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A Novel Body Mass Index-Based Thromboembolic Risk Score for Overweight Patients with Nonvalvular Atrial Fibrillation

ABSTRACT

Background: A novel risk prediction model appears to be urgently required to improve the assessment of thrombotic risk in overweight patients with nonvalvular atrial fibrillation (NVAF). We developed a novel body mass index (BMI)-based thromboembolic risk score (namely AB_2S score) for these patients.

Methods: A total of 952 overweight patients with NVAF were retrospectively enrolled in this study with a 12-month follow-up. The primary endpoint was 1-year systemic thromboembolism and the time to thrombosis (TTT). The candidate risk variables identified by logistic regression analysis were included in the final nomogram model to construct AB_2S score. The measures of model fit were evaluated using area under the curve (AUC), C-statistic, and calibration curve. The performance comparison of the AB_2S score to the $CHADS_2$ and CHA_2DS_2-VASc score was performed in terms of the AUC and decision analysis curve (DAC).

Results: The AB_2S score was constructed using 7 candidate risk variables, including a 3-category BMI (25 to 30, 30 to 34, or ≥35 kg/m^2). It yielded a c-index of 0.885 (95% CI, 0.814-0.954) and an AUC of 0.885 (95% CI, 0.815-0.955) for predicting 1-year systemic thromboembolism in patients with NVAF. Compared to the $CHADS_2$ score and CHA_2DS_2-VASc score, the AB_2S score had greater AUC and DAC values in predicting the thromboembolic risk and better risk stratification in TTT ($P <$ .0001, $P =$ .082, respectively).

Conclusion: Our results highlighted the importance of a BMI-based AB_2S score in determining systemic thromboembolism risk in overweight patients with NVAF, which may aid in decision-making for these patients to balance the effectiveness of anticoagulation from the underlying thrombotic risk.

Keywords: AB_2S score, thrombotic risk, overweight, nonvalvular atrial fibrillation

INTRODUCTION

Nonvalvular atrial fibrillation (NVAF) is a common arrhythmia that increases the risk for ischemic stroke by 4- to 5-fold, according to current clinical reports.[1,2] Direct oral anticoagulants (DOACs) are considered as highly effective anticoagulants for thrombosis prevention in patients with NVAF recommended by the current guidelines,[3] with the advantages of fixed-dose regimens without the requirement of coagulation monitoring. Previous studies indicated that DOACs were associated with better safety and effectiveness in patients across all body mass index (BMI) categories compared to warfarin.[4,5] However, these clinical trials usually lacked the effect of BMI on thromboembolism. Concerning that more and more ischemic events were reported in patients with higher BMIs,[6,7] this "one-size-fits-all" strategy in DOACs raises significant concerns about the effectiveness and safety of DOACs in these patients.

According to previous studies, a higher BMI is regarded as a well-established risk of ischemic events due to the larger body surface area or underexposed of DOACs.[8,9] Besides, positive linear relationship revealed a relation of BMI levels and the incidence of thrombosis in overweight patients with NVAF.[10] However, no guidelines or recommendations for DOACs use have been published specifically among the

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overweight patients. To improve the estimation of thrombotic risk among overweight patients with NVAF, a new risk prediction model seems to be urgently needed.

Recently, the $CHADS_2$ or CHA_2DS_2-VASc risk scores are recommended as risk-predicting approaches for anticoagulation decision in NVAF.[11,12] However, studies indicated that these risk scores have only moderate ability in predicting the risk of stroke.[13] There is even a lack of evidence on the performance of these 2 risk scores in overweight patients. Combining the significant incremental risk predictors of age, stroke, and heart failure, the major component of $CHADS_2$ or CHA_2DS_2-VASc score, we aimed to develop a new risk score with BMI categories (namely the AB_2S risk score) to predict the thrombotic events in overweight patients with NVAF. We also investigated the incremental value of this AB_2S risk score by comparing with the $CHADS_2$ or CHA_2DS_2-VASc risk scores.

METHODS

Study Design and Population
The study was a retrospective single-center observational study and enrolled a total of 952 consecutive overweight patients with NVAF between January 2017 and December 2018. Nonvalvular atrial fibrillation was diagnosed according to the European Society of Cardiology criteria: absolutely irregular RR intervals and no discernible and distinct P waves presented on electrocardiogram.[14]

Patients with age ≥ 18, BMI ≥ 25 kg/m², high risk of stroke and systemic embolism, and DOAC therapy during hospitalization were eligible. Exclusion criteria were patients with incomplete records and severe liver or renal dysfunction or patients lost follow-up.

The study was conducted in accordance with the Basic and Clinical Pharmacology and Toxicology Policy for Experimental and Clinical Studies.[15]

Medication and Radiofrequency Ablation Procedure
The radiofrequency ablation procedure was performed, as described previously.[16] In brief, all patients were treated with dabigatran or rivaroxaban for at least 4 consecutive weeks to achieve stable anticoagulation, discontinued 24 hours before scheduled catheter ablation, and resumed 3 to 4 hours after removing the sheath. Transesophageal echocardiography was applied during the transseptal puncture. Other medications used included beta-blockers, antihypertensives, antiarrhythmics, antiplatelet agents, and proton pump inhibitors at the physician's discretion.

HIGHLIGHTS
- Our results highlighted the importance of a BMI-based AB_2S score in determining systemic thromboembolism risk in overweight patients with NVAF.
- The AB_2S score had a greater performance in predicting the thromboembolic risk compared to CHADS2 score and CHA2DS2- VASc score.

Data Collection
The following demographic and clinical baseline data were obtained from electronic medical records: (1) age, gender, and BMI; (2) comorbidity (history of hypertension, hyperlipidemia, diabetes mellitus, chronic kidney disease, liver disease, stroke, heart failure, and peripheral arterial disease; (3) biochemical blood indicators including estimated glomerular filtration rate (eGFR), platelets (PLT), hemoglobin, activated partial prothrombin time, thrombin time, and left ventricular ejection fraction (LVEF).

Clinical Definition
The age was categorized as <65, 65 to 74, or ≥75 years old. The BMI was categorized as 25 to 30, 30 to 34, or ≥35 kg/m² according to the World Health Organization. The eGFR was dichotomized into ≥60 versus <60 mL/min per 1.73 m². Platelet counts $<125 \times 10^9$/L and LVEF at <40% were derived from the previous report.[10] The CHA_2DS_2-VAS_C and $CHADS_2$ scores were calculated to assess the risk of thrombosis.[17]

Follow-up and Study Outcomes
All patients were followed up once a month for 12 months. The primary endpoint was the recurrence of systemic thromboembolism, which is defined as pulmonary embolism (PE), venous thromboembolism (VTE), stroke, or cardiac embolism. Events were assessed according to the Antithrombotic Therapy and Prevention of Thrombosis Guidelines.[18] The time to thrombosis (TTT)—defined as the time to the first stroke or systemic embolism from enrollment—was documented.

Model Development and Evaluation
Before constructing the predictive model, the logistic regression (LR) analysis was adopted to screen the candidate predictor variables using the "Regression Modeling Strategies" package in R software. The results in the LR analysis were represented by odds ratio with 95% CI and *P*-value.[19] These candidate predictor variables with statistical significance were finally used to develop a clinical prediction risk thromboembolic score (namely AB_2S score) and presented as a nomogram model using R software.[20]

The measures of model fit, including the area under curve (AUC) of receiver operating characteristic curve and the C-statistic, were calculated via the R software.[21,22] Besides, to minimize false-positive variable selection, a corrected calibration curve that includes 2000 bootstrap samples was used to verify the correlation between the calibration curve and the standard curve.[23] To verify the clinical efficacy of the AB_2S score model, the decision analysis curve (DAC) was employed by analyzing the net benefit under different risk thresholds compared with CHA_2DS_2-VASc and $CHADS_2$ scores.[24]

Statistical Analysis
Quantitative data were reported as means with SDs (mean ± SD) and compared by Student's *t* test. Qualitative data were presented as absolute numbers and percentages compared by chi-square test or Fisher's exact probability test. The backward stepwise model selection procedure was applied first to evaluate the variables with best model

Table 1. Baseline Characteristics of Overweight Patients with Nonvalvular Atrial Fibrillation (n = 952)

Characteristics		Nonthrombotic Events	Thrombotic Events	P
n		930	22	
BMI, kg/m^2 (mean ± SD)		29.76 ± 3.71	32.17 (4.14)	.003
Age, years (mean ± SD)		65.62 ± 12.14	75.82 (9.89)	<.001
Hb, 10^9/L (mean ± SD)		136.27 ± 16.54	134.00 (23.39)	.529
PLT, 10^9/L (mean ± SD)		196.38 ± 56.06	177.91 (67.70)	.129
eGFR, mL/min/1.73 m^2 (mean ± SD)		79.45 ± 27.40	63.50 (17.49)	.007
APTT, s (mean ± SD)		30.69 ± 5.98	30.83 (4.82)	.911
TT s (mean ± SD)		29.21 ± 32.60	28.93 (31.66)	.968
Age, years (%)	<65	393 (42.3)	4 (18.2)	.001
	65-74	318 (34.2)	5 (22.7)	
	≥75	219 (23.5)	13 (59.1)	
Sex (%)	Female	561 (60.3)	16 (72.7)	.239
Smoke (%)		184 (19.8)	5 (22.7)	.732
Alcohol (%)		121 (13.0)	4 (18.2)	.478
Comorbidity				
Hypertension (%)		716 (77.0)	17 (77.3)	.975
Hyperlipidemia (%)		207 (22.3)	3 (13.6)	.335
Chronic kidney disease (%)		95 (10.2)	9 (40.9)	<.001
Diabetes mellitus (%)		241 (25.9)	7 (31.8)	.533
Liver failure (%)		48 (5.2)	0 (0.0)	.274
Stroke (%)		135 (14.5)	9 (40.9)	.001
Heart failure (%)		118 (12.7)	12 (54.5)	<.001
Biochemical Indicators				
BMI, kg/m^2 (%)	<30	505 (54.3)	4 (18.2)	<.001
	30-34	299 (32.2)	8 (36.4)	
	≥35	126 (13.5)	10 (45.5)	
LVEF < 40% (%)		36 (3.9)	6 (27.3)	<.001
eGFR < 60 mL/min/1.73 m^2 (%)		112 (12.0)	11 (50.0)	<.001
PLT < 125 (10^9/L) (%)		70 (7.5)	5 (22.7)	.009
Medication				
DOACs (%)	Dabigatran	503 (54.1)	10 (45.5)	.422
	Rivaroxaban	427 (45.9)	12 (54.5)	
Antihypertension agent (%)		683 (73.4)	17 (77.3)	.687
Statin (%)		289 (31.1)	11 (50.0)	.059
Antiplatelet (%)		210 (22.6)	7 (31.8)	.307
PPI (%)		315 (33.9)	10 (45.5)	.257
β-blockers (%)		302 (32.5)	13 (59.1)	.009
Antiarrhythmic agent (%)		201 (21.6)	8 (36.4)	.099

APTT, activated partial prothrombin time; BMI, body mass index; DOAC, direct oral anticoagulant; eGFR, estimated glomerular filtration rate; Hb, hemoglobin; LVEF, left ventricular ejection fraction; PLT, platelet; PPI, proton pump inhibitor; TT, thrombin time.

fit by using R software (version 4.11). The variables with P < .10 in the univariate LR analysis and P < .05 in the multivariate LR analysis were determined as candidate predictor variables. The AB$_2$S risk score for an individual patient was determined by assigning points for each candidate predictor variables present and summing. In addition, we collapsed the AB$_2$S score into 3 categories on the basis of the risk score, including low-risk groups, mediated-risk groups, and high-risk groups. Cumulative systemic thromboembolic incidence was estimated by the Kaplan−Meier method, and differences were assessed with the log-rank test for the 3

categorized AB$_2$S risk groups using Statistical Package for the Social Sciences Statistics software (version 25.0). The performance comparison of the 3-category AB$_2$S score to the CHADS$_2$ and CHA$_2$DS$_2$-VASc scores was performed in terms of the AUC and DAC improvement by using R software (version 4.11).[22,24]

RESULTS

Patient Characteristics
A total of 952 overweight patients with NVAF were retrospectively enrolled in our study. A total of 22 (2.3%)

systemic thromboembolism patients were observed during the 12-month follow-up, including 7 (31.8%) in VTE, 5 (22.8%) in stroke, 6 (27.3%) in PE, and 4 (18.2%) in cardiac embolism. Statistically significant differences were found between the systemic thromboembolism and nonsystemic thromboembolism groups in terms of age (75.82 ± 9.89 vs. 65.62 ± 12.14, $P < .001$), BMI (32.17 ± 4.14 vs. 29.76 ± 3.71, $P = .003$), and eGFR (63.50 ± 17.49 vs. 79.45 ± 27.40, $P = .007$). The 2 groups were comparable regarding other baseline characteristics, comorbidity, or concomitant medications. Details are listed in Table 1.

Construction and Validation of the AB_2S Risk Score

After LR analysis, a total of 7 candidate predictor variables were chosen into final nomogram model, included age, BMI, PLT, eGFR, LVEF, history of stroke, and heart failure. The prediction rule for AB_2S risk score assigned 2 points for BMI ≥ 35 kg/m^2 and history of stroke, and 1 point for age ≥ 75 years, BMI from 30 to 34 kg/m^2, eGFR < 60 mL/min per 1.73 m^2, PLT count < 125 × 10^9/L, LVEF <40%, and history of heart failure (Table 2).

The total score of each variables was calculated in the final nomogram model (Figure 1A), which ranged from 0 to 300, and the corresponding risk rate ranged from 0.1 to 0.9. The higher the total score, the higher the risk of systemic thromboembolism in overweight patients with NVAF. The score was 180 points for "BMI ≥ 35 kg/m^2" in this nomogram model. The *c*-index for the final model was 0.885 (95% CI, 0.814-0.954), and AUC was 0.885 (95% CI, 0.815-0.955) (Figure 1B).

The corrected calibration curve showed a goodness of fit of the model, with a mean absolute error of 0.01 and a mean squared error of 0.00042 (Figure 1C).

Distributions of AB_2S score

The AB_2S score ranged from 0 to 8, with the majority of patients in 2 points (n = 273, 28.7%). The majority of patients were classified as 1 and 2 points in the $CHADS_2$ and CHA_2DS_2-VASc risk scores, respectively (Figure 2A). By collapsing the AB_2S score into low (0 points), moderate (1-2 points), and high (3-8 points) risk categories, the incidence of systemic thromboembolism was 2 (9.1%), 9 (40.9%), and 11 (50%) in the low-, mediated-, and high-risk groups, respectively (Figure 2B). While the incidence was 4 (18.2%), 13 (59.1%), and 5 (22.7%) in the 3-category $CHADS_2$ scores and 0, 1 (4.5%), and 21 (95.5%) in the 3-category CHA_2DS_2-VASc scores.

Predicting Clinical Outcome of AB_2S Score

Predicting the 1-year systemic thromboembolism, the AUC score was 0.76 (95% CI, 0.74-0.79) for the 3-category AB_2S score. While predicting the PE, stroke, and PTE events, the AUC AB_2S score was 0.76 (95% CI, 0.74-0.79), 0.76 (95% CI, 0.74-0.79), and 0.76 (95% CI, 0.74-0.79), respectively (Figure 3).

Predicting the TTT, the Kaplan-Meier results illustrated high-risk category of AB_2S score experienced a shorter TTT than the low-risk category (11.1 ± 0.32 months *vs.* 11.96 ± 0.03 months, $P < .001$). Details are listed in Figure 4.

Table 2. Logistic Regression Analysis of 7 Candidate Predictor Variables of Thromboembolism

Characteristics		Univariate		Multivariate		
		OR (95% CI)	*P*	OR (95% CI)	*P*	Score
Intercept				0 (0-0)	.000	
Sex	Male vs. Female	1.409 (0.589-3.722)	.458	2.835 (0.72-13.776)	.157	
Age (years)		1.094 (1.047-1.149)	<.001	1.06 (1.01-1.12)	.026	
	65-74 vs. <65	1.545 (0.406-6.286)	.519	1.69 (0.332-10.156)	.536	
	≥75 vs. <65	5.832 (2.036-20.903)	.002	6.756 (1.381-43.057)	.026	1
BMI (kg/m^2)		1.178 (1.055-1.323)	.004	1.27 (1.11-1.48)	.007	
	25 to 35 vs. <30	3.378 (1.055-12.744)	.048	5.573 (1.396-26.355)	.019	1
	≥35 vs. <30	10.02 (3.293-37.008)	<.001	19.361 (3.779-121.014)	.001	2
Smoke	Yes vs. No	1.192 (0.388-3.059)	.733	0.706 (0.12-3.449)	.682	
Alcohol	Yes vs. No	1.486 (0.424-4.062)	.481	4.042 (0.619-27.463)	.144	
Hypertension	Yes vs. No	1.016 (0.397-3.12)	.975	0.514 (0.139-2.137)	.328	
Hyperlipidemia	Yes vs. No	0.551 (0.129-1.638)	.342	0.456 (0.043-2.694)	.447	
Diabetes mellitus	Yes vs. No	1.334 (0.504-3.203)	.534	0.767 (0.186-2.614)	.688	
Chronic kidney disease	Yes vs. No	6.085 (2.452-14.485)	<.001	0.226 (0.022-3.653)	.232	
Liver failure	Yes vs. No	NA	.987	NA	.994	
Heart failure	Yes vs. No	8.258 (3.487-19.973)	<.001	3.95 (1.17-12.47)	.021	1
Stroke	Yes vs. No	4.077 (1.653-9.637)	.002	5.821 (1.557-22.067)	.008	2
PLT < 125 (10^9/L)	Yes vs. No	3.613 (1.16-9.448)	.014	12.384 (2.639-55.523)	.001	1
eGFR < 60 (mL/min/1.73 m^2)	Yes vs. No	7.304 (3.06-17.439)	<.001	24.184 (1.553-232.842)	.009	1
LVEF < 40%	Yes vs. No	9.312 (3.188-24.165)	<.001	7.40 (1.67-30.17)	.030	1

BMI, body mass index; eGFR, estimated glomerular filtration rate; LVEF, left ventricular ejection fraction; OR, odds ratio; PLT, platelet.
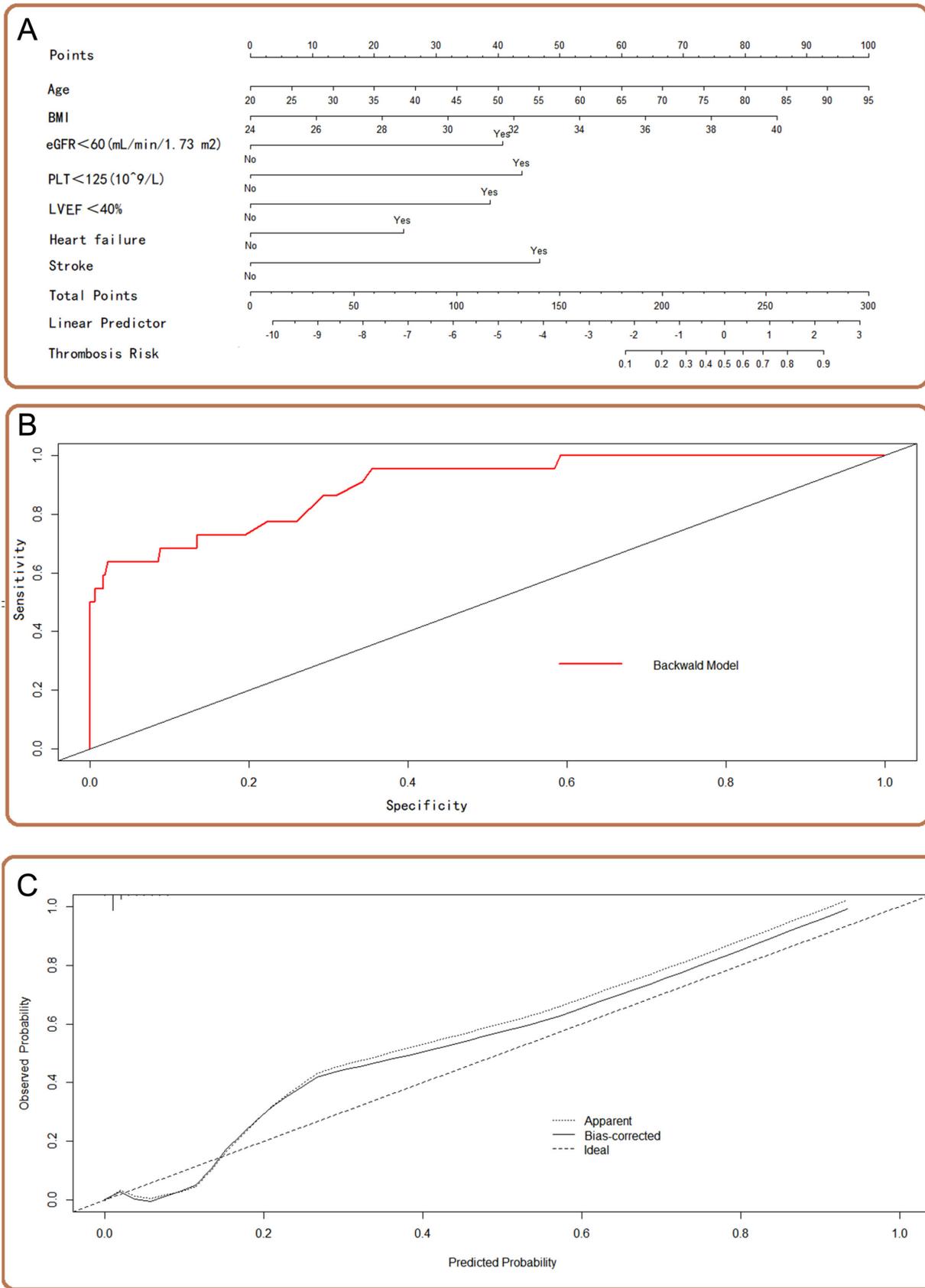
Figure 1 .Traditional measures of model fit. A: The nomogram model; B: The area under the curve of the model; C: The calibration curve of the model. BMI, body mass index; eGFR, estimated glomerular filtration rate; LVEF, left ventricular ejection fraction; PLT, platelet.
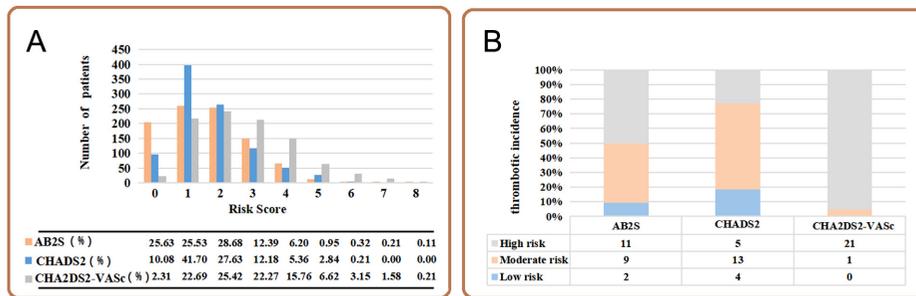
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Figure 2 . Distributions of AB$_2$S risk score. A: Distributions of AB$_2$S risk score in all patients; B: Distributions of AB$_2$S risk score in systemic thromboembolism.

Comparison of the AB$_2$S, CHADS$_2$ and CHA$_2$DS$_2$-VASc Scores
The 3-category AB$_2$S score had a greater AUC in predicting 1-year systemic thromboembolism, PE, stroke, and PTE events than both CHADS$_2$ and CHA$_2$DS$_2$-VASc risk scores (Figure 3). At the same time, there were statistical differences in TTT between the 3-category AB$_2$S and CHADS$_2$ scores ($P < .0001$, $P < .002$, respectively). However, TTT were similar in the 3-category CHA$_2$DS$_2$-VASc scores ($P = .082$) (Figure 4).

In addition, the DCA curve showed that the 3-category AB$_2$S score revealed quite good clinical efficacy than both CHADS$_2$

and CHA$_2$DS$_2$-VASc scores in predicting 1-year systemic thromboembolism, when the risk threshold was between 35% and 80% (Figure 5).

DISCUSSION

In the present study, we developed a AB$_2$S score that accurately predicted 1-year systemic thromboembolism in overweight patients with NVAF and showed good discrimination in risk stratification than CHADS$_2$ and CHA$_2$DS$_2$-VASc scores.

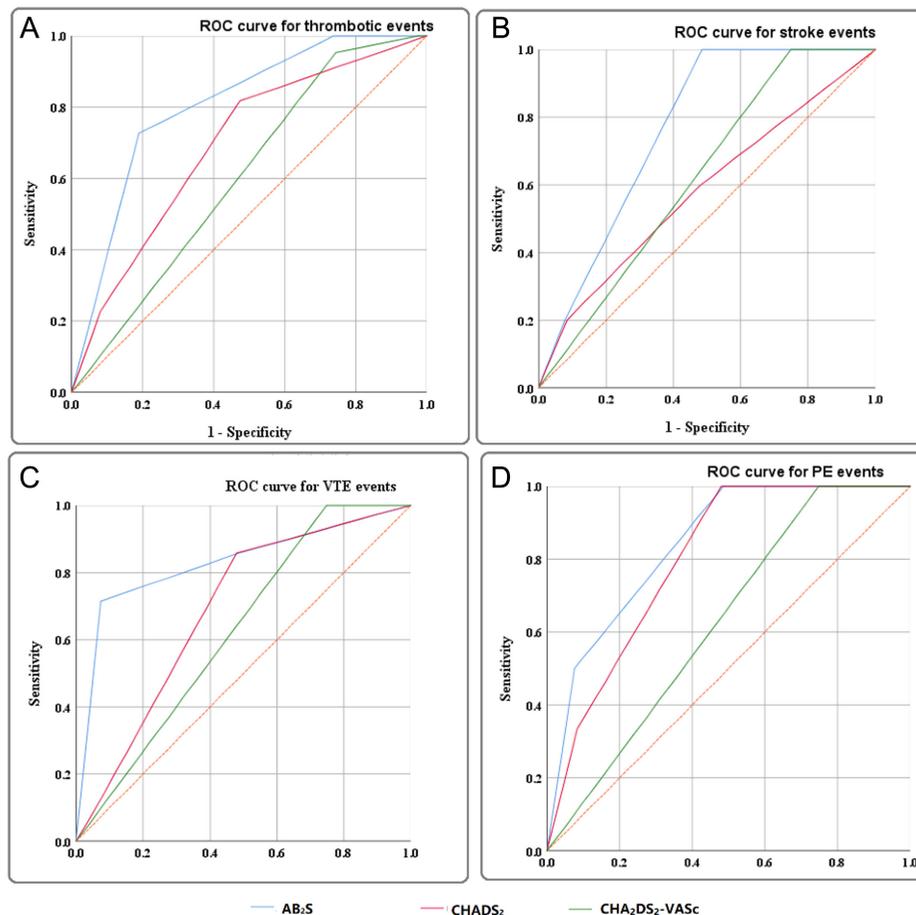In our study, a total of 952 overweight patients with NVAF were included. We found that the 1-year systemic

Figure 3. The receiver operating characteristic curve of 3-category AB$_2$S, CHADS$_2$, and CHA$_2$DS$_2$-VASc risk scores in predicting the systemic thromboembolism, pulmonary embolism, stroke, and venous thromboembolism events. PE, pulmonary embolism; ROC, receiver operating characteristic curve; VTE, venous thromboembolism.
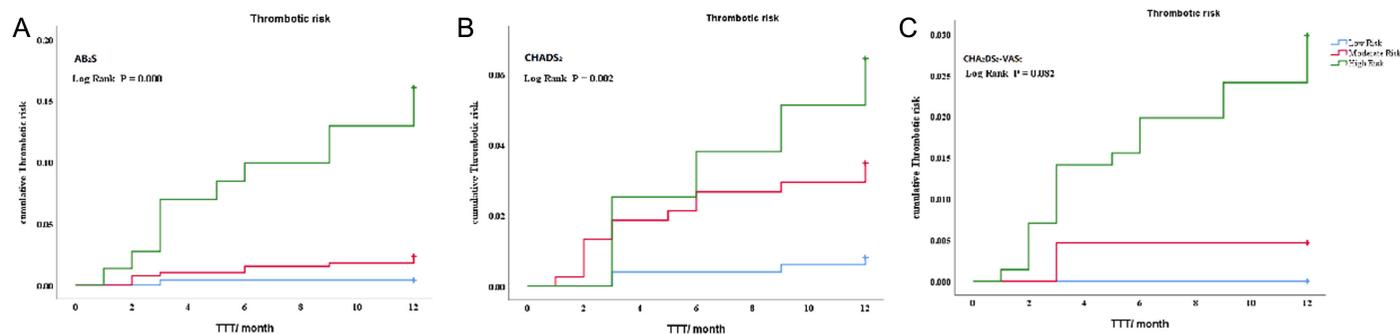
Figure 4 . Kaplan–Meier curves of the time to thrombosis. A: AB$_2$S scores; B: CHADS$_2$ scores; C: CHA$_2$DS$_2$-VASc scores. TTT, time to thrombosis—the first time occurrence of a stroke or systemic embolism from enrollment.

thromboembolic event rate was 2.3%, although every individual was anticoagulated. Such higher thromboembolic event rate in our study may be understood through several explanations. First, both the factors of NVAF and overweight highly increased the risk for ischemic events according to current clinical reports.[1,2,10] Besides, the thromboembolic event was defined as systemic thromboembolic event, which included PE, VTE, stroke, or cardiac embolism. Anyway, we call for high-quality researches to continue exploring the relationship of overweight and thromboembolic events.

The AB$_2$S score comprised 7 independent predictors: age, BMI, PLT, eGFR, LVEF, history of stroke, and heart failure, which were simple to use in clinical practice. Several thrombotic predictors have been reported previously, including age, heart failure, or stroke.[11,25] However, we found BMI was significantly correlated with the incidence of 1-year systemic thromboembolism in overweight patients with NVAF ($P < .001$), together with eGFR, PLT, and LVEF. Previous study demonstrated that higher BMIs usually indicated poor clinical outcomes for NVAF patients treated with DOAC by altering peak plasma concentrations.[7,26] Based on the evidence that the higher BMIs experienced a shorter TTT (HR = 3.716, $P = .001$)[10] and increased thrombosis occur in these patients,[27] one meta-analysis even concluded that a weight-based

dosage adjustment may be necessary for thromboembolic prevention in overweight patients with NVAF.[28] Most importantly, we used a broader range of BMI categories, a decision consistent with multiple prior reports.[10,16] We found strong amplification of 1-year systemic thromboembolism across the entire BMI range, with individuals' BMI ≥ 35 kg/m^2 at nearly double the risk of those BMI < 30 kg/m^2 ($P < .001$). However, individuals who had a history of stroke were at elevated risk regardless of BMI. Thus, BMI and history of stroke were the dominant risk factors in our AB$_2$S risk model.

Other factors, including eGFR, PLT, and LVEF, were also observed significantly associated with the incidence of 1-year systemic thromboembolism and were selected as potent predictors of systemic embolism in overweight patients with NAVF in our study. This results were partially consistent with previous researches.[29,30] Unfortunately, as with multiple prior studies, we did not observe significant incremental risk prediction from gender, hypertension, and diabetes mellitus, the major component of CHA$_2$DS$_2$-VASc score.[30,31] Therefore, a larger sample of randomized controlled studies is needed for further analysis.

Compared to CHA$_2$DS$_2$-VASc scores, we found AB$_2$S score performed better in predicting 1-year systemic thromboembolism in overweight patients with NVAF. The AUC was greater, and there was a positive net reclassification improvement. Although CHA$_2$DS$_2$-VASc score may be helpful in several clinical settings, for example, a CHA$_2$DS$_2$-VASc score of 0 point indicated a small net clinical benefit from warfarin anticoagulation.[32,33] In addition, this score could aid in decision-making for patients with atrial fibrillation or acute coronary syndrome undergoing percutaneous coronary intervention to balance the risk of hemorrhage from the underlying thrombotic risk.[34] However, CHA$_2$DS$_2$-VASc score showed a poor predictive performance (AUC = 0.62) in the 1-year systemic thromboembolism and TTT ($P = .082$) than the AB$_2$S score in our study. It is highly likely that the traditional CHA$_2$DS$_2$-VASc risk score overestimates the thromboembolic risk in overweight patients with NVAF. This results may be comprehensible with several explanations. First, our study did not include the patients who received warfarin anticoagulation. It is known that CHA$_2$DS$_2$-VASc scores have superior prediction for the underlying thrombotic risk of using warfarin.[35] Second, our study population
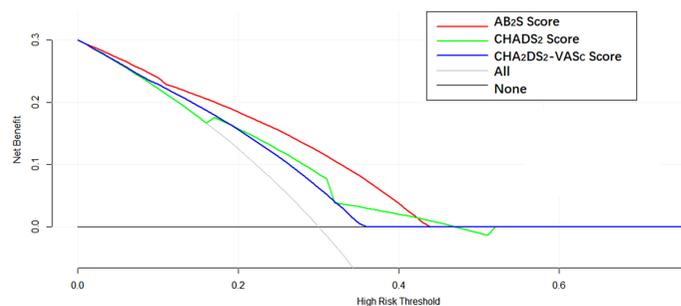

Figure 5 . The decision analysis curve validating the clinical efficacy of the AB$_2$S, CHADS$_2$, and CHA$_2$DS$_2$-VASc scores in predicting 1-year systemic thromboembolism. The y-axis represents the net benefit. The gray solid line represented that all patients had 1-year systemic thrombotic events. The gray dotted line represented that all patients had no systemic thrombotic events. The red, green, and blue solid lines represent the clinical efficacy of AB$_2$S, CHADS$_2$, and CHA$_2$DS$_2$-VASc scores, respectively.

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included only overweight patients (BMI ≥ 25 kg/m^2) with NVAF. To date, no BMI parameter is included in any risk stratification scheme for thromboembolism in atrial fibrillation patients.[36] Thus, the predictive performance of CHA$_2$DS$_2$-VASc scores may be significantly eliminated, as with multiple prior studies.[36,37] Third, 1-year systemic thromboembolism was defined as our endpoint event, while CHA$_2$DS$_2$-VASc risk scores are well known in predicting the risk of ischemic stroke.[38,39]

Study Limitations

Our study has the following limitations: (1) the study had a small sample size with a short follow-up, (2) the incidence of in the 1-year systemic thromboembolism could be underestimated as data were obtained from the medical records, and (3) our data were obtained from a Chinese NVAF overweight population treated with DOACs. The results may not apply to other races or settings.

CONCLUSION

Our results highlighted the importance of including multiple categories of BMI in determining systemic thromboembolism risk in overweight patients with NVAF. The AB$_2$S score's performance showed a greater AUC and clinical efficacy value than the widely used CHADS$_2$ and CHA$_2$DS$_2$-VASc score in terms of systemic thromboembolism prediction, which may aid in decision-making for these patients to balance the effectiveness of anticoagulation from the underlying thrombotic risk.

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