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Use of CHA2DS2-VASc score to predict the risk of ischemic stroke and mortality in patients who underwent coronary artery bypass grafting surgery: a retrospective cohort study

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Abstract. – OBJECTIVE: Ischemic stroke and postoperative atrial fibrillation (POAF) are frequently seen after coronary artery bypass grafting (CABG). CHA2DS2-VASc scoring system is used to predict ischemic stroke and POAF. This study aimed to evaluate CHA2DS2-VASc scores in predicting ischemic stroke after CABG and analyze the effect of POAF on the relationship between CHA2DS2-VASc scores and ischemic stroke.

PATIENTS AND METHODS: Demographic and clinical characteristics of patients who underwent CABG were retrospectively recorded. CHA2DS2-VASc score was calculated for each patient and stratified into low- and high-risk groups. The heart rhythm of the patients was monitored during in-hospital follow-up and ischemic stroke was evaluated. Ischemic stroke and POAF were the primary and secondary outcomes.

RESULTS: There were 383 patients (mean age of 63.1 ± 10.4 years). Ischemic stroke developed in eight (2.1%) patients. There were 248 (64.8%) high-risk patients with CHA2DS2-VASc scores. Patients with ischemic stroke were significantly older ($p = 0.021$) and had higher CHA2DS2-VASc scores ($p < 0.001$). Low and high-risk groups did not reveal any significant difference for ischemic stroke ($p = 0.055$). There were 56 (14.7%) patients with POAF. The relationship between CHA2DS2-VASc scores and ischemic stroke was not affected by POAF ($p = 0.739$). CHA2DS2-VASc scores of ≥3 predicted ischemic stroke ($p < 0.001$) with 100% sensitivity and 64.5% specificity.

CONCLUSIONS: Ischemic stroke was associated with a higher mortality risk after CABG. Higher CHA2DS2-VASc scores were associated with higher ischemic stroke risk. POAF did not significantly affect the relationship between CHA2DS2-VASc scores and ischemic stroke. CHA2DS2-VASc score can be used to predict ischemic stroke and mortality following CABG.

Key Words:

Coronary artery bypass grafting, Postoperative complications, Ischemic stroke, Atrial fibrillation, Mortality rate.

Introduction

Postoperative atrial fibrillation (POAF) is a frequent complication observed after coronary artery bypass grafting (CABG) and other cardiac interventional procedures[1-4]. It was reported that the incidence of POAF in the context of CABG surgery is as high as 40%[5-7]. In most cases, POAF is benign and self-limiting. However, a greater risk of perioperative thromboembolic events and ischemic stroke has been reported[1,5,8-11].

Predicting the POAF-related thromboembolic events in patients who underwent invasive cardiac interventions in advance is likely the key to decreasing the related morbidity and mortality in this patient group as it would allow taking necessary precautions for the risky group in a timely manner[5,11]. For this purpose, several scoring systems, including CHA2DS2-VASc, GRACE (Global Registry of Acute Coronary Events), HATCH [Hypertension, Age (above 75 years), Transient ischemic attack or stroke, Chronic obstructive pulmonary disease, and Heart failure)], and ATRIA (Anticoagulation and Risk Factors in Atrial Fibrillation) have been developed[2,5,11]. Such scoring systems may also be beneficial for accurate assessment of the overall clinical outcomes following the CABG surgery CHA2DS2-VASc scores have been used to predict ischemic stroke in patients with atrial fibrillation, stratify the ischemic stroke risk and guide antithrombotic therapy in patients who underwent CABG surgery[6,9,12].

It has been speculated that higher CHA2DS2-VASc scores are associated with worse clinical outcomes of thromboembolic events in patients who underwent CABG regardless of whether POAF is present or not[1,13]. The research data on the clinical usability of CHA2DS2-VASc scores in predicting the risk of thromboembolic events following CABG surgery in patients with POAF and

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sinus rhythm in the literature are limited. The effectivity of the CHA2DS2-VASc score in patients without POAF is not clear[14]. Similarly, the predictive value of POAF for postoperative thromboembolic events in CABG patients is also unclear.

In view of the foregoing, the objective of this study is to evaluate the predictive power of the CHA2DS2-VASc scoring system in predicting ischemic stroke in patients who underwent CABG and analyze the relationship between POAF and ischemic stroke risk, if any.

Patients and Methods

Research Design

This study was designed as a retrospective study. The study protocol was approved by Toros University Local Ethics Committee (Ethics Committee approval No.: 15.10.2021/108). The study was carried out in accordance with the principles set forth in the Declaration of Helsinki. Written informed consent was obtained from each patient included in the study.

Population and Sample

The population of this study comprised the patients who underwent CABG for the surgical treatment of coronary artery disease during the period between February 2017 and June 2021. As an institutional policy, the medical data of all patients with cardiac surgery were recorded in a pre-specified database. The patients' medical records included in the study were obtained from the hospital information system. The patients aged 18 to 75 years with preoperative sinus rhythm and a complete set of medical data regarding pre-, intra-, and postoperative periods were included in the study, whereas patients with a history of pacemaker application, preoperative use of antiarrhythmic drugs, hyperthyroidism, a history of cardiac surgery, severe heart failure [class III and or IV heart failure based on New York Heart Association (NYHA) classification], moderate or severe mitral stenosis or regurgitation, a history of myocardial infarction within the last three months, and history of dysrhythmia were excluded from the study. 383 patients were found eligible to be included in the study sample after the study inclusion and exclusion criteria were applied to the study population.

Data Collection

The demographic (age, gender) and clinical characteristics [smoking history, comorbidities, New York Heart Association Functional Classification (NYHA-FC), cardiac risk factors, medications] of the patients included in the study were recorded. The results of the laboratory tests, including hematocrit and blood urea nitrogen tests and measurements of creatinine levels and the echocardiographic parameters, including ejection fraction and the diameter of the left ventricle, were also noted. The CHA2DS2-VASc score was calculated for each patient. Accordingly, one point was assigned for each of the following parameters: having congestive heart failure (ejection fraction $< 40\%$), hypertension, being aged between 65 and 74 years old, having diabetes mellitus, having a vascular disease (myocardial infarction or peripheral arterial disease), and being female; and two points were assigned for each of the following parameters: having a history of ischemic stroke or transient ischemic attack and being aged equal to or more than 75 years old. All assigned points were added to find the total CHA2DS2-VASc score, which could be 9 points at the highest[5].

The patients were then categorized into two groups according to their CHA2DS2-VASc scores or the presence of major risk factors (having a history of ischemic stroke or transient ischemic attack, being aged ≥ 75 years). Accordingly, patients with a CHA2DS2-VASc score of 0 or 1 were included in the low-risk group, and patients with a CHA2DS2-VASc score of ≥ 2 or one major risk factor were included in the high-risk group[15].

The CABG surgeries were performed by the same surgical team for all patients included in the study. The operative technique used in these surgeries has been defined in the literature[16,17]. Intraoperative technical details and intraoperative and perioperative complications were recorded for each patient.

Postoperative Follow-Up

During the first five days after the surgery, the patients were monitored for their heart rhythm, and whether they had sinus arrhythmia or dysrhythmia was recorded. The patients were continuously monitored with electrocardiograms and 24-Hour Holter monitoring during the period they were in intensive care units and clinical wards. The recordings of the 12-lead electrocardiograms were evaluated to diagnose new-onset POAF or other dysrhythmic conditions. The timing of POAF was also recorded. An irregular rhythm with the absence of discrete P waves lasting at least 30 seconds was regarded as an episode of POAF[5,10]. Other new-onset arrhythmias, including ventricular tachycardia, ventricular extrasystole, and bradycardia, were also recorded. The decision for the treatment modality of POAF was made at the discretion of the attending physicians.

Postoperative in-hospital complications, including ischemic stroke, as well as the need for transfer to an intensive care unit, length of hospital stay, and mortality, were recorded. Diagnosis of ischemic stroke was made based on physician reports.

Statistical Analysis

The primary and secondary outcomes of the study were the development of postoperative ischemic stroke and POAF, respectively.

Descriptive statistics were expressed as mean ± standard deviation values in the case of continuous variables that were determined to conform to the normal distribution and as median values along with minimum-maximum values in the case of continuous variables that were determined not to conform to the normal distribution. Categorical variables were expressed as numbers and percentages. The Shapiro-Wilk, Kolmogorov-Smirnov, and Anderson-Darling tests were used to analyze whether the numerical variables conformed to the normal distribution. In the comparison of two independent groups, the independent samples *t*-test and the Mann-Whitney U test were used in cases where numerical variables conformed or did not conform to the normal distribution, respectively. The Pearson's Chi-squared test and Fisher's exact test were used to compare the differences between categorical variables in 2x2, and the Fisher-Freeman-Halton test was used to compare the differences between categorical variables in RxC tables.

The Robust ANOVA function in the WRS2 package (The R Foundation for Statistical Computing, Vienna, Austria) was used to analyze the effect of POAF on the differences between the CHA2DS2-VASc scores in patients with and without ischemic stroke. The area under the curve (AUC) function of the receiver-operating characteristic (ROC), that is, the C-statistic, was used to calculate the predictive power of the CHA2DS2-VASc score in predicting ischemic stroke and mortality. The sensitivity and specificity values ranging from 0 to 1 were considered using the C-statistic.

Jamovi project (Jamovi, version 2.2.5.0, 2022, available at: https://www.jamovi.org), JASP software package (Jeffreys' Amazing Statistics Program, version 0.16.1, available at: https://jasp-stats.org), and R Project version 4.1.3 (The R Foundation for Statistical Computing, Vienna, Austria) software packages were used in the statistical analysis. Probability (p) values ≤ 0.5 were deemed to indicate statistical significance.

Results

The mean age of the 383 patients included in the study sample was calculated as 63.1 ± 10.4 years. The male-to-female ratio in the study sample was 1.72. Eight (2.1%) patients developed ischemic stroke during the follow-up period. Most (86.2%) patients had NYHA-FC class II heart failure. Unstable angina and previous myocardial infarction were the most common risk factors, which were determined in 27.7% and 25.8% of the patients, respectively. Chronic obstructive pulmonary disease and hypertension were detected in 52.2% and 47.8% of the patients, respectively. The other clinical characteristics of the patients are detailed in Table I. The patients' median CHA2DS2-VASc score was 2. Of the 383 patients, 248 (64.8%) patients with a CHA2DS2-VASc score of ≥2 or one major risk factor were categorized as high-risk patients.

The patients with ischemic stroke were significantly older and had significantly higher CHA2DS2-VASc scores than those without ischemic stroke ($p = 0.021$ and $p < 0.001$, respectively). The median CHA2DS2-VASc scores in patients with and without ischemic stroke were 4.5 and 2.0, respectively. However, there was no significant difference between the low- and high-risk groups created based on the CHA2DS2-VASc scores in the development of ischemic stroke ($p = 0.055$), as well as in patients' other demographic, clinical, laboratory, and echocardiographic characteristics (Table I).

The surgical metric values and operative details did not have any significant effect on the development of ischemic stroke (Table II). On the other hand, the rates of intraoperative complications such as acidosis, inotropic support, and the use of intra-aortic balloon pumps were significantly higher in patients with ischemic stroke than in those without ischemic stroke ($p < 0.001$ for all cases) (Table II). The comparison of the postoperative complications revealed significant differences between the groups in the development of ischemic stroke. Accordingly, the low-flow state, neurological deficits, and acute renal failure were more frequently seen in patients with ischemic stroke ($p < 0.001$ for all cases).

Table I. Demographic, clinical, laboratory, and echocardiographic characteristics of the patients.

		Patients		
	Overall (n=383)	With ischemic stroke (n=8)	Without ischemic stroke (n=375)	*p*
Age (year)†	63.1 ± 10.4	70.5 [58.0 - 78.0]	63.0 [31.0 - 87.0]	0.021**
Sex‡				
Male	242 (63.2)	7 (87.5)	235 (62.7)	0.267*
Female	141 (36.8)	1 (12.5)	140 (37.3)	
Smoking‡	223 (58.2)	7 (87.5)	216 (57.6)	0.146*
NYHA-FC Class‡				
I	12 (3.1)	0 (0.0)	12 (3.2)	0.430*
II	330 (86.2)	6 (75.0)	324 (86.4)	
III	39 (10.2)	2 (25.0)	37 (9.9)	
IV	2 (0.5)	0 (0.0)	2 (0.5)	
Re-do surgery‡	4 (1.0)	0 (0.0)	4 (1.1)	0.999*
Preoperative cardiac risk factors‡				
Previous myocardial infarction	99 (25.8)	1 (12.5)	98 (26.1)	0.686*
Unstable angina	106 (27.7)	0 (0.0)	106 (28.3)	0.113*
Valvular heart disease	9 (2.4)	0 (0.0)	9 (2.5)	0.999*
Carotis	15 (3.9)	0 (0.0)	15 (4.0)	0.999*
Preoperative atrial fibrillation	7 (1.8)	0 (0.0)	7 (1.9)	0.999*
Peripheral artery disease	1 (0.3)	0 (0.0)	1 (0.3)	0.999*
Preoperative myocardial infarction	2 (0.5)	0 (0.0)	2 (0.5)	0.999*
Comorbidities‡				
Diabetes mellitus	106 (27.7)	4 (50.0)	102 (27.2)	0.225*
Hypertension	183 (47.8)	5 (62.5)	178 (47.5)	0.487*
Chronic obstructive pulmonary disease	200 (52.2)	5 (62.5)	195 (52.0)	0.726*
Hyperlipidemia	262 (68.4)	4 (50.0)	258 (68.8)	0.268*
Medications‡				
Beta blockers	152 (39.7)	2 (25.0)	150 (40.0)	0.486*
Calcium channel blockers	89 (23.2)	4 (50.0)	85 (22.7)	0.089*
Angiotensin-converting enzyme inhibitors	85 (22.2)	1 (12.5)	84 (22.4)	0.691*
Digoxin	6 (1.6)	0 (0.0)	6 (1.6)	0.999*
Dipyramidole	7 (1.8)	0 (0.0)	7 (1.9)	0.999*
Coraspin	222 (58.0)	4 (50.0)	218 (58.1)	0.725*
Clopidogrel	20 (5.2)	0 (0.0)	20 (5.3)	0.999*
CHA2DS2-VASC score§	2.0 [0.0 - 6.0]	4.5 [3.0 - 6.0]	2.0 [0.0 - 5.0]	**<0.001****
CHA2DS2-VASC groups‡				
Low-risk	135 (35.2)	0 (0.0)	135 (36.0)	0.055*
High-risk	248 (64.8)	8 (100.0)	240 (64.0)	
Laboratory investigations				
Hematocrit (%)†	40.1 ± 5.0	38.7 [33.0 - 44.1]	40.0 [24.9 - 55.3]	0.381**
Blood urea nitrogen (mg/dL)§	19.0 [7.0 - 63.0]	21.0 [13.0 - 34.0]	19.0 [7.0 - 63.0]	0.509**
Creatinine (mg/dL)§	1.1 [0.5 - 2.2]	0.9 [0.6 - 2.2]	1.1 [0.5 - 2.2]	0.200**
Echocardiographic measurements				
Ejection fraction (%)§	55.0 [25.0 - 66.0]	55.0 [25.0 - 65.0]	55.0 [25.0 - 66.0]	0.374**
ANAS.SA.§	3.0 [0.0 - 4.0]	3.0 [2.0 - 4.0]	3.0 [0.0 - 4.0]	0.281**
Diameter of the left atrium (mm)§	35.0 [29.0 - 50.0]	35.0 [30.0 - 45.0]	35.0 [29.0 - 50.0]	0.981**
Obstructive lesions (>50%)				
In the left main coronary artery‡	19 (5.0)	0 (0.0)	19 (5.1)	0.999*
Left internal mammary artery‡	331 (86.4)	8 (100.0)	323 (86.1)	0.605*

†: mean ± standard deviation, ‡: n (%), §: median [min-max]. *: Pearson Chi-Square, Fisher's Exact or Fisher Freeman Halton test. **: Mann-Whitney U test. NYHA: New York Heart Association-Functional Capacity.

Table II. Association of the intra- and post-operative findings on the development of ischemic stroke in patients who underwent CABG.

	Overall (n=383)	Patients		p
		With ischemic stroke (n=8)	Without ischemic stroke (n=375)	
Surgical techniques				
Cross clamping time (min)[§]	47.0 [11.0 - 137.0]	40.0 [29.0 - 80.0]	48.0 [11.0 - 137.0]	0.391**
Total pump time (min)[§]	82.0 [0.0 - 701.0]	69.5 [31.0 - 120.0]	82.0 [0.0 - 701.0]	0.306**
Single cross clamping[‡]	223 (58.2)	4 (50.0)	219 (58.4)	0.724*
Type of surgery[‡]				
CABG	372 (97.1)	8 (100.0)	364 (97.1)	0.999*
CABG+valve surgery	11 (2.9)	0 (0.0)	11 (2.9)	
Intra-operative complications[‡]				
Acidosis	22 (5.7)	6 (75.0)	16 (4.3)	**<0.001***
Inotropic support	56 (14.6)	6 (75.0)	50 (13.3)	**<0.001***
Intra-aortic balloon pump	14 (3.7)	4 (50.0)	10 (2.7)	**<0.001***
Post-operative complications[‡]				
Low-flow state	20 (5.2)	6 (75.0)	14 (3.7)	**<0.001***
Neurological deficits	8 (2.1)	8 (100.0)	0 (0.0)	**<0.001***
Acute renal failure	29 (7.6)	5 (62.5)	24 (6.4)	**<0.001***
Detachment	2 (0.5)	0 (0.0)	2 (0.5)	0.999*
Post perfusion syndrome	4 (1.0)	0 (0.0)	4 (1.1)	0.999*

‡: n (%), §: median [min-max]. *: Pearson Chi-Square or Fisher's Exact test. **: Mann-Whitney U test. CABG: coronary artery bypass grafting.

There were 56 (14.7%) patients with new-onset POAF. Compared to 52 (13.9%) patients without ischemic stroke who had POAF, half (50%) of the 8 patients with ischemic stroke had POAF, and the difference between the groups was significant (p = 0.019). Additionally, compared to 4 (1.1%) patients without ischemic stroke who had other arrhythmias, 2 (25.0%) patients with ischemic stroke had other arrhythmias, and the difference between the groups was significant (p = 0.006). Furthermore, the arrhythmias developed significantly earlier in patients with ischemic stroke than those without ischemic stroke (p = 0.002).

The mortality rates in patients with and without ischemic stroke were 37.5% and 1.6%, respectively, and significantly higher in patients with ischemic stroke ($p < 0.001$). In addition, the median duration stay in the intensive care unit was 3 days and 1 day in patients with and without ischemic stroke, respectively, and significantly higher in patients with ischemic stroke ($p < 0.001$). Details about the other parameters monitored during the postoperative follow-up period are given in Table III.

The POAF had no significant effect as a co-variance factor on the relationship between ischemic stroke and the CHA2DS2-VASc score (p = 0.739) (Table IV).

The predictive power of the CHA2DS2-VASc score in predicting ischemic stroke and mortality in the study group is detailed in Table V. CHA2DS2-VASc scores of ≥ 3 predicted ischemic strokes with 100% sensitivity and 64.5% specificity ($p < 0.001$). In addition, CHA2DS2-VASc scores of ≥ 2 predicted mortalities with 88.9% sensitivity and 35.8% specificity.

Discussion

The findings of this study demonstrated that ischemic stroke is a clinical situation associated with a higher mortality risk following the CABG surgery. In this group of patients, higher CHA2DS2-VASc scores were associated with a higher risk of ischemic stroke, whereas POAF did not have any significant effect on the relationship between CHA2DS2-VASc score and ischemic

Table III. Postoperative follow-up data in the study group.

		Patients		
	Overall (n=383)	With ischemic stroke (n=8)	Without ischemic stroke (n=375)	*p*
Amount of drainage in the first 24 hours§	500.0 [0.0 - 3,000.0]	550.0 [100.0 - 2,000.0]	500.0 [0.0 - 3,000.0]	0.746**
Re-intubation‡	14 (3.7)	2 (25.0)	12 (3.2)	**0.031***
Revisional surgery for bleeding‡	12 (3.1)	1 (12.5)	11 (2.9)	0.227*
Post-operative blood transfusion§	1.0 [0.0 - 12.0]	1.5 [0.0 - 5.0]	1.0 [0.0 - 12.0]	0.699**
Post-operative extubation time (hr)§	8.0 [1.0 - 75.0]	8.5 [1.0 - 19.0]	8.0 [1.0 - 75.0]	0.462**
Duration of hospitalization in intensive care unit (day)§	1.0 [1.0 - 45.0]	3.0 [1.0 - 45.0]	1.0 [1.0 - 21.0]	**<0.001****
Length of hospital stay (day)§	7.0 [1.0 - 45.0]	9.5 [1.0 - 45.0]	7.0 [1.0 - 40.0]	0.077**
In-hospital mortality‡				
Survived	374 (97.7)	5 (62.5)	369 (98.4)	**<0.001***
Non-survived	9 (2.3)	3 (37.5)	6 (1.6)	

‡: n (%), §: median [min-max]. *: Pearson Chi-Square or Fisher's Exact test. **: Mann-Whitney U test.

stroke following CABG. There was no significant difference between the low- and high-risk groups created based on the CHA2DS2-VASc scores in the development of ischemic stroke; however, CHA2DS2-VASc scores ≥ 3 and ≥ 2 predicted ischemic stroke and mortality, respectively, with optimum sensitivity and specificity.

The relationship between CHA2DS2-VASc score and postoperative ischemic stroke and mortality in patients who underwent CABG has been previously studied[9]. The use of the CHA2DS2-VASc score in ischemic stroke risk stratification has been investigated in the context of different patient groups[2-4,18-24]. In one of these studies, Hu and Lin[9] reported a positive relationship between the CHA2DS2-VASc score and the thromboembolic outcomes following CABG and concluded that the discriminative power of CHA2DS2-VASc score in predicting the thromboembolic outcomes following CABG was modest at the most[8,12]. In another study, Tu et al[12] demonstrated that high-risk CHA2DS2-VASc scores were significantly associated with mortality in stroke patients both with and without atrial fibrillation. In comparison, in this study, POAF did not have any significant effect on the predictive power of the CHA2DS2-VASc score in predicting thromboembolic events. Therefore, it may be speculated that ischemic stroke is the primary outcome associated with the CHA2DS2-VASc score or the parameters used to calculate the CHA2DS2-VASc score.

The findings reported on the cut-off values of the CHA2DS2-VASc score to be used for stratification of patients based on the ischemic stroke risk in the literature are controversial. As was the case in a number of studies[10,12,15] available in the literature, the stratification of patients with a

Table IV. Impact of postoperative atrial fibrillation on the association between ischemic stroke and the CHADS-VASC score.

	Q	*p*
Ischemic stroke	28.275	**0.001**
Postoperative atrial fibrillation	0.555	0.480
Ischemic stroke* Postoperative atrial fibrillation	0.121	0.739

Method of trimmed means, trim level 0.2, WRS2 package was used.

Table V. Sensitivity, specificity and predictive ability of CHA2DS2-VASc score on the prediction of ischemic stroke and mortality in patients following coronary artery bypass grafting.

	Sensitivity (%)	Specificity (%)	C-Statistic (95% Confidence interval)	*p*
Ischemic stroke				
CHA2DS2-VASc score			0.92 (0.89 - 0.95)	**<0.001**
≥0	100.0	0.0		
≥1	100.0	11.7		
≥2	100.0	36.0		
≥3	100.0	64.5		
≥4	75.0	88.3		
Death				
CHA2DS2-VASc score			0.73 (0.68 - 0.77)	**0.031**
≥0	100.0	0.0		
≥1	88.9	11.5		
≥2	88.9	35.8		
≥3	66.7	63.1		
≥4	55.6	88.0		

CHA2DS2-VASc score of 0 or 1 or at least one major risk factor as the low-risk patients in this study, did not prove to be helpful in predicting the ischemic stroke. This result may be attributed to the fact that the relatively low number (n = 8) of ischemic stroke cases might not have been sufficient to perform a robust analysis. In addition to low- and high-risk grouping, three-tier risk stratification as low-, intermediate-, and high-risk was also reported[2] to have been used for grouping in the literature. Hu and Lin[9] compared patients with CHA2DS2-VASc scores of 1 and 2 with patients with CHA2DS2-VASc scores of 0 and found significant differences between the groups in predicting future ischemic thromboembolic events. Others recommended that patients with CHA2DS2-VASc scores of 0, 1, 2, and 3 should all be compared to predict the perioperative cardiac outcomes following non-cardiac surgery[20]. In comparison, in this study, it was determined that CHA2DS2-VASc scores of ≥3 demonstrated significant predictive value in predicting future ischemic thromboembolic events relative to the CHA2DS2-VASc score of 0. Therefore, further studies are needed to determine the cut-off values of the CHA2DS2-VASc score for optimum predictive efficiency in different clinical situations.

In addition, the relationship between the sum of the positive factors included in the CHA2DS2-VASc scoring system and the risk for ischemic stroke and mortality were also investigated in this study. A network meta-regression analysis revealed that continuous and categorical scores of CHA2DS2-VASc were associated with an increased risk of all-cause mortality[25]. Nevertheless, the optimum cut-off value of the CHA2DS2-VASc score to be used to predict ischemic stroke risk remains a matter of debate. Taken together with the relevant results reported in the literature, the results of this study suggest that using either the sum of the parameters included in the CHA2DS2-VASc scoring system or the risk stratification based on CHA2DS2-VASc scores would be the best options to predict future ischemic complications.

The new-onset POAF has been defined as one of the primary risk factors for the development of thromboembolism in patients who underwent CABG surgery[1]. Several authors reported[1,5,10,11] that almost one-third of patients who underwent CABG developed POAF. The incidence of POAF following the CABG surgery in this study was found as 14.7%, which is lower than the CABG-related POAF incidences reported in the literature. This discrepancy in results may be attributed to the missed POAF episodes or cases missed due to having irregular rhythms lasting less than 30 seconds even though the patients were continuously monitored with an electrocardiogram. Several authors[5,10] concluded that the CHA2DS2-VASc score was an independent risk factor for the new-onset CABG-related POAF. In addition to being an independent risk factor, the

CHA2DS2-VASc score can also predict the risk of POAF. In this study, however, the power of the CHA2DS2-VASc score in predicting the development of POAF was not evaluated. Then again, POAF had no significant effect as a co-variance factor on the relationship between ischemic stroke and the CHA2DS2-VASc score. It may be that there are reciprocal relationships between ischemic stroke, AF, and the CHA2DS2-VASc scores. Further prospective studies are needed to clarify the possible causal relationships between the said parameters.

In addition to the CHA2DS2-VASc score, there are other parameters that are reportedly associated with the development of ischemic stroke following the CABG surgery. These parameters include several demographic and clinical risk factors, such as age, gender, traditional atherosclerotic risk factors, past ischemic events, and disturbed laboratory parameters[20]. In comparison, in this study, as in the study by Chu et al[20], age was the only factor among the demographic and clinical risk factors that was found to be significantly correlated with ischemic events. However, age is already used as a parameter to calculate the CHA2DS2-VASc score. The rates of intraoperative clinical situations such as acidosis, inotropic support, or intra-aortic balloon pump were also significantly associated with postoperative ischemic stroke. Similarly, postoperative complications were also more frequent in patients with ischemic stroke. It is difficult to explain the effect of such intra- and postoperative events on ischemic stroke risk in a retrospective study. Prospective studies are needed to explain the reciprocal relationships between these complex pathophysiological events.

Limitations

There were several limitations in this study. First, it was designed as a single-center, retrospective study. Secondly, only the hospitalized patients were followed-up. Thirdly, ischemic stroke, POAF, and the CHA2DS2-VASc score were not analyzed for long-term risks. Fourthly, certain clinical data regarding the characteristics of POAF, including duration and missed short episodes of AF without medical treatment, either could not be obtained or were lost due to the study's retrospective design. Lastly, the number of patients with ischemic stroke was relatively small compared to the total number of patients included in the study. Prospective large-scale studies are needed to overcome these limitations.

Conclusions

The findings of this study revealed that higher CHA2DS2-VASc scores were associated with a higher risk of ischemic stroke in patients who underwent CABG; however, POAF did not have any significant effect on the relationship between CHA2DS2-VASc scores and risk of ischemic stroke. In conclusion, the CHA2DS2-VASc scores may be used effectively by either utilizing optimum cut-off values or risk stratification groups to predict ischemic stroke and mortality risk in patients who underwent CABG.

Ethics Approval

This study was approved by the Toros University Local Ethics Committee (Ethics Committee approval No.: 15.10.2021/108). The study was carried out in accordance with the principles set forth in the Declaration of Helsinki.

Informed Consent

Written informed consent was obtained from each patient included in the study.

Conflict of Interests

The author has no conflict of interests to declare.

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Availability of Data and Materials

All original data are available and will be provided upon request.

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