Original Article

Direct oral anticoagulants compared with warfarin in patients with left ventricular thrombus: a cohort study from China

Yang Zhou[1], Xiaoxuan Zhang[2], Yang Lin[1], Wenxing Peng[1]^

[1]Department of Pharmacy, Beijing Anzhen Hospital, Capital Medical University, Beijing, China; [2]Department of Pharmacy, PLA General Hospital Medical Supplies Center, Beijing, China

Contributions: (I) Conception and design: All authors; (II) Administrative support: Y Lin, W Peng; (III) Provision of study materials or patients: Y Lin, X Zhang; (IV) Collection and assembly of data: X Zhang, Y Zhou; (V) Data analysis and interpretation: X Zhang, Y Zhou; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Wenxing Peng, MS. Department of Pharmacy, Beijing Anzhen Hospital, Capital Medical University, No. 2, Anzhen Street, Chaoyang District, Beijing 100029, China. Email: shouyipwx@163.com.

Background: Current guidelines recommend vitamin K antagonist (VKA) for left ventricular (LV) thrombus. This study aimed to compare the effectiveness and safety of direct oral anticoagulant (DOAC) and warfarin in Chinese patients with LV thrombus.

Methods: Patients with LV thrombus admitted to Beijing Anzhen Hospital of Capital Medical University between January 2018 and January 2022, were enrolled in this cohort study. The primary endpoint was defined as thrombus resolution within 90 days. The secondary endpoints included thrombus resolution within 180 days, major bleeding events, and minor bleeding events. All patients were followed up for at least 90 days after diagnosis of LV thrombus. Patients were divided into the VKA and DOAC groups according to the anticoagulants. Differences in clinical endpoint events between the two groups were compared.

Results: This study included 129 and 111 patients in the VKA and DOAC groups, respectively. After adjusting for gender and smoking status, no significant difference was observed in thrombus resolution within 90 days between the VKA and DOAC groups. Additionally, there was no difference between the two groups in the secondary endpoints of thrombus resolution within 180 days, major bleeding, and minor bleeding. In subgroup analysis, rivaroxaban and dabigatran did not show significant differences in primary and secondary endpoints.

Conclusions: This study showed no significant difference in thrombus resolution between DOAC and warfarin. DOAC might be an alternative to warfarin for the treatment of LV thrombus. However, further large prospective studies are required to explore the efficacy and safety of DOAC in patients with LV thrombus.

Keywords: Left ventricular thrombus (LV thrombus); direct oral anticoagulant (DOAC); warfarin; rivaroxaban; dabigatran

Submitted Oct 13, 2023. Accepted for publication Dec 15, 2023. Published online Feb 22, 2024.
doi: 10.21037/jtd-23-1582
View this article at: https://dx.doi.org/10.21037/jtd-23-1582

^ ORCID: 0000-0001-7653-4672.

Introduction

The development of left ventricular (LV) thrombus is a serious complication that can occur in patients with acute myocardial infarction (MI) or non-ischemic cardiomyopathy (1). Data suggest that the incidence of LV thrombus among patients with acute coronary syndrome [ST-elevation myocardial infarction (STEMI)] is higher than 15% (2). Regardless of the etiology, LV thrombus is a potential cause of systemic embolization or stroke, which increases the morbidity and mortality in patients with both ischemic and non-ischemic cardiomyopathies. Current evidence shows that anticoagulant therapy can reduce the risk of ischemic events. There is growing evidence of the benefits of off-label use of direct oral anticoagulant (DOAC) in patients with LV thrombus (3,4). Current guidelines suggest patients with LV thrombus could use vitamin K antagonists (VKA) or DOACs for at least 3–6 months (5,6). DOAC overcomes the limitations of narrow treatment window, multiple interactions with other medications, frequent monitoring of warfarin, and good adaptability and compliance. Several studies have compared the safety and effectiveness of warfarin and DOAC in treating LV thrombus (5-7). However, it remains controversial whether DOAC can be used as an alternative to warfarin in patients with LV thrombus. This study aimed to investigate the effectiveness and safety of DOAC compared to warfarin in Chinese patients with LV thrombus. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1582/rc).

Highlight box

Key findings

- The key finding of our study was that there were no significant differences between warfarin and direct oral anticoagulants (DOAC) in primary endpoint of 90-day thrombus resolution, and no significant differences in secondary endpoints such as 180-day thrombus resolution, major and minor bleeding in patients with left ventricular (LV) thrombus.

What is known and what is new?

- Current guidelines recommend vitamin K antagonists (VKA) for LV thrombus. It remains controversial whether direct oral DOAC can be used as an alternative to warfarin in patients with LV thrombus.
- We provided evidence that DOAC and warfarin have quite efficacy in thrombus resolution.

What is the implication, and what should change now?

- DOAC might be an alternative to warfarin for the treatment of LV thrombus in Chinese patients.

Methods

Study population

Patients with LV thrombus admitted to the Beijing Anzhen Hospital of Capital Medical University between January 2018 and January 2022, were included in this study. Patients' eligibility was assessed according to the following inclusion criteria: (I) age >18 years; (II) diagnosis of LV thrombus by transthoracic or transesophageal echocardiography, according to the adjudicated International Classification of Diseases (ICD)-9 or ICD-10 diagnosis code criteria; (III) patients were treated with either DOAC (dabigatran or rivaroxaban) or warfarin within 90 days of diagnosis; (IV) follow-up echocardiography results to thrombus resolution or at least 90 days. The exclusion criteria were as follows: (I) mechanical valve replacement, valvular heart disease, rheumatic heart disease, and atrial thrombosis; (II) contraindication to anticoagulant agents (DOAC or warfarin); (III) active bleeding, bleeding diseases or hematologic disorder; (IV) severe hepatic or renal dysfunction [creatinine clearance rate <30 mL/min]; (V) total platelet count less than 100×10^9/L; (VI) severe anemia (hemoglobin <60 g/L); (VII) treatment with very low doses of DOAC that exceeded the instructions; (VIII) anticoagulant therapy was switched during follow-up (from DOAC to warfarin or from warfarin to DOAC). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Medical Clinical Research Ethics Committee of Beijing Anzhen Hospital (No. 2022247X). Prior to enrolment, all participants completed an informed consent form.

Definition of endpoints and follow-up

The primary endpoint was defined as thrombus resolution within 90 days. The secondary endpoints included thrombus resolution within 180 days, major bleeding events, and minor bleeding events. According to the criteria of International Society of Thrombosis and Haemostasis (ISTH) (8), major bleeding events were defined as fatal or associated with any of the following: (I) a reduction in hemoglobin level of 20 g/L or more, or recorded infusion of at least 2 units of whole blood or red blood cells; (II)

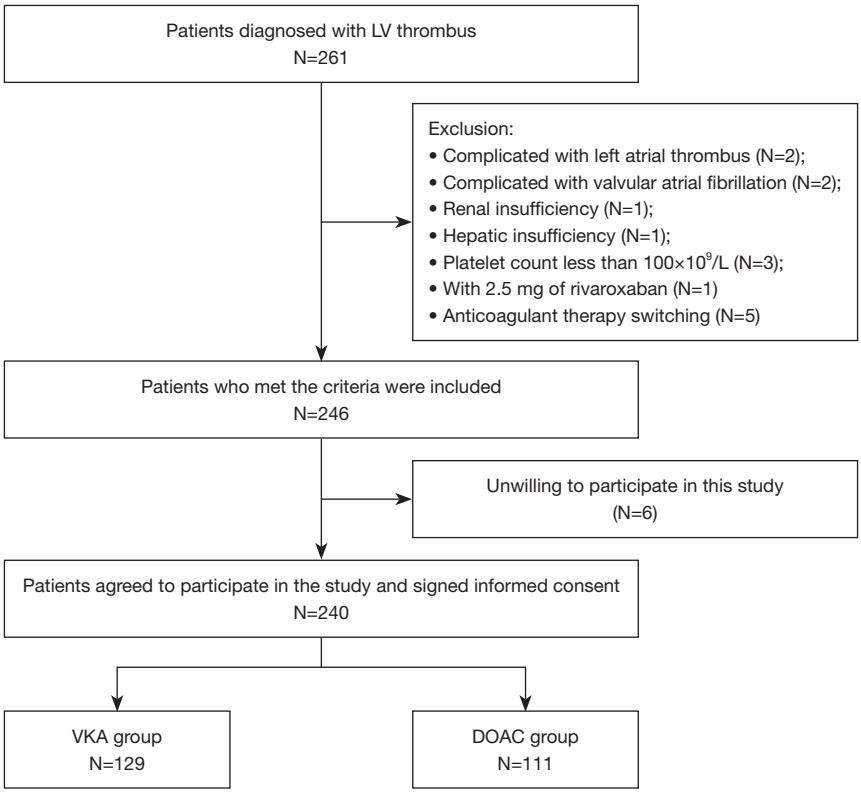

Figure 1 Flowchart of cohort selection. LV, left ventricular; VKA, vitamin K antagonist; DOAC, direct oral anticoagulant.

involvement of important areas or organs (intracranial, spinal, ocular, pericardium, articular, intramuscular with compartment syndrome, retroperitoneum). All other bleeding events were considered as minor bleeding. Bleeding events were identified based on self-reported or electronic medical records. Thrombus resolution was determined based on the patient's transthoracic or transesophageal cardiac ultrasound. All clinical events were validated by at least two cardiologists. All patients were followed up for at least 90 days after diagnosis of LV thrombus. Follow-up information was collected via telephone, electronic medical records or outpatient visits.

Statistical analysis

All statistical analyses were performed using SPSS 23.0 (IBM Corp., Armonk, NY, USA) and R software 4.2.2 (R Project, Vienna, Austria). The Kolmogorov-Smirnov test was used to determine whether continuous data were normal distributed. The analysis of variance (ANOVA) test was used to analyze the results of normal distributed continuous data, which were presented as means ± standard deviation (SD). The Wilcoxon test was used for non-normal distributed continuous variables, which were presented as medians and quartiles. Categorical data were presented as counts and percentages, and the Chi-squared test was used for analysis. Cox regression analysis was used to evaluate the primary endpoint between the two groups. Odds ratios (ORs) or adjusted OR and 95% confidence intervals (CIs) were calculated between groups for primary and secondary endpoints. Statistical significance was set at P values <0.05 to allow for group comparisons.

Results

Patients characteristics

Based on the inclusion and exclusion criteria, a total of 240 patients with LV thrombus were enrolled in the study. *Figure 1* shows the cohort selection process for this study. After data extraction, patients were divided into two groups according to anticoagulant use: 129 patients receiving warfarin were assigned to the VKA group and 111 patients receiving DOACs were assigned to the DOAC group. In the

VKA group, the initial dose of warfarin was 3–6 mg, once a day, and the dose was adjusted according to the monitoring of coagulation indices, and the target range of international normalized ratio (INR) level was maintained between 2.0–3.0. In DOAC group, 88 patients received rivaroxaban 10, 15, or 20 mg, once a day, and 23 patients received dabigatran 110 or 150 mg twice a day. The mean age of the patients was 55.0 (range, 23–88) years in the whole patients. Demographic characteristics, comorbidities and concomitant medication information are shown in *Table 1*. Ninety-two point two percent were male, 48.8% were hypertensive and 35.7% were diabetic in the VKA group, and 82.9% were male, 43.2% were hypertensive and 36.9% were diabetic in the DOAC group. The results showed statistically significant differences in sex, proportion of smokers and atrial fibrillation between the two groups. However, there were no significant differences between other variables.

Primary and secondary endpoints

As shown in *Figure 2*, there was no significant difference in the incidence of thrombus resolution during the follow-up. After adjusting for gender and smoking status, no significant difference was observed in thrombus resolution within 90 days between the VKA and DOAC groups. Additionally,

Table 1 Differences in baseline characteristics in patients treated with DOAC versus warfarin

Variables	VKA group (n=129)	DOAC group (n=111)	P value
Demographics			
Male	119 (92.2)	92 (82.9)	0.026
Age (years)	55 [46, 64]	56 [46, 67]	0.344
BMI (kg/m^2)	26.1 [24.2, 27.7]	26.1 [23.6, 28.7]	0.883
Smoker	82 (63.6)	47 (42.3)	0.001
Drinker	50 (38.8)	36 (32.4)	0.308
Comorbidity			
Hypertension	63 (48.8)	48 (43.2)	0.386
Diabetes mellitus	46 (35.7)	41 (36.9)	0.837
Hyperlipidemia	90 (69.8)	75 (67.6)	0.714
Atrial fibrillation	3 (2.3)	16 (14.4)	0.001
Prior myocardial infarction	80 (62.0)	61 (55.0)	0.268
Prior cerebral infarction	19 (14.7)	18 (16.2)	0.750
NYHA functional class			
Class III/IV	54 (41.9)	48 (43.2)	0.712
Transthoracic echocardiography			
LVEF (%)	38.0 [30.0, 44.5]	36.0 [25.0, 43.0]	0.157
LVED (mm)	56.0 [50.0, 60.8]	56.6 [50.0, 64.0]	0.412
Maximum diameter of thrombus (mm)	19.0 [14.0, 25.5]	19.0 [14.0, 26.0]	0.559
Number of ventricular thrombi			0.982
1	118 (91.5)	102 (91.9)	
2	10 (7.8)	8 (7.2)	
3	1 (0.8)	1 (0.9)	

Table 1 (*continued*)

Table 1 (*continued*)

Variables	VKA group (n=129)	DOAC group (n=111)	P value
Concomitant medication			
Aspirin	70 (54.3)	47 (42.3)	0.065
P2Y12 inhibitor	85 (65.9)	60 (54.1)	0.062
ACE inhibitor/ARB	89 (69.0)	88 (79.3)	0.071
Beta blocker	110 (85.3)	97 (87.4)	0.635
Statins	116 (89.9)	95 (85.6)	0.304
Laboratory examinations at admission			
eGFR (mL/min per 1.73 m^2)	94.5 [83.0, 106.0]	92.2 [80.0, 103.7]	0.415
SCr (μmol/L)	79.4 [68.5, 90.1]	78.8 [62.0, 92.6]	0.911
PLT count (×10^9/L)	224.0 [186.0, 275.5]	213.0 [175.0, 267.0]	0.445
ALT (U/L)	30 [19, 50]	25 [18, 53]	0.500
AST (U/L)	27 [19, 53]	25 [18, 43]	0.097
TBIL (μmol/L)	15.3 [10.2, 20.0]	14.5 [10.3, 22.0]	0.978
DBIL (μmol/L)	3.73 [2.80, 5.74]	4.27 [2.81, 5.91]	0.535
Hemoglobin (g/L)	147 [134, 157]	146 [133, 159]	0.953

Continuous data with non-normal distribution are expressed as median [interquartile range]; categorical data are presented as count (percentage). DOAC, direct oral anticoagulant; VKA, vitamin K antagonist; BMI, body mass index; NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; LVED, left ventricular end diastolic; ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; eGFR, estimated glomerular filtration rate; SCr, serum creatinine; PLT, platelet; ALT, alanine transaminase; AST, aspartate amino transferase; TBIL, total bilirubin; DBIL, direct bilirubin.

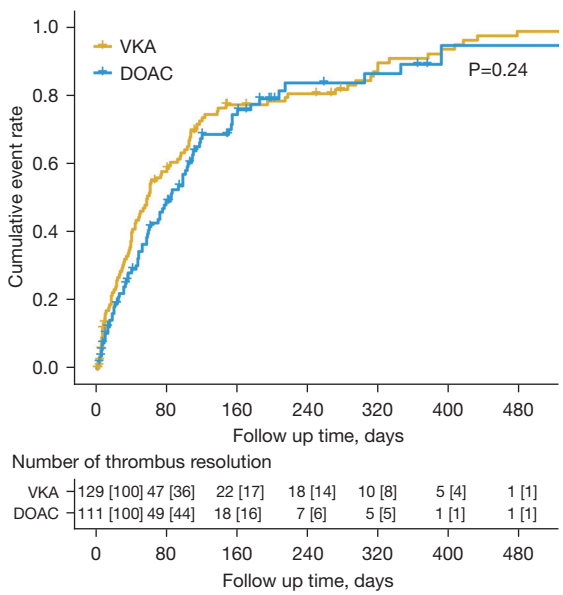

Figure 2 Cumulative event rate of LV thrombus resolution within follow-up. VKA, vitamin K antagonist; DOAC, direct oral anticoagulant; LV, left ventricular.

there was no difference between the two groups in the secondary endpoints of thrombus resolution within 180 days, major bleeding, and minor bleeding (*Table 2*). In subgroup analysis, rivaroxaban and dabigatran did not show significant differences in primary and secondary endpoints (*Table 3*). When stratified by age, estimated glomerular filtration rate (eGFR), gender, smoking status, and left ventricular ejection fraction (LVEF), the VKA and DOAC groups showed quite effective in 90-day thrombus resolution (*Figure 3*).

Discussion

The primary finding of our study was that there were no significant differences between warfarin and DOAC in primary endpoint of 90-day thrombus resolution, and no significant differences in secondary endpoints such as 180-day thrombus resolution, major and minor bleeding. DOAC might be an alternative to warfarin for the treatment of LV thrombus in Chinese patients.

Table 2 Primary and secondary endpoints

Variables	VKA group (n=129)	DOAC group (n=111)	Odds ratio (95% CI)†	P value	Adjusted odds ratio (95% CI)†‡	Adjusted P value‡
Thrombus resolution within 90 days, n (%)	75 (58.1)	57 (51.4)	0.760 (0.456, 1.267)	0.292	0.794 (0.468, 1.347)	0.392
Thrombus resolution within 180 days, n (%)	87 (67.4)	73 (65.8)	0.927 (0.542, 1.588)	0.784	0.954 (0.548, 1.663)	0.869
Bleeding events, n (%)						
Major bleeding	2 (1.6)	0	0.984 (0.963, 1.006)	0.501	–	0.996
Minor bleeding	9 (7.0)	7 (6.3)	0.897 (0.323, 2.494)	0.836	0.940 (0.330, 2.672)	0.907

†, compared with VKA group; ‡, adjusted risk factors of gender, smoking status by logistic regression model. VKA, vitamin K antagonist; DOAC, direct oral anticoagulant; CI, confidence interval.

Table 3 DOAC subgroup analysis

Variables	Rivaroxaban (n=88)	Dabigatran (n=23)	Odds ratio (95% CI)†	P value	Adjusted odds ratio (95% CI)†‡	Adjusted P value‡
Thrombus resolution within 90 days, n (%)	47 (53.4)	10 (43.5)	0.671 (0.266, 1.692)	0.398	0.615 (0.239, 1.583)	0.314
Thrombus resolution within 180 days, n (%)	59 (67.0)	14 (60.9)	0.765 (0.296, 1.973)	0.578	0.730 (0.278, 1.917)	0.523
Bleeding events, n (%)						
Major bleeding	0	0	–	–	–	–
Minor bleeding	4 (4.5)	3 (13.0)	3.150 (0.652, 15.207)	0.154	3.176 (0.635, 15.879)	0.159

†, compared with rivaroxaban group; ‡, adjusted risk factors of gender, smoking status by logistic regression model. DOAC, direct oral anticoagulant; CI, confidence interval.

Although the prevalence of LV thrombus is generally low in the general population, there is still a high incidence in patients with STEMI and anterior MI. Despite the fact that the current guidelines of the American College of Cardiology have long established warfarin as the gold standard for anticoagulation therapy, DOACs are still commonly used in the clinic for the off-label use for LV thrombus. There is a growing body of evidence that is supporting use of DOACs in LV thrombus. However, it remains controversial whether DOACs have an anticoagulant effect comparable to warfarin in patients with LV thrombus, and previous studies have also shown conflicting results. This study adds to the literature, but large prospective studies are still needed before guidelines can be included.

A multicenter retrospective cohort study by Robinson *et al.* (9) reported that DOACs (76.2% apixaban, 24.9% rivaroxaban, 4.9% dabigatran) treatment was associated with an increased risk of ischemic stroke and systemic emboli compared with warfarin treatment, even after adjustment for other factors. However, the authors did not assess bleeding events between the groups, which is a theoretical advantage of DOAC. A recent study showed that the thrombus resolution rates were similar in DOAC and VKA groups, but the time to thrombus resolution occurred significantly earlier in DOAC group and the combined endpoint of any stroke of peripheral embolism was also significantly lower in DOAC group. A meta-analysis (6) involving eight studies revealed that there were no statistically significant differences in thrombus resolution, bleeding complications, stroke or systemic embolization, and mortality in patients with LV thrombus treated with warfarin compared with those treated with DOAC. Our results are consistent with most studies (7,9-12), with no significant difference in thrombus resolution within 90 days. Notably, the antithrombotic effect of warfarin was slightly higher than that of DOAC after 90 days in *Figure 2*, but

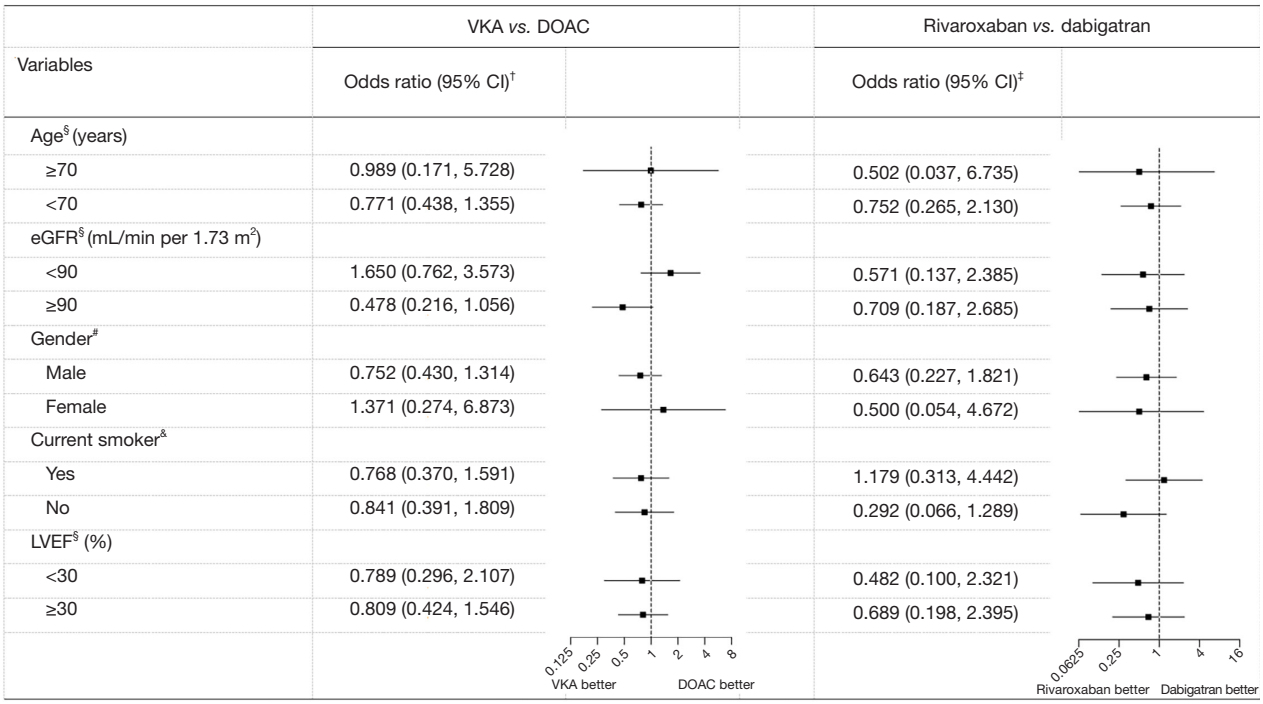

Figure 3 Stratified analysis of VKA and DOAC. †, compared with VKA group; ‡, compared with rivaroxaban group; §, adjusted risk factors of gender, smoking status; #, adjusted risk factor for smoking status; &, adjusted risk factor for gender. VKA, vitamin K antagonist; DOAC, direct oral anticoagulant; CI, confidence interval; eGFR, estimated glomerular filtration rate; LVEF, left ventricular ejection fraction.

there was no significant difference, which may be related to the small number of cases.

The mechanism underlying LV thrombus is not well understood. LV thrombus in acute MI may be associated with stasis, hypercoagulability and endocardial changes (13), which has some similarities to the left atrial thrombus caused by blood stasis caused by atrial fibrillation. It's worth mentioning that the formation mechanism of LV thrombus in anterior STEMI may be different from that in non-ischemic cardiomyopathy, as the improvement of ventricular wall motion after revascularization and medical management facilitate the resolution of LV thrombus. In this study, the proportion of patients with prior MI was 50–60%, and there was no significant difference between the two groups. However, future studies are needed to investigate the mechanism of LV thrombus caused by different etiologies and the differences in medicine efficacy. The primary indication for DOAC is anticoagulation of atrial fibrillation, which prevents the development of blood clots in addition to dissolving existing clots. DOAC may play a role in thrombosis caused by blood stasis.

There are other common non-Food and Drug Administration (FDA)-approved off-label uses of DOAC, including heart failure, superficial vein thrombosis, and pulmonary hypertension (14). The main reason for this is that DOAC has several advantages. DOAC provides patients with predictable efficacy, convenient fixed doses, fewer dietary and drug interactions, and onset of their effect is rapid and can end quickly with interruption. The dose can be adjusted based on creatinine clearance or body weight without frequent laboratory monitoring (15,16). However, the off-label use of this drug remains controversial. In patients with other conditions, such as non-valvular atrial fibrillation (17,18), DOAC has demonstrated a favorable safety profile and comparable efficacy to warfarin therapy. In addition, a potential benefit of DOAC over VKA is the statistically significant reduction in the risk of intracranial haemorrhage (19). However, warfarin remains irreplaceable in patients with mitral stenosis or mechanical heart valve replacement.

In a subgroup analysis, we compared differences in clinical outcomes among different DOAC. As edoxaban and apixaban were not introduced to our center during the study period, we only compared rivaroxaban and dabigatran. The

results showed that rivaroxaban seemed to be superior to dabigatran in 90-day and 180-day thrombus resolution, but the differences were not statistically significant. There were no significant differences in bleeding events between the two drugs. To our knowledge, no randomized controlled study has compared dabigatran with rivaroxaban for the treatment of LV thrombus. Further studies are needed to explore the efficacy and safety of different DOAC in LV thrombus treatment owing to the differences in anticoagulant mechanisms.

The present study had several limitations. First, as a single-center observational cohort study, the patients were not randomized to receive anticoagulation treatment. The selection of anticoagulation agents was at the discretion of endocrinologist, which contributed to selection bias and significant differences in covariates between the two groups. Although most variables did not show significantly differences between the two groups, and we adjusted gender and smoking status by logistics regression model, there may be potential confounding factors influencing the difference between DOAC and warfarin embolism events. Second, the standard dose of DOAC was not fully used in our study. Patients with eGFR >50 mL/min per 1.73 m^2 might be prescribed with 15–20 mg of rivaroxaban once daily or 110–150 mg of dabigatran twice daily, which may also affect the anticoagulant effect of DOAC. Third, we did not have data on adherence to DOAC and duration within the warfarin treatment range and dietary habit in patients with warfarin therapy. Exceeding the treatment range of warfarin can easily increase the risk of bleeding and thrombotic events, which might not have emerged due to the small sample size. Fourth, as only patients taking rivaroxaban or dabigatran were observed, we cannot extrapolate these findings to all DOAC. Finally, this study had a small sample size because of the low incidence of LV thrombus. No significant differences were found in major and minor bleeding events. As the number of cases increases, the difference between the two groups can be compared further. Therefore, further large-scale prospective randomized controlled studies are required.

Conclusions

This study found no significant difference in thrombotic resolution between DOAC and warfarin. DOAC might be an alternative to warfarin for the treatment of LV thrombus in Chinese patients. However, further large prospective studies are required to explore the efficacy and safety of DOAC in patients with LV thrombus.

Acknowledgments

We would like to thank Beijing Anzhen Hospital and all participants included in this study.
Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1582/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1582/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1582/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1582/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Medical Clinical Research Ethics Committee of Beijing Anzhen Hospital (No. 2022247X). Prior to enrolment, all participants completed an informed consent form.

References

1. Cruz Rodriguez JB, Okajima K, Greenberg BH. Management of left ventricular thrombus: a narrative review. Ann Transl Med 2021;9:520.
2. McCarthy CP, Vaduganathan M, McCarthy KJ, et al. Left

Ventricular Thrombus After Acute Myocardial Infarction: Screening, Prevention, and Treatment. JAMA Cardiol 2018;3:642-9.
3. Honan KA, Jogimahanti A, Khair T. An Updated Review of the Efficacy and Safety of Direct Oral Anticoagulants in Treatment of Left Ventricular Thrombus. Am J Med 2022;135:17-23.
4. Dalia T, Lahan S, Ranka S, et al. Warfarin versus direct oral anticoagulants for treating left ventricular thrombus: a systematic review and meta-analysis. Thromb J 2021;19:7.
5. Byrne RA, Rossello X, Coughlan JJ, et al. 2023 ESC Guidelines for the management of acute coronary syndromes. Eur Heart J 2023;44:3720-826.
6. Ibanez B, James S, Agewall S, et al. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J 2018;39:119-77.
7. Alcalai R, Butnaru A, Moravsky G, et al. Apixaban vs. warfarin in patients with left ventricular thrombus: a prospective multicentre randomized clinical trial‡. Eur Heart J Cardiovasc Pharmacother 2022;8:660-7.
8. Schulman S, Kearon C; . Definition of major bleeding in clinical investigations of antihemostatic medicinal products in non-surgical patients. J Thromb Haemost 2005;3:692-4.
9. Robinson AA, Trankle CR, Eubanks G, et al. Off-label Use of Direct Oral Anticoagulants Compared With Warfarin for Left Ventricular Thrombi. JAMA Cardiol 2020;5:685-92.
10. Bass ME, Kiser TH, Page RL 2nd, et al. Comparative effectiveness of direct oral anticoagulants and warfarin for the treatment of left ventricular thrombus. J Thromb Thrombolysis 2021;52:517-22.
11. Iqbal H, Straw S, Craven TP, et al. Direct oral anticoagulants compared to vitamin K antagonist for the management of left ventricular thrombus. ESC Heart Fail 2020;7:2032-41.
12. da Silva Ferreira H, Lima Lopes J, Augusto J, et al. Effect of direct oral anticoagulants versus vitamin K antagonists or warfarin in patients with left ventricular thrombus outcomes: A systematic review and meta-analysis. Rev Port Cardiol 2023;42:63-70.
13. Delewi R, Zijlstra F, Piek JJ. Left ventricular thrombus formation after acute myocardial infarction. Heart 2012;98:1743-9.
14. Brokmeier H, Kido K. Off-label Use for Direct Oral Anticoagulants: Valvular Atrial Fibrillation, Heart Failure, Left Ventricular Thrombus, Superficial Vein Thrombosis, Pulmonary Hypertension-a Systematic Review. Ann Pharmacother 2021;55:995-1009.
15. Rymer JA, Chiswell K, Young L, et al. Analysis of Oral Anticoagulant Dosing and Adherence to Therapy Among Patients With Nonvalvular Atrial Fibrillation. JAMA Netw Open 2023;6:e2317156.
16. Rose DK, Bar B. Direct Oral Anticoagulant Agents: Pharmacologic Profile, Indications, Coagulation Monitoring, and Reversal Agents. J Stroke Cerebrovasc Dis 2018;27:2049-58.
17. Martha JW, Pranata R, Raffaelo WM, et al. Direct Acting Oral Anticoagulant vs. Warfarin in the Prevention of Thromboembolism in Patients With Non-valvular Atrial Fibrillation With Valvular Heart Disease-A Systematic Review and Meta-Analysis. Front Cardiovasc Med 2021;8:764356.
18. Esteve-Pastor MA, Rivera-Caravaca JM, Ruiz-Ortiz M, et al. A comparison of front-line oral anticoagulants for the treatment of non-valvular atrial fibrillation: effectiveness and safety of direct oral anticoagulants in the FANTASIIA registry. Expert Opin Pharmacother 2022;23:1457-65.
19. Archontakis-Barakakis P, Li W, Kalaitzoglou D, et al. Effectiveness and safety of intracranial events associated with the use of direct oral anticoagulants for atrial fibrillation: A systematic review and meta-analysis of 92 studies. Br J Clin Pharmacol 2022;88:4663-75.

Cite this article as: Zhou Y, Zhang X, Lin Y, Peng W. Direct oral anticoagulants compared with warfarin in patients with left ventricular thrombus: a cohort study from China. J Thorac Dis 2024;16(2):884-892. doi: 10.21037/jtd-23-1582