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ORIGINAL RESEARCH

Echocardiographic Algorithm for Post–Myocardial Infarction LV Thrombus

A Gatekeeper for Thrombus Evaluation by Delayed Enhancement CMR

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ABSTRACT

OBJECTIVES The goal of this study was to determine the prevalence of post-myocardial infarction (MI) left ventricular (LV) thrombus in the current era and to develop an effective algorithm (predicated on echocardiography [echo]) to discern patients warranting further testing for thrombus via delayed enhancement (DE) cardiac magnetic resonance (CMR).

BACKGROUND LV thrombus affects post-MI management. DE-CMR provides thrombus tissue characterization and is a well-validated but an impractical screening modality for all patients after an MI.

METHODS A same-day echo and CMR were performed according to a tailored protocol, which entailed uniform echo contrast (irrespective of image quality) and dedicated DE-CMR for thrombus tissue characterization.

RESULTS A total of 201 patients were studied; 8% had thrombus according to DE-CMR. All thrombi were apically located; 94% of thrombi occurred in the context of a left anterior descending (LAD) infarct-related artery. Although patients with thrombus had more prolonged chest pain and larger MI ($p \leq 0.01$), only 18% had aneurysm on echo (cine-CMR 24%). Noncontrast (35%) and contrast (64%) echo yielded limited sensitivity for thrombus on DE-CMR. Thrombus was associated with stepwise increments in basal → apical contractile dysfunction on echo and quantitative cine-CMR; the echo-measured apical wall motion score was higher among patients with thrombus ($p < 0.001$) and paralleled cine-CMR decrements in apical ejection fraction and peak ejection rates (both $p < 0.005$). Thrombus-associated decrements in apical contractile dysfunction were significant even among patients with LAD infarction ($p < 0.05$). The echo-based apical wall motion score improved overall performance (area under the curve 0.89 ± 0.44) for thrombus compared with ejection fraction (area under the curve 0.80 ± 0.61; $p = 0.01$). Apical wall motion partitions would have enabled all patients with LV thrombus to be appropriately referred for DE-CMR testing (100% sensitivity and negative predictive value), while avoiding further testing in more than one-half (56% to 63%) of patients.

CONCLUSIONS LV thrombus remains common, especially after LAD MI, and can occur even in the absence of aneurysm. Although DE-CMR yielded improved overall thrombus detection, apical wall motion on a noncontrast echocardiogram can be an effective stratification tool to identify patients in whom DE-CMR thrombus assessment is most warranted. (Diagnostic Utility of Contrast Echocardiography for Detection of LV Thrombi Post ST Elevation Myocardial Infarction; NCT00539045) (J Am Coll Cardiol Img 2016;9:505–15) © 2016 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

CI = confidence interval

CMR = cardiac magnetic resonance

ECG = electrocardiogram

EF = ejection fraction

LAD = left anterior descending

LV = left ventricular

LVEF = left ventricular ejection fraction

MI = myocardial infarction

OR = odds ratio

ROC = receiver-operating characteristic

TI = inversion time

Left ventricular (LV) thrombus is an important complication of acute myocardial infarction (MI) that impacts embolic event risk and anticoagulant therapy. Echocardiograms (echo) are widely used to assess post-MI LV structure and function but can be limited for LV thrombus in the context of poor image quality or advanced LV remodeling (1,2). Delayed enhancement (DE) cardiac magnetic resonance (CMR) identifies thrombus based on avascular tissue properties, an approach shown to markedly improve detection of thrombus (1–5). However, widespread use of DE-CMR as an initial screening modality for thrombus would entail significant costs and be clinically prohibited for a substantial number of post-MI patients.

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Improved understanding of post-MI thrombus in the current era is critical for optimization of diagnostic testing strategies. Advances in MI management, including prompt and effective coronary reperfusion, have yielded improvements in LV function and remodeling. Widespread use of antiplatelet agents may potentiate the benefits of reperfusion, thereby lessening the likelihood of LV thrombus. However, the risk for thrombus still persists, especially for patients with infarctions in high-risk regions such as the LV apex. Uncertainty regarding the current prevalence and pathophysiology of thrombus limits the ability to develop practical and effective imaging strategies for the millions of post-MI patients at risk for LV thrombus and its complications.

The present study used a tailored multimodality imaging protocol (including state-of-the-art echo and CMR) to examine post-MI LV thrombus. The goals of the study were: 1) to determine the prevalence and predictors of thrombus; 2) to assess the diagnostic performance of optimized current testing strategies (noncontrast and contrast echo) to a reference standard of DE-CMR tissue characterization; and 3) to develop an effective testing algorithm, predicated on routine noncontrast echo findings, to identify post-MI patients warranting further testing for LV thrombus via DE-CMR.

METHODS

STUDY POPULATION. The population comprised patients with acute MI enrolled in a prospective study focused on LV thrombus. Patients were eligible for inclusion if admitted with acute ST-segment elevation MI (≥1.0 mm in at least 2 contiguous electrocardiogram [ECG] leads). Patients with contraindications to CMR (e.g., glomerular filtration rate <30 ml/min/1.73 m^2, ferromagnetic implants, New York Heart Association functional class IV) or taking warfarin (at the time of CMR) were excluded; no patients were excluded based on MI treatment. Patients were approached for study participation using a random selection algorithm targeted for maximum recruitment of 1 patient per week. Participants were similar to nonparticipants with respect to infarct-related artery and MI treatment strategy (both p = NS). Comprehensive clinical data were collected at the time of MI, including cardiac risk factors, coronary artery disease history, and medications. Coronary angiograms were reviewed for infarct culprit vessel.

The present study was conducted at Weill Cornell Medical College with approval of the institutional review board. Participants provided written informed consent for study participation.

IMAGING PROTOCOL. Imaging was performed at a target of 30 days (minimum 7 days) after MI. In accordance with the research protocol, CMR and echo were performed within 24 h by dedicated technologists. Testing included the following: 1) noncontrast echo; 2) contrast echo; 3) cine-CMR; and 4) DE-CMR. To identify factors predicting incremental utility of tailored imaging for thrombus, a contrast echo was performed in all patients (without clinical contraindication) irrespective of image quality or findings of noncontrast echo. Similarly, DE-CMR testing included dedicated imaging using a previously validated long inversion time (long TI) pulse sequence tailored to null LV thrombus (1,2,6).

Cardiac magnetic resonance. CMR was performed using 1.5-T scanners (GE Healthcare, Waukesha, Wisconsin). Cine-CMR used a steady-state free precession pulse sequence. Gadolinium was subsequently administered (0.2 mmol/kg), and DE-CMR was performed 10 to 30 min thereafter using an inversion recovery pulse sequence. Cine-CMR and DE-CMR images were obtained in matching short- and long-axis planes. Contiguous short-axis images were acquired from the level of the mitral annulus through the apex. Long-axis images were acquired in 2-, 3-, and 4-chamber orientations. DE-CMR included standard (TI 250 to 350 ms) imaging for MI, and long TI (TI 600 ms) imaging for dedicated identification of LV thrombus; both were acquired using segmented imaging. Standard and long TI DE-CMR were acquired in matching LV long-axis orientations at equivalent spatial resolution (mean in-plane 1.9 × 1.4 mm).

Echocardiography. Transthoracic echoes were performed by experienced sonographers using commercial equipment (Vivid 7 [GE Healthcare] and Acuson