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● *Original Contribution*

CORRELATION OF GLOBAL STRAIN RATE AND LEFT VENTRICULAR FILLING PRESSURE IN PATIENTS WITH CORONARY ARTERY DISEASE: A 2-D SPECKLE-TRACKING STUDY

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Abstract—The aim of the present study was to evaluate the role of 2-D speckle-tracking imaging in the prediction of left ventricular filling pressure in patients with coronary artery disease (CAD) and normal left ventricular ejection fraction (LVEF). Eighty-four patients with CAD and 30 healthy controls were recruited prospectively. The longitudinal strain rate (SR) curves were determined in three apical views of the left ventricle long axis. Circumferential and radial SR curves were determined in three short-axis views. Left ventricular end-diastolic pressure (LVEDP) was invasively obtained by left heart catheterization. Compared with the 30 controls, the patients with CAD had significantly lower global SR during early diastole (SRe) and higher *E*/SRe in three directions of myocardial deformation. CAD patients with elevated LVEDP had significantly lower SRe and higher *E*/SRe of three deformations. Pearson's correlation analysis revealed that LVEDP correlated positively with *E*/*E*′ ratio, radial SRe and longitudinal and circumferential *E*/SRe. LVEDP correlated negatively with longitudinal and circumferential SRe and radial *E*/SRe. Receiver operating characteristic curve analysis revealed that these SR indexes predicted elevated LVEDP (areas under the curve: longitudinal *E*/SRe = 0.74, circumferential *E*/SRe = 0.74, circumferential SRe = 0.70, longitudinal SRe = 0.69, radial *E*/SRe = 0.68, radial SRe = 0.65), but neither was superior to the tissue Doppler imaging index *E*/*E*' (area under the curve = 0.84). The present study indicates that 2-D speckle-tracking imaging is a practical method for evaluating LV filling pressure, but it might not provide additional advantages compared with *E*/*E*′ in CAD patients. (E-mail: mhydyjy@163.com) **© 2015 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Left ventricular filling pressure, 2-D speckle-tracking imaging, Coronary artery disease.**

INTRODUCTION

Coronary artery disease (CAD) is a complex disease characterized by episodes of myocardial demand/supply mismatch, which are usually inducible by exercise, emotion or other stress (Montalescot et al. 2013; Omland et al. 2013). Evaluation of left ventricular (LV) diastolic function can provide incremental survival and prognostic information in CAD patients (Hillis et al. 2004; Jarnert et al. 2007; Prasad et al. 2011). Doppler echocardiography is proposed for the non-invasive prediction of LV filling pressure (Manouras et al. 2013; Nagueh et al. 2009; Ommen et al. 2000). Although the common ratio of transmittal flow velocity to annular velocity (*E*/*E*′) is clinically useful, it has a number of limitations that can decrease its accuracy in evaluating LV diastolic function (Claessens et al. 2007; Ozer et al. 2008).

Two-dimensional speckle-tracking imaging represents the left ventricular performance of all myocardial segments in multiple directions and intrinsically circumvents most of the drawbacks of Doppler echocardiography (Gokdeniz et al. 2014; Kim et al. 2011; Shanks et al. 2010). Previous studies have indicated that strain rate (SR) variables measured by speckle-tracking imaging can be explored to assess LV diastolic dysfunction in cardiovascular diseases (Chen et al. 2014;

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Dokainish et al. 2008; Kasner et al. 2010; Kimura et al. 2012; Mizuguchi et al. 2008; Nguyen et al. 2010; Wang et al. 2007). Dokainish et al. (2008) found that global longitudinal diastolic strain and SR were useful predictors of LV filling pressure in patients with dyspnea and cardiac disease. Nguyen et al. (2010) found that patients with cardiac disease and preserved ejection fraction had diastolic abnormalities in multiple directions. Furthermore, the ratio of early mitral flow to SR was also correlated with LV filling pressure in patients with heart failure (Kasner et al. 2010) and obstructive hypertrophic cardiomyopathy (Chen et al. 2014). However, in CAD patients with normal LV ejection fraction (LVEF), there are no data on myocardial diastolic function by strain rate imaging in multiple directions, as well as their relationship to invasively measured LV filling pressure.

Therefore, in the present study, we recorded global myocardial SR curves in the longitudinal, circumferential and radial directions in CAD patients with normal LVEF, and compared them with LV filling pressure measured by left heart catheterization, to investigate the value of strain rate imaging in the prediction of LV filling pressure.

METHODS

Study patients

We prospectively enrolled 84 CAD patients at Fuwai Hospital from October 2013 to July 2014. All these patients were in sinus rhythm and undergoing left ventriculography and coronary angiography. Thirty sex- and age-matched healthy controls were also recruited. Patients with inadequate echocardiographic images, severe mitral or aortic valve diseases, dyspnea precluding a 10- to 15-s breath hold, atrial fibrillation or flutter, paced rhythm and LVEF <55% and those who refused to participate in this study were excluded.

The following data were gathered: basic demographic characteristics, parameters of conventional echocardiography and strain rate imaging, medications and hemodynamic data during left heart catheterization. Written informed consent was obtained from all patients. This study complied with the principles outlined in the Declaration of Helsinki and was approved by the institutional review board of Fuwai Hospital.

Conventional echocardiography

All echocardiographic measurements were performed with the patient at rest in the left lateral decubitus position using a Vivid E9 instrument (GE Medical Systems, Horten, Norway). All images were digitally stored for off-line analysis (EchoPAC BT 11.0, GE Medical Systems, Horten, Norway). Mitral inflow measurements, including peak early (E) and peak late (A) velocities, the E/A ratio and the deceleration time (DT) of the E wave, were measured from the apical four-chamber view by pulsed Doppler echocardiography. Peak early diastolic myocardial velocity (E') was measured from the apical four-chamber view by tissue Doppler echocardiography, using a 2-mm sample volume placed at the level of the basal portion of the septal and lateral mitral annulus. The E' wave peak velocity was measured from the above two points (E'_{sep} and E'_{lat}, respectively), and then the mean early diastolic myocardial velocity (E'_{mean}) was calculated. Measurements were performed on four consecutive heartbeats, and the average of these four measurements was taken.

2-D Speckle-tracking imaging

Two-dimensional speckle-tracking echocardiographic image acquisition using a Vivid E9 instrument (GE Medical Systems) was performed with LV apical (apical four-chamber, apical two-chamber and apical long-axis) views and the parasternal short-axis views at the basal, midpapillary and apical levels. To achieve optimal imaging quality for subsequent analyses, the frame rate was set to ≥60 frames/s, as previously described (Ersboll et al. 2014). At each plane, four consecutive cardiac cycles were acquired at end-expiration during a breath hold.

Image analysis was performed off-line using EchoPAC BT 11.0. The LV cavity endocardial border was manually traced, and the 2-D speckle-tracking width was adjusted to cover the whole LV wall thickness so as to obtain SR curves. Manual readjustments were made only when necessary to ensure accurate tracking. LV wall was divided into 18 segments, and each segment was analyzed *individually*. Longitudinal SR was calculated in every 6 segments in each of the three standard LV apical views (four-chamber, two-chamber and apical long-axis), and their average value was used for final analysis. Likewise, circumferential and radial strain rates were calculated in these 18 segments of the three parasternal short-axis views and averaged for ultimate analysis, as described previously (Nguyen et al. 2010). The strain rates obtained from the left ventricle included global early diastolic SR (SRe) and global late diastolic SR (SRa) in the longitudinal, circumferential and radial directions.

Left heart catheterization

All CAD patients were in sinus rhythm during left heart catheterization. Cardiac catheterization and echocardiography were performed on the same day (within 24 h). Left heart catheterization was performed through the radial artery. Before coronary angiography, transducers were balanced before acquisition of hemodynamic data with zero level at the midaxillary line, as described