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PREOPERATIVE LEFT ATRIAL STRAIN AS A PREDICTOR OF POSTOPERATIVE ATRIAL FIBRILLATION IN PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFTING

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ABSTRACT

Objectives: To determine whether preoperative left atrial reservoir strain (LASr) was associated with postoperative atrial fibrillation (POAF) in patients undergoing coronary artery bypass grafting (CABG).

Study Design and Setting: Prospective observational study conducted at Punjab Institute of Cardiology over six months, from December 2025 to May 2026.

Methodology: Eighty adult patients undergoing elective isolated CABG were enrolled. Preoperative clinical assessment, electrocardiography, and conventional echocardiography were performed. Left atrial reservoir strain was assessed using two-dimensional speckle-tracking echocardiography. Patients were continuously monitored postoperatively for new-onset AF. Perioperative beta-blocker and amiodarone use was documented. Patients were categorized into POAF and non-POAF groups. Statistical analysis was performed using SPSS version 27. Logistic regression was used to identify independent predictors of POAF.

Results: POAF occurred in 25 (31.3%) patients. Patients who developed POAF had significantly lower preoperative LASr than those without POAF (21.8±4.7% vs. 28.9±5.3%; $p<0.001$). Left atrial volume index was also higher in the POAF group (33.2±6.7 vs. 28.0±6.1 mL/m²; $p=0.002$). On multivariable analysis, lower LASr independently predicted POAF (OR=0.82, 95% CI: 0.73–0.92; $p=0.001$), along with age and left atrial volume index.

Conclusions: Reduced preoperative LASr was independently associated with POAF following CABG. Preoperative left atrial strain assessment may provide additional risk stratification for patients undergoing CABG.

KEYWORDS: Atrial Fibrillation; Coronary Artery Bypass; Echocardiography; Left Atrium; Postoperative Complications; Risk Assessment; Strain Imaging.

INTRODUCTION

Postoperative atrial fibrillation (POAF) is one of the most frequent complications encountered after cardiac surgery, particularly following coronary artery bypass grafting (CABG). Depending on the surgical population, monitoring strategy, and definition used, POAF has been reported in approximately 20–50% of patients undergoing cardiac surgery, with CABG representing one of the major clinical settings in which this arrhythmia occurs.[1–3] Although POAF is often transient and develops within the first few postoperative days, its occurrence may complicate postoperative recovery through hemodynamic instability, increased need for pharmacological or electrical rhythm management, prolonged intensive care and hospital stay, and an increased risk of thromboembolic complications.[1,3,4] A systematic review and meta-analysis demonstrated that POAF is associated with adverse perioperative outcomes and may also have implications for longer-term cardiovascular outcomes.[2] Consequently, early identification of patients at increased risk of POAF remains an important component of perioperative cardiovascular assessment.

The development of POAF is multifactorial and involves an interaction between pre-existing atrial substrate and acute postoperative triggers. Advanced age, hypertension, impaired ventricular function, renal dysfunction, chronic pulmonary disease, and other cardiovascular comorbidities have been identified as clinical risk factors. [1,5] In addition, cardiac surgery itself produces several transient electrophysiological and inflammatory changes that may facilitate atrial fibrillation. Surgical trauma, autonomic activation, systemic inflammation, oxidative stress, atrial ischemia, alterations in volume status, electrolyte disturbances, and the use of cardiopulmonary bypass can contribute to atrial electrical and structural remodeling.[3,5,6] The combination of a vulnerable atrial substrate with these acute postoperative

triggers can promote conduction heterogeneity, ectopic activity, and re-entry, ultimately resulting in POAF.[3],[6] Despite recognition of these risk factors, conventional preoperative prediction approaches do not reliably identify all patients who will subsequently develop POAF, creating a need for more sensitive markers of atrial vulnerability.

The left atrium has an important role in ventricular filling and cardiovascular adaptation. Its mechanical function can be divided into three phases: reservoir, conduit, and contractile functions. Conventional echocardiographic measurements such as left atrial volume and volume index provide structural information but may not adequately detect early abnormalities in atrial myocardial performance. Speckle-tracking echocardiography allows assessment of myocardial deformation by following acoustic markers within the myocardium throughout the cardiac cycle. Left atrial longitudinal strain can therefore provide functional information that may become abnormal before substantial atrial enlargement develops. [7], [8] The reservoir component, commonly termed left atrial reservoir strain (LASr) or peak atrial longitudinal strain (PALS), reflects the ability of the atrium to expand during ventricular systole and is influenced by atrial compliance, relaxation, and ventricular interaction. The standardized terminology for left atrial deformation includes reservoir, conduit, and contractile strain, although measurements may vary according to imaging platform and acquisition methodology. [7]

Reduced left atrial strain has been increasingly recognized as a marker of atrial cardiomyopathy and structural remodeling. Atrial fibrosis, increased filling pressures, impaired compliance, and altered myocardial relaxation can reduce atrial deformation before overt anatomical remodeling becomes evident. [8], [9] Because atrial fibrosis and mechanical dysfunction are important components of the substrate underlying atrial fibrillation, reduced LA strain may provide clinically relevant information regarding susceptibility to postoperative arrhythmia. Recent work has also demonstrated that speckle-tracking-derived LA strain can identify functional abnormalities that may not be fully reflected by conventional left atrial volume measurements. [10] This makes LA strain a potentially attractive non-invasive parameter for preoperative risk assessment in patients scheduled for CABG.

The association between preoperative LA strain and POAF was initially demonstrated in relatively small CABG cohorts. Earlier investigations showed that patients who developed POAF had lower preoperative LA global strain than patients who remained in sinus rhythm, and LA strain remained associated with POAF after adjustment for conventional clinical and echocardiographic variables. [11] These findings suggested that functional atrial impairment could provide incremental information beyond left atrial size. Subsequent investigations have strengthened this observation. Kislitsina et al. evaluated patients undergoing isolated CABG and demonstrated that abnormalities in preoperative LA strain were associated with subsequent development of POAF, supporting the concept that impaired atrial deformation may identify a pre-existing substrate for postoperative rhythmogenesis. [12]

More recent studies have provided stronger evidence for the predictive value of LA strain in CABG populations. In a prospective multicenter study of 310 patients undergoing CABG, POAF occurred in approximately one-third of participants, and lower preoperative global PALS was associated with a greater risk of POAF. A preoperative global PALS value below 28% was associated with increased postoperative arrhythmia risk after adjustment for relevant clinical variables.[13] Similarly, a study involving patients undergoing off-pump CABG reported an association between reduced LA strain and POAF, suggesting that the predictive relationship may also be present when cardiopulmonary bypass is avoided.[14] A prospective study published in 2025 further reported that preoperative LA strain was associated with POAF in patients undergoing isolated CABG and demonstrated predictive information beyond conventional clinical and echocardiographic parameters.[15]

The growing body of evidence has recently been reinforced by systematic evidence synthesis. A 2026 systematic review and meta-analysis involving 24 observational studies and 2,242 adult cardiac-surgery patients found that preoperative LA reservoir, conduit, and contractile strain were significantly lower among patients who developed POAF. The pooled analysis identified LA reservoir strain as particularly relevant, although substantial heterogeneity was observed between studies, including differences related to echocardiographic vendors, filling pressures, and patient characteristics. [16] These findings support the biological and clinical relevance of preoperative LA deformation while also demonstrating that further study is needed to establish population-specific thresholds and standardized approaches.

Despite these developments, several questions remain regarding the role of preoperative LA strain specifically in patients undergoing CABG. Differences in surgical technique, patient characteristics, strain-analysis software, definition of POAF, and timing of echocardiographic assessment may influence the strength of the observed association. Moreover, conventional parameters such as age, left atrial volume index, left ventricular ejection fraction, and diastolic function remain important and should be considered alongside LA strain rather than replaced by it. Therefore, evaluating LA strain in a defined CABG population may help clarify whether this echocardiographic parameter provides meaningful predictive information for postoperative rhythm disturbances.

The present study was therefore designed to evaluate preoperative left atrial strain as a predictor of postoperative atrial fibrillation in patients undergoing coronary artery bypass grafting. The study focuses on determining whether impaired preoperative LA strain is associated with subsequent development of POAF and whether LA strain may provide additional predictive information beyond conventional clinical and echocardiographic parameters. Establishing such

an association could support more individualized postoperative monitoring and contribute to improved preoperative risk stratification of patients undergoing CABG.

METHODOLOGY

A prospective observational study was conducted at the Punjab Institute of Cardiology, Pakistan, from December 2025 to May 2026. A total of 80 adult patients undergoing elective isolated coronary artery bypass grafting (CABG) were enrolled through consecutive sampling. Patients with previous atrial fibrillation, significant valvular disease, previous cardiac surgery, emergency CABG, or inadequate echocardiographic images were excluded. Preoperative demographic characteristics, cardiovascular risk factors, routine investigations, electrocardiographic findings, and conventional echocardiographic parameters were recorded. Left atrial reservoir strain (LASr/peak atrial longitudinal strain) was assessed using two-dimensional speckle-tracking echocardiography before surgery. Perioperative use of beta-blockers and amiodarone, including preoperative continuation/initiation and postoperative administration, was documented as potential confounding variables. Patients were continuously monitored postoperatively for new-onset atrial fibrillation. POAF was defined as a new episode of AF lasting ≥5 minutes or requiring pharmacological or electrical intervention. Clinical, echocardiographic, operative, and medication-related variables were compared between patients who developed POAF and those who remained in sinus rhythm. Data were analyzed using SPSS version 27.0. Continuous variables were expressed as mean±SD or median (IQR), and categorical variables as frequencies and percentages. Appropriate comparative tests were applied, followed by multivariable logistic regression including beta-blocker and amiodarone exposure to identify independent predictors of POAF. ROC curve analysis was performed to evaluate the predictive performance of LA strain. A p-value <0.05 was considered statistically significant. Ethical approval was obtained from the institutional ethics committee, and written informed consent was obtained from all participants.

RESULTS

A total of **80 patients** undergoing CABG were included in the study. The mean age of the study population was **59.8±8.7 years**, and 62 (77.5%) were male. Postoperative atrial fibrillation (POAF) developed in **25 (31.3%) patients**, while 55 (68.7%) remained in sinus rhythm throughout the postoperative monitoring period. Patients who developed POAF were older and had a higher prevalence of hypertension. Preoperative left atrial reservoir strain was significantly lower among patients who developed POAF compared with those who did not (**21.8±4.7% vs. 28.9±5.3%, p<0.001**).

Table 1. Baseline clinical and demographic characteristics of the study population

Variable	Total (n=80)	POAF (n=25)	No POAF (n=55)	p-value
Age, years	59.8±8.7	63.1±7.2	58.3±9.0	0.018
Male sex	62 (77.5%)	20 (80.0%)	42 (76.4%)	0.719
Hypertension	55 (68.8%)	21 (84.0%)	34 (61.8%)	0.048
Diabetes mellitus	43 (53.8%)	16 (64.0%)	27 (49.1%)	0.224
Dyslipidemia	58 (72.5%)	20 (80.0%)	38 (69.1%)	0.315
Current smoker	31 (38.8%)	11 (44.0%)	20 (36.4%)	0.530
Previous myocardial infarction	29 (36.3%)	11 (44.0%)	18 (32.7%)	0.337
LVEF, %	51.7±7.4	50.1±7.8	52.4±7.1	0.183
LA volume index, mL/m²	29.6±6.8	33.2±6.7	28.0±6.1	0.002
LASr/PALS, %	26.7±6.0	21.8±4.7	28.9±5.3	<0.001

Values are mean±SD or n (%). POAF = postoperative atrial fibrillation; LVEF = left ventricular ejection fraction; LA = left atrial; LASr = left atrial reservoir strain; PALS = peak atrial longitudinal strain.

Table 2. Perioperative characteristics and medication use

Variable	POAF (n=25)	No POAF (n=55)	p-value
Number of grafts	3.1±0.8	2.9±0.7	0.248
Cardiopulmonary bypass time, min	86.4±18.2	81.1±17.5	0.210
Aortic cross-clamp time, min	54.2±13.1	51.0±12.6	0.293
Preoperative beta-blocker use	17 (68.0%)	45 (81.8%)	0.164
Postoperative beta-blocker use	20 (80.0%)	51 (92.7%)	0.118
Amiodarone use	8 (32.0%)	4 (7.3%)	0.006

Electrolyte disturbance	7 (28.0%)	7 (12.7%)	0.091
ICU stay, days	2.8±1.1	2.1±0.8	0.003
Hospital stay, days	9.2±2.7	7.1±1.8	<0.001

Patients who developed POAF had a lower frequency of postoperative beta-blocker use, although this difference was not statistically significant. Amiodarone was used more frequently in patients who developed POAF, primarily reflecting its use for treatment of postoperative arrhythmia rather than prophylaxis. Patients with POAF also had significantly longer ICU and total hospital stays.

Table 3. Multivariable logistic regression analysis of predictors of POAF

Predictor	Adjusted OR	95% CI	p-value
Age, per year	1.06	1.01–1.12	0.027
Hypertension	1.91	0.72–5.08	0.193
LA volume index, per 1 mL/m²	1.07	1.01–1.14	0.031
LVEF, per 1%	0.97	0.92–1.03	0.311
LASr, per 1% increase	**0.82**	**0.73–0.92**	**0.001**
Preoperative beta-blocker use	0.64	0.23–1.79	0.397
Postoperative beta-blocker use	0.58	0.17–1.97	0.383
Amiodarone use	2.74	0.78–9.61	0.114

On multivariable analysis, lower preoperative LA reservoir strain remained independently associated with POAF. Each 1% increase in LASr was associated with an approximately 18% reduction in the odds of POAF (adjusted OR 0.82, 95% CI 0.73–0.92; p=0.001). Age and LA volume index were also independently associated with POAF, whereas beta-blocker and amiodarone exposure did not retain statistical significance after adjustment.

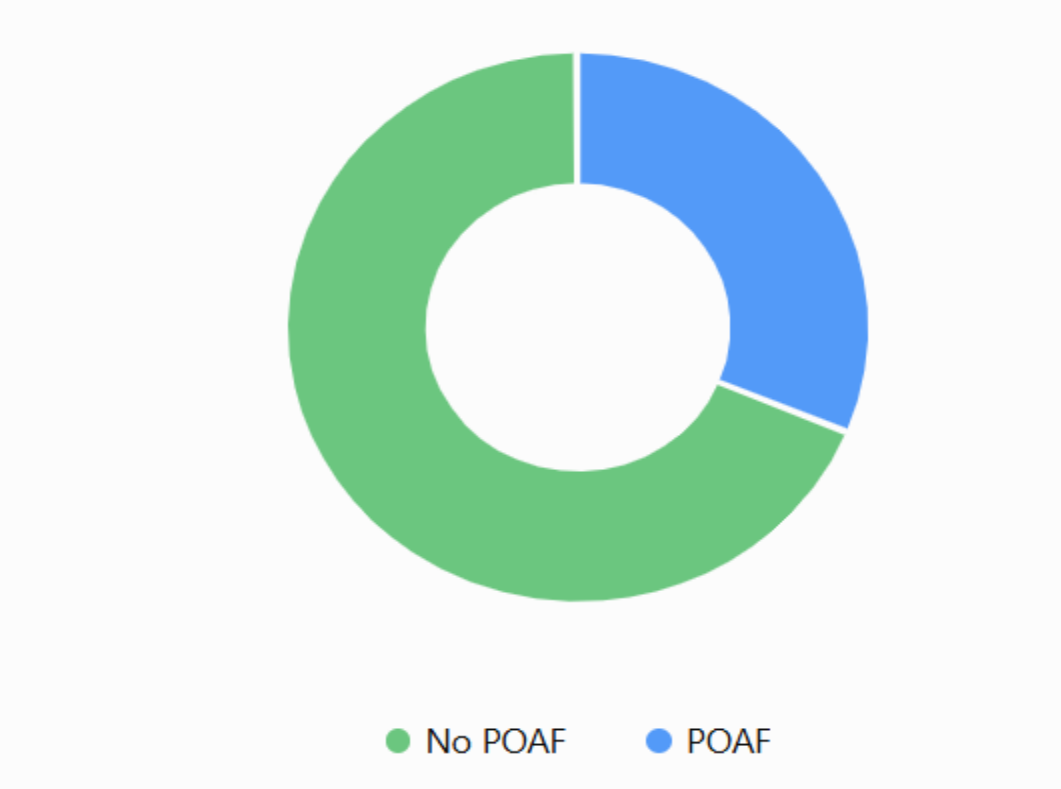


Figure 1. *POAF developed in 25 (31.3%) of 80 patients following CABG.*



Figure 2. *Mean preoperative LA reservoir strain was significantly lower in patients who developed POAF*

In this figure impaired preoperative LA reservoir strain showed a significant association with POAF and remained an independent predictor after adjustment for age, hypertension, LA volume, LVEF, beta-blocker use, and amiodarone exposure.

DISCUSSION

The present study evaluated the association between preoperative left atrial strain and postoperative atrial fibrillation (POAF) in 80 patients undergoing CABG. POAF developed in 25 (31.3%) patients, while 55 (68.7%) remained in sinus rhythm. The principal finding was that patients who developed POAF had significantly lower preoperative left atrial reservoir strain (LASr) than those without POAF (21.8±4.7% vs. 28.9±5.3%; $p<0.001$). Importantly, lower LASr remained independently associated with POAF after adjustment for age, left atrial volume index, LVEF, beta-blocker use, and amiodarone exposure.

The observed POAF incidence of 31.3% was consistent with the frequency reported in previous cardiac-surgery studies. A large systematic review and meta-analysis reported POAF in approximately one-quarter of patients undergoing cardiac surgery and demonstrated associations with longer intensive-care and hospital stays as well as increased early stroke and mortality. [16] In the present study, patients with POAF similarly experienced longer ICU and hospital stays, supporting the clinical importance of postoperative rhythm surveillance.

The most important finding was the significant difference in LASr between the two groups. Reduced LA strain reflects impaired atrial myocardial deformation and may indicate an underlying atrial substrate that is more susceptible to postoperative electrical instability. Recent evidence has increasingly supported the prognostic value of LA strain for AF. A systematic review and meta-analysis found that lower PALS was associated with increased risk of incident AF independently of conventional risk factors. [17] Similarly, three-dimensional LA strain has demonstrated prognostic value for AF, suggesting that atrial deformation provides information beyond conventional measurements of atrial size. [18]

Our findings are also consistent with evidence specifically involving CABG. A prospective multicenter study demonstrated that lower preoperative PALS was associated with POAF, with PALS providing meaningful discrimination for postoperative arrhythmia.[19] A separate study of off-pump CABG patients found that all three phases of LA strain were lower among patients who developed POAF, while LA reservoir strain remained independently associated with the arrhythmia.[20] These findings support the concept that impaired atrial reservoir function represents an important marker of pre-existing atrial vulnerability.

The present study also demonstrated that LA volume index was significantly greater in patients who developed POAF and remained associated with POAF in multivariable analysis. However, the association with LASr was stronger. This may indicate that functional atrial abnormalities can provide information that is not completely captured by conventional structural assessment. LA strain can detect impaired myocardial deformation before marked atrial enlargement occurs and may therefore provide incremental information during preoperative assessment. A 2026 systematic review and meta-analysis involving 24 observational studies further reported that reduced preoperative LA strain parameters were associated with increased POAF risk after cardiac surgery. [21]

Several mechanisms may explain the association between reduced preoperative LASr and POAF. Patients with impaired LA deformation may have pre-existing atrial remodeling, increased filling pressures, reduced compliance, and myocardial fibrosis. CABG subsequently introduces additional triggers, including surgical trauma, autonomic imbalance, inflammation, oxidative stress, ischemia-reperfusion injury, and postoperative volume and electrolyte changes. These processes can promote electrical heterogeneity and re-entry within a vulnerable atrial substrate. [22] Thus, LA strain may serve as an imaging marker of the underlying substrate, whereas postoperative physiological stress acts as the trigger for AF.

Age was another significant predictor of POAF in the present study. Older patients demonstrated a higher frequency of postoperative arrhythmia, which is consistent with the established relationship between age-related atrial remodeling and AF susceptibility. The combination of increasing age and impaired LASr may therefore identify patients with greater pre-existing atrial vulnerability. Nevertheless, LA strain remained independently associated with POAF after adjustment for age, suggesting that its predictive information was not simply a consequence of older age.

Beta-blocker therapy was incorporated into the present analysis because perioperative beta-blockade can modify POAF risk. Although patients without POAF had more frequent postoperative beta-blocker use, the difference was not statistically significant after adjustment. Previous meta-analyses have demonstrated that perioperative beta-blocker therapy can reduce POAF following cardiac surgery. [23],[24] Current CABG recommendations also recognize perioperative beta-blocker therapy as an important preventive strategy when not contraindicated.[25] The lack of an independent association in our cohort may have reflected the relatively small sample size and differences in timing, dose, and continuation of therapy.

Amiodarone was used more frequently among patients who developed POAF. This finding should not be interpreted as evidence that amiodarone increased the risk of POAF because amiodarone was primarily administered after arrhythmia developed in this cohort. Therefore, its higher frequency among POAF patients most likely reflected treatment of established postoperative arrhythmia rather than a causal effect. Evidence from randomized trials and meta-analyses supports the effectiveness of prophylactic amiodarone in reducing POAF when administered according to an appropriate perioperative protocol. [26], [27] This distinction is important when interpreting observational medication data.

The present findings have potential clinical relevance. Preoperative speckle-tracking echocardiography could potentially be incorporated into the routine assessment of selected CABG patients to identify those with impaired atrial mechanical function. Patients with markedly reduced LASr could potentially receive closer postoperative rhythm monitoring and targeted preventive strategies. However, LA strain should currently be regarded as a complementary risk-stratification parameter rather than a replacement for established clinical risk factors or conventional echocardiographic assessment.

The study had several limitations. The sample size was relatively small and was derived from a single cardiac center, which may limit generalizability. The observational design prevented determination of causality. Strain measurements may also be influenced by image quality, software platform, loading conditions, and interobserver variability. In addition, medication exposure, particularly amiodarone, could have been affected by the development of POAF itself, introducing potential reverse-causation bias. Larger multicenter prospective studies using standardized strain acquisition and predefined prophylactic medication protocols are therefore warranted.

CONCLUSION

Preoperative left atrial reservoir strain was significantly reduced in patients who developed postoperative atrial fibrillation following coronary artery bypass grafting. Lower LA strain remained independently associated with POAF after adjustment for relevant clinical, echocardiographic, and perioperative factors. These findings suggest that preoperative speckle-tracking assessment of left atrial function may provide useful additional information for identifying patients at increased risk of POAF. Incorporating LA strain into preoperative echocardiographic assessment may facilitate closer postoperative rhythm monitoring and individualized preventive management.

RECOMMENDATIONS

Routine assessment of left atrial reservoir strain by two-dimensional speckle-tracking echocardiography may be considered as an adjunct to conventional preoperative risk assessment in patients undergoing CABG. Patients with impaired LA strain may benefit from intensified postoperative ECG monitoring and appropriate preventive strategies, including evidence-based use of beta-blockers and, where clinically indicated, amiodarone. Larger multicenter prospective studies are recommended to validate optimal LA strain cut-off values and determine whether LA strain-guided preventive strategies can reduce the incidence and clinical consequences of POAF.

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