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Scores predicting atrial fibrillation after mitral valve surgery: Do we need a more specific score?

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Abstract

Background: Atrial fibrillation after cardiac surgery (POAF) is associated with increased morbidity and mortality. Several scores were used to predict POAF, with variable results. Thus, this study assessed the performance of several scoring systems to predict POAF after mitral valve surgery. Additionally, we identified the risk factors for POAF in those patients.

Methods: This retrospective cohort included 1381 recruited from 2009 to 2021. The patients underwent mitral valve surgery, and POAF occurred in 233 (16.87%) patients. The performance of CHADS2, CHA2DS2-VASc, POAF, EuroSCORE II, and HATCH scores was evaluated.

Results: The median age was higher in patients who developed POAF (60 vs. 54 years; $p < .001$). CHA2-DS2-VASc, POAF, EuroSCORE II, and HATCH scores significantly predicted POAF, with areas under the curve of the receiver operator curve (AUCROC) of 0.56, 0.61, 0.58, and 0.54, respectively. We identified age > 58 years, body mass index > 28 kg/m^2, creatinine clearance < 90 mL/min, reoperative surgery, and preoperative inotropic and intra-aortic balloon pump use as predictors of POAF. We constructed a score from these variables (PSCC-AF). A score > 2 significantly predicted POAF ($p < .001$). The AUCROC of this score was 0.67, which was significantly higher than the AUCROC of the POAF score ($p = .009$).

Conclusion: POAF after mitral valve surgery can be predicted based on preoperative patient characteristics. The new PSCC-AF score significantly predicted POAF after mitral valve surgery and can serve as a bedside diagnostic tool for POAF risk screening. Further studies are needed to validate the PSCC-AF-mitral score externally.

KEYWORDS
atrial fibrillation, cardiac surgery, mitral valve surgery, risk-scoring systems

Monirah A. Albabtain and Elham A. Almathami contributed equally.

1 | BACKGROUND

Atrial fibrillation after cardiac surgery is a common but serious complication.[1,2] The prevalence of postoperative atrial fibrillation (POAF) was estimated to range from 16% to 55%.[2–4] A meta-analysis reported that POAF after cardiac surgery was associated with high early mortality, stroke, prolonged intensive care unit (ICU) stay, and hospital stay.[5] Infections, thromboembolic events, cardiac arrests, and reoperation because of bleeding are complications also seen in POAF patients.[3] The prevalence of POAF was reported to be higher in elderly and hypertensive patients and those with renal impairment, heart failure, and peripheral vascular disease (PAD).[5–7] Predicting POAF may allow early intervention for higher-risk patients to decrease the incidence and complications of POAF.[8]

The $CHADS_2$ and CHA_2DS_2-VASc scores are bedside scores for stroke risk assessment in patients with atrial fibrillation (AF).[9,10] Studies reported that $CHADS_2$ and CHA_2DS_2-VASc scores effectively predicted stroke and thromboembolic risk in patients with AF.[10,11] Multiple studies have shown promising results in investigating the use of $CHADS_2$ and CHA_2DS_2-VASc scores to predict POAF.[9,12,13] Attempts to design a novel prediction model have been made. The POAF score is a bedside tool developed to predict POAF after cardiac surgery, and many variables have been tested for correlation; however, only age, low ejection fraction (EF), low estimated glomerular filtration rate (eGFR) or dialysis, operative urgency, preoperative intra-aortic balloon pump (IABP), heart valve surgery, and chronic obstructive pulmonary disease (COPD) were found to be predictors of POAF.[14] The HATCH score is another prediction tool, a point system that was found to be correlated with the new-onset AF after coronary artery bypass (CABG) surgery.[15]

However, in these studies, the population studied is heterogeneous, and the number is considerably low. The main focus was CABG surgery; fewer patients underwent mitral valve replacement surgery. In the era of big data and precision medicine, it is recommended to have risk-scoring systems tailored for each procedure and specific complications. Thus, this study focused on the utility of these prediction tools in predicting POAF after mitral valve surgery. Predicting POAF will enhance a personalized approach to the preoperative use of prophylaxis treatment for POAF in high-risk patients only and minimize the potential side effects of medications. Therefore, the objectives were to assess the utility of $CHADS_2$, CHA_2DS_2-VASc, POAF, EuroSCORE, and HATCH scores in predicting POAD after mitral valve surgery and to identify its predictors in those patients.

2 | PATIENTS AND METHODS

2.1 | Design and patients

A single-center cohort study was conducted at a tertiary referral center, including patients who underwent mitral valve surgery between 2009 and 2021. We excluded patients with preoperative AF, pacemaker implantation, and patients who underwent ablation procedures for atrial arrhythmia.

2.2 | Study data

Electronic medical records of all patients were reviewed, and variables of the POAF, CHADS2, CHA2DS2-VASc, EuroSCORE II, and HATCH scores were gathered. The CHADS2 and the expanded CHA2DS2-VASc scores were calculated. The POAF was calculated for all patients by assigning 1 point for ages ranging between 60 and 69 and, 2 points for ages ranging from 70 to 79 and 3 points for ages 80 or above, 1 point for each of the following variables if present: COPD, eGFR<15 mL/min per 1.73 m^2, emergency surgery, preoperative IABP, EF < 30%, and valve surgery. The HATCH scoring system consists of hypertension (1 point), COPD (1 point), age (75 years or more) (1 point), heart failure (EF < 40%) (2 points), and stroke or TIA (2 points). Additionally, the predictive ability of EuroSCORE II for POAF was evaluated.

We also tested each of these score variables individually. Those variables that independently had a higher association with the occurrence of POAF were tested in multiple combinations to find the best predictive model of POAF in our population.

2.3 | Primary endpoint

The primary outcome was POAF. POAF was defined as new-onset AF occurring postoperatively and requiring treatment.[16]

2.4 | Ethical approval

The data collection of this study was approved by the Institutional Review Board (IRB) (Reference number: 1650), and the IRB waived the need for patient consent because of the retrospective design.

2.5 | Statistical analysis

The *t*-test or the Wilcoxon test was used to compare continuous data. The chi-squared or Fisher exact test was used for categorical data. We utilized the mean, standard deviation, median, 25th–75th percentiles or numbers and percentages to present the data. Multivariable logistic regression analysis was performed, and variable selection was performed using the best subset selection method. All preoperative variables, including patients' demographics, comorbidities, laboratory results, and echocardiographic data, were included in the selection. The best subset was chosen according to the adjusted R2, Mallow's Cp, and Bayesian information criteria (BIC). Backward elimination was performed to keep variables with a *p*-value of less than .05 in the final model. Continuous variables were dichotomized at the best cutoff point. Selected variables were introduced into a multivariable logistic regression model, and variables with a *p*-value of less than .05 were retained in the final model. Model discrimination was calculated using the area under the receiver operator curve. To generate a simplified score, one point was given if the odds ratio was from 1 to 2 and two points if the odds ratio was more than 2.[17] The AUCs of different scores were compared. K-fold cross-validation was used to validate the score. Patients missing any of the tested score components were excluded. Analyses were performed using Stata 18 (Stata Corp, College Station, TX, USA).

3 | RESULTS

3.1 | Comparison of patients with and without POAF

The study included 1381 patients; 233 (16.87%) developed POAF. The median age in the POAF group was higher than in patients without POAF. The need for emergency surgery was higher in the POAF group ($n=15$; 6.4%) than in the no-POAF group ($n=38$; 3.3%). The additive EuroSCORE II was higher in the POAF group, ranging from 2 to 7.4, with a median of 3.6, than in the no-POAF group, ranging from 1.6 to 5.6, with a median of 2.8 ($p<.001$). The use of an IABP was more common in the POAF group ($n=11$; 4.7%) and ($n=10$; 0.9%) in the no-POAF group. The use of inotropes was also significantly higher in the POAF group. Creatinine clearance was significantly lower in the POAF group than in the no-POAF group. Patients with POAF had significantly longer cardiopulmonary bypass and ischemic times (Table 1).

3.2 | Scores and prediction of POAF

The median CHADS2 score was 1 (25th–75th percentile: 0–2). The CHADS2 score did not significantly predict POAF (OR: 1.11 (95% CI: 0.99–1.24), $p=.083$). The area under the receiver operator curve (AUCROC) was 0.56. The median CHA2-DS2-VASc score was 2 (25th–75th percentile: 1–3). The score predicted POAF (OR: 1.13 (95% CI: 1.04–1.24), $p=.003$). EuroSCORE II was a significant predictor for POAF (OR: 1.02 (95% CI: 1.002–1.04), $p=.026$), and the AUC was 0.58. The median HATCH score was 1 (25th–75th percentiles: 0–3). The HATCH score predicted POAF significantly (OR: 1.24 (95% CI: 1.01–1.25); $p=.026$), and the AUCROC was 0.54. The median POAF score was 1 (25th–75th percentiles: 1–2), and it was a significant predictor for POAF (OR 1.55 (95% CI: 1.36–1.76) $p<.001$). The ROCAUC of the POAF score was 0.61 (Table 2).

3.3 | Prediction of POAF

Predictors of POAF were age > 58 years, BMI > 28 kg/m^2, creatinine clearance < 90 mL/min, preoperative IABP, preoperative inotropes, and preoperative surgery (Table 3).

TABLE 1 Comparison of the preoperative and operative data between patients with and without postoperative atrial fibrillation (POAF).

Variable	No-POAF ($n=1148$)	POAF ($n=233$)	*p*-value
Preoperative data			
Age, years	54 (44–63)	60 (51–70)	<.001
Male	628 (54.7)	130 (55.8)	.760
BMI, kg/m^2	27.4 (24–31.6)	28.6 (24–32)	.131
Smoking	93 (8.1)	11 (4.7)	.075
Poor mobility	31 (2.7)	11 (4.7)	.101
Previous cardiac surgery	131 (11.6)	34 (14.8)	.171
Prior myocardial infarction	216 (18.8)	49 (21)	.434
NYHA III or IV	822 (71.6)	166 (71.2)	.912
EuroSCORE II	2.8 (1.6–5.6)	3.6 (2–7.4)	<.001
Hypertension	544 (47.4)	119 (51.1)	.304
COPD	34 (3)	10 (4.3)	.292
Active endocarditis	37 (3.2)	10 (4.3)	.412
Prior stroke	44 (3.8)	12 (5.2)	.353
CrCl (mL/min)	95.4 (70–124.6)	80.4 (58.9–106.4)	<.001
Dialysis	33 (2.9)	15(6.5)	.007
Diabetes mellitus	495 (43.1)	100 (42.9)	.955
Extracardiac arteriopathy	21 (1.8)	7 (3)	.246
β-blockers	738 (72.07%)	140 (72.16%)	.979
IABP	10 (0.9)	11 (4.7)	<.001
Pre-inotropes	151 (13.2)	56 (24)	.002
Pre-ventilation	132 (11.5)	44 (18.9)	.002
Ejection fraction (%)	50 (35–55)	45 (35–55)	.105
End-diastolic diameter (mm)	54 (48–59)	53 (48–58)	.165
Mitral stenosis	248 (21.77%)	53 (23.04%)	.671
Mitral regurgitation			.277
No	50 (4.36%)	18 (7.76%)	
Mild	91 (7.94%)	19 (8.19%)	
Moderate	333 (29.06%)	63 (27.16%)	
Moderately severe	135 (11.78%)	29 (12.50%)	
Severe	537 (46.86%)	103 (44.40%)	
Operative data			
Emergency surgery	38 (3.3)	15 (6.4)	.024
Incision			.184
Median sternotomy	1091 (96.98%)	223 (98.67%)	
Minimal invasive	34 (3.02%)	3 (1.33%)	
Trans-septal approach	806 (83.01%)	180 (86.54%)	.212
CPB time, min	130 (99–164)	138 (108–168)	.048

TABLE 1 (Continued)

Variable	No-POAF (n = 1148)	POAF (n = 233)	p-value
Ischemic time, min	100 (75–126)	109 (80–133)	.028
CABG+ mitral valve	462 (40.2)	98 (42.1)	.607

Note: Data are expressed as the mean ± SD or median and (25th–75th percentiles), and categorical data are expressed as numbers and percentages.

Abbreviations: BMI, body mass index; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; CPB, cardiopulmonary bypass; CrCl, creatinine clearance; IABP, intra-aortic balloon pump; NYHA, New York Heart Association.

TABLE 2 The area under the curve (AUC) of the receiver operator curve and the odds ratio of the scores predicting postoperative atrial fibrillation after mitral valve surgery.

Risk score model	AUC	OR (95% CI)	p-value
CHADS2	0.53	1.11 (0.99–1.24)	.083
CHA2DS2-VASc	0.56	1.13 (1.04–1.24)	.003
EuroSCORE II	0.58	1.02 (1.002–1.04)	.026
HATCH	0.54	1.24 (1.01–1.25)	.026
POAF	0.61	1.55 (1.36–1.76)	<.001
PSCC-AF	0.67	1.35 (1.26–1.45)	<.001

TABLE 3 Predictors of postoperative atrial fibrillation (POAF) in patients who underwent mitral valve surgery.

	OR (95% CI)	p-value	Final scoring
Age > 58 years	1.89 (1.34–2.60)	<.001	1
Body mass index >28 kg/m^2	1.55 (1.14–2.09)	.005	1
Creatinine clearance <90 mL/min	1.59 (1.13–2.22)	.007	1
Preoperative intra-aortic balloon pump	4.01 (1.63–9.84)	.002	2
Preoperative inotropes	1.98 (1.38–2.85)	<.001	1
Reoperative surgery	1.73 (1.13–2.64)	.011	1

The new score (PSCC-AF) was constructed by giving 1 point to age, 1 point to BMI, 1 point to creatinine clearance, 1 point to reoperative surgery, 2 points to preoperative IABP, and 1 point to preoperative inotropes. The median score was 2 (25th–75th percentiles: 1–2), and the maximum was 5. The best cutoff point that predicted POAF was >2 points. The new score had an AUCROC of the receiver operator curve of 0.67. The score was internally validated using a 10-fold cross-validated AUC (Figure 1).

The predictive power of the new score was compared to that of the POAF score by comparing the two AUCROCs. The new score predicted POAF significantly higher than the POAF score ($p = .009$) (Figure 2).

The study duration was divided into two eras: from 2009 to 2016 and from 2016 to 2021. The incidence of POAF was significantly higher in the era after 2016 (106 (19.89%) vs. 127 (14.98%); $p = .018$). The predictive ability of the generated score was tested against the two eras separately. The score significantly predicted AF before 2016 (OR: 1.94 (95% CI: 1.61–2.34); $p < .001$) and after 2016 (OR: 1.58 (95% CI: 1.29–1.93); $p < .001$).

4 | DISCUSSION

Postoperative atrial fibrillation after cardiac surgery is a common complication and affects almost 50% of patients,[18] and patients with new-onset AF experience short- and long-term adverse effects.[1,19] Several risk factors for POAF after cardiac surgery have been identified.[20,21] Several studies have shown that preoperative prophylaxis of AF effectively reduces the incidence of POAF; however, treatment has potential adverse effects, and targeting high-risk patients will improve precision and personalized medicine.[3,8,22] Furthermore, in the era of big data, clinicians need scores specific to each procedure since most scores predicting POAF were evaluated on CABG patients with different characteristics than mitral valve patients.

This study assessed the utility of CHADS2, CHA2DS2-VASc, EuroSCORE II, POAF, and HATCH scores in predicting postoperative atrial fibrillation after mitral valve surgery. The performance of those scoring systems was comparable and not a robust predictor of POAF in our population. Additionally, we evaluated risk factors for POAF and constructed a risk-scoring system that showed higher predictive ability than these risk scores.

Several risk factors for POAF after cardiac surgery have been reported in other studies. Advanced age is the most commonly reported risk factor for POAF, which could be related to the pathological process occurring in the left atrium with aging.[23] Shen and associates reported that the risk of POAF increased linearly with age.[24] They reported a high POAF risk in patients older than 55, and the risk increased five times in patients aged 72 years or older. This is also evident in POAF scores, where older patients were given higher points for the possibility of POAF. In this study, age above 58 years was an independent predictor of POAF. We also identified BMI > 28 kg/m^2 as a risk factor for POAF. Perrier and associates found that BMI > 35 kg/m^2 was a risk factor for POAF after CABG.[25] Chandy and colleagues reported that a higher body surface area was associated with an increased risk of POAF.[26] These factors could contribute to an increased risk of POAF either owing to increased atrial fat or surface area.[23] High preoperative creatinine clearance, chronic kidney disease, and renal failure were found to be risk factors for POAF.[27] This is consistent with what was reported in our study, that creatinine clearance<90 mL/min was an independent risk factor for POAF after mitral valve surgery. This could be because of exacerbation of the inflammatory process after cardiac surgery in patients with chronic conditions.[23] Reoperative cardiac surgery is associated with increased fibrosis and adhesions, which could consequently increase the risk of POAF. Several studies have demonstrated that either pre- or postoperatively unstable hemodynamics were associated with an increased risk of POAF.[27,28]

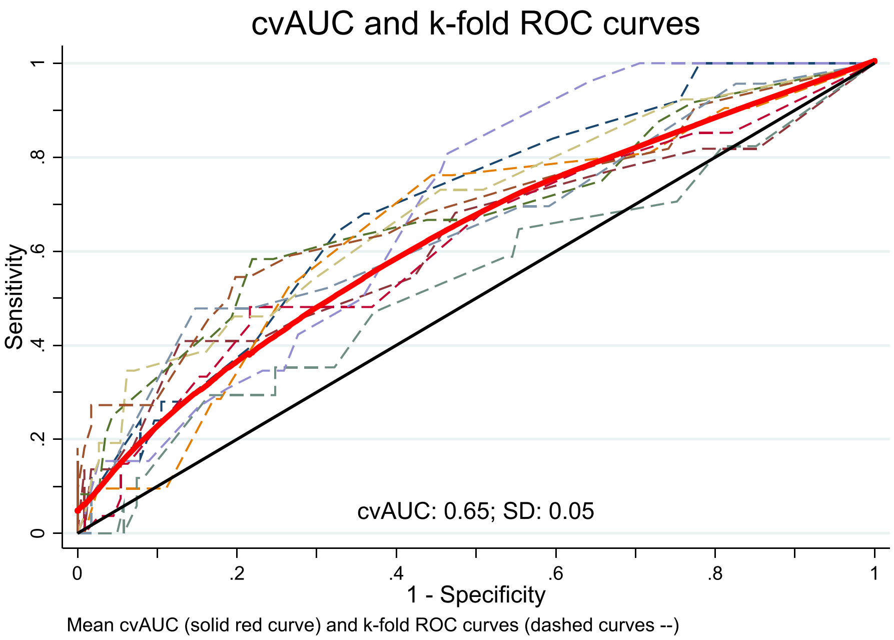

FIGURE 1 10-fold cross-validation AUC for the PSCC-AF score with the mean cvAUC of 0.65 and standard deviation of .05.

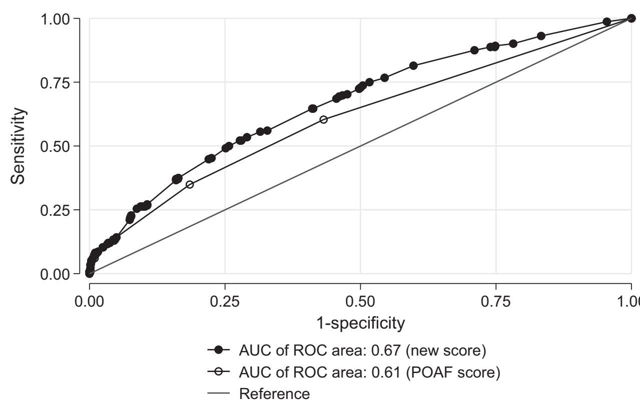

FIGURE 2 Comparison of the area under the curve of the receiver operator curve of the new score and the POAF score.

This study reported that reoperative surgery, preoperative inotropes, and IABP are risk factors for POAF. Furthermore, other studies reported diverse risk factors other than those reported in our series, such as congestive heart failure, chronic obstructive pulmonary disease, hypertension, left ventricular dysfunction, diabetes, and hypothyroidism.[23,29–31]

Several scoring systems have been tested to predict atrial fibrillation after cardiac surgery. CHADS2 and CHA2DS2-VASc scores were originally developed to predict stroke risk in patients with atrial fibrillation.[32] These scores were evaluated for the prediction of POAF. Yin and colleagues reported that both were associated with POAF; the higher the score, the higher the possibility of developing POAF.[9] This is partially consistent with our results since the CHA2DS2 score predicted POAF, while CHADS2 did not significantly predict POAF. The HATCH score was found to be an independent predictor of POAF in coronary artery bypass surgery patients.[33] The AUCROC of the Hatch score in our study was 0.54, while another study reported an AUC of 0.77 for POAF after CABG.[34] The EuroSCORE II is used to stratify the operative risk of cardiac surgery,[35] and this study reported that it was a significant predictor of POAF. The POAF score was a significant predictor of POAF in our study and others.[36] The POAF score achieved the highest AUCROC in our patients; however, one of the striking differences between our study and others is the population type. We included patients who underwent mitral valve surgery; however, other studies focused on CABG. This indicates that each type of surgery has its own intrinsic risk factors, and developing a score specific to each procedure and complication is recommended. This approach is suitable in the era of big data and personalized medicine. Accurate predictions will improve target therapy and limit the side effects of prophylactic medications if administered to all patients.

Therefore, we developed a new score (PSCC-AF) from the independent risk factors for POAF after mitral valve surgery by assigning points to each factor depending on their odds ratio. The score achieved the highest AUCROC in our population compared to the other scores evaluated, and the AUCROC was significantly higher than that of the POAF score. The score was internally validated using cross-validation. The new score is simple, easy to calculate, and specific to mitral valve surgery. It allows faster identification of patients at higher risk of developing POAF and in whom prophylactic measures such as antiarrhythmic therapies would be appropriate to prevent related unwanted adverse events. Preoperative prophylactic antiarrhythmic therapy could be directed to high-risk patients, therefore, minimizing the side effects of the medications. Future studies on a larger population are warranted to assess the model's generalizability and its benefits in guiding the decision of prophylaxis measures of POAF.

4.1 | Study limitations

The study is limited by being a single-center experience. The score should be evaluated on other patients from other centers to assess its performance and to validate it externally. The score developed is related to mitral valve surgery, and its performance on different types of cardiac surgery cannot be predicted. POAF was diagnosed as AF episodes that needed treatment. Several brief episodes may have passed unnoticed, and their clinical effects were not recognized. Additionally, preoperative medications could have affected the POAF. We evaluated the effect of preoperative β-blockers, while other medications could have affected POAF and were not evaluated. Lastly, the study is retrospective in design, and all factors that could affect POAF cannot be captured from the medical records. Furthermore, postoperative variables could affect POAF, and the temporal relationship between postoperative medications, events, and POAF cannot be precisely determined.

5 | CONCLUSIONS

POAF after mitral valve surgery can be predicted based on preoperative patient characteristics. The new PSCC-AF score significantly predicted POAF after mitral valve surgery and can serve as a bedside diagnostic tool for POAF risk screening. High-risk POAF patients could benefit from preoperative prophylactic therapy. Further studies are needed to validate the PSCC-AF-mitral score externally and evaluate the use of prophylactic antiarrhythmics in those patients.

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None.

CONFLICT OF INTEREST STATEMENT

Authors declare no conflict of interests for this article.

DATA AVAILABILITY STATEMENT

Data are available upon reasonable request after approval of the institution to release the data.

PATIENT CONSENT STATEMENT

N/A.

CLINICAL TRIAL REGISTRATION

N/A.

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