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The Association between Atrial Fibrillation Detected After Stroke and Coronary Artery Calcification Score

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Abstract

Background Studies have shown a correlation between coronary artery calcification score (CACS) and atrial fibrillation (AF). However, the relationship between CACS and AF detected after stroke (A FDAS) remains unclear. The purpose of this study was to explore the correlation between CACS and AFDAS.

Methods From February 2023 to February 2024, 845 patients diagnosed with ischemic stroke in the Affiliated Hospital of Xuzhou Medical University were consecutively enrolled. CACS was obtained by cardiac CT using the Agatston scoring method, and the presence of AF was determined through 24-hour continuous ECG monitoring or a 12-lead electrocardiogram after stroke.

Results A total of 56 (6.6%) patients were diagnosed with AFDAS. After adjusting for potential confounders, multivariate logistic regression analysis showed that CACS4 (OR = 3.44, 95% CI: 1.91–6.19, $p < 0.001$) was an independent risk factor for AFDAS. The area under the ROC curve (AUC) for the single high CACS was 0.66 (95% CI: 0.59–0.72), while the baseline clinical model (heart failure + CRP + NT-proBNP) achieved an AUC of 0.66 (95% CI: 0.58–0.74). Following the incorporation of CACS4, the new predictive model demonstrated significantly enhanced predictive performance, with an AUC of 0.72 (95% CI: 0.64–0.80). Additionally, the Net Reclassification Index (NRI) and Integrated Discrimination Improvement (IDI) analyses demonstrated that the new predictive model exhibited statistically significant improvements compared to baseline clinical model, with CACS effectively optimizing AFDAS prediction framework.

Conclusions High CACS(CACS>300) is an independent risk factor for AFDAS and can optimize AFDAS risk stratification, thereby enhancing its identification performance.

Introduction

Stroke has become one of the main causes of death and disability among residents in recent years. As a non-communicable disease, stroke poses a huge threat to the health of residents [1, 2]. Atrial fibrillation (AF), the most common arrhythmia, significantly increases the risks of stroke and death, seriously affecting the quality of life of patients [3]. In recent years, the prevention and prognosis of AF detected after stroke (AFDAS) have received increasing attention. AFDAS has a high incidence, and AFDAS patients often have paroxysmal or asymptomatic AF, which is not easy to detect [4]. AFDAS poses a great threat to the life and health of residents, and there is currently no clear and effective targeted treatment for AFDAS[5]. Therefore, it is important to investigate the risk factors related to atrial fibrillation after stroke for effective risk prediction of AFDAS.It can help to identify high-risk groups early, stratify AFDAS risk prediction, and improve the ability of AFDAS risk prediction.

Coronary artery calcification score (CACS) is the result of the stabilization of coronary atherosclerotic plaques, which is directly related to the degree of coronary atherosclerosis and is an important indicator for predicting cardiovascular risk [6]. Since the calculation method of CACS was proposed by Agatston et

al. in 1990[7, 8], its clinical significance has been continuously explored. At the same time, relevant studies have shown that there is a correlation between CACS and AF, which may have clinical value in the risk stratification of thromboembolism and preventive cardiac disease treatment in AF patients[9, 10]. Similarly, studies have shown that CACS is associated with stroke events [11]. However, the relationship between CACS and AFDAS remains unclear.

This study investigated the clinical association between CACS and AFDAS.

Methods

Study Design and Participants

This was a single-center retrospective study that continuously enrolled patients diagnosed with ischemic stroke at the Affiliated Hospital of Xuzhou Medical University from February 2023 to February 2024. All patients underwent 12-lead electrocardiogram or further ≥ 24-hour Holter electrocardiographic monitoring/telemetry following stroke, as determined by the clinical judgment of the attending physician.Inclusion criteria: patients aged ≥ 18 years, diagnosed with ischemic stroke, who underwent cardiac CT plain scan and had 12-lead electrocardiogram or further ≥ 24-hour Holter electrocardiographic monitoring/telemetry after stroke. Exclusion criteria : patients with thyroid dysfunction; those with a history of stroke; individuals with previous severe rheumatic valvular heart disease; patients with prior diagnoses of heart failure or cardiomyopathy; those with known history of atrial fibrillation; those presenting with systemic inflammatory response upon admission; individuals with preexisting autoimmune diseases; patients diagnosed with malignancies; and those with malignant hematologic disorders. According to the presence or absence of AF on 12-lead electrocardiogram or further ≥ 24-hour Holter electrocardiographic monitoring/telemetry after stroke, the patients were divided into two groups: (1) the Non-AFDAS group. (2) the AFDAS group. The AF definition : Irregularly irregular R-R intervals, absence of distinct repeating P waves, and irregular atrial activations[12]. AFDAS is defined as atrial fibrillation detected for the first time after an acute ischemic stroke.This study was approved by the Ethics Committee of the Affiliated Hospital of Xuzhou Medical University Ethical approval number:XYFY2024-KL351-01.According to the relevant regulatory guidelines of the Institutional Review Board (IRB), written informed consent was waived as the study posed no risk to the patients. The inclusion and exclusion criteria are shown in Fig. 1.

Clinical Data Collection

Baseline data and clinical diagnoses of the enrolled patients were obtained from the electronic medical record system of the Affiliated Hospital of Xuzhou Medical University, including age, gender, BMI, estimated glomerular filtration rate (eGFR), blood pressure, heart rate, CRP, BNP, cholesterol, triglyceride, high-density lipoprotein, low-density lipoprotein, troponin, National Institutes of Health Stroke Scale (NIHSS) score, past medical history (including coronary heart disease, diabetes, hypertension, heart

failure, stroke), and electrocardiographic monitoring information. All enrolled patients underwent cardiac CT plain scan, and the coronary artery calcification score (CACS) was obtained using the Agatston scoring method [7].Similar to the methods of Greenland, Detrano et al. [11, 12], the coronary artery calcification score (CACS) was divided into four grades: CACS1 (CACS = 0), CACS2 (1 ≤ CACS ≤ 100), CACS3 (101 ≤ CACS ≤ 300), and CACS4 (> 300)[13, 14].

Statistical Analysis

The Kolmogorov-Smirnov test was used to assess the normality of the data. Student's t-test was used for normally distributed continuous variables expressed as mean ± standard deviation. The Mann-Whitney U test was used for non-normally distributed continuous variables expressed as median (Q1, Q3). Categorical variables were expressed as frequency (n %) and analyzed using the chi-square test. All variables were analyzed using univariate logistic regression analysis .Variables demonstrating a p-value < 0.1 in univariate regression analysis were retained for inclusion in the multivariable logistic regression model. A baseline clinical model was constructed using established risk factors for AF (heart failure, CRP, and NT-proBNP) based on previous studies. A new prediction model was then built by adding CACS4 to the baseline model. The Net Reclassification Index (NRI) and Integrated Discrimination Improvement (IDI) of the two models were calculated. The sensitivity and specificity of CACS in predicting AFDAS were evaluated using the ROC curve of the subjects' work characteristics. P < 0.05 was considered statistically significant. Statistical analysis was performed using SPSS 27.0 (Inc, Chicago, IL, USA) and R (Lucent Technologies, New Jersey, USA)

Results

Baseline Characteristics Comparison Between Groups

Among the 845 enrolled patients, the mean age was 65.12 ± 10.22 years, and the BMI was 25.50 ± 3.70. According to the presence or absence of AFDAS, they were divided into the NOAF group (n = 789, 93.4%) and the Non-NOAF group (n = 56, 6.6%).

As shown in Table 1, compared with the Non-AFDAS group, patients in the AFDAS group were older (68.45 ± 8.97 vs. 64.88 ± 10.27, P = 0.012), had a higher mean CACS (486.50 vs. 125.00, P < 0.001), higher CRP (4.59 vs. 1.70, P = 0.003), higher NT-proBNP (237.76 vs. 176.52, P = 0.005), higher hsTnT (11.55 vs. 7.60, P = 0.009), less newly diagnosed heart failure (16.39% vs. 83.61%, P < 0.001), and fewer patients with CACS2 and CACS4 (1.23% vs. 98.77%, P < 0.001; 12.33% vs. 87.67%, P < 0.001).

Table 1
Baseline characteristics

Variables	Total (n = 845)	Non-AFDAS (n = 789)	AFDAS (n = 56)	*P*
Age, years	65.12 ± 10.22	64.88 ± 10.27	68.45 ± 8.97	0.012
BMI, kg/m^2	25.50 ± 3.70	25.52 ± 3.73	25.21 ± 3.26	0.554
eGFR, mL/min/1.73m^2	102.39 ± 39.67	101.26 ± 17.43	118.37 ± 139.69	0.364
HR, bpm	75.07 ± 10.71	75.01 ± 10.73	75.96 ± 10.52	0.518
SBP, mmHg	138.47 ± 19.35	138.77 ± 19.48	134.20 ± 17.04	0.087
DBP, mmHg	82.36 ± 12.08	82.43 ± 12.06	81.36 ± 12.37	0.521
NIHSS	0.50 ± 2.00	0.46 ± 1.92	1.04 ± 2.89	0.146
LVEF, %	53.70 ± 5.39	53.65 ± 5.37	54.35 ± 5.62	0.350
LAD, mm	33.42 ± 4.01	33.35 ± 4.02	34.41 ± 3.80	0.055
CACS	142.00 (31.00, 394.00)	125.00 (30.00, 363.00)	486.50 (157.80, 693.00)	< .001
CRP, mg/L	1.80 (0.60, 6.20)	1.70 (0.60, 5.80)	4.59 (0.67, 13.92)	0.003
NT-proBNP, pg/mL	183.30 (75.00, 347.51)	176.52 (73.82, 345.25)	237.76 (134.44, 436.99)	0.005
hsTnT, ng/mL	7.77 (5.10, 14.71)	7.60 (5.00, 14.60)	11.55 (6.69, 18.20)	0.009
TSH, mIU/L	2.37 (1.40, 3.52)	2.38 (1.40, 3.52)	2.35 (1.37, 3.61)	0.962
TC, mmol/L	4.17 (3.44, 4.96)	4.17 (3.44, 4.96)	4.17 (3.58, 4.97)	0.451
TG, mmol/L	1.39 (0.98, 1.93)	1.40 (1.00, 1.91)	1.23 (0.92, 2.38)	0.289
LDL, mmol/L	2.27 (1.65, 2.84)	2.26 (1.67, 2.81)	2.35 (1.46, 3.13)	0.912
HDL, mmol/L	1.16 (0.90, 1.40)	1.15 (0.90, 1.40)	1.23 (0.94, 1.42)	0.251
Female, n(%)	294 (34.79)	277 (94.22)	17 (5.78)	0.471

Note: AFDAS=Atrial fibrillation detected after stroke BMI = Body mass index, eGFR=estimated Glomerular Filtration Rate, HR = Heart rate, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, LVEF = Left Ventricular Ejection Fraction, LAD = Left Atrial Diameter, CACS = Coronary Artery Calcium Score, CRP = C-reactive Protein,NT-proBNP = N-terminal pro-B-type natriuretic peptide, hsTnT = high-sensitivity Troponin T, TSH = Thyroid-Stimulating Hormone, TC = Total Cholesterol, TG = Triglyceride, LDL = Low Density Lipoprotein, HDL = High Density Lipoprotein, CHD = Coronary Heart Disease

(This table should be placed on line 103 of the article.)

Variables	Total (n = 845)	Non-AFDAS (n = 789)	AFDAS (n = 56)	*P*
CHD, n(%)	261 (30.89)	240 (91.95)	21 (8.05)	0.268
Heart failure, n(%)	61 (7.22)	51 (83.61)	10 (16.39)	0.004
Hypertension, n(%)	558 (66.04)	522 (93.55)	36 (6.45)	0.775
Diabetes, n(%)	232 (27.46)	221 (95.26)	11 (4.74)	0.175
Smoking, n(%)	78 (9.23)	74 (94.87)	4 (5.13)	0.576
CACS 1, n(%)	134 (15.86)	131 (16.60)	3(5.36)	0.026
CACS 2, n(%)	244 (28.88)	236 (29.91)	8 (14.29)	0.013
CACS 3, n(%)	175 (20.71)	166 (21.03)	9 (16.10)	0.375
CACS 4, n(%)	292 (34.56)	256 (32.45)	36 (64.29)	< .001

Note: AFDAS=Atrial fibrillation detected after stroke BMI = Body mass index, eGFR=estimated Glomerular Filtration Rate, HR = Heart rate, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, LVEF = Left Ventricular Ejection Fraction, LAD = Left Atrial Diameter, CACS = Coronary Artery Calcium Score, CRP = C-reactive Protein,NT-proBNP = N-terminal pro-B-type natriuretic peptide, hsTnT = high-sensitivity Troponin T, TSH = Thyroid-Stimulating Hormone, TC = Total Cholesterol, TG = Triglyceride, LDL = Low Density Lipoprotein, HDL = High Density Lipoprotein, CHD = Coronary Heart Disease

(This table should be placed on line 103 of the article.)

Logistic Regression Analysis Results

As shown in Supplementary Table 1, in univariate logistic regression analysis, age (OR = 11.36, 95% CI: 1.71–75.20, p = 0.012), CACS (OR = 1.01, 95% CI: 1.01–1.01, p < 0.001), heart failure (OR = 3.15, 95% CI: 1.50–6.60, p = 0.002), CRP (OR = 1.02, 95% CI: 1.01–1.04, p < 0.001), NT-proBNP (OR = 1.55, 95% CI: 1.19–2.02, p = 0.001), CACS4 (OR = 3.75, 95% CI: 2.13–6.60, p < 0.001), were associated with AFDAS. According to the variables with p < 0.1 in univariate logistic regression analysis include age, CACS, heart failure, CRP, NT-proBNP, CACS4, systolic blood pressure, and NIHSS were included in multivariate logistic regression analysis. After adjusting for potential confounders, as shown in Table 2, CACS4 (OR = 3.44, 95% CI: 1.91–6.19, p < 0.001), heart failure (OR = 3.52, 95% CI: 1.60–7.75, p = 0.002), CRP (OR = 1.02, 95% CI: 1.01–1.03, p = 0.002), and NT-proBNP (OR = 1.44, 95% CI: 1.09–1.90, p = 0.011) were independent risk factors for AFDAS.

Table 2
Multivariate logistic regression analysis

Variables	***P***	**OR (95%CI)**
Heart failure	0.002	3.52 (1.60 ~ 7.75)
CACS 4	< .001	3.44 (1.91 ~ 6.19)
Age	0.057	7.24 (0.94 ~ 55.52)
CRP	0.002	1.02 (1.01 ~ 1.03)
NT-proBNP	0.011	1.44 (1.09 ~ 1.90)
SBP	0.168	0.99 (0.97 ~ 1.00)
NIHSS	0.134	1.07 (0.98 ~ 1.17)
Note: CACS = Coronary Artery Calcium Score, CRP = C-reactive Protein, NT-proBNP = N-terminal pro-B-type natriuretic peptide, SBP = Systolic blood pressure		
(This table should be placed on line 115 of the article.)		

Discriminatory Capacity of CACS for AFDAS

Supplemental Table 2 and Fig. 2 presents a comparative analysis of the predictive efficiency of different models for AFDAS. The area under the receiver operating characteristic (ROC) curve (AUC) for the high CACS alone was 0.66 (95% CI: 0.59–0.72), with a sensitivity of 0.64 and a specificity of 0.68. The Baseline clinical model exhibited an AUC of 0.66 (95% CI: 0.58–0.74), demonstrating a sensitivity of 0.43 and a specificity of 0.84. Following the incorporation of CACS4, the new prediction model demonstrated a statistically significant improvement in predictive performance, achieving an AUC of 0.72 (95% CI: 0.64–0.80), with a sensitivity of 0.63 and a specificity of 0.77. The Baseline clinical model was constructed with CRP, NT-proBNP, and heart failure, and the new prediction model was constructed with CRP, NT-proBNP, heart failure, and CACS4. As shown in Table 3, the IDI (Estimate: 0.04, 95% CI: 0.02–0.05, $p < 0.001$) indicated that the new prediction model (heart failure, CRP, BNP, CACS4) had a significant improvement in the identification of high-risk groups in AFDAS compared with the Baseline clinical model (heart failure, CRP, BNP). The NRI (estimated value: 0.64, 95% CI: 0.38–0.90, $p < 0.001$) demonstrated that the new prediction model could more effectively reclassify high-risk individuals for AFDAS compared to the Baseline clinical model.

Table 3
Discrimination accuracy and reclassification of risk markers of AFDAS

	NRI		IDI	
	Estimate (95% CI)	**P value**	**Estimate (95% CI)**	**P value**
Baseline clinical model	Reference	-	Reference	-
New Prediction Model, continuous	0.64 (0.38–0.90)	< 0.001	0.04 (0.02–0.05)	< 0.001
Note: Baseline clinical model included heart failure, CRP, NT-proBNP, New Prediction Model included heart failure, CRP, NT-proBNP, CACS4. Abbreviations: CI = confidence interval,IDI = integrated discrimination index,NRI = net reclassification improvement.				
(This table should be placed on line 169 of the article.)				

Restricted Cubic Spline Of CACS

As shown in Fig. 3, the Restricted Cubic Spline (RCS) with four nodes was used to fit the nonlinear relationship between CACS and AFDAS. There is a linear relationship between CACS and AFDAS (overall $p < 0.001$, nonlinear $p < 0.001$). The RCS curve is an S-shaped curve with a reference value of 142. These results indicate that the CACS has reliable stratification performance.

Discussion

This study is the first to propose the correlation between high CACS (CACS4) and AFDAS. The main findings of this study are that high CACS can be used as an independent risk factor for AFDAS, and adding CACS4 can improve the identification efficiency of the model combining heart failure, CRP, and BNP in identifying AFDAS, significantly enhancing the identification ability for AFDAS.

The CACS is an important predictor of coronary atherosclerosis. Similarly, CACS is also an independent risk factor for atrial fibrillation [15]. In recent years, studies have shown that high CACS is closely related to the prediction of future atrial fibrillation [15–18]. The relationship between CACS and AFDAS remains unclear. Our study found that high CACS was associated with the prediction of AFDAS occurrence. High CACS is an independent risk factor for AFDAS.

Stroke may be accompanied by high CACS[19]. At the same time, AF may indirectly increase the risks of stroke and AF through shared atherosclerotic risk factors such as hypertension[11, 20], which may be the mechanism for the association between high CACS and AFDAS. At present, the physiological connection between CACS and AFDAS is still unclear. Some studies have shown that high CACS is associated with pulmonary vein dilation, which can increase PV electrical activity and induce AF. The mechanism of AF may be due to increased PV discharge and triggered activity [21–23]. Although no significant statistical difference was observed between the non-AFDAS group and the AFDAS group (33.35 ± 4.02 vs 34.41 ±

3.80, P = 0.055), the AFDAS group still exhibited higher left atrial diameter (LAD), which may be associated with atrial remodeling and the duration of chronic atrial fibrillation. However, the atrial fibrillation cases in our study were newly diagnosed AF following stroke, hence no significant statistical difference in LAD was found between the two groups. This discrepancy may also be related to the relatively small sample size of our study.In addition, patients with high CACS are more likely to have coronary heart disease and heart failure, which increase the risk of AF [24–26].Coronary atherosclerosis is the pathophysiological process linking CACS and stroke. Coronary artery calcium often exists in other parts of the coronary arteries, and blood flow direction can push any calcium that has shifted along the coronary arteries in most cases, which may affect myocardial flow rather than retrograde into the aorta and then into cerebral circulation. Additionally, the presence and extent of coronary artery disease have been shown to be associated with stroke [24].Studies have suggested a clinical association between CACS and the expression of inflammatory and oxidative stress biomarkers[25]. Notably, inflammation exhibits a critical clinical correlation with stroke, as post-stroke inflammatory responses may exacerbate secondary injury[26]. Concurrently, oxidative stress and inflammation are implicated in adverse atrial structural and electrical remodeling, which contribute to the initiation and perpetuation of AF[27].

Recent studies have further highlighted the prognostic role of inflammatory markers in AF. For instance, elevated high-sensitivity C-reactive protein (hs-CRP) levels have been associated with worse outcomes in patients with non-valvular AF[28]. Moreover, a meta-analysis demonstrated that anti-C1q antibody levels correlate with adverse outcomes in AF patients, underscoring the involvement of immune-mediated inflammation[29]. The interplay between AF and coronary artery disease, as reviewed by[30], also emphasizes shared inflammatory pathways that may contribute to the development of both conditions. These observations reinforce the hypothesis that inflammation links CACS to AFDAS, and future studies incorporating comprehensive inflammatory panels could elucidate these mechanisms.

These findings suggest that inflammation-related pathological mechanisms may underlie the relationship between CACS and AFDAS. Furthermore, while the precise mechanisms of AFDAS remain incompletely elucidated, emerging evidence indicates that AFDAS may arise from neurogenic electrical activation following stroke [31], potentially predisposing to its onset.

The relationship between AF and coronary artery disease is bidirectional and synergistic. AF can promote myocardial ischemia and systemic inflammation, accelerating atherosclerosis[32]. Conversely, coronary artery calcification may increase left atrial pressure and induce atrial remodeling, predisposing to AF[33]. In patients with persistent non-valvular AF, coronary angiography often reveals significant CAD, which is associated with worse outcomes[34]. This vicious cycle likely contributes to the elevated risk of AFDAS in individuals with high CACS, and underscores the importance of integrated management of both conditions.

In a cohort study, 27,962 patients were measured for CACS and 622 patients developed AF. The ROC curve showed that the area under the curve of AF within one year was 0.68(0.65–0.71), confirming that

high CACS is associated with a high risk of subsequent AF and may help identify high-risk AF patients earlier[14]. We conducted a retrospective study of stroke patients and found that the ROC area under the curve (AUC) of CACS4 was 0.66 (95% CI: 0.59–0.72), which was similar to previous studies, CACS was confirmed to be closely related to the identification of AFDAS.

Consistent with previous studies, heart failure, BNP, and CRP are also independent risk factors for AFDAS. A baseline clinical model including age, heart failure, BNP, and CRP and a new prediction model with the addition of CACS4 were constructed. The AUCs of the new predictive model and the baseline clinical model were compared, along with integrated discrimination improvement (IDI) and net reclassification improvement (NRI) analyses. The results demonstrated that incorporating CACS4 significantly optimized the baseline risk prediction model and enhanced the identification efficiency for AFDAS. This study contributes further evidence for risk stratification in AFDAS, supporting early intervention for atrial fibrillation in stroke patients with elevated CACS. Such measures could mitigate stroke-related morbidity and, in some cases, avert the development of AFDAS altogether. It can also enable early prevention in high-risk populations and reduce the occurrence of disabling and fatal adverse events caused by AFDAS.

Limitations

First,This is a single-center retrospective study with selection bias and a relatively small sample size. Stronger evidence from multi-center, prospective studies is needed in the future to increase reliability.Second,The diagnosis of AF in patients after stroke is confirmed based 12-lead electrocardiogram or further ≥ 24-hour Holter electrocardiographic monitoring/telemetry after stroke. Some patients have not completed long-term ECG testing, and some patients exhibit hidden or asymptomatic symptoms, thus no long-term ECG testing has been conducted. So some atrial fibrillation patients may be lost. And unmeasured confounders such as lifestyle factors (e.g., smoking, physical activity, diet) and genetic predisposition were not assessed, which may have influenced the observed association. Future studies should incorporate these variables to better isolate the independent effect of CACS. Finally,Although this study proves that high CACS is an independent risk factor for AFDAS, it does not involve the pathophysiological connection between high CACS and AFDAS. The current mechanism is still unclear and needs further clinical exploration. Furthermore, prospective longitudinal studies with serial CACS measurements and extended follow-up are warranted to establish the temporal relationship between CACS progression and AFDAS development, and to identify optimal time windows for intervention.

Conclusions

High CACS(CACS>300) is an independent risk factor for AFDAS and can optimize AFDAS risk stratification, thereby enhancing its identification performance.

Abbreviations

AF
atrial fibrillation
AFDAS
atrial fibrillation detected after stroke
CACS
coronary artery calcification score

Declarations

Ethics approval and consent

The Ethics Committee of the Affiliated Hospital of Xuzhou Medical University reviewed and approved this study. In accordance with relevant Institutional Review Board (IRB) regulatory guidelines, written informed consent was waived due to the minimal risk posed to participants.Clinical trial number: not applicable.

Availability of data and material

The datasets generated during and/or analyzed during the current study are available by request from the correspondence (chen.wensu@163.com).

Consent for publication

Not applicable.

Competing interest

The authors declare that the study was conducted without any commercial or financial relationships construed as a potential conflict of interest.

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Author contribution

MCD, and PL performed the experiments and analyzed the data. MCD and PL were involved in data collection. MCD wrote the manuscript. ZQZ and WSC directed the entire research work and corrected the articles. All authors read and approve the manuscript and agree to be accountable for all aspects of the research in ensuring that the accuracy or integrity of any part of the work is appropriately investigated and resolved.

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References

1. TU W J, WANG LD. China stroke surveillance report 2021[J/OL]. Military Med Res. 2023;10:33. 10.1186/s40779-023-00463-x.
2. WANG Y, LI Z, ZHAO X, et al. Stroke care quality in China: Substantial improvement, and a huge challenge and opportunity[J/OL]. Int J Stroke. 2017;12(3):229–35. 10.1177/1747493017694392.
3. Chinese Society of Cardiology, Chinese Society of Pacing and Electrophysiology. Chinese guidelines for the diagnosis and treatment of atrial fibrillation[J/OL]. Chin J Cardiol. 2023;51(06):572–618. 10.3760/cma.j.cn112148-20230416-00221.
4. HIMMELREICH JC, LUCASSEN W A, COUTINHO JM, et al. 14-day Holter monitoring for atrial fibrillation after ischemic stroke: The yield of guideline-recommended monitoring duration[J/OL]. Eur Stroke J. 2023;8(1):157–67. 10.1177/23969873221146027.
5. SPOSATO L A, SEIFFGE DJ. Atrial Fibrillation Detected After Stroke and Increased Risk of Death[J/OL]. Neurology. 2021;96(12):557–9. 10.1212/WNL.0000000000011640.
6. WEXLER L, BRUNDAGE B, CROUSE J, et al. Coronary Artery Calcification: Pathophysiology, Epidemiology, Imaging Methods, and Clinical Implications: A Statement for Health Professionals From the American Heart Association[J/OL]. Circulation. 1996;94(5):1175–92. 10.1161/01.CIR.94.5.1175.
7. AGATSTON AS, JANOWITZ W R, HILDNER F J, et al. Quantification of coronary artery calcium using ultrafast computed tomography[J/OL]. J Am Coll Cardiol. 1990;15(4):827–32. 10.1016/0735-1097(90)90282-T.
8. SUZUKI Y, MATSUMOTO N. Coronary artery calcium score: Current status of clinical application and how to handle the results[J/OL]. J Cardiol. 2022;79(5):567–71. 10.1016/j.jjcc.2021.11.020.
9. CHEN L Q TSIAMTSIOURISE, SINGH H, et al. Prevalence of Coronary Artery Calcium in Patients With Atrial Fibrillation With and Without Cardiovascular Risk Factors[J/OL]. Am J Cardiol. 2020;125(12):1765–9. 10.1016/j.amjcard.2020.03.018.
10. LEE S H, LEE M Y, SHIN S Y, et al. Relationship between Cardiovascular Calcium and Atrial Fibrillation[J/OL]. J Clin Med. 2022;11(2):371. 10.3390/jcm11020371.
11. KWOK C S, LIP G Y H BENNETTS. Coronary artery calcium score and its association with stroke: A systematic review and meta-analysis[J/OL]. Eur J Clin Invest. 2023;53(2):e13892. 10.1111/eci.13892.
12. 2020 ESC. Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS) | European Heart Journal | Oxford Academic[EB/OL]. [2025-05-02]. https://academic.oup.com/eurheartj/article/42/5/373/5899003

13. GREENLAND P, LABREE L, AZEN S P, et al. Coronary artery calcium score combined with Framingham score for risk prediction in asymptomatic individuals[J/OL]. JAMA. 2004;291(2):210–5. 10.1001/jama.291.2.210.
14. DETRANO R, GUERCI A D, CARR JJ, et al. Coronary calcium as a predictor of coronary events in four racial or ethnic groups[J/OL]. N Engl J Med. 2008;358(13):1336–45. 10.1056/NEJMoa072100.
15. O'NEAL W T, EFIRD J T, DAWOOD F Z, et al. Coronary Artery Calcium and Risk of Atrial Fibrillation (from the Multi-Ethnic Study of Atherosclerosis)[J/OL]. Am J Cardiol. 2014;114(11):1707–12. 10.1016/j.amjcard.2014.09.005.
16. VINTER N, CHRISTESEN A M S MORTENSENLS, et al. Coronary artery calcium score and the long-term risk of atrial fibrillation in patients undergoing non-contrast cardiac computed tomography for suspected coronary artery disease: a Danish registry-based cohort study[J/OL]. Eur Heart J - Cardiovasc Imaging. 2018;19(8):926–32. 10.1093/ehjci/jex201.
17. O'NEAL W T, EFIRD J T, QURESHI W T et al. Coronary Artery Calcium Progression and Atrial Fibrillation: The Multi-Ethnic Study of Atherosclerosis[J/OL]. Circulation: Cardiovascular Imaging, 2015, 8(12): e003786. 10.1161/CIRCIMAGING.115.003786
18. PAN N, TSAO H, CHANG N, et al. Dilated Left Atrium and Pulmonary Veins in Patients with Calcified Coronary Artery: A Potential Contributor to the Genesis of Atrial Fibrillation[J/OL]. J Cardiovasc Electrophys. 2009;20(2):153–8. 10.1111/j.1540-8167.2008.01290.x.
19. CHAIKRIANGKRAI K, JHUN H Y, PALAMANER SUBASH SHANTHA, G, et al. Coronary artery calcium score as a predictor for incident stroke: Systematic review and meta-analysis[J/OL]. Int J Cardiol. 2017;236:473–7. 10.1016/j.ijcard.2017.01.132.
20. DUBOW J, FINK ME. Impact of Hypertension on Stroke[J/OL]. Curr Atheroscler Rep. 2011;13(4):298–305. 10.1007/s11883-011-0187-y.
21. KALIFA J, JALIFE J, ZAITSEV A V, et al. Intra-Atrial Pressure Increases Rate and Organization of Waves Emanating From the Superior Pulmonary Veins During Atrial Fibrillation[J/OL]. Circulation. 2003;108(6):668–71. 10.1161/01.CIR.0000086979.39843.7B.
22. CHANG S L, CHEN Y C, CHEN Y J, et al. Mechanoelectrical feedback regulates the arrhythmogenic activity of pulmonary veins[J/OL]. Heart. 2007;93(1):82–8. 10.1136/hrt.2006.089359.
23. PAN N, TSAO H, CHANG N, et al. Dilated Left Atrium and Pulmonary Veins in Patients with Calcified Coronary Artery: A Potential Contributor to the Genesis of Atrial Fibrillation[J/OL]. J Cardiovasc Electrophys. 2009;20(2):153–8. 10.1111/j.1540-8167.2008.01290.x.
24. OLESEN K K W MADSENM, LIP G Y H, et al. Coronary artery disease and risk of adverse cardiac events and stroke[J/OL]. Eur J Clin Invest. 2017;47(11):819–28. 10.1111/eci.12804.
25. CHEN D, LIANG M, JIN C, et al. Expression of inflammatory factors and oxidative stress markers in serum of patients with coronary heart disease and correlation with coronary artery calcium score[J/OL]. Experimental Therapeutic Med. 2020;20(3):2127–33. 10.3892/etm.2020.8958.
26. JAYARAJ RL, AZIMULLAH S, BEIRAM R, et al. Neuroinflammation: friend and foe for ischemic stroke[J/OL]. J Neuroinflamm. 2019;16(1):142. 10.1186/s12974-019-1516-2.

27. KARAM B S, CHAVEZ-MORENO A, KOH W, et al. Oxidative stress and inflammation as central mediators of atrial fibrillation in obesity and diabetes[J/OL]. Cardiovasc Diabetol. 2017;16(1):120. 10.1186/s12933-017-0604-9.
28. Batta A, Hatwal J, Panda P, Sharma Y, Wander GS, Mohan B. Impact of initial high sensitivity C-reactive protein on outcomes in nonvalvular atrial fibrillation: an observational study. Future Cardiol. 2024;20(5–6):295–303. 10.1080/14796678.2024.2354110.
29. Zhang S, Xu W, Xu J, Qiu Y, Wan Y, Fan Y. Association of C-reactive protein level with adverse outcomes in patients with atrial fibrillation: A meta-analysis. Am J Med Sci. 2024;367(1):41–8. 10.1016/j.amjms.2023.11.009.
30. Batta A, Hatwal J, Batta A, Verma S, Sharma YP. Atrial fibrillation and coronary artery disease: An integrative review focusing on therapeutic implications of this relationship. World J Cardiol. 2023;15(5):229–43. 10.4330/wjc.v15.i5.229.
31. GONZÁLEZ TOLEDO M E, KLEIN F R, RICCIO P M, et al. Atrial Fibrillation Detected after Acute Ischemic Stroke: Evidence Supporting the Neurogenic Hypothesis[J/OL]. J Stroke Cerebrovasc Dis. 2013;22(8):e486–91. 10.1016/j.jstrokecerebrovasdis.2013.05.015.
32. Mekhael M, Marrouche N, Hajjar AHE, Donnellan E. The relationship between atrial fibrillation and coronary artery disease: Understanding common denominators. Trends Cardiovasc Med. 2024;34(2):91–8. 10.1016/j.tcm.2022.09.006.
33. Batta A, Hatwal J, Sharma YP. Assessment of Coronary Artery Disease in Non-Valvular Atrial Fibrillation: Is This Light at the End of the Tunnel? Vasc Health Risk Manag. 2024;20:493–9. 10.2147/VHRM.S484638. Published 2024 Nov 8.
34. Sharma YP, Batta A, Makkar K, et al. Angiographic profile and outcomes in persistent non-valvular atrial fibrillation: A study from tertiary care center in North India. Indian Heart J. 2022;74(1):7–12. 10.1016/j.ihj.2021.12.010.

Figures

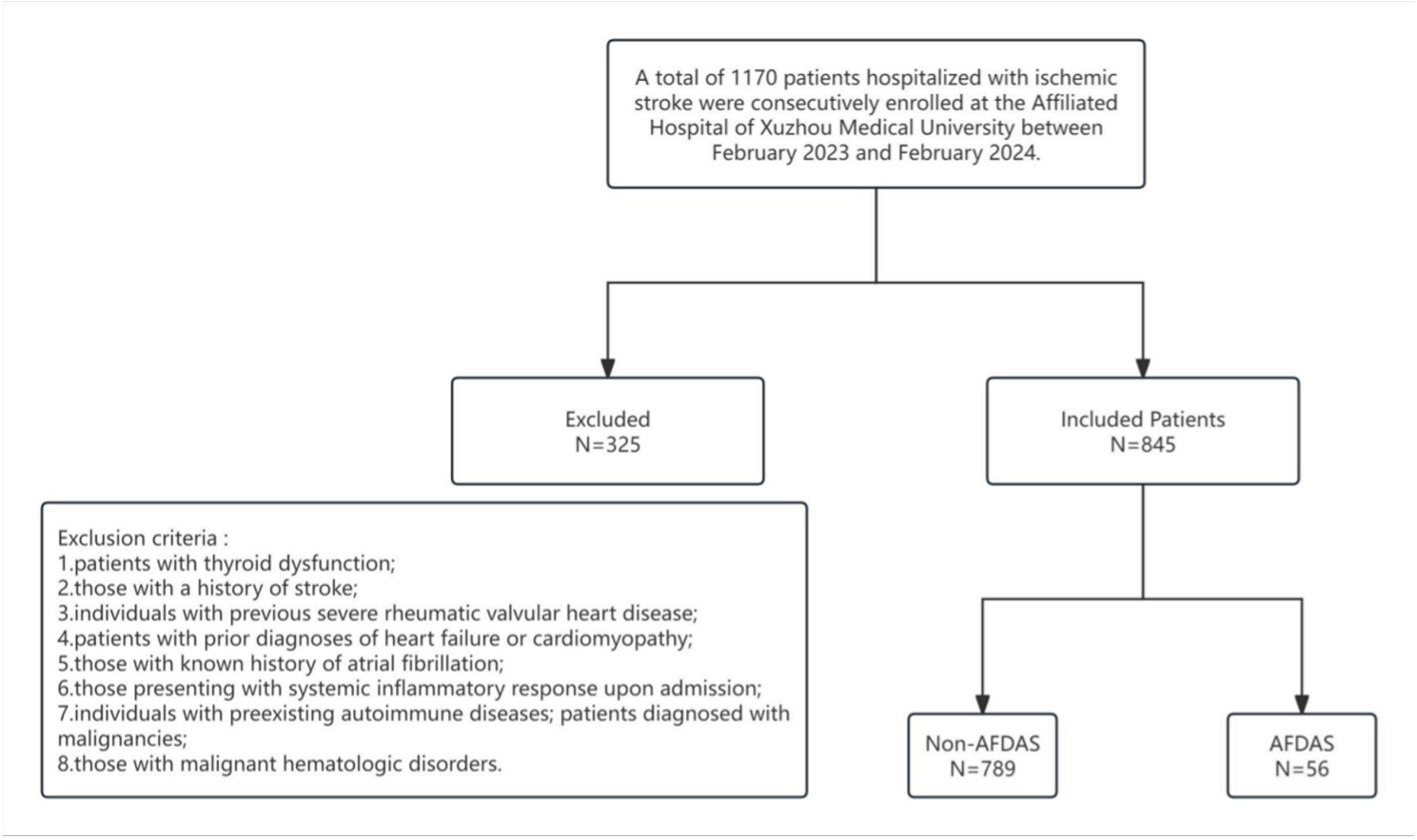


Figure 1

Study flowchart. AFDAS: Atrial fibrillation detected after stroke

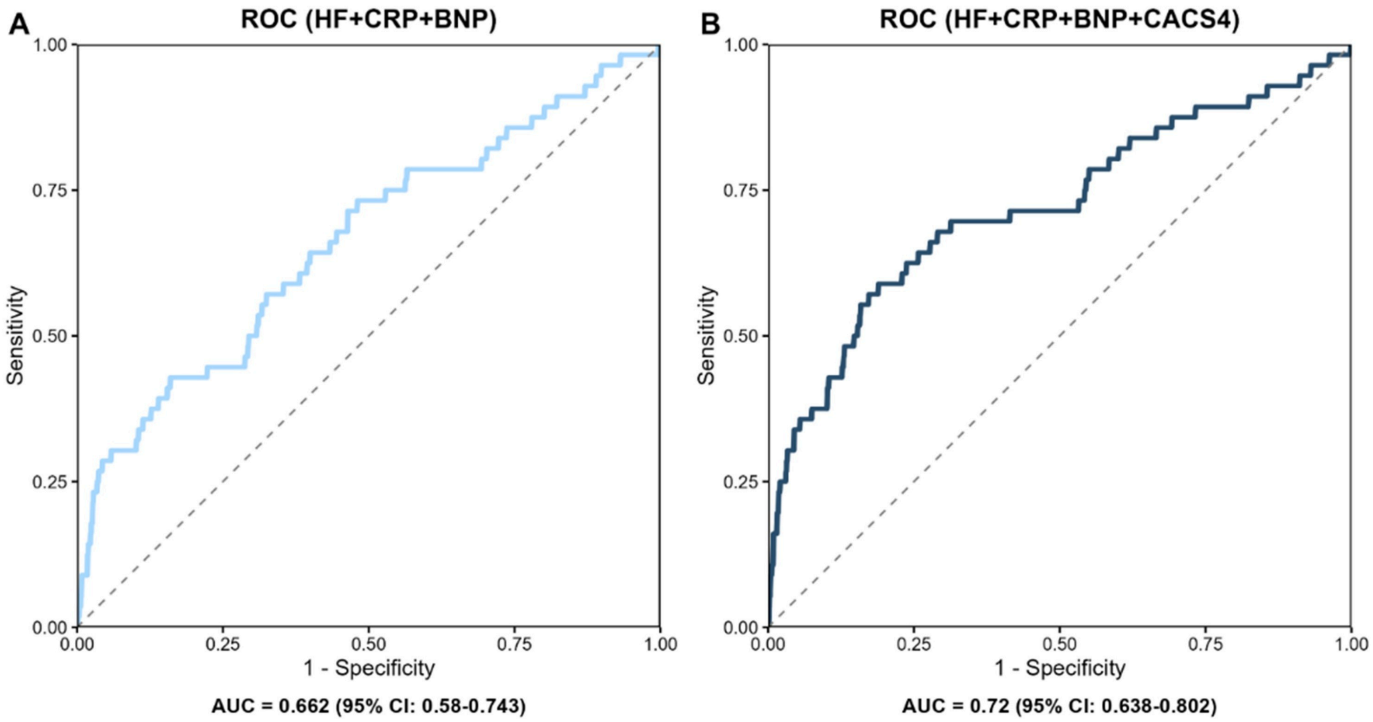


Figure 2

Compare the receiver operating characteristic (ROC) curves of two predictive models. Panel A, Baseline clinical model, (included heart failure, CRP, NT-proBNP). Panel B, tBaseline clinical model+CACS4, The area under the curve is included.

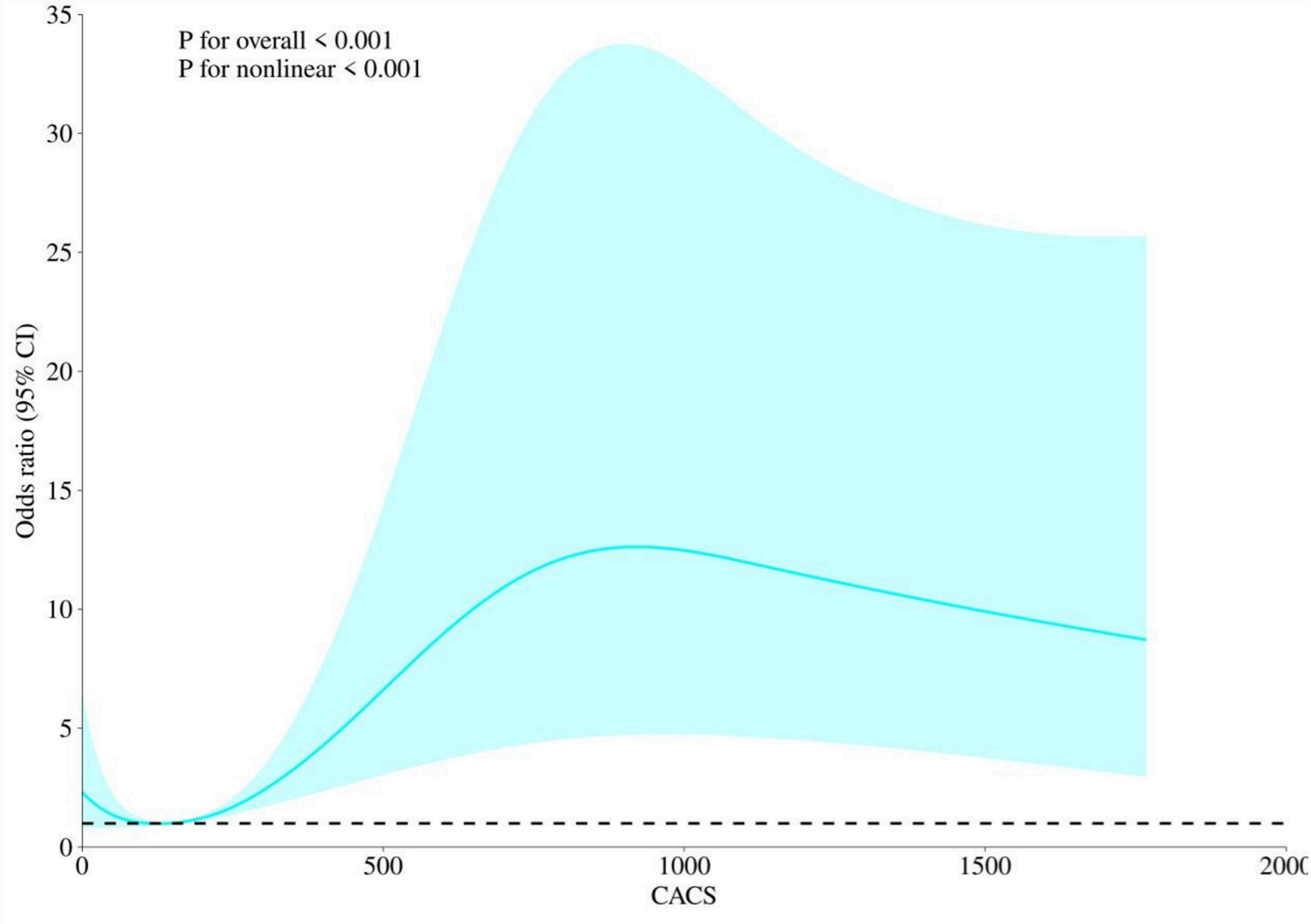


Figure 3

Restricted Cubic Spline Of CACS. CACS: Coronary Artery Calcium Score

Supplementary Files

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- SupplementaryTables.docx