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Layer-specific quantification of myocardial deformation may disclose the subclinical systolic dysfunction and the mechanism of preserved ejection fraction in patients with hypertension

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ABSTRACT

Background: Systemic hypertension (HTN) leads to left ventricular (LV) remodeling, which results in diastolic dysfunction in the presence of preserved ejection fraction (EF). The goal of this study was to explore subclinical LV systolic dysfunction and the mechanism of preserved EF using layer-specific quantification of myocardial deformation in HTN patients.

Methods: One hundred and twenty HTN patients (mean blood pressure (BP) 165 ± 20/ 96 ± 16 mmHg) and 120 age and gender matched volunteers (mean BP 120 ± 10/76 ± 8 mmHg) were studied. Left ventricular echocardiographic parameters including LV ejection fraction (LVEF), global and regional peak longitudinal, circumferential 2D systolic layer strain and LV twist were measured. The associations between these parameters were studied against LV relative wall thickness (RWT) and LV mass index.

Results: LVEF was normal in all HTN patients. The RWT and LV mass index were higher in HTN group (0.40 ± 0.06 vs 0.35 ± 0.03, p < 0.0001; 84 ± 24 vs 63 ± 11 g/m2, p < 0.0001). The absolute value of layer and global longitudinal strain was significantly lower in HTN group (−24 ± 3 vs −26 ± 3%, p < 0.0001;. 21 ± 3 vs −23 ± 3%, p < 0.0001, respectively). Global circumferential strain (−40 ± 6 vs −35 ± 5%, −31 ± 7 vs −27 ± 4% respectively, p < 0.0001), and the LV twist (23 ± 5 vs 18 ± 6 degree, p < 0.0001) were higher in HTN group.

Conclusions: This study revealed that hypertension resulted in increased RWT and LV mass. Impairment in layer and global longitudinal strain found in HTN patients may indicate early systolic dysfunction due to impaired endomyocardial function. Enhancement of circumferential strain and LV twist may be a compensatory mechanism to maintain LVEF in these patients.

1. Introduction

Arterial hypertension leads to the development of left ventricular (LV) concentric remodeling and hypertrophy. Previous study using standard echocardiography has demonstrated that impairment of mid-wall fractional shortening of the circumferential fibers precedes the reduction of LV ejection fraction (LVEF) in patients with hypertension [1]. The development of Doppler echocardiography has offered new approaches to study the pathophysiology and the clinical implications of hypertensive heart disease [2,3]. Speckle-tracking echocardiography has furthered the understanding of the complexity of different LV deformation due to hypertension [4]. The goal of this study was to explore the mechanism of subclinical LV systolic dysfunction and preserved LVEF in patients with hypertension using layer-specific quantification of myocardial deformation.

2. Methods

2.1. Study population

We enrolled patients who were diagnosed with essential hypertension from September 2012 to August 2015. The diagnosis of essential hypertension was defined as systolic blood pressure > 140 mmHg and/or diastolic blood pressure > 90 mmHg on two separate visits. If patients were treated with antihypertensive medications at the time of recruitment, antihypertensive medications were continued during the study period to more effectively reflect the clinical situation. Exclusion criteria were as follows: (1) any cardiac symptoms including chest pain or exertional dyspnea; a history or any suspicion of the presence of coronary artery disease; (2) uncontrolled arrhythmia; (3) chronic

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renal failure; (4) other severe comorbidities that may affect cardiac function; (5) secondary cause of hypertension; (6) QRS duration ≥120 ms or any type of intraventricular conduction delay; and (6) inadequate echocardiographic images that would preclude analyses. The 120 patients with hypertension and 120 age- and gender-matched volunteers (as control group) were studied. All of the controls had no cardiac symptoms and no significant medical histories, as well as normal electrocardiographic and echocardiographic findings. The study protocol was approved by the institutional review board of our hospitals, and written informed consent was obtained from all participants before study enrollment.

2.2. Echocardiography

2.2.1. Transthoracic 2D data acquisitions

The patients were examined in the left lateral decubitus position using a Vivid E9 commercial ultrasound scanner (E9, GE Health Care, Milwaukee, WI) with phased-array transducers (M5S-D and 4V-D). Two-dimensional data acquisitions were obtained from parasternal long-axis and short-axis views and the three standard apical views. For each view, three consecutive cardiac cycles were recorded during quiet respiration. Grayscale recordings were optimized for LV evaluation at a frame rate of ≥50 frame/s. The mitral inflow velocity was obtained from the apical 4-chamber view by placing a pulsed-wave Doppler sample volume between mitral leaflet tips during diastole. The cursor of continuous wave Doppler was put between LV outflow and inflow tracts, and a tracing of LV outflow tract and inflow waves were recorded from the apical 5-chamber view. Tissue Doppler imaging (TDI) was performed to measure mitral annulus excursion. Pulsed-wave sample volume was placed at the septal corner of the mitral valve annulus. Early diastolic (E′) mitral peak velocity was recorded.

2.3. Analysis of 2D and Doppler parameters

Left atrial diameters, left ventricular diastolic diameters (LVDD), interventricular septal and posterior wall thickness (IVSTD and PWTD) were measured. The relative wall thickness (RWT) was calculated as the sum of anteroseptal and posterior wall thickness divided by the LV end-diastolic dimension. The left ventricular volumes were measured by biplane 2D Simpson's method.

The peak early (E) and late (A) transmitral flow velocities and deceleration time of E velocity were measured; the ratio of early-to-late peak velocities (E/A) was calculated. From TDI, the early diastolic (E′) at the septal corner of the mitral valve annulus was measured; the E/E′ ratio was calculated.

2.4. Analysis of 2D strain parameters

All data of 3-layer speckle tracking was analyzed off line using a dedicated automated software (EchoPAC PC, Version113; GE Health Care,

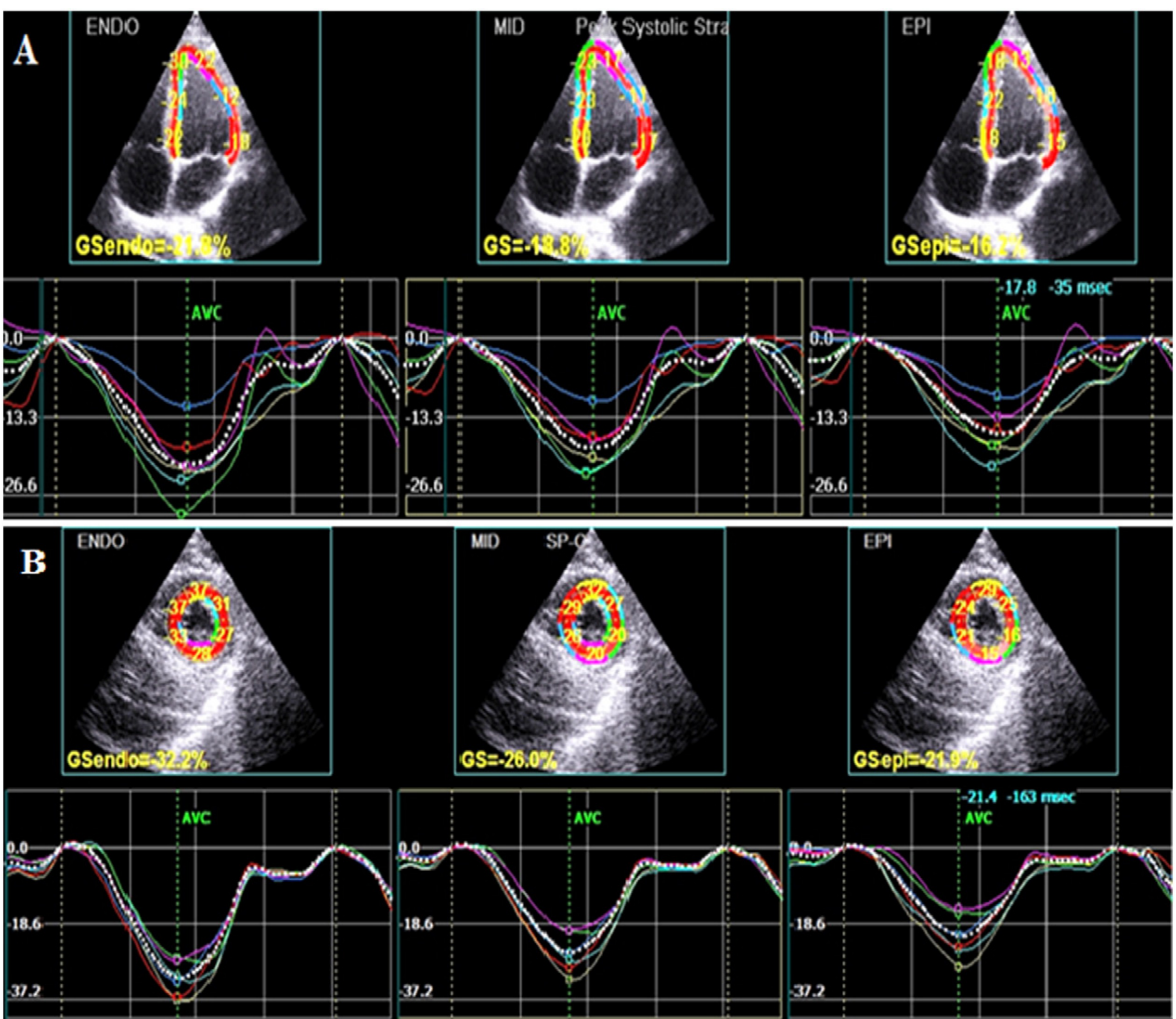

Fig. 1. This figure showed the 3 layers of LV segmental longitudinal strain curves (A), and circumferential strain curves (B).