ABC-AF-Stroke score predicts thromboembolism in non-anticoagulated patients following successful atrial fibrillation ablation: a report from the Chinese Atrial Fibrillation Registry

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Abstract

Background: The age, biomarkers, and clinical history (ABC)-atrial fibrillation (AF)-Stroke score have been proposed to refine stroke risk stratification, beyond what clinical risk scores such as the CHA2DS2-VASc score can offer. This study aimed to identify risk factors associated with thromboembolism and evaluate the performance of the ABC-AF-Stroke score in predicting thromboembolism in non-anticoagulated AF patients following successful ablations.

Methods: A total of 2692 patients who underwent successful ablations with discontinued anticoagulation after a 3-month blanking period in the Chinese Atrial Fibrillation Registry (CAFR) between 2013 and 2019 were included. Cox regression analysis was conducted to present the association of risk factors with thromboembolism risk. The ABC-AF-Stroke score was evaluated in terms of discrimination, including concordance index (C-index), net reclassification improvement (NRI) and integrated discrimination improvement (IDI), clinical utilization by decision curve analysis (DCA), and calibration by comparing the predicted risk with the observed annualized event rate.

Results: After a median follow-up of 3.5 years, 64 patients experienced thromboembolism events. Age, prior history of stroke/transient ischemic attack (TIA), high-sensitivity cardiac troponin T(cTnT-hs), and N-terminal pro-B-type natriuretic peptide (NT-proBNP) were independently associated with thromboembolism risk. The ABC-AF-Stroke score performed statistically significantly better than the CHA2DS2-VASc score in terms of C-index (0.67, 95% confidence interval [CI]: 0.59–0.74 vs. 0.60, 95% CI: 0.52–0.67, P = 0.030) and reclassification capacity. The DCA implied that the ABC-AF-Stroke score could identify more thromboembolism events without increasing the false positive rate compared to the CHA2DS2-VASc score. The calibration curve showed that the ABC-AF-Stroke score was well calibrated in this population.

Conclusions: In this real-world study enrolling non-anticoagulated AF patients following successful ablations, age, prior history of stroke/TIA, level of NT-proBNP, and cTnT-hs were independently associated with an increased risk of thromboembolism. The ABC-AF-Stroke score was well-calibrated and statistically significantly outperformed the CHA2DS2-VASc score in predicting thromboembolism risk.

Keywords: Atrial fibrillation; ABC-AF-Stroke score; CHA2DS2-VASc; Thromboembolism; Catheter ablation

Introduction

Atrial fibrillation (AF) was commonly associated with stroke and thromboembolism, conferring a high mortality and morbidity, as well as healthcare costs.1 Catheter ablation and early rhythm control could potentially reduce the risk of stroke and improve the prognosis of AF patients.2 However, the optimal approach to anticoagulation strategies after a successful ablation procedure remained debated, as the risks and benefits of long-term anticoagulation vary among AF patients. An individualized stroke-predicted score would be useful to identify...
patients with various risks of post-ablation thromboembolism, and further assist in decision-making on oral anticoagulation.

Biomarkers and biomarker-based risk scores have been proposed to refine stroke risk stratification, beyond what simple clinical risk factor based risk scores such as the CHADS2 and CHA2DS2-VASC scores can offer.[3] The age, biomarkers, and clinical history (ABC)-AF-Stroke score integrating age, biomarkers (N-terminal pro-B-type natriuretic peptide [NT-proBNP], high-sensitivity cardiac troponin T [cTnT-hs]), and clinical history (prior stroke or transient ischemic attack [TIA]), has recently been proposed and validated using anticoagulated clinical trial cohorts, with statistically significantly superior discrimination performance in predicting thromboembolism risk when compared with CHA2DS2-VASC score.[4-6] External validation of ABC-AF-Stroke score has also been demonstrated in AF patients receiving only antiplatelet therapy.[7] However, there is no evidence of using the ABC-AF-Stroke score in patients undergoing successful AF ablation, especially in those discontinuing oral anticoagulation after ablation procedures.

In this study, we aimed, first, to determine the risk factors associated with thromboembolism in patients discontinuing anticoagulation therapy after successful ablation, and second, to evaluate the performance of ABC-AF-Stroke score in predicting thromboembolism events, using a nationwide prospective Chinese AF cohort.

Methods

Ethic approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Beijing Anzhen Hospital (No. D11110700300000). Written informed consent was obtained from all study participants.

Participants

Participants in our study were enrolled between 2013 and 2019 in the Chinese Atrial Fibrillation Registry (CAFR), which is one of the largest prospective observational cohorts in China, involving 31 hospitals all over the country.

Inclusion criteria are the following: (1) AF patients underwent catheter ablation; (2) no AF recurrence within the first year after ablation procedures, except for the first 3 months; (3) discontinuation of anticoagulation therapy for at least one year since the time of ablation procedure, except for the first 3 months; (4) patients who suffered from thromboembolism events within the first year and did not receive anticoagulation therapy before the occurrence of events; and (5) blood samples were collected at baseline. Exclusion criteria included: (1) valvular AF, such as moderate to severe mitral stenosis or mechanical valve prosthesis; (2) the occurrence of thromboembolism events in the first 3 months after ablation procedures; and (3) unstable conditions, including any acute coronary syndrome, stroke/TIA, and acute onset of heart failure in the previous 3 months before enrollment.

Data collection

Detailed information, including study design, baseline characteristics, and follow-up data, had been described previously.[8] Information including social demographics, comorbidities, physical examination, laboratory tests, and medications was collected at baseline; clinical outcomes such as death, stroke, and major bleeding events were recorded during the follow-up visits. All results were gathered by cardiovascular specialists with the appropriate training and/or nurse practitioners in outpatient clinics or via telephone interviews, and stored by a web-based data collection system. Our investigation only made use of anonymized data.

ABC-AF-Stroke score

The ABC-AF-Stroke score was calculated by the ABC-AF stroke equation proposed by Hijazi et al.[4] This calculator provided the estimated 1-year risk of stroke and systemic embolism (SE), which referred to the probability of stroke and SE events at one year for patients. Our study used the “Troponin T” version of the ABC-AF-stroke score presented in their online supplemental data.[4] Briefly, the predicted risk at one year was obtained through the estimated event-free probability calculated by baseline survival at one year and linear predictors, which were the weighted sum of predictors (components of ABC-AF-Stroke score). The detailed calculation procedure was shown in the Supplementary File, http://links.lww.com/CMJ9/B700.

Blood sample and biomarker detection

Blood samples that were ethylene diamine tetraacetic acid (EDTA)-anticoagulated and taken prior to ablation procedures from patients who had signed up for the registry study were used to measure the two biomarkers (NT-proBNP and cTnT-hs) that make up the ABC-AF-Stroke score. Following centrifugation, plasma samples were obtained and stored at −70°C until being centrally examined. The Elecsys TnT-hs and Elecsys proBNP II assays (Roche Diagnostics International Ltd, Mannheim, Germany) were used to assess NT-proBNP and cTnT-hs utilizing Cobas e 801 analyzers (Roche Diagnostics International Ltd). TnT-hs and NT-proBNP had lower limits of detection of 3.0 pg/mL and 5.0 pg/mL, respectively.

Monitoring strategies after the ablation procedure

All patients received follow-up visits at 3, 6 and 12 months after ablation and every 6 months thereafter. The 24 h Holter monitoring once a month was used for detection of AF recurrence in the first three months after ablation procedures. Electrocardiograph (ECG) or 24 h Holter monitoring was requested every 6 months thereafter.
Symptom-triggered and opportunistic examinations that involved ECG or 24 h Holter were also recorded during the follow-up. ECGs were sent to the follow-up center if there were any concerns to enable the cardiologists who conducted the ablation to verify the diagnosis.

A post-ablation episode of AF, atrial flutter, or atrial tachycardia lasting >30 s was considered an AF recurrence. The episode of atrial arrhythmia in the first three months (the blanking period) is not indicative of AF recurrence. Patients without evidence of AF recurrence within the first year (except for the first 3 months) using the aforementioned strategies were considered to have undergone successful AF ablation.

In our investigation, the follow-up period was started after the AF ablation procedure. Person-time was censored at the time when the patient started oral anticoagulant therapy, AF recurred, the first thromboembolism occurred, death occurred, or at the time when the data were analyzed.

Post-procedural anticoagulation strategy

On the evening of the ablation procedure, adjusted-dose warfarin (international normalized ratio [INR] 2.0–3.0) was restarted; or non-vitamin K antagonist oral anticoagulants (NOACs; e.g., dabigatran 150/110 mg b.i.d. or rivaroxaban 20/15 mg q.d.) were resumed the next day after the procedure. Anticoagulation was continued for at least three months. The long-term anticoagulation strategies after the first three months were determined by cardiologists according to the AF recurrence and stroke risk profile.

Clinical outcome

The clinical outcome in this study was thromboembolism, a composite endpoint of ischemic stroke and SE. Ischemic stroke refers to a sudden onset of localized or widespread neurological impairment brought by arterial infarction in the brain, spinal cord, or retina. Stroke may be diagnosed by imaging tests (computed tomography or magnetic resonance imaging scans) that reveal acute infarct lesions matching neurological symptoms. Acute arterial blockage of an extremity or organ that could be verified by imaging, surgery, or autopsy was defined as SE. An independent committee determined the clinical outcome by all medical documents pertaining to these incidents. During follow-up, only the first incident of one kind was taken into account if a patient encountered more than one events.

Statistical analysis

Continuous variables were presented as mean ± standard deviation (SD) or median (interquartile range [IQR]), and categorical variables were shown as number and proportions.

Baseline characteristics and biomarker levels were shown by classifying the ABC-AF-Stroke score into low, medium, and high risk (<1%, 1–2%, and >2%) groups. Analysis of variance, Wilcoxon rank-sum tests, and chi-squared test were employed to identify the difference in baseline information divided by the three risk groups. Univariate and multivariate Cox regression were conducted to evaluate the association of clinical factors and biomarkers with clinical outcomes. The incidence rate of thromboembolism was calculated within the low, medium, and high risk groups of the ABC-AF-Stroke score and CHA2DS2-VASc score (0, 1, and ≥2 points for men and 1, 2, and ≥3 points for women), and reported as the number of events per 100 person-year. The cumulative thromboembolism rate was graphically shown with the Kaplan–Meier curve and compared with the log-rank test by the ABC-AF-Stroke score categorizations. Discriminative performance of ABC-AF-Stroke score and CHA2DS2-VASc score were presented as C-indices.[9] Net reclassification improvement (NRI) and integrated discrimination improvement (IDI) were calculated to reveal the reclassification improvement when comparing two scores.[10] Decision curve analysis (DCA) was plotted to show the net benefit of clinical utilization of ABC-AF-Stroke score in identifying thromboembolism events compared with the CHA2DS2-VASc score.[11] Finally, a calibration curve was plotted to further exhibit the calibration of the ABC-AF-Stroke score by comparing the predicting event risk with the observed annualized event rate.

Data were analyzed using R version 4.1.2 (R Foundation for Statistical Computing, Vienna, Austria) and P-value <0.05 was considered statistically significant.

Results

In our study, a total of 2692 participants were included (age, 59.6 ± 11.0 years; 32.1% [864/2692] female). Baseline characteristics and biomarker levels in the low- (n = 2197), medium- (n = 418), and high- (n = 77) risk groups using the ABC-AF-Stroke risk score were shown in Table 1.

Patients with higher ABC-AF-Stroke risk scores were more likely to be older, and to have lower estimated glomerular filtration rate (eGFR) levels, larger proportions of persistent or permanent AF, and more concomitant conditions, such as hypertension and a history of ischemic stroke/TIA. From the low- to high-risk group, mean CHA2DS2-VASc and HAS-BLED scores gradually increased.

Levels of cTnT-hs gradually elevated from 7.2 ng/L in the low-risk group to 16.0 ng/L in high-risk group. NT-proBNP levels were slightly lower in the high-risk group than in the medium-risk group (992 ng/mL vs. 998 ng/mL, P <0.001), but the first and third quartiles were higher than those in the medium-risk group (661 ng/mL vs. 314 ng/mL; 1887 ng/mL vs. 1667 ng/mL, respectively).

Clinical events during follow up

Throughout the follow-up of 3.5 (range, 2.3–5.0) years, there was no significant difference in follow-up time among the three risk groups [Table 1]. Thromboembolism episodes occurred in 64 patients. Age, prior isch-
an independent association
proBNP were all linked to an elevated risk of thrombo-
uretic peptide
SD: -terminal pro-B-type natri-
labile INR,
bleeding history or predisposition;
Estimated glomerular filtration rate estimated by the Chronic Kidney Disease Epidemiology Collaboration Equation,
and sex category
High-sensitivity cardiac troponin T
female
age of
stroke/TIA:
75
BMI:
Body mass index;
–statistic for analysis of variance
interquartile range
NT-proBNP:
TIA: Transient ischemic attack
Table
Table 1: Baseline characteristics of atrial fibrillation patients stratified by ABC-AF-Stroke score.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Low risk (n = 2197)</th>
<th>Medium risk (n = 418)</th>
<th>High risk (n = 77)</th>
<th>Statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>58.3 ± 10.9</td>
<td>65.4 ± 9.5</td>
<td>66.5 ± 9.2</td>
<td>93.94†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.7 ± 3.4</td>
<td>25.4 ± 3.3</td>
<td>25.5 ± 3.5</td>
<td>1.69†</td>
<td>0.185</td>
</tr>
<tr>
<td>Female</td>
<td>690 (31.4)</td>
<td>145 (34.7)</td>
<td>29 (37.7)</td>
<td>2.86†</td>
<td>0.239</td>
</tr>
<tr>
<td>AF type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paroxysmal</td>
<td>1657 (75.4)</td>
<td>232 (55.5)</td>
<td>30 (39.0)</td>
<td>108.53†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Persistent/permanent</td>
<td>540 (24.6)</td>
<td>186 (44.5)</td>
<td>47 (61.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smoking</td>
<td>276 (12.6)</td>
<td>39 (9.3)</td>
<td>8 (10.4)</td>
<td>3.67†</td>
<td>0.160</td>
</tr>
<tr>
<td>Current alcohol consumption</td>
<td>275 (12.5)</td>
<td>55 (13.2)</td>
<td>12 (15.6)</td>
<td>0.72†</td>
<td>0.697</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>234 (10.7)</td>
<td>53 (12.7)</td>
<td>12 (15.6)</td>
<td>3.07†</td>
<td>0.215</td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>7 (0.3)</td>
<td>4 (1.0)</td>
<td>0</td>
<td></td>
<td>1.047</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1233 (56.1)</td>
<td>271 (64.8)</td>
<td>60 (77.9)</td>
<td>23.74†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>437 (19.9)</td>
<td>118 (28.2)</td>
<td>20 (26.0)</td>
<td>15.54†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Heart failure</td>
<td>68 (3.1)</td>
<td>38 (9.1)</td>
<td>7 (9.1)</td>
<td>36.11†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ischemic stroke or TIA</td>
<td>34 (1.5)</td>
<td>110 (26.3)</td>
<td>56 (72.7)</td>
<td>804.69†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>cGFR (CKD-EPI) (mL·min⁻¹·1.73 m²)</td>
<td>92.1 (82.0, 100.5)</td>
<td>84.1 (72.7, 93.3)</td>
<td>80.2 (67.9, 89.1)</td>
<td>143.31†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CHA²DS²-VASc</td>
<td>1 (1, 2)</td>
<td>3 (2, 4)</td>
<td>4 (3, 5)</td>
<td>344.13†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HAS-BLED</td>
<td>1 (1, 2)</td>
<td>2 (1, 2)</td>
<td>3 (2, 3)</td>
<td>244.06†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Biomarker levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cTnT-hs (ng/L)</td>
<td>7.2 (5.6, 9.6)</td>
<td>12.2 (8.9, 17.7)</td>
<td>16.0 (10.5, 45.1)</td>
<td>462.85†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NT-proBNP (ng/mL)</td>
<td>147 (64, 350)</td>
<td>998 (314, 1667)</td>
<td>992 (661, 1887)</td>
<td>606.03†</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Follow-up time (years)</td>
<td>3.5 (2.3, 5.0)</td>
<td>3.5 (2.0, 5.0)</td>
<td>3.9 (2.2, 5.5)</td>
<td>2.93‡</td>
<td>0.230</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard deviation for normal distributed continuous variables, median (interquartile range) for skew continuous variables, or n (%) for categorical variables. *P-statistic for analysis of variance; †P² for chi-squared test; ‡P-statistic for Wilcoxon rank-sum test. ABC-AF-Stroke: Age, biomarkers (N-terminal fragment B-type natriuretic peptide, high-sensitivity troponin), and clinical history (prior stroke/TIA); AF: Atrial fibrillation; BMI: Body mass index; CHA²DS²-VASc: Cardiac failure or dysfunction, hypertension, age ≥75 years (doubled), diabetes mellitus, stroke (doubled)–vascular disease, age of 65–74 years, and sex category (female); cTnT-hs: High-sensitivity cardiac troponin T; cGFR (CKD-EPI): Estimated glomerular filtration rate estimated by the Chronic Kidney Disease Epidemiology Collaboration Equation; HAS-BLED: Uncontrolled hypertension, abnormal renal and/or hepatic function, stroke, bleeding history or predisposition, labile INR, elderly, and drugs or excessive alcohol drinking. INR: International Normalized Ratio; IQR: Interquartile range; NT-proBNP: N-terminal pro-B-type natriuretic peptide; SD: Standard deviation; TIA: Transient ischemic attack; ‡Not available.

emeric stroke/TIA, log-transformed cTnT-hs, and NT-
proBNP were all linked to an elevated risk of thrombo-
embolism according to univariate analysis [Table 2].

After multivariate analysis, an independent association
was observed between the clinical outcome and age, prior ischemic stroke/TIA, log-transformed cTnT-hs, and NT-
proBNP. Prior history of stroke/TIA was demonstrated to have the greatest association with thromboembolism among these factors (HR: 2.14, 95% confidence interval [CI]: 1.11–4.13, P = 0.023), followed by the cardiac biomarkers, and age in descending order [Table 2].

Table 2: Association of thromboembolism events with clinical characteristics and biomarkers using Cox regression.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Univariate Cox regression</th>
<th>Multivariate Cox regression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Age (per year)</td>
<td>1.03</td>
<td>1.01–1.05</td>
</tr>
<tr>
<td>Female</td>
<td>1.03</td>
<td>0.61–1.75</td>
</tr>
<tr>
<td>Persistent AF</td>
<td>1.49</td>
<td>0.89–2.48</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.15</td>
<td>0.70–1.90</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>1.23</td>
<td>0.58–2.57</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.11</td>
<td>0.62–2.00</td>
</tr>
<tr>
<td>Heart failure</td>
<td>1.32</td>
<td>0.41–4.22</td>
</tr>
<tr>
<td>Ischemic stroke or TIA</td>
<td>2.51</td>
<td>1.31–4.81</td>
</tr>
<tr>
<td>cTnT-hs (per double increase)</td>
<td>1.31</td>
<td>1.13–1.52</td>
</tr>
<tr>
<td>NT-proBNP (per double increase)</td>
<td>1.42</td>
<td>1.17–1.72</td>
</tr>
</tbody>
</table>

*Persistent AF might be related to thromboembolism risk in clinical practice, so we included this variable in multivariate analysis despite the non-significant association in univariate analysis. AF: Atrial fibrillation; CI: Confidence interval; cTnT-hs: High-sensitivity cardiac troponin T; HR: Hazard ratio; NT-proBNP: N-terminal fragment B-type natriuretic peptide; TIA: Transient ischemic attack.
According to the ABC-AF-Stroke score categories, 34, 20, and 10 events occurred in low-, medium- and high-risk groups, with corresponding incidence rates of 0.43, 1.37, and 3.44 per 100 person-years, respectively [Table 3]. Compared to the CHA\textsubscript{2}DS\textsubscript{2}-VASc score categories (0, 1, and ≥2 points for men and 1, 2, and ≥3 points for women), there were 11, 16, and 37 events that occurred in the low-, medium- and high-risk categories, with respective incidence rates of 0.47, 0.48, and 0.91 per 100 person-years. As shown in Figure 1, cumulative incidence rate curves demonstrated a significant variation in thromboembolism risk among the ABC-AF-Stroke score categories (P for log-rank <0.001).

**Comparing ABC-AF-Stroke and CHA\textsubscript{2}DS\textsubscript{2}-VASc scores**

With a higher C-index than that of the CHA\textsubscript{2}DS\textsubscript{2}-VASc score, the ABC-AF-Stroke score performed better in predicting thromboembolism events (0.67 [95% CI: 0.59–0.74] vs. 0.60 [95% CI: 0.52–0.67], P = 0.030). Reclassification analyses showed that the ABC-AF-Stroke score had a higher reclassification capacity at the 1-year follow-up, in terms of NRI (47.4%, 95% CI: 21.8–71.2%, P <0.001) and IDI (0.5%, 95% CI: 0.1–0.7%, P = 0.004), compared with the CHA\textsubscript{2}DS\textsubscript{2}-VASc score [Table 4].

The entire population in our study was separated into nine subgroups by both the ABC-AF-Stroke and CHA\textsubscript{2}DS\textsubscript{2}-VASc scores in order to further compare the discrimination capacity [Figure 2]. Within the subgroups by CHA\textsubscript{2}DS\textsubscript{2}-VASc score categories, the ABC-AF-Stroke score may effectively identify individuals with varying risk levels. Almost half of patients were classified as high risk by the CHA\textsubscript{2}DS\textsubscript{2}-VASc score, and of those, nearly 70% were further graded as low risk by the ABC-AF-Stroke score, with an incidence rate of 0.47 per 100 person-years. Almost all patients who were considered to be at high risk for thromboembolism based on the ABC-AF-Stroke score were assigned to the subgroup with the greatest incidence rate of thromboembolism (3.66 per 100 person-years).

In comparison to the CHA\textsubscript{2}DS\textsubscript{2}-VASc score, DCA demonstrated a better net benefit of using the ABC-AF-Stroke score for recognizing thromboembolism episodes without increasing the false positive rate [Figure 3]. The calibration curve showed that the ABC-AF-Stroke score was well-calibrated by comparing anticipated thromboembolism risk using ABC-AF-Stroke score with the observed annualized event rate [Figure 4].

**Discussion**

In this study, our principal findings were that clinical factors and biomarkers including age, prior history of stroke, level of cTnT-hs, and NT-proBNP were independently associated with thromboembolism and that the ABC-AF-Stroke score, which comprised of the above-

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**Table 3: Distribution of thromboembolism events and incidence rate according to risk score categories.**

<table>
<thead>
<tr>
<th>Groups</th>
<th>CHA\textsubscript{2}DS\textsubscript{2}-VASc score</th>
<th>ABC-AF-Stroke score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n Number of events</td>
<td>Incidence rate (per 100 person-years)</td>
</tr>
<tr>
<td>Low risk</td>
<td>638 11</td>
<td>0.47</td>
</tr>
<tr>
<td>Medium risk</td>
<td>909 16</td>
<td>0.48</td>
</tr>
<tr>
<td>High risk</td>
<td>1145 37</td>
<td>0.91</td>
</tr>
</tbody>
</table>

ABC-AF-Stroke: Age, biomarkers (N-terminal fragment B-type natriuretic peptide, high-sensitivity troponin), and clinical history (prior stroke/TIA); CHA\textsubscript{2}DS\textsubscript{2}-VASc: Cardiovascular failure or dysfunction, hypertension, age ≥75 years (doubled), diabetes mellitus, stroke (doubled)–vascular disease, age of 65–74 years, and sex category (female); TIA: Transient ischemic attack.

**Table 4: Discrimination of ABC-AF-Stroke score in comparison with CHA\textsubscript{2}DS\textsubscript{2}-VASc score.**

<table>
<thead>
<tr>
<th>Score</th>
<th>C-index</th>
<th>95% CI</th>
<th>P-value</th>
<th>P-value</th>
<th>IDI at 1 year (%)</th>
<th>P-value</th>
<th>NRI at 1 year (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC-AF-Stroke score</td>
<td>0.67</td>
<td>0.59–0.74</td>
<td>&lt;0.001</td>
<td>0.030</td>
<td>0.5%</td>
<td>0.004</td>
<td>47.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CHA\textsubscript{2}DS\textsubscript{2}-VASc score</td>
<td>0.60</td>
<td>0.52–0.67</td>
<td>&lt;0.001</td>
<td>(0.1–0.7%)</td>
<td>(21.8–71.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ABC-AF-Stroke indicates age, biomarkers (N-terminal fragment B-type natriuretic peptide, high-sensitivity troponin), and clinical history (prior stroke/TIA); CHA\textsubscript{2}DS\textsubscript{2}-VASc: Cardiac failure or dysfunction, hypertension, age ≥75 years (doubled), diabetes mellitus, stroke (doubled)–vascular disease, age of 65–74 years, and sex category (female). For C-index comparison, CI: Confidence interval; IDI: Integrated discriminatory improvement; NRI: Net reclassification index; TIA: Transient ischemic attack.
mentioned four risk factors, was well-calibrated in this population. Second, the ABC-AF-Stroke score outperformed the simple CHA2DS2-VASc score in predicting thromboembolism events. This might help optimize anticoagulation therapy for patients undergoing ablation procedures. To our knowledge, this is the first study evaluating the performance of the ABC-AF-Stroke score in predicting thromboembolism in patients with AF not receiving anticoagulation following successful ablation.

Research about the association of NT-proBNP and troponin T with thromboembolism risk in patients undergoing catheter ablations was limited. Only one study with 227 patients concluded that increasing level of troponin T was an independent predictor for the composite endpoint including death, stroke, acute coronary syndrome, and hospitalization due to heart failure after catheter ablation.12 Results in our study showed that pre-ablation levels of NT-proBNP and cTnT-hs were independently associated with an increased risk of thromboembolism, which further provided some evidence for the correlation between biomarkers and prognosis after successful ablation of AF. Prior history of stroke had been commonly acknowledged as an important predicting factor for recurrence of thromboembolism in AF patients undergoing ablation procedures.13-15 The effectiveness of the CHA2DS2-VASc score, which incorporated the prior history of stroke/TIA as a significant consideration (2 points), on predicting post-ablation stroke risk had also been assessed in a number of studies. For example, Chao et al16 reported that CHA2DS2-VASc score was a useful predictor of composite events including death and thromboembolism in patients with AF after catheter ablation, with an area under receiver-operator characteristic curve (AUC) of 0.83. The performance was also similarly outstanding after excluding patients that received long-term anticoagulation medication following ablation (AUC = 0.83).17

In our research, thromboembolism was not significantly associated with any other clinical components of CHA2DS2-VASc score, with the exception of age and the prior history of stroke. In contrast with the aforementioned studies, we did not include thromboembolism episodes that occurred after an AF recurrence. Although the predictive performance of the CHA2DS2-VASc score might be weakened by excluding those events, the evaluation of thromboembolic risk prediction in successful post-ablation patients would be more optimal.

International guidelines advocated long-term anticoagulation in AF patients receiving catheter ablation based...
on the risk of stroke rather than the apparent success or failure of the ablation treatment.\cite{18,19} The question of how to assess the risk of thromboembolism and decide on anticoagulation strategies following ablation had not been resolved. Multiple studies have compared the thromboembolism risk between groups receiving continuous oral anticoagulation (on-OAC) and discontinuous anticoagulation (off-OAC) therapy in AF patients with CHA$_2$DS$_2$-VASc scores of ≥ 2 points who underwent ablation procedures, and the results were different.\cite{13-15,20} An explanation for the heterogeneity might be the different percentage of AF recurrence and recurrence-related stroke events, and the modest predictive performance of CHA$_2$DS$_2$-VASc score. Our study not only filled a gap in the use of the ABC-AF-Stroke score by first examining how well it predicted thromboembolism occurrences in AF patients who had successfully undergone ablation procedures without receiving long-term anticoagulant treatment, but also implied that the ABC-AF-Stroke score helped reliably identify patients with a high risk of thromboembolism and may help support decisions regarding anticoagulant medication by further stratifying patients with distinct risk levels within CHA$_2$DS$_2$-VASc categories.

Several limitations characterizing our study need to be mentioned. First, the results obtained in our study cannot be extrapolated to all patients underwent catheter ablations, as we only enrolled those discontinuing anticoagulation therapy after ablation procedures. Nevertheless, our findings had implications for determining patients who were at high risk of thromboembolism and should not discontinue anticoagulation therapy after successful ablations. Second, we only used the pre-ablation biomarker levels to evaluate the performance of the prediction model, as post-ablation blood samples were not available in our study. Finally, the benefits of identifying high-risk patients by ABC-AF-Stroke score must be weighed against the cost of anticoagulation therapy, assay variability, diurnal variations, and requirements for blood sample analysis.

In conclusion, in this real-world study enrolling AF patients not receiving anticoagulation therapy following successful ablation procedures, age, prior history of stroke/TIA, level of NT-proBNP, and cTnT-AAs were independently associated with an increased risk of thromboembolism. The biomarker-based ABC-AF-Stroke score was well-calibrated and statistically outperformed the simple CHA$_2$DS$_2$-VASc score in predicting thromboembolism risk.

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**Conflicts of interest**

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**References**


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