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Predicting postoperative atrial fibrillation using CHA_2DS_2-VASc scores

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ABSTRACT

Background: Postoperative atrial fibrillation (POAF) is the most frequent complication of cardiac surgery and is associated with increased morbidity and mortality. Pharmacologic prophylaxis is the main method of preventing POAF but needs to be targeted to patients at high risk of developing POAF. The CHA_2DS_2-VASc scoring system is a clinical guideline for assessing ischemic stroke risk in patients with atrial fibrillation. The present study evaluated the utility of this scoring system in predicting the risk of developing *de novo* POAF in cardiac surgery patients.
Materials and methods: A total of 2385 patients undergoing cardiac surgery at our institution from 2008–2014 were identified for analysis. Each patient was assigned a CHA_2DS_2-VASc score and placed into a low- (score of 0), intermediate- (1), or high-risk (≥2) group. A multivariate regression model was created to control for known risk factors of atrial fibrillation.
Results: POAF occurred in 380 of 2385 patients (15.9%). Mean CHA_2DS_2-VASc scores among patients with POAF and without POAF were 3.6 ± 1.7 and 2.8 ± 1.7, respectively ($P < 0.0001$). Using multivariate analysis, as a patient's CHA_2DS_2-VASc score rose from 0–9, the risk of developing POAF increased from 8.2%–42.3%. Each point increase was associated with higher odds of developing POAF (adjusted odds ratio, 1.27; 95% confidence interval, 1.18–1.36, $P < 0.0001$). Compared with low-risk patients, patients in the high-risk group were 5.21 times more likely to develop POAF ($P < 0.0001$).
Conclusions: The CHA_2DS_2-VASc algorithm is a simple risk-stratification tool that could be used to direct pharmacologic prophylaxis toward patients most likely to experience POAF.
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1. Introduction

Postoperative atrial fibrillation (POAF) is the most common complication occurring after cardiac surgery and varies in incidence depending on surgery type [1]. It occurs in nearly 30% of coronary artery bypass grafting (CABG) cases and in 40%–50% of patients after isolated valve surgery or combined cases [2,3]. Associated with increased costs, mortality, and

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Table 1 – CHA_2DS_2-VASc scoring criteria.

Variable	Score
Congestive heart failure/left ventricular dysfunction	1
Ejection fraction <40% with clinical evidence of heart failure or New York Heart Association Functional Class II or greater	
Hypertension	1
Age ≥75 y	2
Diabetes mellitus	1
Stroke/transient ischemic attack/thromboembolism	2
Vascular disease	1
Prior myocardial infarction, peripheral arterial disease, or complex aortic plaque	
Age 65–74 y	1
Sex category (i.e. female gender)	1

postoperative adverse events, POAF predisposes patients to a higher risk of stroke and substantially increases the cost of postoperative care [4,5]. POAF is especially hazardous in elderly patients and those with left ventricular dysfunction, characteristics that are common to most cardiac surgery patients [6,7].

Preoperative clinical risk factors for the development of POAF include hypertension, diabetes, obesity, valvular heart disease, increased age, and left atrial electrophysiological characteristics such as size, scarring, and perhaps heterogeneous conduction [8]. During the postoperative period, increased sympathetic activation, exaggerated inflammatory response, and oxidative stress may contribute to the development of POAF [5,8].

Current strategies to prevent POAF rely mainly on medications such as amiodarone, magnesium, and beta-blockers [9]. When administered prophylactically, these agents are often given without accounting for a patient's true probability of developing POAF [10]. Given the inherent risks of routine pharmacologic prophylaxis and emphasis on surgical quality improvement, a simple scoring system to predict the probability of experiencing POAF is needed.

The CHA_2DS_2-VASc scoring system is routinely used to predict ischemic stroke risk in patients with atrial fibrillation (AF). Interestingly, many components of this score are associated with the development of structural heart disease and POAF [11]. In small populations, others have suggested the CHA_2DS_2-VASc score to be predictive of POAF in patients undergoing CABG and/

Table 2 – Baseline clinical and operative characteristics.

Characteristic	Total (N = 2385)	NPOAF (*n* = 2005)	POAF (*n* = 380)	*P* value
CHA_2DS_2-VASc characteristics				
Congestive heart failure or LV dysfunction	39.0	37.1	49.0	<0.0001
Hypertension, %	64.2	62.3	74.2	<0.0001
Age, y (mean ± SD)	61.8 ± 14.6	60.4 ± 14.8	69.0 ± 11.3	<0.0001
65–74, %	26.8	25.3	33.9	<0.0001
≥75, %	19.5	16.8	34.5	<0.0001
Diabetes mellitus, %	26.3	26.4	25.3	0.66
Stroke, %	9.9	9.5	11.8	0.19
Vascular disease, %	39.7	38.3	47.4	0.001
Sex category (female), %	34.1	34.2	33.4	0.81
Risk factors				
Smoker, %	20.9	20.8	21.6	0.73
Body mass index, kg/m^2 (mean ± SD)	27.1 ± 6.2	27.1 ± 6.2	27.2 ± 6.1	0.62
Anemia, %	49.3	49.6	47.6	0.50
Dyslipidemia, %	53.2	51.2	63.7	<0.0001
Elevated creatinine, %	14.8	15.0	14.0	0.64
Dialysis, %	5.7	5.9	4.7	0.47
Endocarditis, %	4.2	4.2	4.5	0.78
Mitral insufficiency, %	30.2	29.5	34.2	0.07
Aortic insufficiency, %	21.5	20.2	28.4	<0.0001
Preoperative meds, %				
Beta-blocker	57.0	55.8	63.2	0.008
Statin	47.5	46.3	54.0	0.007
Anticoagulant	12.7	12.7	12.6	1.00
Aspirin	48.8	47.9	53.7	0.04
Coumadin	5.1	5.4	3.7	0.20
Type of operation, %				
Multiple valve surgery	44.8	42.5	56.8	<0.0001
Isolated aortic valve surgery	16.8	16.3	19.5	0.14
Isolated mitral valve surgery	10.6	10.6	10.5	1.00
Isolated CABG	25.5	25.3	26.3	0.70
Combined valve and bypass grafting	12.3	10.6	21.3	<0.0001
Operative characteristics				
Cardiopulmonary bypass time, min (mean ± SD)	160.4 ± 73.4	160.3 ± 74.4	160.6 ± 69.0	0.94
Cross-clamp time, min (mean ± SD)	114.6 ± 53.8	113.8 ± 54.0	118.2 ± 52.7	0.20

LV = left ventricular; SD = standard deviation.

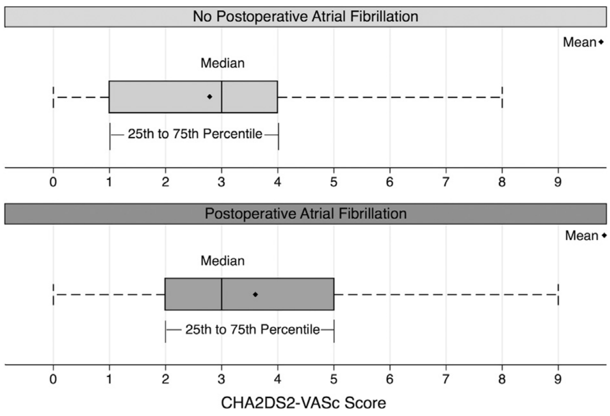

Fig. 1 – Distribution of CHA_2DS_2-VASc scores.

or valve-related procedures [12,13]. In the present study, we aimed to evaluate the utility of the CHA_2DS_2-VASc scoring algorithm in predicting the risk of developing *de novo* POAF in a large cohort of cardiac surgical patients.

2. Materials and methods

Our institutional Society of Thoracic Surgeons database was used to identify 3836 adult patients that underwent cardiac surgery at Ronald Reagan Medical Center at University of California, Los Angeles from January 2008–May 2014. Exclusion criteria included previous history of AF or flutter, operations or medications for arrhythmia, transplant operations, or the use of extracorporeal membrane oxygenation, ventricular assist devices, and off-pump CABG.

Patients were divided into two groups as follows: those who developed *de novo* POAF (POAF group) and those who did not (NPOAF group). CHA_2DS_2-VASc scores were calculated using the database and patient-level clinical data based on definitions established in the STS Adult Cardiac Database Specifications version 2.81 [14]. The scoring system and variables are presented in Table 1. Patients were stratified into low- (CHA_2DS_2-VASc score = 0), intermediate- (1), and high-risk (≥2) groups based on previously published guidelines [15].

The primary outcome variable was development of *de novo* AF. This was defined according to the STS Adult Cardiac Surgery database criteria as AF requiring treatment, lasting at least 30 seconds, and occurring within 30 days of the original operation. AF was detected via telemetry and an automated alarm system while in the hospital. In addition, the bedside nurse recorded the rhythm when any change was detected. After discharge, AF was noted based on self-reporting by the patient as having had an electrocardiographic examination documenting the arrhythmia, or readmission due to AF. Secondary outcome variables included total time spent in the intensive care unit, duration of hospital stay, and in-hospital mortality.

Patients were compared with respect to demographics and various risk factors using Student *t*-test and Fisher exact test. To account for potentially confounding variables and established risk factors of POAF, a multivariate logistic regression model was developed with the following independent variables: smoking, body mass index, anemia (hematocrit <39 if male, <36 if female), dyslipidemia, elevated creatinine (>1.5 mg/dL if male, >1.4 if female), dialysis, mitral insufficiency, aortic insufficiency, preoperative beta-blocker use, preoperative statin use, preoperative anticoagulant and/or aspirin use, and valvular surgical procedures. CHA_2DS_2-VASc component variables were not incorporated in the regression model to avoid interdependence.

For each CHA_2DS_2-VASc score, we calculated the predicted probability of developing POAF and an adjusted odds ratio (AOR) with 95% confidence intervals. STATA 13.0 software was used for all statistical analysis (StataCorp 2013, College Station, TX). Results were considered significant if *P* values were <0.05.

3. Results

Of the 3836 patients who underwent cardiac operations at our institution during the study period, 2385 patients (65.9% male) were included in the analysis, of which 380 (15.9%) developed POAF. Baseline clinical and operative characteristics are summarized in Table 2. Patients in the POAF group were older and were more likely to have dyslipidemia, heart failure, and valvular heart disease. Mean CHA_2DS_2-VASc scores in the POAF and NPOAF groups were 3.6 ± 1.7 and 2.8 ± 1.7, respectively ($P < 0.0001$), as shown in Figure 1. Moreover, POAF

Table 3 – Patient outcomes.

Outcome	Total (*N* = 2385)	NPOAF (*n* = 2005)	POAF (*n* = 380)	*P* value
Primary variables				
CHA_2DS_2-VASc score (mean ± SD)	2.9 ± 1.7	2.8 ± 1.7	3.6 ± 1.7	<0.0001
Low risk (0), %	6.5	7.2	2.6	<0.0001
Intermediate risk (1), %	16.4	17.9	8.9	<0.0001
High risk (≥2), %	77.1	74.9	88.4	<0.0001
Secondary variables				
Total intensive care unit time, h (mean ± SD)	123.1 ± 230.5	113.1 ± 211.4	176.3 ± 307.2	<0.0001
Length of stay, d (mean ± SD)	13.1 ± 16.8	12.7 ± 17.1	15.6 ± 14.4	0.002
Postoperative length of stay, d (mean ± SD)	10.2 ± 12.1	9.6 ± 11.9	13.3 ± 12.6	<0.0001
In-hospital mortality, %	2.3	2.0	3.4	0.13

SD = standard deviation.

Table 4 – AOR for developing POAF.

Outcome	Odds ratio (95% CI)	P value
CHA_2DS_2-VASc score	1.27 (1.18–1.36)	<0.0001
Low risk (0)	1.00 (reference)	
Intermediate risk (1)	1.97 (1.31–2.92)	0.19
High risk (≥2)	5.21 (3.72–7.26)	<0.0001
Body mass index, kg/m^2	1.00 (0.98–1.02)	0.69
Dyslipidemia	1.22 (0.93–1.60)	0.14
Smoking	0.98 (0.74–1.30)	0.90
Anemia	0.80 (0.63–1.01)	0.07
Elevated creatinine	0.91 (0.63–1.32)	0.62
Dialysis	0.75 (0.42–1.35)	0.34
Mitral insufficiency	0.90 (0.70–1.17)	0.44
Aortic insufficiency	1.15 (0.87–1.52)	0.32
Preoperative anticoagulant	0.95 (0.67–1.34)	0.75
Preoperative Coumadin	0.65 (0.36–1.16)	0.15
Preoperative beta-blocker	1.16 (0.91–1.49)	0.23
Preoperative statin	1.08 (0.83–1.39)	0.57
Preoperative aspirin	0.96 (0.75–1.23)	0.77
Valve surgery	1.71 (1.32–2.20)	<0.0001

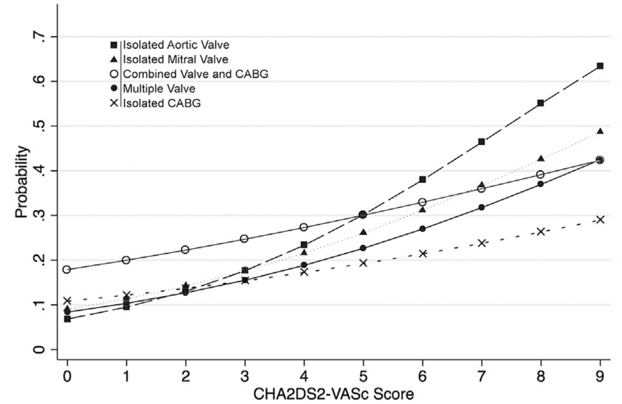

Fig. 3 – Risk of POAF by type of surgery.

patients had significantly longer intensive care unit and hospital lengths of stay, as seen in Table 3 ($P < 0.0001$ and $P = 0.002$, respectively).

After multivariate analysis to control for intergroup differences, a higher CHA_2DS_2-VASc score was associated with significantly higher odds of developing POAF (AOR, 1.27 for each point increase in score; 95% confidence interval, 1.18–1.36; $P < 0.0001$, Table 4). As a patient's CHA_2DS_2-VASc score increased from 0–9, their probability of developing POAF rose from 8.2%–42.3% ($P < 0.0001$, Fig. 2). The multivariate regression was used to determine the risk of POAF based on type of surgery as well (Fig. 3). In addition, valvular operations were found to be a significant risk factor for POAF ($P < 0.0001$, Table 4).

On stratification of patients into risk categories based on CHA_2DS_2-VASc score, the rates of POAF in the low- (0), intermediate- (1), and high-risk (≥2) categories were 6.9%, 9.5%, and 22.4%, respectively (Fig. 4). After multivariate regression analysis, patients in the high-risk group had a significantly higher chance of developing POAF when compared with the low-risk group (AOR = 5.21, $P < 0.0001$). This risk classification scheme showed 74.2% sensitivity and 44.7% specificity, correctly identifying 49.4% of patients when using a designation of "high-risk" as predictive of POAF. The utility of this risk classification model is expressed as a receiver operating characteristic curve shown in Figure 5, with an area under the curve of 65.7%.

4. Discussion

In this study, we have demonstrated that a higher CHA_2DS_2-VASc score was significantly associated with increasing odds of developing POAF. Similarly, patients categorized as high-risk (CHA_2DS_2-VASc score ≥2) were significantly more likely to experience POAF compared with low-risk (0) patients.

Although CHA_2DS_2-VASc scores have been widely used to assess ischemic stroke risk in patients with AF, only limited studies exist on the association between CHA_2DS_2-VASc scores and the development of POAF. In a smaller study restricted to CABG patients, Borde *et al.* [13] conducted a retrospective review of 729 patients in India and found that higher CHA_2DS_2-VASc scores predicted POAF. A similar conclusion was reached by Chua *et al.* [12], based on a prospective study of 277 patients undergoing CABG and/or valve procedures. The findings of the present study serve to validate these previous reports in a larger patient population not limited to CABG and/or valvular procedures.

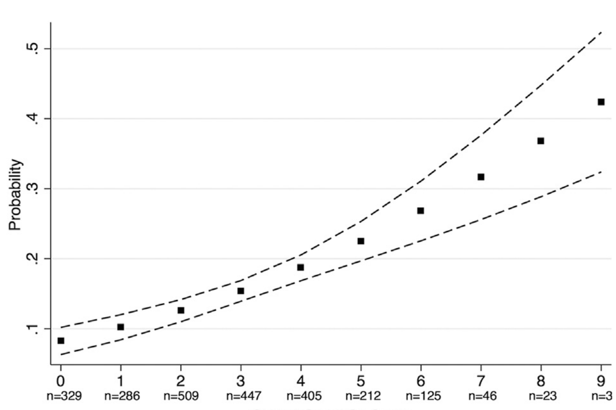

Fig. 2 – CHA_2DS_2-VASC score and probability of POAF.

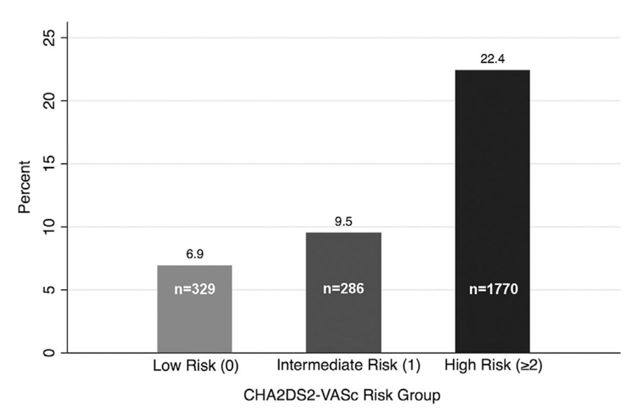

Fig. 4 – Rates of POAF by CHA_2DS_2-VASc risk group.

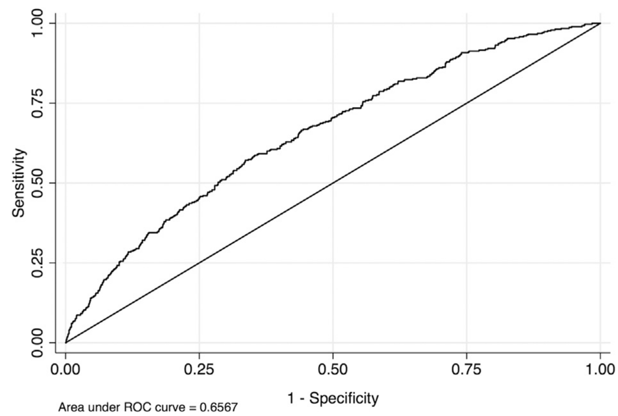

Fig. 5 – Receiver operating characteristic curve of CHA_2DS_2-VASc stratification scheme.

The CHA_2DS_2-VASc scoring system was originally introduced as a refinement of the $CHADS_2$ scoring system, an older algorithm for predicting ischemic stroke risk in AF patients [16]. Sareh *et al.*, as well as others, have shown that $CHADS_2$ can be further used as a predictor of POAF [12,13,17]. When comparing $CHADS_2$ with CHA_2DS_2-VASc, it appears that CHA_2DS_2-VASc may be more accurate in identifying patients who are truly at a low risk of developing POAF. Chua *et al.* found that POAF occurred in 21% of patients with $CHADS_2$ scores of 0 and 6% of patients with CHA_2DS_2-VASc scores of 0. This effect may be due to the inclusion of additional variables that compose the CHA_2DS_2-VASc score.

Consistent with previous studies, our model also identified valvular operations as an independent predictor of POAF [18–20]. Valvular lesions are associated with known electroanatomic risk factors for development of AF such as structural heart disease, atrial dilation, and fibrosis. Additionally, operations to treat valvular disease often require longer cross-clamp times and techniques such as bicaval cannulation and intracardiac dissection—all of which are implicated in POAF [5].

Several organizations have produced guidelines for prophylaxis against POAF [21–23]. However, many institutions do not regularly implement these guidelines, due to concerns of unnecessary exposure to medications. Routine prophylaxis may expose up to 70% of cardiac surgery patients to antiarrhythmic drugs and their subsequent side effects [24,25]. With recent reports questioning the safety of perioperative beta-blockers, the cornerstones of POAF therapy, appropriate targeting of patients for prophylaxis has received renewed attention [26–28]. The CHA_2DS_2-VASc scoring system could be used to identify patients at the highest risk of developing POAF, thus avoiding nonselective prophylaxis.

Our study has several limitations. First, this report represents our findings from a single academic medical center. However, the large patient cohort and numerous variables included in our logistic regression would make the results generally applicable. Second, the rate of POAF observed in this study is lower than rates reported in the literature. This is likely due to defining POAF as *de novo* AF requiring treatment and excluding patients with a prior history of this arrhythmia. Additionally, our database did not capture data on pattern, treatment, or long-term follow-up of POAF. Finally, a significant proportion of patients in the database were excluded based on criteria or having incomplete records. This exclusion had to be made to provide a meaningful multivariate regression model.

5. Conclusions

In summary, CHA_2DS_2-VASc scores are independent predictors of developing POAF. Patients with a score of ≥ 2 are significantly more likely to experience POAF compared with patients with a score of <2. These findings warrant further validation in large populations of cardiac surgical patients across many centers. This scoring system could be readily incorporated into a targeted prophylactic regimen, which may improve patient safety by both reducing the incidence of POAF and avoiding unnecessary pharmacologic exposure.

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Disclosure

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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