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Preoperative Left Atrial Parameters as Predictive Factors for Post-Coronary Artery Bypass Grafting Atrial Fibrillation

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Abstract

Background: Atrial fibrillation (AF) is the most common arrhythmia following coronary artery bypass grafting (CABG), affecting 10% to 40% of patients. Multiple patient-specific and anatomical factors are associated with AF, among which left atrial (LA) size is a key predictor. This study aimed to derive a simple clinical index to identify patients at high risk for AF using available preoperative predictors, including the left atrial volume index (LAVI).

Methods: This prospective observational cohort study enrolled 140 adult patients of both sexes with preoperative sinus rhythm undergoing isolated CABG. Patients were categorized into two groups: an AF group (n=9) and a non-AF group (n=131).

Results: Patients who developed postoperative AF had a significantly higher risk of mortality (p = 0.049), cardiovascular complications (p = 0.034), and congestive heart failure (p = 0.043). However, no significant differences were observed in surgical site infection (p = 0.97) or renal failure (p = 0.56). AF was not a direct cause of death but served as a predictor of increased mortality and other complications. There were no differences in left atrial diameter (3.9 vs. 4.2 cm, p= 0.054) or LAVI (31 vs. 31.6 ml/m3, p= 0.635) between patients with and without postoperative AF, respectively.

Conclusion: Left atrial diameter and LAVI were not found to be significant independent predictors of postoperative AF. However, the development of AF was strongly associated with increased risks of mortality, cardiovascular complications, and congestive heart failure. These findings underscore that postoperative AF, while not a direct cause of death, is a critical marker of adverse outcomes following CABG.

KEYWORDS

Atrial Fibrillation; Coronary Artery Bypass; Left Atrium

Introduction

Atrial fibrillation (AF) is one of the most common complications following cardiac surgery, occurring in approximately 10% to 40% of patients undergoing coronary artery bypass grafting (CABG) [1]. It typically develops within the first five postoperative days, with the peak incidence between 24 and 72 hours, and is rarely observed beyond the first postoperative week [2]. Postoperative AF increases the risk of stroke fourfold compared to patients who maintain a normal heart rhythm [3]. It is frequently associated with serious complications such as heart failure and electrolyte imbalances [4], and it

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doubles the risk of postoperative mortality [5]. These complications elevate treatment costs by prolonging hospital stays, increasing intensive care unit readmissions, and raising the need for medication or reintubation [6].

Multiple patient-related and cardiac factors are associated with AF, among which left atrial (LA) size is considered one of the most significant [7]. Large-scale studies have shown that greater LA diameter and volume are linked to AF, particularly in patients with cardiomyopathy [8]. However, a smaller study found that LA size was not useful for predicting AF after CABG [9]. Several peri- and postoperative factors have been identified as predictors of postoperative AF [9-10]. It is notable, however, that LA diameter and the left atrial volume index (LAVI)—both recognized as important predictors of post-CABG AF—were not included in prediction models. To date, no predictive models for post-CABG AF have incorporated LA size as a variable [10]. The aim of this study was to analyze preoperative factors associated with LA echocardiographic parameters and the development of postoperative AF within 7 days following CABG.

Patients and Methods

Study Design and Population

This prospective observational cohort study was conducted from September 2023 to May 2024 after obtaining approval from the Institutional Ethical Committee of Faculty of Medicine, Cairo University. Written informed consent was obtained from all participants.

We enrolled 140 adult patients of both sexes with ischemic heart disease (IHD), all of whom were in preoperative sinus rhythm and scheduled for isolated CABG.

Exclusion Criteria

Patients were excluded if they had any of the following:

- Rheumatic heart valve disease
- Preoperative atrial fibrillation or other significant arrhythmias
- History of prior cardiac surgery
- Emergency surgery
- Electrolyte imbalances

Preoperative Assessment

All patients underwent a comprehensive evaluation, including:

- Detailed history taking
- General and cardiac physical examination
- Routine preoperative laboratory investigations:
  - Complete blood count (CBC)
  - Liver function tests (bilirubin, liver enzymes, serum albumin, total proteins, prothrombin time)
  - Kidney function tests (serum urea and creatinine)
  - Fasting blood glucose
  - Serum electrolytes (sodium, potassium, calcium, phosphorus)
- Radiological and cardiac investigations:
  - Plain chest X-ray
  - 12-lead electrocardiography (ECG)
  - Preoperative duplex ultrasound of the carotid arteries and both lower limbs
  - Coronary angiography findings

Surgical Procedure

All patients received standardized anesthetic management. Surgical techniques included both on-pump and off-pump approaches, performed via full median sternotomy with the patient in the supine position. The left internal mammary artery (LIMA) was harvested either as a skeletonized or pedicled graft. Saphenous venous grafts were used in the majority of cases; the right internal mammary artery or radial artery was harvested in select patients. The pericardium was opened in all cases.

Stabilization devices were used to facilitate anastomosis on the beating heart in patients who underwent off-pump CABG. For on-pump CABG, aorto-atrial cannulation was performed for cardiopulmonary bypass (CPB). A cardioplegia cannula was secured in the ascending aorta for antegrade warm blood cardioplegia and aortic root venting. After graft preparation, CPB was initiated. In mild hypothermia, myocardial protection was achieved with intermittent warm-blood antegrade cardioplegia: an initial dose (15–20 mEq) administered over 3 minutes, followed by subsequent doses (7–10 mEq) over 2 minutes after each distal anastomosis. Target vessels were

identified angiographically and confirmed by visual and epicardial inspection. Distal anastomoses were constructed using continuous sutures with 7/0 or 8/0 polypropylene. After completing all distal anastomoses, the aortic cross-clamp was removed. Following restoration of cardiac contractility, an aortic side-biting clamp was applied. A small aortotomy was created using an aortic punch, and proximal end-to-side anastomoses were performed with continuous 6/0 polypropylene sutures. The clamp was then removed, air was evacuated from the grafts, and hemostasis was verified. Weaning from CPB was guided by hemodynamic status, with inotropic support or intra-aortic balloon pump insertion as indicated. Chest tubes were placed in the left pleural cavity and anterior mediastinum. The pericardium was left open anteriorly in both groups. No retrocardiac drains were placed to avoid mechanical irritation. Heparin was reversed with protamine sulfate (1:1 ratio) at the end of CPB.

Postoperative Care

All patients were transferred to the intensive care unit (ICU) on mechanical ventilation with continuous monitoring:

- Heart rate via multi-lead monitor
- Blood pressure via arterial line
- Hourly urine output and chest tube drainage

Arterial blood gas analysis was performed every 2 hours for the first 24 hours, then every 8 hours for the next 48 hours. A 12-lead ECG was obtained upon ICU admission and every 12 hours thereafter. Routine laboratory tests (CBC, liver and renal function, coagulation profile) were conducted daily.

Mechanical ventilation was weaned when the following criteria were met:

- Minimal ventilator settings (FiO_2 < 0.45, PIP < 18 cmH_2O, rate < 20/min, SIMV mode with pressure support)
- Clinical tolerance and adequate blood gases
- Hemodynamic stability without active bleeding, arrhythmia, or low cardiac output syndrome

Extubation was performed once the patient was awake, recovered from sedation, and demonstrated full motor power. Inotropic support was weaned based on blood pressure, heart rate, peripheral perfusion, urine output, and serum lactate levels.

Patients were transferred to the ward after weaning from inotropes and mechanical ventilation, following chest tube removal and confirmation of hemodynamic stability. Discharge criteria included:

- Hemodynamic stability
- Absence of sepsis
- Stable sternum
- Clean wounds
- Normal clinical examination of the chest, central nervous system, and vascular system

Outcome Measures

Primary Outcome:

Development of atrial fibrillation within 7 days postoperatively and its association with preoperative left atrial diameter and LAVI measured by transthoracic echocardiography (TTE).

Secondary Outcomes:

Incidence of heart failure, arrhythmias, pulmonary embolism, myocardial infarction, cardiogenic pulmonary edema, cardiovascular events, renal failure, duration of inpatient care, hospitalization length, and mortality.

Sample Size Calculation

Using G*Power software (version 3.0.01) with reference to prior literature [11], a sample size of 140 patients was determined to achieve 95% power with an alpha error of 5% and an effect size of 0.59.

Statistical analysis

Statistical analysis was performed using SPSS version 26 (IBM Inc., Chicago, IL, USA). A two-tailed p-value of <0.05 was considered statistically significant for all tests. Continuous variables were assessed for normality using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots. Normally distributed continuous variables are

Table 1: The demographics and baseline data of the patients who underwent isolated coronary artery bypass grafting. Data were presented as mean±SD or numbers and percentages.

Variable	Value
Age (years)	53.5 ± 9.53
Male	130 (92.86%)
Female	10 (7.14%)
Weight (kg)	87.6 ± 9.26
Height (cm)	172.9 ± 5.71
Body mass index (kg/m²)	29.3 ± 2.55
Body surface area (m²)	2.1 ± 0.12
Diabetes mellitus	66 (47.14%)
Hypertension	68 (48.57%)
Smoking	107 (76.43%)
Chest pain	102 (72.86%)
Heart rate (beats/min)	75.6 ± 10.83
Number of coronary grafts	
Single graft	3 (2.1%)
Two grafts	10 (7.1%)
Three grafts	27 (19.2%)
Four grafts	70 (50%)
Five grafts	30 (21.4%)
Intraoperative adrenaline	32 (22.9%)
Intraoperative adrenaline and noradrenaline	69 (49.3%)
Left ventricular end-diastolic diameter (cm)	5.3 ± 0.61
Left ventricular end-systolic diameter (cm)	3.8 ± 0.61
Ejection fraction (%)	50.7 ± 12.76
Operative time (min)	312 ± 48
Cardiopulmonary bypass time (min)	168 ± 39
Cross-clamp time (min)	89 ± 16

presented as mean ± standard deviation (SD), while non-normally distributed variables are presented as median (interquartile range, IQR). Categorical variables are presented as frequencies and percentages (n, %). Independent samples t-tests were used to compare normally distributed continuous variables between the two groups. For non-normally distributed continuous variables, the Mann-Whitney U test was employed. Differences in proportions for categorical variables between the AF and non-AF groups were analyzed using the Chi-square (χ^2) test. When the expected count in any cell of a contingency table was less than 5, Fisher's exact test was used instead. Paired t-test was used to compare pre and postoperative continuous data.

Results

The study included 140 patients who underwent isolated CABG. The demographic and baseline characteristics of the cohort are presented in Table 1. The mean age was 53.5 ± 9.53 years, and the majority of patients were male (92.86%).

Operative data indicated that the majority of patients received four (50%) or five (21.4%) grafts. The mean operative time was 312 ± 48 minutes. All patients were in normal sinus rhythm preoperatively.

Postoperative AF occurred in 9 patients (6.43%). As shown in Table 2, there was no significant difference in preoperative left atrial diameter (p=0.054) or LAVI (p=0.635) between the AF and non-AF groups. However, patients who developed AF had significantly longer hospital stays (p=0.043) and ICU stays (p=0.038).

The incidence of adverse outcomes was higher in the AF group. Patients with postoperative AF had a significantly increased risk of mortality (11.1% vs. 2.3%, p=0.049), cardiovascular complications (11.1% vs. 1.5%, p=0.034), and congestive heart failure (11.1% vs. 0.76%, p=0.043). There were no significant differences in the rates of renal failure (p=0.57) or surgical site infection (p=0.96) between the groups.

Postoperative laboratory investigations revealed significant changes compared to preoperative values (Table 3). Total leukocyte count (TLC), creatinine, urea, ALT, AST, and C-reactive protein (CRP) were significantly higher postoperatively (p<0.001). Conversely, platelet count, potassium, and magnesium levels were significantly lower postoperatively (p<0.001). Hemoglobin and sodium levels showed no significant change.

Discussion

Atrial fibrillation is a frequent complication after CABG, contributing to increased morbidity, longer hospital stays, and higher healthcare costs [12 - 14]. This study investigated the role of preoperative LA parameters as predictors for

Table 2: Comparison of left atrial parameters and surgical outcomes between patients with and without postoperative atrial fibrillation following isolated coronary artery bypass grafting. Data were presented as mean±SD or numbers and percentages.

Variable	AF group (n=9)	Non-AF group (n=131)	P-value
Left atrial diameter (cm)	3.92 ± 0.42	4.18 ± 0.39	0.054
Left atrium volume index (ml/m²)	31.03 ± 3.38	31.64 ± 3.72	0.635
Hospital stay (days)	16 ± 12.7	6 ± 1.4	0.043
ICU stay (days)	13 ± 11.3	3 ± 1.4	0.038
Mortality	1 (11.1%)	3 (2.3%)	0.049
Cardiovascular complications	1 (11.1%)	2 (1.5%)	0.034
Congestive heart failure	1 (11.1%)	1 (0.76%)	0.043
Renal failure	1 (11.1%)	0 (0.0%)	0.57
Surgical site infection	2 (22.2%)	14 (10.7%)	0.96

postoperative AF (POAF) in a cohort of 140 patients undergoing isolated CABG.

The incidence of POAF in our study was 6.43% (9 patients), which is at the lower end of the 10-40% range reported in the literature [1]. This lower incidence may be attributed to our strict exclusion criteria, which omitted patients with pre-existing arrhythmias, rheumatic valve disease, emergency surgery, or prior cardiac operations—all known risk factors for POAF.

Our primary finding was that neither preoperative LA diameter nor LAVI was significantly associated with the development of POAF. The mean LA diameter and LAVI were not statistically different between the AF and non-AF groups (p=0.054 and p=0.635, respectively). This result is consistent with some previous studies. For instance, Omar et al. [15] also reported no significant difference in LA diameter between patients who developed POAF and those who remained in sinus rhythm. Similarly, Zaman et al. [9] found LA size to be a poor predictor in their risk stratification model. In contrast, other large-scale studies have established a strong link between increased LA size and AF [7, 8]. The discrepancy may arise from differences in patient populations. Our study's exclusion of patients with significant structural heart disease or chronic AF, where LA remodeling is more pronounced, likely contributed to the lack of association. The patients in our cohort had relatively similar LA dimensions, reducing the predictive power of this variable.

Table 3: Comparison of preoperative and postoperative laboratory results. Data were presented as mean±SD or numbers and percentages.

Investigation	Preoperative	Postoperative	P-value
Hemoglobin (g/dl)	13.25 ± 0.81	12.6 ± 11.12	0.492
Total leukocyte count (× 10^3/µL)	6.81 ± 1.41	16.2 ± 16.46	<0.001
Platelets (× 10^3/µL)	300.94 ± 61.3	211.98 ± 54.59	<0.001
Creatinine (mg/dL)	0.98 ± 0.18	1.15 ± 0.12	<0.001
Urea (mg/dL)	33.02 ± 7.17	42.29 ± 7.34	<0.001
Sodium (mEq/L)	139.84 ± 2.55	139.91 ± 2.65	0.836
Potassium (mEq/L)	4.07 ± 0.16	3.95 ± 0.2	<0.001
Magnesium (mg/dL)	2.06 ± 0.16	1.93 ± 0.2	<0.001
Alanine aminotransferase (U/L)	18.59 ± 6.56	38.73 ± 42.28	<0.001
Aspartate aminotransferase (U/L)	24.34 ± 7	37.84 ± 26.3	<0.001
C-reactive protein (mg/dL)	4.19 ± 0.91	34.94 ± 39.4	<0.001

Despite the lack of association with LA size, the development of POAF had significant clinical consequences. Patients in the AF group experienced significantly longer ICU and total hospital stays, consistent with findings from numerous other studies [6]. More importantly, POAF was associated with a significantly higher risk of mortality, cardiovascular events, and congestive heart failure. The mortality rate was 11.1% in the AF group compared to 2.3% in the non-AF group (p=0.049). This finding aligns with Omar et al. [15], who also observed higher early mortality in their POAF group. This underscores that while POAF itself may not be the direct cause of death, it serves as a powerful marker for a patient's vulnerability to severe postoperative complications.

The study also highlighted the systemic inflammatory response following CABG. Postoperatively, we observed significant elevations in inflammatory markers, such as CRP and TLC, as well as markers of organ stress, including creatinine, urea, and liver enzymes (ALT, AST). This is a well-documented phenomenon, often attributed to ischemia-reperfusion injury and contact with the cardiopulmonary bypass circuit [16]. The significant decrease in platelets, potassium, and magnesium levels post-surgery is also a known consequence of hemodilution, consumption during CPB, and postoperative diuresis [17-19]. These physiological shifts create an arrhythmogenic substrate that can contribute to the onset of POAF.

Our operative times, with a mean CPB time of 168 minutes and cross-clamp time of 89 minutes, are within the range of complex CABG procedures. These durations are longer than those reported in some studies, such as Nagi et al. [14], which could be due to differences in surgical complexity and patient case mix across institutions.

Limitations

This study has several limitations. First, the patient cohort was predominantly male, which prevented any analysis of gender-based differences in POAF incidence. Second, the relatively small number of patients who developed AF (n=9) limits the statistical power to detect smaller differences and build a robust predictive model. Third, a detailed medication history, particularly the use of beta-blockers or ACE inhibitors, was not fully analyzed, which could have influenced the incidence of POAF. Future research with a larger, more diverse cohort is needed to further clarify the complex interplay of factors leading to POAF after CABG.

Conclusion

In this prospective cohort study of patients undergoing isolated CABG, preoperative left atrial diameter and LAVI were not found to be significant predictors of postoperative atrial fibrillation. However, the development of AF was a critical marker of adverse outcomes, strongly associated with increased mortality, cardiovascular complications, congestive heart failure, and prolonged hospital stays. The study also confirmed the significant systemic inflammatory and metabolic changes that occur following CABG. While LA size may not be a reliable predictor in a low-risk population, the occurrence of POAF itself remains a major clinical concern that warrants vigilant monitoring and management.

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