Expert Review on the Prognostic Role of Echocardiography after Acute Myocardial Infarction

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Acute myocardial infarction (AMI) remains a leading cause of morbidity and mortality worldwide, placing a major economic and resource burden on public health systems. During hospitalization, all AMI patients should be evaluated with transthoracic echocardiography, a noninvasive, low-cost, and easily available bedside imaging tool that allows the detection of myocardial walls involved in the ischemic process, damage extent, functional consequences, and mechanical complications. Moreover, and more importantly, transthoracic echocardiography can provide information on short- and long-term outcomes after AMI. The purpose of this review is to clarify the role of standard and advanced echocardiographic parameters for an early identification of patients at high risk for developing adverse events and mortality after AMI. Standard echocardiography (in particular left ventricular ejection fraction, wall motion score index, and diastolic measurements including E velocity deceleration time and E/e′ ratio) proposes powerful parameters for risk stratification after AMI. Advanced echocardiographic technologies, in particular speckle-tracking–derived longitudinal strain, coronary flow velocity reserve, and myocardial contrast echocardiography (contrast defect index), can provide additional prognostic value beyond standard techniques. Therefore, echocardiography plays a fundamental role in predicting short- and long-term prognosis, and a more accurate risk stratification of patients may be useful to drive therapy and follow-up after AMI. Accordingly, a comprehensive echocardiography-based algorithm would be welcome for an early stratification of cardiovascular risk in patients experiencing AMI. (J Am Soc Echocardiogr 2017;30:431-43.)

Keywords: Acute myocardial infarction, Echocardiography, Doppler, Speckle-tracking echocardiography, Myocardial contrast agents, Real-time three-dimensional echocardiography

The use of transthoracic echocardiography in the coronary care unit has several advantages including easy availability and applicability at bedside, low cost, fast performance, and safety. In case of suspected acute myocardial infarction (AMI), echocardiography can identify regional wall motion abnormalities (WMAs), suggestive of myocardial ischemia or necrosis, and rule out alternative pathologies associated with chest pain such as acute aortic dissection, pericardial effusion, aortic valve stenosis, hypertrophic cardiomyopathy, or right ventricular (RV) dilation due to pulmonary embolism. Echocardiography also has an immediate impact on therapeutic decision making. In fact, it identifies patients with post-AMI mechanical complications who require life-saving surgical intervention. Diagnostic accuracy of standard echocardiography may be further improved by the application of advanced ultrasound technologies such as speckle-tracking echocardiography (STE), myocardial contrast echocardiography (MCE), and real-time three-dimensional (3D) echocardiography (RT3DE).[1] STE may even predict acute coronary occlusion in patients with non-ST-elevation myocardial infarction (NSTEMI) who do not present major electrocardiogram (ECG) abnormalities but urgently need revascularization.[2] Both American and European guidelines that deal with the management of NSTEMI and ST-elevation myocardial infarction (STEMI) recommend echocardiography as the elective cardiac imaging modality for identifying patients at high risk for adverse short-term (during hospitalization) and long-term (after hospital discharge) cardiovascular events, in particular reinfarction and death.[3-6] Accordingly, echocardiographic assessment of infarct size and left ventricular (LV) function at rest should be performed before discharge. Repeated assessment of LV ejection fraction (LVEF), also soon after discharge, is also needed in patients with life-threatening arrhythmias to select appropriate candidates for cardioverter defibrillator. In post-AMI patients (4–6 weeks after the acute event), pharmacological stress echocardiography (SE) is also considered as an alternative to myocardial perfusion scintigraphy to detect inducible myocardial ischemia and viability, two factors that further stratify prognosis and address management in this clinical setting.

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Abbreviations

2D = Two-dimensional

3D = Three-dimensional

ACEi = Angiotensin-converting enzyme inhibitors

AF = Atrial fibrillation

AMI = Acute myocardial infarction

CDI = Contrast defect index

CFVR = Coronary flow velocity reserve

COSTAMI = Cost of Strategies after Myocardial Infarction

CTDI = Color tissue Doppler imaging

CV = Cardiovascular

DT = Deceleration time

ECG = Electrocardiogram

EDV = End-diastolic volume

EF = Ejection fraction

ESV = End-systolic volume

GLS = Global longitudinal strain

GLSr = Global longitudinal strain rate

HF = Heart failure

HR = Hazard ratio

ICD = Implantable cardioverter defibrillator

LA = Left atrial, atrium

LAVi = Left atrial volume index

LS = Longitudinal strain

LV = Left ventricular, ventricle

LVEF = Left ventricular ejection fraction

MAPSE = Mitral annular plane systolic excursion

MCE = Myocardial contrast echocardiography

MR = Mitral regurgitation

NSTEMI = Non-ST-elevation myocardial infarction

OR = Odds ratio

PASP = Pulmonary artery systolic pressure

PCI = Percutaneous coronary intervention

RFP = Restrictive filling pattern

RT3DE = Real-time three dimensional echocardiography

RV = Right ventricular, ventricle

RVFAC = Right ventricular fractional area change

RWT = Relative wall thickness

SCD = Sudden cardiac death

SE = Stress echocardiography

STE = Speckle-tracking echocardiography

STEMI = ST-elevation myocardial infarction

TAPSE = Tricuspid annular plane systolic excursion

TDI = Tissue Doppler imaging

WMA = Wall motion abnormality

WMSI = Wall motion score index

The prognostic value of several echo measurements after AMI has been documented. They include mainly two-dimensional (2D) and Doppler ultrasound but also advanced echocardiographic techniques. Nevertheless, their importance has not been completely underlined. In this review, we highlight the role and potentialities of both standard and advanced echocardiographic techniques in identifying high-risk patients and also propose a final comprehensive echo exam that is able to stratify the prognosis early after AMI (within 2 weeks after AMI).

STANDARD ECHOCARDIOGRAPHIC TECHNOLOGIES

Motion-Mode

Motion mode (M-mode) provides high temporal and spatial resolution of tissue motion along a single ultrasound beam. The assessment of LV mass and geometry is one of the most important clinical applications of M-mode. The prognostic role of LV mass has been shown after AMI. In 603 patients with AMI complicated by LV systolic dysfunction, heart failure (HF), or both, each 10-g/m^2 increase in LV mass index and each 0.1-unit increase in relative wall thickness (RWT) were independently associated with all-cause mortality, cardiovascular (CV) death, and HF hospitalization. Among LV geometric patterns, concentric LV hypertrophy showed a stronger association with CV mortality, HF, reinfarction, stroke, and sudden cardiac death (SCD).[7] M-mode can also provide information on LV longitudinal systolic function through the quantitation of atrioventricular plane displacement, since during cardiac systole, the atrioventricular plane moves towards the apex. In 271 patients with AMI, reduced mitral annular plane systolic excursion (MAPSE) was independently associated with all-cause mortality, HF hospitalization, reinfarction, and unstable angina; the incidence of death was 31.3% in patients with MAPSE $<$8 mm and 10.1% in those with MAPSE $>$8 mm.[8] In addition, tricuspid annular plane systolic excursion (TAPSE) was an independent predictor of mortality after AMI, with the incidence of death being 4% in the presence of TAPSE $\geq$20 mm, 9% with TAPSE = 16–19 mm, and 45% with TAPSE $\leq$15 mm.[9] However, M-mode has intrinsic limitations for assessing AMI patients. Mainly, the analysis of regional WMA is limited to only two walls (anterior septum and posterior wall), and no information is obtainable on evidence and magnitude of LV global systolic dysfunction.[10] Accordingly, M-mode echo is only an adjunct to other echocardiographic techniques after AMI.

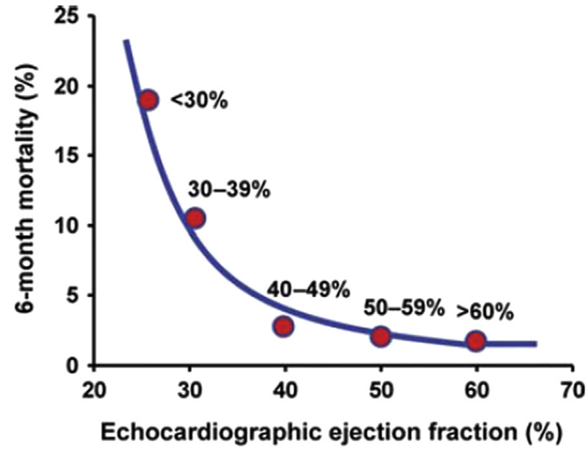

Figure 1 Hyperbolic inverse relation between LVEF and 6-month all-cause mortality after AMI. EF values drive patient management, with those > 40% being in the ischemia domain and those < 35% in the viability domain. (Modified from Volpi *et al.*[13]).

Two-Dimensional Echocardiography

The assessment of cardiac chamber size and function by 2D echocardiography provides very important prognostic information after AMI. The most used parameter is LVEF, which is obtained as the percent ratio between stroke volume and end-diastolic volume (EDV). LVEF has a very well established short-term[11] and long-term[12] prognostic value in this clinical setting. Worthy of note, the LVEF mortality curve after AMI exhibits a typical hyperbolic increasing with an upturn in mortality occurring at values $<$40% (Figure 1).[13] In 417 patients with AMI, an LVEF $<$ 40% was an independent predictor of the combined endpoint of death, congestive HF, and recurrent AMI (odds ratio [OR] = 3.82;