

Left Ventricular Thrombus After Acute Myocardial Infarction Screening, Prevention, and Treatment

Cian P. McCarthy, MB, BCh, BAO; Muthiah Vaduganathan, MD, MPH; Killian J. McCarthy, MB, BCh, BAO;
James L. Januzzi Jr, MD; Deepak L. Bhatt, MD, MPH; John W. McEvoy, MB, BCh, MHS

IMPORTANCE Left ventricular (LV) thrombus is a complication of acute myocardial infarction (MI) and is associated with systemic thromboembolism. With randomized clinical trials investigating the optimal antithrombotic regimen in patients with MI who require concomitant chronic anticoagulation and with the emergence of the direct-acting oral anticoagulants, treatment options for post-MI LV thrombus have become more complicated. Herein, we review the epidemiology, pathogenesis, diagnosis, prevention, and treatment of LV thrombus after acute MI.

OBSERVATIONS Contemporary epidemiologic data suggest the incidence of LV thrombus, detected using optimal imaging modalities, may be as high as 15% in patients with ST-segment elevation MI and up to 25% in patients with anterior MI. While a standard transthoracic echocardiogram is commonly used for screening, it is limited by low sensitivity for LV thrombus detection, necessitating the addition of contrast (unless contraindicated) and/or use of cardiac magnetic resonance imaging when pretest probability is high. To our knowledge, there are no existing randomized clinical trials evaluating the safety and efficacy of anticoagulation in the prevention or treatment of LV thrombus after MI, and clinicians must rely on available epidemiologic and trial-generated data from related entities to guide treatment. Randomized clinical trials have confirmed that triple therapy increases bleeding rates compared with less potent antithrombotic regimens after MI, and observational data suggest that triple therapy regimens may not prevent LV thrombus formation. On the other hand, if an LV thrombus is detected, anticoagulation is essential to prevent systemic thromboembolism. We offer 1 approach to treatment, grounded in the best available data.

CONCLUSIONS AND RELEVANCE Uncertainties remain regarding the optimal screening pathway, frequency of follow-up imaging, candidate selection for thromboprophylaxis, and treatment strategies for post-MI LV thrombus. Ongoing studies from related therapeutic areas of varying antithrombotic regimens will continue to inform the optimal approach to treatment; however, more dedicated study of this clinical conundrum is also needed.

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Author Affiliations: Department of Medicine, Massachusetts General Hospital, Boston (C. P. McCarthy); Brigham and Women's Hospital Heart and Vascular Center, Harvard Medical School, Boston, Massachusetts (Vaduganathan, Bhatt); Department of Internal Medicine, Beth Israel Deaconess Medical Center, Boston, Massachusetts (K. J. McCarthy); Division of Cardiology, Massachusetts General Hospital and Baim Institute for Clinical Research, Boston (Januzzi); Division of Cardiology, Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, Maryland (McEvoy).

Corresponding Author: John W. McEvoy, MB, BCh, MHS, Johns Hopkins Coronary Care Unit and Division of Cardiology, Department of Medicine, Blalock 524C, 600 N Wolfe St, Baltimore, MD 21287 (jmcevoy1@jhmi.edu).

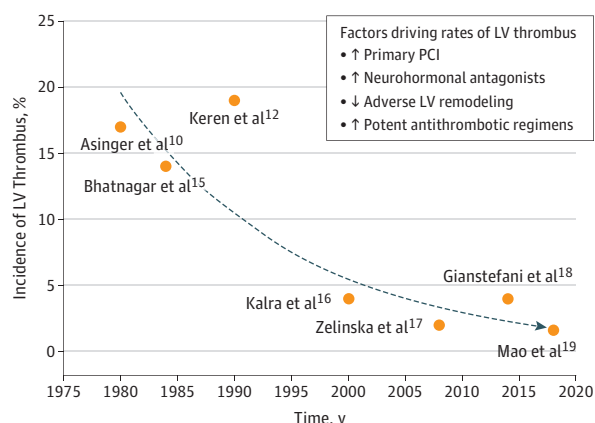
With the widespread uptake of primary percutaneous coronary intervention (PCI) and improved overall periprocedural care, survival after acute myocardial infarction (MI) has improved.¹ Despite these advances, postinfarct complications continue to be a significant cause of morbidity and mortality. Post-MI left ventricular (LV) thrombus remains relatively common, with an estimated incidence of up to 15% in the PCI era, and is met with distinct challenges in detection, prevention, and treatment.^{2,3} The addition of oral anticoagulation (OAC) to dual antiplatelet therapy (DAPT) is recommended by the American College of Cardiology Foundation/American Heart Association (AHA) guidelines in the treatment, and in certain circumstances, prevention of LV thrombus.⁴ However, with accumulating evidence now suggesting that double therapy (single antiplatelet therapy plus OAC) is associated with lower bleeding and potentially similar efficacy com-

pared with triple therapy (DAPT plus OAC) in a variety of scenarios,⁵⁻⁹ optimal antithrombotic strategies in LV thrombus may require reconsideration. Additional uncertainties exist over the use of direct-acting oral anticoagulants (DOACs) in this cohort. We review the epidemiology, pathogenesis, diagnosis, prevention, and treatment of LV thrombus after acute MI and offer guidance regarding a practical antithrombotic approach in this setting.

Epidemiology

There is substantial variation in the reported incidence of LV thrombus after MI, likely reflective of variation in the imaging modality used for diagnosis and the timing and frequency of screening. Use of revascularization techniques has clearly improved rates of LV throm-

Figure 1. Temporal Trend in Incidence of Left Ventricular Thrombus as Diagnosed by Echocardiogram



LV indicates left ventricular; PCI, primary percutaneous coronary intervention.

bus formation: in the thrombolytic era with 2-dimensional echocardiography, LV thrombus was observed in 17% of all patients after acute MI ($n = 12$ of 70),¹⁰ with the incidence up to 34% to 57% in those with anterior MI.¹⁰⁻¹³ With the introduction of PCI in the 1980s,¹⁴ the incidence of LV thrombus post-MI has declined (Figure 1).¹⁵⁻¹⁹ In a 2016 meta-analysis examining 10 076 patients with ST-segment elevation MI (STEMI), the incidence of LV thrombus (diagnosed using echocardiography) was 3% ($n = 202$ of 7471) (9% [$n = 314$ of 3447] in anterior MI).²⁰ However, the presence of LV thrombus may be missed by standard transthoracic echocardiography (TTE). Indeed, examining 200 patients with STEMI after primary PCI who underwent both contrast cardiac magnetic resonance imaging (CMR) and noncontrast TTE, Delewi et al³ found the incidence to be higher: 9% in all patients and 14% in those with anterior MI. Of the 17 thrombi visualized on CMR, only 4 were detected on TTE.³ An additional 6% of patients (12 of 194) were diagnosed as having LV thrombus on repeated CMR at 4 months, resulting in a cumulative incidence of approximately 15% overall and 25% in anterior MI.³

In light of the limited sensitivity of TTE and lack of availability of CMR in the thrombolytic era, it is thus suspected that the incidence of LV thrombus was in fact higher than reported in early studies. Nonetheless, several factors may have contributed to temporal declines in incidence of LV thrombus, including (1) greater uptake and prompt deployment of primary PCI resulting in smaller infarct sizes, (2) greater use of neurohormonal agents attenuating adverse LV remodeling, (3) fewer patients transitioning from acute MI to LV dysfunction to ischemic cardiomyopathy, and (4) greater use of more potent antithrombotic combinations (Figure 1).

Unfortunately, the incidence of systemic embolism in patients with LV thrombus has remained high. A meta-analysis in 1993 reported an incidence of systemic embolism to be approximately 9%, with a 33% absolute risk reduction with anticoagulation.²¹ A 2018 study by Maniwa et al²² of 92 patients with LV thrombus following MI found the incidence of systemic embolism to be 16% over 5 years.²² Of the 84 patients treated with warfarin, only 34 patients achieved a time in therapeutic range of at least 50%.²² In those patients, the rate of systemic embolism was actually quite low, at 3%.

In contrast, in patients with a time in therapeutic range less than 50%, the rate of systemic embolism was much higher at 19%.²²

Pathogenesis of LV Thrombus

As with all thrombus formation, Virchow triad (hypercoagulability, endothelial injury, and blood stasis) plays an important role in LV thrombus formation after MI. Tissue necrosis leads to LV dyskinesia or akinesis, with resultant intracavitary blood stasis. However, in other pathological states with similar degrees of LV systolic dysfunction, such as stress cardiomyopathy, in-hospital rates of LV thrombus have been reported as low as 1% to 2% despite infrequent use of anticoagulation (4% to 8% of patients).²³ Thus, the inciting event and myocardial substrate may modulate risk of LV thrombus formation beyond LV dysfunction alone. Subendothelial tissue injury causes inflammation and collagen exposure, serving as a nidus for platelet aggregation and activation of the clotting cascade. Indeed, persistent hypercoagulable states are observed for up to 6 months after MI.²⁴ The resultant LV thrombus is made up of fibrin, platelets, and red blood cells.²⁵

Diagnostic Modalities

Transthoracic echocardiography is the diagnostic modality most commonly used for assessing the presence, size, and shape of LV thrombus. Transthoracic echocardiography is widely available and low cost. An LV thrombus is recognizable as an echodense mass with margins distinct from the endocardium. Recently formed thrombus can be highly mobile, protruding into the ventricular cavity, whereas older thrombus tends to have a smooth cavitory surface and is typically more static; more chronic thrombus may calcify and/or develop central cavitation. The presence of an LV thrombus should be suspected contiguous to areas of LV wall akinesis or dyskinesia, especially in patients with a large infarct size and/or in those with an ejection fraction of 40% or less. Yet, despite a specificity of 95% to 98%, a low sensitivity of approximately 21% to 35% for LV thrombus diagnosis^{3,26,27} suggests that many thrombi will be missed using TTE alone. The addition of intravenous contrast to TTE may improve delineation of the LV endocardial border facilitating improved sensitivity (approximately 64%), while providing similar specificity (Table 1).²⁷ The utility of transesophageal echocardiography for diagnosing LV thrombus is limited because the apex is often not well visualized.²⁶

The most accurate modality for diagnosing LV thrombus is delayed-enhancement CMR, with a sensitivity of 82% to 88% and specificity of 99% to 100% (relative to surgical or pathological validation).²⁶ Gadolinium contrast will demonstrate uptake within infarcted and, to a lesser extent, viable myocardium, but not in thrombi owing to their avascular composition. Nevertheless, cost, availability, and technical expertise have limited its widespread use. Screening algorithms have been proposed that use the extent of wall-motion abnormalities on TTE to trigger consideration of subsequent imaging with CMR.²⁷ High apical LV wall motion scores yield sensitivity approaching 100% and specificity greater than 60% and low apical LV wall motion scores allow appropriate avoidance of further testing in a large proportion of patients. How-

Table 1. Imaging Modalities Used to Diagnose Left Ventricular Thrombus

Imaging Modality	% Range		Predictive Value		References
	Sensitivity	Specificity	Positive	Negative	
Noncontrast transthoracic echocardiogram ^a	21-35	95-98	67	94	Delewi et al, ³ Srichai et al, ²⁶ Weinsaft et al ²⁷
Contrast transthoracic echocardiogram, ^a No. (%)	9 (64)	174 (99)	9 (82)	174 (97)	Weinsaft et al ²⁷
Transesophageal echocardiogram, ^b No. (%)	39 (39)	232 (97)	39 (87)	232 (79)	Srichai et al ²⁶
Delayed-enhancement cardiac magnetic resonance imaging ^b	82-88	99-100	100	98	Delewi et al, ³ Srichai et al ²⁶

^a Noncontrast and contrast transthoracic echocardiogram compared with cardiac magnetic resonance imaging^{3,27} or surgical/pathological validation.²⁶

^b Transesophageal echocardiogram and delayed-enhancement cardiac magnetic resonance imaging compared with surgical/pathological validation.²⁶

Table 2. Guidelines on the Prevention and Treatment of Left Ventricular Thrombus

Guidelines	Recommendation	Target INR	Duration of Therapy, mo	Class of Recommendation	Level of Evidence
Prevention					
2013 ACCF/AHA STEMI	Anticoagulation may be considered in patients with STEMI with anterior apical akinesis or dyskinesis	Target INR 2.0 to 2.5 may be considered when combining with DAPT	3	IIb	C
2014 AHA/ASA stroke prevention	Treatment with vitamin K antagonist may be considered in patients with ischemic stroke or TIA in the setting of acute anterior STEMI with anterior apical akinesis or dyskinesis	2.5 (Range, 2.0-3.0)	3	IIb	C
2017 ESC STEMI	No recommendation provided	NA	NA	NA	NA
Treatment					
2013 ACCF/AHA STEMI	Anticoagulant therapy with a vitamin K antagonist is reasonable for patients with STEMI and asymptomatic LV mural thrombi	2.0 to 2.5 When combining with DAPT	3	IIa	C
2014 AHA/ASA stroke prevention	Treatment with vitamin K antagonist therapy is recommended in most patients with ischemic stroke or TIA in the setting of acute MI complicated by LV mural thrombus	2.5 (Range, 2.0-3.0)	3	I	C
2017 ESC STEMI	Oral anticoagulation should be considered, guided by repeated echocardiography and with consideration of bleeding risk and need for concomitant antiplatelet therapy	Not provided	6	IIa	C

Abbreviations: AHA, American Heart Association; ACCF, American College of Cardiology Foundation; ASA, American Stroke Association; DAPT, dual antiplatelet therapy; ESC, European Society of Cardiology; INR, international normalized ratio; LV, left ventricular; NA, not applicable; STEMI, ST-segment elevation myocardial infarction; TIA, transient ischemic attack.

ever, specific clinical pathways require further validation prior to widespread application.

Prevention

Identifying safe and effective strategies to prevent and treat post-MI LV thrombus remains worthwhile. Unfortunately, to date, there have been no randomized clinical trials (RCTs) evaluating the safety and efficacy of OAC in this setting. Given the declining incidence of LV thrombus, such dedicated RCTs appear unlikely to occur, and thus we rely on available data from related entities to guide treatment.

The 2013 American College of Cardiology Foundation/AHA STEMI guidelines advise that OAC may be considered in patients with STEMI with anterior apical akinesis or dyskinesis to prevent LV thrombus formation (Table 2).⁴ Similarly, the AHA/American Stroke Association 2014 guidelines on stroke prevention advise that anticoagulation may be considered for 3 months in patients with acute anterior STEMI and ischemic stroke or transient ischemic attack who have anterior apical akinesis or dyskinesis.²⁸ In contrast, the European Society of Cardiology 2017 STEMI guidelines do not provide any mention or recommendation on strategies to prevent LV thrombus formation.²⁹

The evidence supporting these recommendations originates from older observational data. In 1993, a meta-analysis²¹ reported

a 5.5-fold increased relative risk of emboli in patients with acute anterior MI and LV thrombus compared with those without LV thrombus.²¹ The authors found a 68% lower risk of mural thrombus formation in patients with anterior MI who received anticoagulation.²¹ However, this meta-analysis was performed prior to the modern reperfusion era, without concomitant DAPT use, and the complications of anticoagulation were not reported. As a result, the possible benefit of anticoagulation in these cohorts must now be balanced against the considerable bleeding risk associated with anticoagulation in patients who additionally require DAPT.^{5,6}

Data from 2015 to 2017 have suggested potentially less demonstrable benefits with OAC in the prevention of LV thrombus. In an observational study of 460 patients with anterior STEMI and apical akinesis or dyskinesis who underwent PCI, Le May et al³⁰ compared outcomes in patients who did and did not receive warfarin.³⁰ Compared with patients in the no warfarin group, patients treated with warfarin had higher rates of composite all-cause mortality, stroke, reinfarction, and major bleeding within 180 days (15% vs 5%), death (5% vs 2%), stroke (3% vs 0.3%), and major bleeding (9% vs 2%).³⁰ There were no differences in LV thrombus formation between groups. In a similar observational study undertaken by Shavadia et al³¹ of 398 patients with anterior STEMI with LV dysfunction, prophylactic warfarin use was not associated with lower composite end point of recurrent ischemia, stroke/transient ischemic attack/systemic embolism, or all-cause death but was associated with higher major bleeding rates at 1 year (2.5% vs 1.2%).³¹ In a secondary analysis of the Harmonizing Outcomes With Revascularization and Stents in Acute Myocardial Infarction (HORIZONS-AMI) trial,⁵ OAC was commonly prescribed for severely reduced LV ejection fraction with a large akinetic area ($n = 30$ of 126 [24%]), atrial fibrillation ($n = 30$ of 126 [24%]), and mural thrombus ($n = 29$ of 126 [23%]).⁵ Patients treated with triple therapy vs DAPT had comparable ischemic outcomes but had significantly increased rates of major in-hospital bleeding (17% vs 7%; $P < .001$).⁵

Randomized clinical trials evaluating the adjunctive role of OAC after MI have largely corroborated these observational findings. Although not specifically undertaken to assess efficacy of LV thrombus prevention, the Apixaban for Prevention of Acute Ischemic Events 2 (APPRAISE-2) trial raised concerns of bleeding with triple therapy after MI.³² The investigators found that the addition of full-dose apixaban (5 mg, twice daily) to DAPT in patients with acute coronary syndrome (ACS) with at least 2 additional risk factors for recurrent ischemic events increased the risk of major bleeding events from 0.5% to 1.3% ($P = .001$) without reducing major adverse cardiovascular events.³² In the Anti-Xa Therapy to Lower Cardiovascular Events in Addition to Standard Therapy in Subjects With Acute Coronary Syndrome 2-Thrombolysis in Myocardial Infarction 51 (ATLAS ACS 2-TIMI 51) trial, the addition of reduced doses of rivaroxaban to DAPT after STEMI reduced a composite of cardiovascular death, MI, or stroke from 10.6% to 8.4% ($P = .02$) but increased major bleeding (2.2% vs 0.6%; $P < .001$) and intracranial hemorrhage (0.6% vs 0.1%; $P = .02$).³³ However, the 2.5-mg twice-daily dose of rivaroxaban when added largely to a background of aspirin and clopidogrel significantly reduced the rate of all-cause mortality vs placebo.

The use of prophylactic anticoagulation to prevent ischemic events has also been investigated in heart failure. In the Warfarin

vs Aspirin in Reduced Cardiac Ejection Fraction (WARCEF) study, among patients with heart failure and LV ejection fraction of 35% or less in sinus rhythm, warfarin reduced the risk of ischemic stroke compared with aspirin; however, this was offset by an increased risk of major hemorrhage.³⁴ In 2017, the Cardiovascular Outcomes for People Using Anticoagulation Strategies (COMPASS) trial demonstrated that rivaroxaban (2.5 mg twice daily) reduced the risk of ischemic events compared with placebo on a background of low-dose aspirin in a broad population of patients with stable coronary or peripheral artery disease.³⁵⁻³⁸ Interestingly, ischemic stroke was also significantly reduced, as was cardiovascular mortality. Whether a similar strategy of low-dose DOAC in addition to a single antiplatelet agent is also effective in the prevention of LV thrombus is an interesting, although as yet untested, possibility.

Treatment

The 2013 American College of Cardiology Foundation/AHA STEMI guidelines advise that it is reasonable to add OAC to DAPT among patients with STEMI and asymptomatic LV thrombus for 3 months, targeting a lower international normalized ratio (INR) goal of 2.0 to 2.5 (Table 2).⁴ The AHA/American Stroke Association 2014 stroke prevention guidelines recommend a similar duration, targeting a higher INR of 2.5.²⁸ The European Society of Cardiology 2017 STEMI guidelines advise that once an LV thrombus is diagnosed, OAC should be considered for up to 6 months, guided by repeated echocardiography and with consideration of bleeding risk and need for concomitant antiplatelet therapy.²⁹ The guidelines acknowledge the lack of prospective RCT data in this area.²⁹

While to our knowledge, there are no RCTs comparing double therapy (single antiplatelet agent plus OAC) with triple therapy in patients with ACS with an LV thrombus, several RCTs suggest that a single antiplatelet agent is associated with a reduced bleeding risk with potentially similar efficacy compared with DAPT in patients with ACS on concomitant OAC for alternative reasons.^{7,8,39} For instance, in the Randomized Evaluation of Dual Antithrombotic Therapy with Dabigatran vs Triple Therapy With Warfarin in Patients With Nonvalvular Atrial Fibrillation Undergoing Percutaneous Coronary Intervention (RE-DUAL PCI) trial, among 2725 patients with atrial fibrillation undergoing PCI (51% for ACS), double therapy (comprising dabigatran, 110 mg, twice daily plus a P2Y₁₂ inhibitor) was associated with reduced major or clinically relevant nonmajor bleeding rates compared with triple therapy (15% vs 27%).⁶ Additionally, double therapy was associated with similar rates of composite thromboembolic events, death, MI/stent thrombosis, and unplanned revascularization compared with triple therapy.⁶ Ongoing trials (ClinicalTrials.gov identifiers: NCT02415400 and NCT02866175) are investigating similar strategies with apixaban and edoxaban and will continue to expand our understanding of the composite safety and efficacy of DOACs in combination regimens.

It is important to recognize that all contemporary trials evaluating triple vs double antithrombotic regimens were not powered to definitively assess these ischemic efficacy end points; such a trial in the contemporary era would require much larger samples followed for prolonged durations.

Direct Oral Anticoagulants

The need for frequent monitoring, slow onset, narrow therapeutic range, dietary restrictions, and multiple drug interactions associated with warfarin have contributed to increasing uptake of DOACs worldwide.^{40,41} Additionally, DOACs may achieve more consistent anticoagulant effects with an up to 50% reduced risk of intracranial hemorrhage.⁴² This favorable pharmacologic and clinical profile makes the use of DOACs attractive in patients with known or suspected LV thrombus.

The formation of an LV thrombus is similar to that of a left atrial appendage thrombus, occurring in a low-flow and low-shear environment; this contrasts with thrombus formation in the setting of mechanical heart valves, which is predominantly contact-pathway mediated.⁴³ Given the efficacy of DOACs in patients with atrial fibrillation and venous thromboembolism,⁴⁴⁻⁵⁰ it is thus reasonable to assume their efficacy in patients with LV thrombus, while thrombotic situations with heavy contact-pathway activation (mechanical valves and LV assist devices⁵¹) continue to warrant warfarin. Indeed, there are now several case reports reporting LV thrombus resolution with apixaban,^{52,53} rivaroxaban,⁵⁴⁻⁵⁷ and dabigatran.⁵⁸

Lower doses of DOACs have been studied for extended-duration thromboprophylaxis after hospitalization in medically ill patients and have suggested potential therapeutic effects on stroke risk. For instance, among 7513 hospitalized patients, extended-duration thromboprophylaxis with the factor Xa inhibitor betrixaban resulted in fewer strokes (0.5% vs 1%) compared with enoxaparin during a 2- to 3-month follow-up.⁵⁹ The COMMANDER-HF trial is currently randomizing patients with chronic heart failure, LV ejection fraction 40% or less, and concomitant significant coronary artery disease to rivaroxaban, 2.5 mg, twice daily vs placebo, and will likely provide more insight into low-dose DOAC efficacy in thromboprophylaxis in at-risk patients.⁶⁰

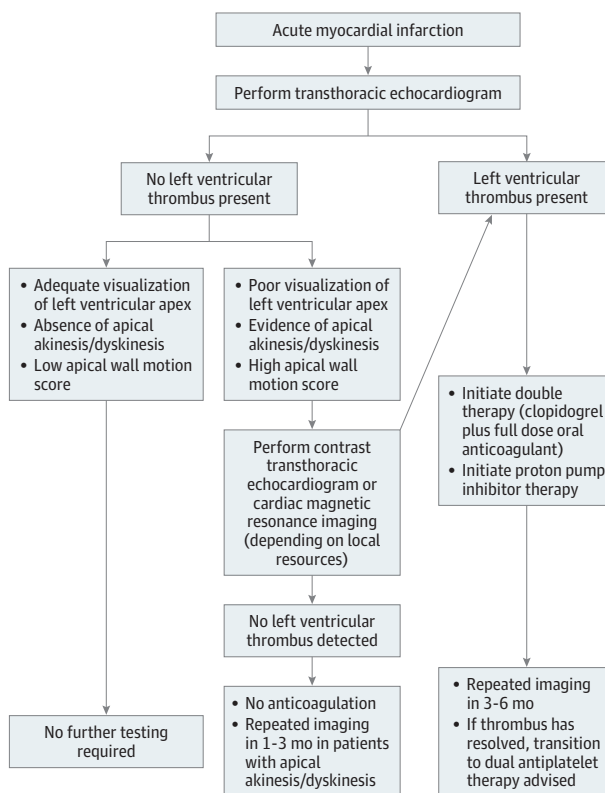
In 2014, the AHA/American Stroke Association guidelines on stroke prevention introduced a new recommendation advising that low-molecular-weight heparin, dabigatran, rivaroxaban, or apixaban may be considered as an alternative to vitamin K antagonists for post-MI LV thrombus or anterior or apical wall-motion abnormalities with an LV ejection fraction less than 40%, who are intolerant of vitamin K antagonists because of nonhemorrhagic adverse events (Class IIb; Level of Evidence: C).²⁸

Screening, Prevention, and Treatment of LV Thrombus: A Practical Approach

Screening

Cardiac magnetic resonance imaging remains the criterion standard diagnostic modality; however, cost and availability limit its widespread utility. As such, standard TTE is typically the screening modality of choice and should be performed within 24 hours of admission in those at high risk for apical LV thrombus (eg, those with large or anterior MI or those receiving delayed reperfusion). If (1) the LV apex is poorly visualized, (2) anterior or apical wall motion abnormalities are present, or (3) high apical wall motion scores are cal-

Figure 2. A Practical Approach to Left Ventricular Thrombus Diagnosis and Treatment



culated (≥ 5 on noncontrast TTE²⁷), contrast TTE or CMR should be considered based on local availability and resources (Figure 2), although this screening algorithm warrants further evaluation.

Prophylaxis

Randomized clinical trials have confirmed that triple therapy increases clinically significant bleeding rates compared with less potent antithrombotic regimens, and observational data have suggested these intensive regimens may not lower risk of LV thrombus formation in the modern era.^{30,61} As such, limiting the use and duration of triple antithrombotic therapy appears worthwhile. In patients without a known LV thrombus on initial imaging, one approach may involve serial imaging of patients with STEMI with anterior apical akinesis or dyskinesis, with a repeated TTE or CMR at 1 to 3 months after MI. In patients who do not have evidence of LV thrombus on serial imaging, the addition of OAC could be omitted. The COMMANDER-HF trial may provide more clarity on the prophylactic use of low-dose OAC in patients with severe LV dysfunction; however, until further data are available, the role of OAC, even at lower doses, in at-risk patients during this period of serial imaging is uncertain.

Treatment

In patients with a diagnosed LV thrombus, OAC should be started immediately. Given high risks of stroke and systemic thromboembolism, we would recommend bridging with a parenteral anticoagulant until a therapeutic INR (2.0-3.0) is achieved for 24 hours

when newly initiating warfarin. If using either dabigatran or edoxaban, 5 days of parenteral anticoagulation overlap is reasonable before starting oral therapy alone.^{50,62,63} While bridging with parenteral anticoagulation is not required for apixaban or rivaroxaban, higher initial loading doses may be warranted, consistent with clinical practical guidelines for venous thromboembolism.⁶³ If the LV thrombus is large or highly mobile, unfractionated heparin infusion with close in-hospital monitoring may be considered in select cases.

If an LV thrombus is detected, double therapy, using a P2Y₁₂ inhibitor combined with full-dose warfarin (goal INR, 2.0-3.0), may be preferred vs triple therapy in light of accumulating evidence suggesting reduced bleeding risks of this approach (Figure 2). In patients in whom achieving therapeutic anticoagulation with warfarin is expected to be a challenge (ie, nonadherence to dietary restrictions or frequent INR checks or multiple drug interactions), a full-dose DOAC would be preferred. When used in combination with an OAC, clopidogrel may be preferred vs aspirin and vs more potent P2Y₁₂ inhibitors. Indeed, in RE-DUAL PCI, among patients in the double therapy arm, dabigatran plus ticagrelor was associated with higher major and nonmajor clinically relevant bleeding, and a higher composite event rate of thromboembolic events/death/unplanned revascularization compared with clopidogrel plus dabigatran, a finding consistent in both dabigatran dosing arms, although that could be attributable to higher baseline risk.⁶ Furthermore, in patients receiving clopidogrel as the single antiplatelet agent (ie, in whom aspirin has been discontinued), there might be a role for platelet function testing, although randomized trials are needed. In patients at high risk of recurrent MI or stent thrombosis (very high-risk lesion, suboptimal stent placement, or history of stent thrombosis), a short course (eg, 1 month) of triple therapy might be considered when balanced against the risk of bleeding, for which bleeding risk scores may be helpful.²⁹ Lower doses of OAC should not be used in patients with known LV thrombus given uncertain efficacy.

Gastroprotection and Bleeding Reduction Strategies

In addition to less potent antithrombotic regimens, adjunctive bleeding reduction or avoidance strategies should be considered. Gastrointestinal bleeding represents 1 of the most frequent sources of clinically relevant bleeding in patients treated with combination an-

tithrombotic therapies.^{7,39} Although the effects of various antithrombotic agents may vary with respect to site of gastrointestinal bleeding,⁶⁴ general gastroprotective strategies may reduce overall bleeding potential. The role of proton-pump inhibitor therapy in patients treated with aspirin and DOAC is being studied in the second randomization strata of the COMPASS trial.⁶⁵ While awaiting these data, and consistent with clinical practice guidelines for STEMI,²⁹ it is reasonable to treat all patients with proton-pump inhibitor therapy while receiving combination antithrombotic regimens.

Duration of Therapy

Double therapy should be administered for a minimum of 3 months, at which point repeated imaging should be performed. If the LV thrombus has resolved, a transition to DAPT is then advised, which should be continued for at least 1 year. Select patients may have adherent or well-organized thrombus or spontaneous echocontrast in areas of persistent significant wall-motion abnormalities that is visualized on serial imaging despite therapeutic OAC. The optimal duration of OAC in these patients is unclear, and decisions regarding continuation of OAC should be made on a case-by-case basis.

Conclusions

Despite advances in PCI and medical therapies, LV thrombus formation remains a challenging complication of acute MI. Early detection, which is heavily reliant on the sensitivity of imaging modality used for screening, is important to prevent the high rates of thromboembolic complications associated with established LV thrombus. Uncertainties remain regarding the optimal screening pathway, frequency of imaging, candidate selection for thromboprophylaxis, and antithrombotic regimens for treatment. We offer 1 approach, grounded in the best available, but limited, data that emphasizes safe and prompt treatment. Nevertheless, with a lack of clear RCT data and great variability in the presentation and associated complications of LV thrombus, individualized approaches will continue to be necessary. Ongoing studies from related therapeutic areas of varying antithrombotic regimens will continue to inform the optimal antithrombotic strategy for LV thrombus.

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Drafting of the manuscript: C. McCarthy, Vaduganathan, K. McCarthy, Januzzi Jr.

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Communications (editor in chief, *Journal of Invasive Cardiology*), *Journal of the American College of Cardiology* (guest editor; associate editor), Population Health Research Institute (clinical trial steering committee), Slack Publications (chief medical editor, *Cardiology Today's Intervention*), Society of Cardiovascular Patient Care (Secretary/Treasurer), WebMD (CME steering committees); has other relationships with Clinical Cardiology (deputy editor), NCDR-ACTION Registry Steering Committee (chair), VA CART Research and Publications Committee (chair); receives research funding from Abbott, Amarin, Amgen, AstraZeneca, Bristol-Myers Squibb, Chiesi, Eisai, Ethicon, Forest Laboratories, Ironwood, Ischemix, Lilly, Medtronic, Pfizer, Roche, Sanofi Aventis, and The Medicines Company; receives royalties from Elsevier (editor, *Cardiovascular Intervention: A Companion to Braunwald's Heart Disease*); is site coinvestigator for Biotronik, Boston Scientific, and St Jude Medical (now Abbott); is a trustee for the American College

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