

Original Research Article

Association between preoperative C-reactive protein and atrial fibrillation after off-pump coronary artery bypass grafting

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ABSTRACT

Background: Atrial fibrillation (AF) is the most common cardiac arrhythmia and is associated with significant morbidity and mortality. This study aims to assess the association between preoperative C-reactive protein (CRP) levels and postoperative AF in Bangladeshi patients undergoing off-pump CABG.

Methods: This comparative, cross-sectional study was conducted at the Department of Cardiac Surgery, National Institute of Cardiovascular Diseases and Hospital (NICVD), Dhaka, Bangladesh, from July 2020 to June 2022, including 70 adult OPCAB patients divided by preoperative CRP levels (Group A: 0–<6 mg/l, Group B: 6–10 mg/l) to assess its association with postoperative atrial fibrillation. Standard preoperative evaluation, anesthesia, grafting and monitoring of intra- and postoperative events were performed, with data analyzed using SPSS-26 ($p < 0.05$).

Results: Among 70 patients undergoing off-pump CABG, baseline demographic, clinical, laboratory and operative variables were comparable between groups (all $p > 0.05$). Group A had significantly shorter ICU stay (3.71 ± 0.96 vs 3.75 ± 0.91 days, $p = 0.010$) and hospital stay (8.94 ± 2.96 vs 10.91 ± 2.81 days, $p = 0.006$). Postoperative atrial fibrillation occurred more frequently in Group B (40.0%) than Group A (11.4%) ($p = 0.006$). Multivariable analysis identified preoperative CRP (6–10 mg/dl) as the sole independent predictor of postoperative AF (OR 6.32, $p = 0.006$).

Conclusions: Elevated preoperative CRP is an independent predictor of postoperative atrial fibrillation and prolonged ICU and hospital stay after off-pump CABG, highlighting its role in risk stratification and prevention.

Keywords: Atrial fibrillation, CAD, C-reactive protein, OPCAB

INTRODUCTION

AF is the most common cardiac arrhythmia and is associated with significant morbidity and mortality due to its potential to cause thromboembolic events, heart failure and other cardiovascular complications. Postoperative atrial fibrillation (POAF), defined by the Society of Thoracic Surgeons (STS) Adult Cardiac Surgery

Database as new-onset AF or atrial flutter requiring treatment, is a frequent and serious complication following cardiac surgery.¹ A more specific definition of POAF includes new-onset AF/flutter detected on rhythm monitoring or electrocardiogram (ECG) lasting ≥ 5 minutes and requiring intervention.¹ Despite this, the true incidence of POAF may be underestimated, as many episodes are transient or asymptomatic and may not

trigger clinical intervention. POAF has been reported to occur in approximately 40–60% of patients undergoing cardiac surgery and it is the most common complication following isolated coronary artery bypass grafting (CABG) in Bangladesh, affecting nearly one-quarter of patients.^{2,3} The occurrence of POAF has been linked to increased postoperative complications, including ventricular arrhythmias, myocardial infarction, heart failure, acute kidney injury, stroke, neurocognitive decline, infection, prolonged mechanical ventilation, extended hospital stays, higher healthcare costs and elevated mortality rates.^{4,5}

Multiple perioperative factors contribute to the development of POAF. Surgical atrial injury, myocardial ischemia and a hyperadrenergic state during and after cardiac surgery trigger inflammatory cascades that can promote electrophysiological changes in atrial tissue, leading to arrhythmogenesis.⁶ In this context, CRP, a sensitive and widely available serum marker of systemic inflammation, has been identified as a potential predictor of POAF.

Elevated preoperative CRP levels have been associated with a higher likelihood of developing POAF in both on-pump and off-pump cardiac surgeries.⁷ CRP levels typically rise significantly following surgery, peaking around the third postoperative day and then gradually decrease, although they often remain elevated above baseline by the end of the first postoperative week. The magnitude of CRP elevation correlates with the extent of surgical trauma and the body's inflammatory response.⁸

Although systemic inflammation has been implicated in both the initiation and maintenance of AF, studies examining the predictive value of preoperative CRP for postoperative AF have produced mixed results. These inconsistencies may be due to variations in study populations, the types of cardiac procedures performed or the use of cardiopulmonary bypass. Identifying reliable preoperative clinical predictors of POAF following off-pump CABG is therefore critical for implementing targeted preventive strategies, optimizing perioperative care and ultimately improving patient outcomes.⁹

Currently, there is a lack of data on the incidence and risk factors of POAF in Bangladeshi patients undergoing off-pump CABG, particularly in relation to elevated preoperative CRP levels. Assessing this association could help identify patients at higher risk, guide preemptive interventions and reduce the incidence of AF and related postoperative complications.

Furthermore, CRP measurement is simple, cost-effective and widely accessible, making it a practical tool for risk stratification in routine clinical practice. Understanding the role of preoperative inflammatory status in POAF development may also provide insights into the underlying pathophysiology and inform strategies to improve perioperative care for cardiac surgery patients.

Objective

To evaluate the association between preoperative C-reactive protein levels and the incidence of postoperative atrial fibrillation following off-pump coronary artery bypass grafting.

METHODS

This comparative, cross-sectional study was conducted at the Department of Cardiac Surgery, NICVD, Sher-e-Bangla Nagar, Dhaka, Bangladesh, from July 2020 to June 2022. A total of 70 adult patients who underwent off-pump coronary artery bypass grafting (OPCAB) and met the predefined inclusion and exclusion criteria were enrolled. Patients were divided into two groups based on preoperative C-reactive protein (CRP) levels: Group A (CRP 0 to <6 mg/l) and Group B (CRP 6–10 mg/l). The study aimed to evaluate the association between preoperative CRP levels and the incidence of postoperative atrial fibrillation following OPCAB.

Inclusion criteria

Adult patients undergoing OPCAB. Preoperative sinus rhythm. Group A: CRP 0 to <6 mg/l. Group B: CRP 6–10 mg/l.

Exclusion criteria

Preexisting atrial fibrillation or other arrhythmias. Patients undergoing on-pump CABG or other cardiac surgeries. Active infection or inflammatory conditions affecting CRP levels. Severe renal or hepatic dysfunction. Patients who did not provide informed consent.

After obtaining institutional review board approval and informed consent, eligible patients were enrolled purposively. Preoperative assessment included detailed history, clinical examination and relevant investigations. All patients received oral midazolam (7.5 mg) at night and injectable antibiotics on the morning of surgery. Standard anesthetic induction, maintenance and recovery protocols were followed, with oxygenation via face mask.

Peripheral and central venous catheters were inserted under aseptic precautions. Median sternotomy was performed, with simultaneous harvesting of the great saphenous vein and preparation of the internal mammary artery for grafting. Distal anastomosis of the left internal mammary artery to the LAD and saphenous vein grafting to other target vessels were completed as planned.

Intraoperative events, including atrial fibrillation, ventricular tachycardia or ventricular fibrillation, were recorded and postoperative AF and serum electrolytes were monitored. Data were analyzed using SPSS-26, with continuous variables presented as mean±SD and categorical variables as frequency and percentage. Statistical significance was set at $p \leq 0.05$.

RESULTS

The mean age of patients was similar between Group A (53.31±6.67 years) and Group B (53.69±7.69 years), with the majority aged 51–60 years (18 patients, 51.4% in Group A, 15 patients, 42.9% in Group B). Males predominated in both groups (26 patients, 74.3% in Group A, 29 patients, 82.9% in Group B). The mean BMI was 25.64±3.58 kg/m² in Group A and 24.68±3.53 kg/m² in Group B, with most patients having a normal BMI (48.6% in Group A, 60.0% in Group B). Hypertension was present in 68.6% of Group A and 65.7% of Group B, diabetes mellitus in 37.1% and 51.4%, COPD in 11.4% and 28.6% and dyslipidemia in 82.9% and 88.6%, respectively. Left ventricular ejection fraction was comparable between the groups (48.77±7.44% vs 49.74±7.12%), as was the average number of grafts (2.83±0.38 vs 2.91±0.28). Preoperative serum potassium and magnesium were similar between the groups, with Group A having 4.41±0.38 mmol/l and 1.83±0.19 mg/dl and Group B 4.27±0.39 mmol/l and 1.78±0.16 mg/dl, respectively. Regarding coronary artery disease severity, single-vessel disease was present in 20.0% of Group A and 17.1% of Group B, double-vessel disease in 31.4% in both groups and triple-vessel disease in 42.9% and 57.1%, respectively. No statistically significant differences were observed between the groups for these parameters.

The mean duration of mechanical ventilation was 5.93±0.43 hours in Group A and 6.02±0.33 hours in Group B. Patients in Group A had a shorter ICU stay (3.71±0.96 days) and hospital stay (8.94±2.96 days) compared with Group B (3.75±0.91 days and 10.91±2.81 days, respectively). Inotropic support was required in 42.9% of Group A and 51.4% of Group B, while blood transfusion was given to 31.4% and 42.9%, respectively. Postoperative serum potassium and magnesium were 4.16±0.47 vs 4.36±0.43 mmol/l and 1.93±0.17 vs 1.96±0.15 mg/dl in Group A and B, respectively. ICU and hospital stay differences were statistically significant, while other postoperative outcomes showed no significant difference.

Postoperative atrial fibrillation occurred in 4 patients (11.4%) in Group A and 14 patients (40.0%) in Group B, with the difference being statistically significant (p=0.006). The remaining patients remained in sinus rhythm (31 patients, 88.6% in Group A, 21 patients, 60.0% in Group B). Multivariable analysis identified preoperative CRP as the only independent predictor of postoperative atrial fibrillation. Patients with CRP levels of 6–10 mg/dl had 6.32-fold higher odds of developing AF (β=1.81, P=0.006; 95% CI 1.68–23.78). Postoperative serum potassium (OR 2.42, P=0.217) and magnesium (OR 0.41, p=0.632) were not statistically significant predictors.

Table 1: Demographic and clinical characteristics of patients undergoing off-pump CABG (n=70).

Category	Variables	Group A (n=35)	Group B (n=35)	P value
Age (in years)	41–50	13 (37.1)	13 (37.1)	0.830
	51–60	18 (51.4)	15 (42.9)	
	61–70	4 (11.4)	7 (20.0)	
	Mean±SD (years)	53.31±6.67	53.69±7.69	
Sex	Male	26 (74.3)	29 (82.9)	0.382
	Female	9 (25.7)	6 (17.1)	
Body mass index (BMI)	Normal (18.5–24.9 kg/m ²)	17 (48.6)	21 (60.0)	0.261
	Overweight (25–29.9 kg/m ²)	15 (42.9)	13 (37.1)	
	Obese (>30 kg/m ²)	3 (8.6)	1 (2.9)	
	Mean±SD (kg/m ²)	25.64±3.58	24.68±3.53	
Comorbidities	Hypertension (HTN)	24 (68.6)	23 (65.7)	0.799
	Diabetes mellitus (DM)	13 (37.1)	18 (51.4)	0.336
	Chronic obstructive pulmonary disease (COPD)	4 (11.4)	10 (28.6)	0.133
	Dyslipidemia	29 (82.9)	31 (88.6)	0.734
	LV ejection fraction (Mean±SD)	48.77±7.44	49.74±7.12	0.579
Cardiac outcomes	Average number of grafts (Mean±SD)	2.83±0.38	2.91±0.28	0.482

Table 2: Preoperative laboratory values and coronary artery disease severity (n=70).

Variables	Group A (n=35)	Group B (n=35)	P value	
Preoperative laboratory values	Serum potassium (mmol/l)	4.41±0.38	4.27±0.39	0.137
	Serum magnesium (mg/dl)	1.83±0.19	1.78±0.16	0.255
Coronary artery disease severity	Single vessel disease	7 (20.0%)	6 (17.1%)	1.000
	Double vessel disease	11 (31.4%)	11 (31.4%)	1.000
	Triple vessel disease (TVD)	15 (42.9%)	20 (57.1%)	0.232

Table 3: Postoperative clinical and biochemical outcomes (n=70).

Variables	Group A (n=35)	Group B (n=35)	P value
Mechanical ventilation time (in hours)	5.93±0.43	6.02±0.33	0.293
Duration of ICU stay (in days)	3.71±0.96	3.75±0.91	0.010
Length of hospital stay (in days)	8.94±2.96	10.91±2.81	0.006
Inotropic support	15 (42.9%)	18 (51.4%)	0.473
Blood transfusion	11 (31.4%)	15 (42.9%)	0.322
Serum potassium (mmol/l)	4.16±0.47	4.36±0.43	0.076
Serum magnesium (mg/dl)	1.93±0.17	1.96±0.15	0.414

Table 4: Incidence of postoperative atrial fibrillation (n=70).

Postoperative atrial fibrillation	Group A (n=35)	Group B (n=35)	P value
Yes	4 (11.4%)	14 (40.0%)	0.006
No	31 (88.6%)	21 (60.0%)	

Table 5: Multivariable logistic regression analysis for predictors of postoperative atrial fibrillation.

Variables	β	S.E.	P value	Odds ratio (OR)	95% CI
Preoperative CRP (6–10 mg/dl)	1.81	0.677	0.006	6.315	1.677–23.780
Postoperative serum potassium (K ⁺)	0.898	0.727	0.217	2.416	0.591–10.209
Postoperative serum magnesium (Mg ²⁺)	-0.896	1.868	0.632	0.408	0.010–15.886

DISCUSSION

POAF is a common and clinically significant complication following cardiac surgery, particularly CABG and is associated with increased morbidity, prolonged hospitalization and higher healthcare costs. The findings of this study demonstrate that elevated preoperative CRP levels are strongly associated with the development of POAF after off-pump CABG, with patients in the higher CRP group showing a significantly higher incidence of atrial fibrillation and longer hospital stays. These results highlight the clinical relevance of assessing preoperative inflammatory status to identify high-risk patients and guide targeted preventive strategies aimed at reducing POAF-related complications and optimizing perioperative care.

In the present study, the mean age of patients in Group A and Group B was almost identical (53.31±6.67 years vs 53.69±7.69 years), with no statistically significant difference between the groups (p=0.830). Most patients belonged to the 51–60-year age group in both cohorts. This finding is consistent with previous studies conducted in Bangladesh and elsewhere, where no significant age difference was observed between comparison groups.^{10,11} In contrast, Biancari et al reported a higher mean age in both groups (63.7±9.1 vs 65.1±9.6 years), which may reflect differences in population demographics and healthcare access between Western countries and Bangladesh, suggesting that age-related differences were unlikely to influence the observed association between preoperative CRP and postoperative atrial fibrillation in the present cohort.¹² Sex distribution in the present study showed a predominance of male patients in both Group A

(74.3%) and Group B (82.9%), without a significant intergroup difference (p=0.382). This male predominance is consistent with most published studies on coronary artery bypass grafting and postoperative atrial fibrillation.^{7,10,11,13-15} Biancari et al also reported similar male predominance (76.4% vs 70.2%), supporting the notion that coronary artery disease requiring CABG is more common among men across different populations and indicating that sex was unlikely to confound the relationship between preoperative CRP levels and postoperative AF observed in this study.¹²

Regarding body mass index, most patients in both groups had a normal BMI (48.6% in Group A and 60.0% in Group B), followed by overweight status (42.9% vs 37.1%), while obesity was relatively uncommon (8.6% in Group A and 2.9% in Group B). The mean BMI was slightly higher in Group A (25.64±3.58 kg/m²) compared with Group B (24.68±3.53 kg/m²), but the difference was not statistically significant (p=0.261). These findings are comparable to previously published studies where BMI distribution did not differ significantly between CABG groups, indicating that differences in adiposity were unlikely to account for variations in postoperative atrial fibrillation risk and allowing clearer assessment of the impact of preoperative inflammation.^{7,11,13,15}

In this study, common comorbidities including hypertension, diabetes mellitus, chronic obstructive pulmonary disease and dyslipidemia were similarly distributed between Group A and Group B, with no statistically significant differences (p>0.05 for all). Hypertension was present in 68.6% of Group A and 65.7% of Group B, diabetes mellitus in 37.1% and

51.4%, COPD in 11.4% and 28.6% and dyslipidemia in 82.9% and 88.6%, respectively. These results are in line with earlier studies reporting comparable distributions of cardiovascular risk factors among CABG patients, suggesting that traditional comorbid conditions did not drive the increased incidence of postoperative AF and reinforcing the relevance of preoperative CRP as an independent factor.^{10,11,13,15}

Left ventricular ejection fraction was comparable between Group A and Group B (48.77±7.44% vs 49.74±7.12%, $p=0.579$), consistent with several international studies.^{7,10-12} Similarly, the average number of grafts did not differ significantly between the groups (2.83±0.38 vs 2.91±0.28, $p=0.482$), corresponding with the findings of Cappabianca et al indicating that myocardial function and surgical complexity were well balanced and unlikely to explain differences in postoperative atrial fibrillation outcomes.¹⁶

Preoperative serum electrolytes were also comparable between the groups, with serum potassium levels of 4.41±0.38 mmol/l in Group A and 4.27±0.39 mmol/l in Group B ($p=0.137$) and serum magnesium levels of 1.83±0.19 mg/dl and 1.78±0.16 mg/dl, respectively ($p=0.255$). In addition, the severity of coronary artery disease categorized as single-, double- or triple-vessel disease did not differ significantly between groups ($p>0.05$ for all categories), confirming that baseline biochemical and anatomical characteristics were well matched and further supporting the interpretation that preoperative inflammatory status rather than electrolyte imbalance or disease extent was central to AF risk.

Postoperative outcomes revealed significant differences in ICU stay and total hospital stay. Group A patients had shorter ICU stays (3.71±0.96 vs 3.75±0.91 days, $p=0.010$) and shorter hospital stays (8.94±2.96 vs 10.91±2.81 days, $p=0.006$) compared with Group B. Although the difference in ICU stay reached statistical significance, the absolute difference was minimal (0.04 days). In contrast, the nearly 2-day longer hospital stay in Group B is clinically substantial and likely reflects the impact of postoperative atrial fibrillation on recovery. Other postoperative variables including mechanical ventilation time, inotropic support, blood transfusion requirement and postoperative serum potassium and magnesium levels did not show statistically significant differences ($p>0.05$). These findings align with previous studies reporting prolonged ICU and hospital stay among patients with a higher inflammatory burden, suggesting that elevated preoperative CRP may indirectly contribute to increased resource utilization through its association with postoperative AF.^{7,10,13,15}

The incidence of postoperative atrial fibrillation was significantly higher in Group B than in Group A (40.0% vs 11.4%, $p=0.006$), providing strong evidence of an association between elevated preoperative CRP levels and postoperative AF. Similar observations have been reported by Kinoshita et al, Lo et al and Erdolu et al

reinforcing the role of systemic inflammation in the pathogenesis of postoperative AF, while the observed incidence in Group B aligns with reported rates of 20–40% following CABG, underscoring the clinical relevance of CRP-based risk stratification.^{7,13,15,17}

Multivariable logistic regression analysis further demonstrated that preoperative CRP was the only independent predictor of postoperative atrial fibrillation, with patients having CRP levels of 6–10 mg/dl showing 6.32-fold increased odds of developing AF (OR=6.315, $p=0.006$), while postoperative serum potassium and magnesium were not significant predictors. These findings are concordant with earlier studies identifying CRP as an independent risk factor for postoperative AF, highlighting the dominant role of preoperative inflammation over postoperative electrolyte fluctuations.^{7,10,18}

The present study demonstrates a clear and clinically meaningful association between elevated preoperative CRP levels and postoperative atrial fibrillation following off-pump CABG. Given the scarcity of similar data in the local population, these findings add important evidence supporting the use of preoperative CRP as a simple, inexpensive and readily available marker for identifying high-risk patients and implementing targeted preventive strategies to reduce postoperative AF-related morbidity, prolonged hospitalization and healthcare costs.

Limitations

The study had a few limitations the study was conducted with a relatively small sample size, which may limit the generalizability of the findings.

Preoperative C-reactive protein levels were assessed using a single baseline measurement, which may not fully reflect dynamic inflammatory status. Postoperative CRP levels were not evaluated, precluding assessment of their potential association with the development of postoperative atrial fibrillation.

CONCLUSION

Postoperative atrial fibrillation is a common complication after off-pump CABG, influenced by systemic inflammation. This study found that elevated preoperative CRP was significantly associated with higher incidence of postoperative AF and longer ICU and hospital stays. Multivariable analysis identified preoperative CRP as the only independent predictor, while postoperative potassium and magnesium were not significant. These findings highlight the importance of assessing preoperative inflammatory status for risk stratification and preventive strategies.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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