New-onset postoperative atrial fibrillation after mitral valve surgery: Determinants and the effect on survival

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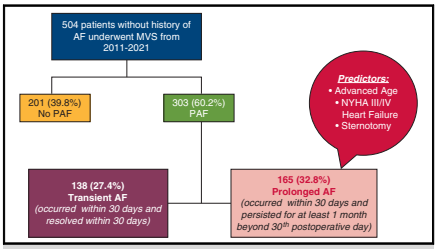
ABSTRACT

Objective: Mitral valve surgery (MVS) carries substantial risk of postoperative atrial fibrillation (PAF). Identifying patients who benefit from prophylactic left atrial appendage amputation (LAAA) or maze is ill-defined. To guide such interventions, we determined preoperative predictors of PAF and investigated 3-year survival of patients with PAF.

Methods: We performed a retrospective analysis of patients undergoing isolated MVS (N = 670) between 2011 and 2021. Patients with preoperative atrial fibrillation, LAAA or pulmonary vein isolation were excluded. Patient characteristics were compared between those without PAF and those who developed transient or prolonged PAF. Predictors of any PAF and prolonged PAF were identified using multivariable regression analysis.

Results: In total, 504 patients without preoperative atrial fibrillation underwent isolated MVS. Of them, 303 patients (60.2%) developed PAF; 138 (27.3%) developed transient and 165 (32.7%) developed prolonged (beyond 30 days) PAF. Patients with PAF were older (65.7 vs 54.3 years, $P < .001$), with larger left atria (4.8 vs 4.3 cm, $P < .001$), greater prevalence of hypertension (60% vs 47.8%, $P < .05$), and were New York Heart Association class III/IV (36% vs 8.5%, $P < .001$). Independent predictors of PAF included left atria volume index (odds ratio [OR], 1.02; $P < .003$), older age (OR, 1.04; $P < .001$), heart failure (OR, 6.73; $P < .001$), and sternotomy (OR, 2.19; $P < .002$). Age, heart failure, and sternotomy were independent predictors of prolonged PAF. Patients with PAF had greater mortality at 3 years compared with those without PAF (5.3% vs 0.5%, $P < .005$). On multivariable analysis, PAF was associated with increased mortality (hazard ratio, 7.81; $P < .046$).

Conclusions: PAF is common after MVS and associated with late mortality. Older age, advanced heart failure, and sternotomy are associated with prolonged PAF. These factors may identify patients who would benefit from prophylactic LAAA or ablation during MVS. (JTCVS Open 2023;16:305-20)



Advanced age, heart failure, and sternotomy are predictors for prolonged PAF after MVS.

CENTRAL MESSAGE

Older age, advanced heart failure, and sternotomy identify a subgroup of patients at high risk of developing prolonged atrial fibrillation after mitral valve surgery.

PERSPECTIVE

Prophylactic surgical interventions such as maze or LAAA during mitral valve surgery may reduce the risk of morbidity and mortality associated with atrial fibrillation and negate the need of long-term anticoagulation. Prospective randomized trials are warranted to validate this hypothesis.

Atrial fibrillation (AF) is a frequent complication and is the most common arrhythmia after cardiac surgery, with an incidence of 30% to 50%.[1] Postoperative atrial fibrillation (PAF) is associated with increased mortality and morbidity,[2] longer hospital stay,[3] and increased hospitalization cost.[4] New-onset PAF is common after mitral valve surgery (MVS), and the incidence of PAF is reported up to more than 50% in isolated MVS including mitral valve repair or replacement.[5] The development of persistent PAF imposes the need for long-term

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Abbreviations and Acronyms

AF = atrial fibrillation
CABG = coronary artery bypass graft
CI = confidence interval
EKG = electrocardiogram
HR = hazard ratio
IABP = intra-aortic balloon pump
IQR = interquartile range
LA = left atria
LAAA = left atrial appendage amputation or ligation
LAVI = left atrial volume index
LV = left ventricle
MV = mitral valve
MVS = mitral valve surgery
NYHA = New York Heart Association
OR = odds ratio
PAF = postoperative atrial fibrillation
PVI = pulmonary vein isolation

anticoagulation with its attendant risks of bleeding and stroke. Prophylactic surgical interventions such as left atrial appendage amputation or ligation (LAAA) can be used as an adjunctive therapy during MVS, but they impose financial cost, discouraging their routine use, and current guidelines do not suggest use of ablation surgery during MVS in patients without history of AF.

Although PAF is widely documented, its incidence and impact on mortality after MVS are poorly defined. Estimates of PAF are largely gleaned from patients undergoing coronary artery bypass graft surgery (CABG) and valve surgery[6,7] and mostly included mitral valve replacement rather than valve repair. In addition, the incidence of transient or persistent PAF is rarely reported, and their impact on outcomes is not defined. This lack of data on the incidence, predictors, and long-term outcomes of PAF after isolated MVS hinders the management of these patients and the potential use of preventive strategies. In patients undergoing isolated MVS, we aimed to investigate the incidence of transient or prolonged PAF, assess the predictors of PAF, and determine the impact of PAF on long-term survival.

METHODS

Study Sample

Institutional research review board approval (STUDY00001663; approved June 30, 2020) was obtained for the completion of this study and waived the need for patient consent. A retrospective cohort analysis was performed on all adult patients undergoing isolated MVS at a single institution (University of Minnesota) between July 2011 and June 2021. Only patients with evidence of preoperative sinus rhythm and without a history of AF were included. Exclusion criteria were (1) preoperative history of paroxysmal or chronic AF; (2) prophylactic LAAA, pulmonary vein isolation (PVI), or maze procedure at the time of MVS; or (3) redo cardiac surgery or death within 30 days. All patients were monitored with continuous telemetry in immediate postoperative period of hospitalization and received AF prophylaxis with oral beta-blocker as soon as possible in postoperative setting once the patient was off chemical inotropic agents with no vasopressor support. For patients who developed PAF, hemodynamically stable patients were treated with intravenous beta-blocker as a first-line therapy. For patients with AF unresponsive to beta-blocker therapy, intravenous amiodarone or digoxin was initiated for rhythm or rate control, respectively, as a second-line therapy. Patients who were hemodynamically unstable at the time of AF were treated with synchronized cardioversion starting at 100 J followed by amiodarone.

Study Outcomes

The primary outcome was the development of PAF. PAF was defined as new AF (by electrocardiogram [EKG] or continuous telemetry monitoring) that lasted at least 30 minutes during the postoperative stay in the hospital. Patients with evidence of PAF were further categorized based on the timing of onset and duration. Transient PAF was defined as PAF that developed within the first 30 days after surgery and that subsequently resolved within the first 30 days. Prolonged PAF was defined as PAF that developed within the first 30 days after surgery and then persisted for any duration beyond the 30th postoperative day. New-onset AF beyond 60 days was not assessed as part of this study. A secondary outcome was all-cause mortality, which was defined as death from any cause beyond 30 days.

Data Collection and Follow-up

After discharge, patients were typically seen in outpatient setting at 1, 2, and 6 months postoperatively and then annually or as determined by patient's primary cardiologist. At each of these visits, clinical examination and EKG were performed. All episodes of AF reported were confirmed by investigator's review of EKGs or prints of telemetry monitoring. Follow-up was 99% at 3 months' postoperatively. Death was determined by chart review. Demographic data, known risk factors for mortality, and clinical characteristics of patients were collected. Covariates included patient's age, race, sex, body mass index, Society of Thoracic Surgeons predicted risk of mortality, history of hypertension, hyperlipidemia, diabetes, chronic lung disease, endocarditis, obstructive sleep apnea, smoking status, New York Heart Association (NYHA) classification, preoperative creatinine or use of dialysis, preoperative beta-blocker, preoperative or intraoperative intra-aortic balloon pump, and median sternotomy or minithoracotomy. Comprehensive 2-dimensional echocardiography was performed before MVS in accordance with American Society of Echocardiography guidelines.[8] The following echocardiographic parameters were collected from the report: right ventricle dysfunction (mild, moderate, severe), LV ejection fraction, mitral valve area, mitral valve mean gradient (mm Hg), binary indicator for left atrial (LA) enlargement as well as LA volume (when available), and binary indicator of left ventricular (LV) hypertrophy. LA enlargement was defined as a left atrial anteroposterior diameter greater than 38 mm in female patients and greater than 40 mm in male patients; if LA volume available then greater than 52 mL in female patients and greater than 59 mL in male patients, and left atrial volume index (LAVI) greater than 34 mL/m^2. LV hypertrophy was defined as LV mass index greater than 100 (female) and greater than 110 (male). For values that were not reported in echocardiogram report, data were manually obtained when possible. Covariates with missing data included LA volume (n = 125), LA diameter (n = 26), and LV hypertrophy (n = 55). A binary indicator of LA enlargement was used for patients with missing data of LA volume.

Statistical Analysis

Categorical variables are presented as n (%) and between-group differences in baseline characteristics were compared using χ^2 test. Continuous normally distributed variables were analyzed using a one-way analysis of variance and presented as mean ± standard deviation. Continuous non-normally distributed variables were analyzed using Kruskal–Wallis test

TABLE 1. Participants' baseline characteristics

Characteristics	No AF (N = 201)	Transient AF (N = 138)	Prolonged AF (N = 165)	*P* value
Indication, n (%)				.0273
Moderate regurgitation	2 (1.0%)	0 (0%)	2 (1.2%)	
Moderate stenosis	1 (0.5%)	0 (0%)	2 (1.2%)	
Severe regurgitation	172 (85.6%)	127 (92.0%)	131 (79.4%)	
Severe stenosis	16 (8.0%)	9 (6.5%)	26 (15.8%)	
Vegetation	10 (5.0%)	2 (1.4%)	4 (2.4%)	
Type of surgery, n (%)				.0005
MV repair	105 (52.2%)	76 (55.1%)	58 (35.2%)	
MV replacement	96 (47.8%)	62 (44.9%)	107 (64.8%)	
Incidence, n (%)				.0135
First	187 (93.0%)	133 (96.4%)	144 (87.3%)	
Redo	14 (7.0%)	5 (3.6%)	21 (12.7%)	
Age, mean (SD)	54.3 (13.5)	61.9 (11.6)	65.7 (12.9)	<.0001
Female, n (%)	80 (39.8%)	59 (42.8%)	69 (41.8%)	.8501
BMI, mean (SD)	26.6 (5.7)	26.5 (4.1)	27.3 (4.8)	.2472
BMI categories, n (%)				.516
≤25	89 (44.3%)	60 (43.5%)	61 (37.0%)	
>25-30	67 (33.3%)	52 (37.7%)	63 (38.2%)	
>30	45 (22.4%)	26 (18.8%)	41 (24.8%)	
Race, n (%)				.0171
African American	19 (9.5%)	2 (1.5%)	10 (6.2%)	
American Indian/Alaskan Native	4 (2.0%)	0 (0%)	0 (0%)	
Asian	9 (4.5%)	6 (4.4%)	6 (3.7%)	
More than 1 race	2 (1.0%)	0 (0%)	1 (0.6%)	
Other	0 (0%)	0 (0%)	1 (0.6%)	
White	165 (82.9%)	129 (94.2%)	144 (88.9%)	
Non-White race, n (%)	34 (17.1%)	8 (5.8%)	18 (11.1%)	.0064
Hypertension, n (%)	96 (47.8%)	77 (55.8%)	99 (60.0%)	.0573
Diabetes, n (%)	23 (11.4%)	17 (12.3%)	16 (9.7%)	.7557
Endocarditis, n (%)	42 (20.9%)	12 (8.7%)	21 (12.7%)	.0052
Chronic lung disease, n (%)	19 (9.5%)	12 (8.7%)	27 (16.4%)	.0571
Sleep apnea, n (%)	24 (11.9%)	21 (15.2%)	42 (25.5%)	.0023
Smoking, n (%)	151 (75.5%)	100 (72.5%)	122 (74.4%)	.8207
Hyperlipidemia, n (%)	98 (48.8%)	79 (57.2%)	94 (57.0%)	.1842
Heart failure, n (%)	34 (16.9%)	37 (26.8%)	81 (49.1%)	<.0001
NYHA class, n (%)				<.0001
I	4 (2.0%)	0 (0%)	2 (1.2%)	
II	13 (6.5%)	13 (9.4%)	20 (12.1%)	
III	13 (6.5%)	19 (13.8%)	53 (32.1%)	
IV	4 (2.0%)	4 (2.9%)	6 (3.6%)	
No	167 (83.1%)	102 (73.9%)	84 (50.9%)	
NYHA class III/IV, n (%)	17 (8.5%)	23 (16.7%)	59 (35.8%)	<.0001
RF: renal failure-dialysis, n (%)	6 (3.0%)	4 (2.9%)	4 (2.4%)	1
Pulmonary HTN (no = 0; mild = 1; moderate = 2; severe = 3), n (%)				.0157
0	137 (69.2%)	86 (62.8%)	85 (51.8%)	
1	32 (16.2%)	26 (19.0%)	39 (23.8%)	
2	12 (6.1%)	17 (12.4%)	20 (12.2%)	
3	17 (8.6%)	8 (5.8%)	20 (12.2%)	

(Continued)

TABLE 1. Continued

Characteristics	No AF (N = 201)	Transient AF (N = 138)	Prolonged AF (N = 165)	*P* value
Pulmonary HTN, n (%)	61 (30.8%)	51 (37.2%)	79 (48.2%)	.0031
RF: creatinine, median (IQR)	0.90 (0.78-1.02)	0.91 (0.80-1.06)	0.91 (0.79-1.10)	.2331
RF: hemoglobin, median (IQR)	13.5 (11.2-14.4)	13.3 (11.7-14.4)	13.5 (11.9-14.6)	.794
STS score, median (IQR)	0.09 (0.06-0.16)	0.08 (0.05-0.18)	0.13 (0.09-0.24)	<.0001
Meds: beta-blockers within 24 h, n (%)	94 (46.8%)	82 (59.4%)	108 (65.5%)	.0011
Meds: beta-blockers within 2 wk, n (%)	57 (28.4%)	47 (34.1%)	83 (50.3%)	<.0001
Meds: calcium channel blocker within 2 wk, n (%)	10 (5.0%)	6 (4.3%)	15 (9.1%)	.1822
Meds: lipid lowering within 24 h, n (%)	42 (20.9%)	37 (26.8%)	50 (30.3%)	.1131
Meds: lipid lowering-medication type, n (%)				.2138
Both	1 (0.5%)	2 (1.4%)	1 (0.6%)	
No	140 (69.7%)	85 (61.6%)	95 (57.6%)	
Nonstatin	3 (1.5%)	2 (1.4%)	5 (3.0%)	
Statin	57 (28.4%)	49 (35.5%)	64 (38.8%)	
BSA, median (IQR)	1.9 (1.8-2.1)	1.9 (1.7-2.1)	2.0 (1.8-2.1)	.078
RV dysfunction (normal = 0; mild = 1; moderate = 2; severe = 3), n (%)				.2976
0	189 (94.0%)	135 (97.8%)	150 (90.9%)	
1	7 (3.5%)	2 (1.4%)	8 (4.8%)	
2	4 (2.0%)	1 (0.7%)	6 (3.6%)	
3	1 (0.5%)	0 (0%)	1 (0.6%)	
RV dysfunction, abnormal, n (%)	12 (6.0%)	3 (2.2%)	15 (9.1%)	.0326
EF%, median (IQR)	60 (55-65)	60 (55-60)	60 (55-60)	.0029
EF%, mean (SD)	59.5 (7.0)	58.2 (7.9)	57.2 (8.5)	.021
EF% < 40%, n (%)	4 (2.0%)	3 (2.2%)	4 (2.4%)	1
MV area, median (IQR)	2.2 (1.3-3.6)	2.8 (1.7-4.0)	1.7 (1.2-2.3)	<.0001
Mean MV gradient, mm Hg, median (IQR)	6.0 (3.0-9.0)	4.0 (2.4-7.0)	6.0 (4.0-9.0)	.0453
LA diameter (>3.8 [female] or >4 cm [male]), median (IQR)	4.3 (3.8-4.8)	4.5 (4.1-4.9)	4.8 (4.3-5.2)	<.0001
LA diameter large, n (%)	132 (71.0%)	109 (83.2%)	142 (88.2%)	.0002
LA volume (>52 [female] or >59 [male]), median (IQR)	89 (67-112)	95 (74-120)	106 (84-141)	<.0001
LA volume large, n (%)	125 (88.7%)	100 (91.7%)	125 (96.2%)	.0577
LAVI (LA volume/BSA), median (IQR)	45 (36-59)	49 (40-63)	56 (44-74)	<.0001
LVMI (LV mass/BSA; >100 [female] or 110 [male]), median (IQR)	106 (87-122)	106 (91-127)	107 (89-130)	.4313
LVMI large, n (%)	79 (45.9%)	63 (52.5%)	80 (51.3%)	.4708
LVEDV, mL, median (IQR)	129 (95-163)	120 (90-158)	112 (75-160)	.335
LVESV, ml, median (IQR)	44 (32-60)	39 (27-62)	50 (30-65)	.3578
LVIDD, cm, median (IQR)	5.3 (4.8-5.8)	5.2 (4.7-5.8)	5.3 (4.7-5.8)	.8885
LVIDS, cm, median (IQR)	3.3 (2.9-3.7)	3.3 (3.0-3.8)	3.4 (2.9-3.9)	.4996
RVSP, mm Hg, median (IQR)	31 (23-44)	31 (23-44)	38 (29-49)	.0047
RASP, mm Hg, median (IQR)	5 (3-8)	5 (5-8)	7 (5-8)	.0291
Procedure, n (%)				<.0001
Minithoracotomy	116 (57.7%)	77 (55.8%)	43 (26.1%)	
Sternotomy	85 (42.3%)	61 (44.2%)	122 (73.9%)	

(Continued)

TABLE 1. Continued

Characteristics	No AF (N = 201)	Transient AF (N = 138)	Prolonged AF (N = 165)	*P* value
Cardiopulmonary bypass time, min, median (IQR)	130 (107-161)	137 (112-162)	129 (105-161)	.3406
IABP (no = 0; yes = 1), n (%)	9 (4.5%)	10 (7.2%)	7 (4.2%)	.4435
Intraoperative blood products, n (%)	56 (27.9%)	44 (31.9%)	68 (41.2%)	.0241
Postoperative blood products, n (%)	55 (27.4%)	45 (32.6%)	66 (40.0%)	.0376
No. days in AF, median (IQR)	(–)	5 (3-12)	160 (62-420)	<.0001
Reoperation (no = 0 bleeding = 1 other cardiac = 2 noncardiac = 3), n (%)				.23
0	188 (94.0%)	128 (92.8%)	154 (93.3%)	
1	5 (2.5%)	6 (4.3%)	6 (3.6%)	
2	0 (0%)	3 (2.2%)	2 (1.2%)	
3	7 (3.5%)	1 (0.7%)	3 (1.8%)	
Reoperation, n (%)	12 (6.0%)	10 (7.2%)	11 (6.7%)	.899
Mortality 3 y, n (%)				.0048
Alive	200 (99.5%)	132 (95.7%)	155 (93.9%)	
Dead	1 (0.5%)	6 (4.3%)	10 (6.1%)	

AF, Atrial fibrillation; *MV*, mitral valve; *SD*, standard deviation; *BMI*, body mass index; *NYHA*, New York Heart Association; *RF*, risk factor; *HTN*, hypertension; *IQR*, interquartile range; *STS*, Society of Thoracic Surgeons; *BSA*, body surface area; *RV*, right ventricle; *EF*, ejection fraction; *LA*, left atria; *LAVI*, left atrial volume index; *LVMI*, left ventricle mass index; *LV*, left ventricle; *LVEDV*, left ventricle end diastolic volume; *LVESV*, left ventricle end systolic volume; *LVIDD*, left ventricular internal diameter end diastole; *LVIDS*, left ventricular internal diameter end systole; *RVSP*, right ventricle systolic pressure; *RASP*, right atria systolic pressure; *IABP*, intra-aortic balloon pump.

and presented as median with interquartile range. The Shapiro–Wilk test was used to assess normality. Missing data for LV end systolic or diastolic volume, LV hypertrophy, right ventricle systolic pressure, and right atrial systolic pressure were imputed using a multiple imputation model.

Univariate and multivariate logistic regression analyses were performed to evaluate predictors of PAF. Two separate models were used. The first model compared patients who did not develop PAF with those who developed any PAF (ie, transient and prolonged). In the second model, patients who did not develop PAF and those who developed transient PAF were compared with those who developed prolonged PAF. All covariates were considered for inclusion in aforementioned models, and the final model was determined using the purposeful selection method and clinical relevance of covariates.[9] Covariates were entered into the model if they had a *P* value <.20 on univariate analysis. Using iterative method, covariates were then removed from the model if they were nonsignificant and not a confounder. Finally, any variable not selected for original model was added back one at a time, with significant covariates and confounders retained. Odds ratios (ORs) are presented with 95% confidence intervals (CIs). For all analyses, patients were censored at the date of their last known contact at our institution or their primary cardiologist.

Cumulative survival curves were produced according to Kaplan–Meier method and differences between groups were compared with log-rank test. To address variables that confound the relationship between development of PAF and survival, a multivariable Cox proportional hazards regression model was constructed to identify independent risk factors for mortality. All statistical analyses were performed with SAS 9.4 software (SAS Institute Inc). ORs and hazard ratios (HRs) with 95% CIs and *P* values were reported.

RESULTS

Patients Characteristics

A total of 670 patients underwent isolated MVS including mitral valve repair or replacement during the study period at our institution. Of these, 504 patients fulfilled the eligibility criteria (111 patients had preoperative AF, 34 patients underwent LAAA or PVI or maze procedure during MVS, 13 patients died within 30 days, 5 patients underwent redo cardiac surgery within 30 days, and 3 patients had missing data). Baseline characteristics are summarized in Table 1. Mean age was 60 ± 13 years, body mass index was 26.8 ± 5, and 59% of patients were male. Hypertension was present in 54%, diabetes in 11%, chronic lung disease in 11.5%, NYHA class III/IV heart failure in 20%, and pulmonary hypertension in 38% Mean LV ejection fraction was 58.4 ± 7.8%, LA diameter was 4.56 ± 0.78, and LAVI was 53.4 ± 21.3. The indication for surgery was mitral valve (MV) regurgitation in 434, MV stenosis in 54, and MV vegetation in 16 patients. Mitral valve repair was performed in 47% of patients and replacement in 53% patients. In our study cohort, 53% patients underwent traditional median sternotomy, and 47% patients underwent minithoracotomy.

Median follow-up time for all patients was 36 months (interquartile range [IQR], 24-37 months), with 58% of patients having longer than 3 years of follow-up. All patients had a documented postoperative EKG and follow-up was 99% at 3 months, 93% at 6 months, 87% at 1 year.

Prevalence and Predictors of PAF

In total, 303 (60.2%) patients developed PAF, of whom 138 patients (27.4%) developed transient PAF that resolved within 30 days postoperatively, and 165 patients (32.8%) developed prolonged PAF (Figure 1, *A*). The median duration of PAF was 5 days (IQR, 3-12) for transient PAF and 160 days (IQR, 62-420) for prolonged PAF. Prevalence of PAF during the study period from 2011 to 2021 showed

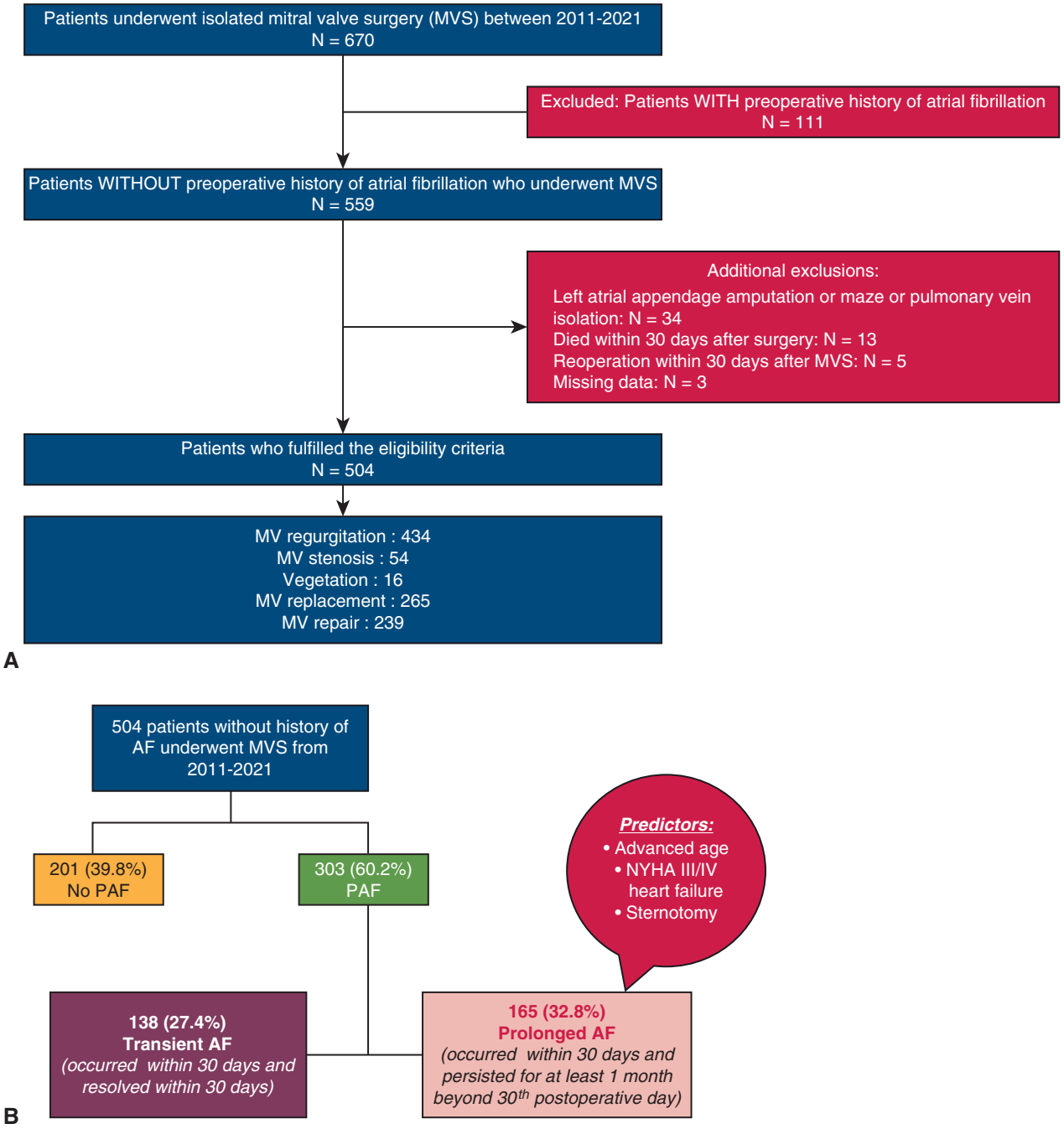


FIGURE 1. A, Overview of final study sample of patients underwent isolated MVS. B, Distribution of patients who developed transient versus prolonged PAF after MVS and predictors for prolonged PAF after MVS. *MV*, Mitral valve; *AF*, atrial fibrillation; *PAF*, postoperative atrial fibrillation; *NYHA*, New York Heart Association.

the percentage of patients with prolonged PAF doubled during this time (Figure 2).

Baseline characteristics of patients who did not develop PAF, those who developed transient PAF, and those who developed prolonged PAF are compared and summarized in Table 1. Compared with patients without PAF, those who developed prolonged PAF were older (54.3 vs 65.7 years, $P < .001$), had a greater incidence of hypertension (47.8% vs 60%, $P = .057$), chronic lung disease (9.5% vs 16.4%, $P = .057$), NYHA III/IV heart failure (8.5% vs 36%, $P < .001$), obstructive sleep apnea (12% vs 25.5%, $P = .002$), pulmonary hypertension (30.8% vs 48.2%, $P = .003$), and sternotomy (42.3% vs 73.9%, $P < .001$). Patients who developed prolonged PAF were

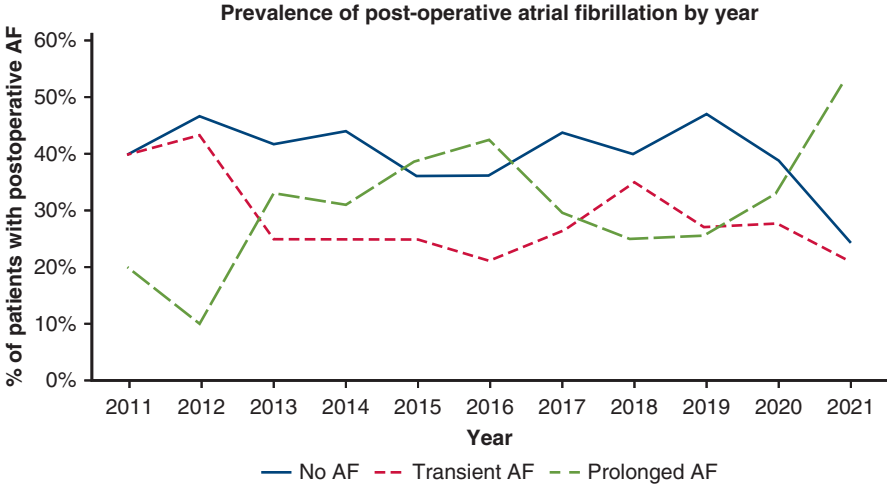


FIGURE 2. Prevalence of postoperative AF during the study period 2011-2021. *AF*, Atrial fibrillation.

also more likely to have echocardiographic findings of larger LA size (4.3 cm vs 4.8 cm, $P < .001$) and greater LAVI (45 vs 56, $P < .001$). There were no statistical differences in sex, body mass index, presence of diabetes, hyperlipidemia, smoking, creatinine, or time on cardiopulmonary bypass between groups (all $P > .05$).

Table 2 lists associated variables of any PAF and Table 3 lists associated variables of prolonged PAF after MVS. Independent associators of any PAF, transient or prolonged, included older age (OR, 1.04; 95% CI, 1.02-1.06; $P < .001$), greater incidence of NYHA class III/IV heart failure (OR, 6.73; 95% CI, 2.55-17.82; $P < .001$), use of preoperative beta-blocker medications (OR, 2.11; 95% CI, 1.28–3.47; $P = .003$), increased LAVI (OR, 1.02; 95% CI, 1.01-1.04; $P = .003$), and use of sternotomy (OR, 2.19; 95% CI, 1.33-3.61; $P = .002$). Independent predictors specifically of prolonged PAF included older age (OR, 1.08; 95% CI, 1.03-1.12; $P < .001$), greater incidence of heart failure (OR, 3.48; 95% CI, 1.27-9.53; $P = .015$), and use of sternotomy (OR, 4.30; 95% CI, 1.56-11.88; $P = .004$).

Association of PAF With Mortality

Patients who developed PAF had significantly increased mortality compared with patients without PAF (5.3% vs 0.5%, $P = .005$) (Figure 3, *A* and *B*). On multivariable analysis, predictors of 3-year mortality included PAF (transient or prolonged) (HR, 7.81; 95% CI, 1.03-59.07, $P = .047$), chronic lung disease (HR, 4.14; 95% CI, 1.57-10.93, $P = .004$), and intraoperative use of blood products (HR, 4.85; 95% CI, 1.57-14.97, $P = .006$) (Table 4). Of note, the 95% CI for PAF is wide, as only 1 patient died in the no-PAF category.

DISCUSSION

In a large cohort of patients undergoing isolated MVS at a single moderate-volume center, we report a high incidence of PAF. Older age, advanced heart failure, and use of sternotomy are independent predictors of prolonged PAF (Figure 1, *B*). PAF is associated with all-cause 3-year mortality.

Prevalence and Predictors of PAF

The incidence of PAF has mainly been reported after CABG,[2,4] with limited studies reporting the incidence after MVS. New-onset PAF has been reported in 24% of patients after surgery for mitral regurgitation[10] and in 39% of patients after surgery for mitral stenosis.[11] Overall, the incidence of new-onset PAF in patients undergoing MVS is between 14% and 42%.[12,13] A study of 762 patients undergoing isolated MVS for mitral regurgitation from Kernis and colleagues[10] showed an incidence of 24%, with 18% for early PAF (within 2 weeks) and 19% at 10 years for late PAF. Another study of 856 patients who underwent MVS with or without concomitant coronary or tricuspid valve surgery from Bramer and colleagues[13] reported an incidence of 42% after MVS. The differences between the reported lower incidences in previous studies and the higher ones in our study are likely related to varied AF criteria, patient differences, and greater use of mitral valve repair. In the study by Kernis and colleagues,[10] 72% patients underwent mitral valve repair and 28% patients underwent mitral valve replacement. In our study, we reported a greater percentage of patients who underwent mitral valve replacement and perhaps one of the reasons contributing to greater incidence of PAF after MVS. Previous studies have documented the inconsistent role of enlarged LA size in subsequent PAF after cardiac surgery, with inconsistent findings, as it was not evaluated in most of the largest studies. In this study, LA size was a strong predictor of PAF, specifically, prolonged PAF after MVS. Greater LAVI has shown to be the independent predictor of PAF even after adjusting for various factors such as

TABLE 2. Associated variables of PAF at any time postoperatively

Characteristics	Univariate analysis			Multivariate analysis (AIC = 391.0)	
	OR (95% CI)	*P* value	AIC	OR (95% CI)	*P* value
MV replacement	1.38 (0.97-1.97)	.0780	678.8		
Redo	1.25 (0.64-2.46)	.5119	681.5		
Age	1.06 (1.04-1.07)	<.0001	619.4	1.04 (1.02-1.06)	.0001
Sex, female	1.11 (0.77-1.59)	.5854	681.6		
BMI >30	0.98 (0.64-1.51)	.9418	681.9		
Race, non-White	0.46 (0.27-0.80)	.0056	666.4		
Hypertension	1.52 (1.06-2.17)	.0231	676.7		
Diabetes	0.95 (0.54-1.66)	.8464	681.9		
Endocarditis	0.46 (0.28-0.76)	.0023	672.6		
Chronic lung disease	1.42 (0.79-2.53)	.2407	680.5		
Sleep apnea	1.94 (1.16-3.22)	.0110	675.0		
Smoking	0.90 (0.60-1.36)	.6175	678.8		
Hyperlipidemia	1.40 (0.98-2.00)	.0663	678.5		
Heart failure	3.13 (2.03-4.84)	<.0001	652.6		
NYHA class 3/4	4.02 (2.30-7.01)	<.0001	652.9	6.73 (2.55-17.82)	.0001
RF: renal failure (dialysis)	0.88 (0.30-2.58)	.8177	681.9		
Pulmonary HTN	1.71 (1.17-2.49)	.0056	666.5		
RF: creatinine	1.10 (0.92-1.31)	.3110	680.8		
RF: hemoglobin	1.04 (0.96-1.13)	.3526	681.0		
STS score	2.68 (0.74-9.74)	.1331	679.5		
Meds: beta-blockers within 24 h	1.91 (1.33-2.75)	.0004	669.4	2.11 (1.28-3.47)	.0032
Meds: beta-blockers within 2 wk	1.90 (1.30-2.78)	.0010	670.8		
Meds: calcium channel blocker within 2 wk	1.42 (0.66-3.09)	.3731	681.1		
Meds: lipid lowering within 24 h	1.52 (1.00-2.32)	.0498	678.0		
BSA	1.15 (0.55-2.39)	.7149	681.8		
RV dysfunction	0.99 (0.47-2.11)	.9890	681.9		
EF %	0.97 (0.95-0.99)	.0121	675.2		
MV area	0.94 (0.78-1.13)	.4960	328.5		
Mean MV gradient, mm Hg	0.99 (0.95-1.03)	.6274	327.8		
LA diameter enlargement (>3.8 [female] or >4 cm [male])	2.50 (1.58-3.96)	<.0001	627.3		
LA volume enlargement (>52 [female] or >59 [male])	2.06 (0.97-4.35)	.0594	501.7		
LAVI (LA volume/BSA)	1.02 (1.01-1.04)	<.0001	486.7	1.02 (1.01-1.04)	.0034
LVMI enlargement (LV mass/BSA; >100 [female] or 110 [male])	1.27 (0.86-1.85)	.2263	599.2		
LVEDV, mL	1.00 (0.99-1.00)	.4088	266.0		
LVESV, mL	1.00 (0.99-1.02)	.3813	278.3		
LVIDD, cm	0.95 (0.75-1.20)	.6886	653.0		
LVIDS, cm	1.15 (0.89-1.50)	.2861	651.0		
RVSP, mm Hg	1.01 (0.99-1.02)	.2935	426.3		
RASP, mm Hg	1.05 (0.97-1.13)	.2099	393.9		
Sternotomy	2.08 (1.45-2.99)	<.0001	665.9	2.19 (1.33-3.61)	.0020
Cardiopulmonary bypass time, min	1.00 (1.00-1.01)	.3482	681.0		

(Continued)

TABLE 2. Continued

Characteristics	Univariate analysis			Multivariate analysis (AIC = 391.0)	
	OR (95% CI)	*P* value	AIC	OR (95% CI)	*P* value
IABP	1.27 (0.55-2.90)	.5742	681.6		
Intraoperative blood products	1.52 (1.03-2.24)	.0343	677.3		
Postoperative blood products	1.53 (1.04-2.26)	.0306	677.1		
Reoperation	1.17 (0.56-2.43)	.6802	679.9		

AIC, Akaike information criterion; *OR*, odds ratio; *CI*, confidence interval; *MV*, mitral valve; *BMI*, body mass index; *NYHA*, New York Heart Association; *HTN*, hypertension; *RF*, risk factor; *STS*, Society of Thoracic Surgeons; *BSA*, body surface area; *RV*, right ventricle; *EF*, ejection fraction; *LA*, left atria; *LAVI*, left atrial volume index; *LVMI*, left ventricle mass index; *LVEDV*, left ventricle end diastolic volume; *LVESV*, left ventricle end systolic volume; *LVIDD*, left ventricular internal diameter end diastole; *LVIDS*, left ventricular internal diameter end systole; *RVSP*, right ventricle systolic pressure; *RASP*, right atria systolic pressure; *IABP*, intra-aortic balloon pump.

age, sex, type of surgery, LV function, presence or absence of heart failure, and other medical comorbidities. In Framingham study, a 5-mm incremental increase in LA diameter was associated with a 39% increased risk for subsequent development of PAF.[14] The Cardiovascular Health Study showed a 4-fold increase in the risk of new PAF with an LA diameter >5 cm.[15] In our study, the mean LA diameter in patients with PAF was 4.5 cm (4.1-4.9) and 4.8 cm (4.3-5.2) after transient and prolonged PAF, respectively. Our study tracked new-onset PAF beyond the initial hospitalization, as opposed to other studies that only focused on the immediate postoperative period. In our study, 27% of patients developed transient PAF in the immediate postoperative period that subsequently resolved. These patients are less likely to require long-term antiarrhythmic or anticoagulation interventions and the long-term impact on morbidity and mortality is not evident. On the contrary, 32% of patients with prolonged PAF that persisted beyond 1 month after surgery represents a population that is likely to require anticoagulation therapy with greater impact on morbidity and mortality and is most likely to benefit from prophylactic interventions. We excluded patients with preoperative history of AF to reduce confounding from recurrence of preexisting arrhythmic conditions. Thus, we identify a specific group of high-risk patients based on their preoperative risk profile that could benefit from prophylactic treatments.

Consistent with our findings, previous studies have demonstrated age and heart failure to be important predictors of PAF after cardiac surgery. Mahoney and colleagues[16] developed a predictive model for PAF after valvular surgery that included age and chronic lung disease or chronic obstructive pulmonary disease and had a predictive value of 0.665. Other studies have proposed variables such as age, left atrial volume, chronic obstructive pulmonary disease, emergent nature of surgery, use of preoperative or intraoperative balloon pump, left ventricular ejection fraction <30%, and any valvular surgery as independent predictors of PAF.[17,18] However, advanced age was found to be the only consistent predictor among all the studies.[7,16,17,19,20] This inconsistency among different studies is likely due to varied clinical populations and the types of surgeries performed. In our study, we specifically focused on isolated MVS to increase the specificity of our findings. In addition, we included relevant variables to determine a set of risk factors that could be used to make crucial preoperative or intraoperative treatment decisions about interventional prophylaxis. Our findings may therefore add more clinical utility for the surgeon when determining the role of prophylactic treatment options in MVS.

Similar to previous studies, our results demonstrated traditional median sternotomy to be an independent risk factor of prolonged PAF.[21] PAF may be related to fluid shifts, oxidative stress, inflammation, catecholamine release, and altered sympathetic and parasympathetic activity during cardiac surgery.[22] In addition, direct injury to the atria either from manipulation or incision during surgery may disrupt electrical conduction,[22] which may contribute to refractoriness and the formation of reentry wavelets. The decreased incidence of prolonged PAF with the minimally invasive approach such as minithoracotomy, could result from less atrial injury with less manipulation and injury to the heart including aortic and atrial cannulation, lower inflammatory response and less air-drying of the atrial epicardium. Although preoperative beta-blocker use was found to be associated with the development of PAF, this is likely a confounded association. Patients who were at high risk for PAF were also found to have other medical comorbidities, such as heart failure, and were prescribed preoperative beta blockers at a greater rate.

Association of PAF With Mortality

The effect of PAF after MVS on mortality has been studied by other investigators with conflicting results.[2,23,24] Almassi and colleagues[2] studied PAF-related 6-month survival after cardiac surgery. In a population of almost 4000 patients, only 2% of the patients underwent MVS (isolated or combined). Moreover, no analysis was done specifically for patients who underwent valve surgery, and therefore no conclusions could be drawn about survival after valve surgery. Mariscalco and Engstrom[23] showed an increased HR for late mortality in patients with new PAF after CABG surgery. However, patients with new-onset PAF who underwent isolated valvular surgery or combined

TABLE 3. Associated variables of prolonged PAF

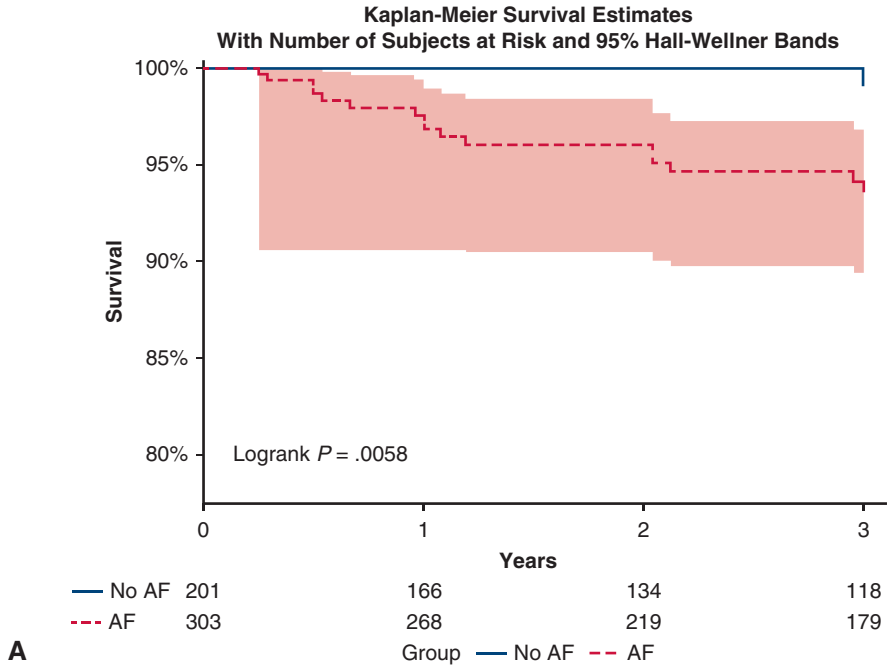
Characteristics	Univariate analysis			Multivariate analysis (AIC = 122.4)	
	OR (95% CI)	*P* value	AIC	OR (95% CI)	*P* value
MV replacement	2.11 (1.44-3.10)	.0001	626.4		
Redo	2.46 (1.28-4.71)	.0068	634.1		
Age	1.05 (1.04-1.07)	<.0001	597.2	1.08 (1.03-1.12)	.0006
Sex, female	1.03 (0.71-1.51)	.8614	641.3		
BMI >30	1.25 (0.80-1.94)	.3230	640.4		
Race, non-White	0.88 (0.49-1.57)	.6557	632.1		
Hypertension	1.44 (0.99-2.10)	.0585	637.8		
Diabetes	0.80 (0.44-1.48)	.4816	640.9		
Endocarditis	0.77 (0.45-1.32)	.3442	640.4		
Chronic lung disease	1.94 (1.12-3.38)	.0186	636.0		
Sleep apnea	2.23 (1.39-3.57)	.0008	630.4		
Smoking	1.01 (0.66-1.54)	.9751	638.3		
Hyperlipidemia	1.21 (0.83-1.76)	.3151	640.4		
Heart failure	3.64 (2.44-5.44)	<.0001	600.9	3.48 (1.27-9.53)	.0150
NYHA class3/4	4.16 (2.63-6.58)	<.0001	603.2		
RF: renal fail-dialysis	0.82 (0.25-2.65)	.7366	641.3		
Pulmonary HTN	1.85 (1.26-2.71)	.0016	625.9		
RF: creatinine	1.09 (0.93-1.27)	.3097	640.4		
RF: hemoglobin	1.04 (0.96-1.14)	.3491	640.5		
STS score	5.35 (1.56-18.38)	.0078	634.3		
Meds: beta blockers within 24 h	1.75 (1.19-2.58)	.0042	633.0		
Meds: beta blockers within 2 wk	2.29 (1.56-3.35)	<.0001	623.3		
Meds: calcium channel blocker within 2 wk	2.02 (0.97-4.19)	.0595	637.9		
Meds: lipid lowering within 24 h	1.43 (0.94-2.17)	.0919	638.6		
BSA	2.19 (1.00-4.78)	.0494	637.4		
RV dysfunction	2.16 (1.03-4.53)	.0418	637.3		
EF %	0.97 (0.95-1.00)	.0197	635.9		
MV area	0.68 (0.55-0.84)	.0003	324.9		
Mean MV gradient, mm Hg	1.02 (0.98-1.06)	.3759	340.6		
LA diameter enlargement (>3.8 [female] or >4 cm [male])	2.36 (1.37-4.06)	.0020	604.1		
LA volume enlargement (>52 [female] or >59 [male])	2.78 (1.04-7.44)	.0420	487.3		
LAVI (LA volume/BSA)	1.02 (1.01-1.03)	<.0001	472.4		
LVMI enlargement (LV mass/BSA; >100 [female] or 110 [male])	1.11 (0.75-1.64)	.5928	582.8		
LVEDV, mL	1.00 (0.99-1.00)	.6664	274.2		
LVESV, mL	1.00 (0.99-1.02)	.3484	288.8		
LVIDD, cm	1.02 (0.80-1.30)	.9032	614.6		
LVIDS, cm	1.13 (0.86-1.48)	.3749	613.1		
RVSP, mm Hg	1.02 (1.00-1.03)	.0255	406.0		
RASP, mm Hg	1.03 (0.96-1.11)	.4342	360.8		
Sternotomy	3.75 (2.49-5.64)	<.0001	597.4	4.30 (1.56-11.88)	.0049
Cardiopulmonary bypass time, min	1.00 (1.00-1.00)	.7560	641.3		
IABP	0.75 (0.31-1.81)	.5178	640.9		
Intraoperative blood products	1.68 (1.14-2.47)	.0091	634.6		

(Continued)

TABLE 3. Continued

Characteristics	Univariate analysis			Multivariate analysis (AIC = 122.4)	
	OR (95% CI)	*P* value	AIC	OR (95% CI)	*P* value
Postoperative blood products	1.59 (1.08-2.35)	.0190	635.9		
Reoperation	1.03 (0.49-2.17)	.9463	640.6		

AIC, Akaike information criterion; *OR*, odds ratio; *CI*, confidence interval; *MV*, mitral valve; *BMI*, body mass index; *NYHA*, New York Heart Association; *RF*, risk factor; *HTN*, hypertension; *STS*, Society of Thoracic Surgeons; *BSA*, body surface area; *RV*, right ventricle; *EF*, ejection fraction; *LA*, left atria; *LAVI*, left atrial volume index; *LVMI*, left ventricle mass index; *LV*, left ventricle; *LVEDV*, left ventricle end diastolic volume; *LVESV*, left ventricle end systolic volume; *LVIDD*, left ventricular internal diameter end diastole; *LVIDS*, left ventricular internal diameter end systole; *RVSP*, right ventricle systolic pressure; *RASP*, right atria systolic pressure; *IABP*, intra-aortic balloon pump.



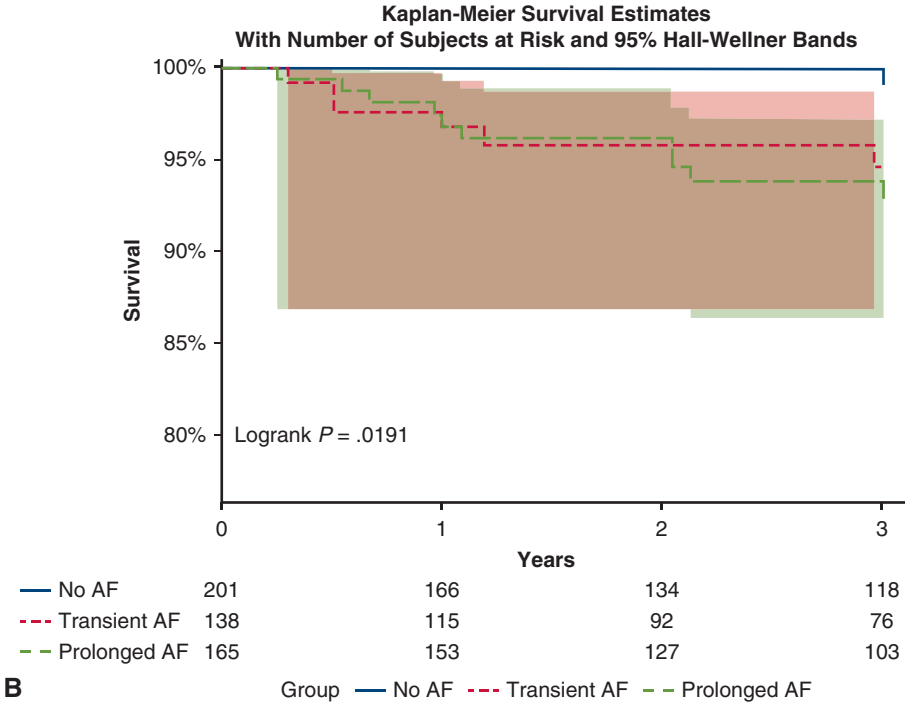


FIGURE 3. A, Kaplan–Meier survival curves with log rank test comparing no PAF versus PAF (transient and prolonged combined). B, Kaplan–Meier survival curves with log rank test comparing 3 groups (no PAF, transient PAF, and prolonged PAF). *AF*, Atrial fibrillation.

TABLE 4. Multivariable analysis of 3-year mortality

Characteristics	Univariate analysis			Multivariate analysis (AIC = 181.5)	
	HR (95% CI)	*P* value	AIC	HR (95% CI)	*P* value
AF (transient and prolonged combined)	9.98 (1.32-75.20)	.02563	195.3	7.81 (1.03-59.07)	.0466
MV replacement	6.82 (1.56-29.82)	.01077	195.0		
Redo	1.44 (0.33-6.28)	.63045	204.9		
Age	1.04 (1.00-1.09)	.04110	200.5		
Sex, female	1.99 (0.76-5.23)	.16213	203.1		
BMI >30	1.49 (0.53-4.23)	.45273	204.6		
Race, non-White	1.60 (0.46-5.56)	.46223	204.2		
Hypertension	2.12 (0.75-6.02)	.15817	202.9		
Diabetes	2.73 (0.89-8.38)	.07887	202.6		
Endocarditis	2.05 (0.67-6.29)	.20927	203.7		
Chronic lung disease	5.19 (1.98-13.64)	.00083	195.8	4.14 (1.57-10.93)	.0041
Sleep apnea	1.47 (0.48-4.52)	.49863	204.7		
Smoking	2.00 (0.57-6.97)	.27817	203.6		
Hyperlipidemia	1.28 (0.49-3.36)	.61892	204.8		
Heart failure	4.54 (1.68-12.28)	.00288	195.7		
NYHA class3/4	3.07 (1.17-8.06)	.02305	200.5		
RF: renal fail-dialysis	5.77 (1.31-25.35)	.02038	201.6		
Pulmonary HTN	2.31 (0.88-6.06)	.08985	201.8		
RF: creatinine	1.20 (0.97-1.48)	.10163	203.3		
RF: hemoglobin	0.69 (0.56-0.85)	.00048	193.1		
STS score	17.97 (2.16-149.43)	.00752	199.8		
Meds: beta blockers within 24 h	1.45 (0.54-3.93)	.46190	204.5		
Meds: beta blocker within 2 wk	1.15 (0.44-3.03)	.77104	205.0		
Meds: calcium channel blocker within 2 wk	2.04 (0.47-8.91)	.34490	204.4		
Meds: lipid lowering within 24 h	1.42 (0.50-4.03)	.51324	204.7		
BSA	0.58 (0.08-4.05)	.58541	204.8		
RV dysfunction	3.63 (1.04-12.65)	.04275	202.0		
EF %	0.96 (0.91-1.00)	.06315	202.2		
MV area	1.49 (1.07-2.08)	.01728	123.2		
Mean MV gradient, mm Hg	0.95 (0.84-1.08)	.47127	116.2		
LA diameter enlargement (>3.8 [female] or > 4 cm [male])	0.93 (0.26-3.31)	.91417	179.4		
LA volume enlargement (>52 [female] or > 59 [male])	Can't be estimated due to no one died among patients without LA volume enlargement				
LAVI (LA volume/BSA)	1.02 (1.01-1.04)	.00097	131.1		
LVMI enlargement (LV mass/BSA; >100 [female] or 110 [male])	1.30 (0.45-3.76)	.62223	167.0		

(Continued)

TABLE 4. Continued

Characteristics	Univariate analysis			Multivariate analysis (AIC = 181.5)	
	HR (95% CI)	*P* value	AIC	HR (95% CI)	*P* value
LVEDV, mL	0.98 (0.96-1.01)	.14708	59.8		
LVESV, mL	0.99 (0.95-1.03)	.51803	62.7		
LVIDD, cm	0.60 (0.37-0.97)	.03688	176.9		
LVIDS, cm	0.87 (0.41-1.85)	.72572	180.2		
RVSP, mm Hg	1.01 (0.98-1.05)	.37727	145.2		
RASP RVSP, mm Hg	0.89 (0.71-1.12)	.32632	131.5		
Sternotomy	2.04 (0.72-5.78)	.18105	203.2		
Cardiopulmonary bypass time, min	1.00 (0.99-1.01)	.89283	205.1		
IABP	1.55 (0.21-11.74)	.66978	204.9		
Intraoperative blood products	6.31 (2.06-19.35)	.00128	192.3	4.85 (1.57-14.97)	.0060
Postoperative blood products	3.66 (1.36-9.91)	.01051	198.1		
Reoperation	3.09 (0.89-10.75)	.07630	202.6		

AIC, Akaike information criterion; *OR*, odds ratio; *CI*, confidence interval; *AF*, atrial fibrillation; *MV*, mitral valve; *BMI*, body mass index; *NYHA*, New York Heart Association; *RF*, risk factor; *HTN*, hypertension; *STS*, Society of Thoracic Surgeons; *BSA*, body surface area; *RV*, right ventricle; *EF*, ejection fraction; *LA*, left atria; *LAVI*, left atrial volume index; *LVMI*, left ventricle mass index; *LV*, left ventricle; *LVEDV*, left ventricle end diastolic volume; *LVESV*, left ventricle end systolic volume; *LVIDD*, left ventricular internal diameter end diastole; *LVIDS*, left ventricular internal diameter end systole; *RVSP*, right ventricle systolic pressure; *RASP*, right atria systolic pressure; *IABP*, intra-aortic balloon pump.

CABG and valvular surgery did not have an increased risk. No separate analysis was done for patients with isolated aortic or mitral valve surgeries. Although recent studies have shown an independent effect of PAF on mortality after aortic valve surgery,[24,25] the effect of PAF on late survival after MVS has not been well described. One study with 361 patients with MVS and median follow-up of 3.1 years demonstrated that PAF was an independent predictor of all-cause late mortality, defined as death beyond 30 days, but was not associated with increased early mortality. This group experienced significantly more in-hospital cerebrovascular events, which may have contributed to increased late mortality in these patients.[13] Another study by Doshi and colleagues[26] with patients who underwent 2580 transcatheter MV repair showed no significant differences in adjusted major adverse cardiac and cerebrovascular events rates and in-hospital mortality for patients with and without PAF. However, patients with PAF had longer median lengths of stay and greater associated resource use costs, which they state may have been due to PAF, older age, and increased comorbidities in patients with PAF. Other studies have shown similar non-significant differences in mortality between patients with and without PAF after MVS, but show an increasing trend towards mortality or stroke and increased risk of recurrent myocardial infarction.[10,12,27]

Previous studies have investigated the role of prophylactic surgical interventions to reduce the risk of new-onset PAF after cardiac surgery. In a retrospective cohort study of 75,782 patients undergoing cardiac surgery (propensity score-matched cohort of 8590 patients), 25% of the patients did not have history of preoperative AF. Overall in the propensity score–matched patients, LAAO was associated with reduced risk of stroke and mortality; however, when looking at patients without preoperative AF, there was no difference in stroke and survival but an increased risk of postoperative AF in patients who underwent LAAO.[28] A meta-analysis of patients who underwent cardiac surgery with concomitant LAAA showed a survival benefit and reduced incidence of stroke.[29] Prophylactic management of new-onset PAF for patients undergoing MVS is primarily through medical therapy as recommended by the 2014 American Heart Association/American College of Cardiology/Heart Rhythm Society guidelines on the management of AF. Currently, studies on prophylactic surgical or transcatheter ablation in MVS are few to none due to the uncertainty in benefits and risks of ablation in patients who present with sinus rhythm and the frequently transient nature of PAF.[30,31] The Left Atrial Appendage Exclusion for Prophylactic Stroke Reduction (LeAPPs) trial is prospective, randomized, multicenter, and multinational study that is underway to evaluate the effectiveness of left atrial appendage exclusion for the prevention of ischemic stroke or systemic arterial embolism in patients undergoing cardiac surgery who have risk factors for AF and ischemic stroke. Prophylactic surgical ablation has been reported for "high-risk" (such as rheumatic heart disease patients undergoing MV repair) procedures.[32] As these high-risk patient populations are rarely found within the United States, however, this prophylactic approach to prevent AF is not commonplace. PAF in the field of MV disease has great potential to reduce the incidence of PAF, reduce

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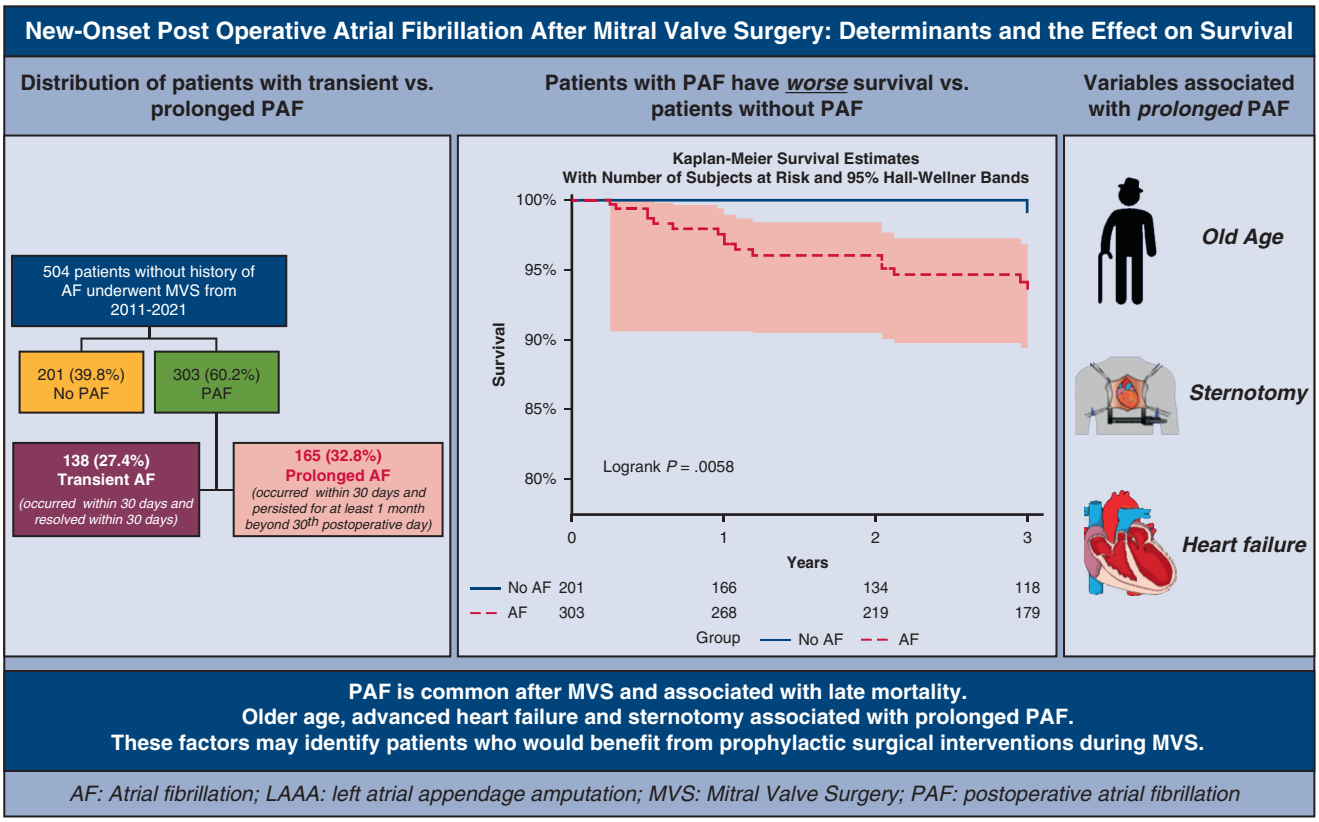

FIGURE 4. Study design and implication of study. *PAF*, Postoperative atrial fibrillation; *AF*, atrial fibrillation; *MVS*, mitral valve surgery; *NYHA*, New York Heart Association.

mortality, and improve the quality of life for patients undergoing MVS due to the high incidence of PAF in these patients and opportunities for concomitant prophylactic ablative therapy. Currently, few studies exist to determine whether prophylactic ablation during MVS is safe without increasing the risk of developing PAF and effective in reducing PAF for patients who present with sinus rhythm but may be at risk of PAF.[30,31] With no difference in Society of Thoracic Surgeons morbidity and mortality and pacemaker implantation over 30 days, patients who underwent concomitant surgical ablations had fewer incidences of AF at hospital discharge and lower health care costs.[33] Prophylactic surgical intervention such as ablation is promising, especially due to the high likelihood of developing PAF after MVS, however, there is currently no evidence to support this practice.

Our study identified a subgroup of patients who are at high risk for developing PAF after MVS, and PAF is associated with all-cause 3-year mortality. Therefore, these findings underscore the importance of considering prophylactic surgical therapy through LAA closure, PVI, or concomitant surgical ablation in this subset of high-risk patients. This may reduce the incidence of PAF and may ultimately improve the survival after MVS.

Limitations

This study has some limitations. This was a single-center retrospective study, and despite a relatively large sample size, it is prone to selection bias. We have shown PAF is less prevalent patients undergoing minithoracotomy, but there is the possibility of surgeons' bias in selecting patients who are less complicated for minimally invasive surgery. AF was considered to be present only when objectively documented and the lack of extensive EKG monitoring before surgery may have led to an underestimation of preexisting paroxysmal AF. Similarly, the incidence of PAF after MVS was likely underestimated, as patients were not subjected to extensive continuous monitoring after discharge and diagnosis was dependent on outpatient physician visits. Lastly, the causes of death are unknown and therefore AF as

the cause of increased mortality cannot be definitively established.

CONCLUSIONS

PAF is common after isolated MVS and is associated with late mortality. Older age, advanced heart failure, and sternotomy identify a subgroup of patients at high risk for developing PAF, particularly prolonged PAF after MVS. Prophylactic surgical interventions such as ablation or LAAA during MVS may be targeted towards this subgroup of high-risk patients (Figure 4).

Conflict of Interest Statement

Dr Huddleston is an American Transplant Congress invited speaker. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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