



# Clinical Features Associated with ‘Normal Range’ Fibrin D-Dimer Levels in Atrial Fibrillation Patients with Left Atrial Thrombus

Clinical and Applied  
Thrombosis/Hemostasis  
Volume 28: 1-6  
© The Author(s) 2022  
Article reuse guidelines:  
sagepub.com/journals-permissions  
DOI: 10.1177/10760296221133380  
journals.sagepub.com/home/cat  


Ying Bai, PhD<sup>1</sup> , Si-Qing Luo, MD<sup>2</sup>, Si-Tong Liu, MD<sup>1</sup>,  
Ling Gong, PhD<sup>1</sup>, Peng Zhong, MD<sup>3</sup>, Zhen-Zhou Wang, PhD<sup>4</sup>,  
Gregory YH Lip, MD<sup>5,6</sup>, Yi-Xi Zou, PhD<sup>7</sup>, and Wei-Hua Guo, MD<sup>2</sup>

## Abstract

**Background:** Left atrial thrombus (LAT) often complicates with atrial fibrillation (AF). The evidence whether fibrin D-dimer levels could be used as a predictive biomarker for LAT is contradictory. This study firstly investigated the relationship between ‘normal range’ D-dimer and prevalent LAT. Second, we explored factors contributing to normal D-dimer levels in the presence of LAT. **Methods:** We studied 244 AF patients with LAT (mean age: 59.9 years, SD: 11.7; 53.3% female); of these, 103 (42.2%) had normal D-dimer, 25 (10.2%) had atrial thrombus exclusion score (ATE score) of 0, 19 (16.7%) males had CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 0, 21 (16.2%) females had CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 1 and 16 had overlapped ATE score of 0 and CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 0 (N = 8 if male) or CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 1 (N = 8 if female). Using multivariate binary analysis, larger left atrial diameter (LAD; adjusted OR: 1.06, 1.03–1.10, p = 0.001) were associated with increased D-dimer. Patients with high body mass index (BMI), hypertension history and previous anticoagulation were more likely to show normal range D-dimer levels in the presence of LAT. **Conclusions:** A high prevalence (42.2%) of ‘normal range’ D-dimer levels was found in AF patients with LAT, especially in those with hypertension, high BMI and prior anticoagulation. D-dimer levels of those patients with larger LAD were more likely to be increased.

## Keywords

atrial fibrillation, left atrial thrombus, d-dimer, left atrial diameter

Date received: 11 August 2022; revised: 16 September 2022; accepted: 29 September 2022.

## Key Messages:

What is already known about this subject:

There are contradictory opinions on whether D-dimer could be considered as a biomarker for the existence of left atrial thrombus (LAT).

What this study adds:

A high prevalence (42.2%) of ‘normal range’ D-dimer levels was found in AF patients with LAT, especially in those with hypertension, high BMI and prior anticoagulation. D-dimer levels of those patients with larger LAD were more likely to be increased.

How might this impact clinical practice:

LAT is common in AF patients showing normal D-dimer. Larger LAD were associated with increased D-dimer while hypertension history, higher BMI and previous

<sup>1</sup> Cardiovascular Center, Beijing Tongren Hospital, Capital Medical University, Beijing, China

<sup>2</sup> Dongzhimen Hospital, Beijing University of Chinese Medicine, Beijing, China

<sup>3</sup> Department of Ultrasound, Beijing Friendship Hospital, Capital Medical University, Beijing, China

<sup>4</sup> Trauma Medicine Center, Peking University People's Hospital, Beijing, China

<sup>5</sup> Liverpool Centre for Cardiovascular Science at University of Liverpool, Liverpool John Moores University and Liverpool Heart & Chest Hospital, Liverpool, UK

<sup>6</sup> Department of Clinical Medicine, Aalborg University, Aalborg, Denmark

<sup>7</sup> Department of Cardiac Surgery, Beijing Anzhen Hospital, Capital Medical University, Beijing, China

## Corresponding Authors:

\*Yi-Xi Zou, Department of Cardiac Surgery, Beijing Anzhen Hospital, Capital Medical University, Beijing, 100029, China.

Email: xihun00@sina.com OR

Wei-Hua Guo, Dongzhimen Hospital, Beijing University of Chinese Medicine, 101121, China.

Email: weihuaguo2005@163.com



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use,

reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access page (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

anticoagulation were associated with normal D-dimer with existing LAT.

## Introduction

Atrial fibrillation (AF) is a common arrhythmia, leading to stroke and systemic embolism,<sup>1, 2</sup> with thromboembolism arising from the left atrial thrombus (LAT). Although transesophageal echocardiography (TEE) is often used to exclude LAT in patients scheduled for radiofrequency ablation,<sup>3</sup> they are sometimes impractical for urgent cardioversion. Therefore, an efficient biomarker is necessary for excluding LAT in AF patients. Unfortunately, no such biomarker is currently recommended for predicting the existence of LAT.

Some studies found normal fibrin D-dimer (an index of fibrin turnover and a biomarker of thrombogenesis<sup>4</sup>) to be useful for excluding LAT in AF patients,<sup>5</sup> which is contradictory to our clinical experience and another study.<sup>6</sup>

Therefore, understanding the possible factors associated with normal range of D-dimer in the existence of LAT would be clinically helpful. This study firstly investigated the relationship between 'normal range' D-dimer and prevalent LAT confirmed by TEE. Second, we explored factors contributing to normal D-dimer levels in the presence of LAT.

## Methods

Patients' medical records with the diagnoses of AF and LAT between September 2008 and April 2021 were retrospectively reviewed to obtain detailed information on demographics, comorbidities and laboratory examinations. We included patients with both AF and LAT confirmed by TEE. Patients would be excluded if there was any of the following items: (i) No results of D-dimer and TEE test with the interval of less than 24 h could be obtained during the period of hospitalization; (ii) Contemporarily diagnosed with deep venous thrombosis (DVT) and/or pulmonary embolism (PE); and (iii) With stroke or systemic embolism related with LAT, and (iv) Patients with intra-atrial spontaneous echo-contrast or slow blood flow. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by clinical research ethics committee of our centers and individual consent for this retrospective analysis was waived.

### TEE Tests

Instruct the patient to lie on his side facing the doctor, remove the foreign body in the patient's mouth, and give ECG and blood pressure monitoring. In the local anesthesia state, the dental pad is placed first, and the probe is gently delivered from the patient's dental pad to the posterior pharyngeal wall by holding the front 1/3 of the probe body. When the probe is placed in the middle of the esophagus, the depth of the ultrasound image is 14 cm, and the rotation Angle is 0°–10°, four

heart chambers, namely left and right atria and left ventricles, can be seen. When the probe reached a depth of 32–40 cm, the left atrial appendage and pulmonary vein income of the patient were completely displayed by retreating to the back of the left atrium and adjusting the section angle. In the diagnosis of left atrial thrombosis, we focus on the presence of lumpy echo.<sup>7</sup>

### D-Dimer Tests

Equivalent effectiveness of plasma D-dimer levels tested by different methods were proved by previous studies.<sup>8</sup> D-dimer values were classified into 'normal range' D-dimer (Group 1) and increased D-dimer group. The former was defined as D-dimer levels  $\leq$  the ULRR while the increased D-dimer group was further divided into two groups:  $>$  ULRR but  $\leq$  two times of the ULRR (Group 2), and  $>$  two times of the ULRR (Group 3). We also investigated the distribution of LAT in relation to the atrial thrombus exclusion (ATE) score<sup>8</sup> and CHA<sub>2</sub>DS<sub>2</sub>-VASc score.<sup>9</sup>

The atrial thrombus exclusion (ATE) score was defined as follows<sup>8</sup>: hypertension (1 point), heart failure (1 point), history of stroke (1 point) and D-Dimer level  $>270$  ng/ml (1 point). The CHA<sub>2</sub>DS<sub>2</sub>-VASc score was defined as follows<sup>9</sup>: congestive heart failure (1 point), hypertension (1 point), age: 65–74 years (1 point), diabetes mellitus (1 point), previous transient ischemic attack(TIA) or stroke (2 points), peripheral artery disease (1 point), age:  $>75$  years (2 points), female sex (1 point).

### Statistical Analysis

Categorical variables in this study were expressed as numbers and percentages and compared with Chi-squared comparisons. Continuous variables were shown as mean  $\pm$  standard deviation, SD. The stratification of D-dimer levels, ATE scores and CHA<sub>2</sub>DS<sub>2</sub>-VASc scores were reported for the whole included population and then according to sex subgroups. Odds ratios (OR) and 95% confidence intervals (CI) for possible risk factors (age, sex, body mass index [BMI], hypertension, diabetes mellitus [DM], stroke/transient ischemic attack [TIA] history, heart failure [HF], previous anticoagulation, LAT, left ventricular ejection fraction [LVEF], creatine level and hemoglobin) of different stratification of D-dimer levels were calculated with binary univariate and multivariate logistic regression, respectively. ROC curves with the largest Youden index were used to calculate the cut-off values of continuous variables. Variables categorized with cut-off value were then calculated by adjusted multivariate logistic regression analysis. Statistical analysis was performed using SPSS 24.0 software package (SPSS Inc).

## Results

In the present analysis, 310 patients with AF and LAT were retrospectively reviewed. After excluding 66 patients with no

D-dimer test done within one day peri-examination period of TEE (N=37) or with concurrent PE or DVT (N=24) or stroke/systemic embolism (N=5), 244 patients (mean age: 59.9 years, SD: 11.7; 53.3% female) were included in the final analysis. Patients with increased D-dimer levels (Group 2 and Group 3) were more likely to be female, have lower BMI, HF history, larger LAD, and lower hemoglobin; however, patients with normal range of D-dimer levels (Group 1) were more likely to have hypertension, DM history and higher baseline systolic blood pressure. Baseline characteristics are summarized in Table 1. In our study, a total of 57 patients took Warfarin, and 25 of them had “normal” D-dimer levels. Three were on dabigatran and six were on rivaroxaban, and all of them had “normal” D-dimer levels.

### Distribution of D-Dimer Levels

There were altogether 103 (42.2%) patients in Group 1, 61(25.0%) in Group 2 and 80 (32.8%) in Group 3. The upper limit of the reference range (ULRR) of D-dimer of each method was 243 ng/ml for 186 patients (median: 279.00, interquartile range [IQR]: 479.00 ng/ml), 300ug/l for 4 patients (median: 187.50, IQR: 178.50 ng/ml), 1.5 mg/L for 25 patients (median: 1800.00, IQR: 4100.00 ng/ml) and 0.55 mg/L for 15 patients (median: 1490.00, IQR: 3550.00 ng/ml), respectively. Of these patients, 25 (10.2%) had ATE score of 0, 19 (16.7%) male AF patients had CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 0 and 21(16.2%) female AF patients had CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 1. 16 had overlapped ATE score of 0 and CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 0 (N=8 if male) or CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 1(N=8, if female) [Figure 1].

Males were more likely to have normal D-dimer levels compared with females (p=0.01). The differences of the

distribution of D-dimer, ATE score and CHA<sub>2</sub>DS<sub>2</sub>-VASc scores between male and female patients are shown in Figure 1.

### Factors Associated with Increased D-Dimer Levels

Using multivariate binary analysis, larger left atrial diameter (adjusted OR: 1.06, 1.03–1.10, p=0.001) was associated with increased D-dimer. Patients with high body mass index (BMI), hypertension history and previous anticoagulation were more likely to show normal range D-dimer levels in the presence of LAT (Table 2). A cut-off value of 51.2 mm of LAD was found using ROC curves with sensitivity of 48.9% and specificity of 77.3%. In order to increase the clinical application, we used categorical variables of LAD of 51.2 mm by ROC curve with biggest Youden value and 3 times of higher risk of increased D-dimer was seen in those with LAD 51.2 mm than those with LAD <51.2 mm (OR:3.25, 95% CI:1.66–6.37, p<0.001). The cut-off values for other continuous variables of age, BMI, creatinine, hemoglobin, LVEF were 77.5 years, 15.82 kg/m<sup>2</sup>, 60.85 umol/L, 68.5 g/L, 43.5%, respectively.

### Discussion

In the current analysis, a high prevalence (42.2%) of ‘normal range’ D-dimer was found in AF patients with LAT, especially in those with hypertension, high BMI and prior anticoagulation. D-dimer levels of those patients with larger left atrial diameter (LAD) were more likely to be increased.

Left atrial thrombus is an occult complication of AF,<sup>10</sup> which was often undetected before the development of ischemic stroke or systemic embolism. Although TEE is probably the most effective and applicable method for detecting atrial thrombi, it could only be performed by specially trained professionals and may be inconvenient in the setting of urgent cardioversion.

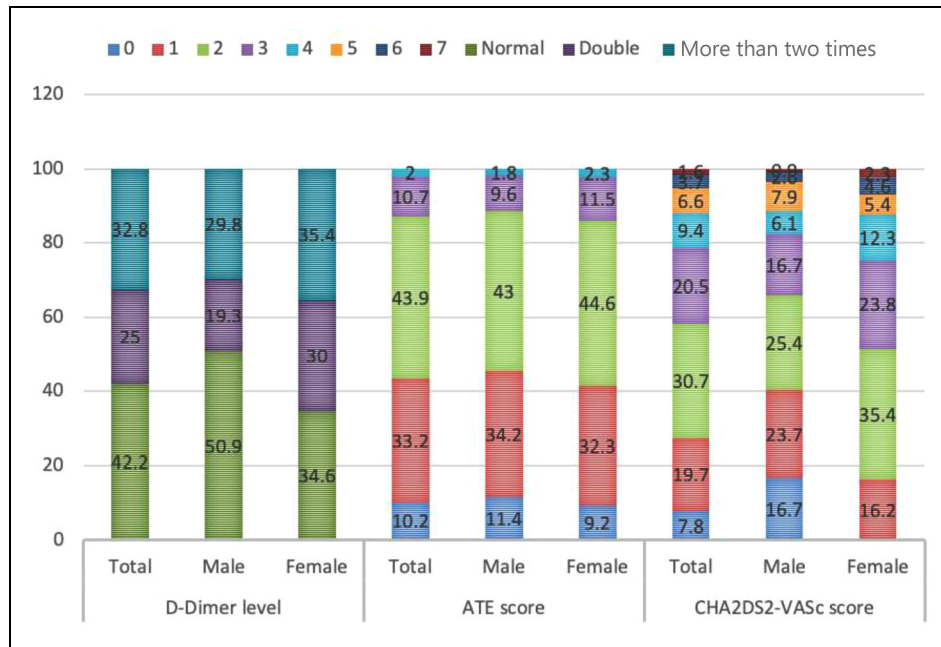
D-dimer has been proposed as a potential biomarker based on the finding that increased D-dimer levels were more likely to be seen in AF patients with atrial thrombi,<sup>11</sup> but no consistent cut-off point could be achieved due to the heterogeneity of cut-off points in different studies.<sup>8, 12–14</sup> The possibility of missed diagnosis could not be neglected, given the high prevalence (42.2%) of AF patients with LAT with normal D-dimer levels in this study. A similar concern was raised by Bejinariu et al,<sup>6</sup> whereby D-dimer failed to predict the thrombus formation in the left atrium. One possible reason was that D-dimer serves as an indirect marker of thrombotic activity, but the thrombi was usually in a stagnant state with a LAT. Also, a peripheral venous measurement of D-dimer levels may reflect systemic circumstances, rather than pathology within the left atrium (ie the presence of a LAT).

Previous studies have shown the equivalent effectiveness of different plasma D-dimer testing methods.<sup>8, 15</sup> Therefore, we used the D-dimer value as a continuous variable with 270ng/ml as the recommended cut-off point according to the ATE score and found that 25 of the included AF patients had LAT

**Table 1.** Baseline Characteristics of the Whole Study Population.

Variables	Normal D-dimer	Increased D-dimer	P value
Number	103	141	NA
Age	59.38 ± 10.89	60.44 ± 12.19	0.48
Female, N (%)	45 (43.69)	85 (60.28)	0.01
SBP, mm Hg	126.42 ± 17.44	126.38 ± 14.37	0.01
BMI, kg/m <sup>2</sup>	25.10 ± 3.67	23.48 ± 3.42	0.001
Hypertension	49 (47.57)	30 (21.28)	<0.001
Diabetes mellitus	25 (24.27)	11 (7.80)	<0.001
Prior HF	50 (48.54)	87 (61.70)	0.05
Prior stroke/TIA	15 (14.56)	14 (9.92)	0.32
Malignant tumor	6 (5.83)	6 (4.26)	1.00
Previous anticoagulant	34 (33.01)	33 (23.40)	0.11
Creatinine	86.39 ± 95.35	87.12 ± 96.07	0.95
Hemoglobin, g/L	141.06 ± 20.33	133.47 ± 20.76	0.005
LAD, mm	46.90 ± 9.37	52.68 ± 11.04	<0.001
LVEF, %	56.20 ± 11.25	56.05 ± 10.05	0.92

N, number; BMI, body mass index; HF, heart failure; TIA, transient ischemic attack; LAD, left atrial diameter; LVEF, left ventricular ejection fraction



**Figure 1.** Distribution of D-dimer levels, ATE scores and CHA2DS2-VASc scores.

ATE, Atrial thrombus exclusion; ATE score: hypertension (1 point), heart failure (1 point), history of stroke (1 point) and D-Dimer level >270 ng/ml (1 point).

CHA<sub>2</sub>DS<sub>2</sub>VASc score: congestive heart failure (1 point), hypertension (1 point), age: 65–74 years (1 point), diabetes mellitus (1 point), previous TIA or stroke (2 points), peripheral artery disease (1 point), age: >75 years (2 points), female (1 point).

**Table 2.** Factors Associated with Increased D-Dimer.

Factors	Unadjusted		Adjusted	
	OR (95% CI)	p value	OR (95% CI)	p value
Age	1.01 (0.99 – 1.03)	0.48	1.03 (1.00 – 1.06)	0.05
Female	1.96 (1.17 – 3.28)	0.01	1.11 (0.57 – 2.18)	0.76
BMI	0.88 (0.81 – 0.95)	0.001	0.89 (0.80 – 0.98)	0.02
Hypertension history	0.30 (0.17 – 0.52)	<0.001	0.43 (0.19 – 0.97)	0.04
DM history	0.26 (0.12 – 0.57)	0.001	0.47 (0.18 – 1.21)	0.12
HF history	1.71 (1.02 – 2.86)	0.04	1.15 (0.61 – 2.18)	0.66
Previous stroke/TIA	0.65 (0.30 – 1.41)	0.27	0.67 (0.21 – 2.11)	0.50
Previous anticoagulation	0.62 (0.35 – 1.09)	0.10	0.47 (0.24 – 0.97)	0.04
Creatinine	1.00 (0.997 – 1.003)	0.95	1.002 (0.999 – 1.005)	0.26
Hemoglobin	0.98 (0.97 – 1.00)	0.006	0.99 (0.98 – 1.01)	0.52
LAD	1.06 (1.03 – 1.09)	<0.001	1.06 (1.03 – 1.10)	0.001
LVEF	1.00 (0.97 – 1.02)	0.92	0.99 (0.96 – 1.03)	0.67

DM, diabetes mellitus HF, heart failure; TIA, transient ischemic attack; LAD, left atrial diameter; LVEF, left ventricular ejection fraction

even if their ATE score was 0. Similarly, CHA<sub>2</sub>DS<sub>2</sub>-VASc score has been associated with intra-atrial thrombus in previous studies.<sup>16, 17</sup> Among the participants of our study with LAT confirmed by TEE, 19 male had CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 0 and 21 female had CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 1. The use of oral anticoagulant drugs before D-dimer measurements increased the potential of normal range D-dimer levels in AF patients with LAT according to our results and previous paper.<sup>18, 19</sup>

Larger left atrial diameter was associated with increased D-dimer in AF patients with LAT in our study, which may be explained by D-dimer being a biomarker of degenerated

fibrinogen during active thrombus formation,<sup>20</sup> which was more likely to be present and active in larger atria as shown in previous studies.<sup>16, 21</sup> We found that the larger LAD was associated with increased D-dimer. The probability of increased D-dimer was 1.06 times every 1 mm increase in LAD. In order to raise the clinical application, we used categorical variables of LAD of 51.2 mm by ROC curve with biggest Youden index and 3 times of higher risk of increased D-dimer was seen in those with LAD ≥51.2 mm than those with LAD <51.2 mm (OR:3.25,95% CI:1.66–6.37, p<0.001). We obtained a P value of 0.05 for the variable of age, which is the boundary P value with an OR

value of 1.03 (1.00–1.06), so we did not count age as a strong predictor. Hypertension history and anticoagulation were factors associated with normal D-Dimer, as novel insights from our analysis. Of note, hypertension history showed a positive correlation with normal D-dimer and higher baseline systolic blood pressures in the Group 1 further supports this association. Despite the preventive effect of oral anticoagulation on the LAT, D-dimer was usually normal even if residual LAT remains after anticoagulation. Physicians should be encouraged to focus on possible existence of LAT in these patients as well as in those with hypertension history, higher BMI and previous anticoagulation even if patients had a normal range of D-dimer.

### Limitations

There are several limitations in our study. First, this is a retrospective analysis collecting data from tertiary hospitals. Second, there is a selection bias of patients who received TEE examinations. These patients were usually scheduled for radiofrequency ablation and generally had fewer comorbidities and lower risks of LAT. Third, all the patients we included had TEE and LAT. However, because PE/DVT or stroke/systemic embolism could increase the D-dimer level,<sup>22, 23</sup> therefore, the stability of this study increased by excluding these conditions and then the probability of increase D-dimer caused by these diseases decreased to the utmost. Fourth, LAD was used as a more convenient measurement in the current analysis rather than left atrial size or left atrial volume, as LAD was more popular than other parameters in clinical practice. Fifth, our population were indeed heterogeneous, because the population we included had many underlying diseases, but all of them had AF and LAT which is the homogeneity in choosing them. Sixth, since TEE may not be appropriate for all patients with LAT in certain emergency situations, it was of great importance to find a biomarker. Unfortunately, although D-dimer is sometimes considered the most promising biomarker, 42.2% of the AF patients with LAT had normal D-dimer, which suggested a high possibility of misdiagnosis. Therefore, this study was performed to remind the clinicians that D-dimer might be normal in AF patients with hypertension, increased BMI, and previous anticoagulation, despite the existence of LAT. Actually, a more efficient and convenient biomarker is necessary for emergent screening of LAT, which needs further exploration.

### Conclusions

A high prevalence (42.2%) of ‘normal range’ D-dimer levels was found in AF patients with LAT, especially in those with hypertension, increased BMI, and previous anticoagulation. D-dimer levels of those patients with larger LAD were more likely to be increased.

### Abbreviations

LAT Left atrial thrombus  
AF Atrial fibrillation

TEE Transesophageal echocardiography  
ATE atrial thrombus exclusion  
DVT deep venous thrombosis  
PE pulmonary embolism  
ULRR upper limit of the reference range  
OR Odds ratios  
CI confidence intervals  
BMI body mass index  
DM diabetes mellitus  
TIA transient ischemic attack  
HF heart failure  
LAD left atrial diameter  
LVEF left ventricular ejection fraction

### Acknowledgements

None.

### Availability of Data and Material

Data and material could be provided when necessary.

### Competing Interests:

The authors report no relationships that could be construed as a conflict of interest.

### Consent for Publication

Yes.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by clinical research ethics committee of our centers and individual consent for this retrospective analysis was waived.

### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article

### Funding Sources

This study was supported by grants from National Natural Science Foundation of China (81800291)

### ORCID iD

Ying Bai  <https://orcid.org/0000-0002-5334-7329>

### References

- McHorney CA, Peterson ED, Laliberte F, et al. Comparison of adherence to rivaroxaban versus apixaban among patients with atrial fibrillation. *Clin Ther.* 2016;38(11):2477-2488.
- Chao TF, Joung B, Takahashi Y, et al. 2021 Focused update consensus guidelines of the Asia pacific heart rhythm society on

- stroke prevention in atrial fibrillation: Executive summary. *Thromb Haemostasis*. 2022;122(1):20-47.
3. Calkins H, Hindricks G, Cappato R, et al. 2017 HRS/EHRA/ECAS/APHRS/SOLAECE expert consensus statement on catheter and surgical ablation of atrial fibrillation. *Europace*. 2018;20(1):e1-e160.
  4. Lip GY, Lowe GD. Fibrin d-dimer: A useful clinical marker of thrombogenesis? *Clinical Science (London, England: 1979)*. 1995;89(3):205-214.
  5. Almorad A, Ohanyan A, Pintea Bentea G, et al. D-dimer blood concentrations to exclude left atrial thrombus in patients with atrial fibrillation. *Heart*. 2021;107(3):195-200.
  6. Bejinaru AG, Hartel DU, Brockmeier J, Oeckinghaus R, Herzer A, Tebbe U. Left atrial thrombi and spontaneous echo contrast in patients with atrial fibrillation: Systematic analysis of a single-center experience. *Herz*. 2016;41(8):706-714.
  7. Hahn RT, Abraham T, Adams MS, et al. Guidelines for performing a comprehensive transesophageal echocardiographic examination: Recommendations from the American society of echocardiography and the society of cardiovascular anesthesiologists. *Journal of the American Society of Echocardiography: Official Publication of the American Society of Echocardiography*. 2013;26(9):921-964.
  8. Milhem A, Ingrand P, Treguer F, et al. Exclusion of intra-atrial thrombus diagnosis using d-dimer assay before catheter ablation of atrial fibrillation. *JACC Clin Electrophysiol*. 2019;5(2):223-230.
  9. Lip GY, Nieuwlaet R, Pisters R, Lane DA, Crijns HJ. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: The euro heart survey on atrial fibrillation. *Chest*. 2010;137(2):263-272.
  10. Zhan Y, Joza J, Al Rawahi M, et al. Assessment and management of the left atrial appendage thrombus in patients with nonvalvular atrial fibrillation. *Can J Cardiol*. 2018;34(3):252-261.
  11. Heppell RM, Berkin KE, McLenachan JM, Davies JA. Haemostatic and haemodynamic abnormalities associated with left atrial thrombosis in non-rheumatic atrial fibrillation. *Heart*. 1997;77(5):407-411.
  12. Habara S, Dote K, Kato M, et al. Prediction of left atrial appendage thrombi in non-valvular atrial fibrillation. *Eur Heart J*. 2007;28(18):2217-2222.
  13. Du X, Wang Y. The diagnostic efficacy of cardiac cta combined with d-dimer assay for the detection of left atrial thrombus in patients with atrial fibrillation. *Am J Emerg Med*. 2019;37(10):1922-1926.
  14. Somloi M, Tomcsanyi J, Nagy E, Bodo I, Bezzegh A. D-dimer determination as a screening tool to exclude atrial thrombi in atrial fibrillation. *Am J Cardiol*. 2003;92(1):85-87.
  15. Engelhardt W, Palareti G, Legnani C, Gringel E. Comparative evaluation of d-dimer assays for exclusion of deep venous thrombosis in symptomatic outpatients. *Thromb Res*. 2003;112(1-2):25-32.
  16. Scherr D, Dalal D, Chilukuri K, et al. Incidence and predictors of left atrial thrombus prior to catheter ablation of atrial fibrillation. *J Cardiovasc Electrophysiol*. 2009;20(4):379-384.
  17. Uz O, Atalay M, Dogan M, et al. The cha2ds2-vasc score as a predictor of left atrial thrombus in patients with non-valvular atrial fibrillation. *Med Princ Pract*. 2014;23(3):234-238.
  18. Hao L, Zhong JQ, Zhang W, et al. Uninterrupted dabigatran versus warfarin in the treatment of intracardiac thrombus in patients with non-valvular atrial fibrillation. *Int J Cardiol*. 2015;190(2015):63-66.
  19. Lin C, Bao Y, Hua W, et al. Differences in d-dimer blood concentration in atrial fibrillation patients with left atrial thrombus or severe left atrial spontaneous echo contrast. *Journal of Interventional Cardiac Electrophysiology : An International Journal Of Arrhythmias And Pacing*. 2022;64(2):341-347.
  20. Weitz JI, Fredenburgh JC, Eikelboom JW. A test in context: D-dimer. *J Am Coll Cardiol*. 2017;70(19):2411-2420.
  21. Ellis K, Ziada KM, Vivekananthan D, et al. Transthoracic echocardiographic predictors of left atrial appendage thrombus. *Am J Cardiol*. 2006;97(3):421-425.
  22. Sendama W, Musgrave KM. Decision-making with d-dimer in the diagnosis of pulmonary embolism. *Am J Med*. 2018;131(12):1438-1443.
  23. Wells PS, Anderson DR, Rodger M, et al. Evaluation of d-dimer in the diagnosis of suspected deep-vein thrombosis. *N Engl J Med*. 2003;349(13):1227-1235.