Correlation Between Serum Albumin and D-Dimer Levels in 909 Patients with Non-Valvular Atrial Fibrillation: A Retrospective Study from a Single Center in China

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
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Background: D-dimer level can reflect the hypercoagulable state of atrial fibrillation (AF) and predict thromboembolic events. However, no effective indicator associated with D-dimer of AF patients has been found to prevent thromboembolic events in AF. This retrospective study from a single center aimed to investigate the correlation between serum albumin and D-dimer levels in 909 patients with non-valvular AF (NVAF) and 653 subjects in sinus rhythm.

Material/Methods: A total of 909 NVAF patients and 653 sex- and age-matched sinus rhythm participants were used to compare serum albumin and D-dimer levels. Serum albumin was determined by colorimetry, and D-dimer level was determined by latex-enhanced photoimmunoassay. We analyzed the correlation of serum albumin and D-dimer with NVAF by correlation analysis, logistic regression analysis, and receiver operating characteristic (ROC) curve.

Results: Albumin ($P<0.001$) and D-dimer ($P<0.001$) were significantly associated with NVAF. Among NVAF patients, D-dimer level was negatively correlated with albumin levels ($P<0.001$), and albumin level was an independent risk factor of abnormal D-dimer level (>0.5 ug/mL), which was also an effective predictor of abnormal D-dimer level (the area under the ROC curve was 0.77, $P<0.001$), and the optimal cutoff value was 36.95 g/L.

Conclusions: Serum albumin and D-dimer levels were significantly associated with NVAF. In NVAF patients, D-dimer level was inversely correlated with albumin levels, and albumin level was an independent risk factor and effective predictor of abnormal D-dimer level. Close examination and supplementation of serum albumin can prevent thromboembolic events, but further clinical research and confirmation are needed.

Keywords: Atrial Fibrillation • Fibrin Fragment D • Retrospective Studies • Serum Albumin

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Background

Atrial fibrillation (AF) is a common clinical arrhythmia [1]. With the advancement of medical care, the medical burden and complications caused by AF have gradually attracted increased attention, and the importance of treating AF has become self-evident [2]. Epidemiology data show that the incidence of AF has been increasing globally in the past 20 years, and will continue to increase over the next 30 years [2]. The number of adults with atrial fibrillation in the EU is projected to grow to 17.9 million by 2060 (95% CI: 13.6-23.7 million) [3]. It is widely accepted that AF is closely associated with hypercoagulability [4], which can lead to atrial thrombosis and further embolisms such as ischemic stroke. Therefore, AF is an important risk factor for ischemic stroke [5]. The presence of AF increases the risk of a cerebrovascular accident by 2.6-fold to 4.5-fold [6], and given the asymptomatic nature of AF, this risk may be underestimated [7]. Assessing the risk of stroke and preventing thromboembolic events in AF patients is accepted practice [1]. Although the risks and benefits of anticoagulation in AF patients are controversial [1,8], it is important to detect thromboembolic risk in patients with AF.

D-dimer level is commonly used for stratification of venous thromboembolism risk and is the criterion standard used to reflect coagulation activation or fibrinolysis [9]. Several studies have shown that hypercoagulability and thromboembolic risk in patients with AF can be reflected by D-dimer level [10-13]. Even with warfarin anticoagulation, D-dimer level predicts thromboembolic events in patients with non-valvular AF (NVAF) [13]. D-dimer level is also significantly correlated with the infarct size and functional prognosis after cardioembolic stroke in patients with NVAF [14]. Therefore, looking for influencing factors related to D-dimer level may help to reduce the risk of thromboembolism in patients with NVAF.

Serum albumin is widely involved in many physiological functions such as transport of substances within the human body and regulates inflammation and oxidative stress [15]. Albumin has anti-inflammatory activity [16,17], and chronically low albumin levels are often accompanied by a systemic inflammatory response [18,19]. There is increasing evidence that low serum albumin levels are closely related to cardiovascular diseases, including ischemic heart disease, AF, and heart failure [15,20]. The correlation between low serum albumin levels and the occurrence of AF has been increasingly demonstrated [21-23]. In addition, the development of thromboembolism, a complication of AF, is also associated with inflammatory activity and oxidative stress [24,25]. D-dimer, a degradation product of fibrin, which reflects the risk of thromboembolism, also influences the inflammatory response [26,27]. Serum albumin and D-dimer seem to participate in the same pathophysiological process in AF, and a study has found that normal serum albumin can inhibit platelet aggregation [28].

Therefore, we reasonably hypothesized that: (1) serum albumin and D-dimer and their associations might be associated with NVAF; and (2) serum albumin might be associated with risk factors for the hypercoagulable state in NVAF patients, possibly due to inflammatory response and oxidative stress affecting coagulation status and thromboembolism [24-26]. This retrospective, single-center aimed to investigate the correlation between serum albumin and D-dimer levels in 909 patients with non-valvular AF (NVAF) and 653 subjects in sinus rhythm at the Affiliated Hospital of Shandong University of Traditional Chinese Medicine, Jinan City, Shandong Province, China.

Material and Methods

Patients and Methods

This case-control, retrospective study was conducted according to the principles of the Declaration of Helsinki and was approved by the Medical Research Ethics Committee of the Affiliated Hospital of Shandong University of Traditional Chinese Medicine. The data were anonymized and the Ethics Committee of the Affiliated Hospital of Shandong University of Traditional Chinese Medicine (NO.2021-022-LY) waived the need for informed consent.

The study group consisted of 909 patients with NVAF who were treated in the Affiliated Hospital of Shandong University of Traditional Chinese Medicine from January 2005 to January 2022, and the control group consisted of 653 sex- and age-matched participants with sinus rhythm and no history of AF. The inclusion criteria of patients were: (a) admitted to the hospital meeting the diagnostic criteria for AF [29] or with a history of AF; and (b) aged 18-80 years. Exclusion criteria were: (a) valvular AF/prosthetic heart valve; (b) concomitant diseases: hematological disease, malignancy, surgery or other trauma; and (c) taking drugs that affect D-dimer or albumin levels, except anticoagulants.

Data Collection

All data were based on hospital medical records. Demographic data (age and sex), medical history (coronary heart disease [CHD], diabetes, hypertension, and ischemic stroke), medication use, CHA2DS2-VASc scores, and laboratory blood parameters were retrospectively collected for this study.

Blood samples were collected from fasting patients upon admission, and sent to the Laboratory Department of the Affiliated Hospital of Shandong University of Traditional Chinese Medicine for laboratory blood index determination. D-dimer level was determined using a latex-enhanced photometric immunoassay (Stago automated coagulation instrument), and the upper limit of normal was 0.5 ug/mL. Albumin, globulin, serum uric acid (SUA),

Table 1. Baseline characteristics of the study population.

	AF	Control	P value
n	909	653	
Age (years)	69.54±8.56	69.51±8.08	0.932
Gender (male)	491 (54.0%)	353 (54.1%)	0.987
CHD	722 (79.4%)	179 (27.4%)	<0.001
Hypertension	632 (69.5%)	286 (43.8%)	<0.001
Diabetes	276 (30.4%)	144 (22.1%)	<0.001
Ischemic stroke	364 (40.0%)	112 (17.2%)	<0.001
WBC (10^9/L)	6.24 (2.56)	5.45 (2.06)	<0.001
NLR	2.44 (2.22)	1.97 (1.12)	<0.001
PCV (%)	40.0 (7.3)	41.1 (5.4)	<0.001
MPV (fL)	10.5 (1.3)	10.0 (1.1)	<0.001
INR	1.08 (0.27)	0.96 (0.08)	<0.001
FIB (g/L)	3.37 (1.00)	3.29 (0.87)	<0.001
D-dimer (ug/mL)	0.40 (0.60)	0.28 (0.16)	<0.001
Albumin (g/L)	38.00 (5.8)	41.45 (4.2)	<0.001
Globulin (g/L)	27.3 (5.3)	27.7 (5.3)	0.056
SUA (umol/L)	346 (150.50)	291 (98.75)	<0.001
TG (mmol/L)	1.08 (0.69)	1.10 (0.69)	0.235
GLU (mmol/L)	5.58 (1.61)	5.53 (1.40)	0.627

AF – atrial fibrillation; CHD – coronary heart disease; WBC – white blood cell; NLR – neutrophil to lymphocyte ratio; PCV – packed cell volume; MPV – mean platelet volume; INR – international normalized ratio; FIB – fibrinogen; SUA – serum uric acid; TG – triglycerides; GLU – glucose.

triglycerides (TG), and glucose (GLU) levels were determined by colorimetry (OLYMPUS-AU2700, Automatic Biochemical Analyzer). Fibrinogen (FIB) and international normalized ratio (INR) were measured by an instrumental method (Stago automated coagulation instrument). White blood cell (WBC), neutrophil, lymphocyte, packed cell volume (PCV), and mean platelet volume (MPV) were determined using SYSMEX BC-5000, a hematology analyzer. B-type natriuretic peptide level (BNP) was determined using electrochemiluminescence (Elecsys 2010 system, Roche Diagnostic).

Statistical Analysis

IBM SPSS Statistics version 21.0 (SPSS, Inc., Chicago, Illinois, USA) was used for statistical analysis. For continuous variables, normally distributed or approximately normally distributed data were presented as mean±standard deviation (SD), and non-normally distributed data were presented as the median and interquartile range (IQR). Categorical variables were presented as numerical values and percentages. Continuous variables between 2 groups were compared by *t* test or Mann-Whitney U test. Pearson and spearman correlation analysis was used to explore interrelationships. We divided AF patients into 2 groups according to the D-dimer level (0.5 ug/mL). Categorical variables were compared by chi-square distribution. Univariate and multivariate logistic regression were used to correct for potential confounding factors, explore the correlation of serum albumin, D-dimer, and NVAF, and determine whether serum albumin affects D-dimer levels in NVAF patients. The receiver operating characteristic (ROC) curve of GraphPad Prism version 9.0.0 (GraphPad Software Inc., La Jolla, CA, USA) was used to analyze the predictive ability of research indicators. Two-tailed *P* values <0.05 were considered statistically significant and these results were further analyzed.

Results

Baseline Characteristics of the Study Population

The baseline characteristics of the AF group and the control group are shown in **Table 1**. A total of 909 patients were

Table 2. Association of D-dimer and albumin with AF by logistic regression.

	D-dimer		Albumin	
	OR	P value	OR	P value
Model 1	3.46 (2.31-5.16)	<0.001	0.84 (0.81-0.86)	<0.001
Model 2	2.55 (1.73-3.76)	<0.001	0.83 (0.80-0.86)	<0.001
Model 3	3.33 (2.02-5.33)	<0.001	0.87 (0.84-0.91)	<0.001
Model 4	2.52 (1.60-3.98)	<0.001	0.85 (0.81-0.89)	<0.001

Model 1, Original, no confounders were adjusted for. **Model 2,** CHD, diabetes, hypertension, and ischemic stroke were adjusted.
Model 3, WBC, NLR, PCV, MPV, INR, FIB, SUA were adjusted. **Model 4,** all confounders were adjusted for. WBC – white blood cell;
NLR – neutrophil to lymphocyte ratio; PCV – packed cell volume; MPV – mean platelet volume; INR – international normalized ratio;
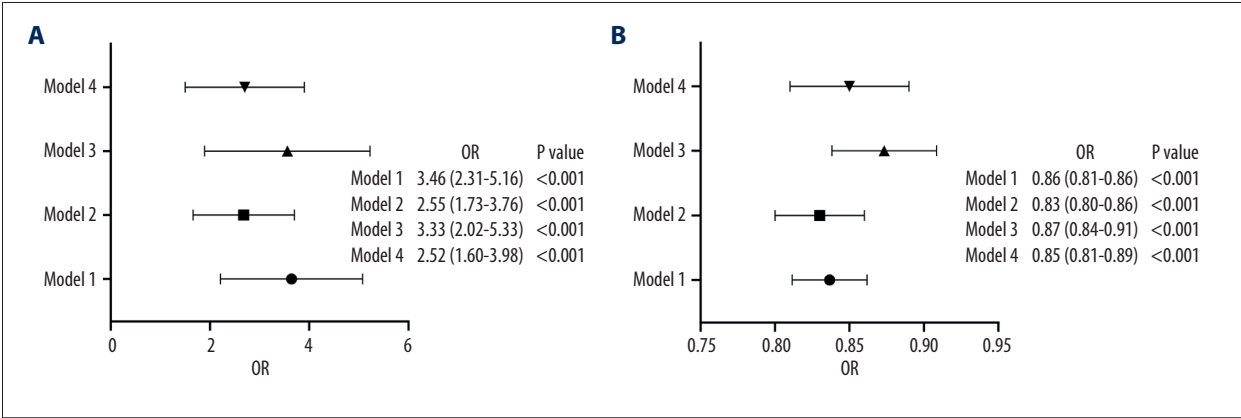FIB – fibrinogen; SUA – serum uric acid.

Figure 1. Correlation of albumin and D-dimer with AF. (**A**) Multiple adjusted ORs for the association of D-dimer levels with AF.
(**B**) Multiple adjusted ORs for the association of albumin levels with AF. AF, atrial fibrillation. The figure was created using
GraphPad Prism version 9.0.0 (GraphPad Software, Inc., La Jolla, CA, USA).

included in the AF group, including 491 males, with an average age of 69.54±8.56 years; 653 subjects in sinus rhythm with no history of AF were included in the control group, including 353 males, with an average age of 69.51±8.08 years. Compared with controls, AF patients were more likely to have a history of CHD ($P<0.001$), hypertension ($P<0.001$), diabetes ($P<0.001$), and ischemic stroke ($P<0.001$). In addition, AF patients showed higher levels of WBC, neutrophil-to-lymphocyte ratio (NLR), MPV, INR, FIB, D-dimer, SUA, and lower levels of PCV and albumin. These factors were statistically significant between AF and controls. There were no significant differences in sex, age distribution, and levels of globulin, TG, and GLU between the 2 groups.

Association Between D-Dimer, Albumin, and AF

Univariate logistic regression was used to determine the association between D-dimer, albumin, and AF, and multiple logistic regression was used to adjust for confounding factors to improve the accuracy of analysis of the association between D-dimer, albumin, and AF. The results showed that both D-dimer

and albumin were independent risk factors for AF (**Table 2**). After adjusting for CHD, diabetes, hypertension, and ischemic stroke, D-dimer and albumin levels were significantly associated with AF. After adjusting for WBC, NLR, PCV, MPV, INR, FIB, and SUA levels, D-dimer and albumin levels were significantly associated with AF. Then, after adjusting for all the above confounding factors, D-dimer (OR=2.52, 95% CI 1.60-3.98, $P<0.001$) and albumin (OR=0.85, 95% CI 0.81-0.89, $P<0.001$) levels remained significantly associated with AF (**Figure 1**).

In AF patients, we explored the correlation between D-dimer and various variables. After correcting for outliers, we observed that D-dimer was negatively correlated with albumin (r=-0.504, $P<0.001$) and PCV (r=-0.299, $P<0.001$), and was positively correlated with NLR (r=0.185, $P<0.001$) and BNP (r=0.289, $P<0.001$) (**Figure 2**). In addition, WBC showed a very weak correlation with D-dimer (r=0.101, $P=0.002$). Although several variables were associated with D-dimer, only albumin showed a strong correlation with D-dimer, while PCV, BNP, NLR, and WBC all had a weak correlation with D-dimer.
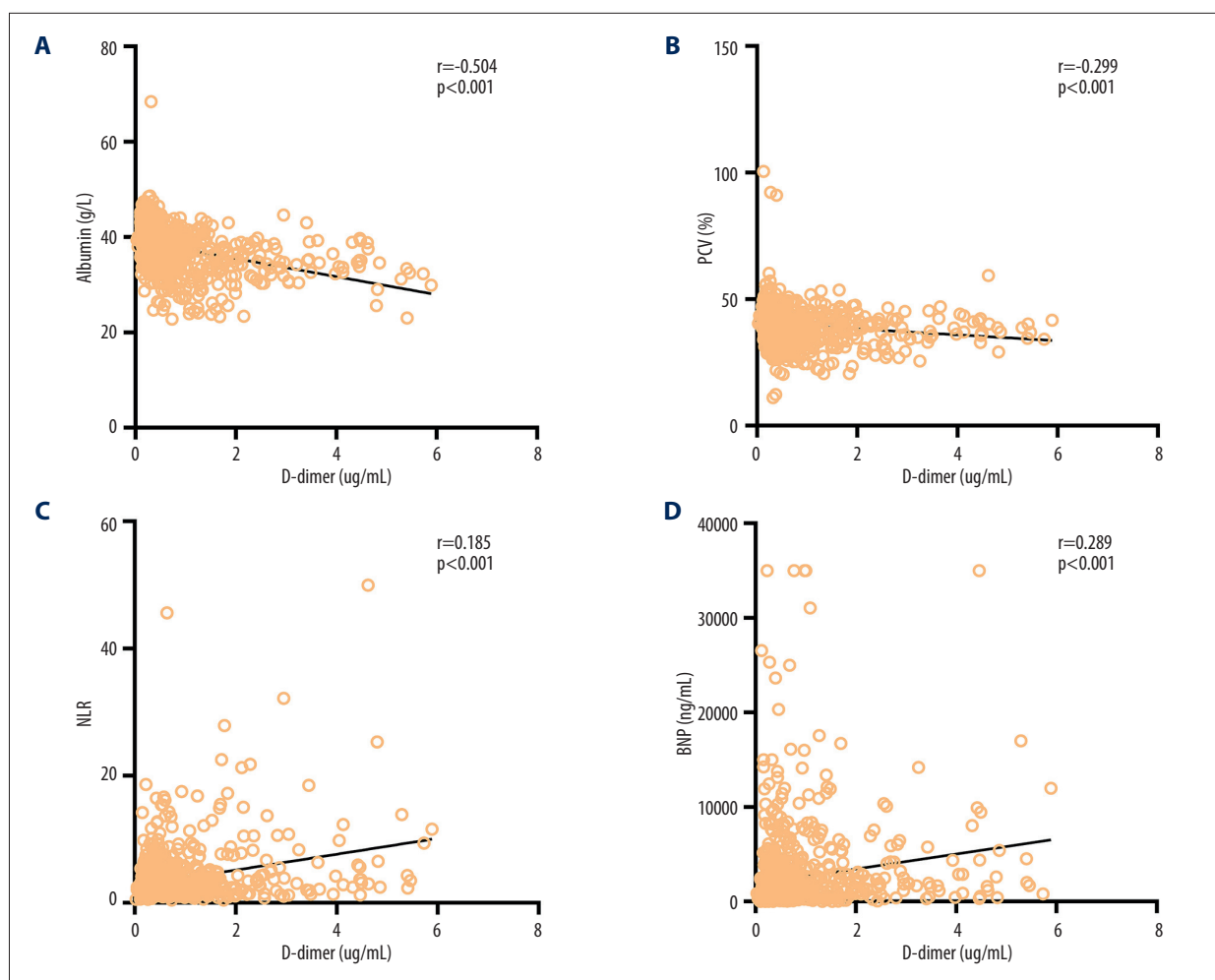
Figure 2. Influencing factors associated with D-dimer levels in AF patients. (**A**) Correlation of D-dimer levels with albumin (r=-0.504, P<0.001). (**B**) Correlation of D-dimer levels with PCV (r=-0.299, P<0.001). (**C**) Correlation of D-dimer levels with NLR (r=0.185, P<0.001). (**D**) Correlation of D-dimer levels with BNP (r=0.289, P<0.001). NLR – neutrophil-to-lymphocyte ratio; PCV – packed cell volume; BNP – B-type natriuretic peptides. The figure was created using GraphPad Prism version 9.0.0 (GraphPad Software, Inc., La Jolla, CA, USA).

Correlation of Albumin with D-Dimer in AF

To further explore the effect of various levels of D-dimer in AF patients and the connection between D-dimer and albumin, we divided AF patients into 2 groups according to the D-dimer cutoff level of 0.5 ug/mL. There were 379 patients in the D-dimer >0.5 ug/mL group and 530 patients in the D-dimer ≤0.5 ug/mL group. The baseline characteristics of the D-dimer group are shown in **Table 3**. Among AF patients, people with high D-dimer levels were more likely to be older (P<0.001) and not using anticoagulants (P<0.001), and they were more likely to be patients with ischemic stroke (P=0.002). Elevations in CHA2DS2-VASc (P<0.001), WBC (P=0.004), NLR (P<0.001), INR (P=0.044), FIB (P<0.001), BNP (P<0.001), and decreases in PCV (P<0.001), albumin (P<0.001), TG (P<0.001) and GLU (P=0.045) were more likely to affect D-dimer. Sex (P=0.685),

CHD (P=0.509), diabetes (P=0.374), hypertension (P=0.827), MPV (P=0.614), globulin (P=0.134), and SUA (P=0.324) had no statistically significant effect on D-dimer.

Variables that were statistically significant in the univariate logistic regression analysis were used for multivariate logistic regression analysis (**Table 4**). Albumin was significantly correlated with D-dimer levels (OR= 0.77, 95% CI 0.73-0.80, P<0.001). After adjustment, the correlation between albumin and D-dimer is shown in **Figure 3**. After adjustment for age, ischemic stroke, anticoagulants, and CHA2DS2-VASc, albumin was significantly associated with D-dimer levels (OR=0.77, 95% CI 0.74-0.81, P<0.001). After adjustment for WBC, NLR, PCV, INR, FIB, BNP, TG, and GLU, albumin was significantly associated with D-dimer levels (OR=0.80, 95% CI 0.76-0.83, P<0.001). After adjusting for the above confounding factors, albumin was

Table 3. Baseline characteristics of D-dimer groups.

	D-dimer >0.5	D-dimer ≤0.5	P value
n	379	530	
Age (years)	72.01±7.30	67.78±8.95	<0.001
Gender (male)	201 (53.0%)	290 (54.7%)	0.616
CHD	305 (80.5%)	417 (78.7%)	0.509
Hypertension	265 (69.9%)	367 (69.2%)	0.827
Diabetes	109 (28.8%)	167 (31.5%)	0.374
Ischemic stroke	174 (45.9%)	190 (35.8%)	0.002
Anticoagulants	76 (20.1%)	226 (42.6%)	<0.001
CHA2DS2-VASc	4 (2)	3 (3)	<0.001
WBC	6.38 (3.12)	6.12 (2.25)	0.004
NLR	2.86 (3.17)	2.31 (1.71)	<0.001
PCV (%)	38.00 (7.85)	41.10 (6.60)	<0.001
MPV (fL)	10.5 (1.2)	10.4 (1.2)	0.101
INR	1.10 (0.21)	1.06 (0.30)	0.044
FIB (g/L)	3.48 (1.42)	3.32 (0.84)	<0.001
BNP (ng/L)	1867.70 (3021.95)	842.70 (1745.80)	<0.001
Albumin (g/L)	35.60 (5.45)	39.60 (5.15)	<0.001
Globulin (g/L)	27.60 (5.95)	27.10 (4.90)	0.134
SUA (umol/L)	346 (180)	346 (138)	0.589
TG (mmol/L)	0.97 (0.63)	1.17 (0.73)	<0.001
GLU (mmol/L)	5.48 (1.72)	5.66 (1.58)	0.045

CHD – coronary heart disease; WBC – white blood cell; NLR – neutrophil to lymphocyte ratio; PCV – packed cell volume; MPV – mean platelet volume; INR – international normalized ratio; FIB – fibrinogen; BNP – B-type natriuretic peptides; SUA – serum uric acid; TG – triglycerides; GLU – glucose.

Table 4. Association of albumin with D-dimer in AF patients by logistic regression.

	OR	P value
Model 1	0.77 (0.73-0.80)	<0.001
Model 2	0.77 (0.74-0.81)	<0.001
Model 3	0.80 (0.76-0.83)	<0.001
Model 4	0.81 (0.77-0.85)	<0.001

Model 1, Original, no confounders were adjusted for.
Model 2, age, ischemic stroke, anticoagulants and CHA2DS2-VASc were adjusted. **Model 3,** WBC, NLR, PCV, INR, FIB, BNP, TG and GLU were adjusted. **Model 4,** all confounders were adjusted for. WBC – white blood cell; NLR – neutrophil to lymphocyte ratio; PCV – packed cell volume; INR – international normalized ratio; FIB – fibrinogen; BNP – B-type natriuretic peptides; TG – triglycerides; GLU – glucose.
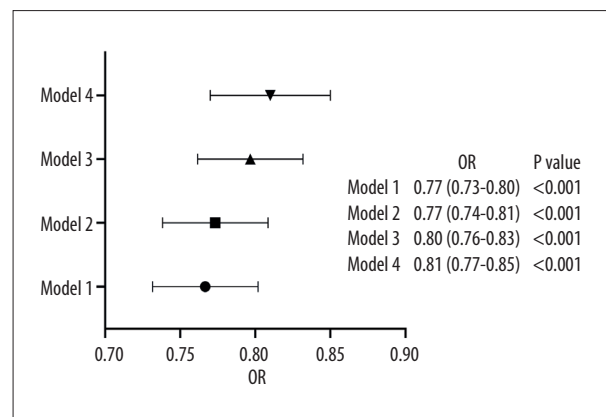

Figure 3. Multiple adjusted ORs for the association of D-dimer levels with albumin. The figure was created using GraphPad Prism version 9.0.0 (GraphPad Software, Inc., La Jolla, CA, USA).
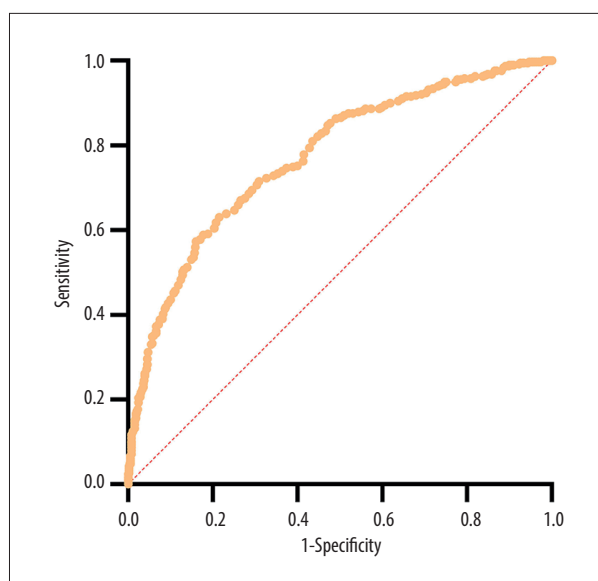
Figure 4. The ROC curve was used to analyze the predictive ability of serum albumin for abnormal D-dimer (>0.5 ug/mL) in AF patients. The area under the ROC curve was 0.77 (95% CI 0.74-0.80, P<0.001), and the optimal cutoff point was 36.95g/L. ROC – receiver operating characteristic. The figure was created using GraphPad Prism version 9.0.0 (GraphPad Software, Inc., La Jolla, CA, USA).

significantly associated with D-dimer level (OR=0.81, 95% CI 0.77-0.85, *P*<0.001), and it can be seen that albumin is an independent risk factor for D-dimer level in AF patients.

The ROC curves were used to analyze the predictive ability of albumin for D-dimer in AF patients. **Figure 4** shows the analysis results of the ROC curve. Albumin can be used as an effective predictor of abnormal D-dimer levels in AF. The area under the ROC curve was 0.77 (95% CI 0.74-0.80, *P*<0.001), indicating that albumin had good accuracy in predicting D-dimer levels in AF. The optimal cutoff point was 36.95 g/L.

Discussion

This case-control study showed that serum albumin and D-dimer were significantly associated with AF. In AF patients, there is an association between serum albumin and D-dimer, and serum albumin was inversely correlated with D-dimer. Albumin is an independent risk factor for D-dimer in AF patients. These associations remained significant whether or not confounding factors were adjusted. This association supports our hypothesis. Serum albumin can be used as an effective predictor of D-dimer levels in AF patients. According to ROC curve analysis, the optimal cutoff point for albumin to predict abnormal D-dimer (>0.5 ug/mL) in AF is 36.95g/L. To the best

of our knowledge, this is the first study to investigate the association of serum albumin with D-dimer in patients with AF.

D-dimer is a specific degradation product of fibrin, which can reflect coagulation activation or fibrinolysis [30]. D-dimer has been used as a common evaluation index for the evaluation of venous thromboembolism and pulmonary embolism [31,32]. However, more and more studies have confirmed that AF patients have higher D-dimer levels, and D-dimer is closely related to the occurrence of AF and its thromboembolic complications [13,33,34]. Hypercoagulability is common in AF patients [30], which is also an important cause of thromboembolic complications and poor prognosis. The D-dimer level can reflect the degree of hypercoagulable state accompanying AF [30]. Several studies have found that D-dimer is an effective indicator for excluding NVAF thromboembolic events[35,36] and assessing the risk of ischemic stroke [34,37-39]. Moreover, D-dimer can predict the prognosis of cardiovascular events and thromboembolic events [40-42]. Although use of anticoagulation in patients with AF has become widely accepted, it also increases the risk of bleeding [43], and in many hospitals the use of anticoagulants is under-therapeutic, and inappropriate anticoagulation can lead to higher mortality [44-46]. For AF patients with higher D-dimer levels, even on anticoagulants, subsequent thromboembolic and cardiovascular events can be effectively predicted [37,40]. Therefore, it is necessary to explore the influencing factors related to the level of D-dimer in patients with AF.

Serum albumin is involved in regulating systemic inflammatory response through pro-inflammatory substances. According to previous reports, low serum albumin levels are often accompanied by a systemic inflammatory response [19], and inflammation is associated with the pathophysiology of AF [24] and can predict the occurrence or recurrence of AF, which has also been verified in the literature [22,23]. In particular, a study with a sample size of 12 833 showed that serum albumin was inversely associated with the incidence of AF, but MR analysis did not support a causal relationship [23]. AF prevention with the goal of serum albumin supplementation is unlikely to be effective. However, the inflammatory response of AF increases thrombus formation [47]. Pro-inflammatory factors can induce platelet activation [48], leukocyte-platelet interactions may also mediate thrombosis [24], and normal serum albumin can inhibit platelet aggregation [28], which reminds us that albumin may interact with thrombosis and hypercoagulability in AF.

Clinical studies have found that D-dimer is an effective predictor of acute ischemic stroke [10]. Even with anticoagulants, D-dimer is also an effective predictor of thromboembolic events in AF patients [13]. A meta-analysis based on 71 studies also showed that D-dimer was significantly associated

with AF patients [33]. Our study found that D-dimer levels were significantly associated with AF (OR=2.52, 95% CI 1.60-3.98, *P*<0.001), and abnormal D-dimer is closely related to ischemic stroke in patients with AF (*P*=0.002), which is consistent with previously reported results. Another prospective study, based on 12 833 participants, showed that serum albumin levels were linearly associated with AF [23]. A clinical study based on 32 130 participants also showed that low serum albumin levels were significantly associated with an increased risk of AF [49]. Our study found similar results, with low serum albumin levels significantly associated with AF (OR=0.85, 95% CI 0.81-0.89, *P*<0.001). In exploring the risk factors associated with D-dimer in AF patients, our analysis showed that serum albumin was significantly associated with D-dimer of AF patients (OR=0.81, 95% CI 0.77-0.85, *P*<0.001) and could serve as an effective predictor of D-dimer levels in AF patients. Albumin is a commonly used clinical indicator, and clinicians should pay more attention to serum albumin levels to improve D-dimer levels and prognosis in patients with AF. Furthermore, we observed that in NVAF patients, D-dimer was negatively correlated with albumin and PCV, and was positively correlated with WBC, NLR, and BNP. Although several variables were significantly correlated with D-dimer, only albumin showed a strong correlation with D-dimer. Among the different D-dimer levels in NVAF patients, albumin also showed significant differences.

Interestingly, after adjusting for multiple confounders, including medical history and laboratory blood parameters, by multivariate logistic regression analysis, the ORs for D-dimer were significantly reduced, and studies also showed that age-adjusted D-dimer significantly improves the specificity of diagnosing venous thromboembolic events, but the ORs of the adjusted albumin did not change significantly. It can be seen that albumin is less affected by confounding factors and has higher specificity. Serum albumin can predict the hypercoagulable state of AF patients, and this suggests that serum albumin supplementation might prevent the development of thromboembolic complications in AF, but this needs further verification.

This study has some shortcomings. First, the sample size of this study was relatively small and was from a single-center institution, so our analysis has the potential to be biased, and we used a retrospective analysis and were unable to explore causality. Second, oxidative stress status of AF patients was not included, and inflammatory markers such as IL-6 and hs-CRP were not adjusted as confounding factors. Albumin can decline with frailty; we only performed age matching, and BMI and other indicators were not included. This is because they were either not measured or were missing at the time of patient admission. Finally, we did not classify AF and were unable to analyze the association of serum albumin and D-dimer between different AF types. It is hoped that there will be large-sample, multi-center studies and prospective cohort studies to further confirm the results of this study.

Conclusions

The results of this study revealed that serum albumin and D-dimer were significantly associated with AF. In AF patients, serum albumin was inversely correlated with D-dimer. We also found that serum albumin is an independent risk factor and effective predictor of abnormal D-dimer (>0.5 ug/mL). This may affect the hypercoagulable state and thromboembolic events of AF due to inflammatory responses. Close examination and supplementation of serum albumin may prevent thromboembolic events, but further clinical research and confirmation are needed.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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