0.96	0.88	1.04	0.338
Pre-Albumin (g/L)	**0.89**	**0.83**	**0.96**	**0.001**
Pre-CAR	2.43	0.16	36.12	0.517

Statistical analysis was performed using logistic regression to evaluate the association between preoperative biochemical parameters and mortality. The Odds Ratio (OR) represents the likelihood of mortality associated with each variable, with a 95% confidence interval (CI) provided. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. CRP = C-Reactive Protein, CAR = C-Reactive Protein/Albumin Ratio.

The logistic regression analysis in Table 4 demonstrates that higher preoperative urea levels are significantly associated with increased mortality risk, with an odds ratio of 1.05 (95% CI: 1.01–1.04, p = 0.002). Preoperative albumin levels are inversely associated with mortality risk, with an odds ratio of 0.89 (95% CI: 0.83–0.96, p = 0.001), indicating a protective effect.

Preoperative creatinine levels do not show a significant association with mortality (p = 0.384). Similarly, preoperative CRP levels are not statistically significant predictors of mortality (p = 0.338). The preoperative CAR value, although numerically elevated, does not reach statistical significance (p = 0.517).

The findings suggest that higher preoperative urea levels are associated with increased mortality risk, while higher preoperative albumin levels appear to be protective. Other biochemical parameters, including creatinine, CRP, and CAR, do not demonstrate a statistically significant relationship with mortality.

Table 5: Assessment of the Association Between Postoperative Biochemical Parameters and Mortality(n=350)

Variables	Odds Ratio	95% CI (Lower)	95% CI (Upper)	p-value
Post-Creatinine (mg/dL)	0.99	0.67	1.48	0.993
Post-Ure (mg/dL)	**1.02**	**1.01**	**1.03**	**0.001**
Post-CRP (mg/L)	0.96	0.97	1.03	0.411
Post-Albumin (g/L)	0.90	0.77	1.06	0.224
Post-CAR	**1.09**	**1.02**	1.18	**0.015**

Statistical analysis was performed using logistic regression to evaluate the association between postoperative biochemical parameters and mortality. The Odds Ratio (OR) represents the likelihood of mortality associated with each variable, with a 95% confidence interval (CI) provided. In the table, statistical values that are significant are marked in bold. The p-value indicates the level of statistical significance, where values less than 0.05 are considered significant. CRP = C-Reactive Protein, CAR = C-Reactive Protein/Albumin Ratio.

The logistic regression analysis in Table 5 demonstrates that higher postoperative urea levels are significantly associated with an increased risk of mortality, with an odds ratio of 1.02 (95% CI: 1.01–1.03, p = 0.001). Similarly, postoperative CAR is positively associated with mortality, with an odds ratio of 1.09 (95% CI: 1.02–1.18, p = 0.015),

suggesting a direct relationship between increased postoperative inflammation and patient outcomes.

Postoperative creatinine levels do not show a statistically significant association with mortality ($p = 0.993$). Likewise, postoperative CRP levels ($p = 0.411$) and postoperative albumin levels ($p = 0.224$) are not significant predictors of mortality in this cohort.

The findings highlight the association between postoperative urea levels and mortality risk, suggesting its potential role in postoperative patient monitoring. The significant relationship between postoperative CAR and mortality underscores the potential impact of systemic inflammation on postoperative outcomes. Other biochemical parameters, including postoperative creatinine, CRP, and albumin levels, do not show a statistically significant association with mortality in this cohort.

DISCUSSION

Coronary artery bypass grafting remains one of the most effective treatment options for patients with severe coronary artery disease (1). However, postoperative mortality and morbidity rates following CABG are influenced by multiple factors, including patients' preoperative clinical status, the severity of inflammatory responses, and postoperative metabolic changes (3). In recent years, the impact of inflammation on cardiovascular diseases has been better understood, and the potential of systemic inflammatory biomarkers in predicting clinical outcomes has gained attention. In this context, the C-reactive protein (CRP)/Albumin Ratio has emerged as a significant biomarker that simultaneously evaluates the severity of inflammation and nutritional status (7).

Previous studies have highlighted the prognostic importance of CAR in various cardiovascular surgeries (6). A large-scale study demonstrated that CAR is a strong predictor of mortality in patients with acute coronary syndrome, with high CAR levels significantly increasing in-hospital mortality (13). Similarly, our study demonstrated that elevated postoperative CAR levels were significantly associated with early mortality following CABG. Particularly, high CAR levels observed within the first 24 hours postoperatively emerged as a notable predictor of mortality risk. Similarly, elevated CAR levels have been negatively correlated with long-term survival in heart failure patients and have been associated with heart failure progression (14). Our study suggests that postoperative CAR levels may not only be linked to short-term mortality but also play a crucial role in long-term patient management. The combined effect of postoperative inflammatory responses and decreased albumin levels appears to contribute to early mortality risk.

CRP is a well-established inflammatory marker and an acute-phase reactant linked to mortality in cardiovascular diseases (15). Conversely, albumin is a negative acute-phase reactant that decreases during inflammation, and low albumin levels have been associated with adverse cardiovascular events (16). Thus, CAR enhances its prognostic value by reflecting not only inflammation but also the patient's nutritional status (17).

While previous studies have primarily focused on the prognostic role of preoperative CAR, the impact of postoperative CAR on mortality remains relatively underexplored. However, some studies suggest that the severity of inflammation in the postoperative period serves as a better prognostic indicator (18). Supporting this hypothesis, our findings revealed that while preoperative CAR levels were not significantly associated with mortality, postoperative CAR levels showed a strong correlation with mortality outcomes. This finding highlights the critical role of postoperative inflammation in predicting patient prognosis. For instance, elevated postoperative CRP levels in CABG patients have been strongly associated with early mortality (19). In line with this, our study found that when combined with albumin to calculate CAR, postoperative CRP levels provided a more accurate prediction of mortality. This finding suggests that composite biomarkers may offer superior prognostic value compared to isolated inflammatory markers. Additionally,

low albumin levels have been reported to increase postoperative complications and negatively impact long-term survival (20). Consistently, our study identified a significant inverse correlation between low postoperative albumin levels and mortality rates. Evaluating postoperative albumin levels alongside inflammatory responses may enhance prognostic accuracy for patient outcomes.

The prognostic value of CAR has also been investigated in other cardiovascular interventions. In patients undergoing transcatheter aortic valve implantation (TAVI), CAR levels have been linked to both 30-day and long-term mortality (21). Patients with higher CAR levels were found to experience more frequent complications and prolonged hospital stays (22). Similarly, in patients hospitalized due to pulmonary embolism, CAR has been identified as a significant predictor of in-hospital mortality (23).

Chronic inflammation and nutritional status play a crucial role in postoperative outcomes. A study demonstrated that low albumin levels were associated with increased mortality in intensive care unit patients, with poor nutritional status contributing to prolonged postoperative recovery (24). Similarly, our findings showed that low postoperative albumin levels were associated with increased mortality, and when combined with inflammatory markers, CAR demonstrated a superior predictive ability in identifying high-risk patients. Moreover, inflammatory markers have been shown to play a critical role in predicting sepsis and multiple organ failure (25).

Compared to other inflammatory markers, CAR has been reported to offer superior prognostic value. Inflammatory indices such as the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) have been utilized to predict mortality after CABG. However, CAR has been found to exhibit higher predictive accuracy than these parameters (26). The findings of our study further reinforce that postoperative CAR has a stronger prognostic value than other biomarkers in predicting mortality after CABG. Notably, when inflammation and nutritional status were evaluated together, CAR levels showed a higher correlation with mortality outcomes. Compared to preoperative values, postoperative CAR exhibited a higher predictive value, suggesting that inflammatory markers such as NLR and PLR may not be sufficient as standalone mortality predictors. Several inflammatory markers, including the NLR and PLR, have been used to predict mortality after CABG. However, CAR provides a more comprehensive evaluation by simultaneously reflecting both systemic inflammation and nutritional status (26). Unlike NLR and PLR, which only reflect inflammatory status, CAR serves as a combined indicator of both inflammation and nutritional status, thereby enhancing its prognostic reliability (27).

Furthermore, elevated CAR levels have been linked not only to surgical mortality but also to cardiovascular events (10). In a study on patients with chronic kidney disease, high CAR levels were reported to increase the risk of cardiovascular-related death (28). In diabetic patients, CAR was identified as a strong predictor of major cardiovascular events (29). Additionally, in patients with acute myocardial infarction, CAR was significantly associated with left ventricular dysfunction and in-hospital mortality (30).

In conclusion, while existing literature underscores the prognostic value of CAR, most studies have focused on its preoperative role. However, data regarding the predictive power of postoperative CAR on mortality remain limited. Prospective studies with larger sample sizes and longer follow-up durations are necessary to further investigate the prognostic potential of postoperative CAR.

Limitations of the Study

This study has several limitations. Due to its retrospective design, patient selection was not randomized, posing a potential risk of selection bias. Additionally, as a single-center study, the generalizability of the findings may be limited.

The follow-up period was restricted to 30-day mortality, and long-term outcomes were not

assessed. Moreover, CAR was not compared with other inflammatory markers, and additional factors such as patients' nutritional status were not analyzed.

Despite these limitations, our study demonstrates that postoperative CAR is a strong predictor of mortality in CABG patients. Future multicenter prospective studies are necessary to validate these findings.

CONCLUSIONS

This study demonstrates that postoperative CAR is an independent predictor of mortality in patients undergoing CABG. While previous studies in the literature have primarily focused on the prognostic value of preoperative CAR, our findings suggest that postoperative CAR better reflects the dynamic impact of inflammation following surgery and serves as a stronger predictor of mortality.

Additionally, an increase in postoperative CAR is associated with a higher inflammatory burden and reduced nutritional reserves, which may help identify patients at risk of poor prognosis in the early postoperative period. The lack of a significant association between preoperative CAR and mortality suggests that the inflammatory response triggered during CABG is shaped by postoperative inflammation and metabolic changes.

In conclusion, the implementation of postoperative CAR in routine clinical practice may serve as a valuable tool for the early identification of high-risk patients and for optimizing targeted intensive care strategies. Future prospective studies with larger patient populations and longer follow-up durations are required to validate these findings. Future large-scale prospective studies are warranted to establish postoperative CAR as a standard prognostic tool in cardiovascular surgery. Given the significant impact of postoperative inflammation on clinical outcomes, our findings highlight the importance of incorporating CAR into routine risk stratification models for CABG patients.

Key points

What is known about the topic?

CABG is an effective surgical intervention that reduces mortality in patients with severe coronary artery disease. However, postoperative complications and mortality rates depend on multiple factors, including the patient's preoperative condition, the severity of inflammatory responses, and metabolic changes. The CAR is a biomarker that simultaneously reflects inflammation severity and nutritional status, making it a valuable prognostic indicator in cardiovascular diseases. The role of preoperative CAR in predicting mortality has been investigated in several studies, with high CAR values consistently associated with poor prognosis. However, there is limited data on the predictive power of postoperative CAR in early mortality following CABG.

What does this study add?

This study establishes postoperative CAR as an independent and strong predictor of mortality in patients undergoing CABG. While previous research has primarily focused on the prognostic value of preoperative CAR, this study demonstrates that postoperative CAR better reflects the dynamic impact of inflammatory processes and exhibits a stronger correlation with mortality. Our findings indicate that elevated postoperative CAR is directly associated with increased inflammation and deteriorating nutritional status, suggesting its potential use in clinical practice to identify patients at risk of poor prognosis in the early postoperative period.

This study highlights the need for incorporating postoperative CAR into routine clinical practice to facilitate early identification of high-risk patients and optimize targeted treatment strategies. Future large-scale prospective studies are necessary to validate these findings and further strengthen the clinical significance of postoperative CAR in predicting mortality following CABG.

Authorship Contribution Statement

All authors have made significant contributions to the work reported, which may include the conception, study design, execution, acquisition of data, analysis and interpretation, or all of these areas; drafting, revising, or critically reviewing the article; giving final approval of the version to be published; agreeing on the journal to which the article has been submitted; and accepting responsibility for all aspects of the work.

Conflict Of Interest Statement

We have no conflict of interest.

Statement On The Use Of Artificial Intelligence

No artificial intelligence application was used.

Financing

No financing available.

REFERENCES

1. Benjamin EJ, et al. Heart disease and stroke statistics—2019 update: a report from the American Heart Association. Circulation. 2019;139(10):e56-e528.
2. Schmidt AF, et al. Unravelling the difference between men and women in post-CABG survival. Front Cardiovasc Med. 2022;9:768972.
3. Montrief T, Koyfman A, Long B. Coronary artery bypass graft surgery complications: A review for emergency clinicians. Am J Emerg Med. 2018;36(12):2289-2297.
4. Gaudino M, et al. Arterial grafts for coronary bypass: a critical review after the publication of ART and RADIAL. Circulation. 2019;140(15):1273-1284.
5. Suleiman M, et al. Early inflammation and risk of long-term development of heart failure and mortality in survivors of acute myocardial infarction: predictive role of C-reactive protein. J Am Coll Cardiol. 2006;47(5):962-968.
6. Aksoy F, Uysal D, Ibrişim E. Relationship between C-reactive protein/albumin ratio and new-onset atrial fibrillation after coronary artery bypass grafting. Rev Assoc Med Bras. 2020;66(8):1070-1076.
7. Pilatis ND, et al. The role of BNP and CRP in predicting the development of atrial fibrillation in patients undergoing isolated coronary artery bypass surgery. Int Scholarly Res Notices. 2013;2013:235018.
8. Liu Y, et al. The prognostic value of C-reactive protein to albumin ratio in patients with sepsis: a systematic review and meta-analysis. Aging Male. 2023;26(1):2261540.
9. Chen C, et al. Association between preoperative hs-CRP/albumin ratio and postoperative SIRS in elderly patients: a retrospective observational cohort study. J Nutr Health Aging. 2022;26(4):352-359.
10. Kahraman S, et al. The prognostic value of C-reactive protein to albumin ratio in patients with isolated degenerative aortic valve stenosis undergoing surgical aortic valve replacement. Braz J Cardiovasc Surg. 2019;35(3):299-306.
11. Berbel-Franco D, et al. The influence of postoperative albumin levels on the outcome of cardiac surgery. J Cardiothorac Surg. 2020;15:1-13.
12. Fang J, et al. Association of preoperative high C-reactive protein to albumin ratio with adverse outcomes after elective non-cardiac surgery in older patients: a multicenter prospective study. J Inflamm Res. 2024;:9255-9268.
13. Çağdaş M, et al. Assessment of relationship between C-reactive protein to albumin ratio and coronary artery disease severity in patients with acute coronary syndrome. Angiology. 2019;70(4):361-368.
14. Park JE, et al. The C-reactive protein/albumin ratio as a predictor of mortality in critically ill patients. J Clin Med. 2018;7(10):333.
15. Ridker PM, et al. Comparison of C-reactive protein and low-density lipoprotein cholesterol levels in the prediction of first cardiovascular events. N Engl J Med. 2002;347(20):1557-1565.
16. Xu, Ruoxin, et al. "Preoperative hypoalbuminemia in patients undergoing cardiac surgery: a meta-analysis." Surgery Today 53.8 (2023): 861-872.
17. Llop-Talaveron J, Badia-Tahull MB, Leiva-Badosa E. An inflammation-based prognostic score, the C-reactive protein/albumin ratio predicts the morbidity and mortality of patients on parenteral nutrition. Clin Nutr. 2018;37(5):1575-1583.
18. Seoudy H, et al. C-reactive protein to albumin ratio in patients undergoing transcatheter aortic valve replacement. Mayo Clin Proc. 2022;97(5):.
19. Karabağ Y, et al. Relationship between C-reactive protein/albumin ratio and coronary artery disease severity in patients with stable angina pectoris. J Clin Lab Anal. 2018;32(7):e22457.
20. Karas PL, Goh SL, Dhital K. Is low serum albumin associated with postoperative complications in patients undergoing cardiac surgery? Interact Cardiovasc Thorac Surg. 2015;21(6):777-786.
21. Katkat F, et al. C-reactive protein to albumin ratio as a novel inflammatory-based marker for 30-day mortality in patients undergoing transcatheter aortic valve replacement. Braz J Cardiovasc Surg. 2022;37(3):292.

22. Mohamed SA, ElHawary R. C-Reactive protein/albumin ratio as an independent predictor of mortality in critically ill pediatric patients. J Child Sci. 2020;10(1):e1-e11.
23. Artac I, et al. Assessment of the relationship between C-reactive protein to albumin ratio and late-term mortality in patients with acute pulmonary embolism. Asian Cardiovasc Thorac Ann. 2023;31(4):332-339.
24. Oh AR, et al. Preoperative C-reactive protein/albumin ratio and mortality of off-pump coronary artery bypass graft. Front Cardiovasc Med. 2024;11:1354816.
25. Oh TK, Song IA, Lee JH. Clinical usefulness of C-reactive protein to albumin ratio in predicting 30-day mortality in critically ill patients: A retrospective analysis. Sci Rep. 2018;8(1):14977.
26. Xu X, et al. Evaluation of the prognostic role of neutrophil-lymphocyte ratio, C-reactive protein-albumin ratio, and platelet-lymphocyte ratio in patients with the co-presentation of coronary artery disease and COVID-19. Infect Drug Resist. 2024;:885-897.
27. Kilinc A, et al. Effects of prognostic nutrition index, neutrophil/lymphocyte ratio, and C-reactive protein/albumin ratio on prognosis undergoing open heart surgery. 2025.
28. Menon V, et al. Relationship between C-reactive protein, albumin, and cardiovascular disease in patients with chronic kidney disease. Am J Kidney Dis. 2003;42(1):44-52.
29. Bayrak M. Predictive value of C-reactive protein/albumin ratio in patients with chronic complicated diabetes mellitus. Pak J Med Sci. 2019;35(6):1616.
30. Çınar T, et al. Prognostic efficacy of C-reactive protein/albumin ratio in ST elevation myocardial infarction. Scand Cardiovasc J. 2019;53(2):83-90.