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● *Original Contribution*

PREDICTION FOR IMPROVEMENT AND REMODELING IN FIRST-ONSET MYOCARDIAL INFARCTION BY SPECKLE TRACKING ECHOCARDIOGRAPHY: IS GLOBAL OR REGIONAL SELECTION BETTER?

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Abstract—Cardiac function improvement and chamber remodeling after the onset of acute myocardial infarction (AMI) is crucial as it is closely related to the outcomes of patients. We sought to investigate the predictive value of left ventricular (LV) global and region of interest (ROI) assessment for prognosis of AMI patients by speckle tracking echocardiography (STE). We prospectively enrolled 81 first-onset AMI patients for baseline and 6-mo follow-up analysis. The echocardiography-derived parameters were compared in receiver operator characteristics (ROC) analysis for predicition of LV remodeling (LVR) (a minimum 20% increase of LV end-diastolic volume) and cardiac function improvement (a minimum 5% increase of LV ejection fraction). The ROI strain was selected by wall motion score index (WMSI) scores ≥2. The time of whole analysis process was recorded. Cut-off values of −9.92% for global circumferential strain (CS) and −5.53% for ROI CS predicted LVR. Cut-off values of −10.40% for global longitudinal strain (LS) and −5.33% for ROI LS predicted cardiac function improvement. Areas under curves of global and ROI parameters were comparable in ROC analysis ($p > 0.05$, all). The time of global analysis was less than the time of ROI analysis ($p < 0.05$) and the reproducibility of global analysis was slightly better than the ROI analysis. Our results demonstrated that STE was valuable for the prediction of LVR and cardiac function improvement after AMI. Compared with ROI parameters, global parameters were more integral and efficient as predictive factors with high predictive power, less analysis time and better reproducibility. (E-mail: qingzhou.wh.edu@hotmail.com)

Key Words: **Speckle tracking, Cardiac function improvement, Left ventricular remodeling, Myocardial infarction.**

INTRODUCTION

As the onset of coronary heart disease, acute myocardial infarction (AMI) leads to severe cardiac adverse events, including cardiac death and chronic heart failure with low-ejection fraction and enlarged cardiac chambers. Thus, predicting cardiac function improvement and chamber remodeling after AMI is crucial because it is closely related to patient outcomes. The predictive power of speckle tracking echocardiography (STE) has been validated by several recent studies. The parameters of global strain, such as global longitudinal strain (LS) and circumferential strain (CS), are sensitive to myocardial infarction patient outcomes, including in-hospital heart failure (Ersboll et al. 2012), left ventricular (LV) adverse remodeling (Huttin et al. 2016; Na et al. 2016) and LV function recovery (Mollema et al. 2010). The predictive power of region of interest (ROI) strain was demonstrated in other studies using the following: ROI selection by culprit vessel territory for cardiac mortality (Hoogslag et al. 2014); all-cause mortality, death or hospitalization for heart failure (Wang et al. 2016); infarct zone in echocardiography for severe arrhythmic events (Nguyen et al. 2015); or transmural myocardial damage for the risk of late systolic remodeling (Huttin et al. 2015). However, it is still unclear whether global or ROI parameters are better for the outcome prediction of AMI patients because the global analysis considers the entire left ventricle and the ROI is focused on the prognostic impact of affected myocardium. It would be clinically valuable to identify the most integral and efficient parameters for predicting the outcomes of AMI patients using both global and ROI STE analyses. Therefore,

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using STE, we investigated and compared the predictive value of LV global and ROI parameters for the prognosis of AMI patients.

MATERIAL AND METHODS

Study population

This was a prospective study and 102 AMI patients were enrolled January 2014–May 2015. All the patients had echocardiography at baseline and at the 6-mo follow-up (before January 2016). The inclusion criteria of our study were the following: first onset AMI with diagnostic evidence, patient history, symptoms, laboratory tests, electrocardiogram (ECG) and more than 75% stenosis or complete occlusion of at least one of the three main coronary branches by coronary angiography. The study was approved by the Ethics Committee of Renmin Hospital of Wuhan University and written informed consent was obtained from all enrolled patients.

Definition of cardiac function improvement and LV remodeling

The definition of cardiac function improvement was a minimum 5% increase of left ventricular ejection fraction (LVEF) from baseline to 6-mo follow-up (ΔLVEF $\geq$5%) (Caracciolo et al. 2010; Mollema et al. 2010). The definition of LV remodeling was a minimum 20% increase of left ventricular end-diastolic volume (LVEDV) from baseline to 6-mo follow-up (ΔLVEDV % $\geq$20%) (Bolognese et al. 2002; Jang et al. 2010; Li et al. 2008; Mannaerts et al. 2004; Nijland et al. 1997).

Clinical data collection of AMI patients

All the AMI patients were evaluated using the Killip classification at baseline (Killip and Kimball 1967; Launbjerg et al. 1992; Rott et al. 1997). The Killip class I patients show no clinical signs of heart failure. The Killip class II patients present rales or crackles in the lungs, a third heart sound and elevated jugular venous pressure. The Killip class III patients have acute pulmonary edema. The Killip class IV patients display cardiogenic shock or hypotension (measured as systolic blood pressure lower than 90 mmHg) and evidence of peripheral vasoconstriction (oliguria, cyanosis or sweating).

The diagnosis and treatment of AMI followed the standards and recommendations of the guidelines (American College of Emergency Physicians et al. 2013; Levine et al. 2011, 2016). All AMI patient clinical data were documented and the results of coronary angiography and ECG at baseline were recorded including the culprit vessel and type of infarction.

Echocardiography

The data analysis workflow is presented in Figure 1. Echocardiographic examinations were performed by one scanner at baseline (at admission and before revascularization) and at the 6-mo follow-up using the GE Vivid E9 ultrasound diagnostic system and M5S probe (GE Vingmed Ultrasound AS, Horten, Norway). In addition to routine echocardiography, we collected dicom images of the parasternal short-axis views (at the levels of mitral valve, papillary muscle and apex), the apical views (at two-chamber, four-chamber and long-axis) and the pulse wave Doppler of aortic valve at apical five-chamber view. All the digital imaging and communications in medicine (DICOM) images were stored at baseline and at the 6-mo follow-up examinations for consecutive five cardiac cycles while patients were at left lateral decubitus position and connected with ECG.

According to the American Society of Echocardiography criteria, LV end-systolic volume (LVESV) and LVEDV were measured during 5 cardiac cycles and averaged from the apical 2- and 4-chamber views by the biplane Simpson's method with automated endocardial tracking using the auto-ejection fraction (auto-EF) algorithm for the calculation of LVEF (Lang et al. 2015). The wall motion score index (WMSI) was determined by dividing LV into 17 segments. Each segment was then scored using the following semi-quantitative scoring system: (1) normal, (2) hypokinetic, (3) akinetic or (4) dyskinetic. The ROI was selected using the segments of WMSI scores $\geq$2.

Data analysis

All images were obtained with a frame rate >60 fps for reliable assessment. The speckle tracking analysis was performed off-line with stored dynamic parasternal and apical images using imaging analysis software (EchoPac v. 113, GE Vingmed Ultrasound AS, Horten, Norway). The myocardial deformation was calculated using a novel algorithm that tracks the frame-to-frame movement on the basis of gray-scale images and 2-D ultrasound speckles (Bachner-Hinenzon et al. 2016; Claus et al. 2015; Shetye et al. 2015; Smiseth et al. 2016). The end-systole was determined by aortic closure timing in the apical 5-chamber view. The longitudinal strain was determined using an automatic analysis process triggered by placing 3 points (2 at the basal segments along the mitral valve annulus and 1 at the apex) inside the endocardium at the apical views while for radial and circumferential strain at least 4 points (anterior, septal, inferior and lateral) at the parasternal views. The global longitudinal, radial and circumferential strain (global LS, RS and CS) were calculated as the average of all segments. The ROI strain of segments selected with scores $\geq$2 in WMSI were averaged as the strain of segments with motion