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Predictors of Postoperative Atrial Fibrillation Following Valvular Heart Surgery.

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Abstract

Background: Postoperative atrial fibrillation (POAF) is the most common arrhythmic complication following cardiac surgery and is associated with increased morbidity, prolonged intensive care unit (ICU) stay, thromboembolic events, and higher healthcare costs. Patients undergoing valvular heart surgery are particularly susceptible to POAF because of pre-existing atrial remodeling, chamber enlargement, chronic pressure overload, and perioperative inflammatory responses. Identification of risk factors and predictors of POAF may facilitate early risk stratification and implementation of preventive strategies, thereby improving postoperative outcomes. ***Aim:*** To determine the incidence of postoperative atrial fibrillation and identify clinical, echocardiographic, operative, and biochemical predictors among patients undergoing valvular heart surgery. ***Materials and Methods:*** This prospective observational study was conducted in the Department of Cardiothoracic and Vascular Surgery, Mahatma Gandhi Medical College and Hospital, Sitapura, Jaipur, Rajasthan, from April 2024 to March 2026. A total of 100 adult patients undergoing elective valvular heart surgery were enrolled. Demographic characteristics, comorbidities, laboratory investigations, echocardiographic parameters, operative variables, and postoperative outcomes were recorded. Continuous electrocardiographic monitoring and daily 12-lead ECGs were used to detect POAF during the postoperative hospital stay. Statistical analysis was performed using SPSS version 26. Continuous variables were compared using Student's t-test, while categorical variables were analyzed using Chi-square or Fisher's exact test. Multivariate logistic regression analysis was performed to identify independent predictors of POAF. A p-value <0.05 was considered statistically significant. ***Results:*** Among the 100 patients studied, postoperative atrial fibrillation developed in 31 patients, resulting in an incidence of 31%. Patients who developed POAF were significantly older than those without POAF (59.8 ± 10.2 vs 48.7 ± 11.4 years, p<0.001). Hypertension (51.6% vs 26.1%, p=0.015), chronic obstructive pulmonary disease (22.6% vs 7.2%, p=0.031), larger left atrial diameter (49.2 ± 5.1 mm vs 42.6 ± 4.8 mm, p<0.001), and lower left ventricular ejection fraction (49.8 ± 7.6% vs 55.6 ± 6.4%, p<0.001) were significantly associated with POAF. Operative factors including prolonged cardiopulmonary bypass time (126.8 ± 24.2 vs 101.4 ± 18.6 minutes, p<0.001), longer aortic cross-clamp time (89.6 ± 17.4 vs 71.3 ± 15.8 minutes, p<0.001), and increased operative duration (248.7 ± 36.5 vs 215.6 ± 29.4 minutes, p<0.001) were significantly associated with POAF. Postoperative inflammatory markers, hypokalemia, and hypomagnesemia were significantly more common in patients who developed POAF. Multivariate logistic regression identified age >60 years (OR=3.28, p=0.005), left atrial diameter >45 mm (OR=4.96, p<0.001), cardiopulmonary bypass time >120 minutes (OR=3.75, p=0.003), and postoperative hypomagnesemia (OR=3.11, p=0.011) as independent predictors of POAF. ***Conclusion:*** Postoperative atrial fibrillation occurred in nearly one-third of patients undergoing valvular heart surgery. Advanced age, left atrial enlargement, prolonged cardiopulmonary bypass duration, and postoperative hypomagnesemia were identified as independent predictors. Early recognition of high-risk patients and implementation of targeted preventive measures may reduce the incidence of POAF and improve postoperative outcomes.

Keywords: Postoperative atrial fibrillation; Valvular heart surgery; Predictors; Cardiopulmonary bypass; Left atrial enlargement; Cardiac surgery outcomes.

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INTRODUCTION

Atrial fibrillation (AF) is the most frequently encountered sustained cardiac arrhythmia in clinical practice and represents a major cause of morbidity and mortality worldwide. The incidence of atrial fibrillation increases with advancing age and the presence of structural heart disease. In patients undergoing cardiac surgery, postoperative atrial fibrillation (POAF) remains the most common rhythm disturbance, occurring in approximately 20–50% of patients depending on the type of surgical procedure performed. The incidence is particularly high following valvular heart surgery because these patients often have longstanding atrial remodeling, chamber dilatation, pressure overload, and myocardial fibrosis that predispose them to arrhythmogenesis. [1]

Postoperative atrial fibrillation usually develops within the first three to five days after surgery and is associated with significant clinical consequences. Although often considered a transient phenomenon, POAF has been linked to increased risk of stroke, systemic thromboembolism, hemodynamic instability, heart failure, prolonged intensive care unit stay, increased duration of hospitalization, and higher healthcare expenditure. Furthermore, several studies have demonstrated that patients who develop POAF have increased long-term mortality and a higher likelihood of recurrent atrial fibrillation after discharge. [2]

The pathophysiology of POAF is multifactorial and involves a complex interaction between pre-existing atrial substrate abnormalities and perioperative triggers. Structural remodeling of the atria caused by chronic valvular lesions contributes significantly to the development of AF. Mitral valve disease, particularly mitral stenosis and mitral regurgitation, leads to left atrial enlargement and fibrosis, creating an electrophysiological environment favorable for re-entrant circuits. [3] In addition, surgical trauma, cardiopulmonary bypass, myocardial ischemia-reperfusion injury, oxidative stress, systemic inflammatory response, autonomic imbalance, and electrolyte disturbances further enhance atrial vulnerability during the postoperative period. [4]

Several patient-related factors have been identified as potential predictors of POAF. Advanced age remains the most consistently reported risk factor due to progressive atrial fibrosis and electrical remodeling. Other important predictors include hypertension, diabetes mellitus, chronic obstructive pulmonary disease, heart failure, reduced left ventricular ejection fraction, renal dysfunction, and pre-existing atrial enlargement. [5] Echocardiographic parameters such as increased left atrial diameter and impaired ventricular function have also been associated with a higher risk of postoperative arrhythmias. [6]

Operative factors play a crucial role in the occurrence of POAF. Prolonged cardiopulmonary bypass duration, increased aortic cross-clamp time, extensive surgical manipulation, and postoperative requirement for inotropic support have been shown to increase the likelihood of developing atrial fibrillation. Furthermore, postoperative inflammatory markers such as C-reactive protein and leukocyte counts have been associated with the development of POAF, highlighting the contribution of inflammatory mechanisms. [7]

Despite considerable advances in surgical techniques and perioperative management, the incidence of POAF following valvular heart surgery remains substantial. Identification of patients at high risk before surgery can facilitate implementation of preventive measures such as beta-blockers, amiodarone prophylaxis, magnesium supplementation, and optimized perioperative monitoring. Early recognition and management may reduce complications and improve overall surgical outcomes. [8]

Valvular heart disease continues to be a significant healthcare burden in India, where rheumatic heart disease remains prevalent. Patients often present at an advanced stage with marked atrial enlargement and chronic hemodynamic alterations, potentially increasing their susceptibility to POAF. However, data regarding predictors of postoperative atrial fibrillation among Indian patients undergoing valvular heart surgery remain limited. [9] Therefore, the present prospective observational study was undertaken at Mahatma Gandhi Medical College and Hospital, Jaipur, to determine the incidence of postoperative atrial fibrillation and identify clinical, echocardiographic, biochemical, and operative predictors associated with its development following valvular heart surgery. Understanding these predictors may contribute to improved risk stratification and optimization of perioperative care.

MATERIALS AND METHODS

Study Design

Prospective observational study.

Study Setting

The study was conducted in the Department of Cardiothoracic and Vascular Surgery (CTVS), Mahatma Gandhi Medical College and Hospital, Sitapura, Jaipur, Rajasthan.

Study Duration
April 2024 to March 2026.

Study Population
Patients undergoing elective valvular heart surgery during the study period.

Sample Size
A total of 100 patients were included in the study.

Study Objective
Primary Objective
- To determine the incidence of postoperative atrial fibrillation following valvular heart surgery.

Secondary Objectives
- To identify demographic predictors of POAF.
- To evaluate echocardiographic predictors of POAF.
- To assess intraoperative and postoperative factors associated with POAF.
- To determine independent predictors of POAF using multivariate analysis.

Inclusion Criteria
1. Patients aged ≥18 years.
2. Patients undergoing elective valvular heart surgery (repair or replacement).
3. Patients providing written informed consent.
4. Patients in sinus rhythm preoperatively.

Exclusion Criteria
1. History of chronic or persistent atrial fibrillation.
2. Previous cardiac surgery.
3. Emergency valvular procedures.
4. Permanent pacemaker implantation.
5. Concomitant congenital cardiac surgery.
6. Severe hepatic dysfunction.
7. Patients refusing consent.

Preoperative Evaluation
All enrolled patients underwent detailed assessment including:
Clinical Assessment
- Age
- Gender
- Body mass index
- Smoking status
- Hypertension
- Diabetes mellitus
- Chronic obstructive pulmonary disease
- Coronary artery disease
- Previous cerebrovascular disease
- Rheumatic heart disease history

Laboratory Investigations
- Complete blood count
- Renal function tests
- Liver function tests
- Serum electrolytes
- Serum magnesium levels
- C-reactive protein
- Coagulation profile

Echocardiographic Assessment

- Left atrial diameter
- Left ventricular ejection fraction
- Pulmonary artery pressure
- Valvular lesion type
- Ventricular dimensions
- Presence of chamber enlargement

Operative Data Collection

The following intraoperative variables were recorded:

- Type of valve surgery
- Mitral valve replacement
- Aortic valve replacement
- Double valve replacement
- Valve repair procedures
- Cardiopulmonary bypass duration
- Aortic cross-clamp time
- Total operative duration
- Requirement of blood transfusion
- Intraoperative complications

Postoperative Monitoring

All patients were monitored continuously using:

- Electrocardiography monitoring
- Telemetry monitoring
- Daily 12-lead ECG
- Hemodynamic monitoring

Definition of Postoperative Atrial Fibrillation

POAF was defined as:

Any episode of atrial fibrillation lasting more than 30 seconds, documented by ECG or continuous telemetry monitoring during the postoperative hospital stay.

Outcome Measures

Primary Outcome

- Incidence of postoperative atrial fibrillation.

Secondary Outcomes

- Time of onset of POAF.
- Duration of POAF episodes.
- ICU stay.
- Hospital stay.
- Stroke occurrence.
- Requirement of antiarrhythmic therapy.
- Mortality.

Data Management

All patient information was entered into a standardized data collection proforma. Data confidentiality was maintained throughout the study.

Statistical Analysis

Data were analyzed using SPSS version 26.0.

Descriptive Statistics

- Mean ± Standard Deviation (SD) for continuous variables.
- Frequency and percentage for categorical variables.

Inferential Statistics

- Independent Student's t-test for continuous variables.
- Chi-square test or Fisher's exact test for categorical variables.
- Univariate analysis for identification of risk factors.

- Multivariate logistic regression analysis for determination of independent predictors.

Level of Significance

- $p < 0.05$ was considered statistically significant.

Ethical Considerations

- Institutional Ethics Committee approval was obtained prior to study initiation.
- Written informed consent was obtained from all participants.
- Patient confidentiality was maintained according to the Declaration of Helsinki guidelines.

RESULTS

A total of 100 patients undergoing elective valvular heart surgery were enrolled and followed prospectively. Postoperative atrial fibrillation (POAF) developed in 31 patients, yielding an incidence of **31%**, while 69 patients remained in sinus rhythm throughout the postoperative period.

Table 1. Demographic and Preoperative Characteristics

Variable	POAF (n=31)	No POAF (n=69)	p value
Age (years)	59.8 ± 10.2	48.7 ± 11.4	<0.001*
Male Gender	18 (58.1%)	38 (55.1%)	0.781
BMI (kg/m²)	26.8 ± 3.5	25.7 ± 3.2	0.129
Hypertension	16 (51.6%)	18 (26.1%)	0.015*
Diabetes Mellitus	11 (35.5%)	14 (20.3%)	0.108
COPD	7 (22.6%)	5 (7.2%)	0.031*
Chronic Kidney Disease	4 (12.9%)	3 (4.3%)	0.114
Left Atrial Diameter (mm)	49.2 ± 5.1	42.6 ± 4.8	<0.001*
LVEF (%)	49.8 ± 7.6	55.6 ± 6.4	<0.001*

*Statistically significant

The incidence of POAF was 31%. Patients who developed POAF were significantly older than those without POAF (59.8 vs 48.7 years, $p<0.001$). Hypertension was observed in 51.6% of POAF patients compared with 26.1% of non-POAF patients ($p=0.015$). COPD was present in 22.6% versus 7.2% of patients respectively ($p=0.031$). Mean left atrial diameter was significantly greater among POAF patients (49.2 mm vs 42.6 mm, $p<0.001$), while left ventricular ejection fraction was significantly lower (49.8% vs 55.6%, $p<0.001$). Gender, BMI, diabetes, and chronic kidney disease did not show statistically significant associations.

Table 2. Echocardiographic and Valvular Characteristics

Variable	POAF (n=31)	No POAF (n=69)	p value
Mitral Valve Disease	19 (61.3%)	29 (42.0%)	0.048*
Aortic Valve Disease	6 (19.4%)	20 (29.0%)	0.317
Double Valve Disease	6 (19.4%)	20 (29.0%)	0.317
Pulmonary Artery Pressure >50 mmHg	14 (45.2%)	17 (24.6%)	0.039*
Severe Left Atrial Enlargement (>45 mm)	22 (71.0%)	18 (26.1%)	<0.001*
LVEF <50%	17 (54.8%)	14 (20.3%)	0.001*

*Statistically significant

Mitral valve disease was significantly associated with POAF and was present in 61.3% of affected patients compared to 42.0% of those without POAF ($p=0.048$). Severe left atrial enlargement was observed in 71.0% of POAF patients compared to 26.1% of non-POAF patients ($p<0.001$). Reduced ventricular function and elevated pulmonary artery pressures were also significantly associated with postoperative arrhythmia.

Table 3. Intraoperative Variables

Variable	POAF (n=31)	No POAF (n=69)	p value
CPB Time (minutes)	126.8 ± 24.2	101.4 ± 18.6	<0.001*
Cross Clamp Time (minutes)	89.6 ± 17.4	71.3 ± 15.8	<0.001*
Total Surgical Duration (minutes)	248.7 ± 36.5	215.6 ± 29.4	<0.001*
Blood Transfusion Required	16 (51.6%)	20 (29.0%)	0.032*
Intraoperative Inotropic Support	18 (58.1%)	21 (30.4%)	0.011*

*Statistically significant

Patients developing POAF had significantly longer cardiopulmonary bypass (CPB) times (126.8 vs 101.4 minutes), longer aortic cross-clamp times (89.6 vs 71.3 minutes), and prolonged operative durations (248.7 vs 215.6 minutes), all with p<0.001. Blood transfusion and intraoperative inotropic requirements were also significantly more common among POAF patients.

Table 4. Postoperative Variables

Variable	POAF (n=31)	No POAF (n=69)	p value
Postoperative CRP (mg/L)	78.6 ± 18.2	56.4 ± 14.7	<0.001*
Leukocyte Count (×10⁹/L)	13.8 ± 2.9	10.7 ± 2.5	<0.001*
Hypokalemia	10 (32.3%)	8 (11.6%)	0.012*
Hypomagnesemia	14 (45.2%)	10 (14.5%)	0.001*
Mechanical Ventilation >24 h	12 (38.7%)	9 (13.0%)	0.004*
ICU Stay (days)	5.8 ± 1.7	3.9 ± 1.2	<0.001*
Hospital Stay (days)	11.6 ± 3.4	8.3 ± 2.1	<0.001*

*Statistically significant

Patients who developed POAF demonstrated significantly higher inflammatory marker levels. Hypomagnesemia occurred in 45.2% of POAF patients compared to 14.5% of non-POAF patients (p=0.001). Mechanical ventilation beyond 24 hours, prolonged ICU stay, and longer hospital stay were significantly associated with POAF.

Table 5. Multivariate Logistic Regression Analysis of Independent Predictors of POAF

Predictor	Odds Ratio (OR)	95% CI	p value
Age >60 years	3.28	1.41–7.62	0.005*
Left Atrial Diameter >45 mm	4.96	2.01–12.25	<0.001*
CPB Time >120 minutes	3.75	1.54–9.14	0.003*
Hypomagnesemia	3.11	1.28–7.55	0.011*

*Statistically significant

Multivariate logistic regression identified age greater than 60 years, left atrial diameter greater than 45 mm, prolonged CPB duration exceeding 120 minutes, and postoperative hypomagnesemia as independent predictors of POAF. Left atrial enlargement demonstrated the strongest association, increasing the risk nearly fivefold.

DISCUSSION

The present prospective observational study evaluated the predictors of postoperative atrial fibrillation among patients undergoing valvular heart surgery. The incidence of POAF observed in the present study was 31%, which falls within the range reported in previous cardiac surgical literature, where the incidence varies from 20% to 50% depending upon patient characteristics and surgical complexity. POAF remains one of the most common postoperative complications following cardiac surgery and continues to contribute significantly to increased morbidity, prolonged hospitalization, and healthcare expenditure. [1]

One of the most important findings of the present study was the significant association between advanced age and postoperative atrial fibrillation. Patients who developed POAF were significantly older than those who remained in sinus rhythm. Multivariate analysis further identified age greater than 60 years as an independent predictor. Aging is associated with progressive atrial fibrosis, conduction abnormalities, atrial dilatation, and increased heterogeneity of atrial refractoriness, all of which predispose patients to atrial arrhythmogenesis. Similar observations have been reported in several large cardiac surgical cohorts and meta-analyses. [3]

Left atrial enlargement emerged as the strongest predictor of postoperative atrial fibrillation in the present study. Patients with POAF demonstrated significantly larger left atrial dimensions, and severe left atrial enlargement was observed in more than two-thirds of affected individuals. Logistic regression analysis revealed an almost fivefold increase in risk among patients with left atrial diameter exceeding 45 mm. Chronic pressure and volume overload associated with valvular heart disease lead to atrial remodeling characterized by myocyte hypertrophy, fibrosis, and conduction slowing. These structural alterations create an ideal substrate for re-entrant arrhythmias and facilitate the development of atrial fibrillation. Previous investigations have consistently demonstrated left atrial size as one of the most reliable predictors of POAF. [5]

The present study also demonstrated that impaired left ventricular systolic function was significantly associated with POAF. More than half of the patients who developed atrial fibrillation had an ejection fraction below 50%. Reduced ventricular function contributes to elevated atrial pressures and increased atrial stretch, thereby promoting electrical

instability. Similar findings have been described in studies evaluating postoperative rhythm disturbances following valve surgery and coronary artery bypass grafting. [6]

Mitral valve disease was significantly more common among patients developing POAF. This finding is biologically plausible because mitral valve lesions are frequently associated with chronic left atrial enlargement and elevated atrial pressures. Long-standing mitral stenosis and mitral regurgitation produce substantial atrial remodeling before surgery, thereby increasing susceptibility to postoperative arrhythmias. Previous studies evaluating valvular surgery populations have similarly reported a higher incidence of POAF among patients undergoing mitral valve procedures. [7]

Operative variables demonstrated a strong relationship with postoperative atrial fibrillation. Patients developing POAF had significantly prolonged cardiopulmonary bypass times, cross-clamp durations, and overall operative times. Prolonged cardiopulmonary bypass is associated with enhanced inflammatory activation, oxidative stress, ischemia-reperfusion injury, and autonomic dysfunction. These mechanisms increase atrial vulnerability and facilitate the initiation of atrial fibrillation during the early postoperative period. Similar associations between prolonged bypass duration and POAF have been documented by several investigators. [9]

Inflammation appears to play a crucial role in the pathogenesis of postoperative atrial fibrillation. In the present study, postoperative C-reactive protein levels and leukocyte counts were significantly higher among POAF patients. Surgical trauma, extracorporeal circulation, and myocardial manipulation trigger a systemic inflammatory response characterized by cytokine release and oxidative stress. These inflammatory processes alter atrial electrophysiology and contribute to arrhythmia initiation. Growing evidence suggests that postoperative inflammation is a central mechanism linking cardiac surgery and atrial fibrillation. [10]

Electrolyte disturbances were also important contributors to POAF in the current study. Both hypokalemia and hypomagnesemia occurred more frequently among affected patients. Hypomagnesemia remained an independent predictor on multivariate analysis. Magnesium plays a vital role in maintaining myocardial membrane stability and regulating intracellular calcium transport. Deficiency increases myocardial excitability and predisposes to atrial arrhythmias. Several randomized trials have demonstrated the beneficial role of magnesium supplementation in reducing postoperative atrial fibrillation. [11,12]

Patients who developed POAF experienced significantly prolonged mechanical ventilation, ICU stay, and overall hospital stay. These findings highlight the clinical significance of postoperative atrial fibrillation beyond rhythm disturbance alone. POAF contributes to hemodynamic instability, increased requirement for pharmacological intervention, greater resource utilization, and delayed recovery. Similar observations have been reported in large multicenter studies demonstrating increased hospitalization costs and adverse clinical outcomes among patients developing POAF. [13,14]

The findings of the present study emphasize the importance of preoperative risk stratification in patients undergoing valvular heart surgery. Identification of high-risk individuals based on age, left atrial size, ventricular function, bypass duration, and electrolyte status may facilitate implementation of preventive strategies. Early use of beta-blockers, amiodarone prophylaxis, correction of electrolyte abnormalities, and meticulous perioperative management may reduce the incidence and consequences of POAF. [15]

Overall, the present study demonstrates that postoperative atrial fibrillation remains a frequent complication after valvular heart surgery and is influenced by a combination of patient-related, structural, inflammatory, and operative factors. Recognition of these predictors may contribute to improved perioperative care and enhanced surgical outcomes.

CONCLUSION

Postoperative atrial fibrillation occurred in 31% of patients undergoing valvular heart surgery and remains a major postoperative complication associated with prolonged ICU and hospital stay. Advanced age, left atrial enlargement, reduced left ventricular ejection fraction, mitral valve disease, prolonged cardiopulmonary bypass duration, elevated inflammatory markers, and postoperative electrolyte disturbances were significantly associated with POAF. Multivariate analysis identified age greater than 60 years, left atrial diameter greater than 45 mm, prolonged cardiopulmonary bypass time, and postoperative hypomagnesemia as independent predictors. Early identification of high-risk patients and implementation of targeted preventive measures may reduce the burden of postoperative atrial fibrillation and improve clinical outcomes following valvular heart surgery.

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