Ultrasound in Med. & Biol., Vol. ■, No. ■, pp. 1–9, 2016

0301-5629/$ - see front matter

http://dx.doi.org/10.1016/j.ultrasmedbio.2016.01.011

● *Original Contribution*

EVALUATION OF THE RIGHT VENTRICULAR FUNCTION IN PREDIABETES: A 2-D SPECKLE TRACKING ECHOCARDIOGRAPHIC STUDY

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(*Received* 11 *July* 2015; *revised* 3 *January* 2016; *in final form* 23 *January* 2016)

Abstract—Pre-diabetes is a common condition associated with cardiovascular changes. The aim of our study was to evaluate the right ventricular (RV) function as assessed by 2-D speckle tracking echocardiography in pre-diabetic patients. This study recruited 94 patients (33 normal patients, 31 pre-diabetic patients and 30 diabetic patients). The absolute amount of the global peak systolic strain, the systolic strain rate and the early diastolic strain rate of the RV free wall (RVFW) was higher in the control group than in the pre-diabetic and diabetic groups. These indices were not different between the pre-diabetic and diabetic groups. The global late diastolic strain rate of RVFW was the same between the three groups. Also, pre-diabetes and diabetes were the independent predictors of the RVFW global peak systolic strain, systolic strain rate and diastolic strain rate. Our study demonstrated that the RV systolic and diastolic functions were impaired in the pre-diabetic and diabetic patients without obstructive coronary artery disease. Also, pre-diabetes and diabetes were independent predictors of systolic and diastolic functions of the RV. (E-mail: Ali_Hosseinsabet@yahoo.com) © 2016 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Pre-diabetes, Diabetes, Right ventricle, 2-D speckle tracking echocardiography.**

INTRODUCTION

Pre-diabetes has been defined as fasting blood sugar between 100 and 125 mg/dL, blood sugar between 140 and 199 mg/dL 2 h after the usage of 75 g of glucose or glycated hemoglobin (HbA1c) between 5.7 and 6.4% (American Diabetes Association 2014). About 33% of people in developed and developing countries are affected by pre-diabetes (Kones and Rumana 2014; Sadeghi et al. 2015), roughly 30% of patients presenting with myocardial infarction have pre-diabetes (Arnold et al. 2014) and approximately 60% of patients who are candidates for elective percutaneous coronary intervention are affected by pre-diabetes (Balakrishnan et al. 2015). Moreover, the coronary artery risk factor profile in young pre-diabetic patients is worse than that of the normal population (Shah et al. 2014), and the risk of cardiovascular events in pre-diabetic patients is greater than that in normal patients. Compared to normal patients, the intima-to-media thickness ratio in the carotid artery increases in pre-diabetic patients (Shaye et al. 2012). The compliance index and stiffness index in the peripheral arteries are different from those in normal glycemic state patients (Chou et al. 2013). Also, the coronary artery flow reserve is lower in pre-diabetic patients than in the normal population (Erdogan et al. 2013). Pre-diabetes is associated with subtle myocardial injuries, which are allied to future cardiovascular events (Selvin et al. 2014). Left ventricular (LV) hypertrophy is more common in pre-diabetic patients than in the normal population (De Marco et al. 2011). Furthermore, the relative wall thickness is increased in pre-diabetic patients (Velagaleti et al. 2010). Pre-diabetes is associated with insulin resistance (Tabák et al. 2012), and the LV dysfunction is correlated with insulin resistance (Catena et al. 2013; Di Bello et al. 2010). The LV diastolic dysfunction is impaired in the pre-diabetic population compared with normal patients (Stahrenberg et al. 2010).

There is limited evidence regarding ventricular dysfunction as assessed by 2-D speckle-tracking echocardiography in pre-diabetes (Ceyhan et al. 2012; Tadic et al. 2015). Hypothesizing that the aggravation of glycemic state could be detrimental to the right ventricular (RV) myocardium, we sought to assess RV function by 2-D speckle-tracking echocardiography

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in pre-diabetic patients with near-normal coronary arteries and to compare it with RV function in normal patients and diabetic patients with near-normal coronary arteries.

MATERIALS AND METHODS

Study population

This cross-sectional study consecutively recruited 94 patients who were candidates for selective coronary angiography between November 25, 2014 and January 1, 2015 at Tehran Heart Center, a tertiary referral hospital. After admission, history taking and physical examinations were performed. Our inclusion criteria comprised left ventricular ejection fraction >50%, normal sinus rhythm and coronary artery stenosis <50% in selective coronary angiography. The exclusion criteria consisted of presence of any degree of valvular stenosis; more than mild valvular regurgitation; systolic pulmonary artery pressure >35 mm Hg (by echocardiography); RV systolic motion velocity (Sm) <10 cm/s; tricuspid annular plane systolic excursion (TAPSE) <17 mm; presence of cardiomyopathy; congenital heart diseases; history of radiotherapy or chemotherapy; history of myocardial infarction, cardiac surgery or coronary stenting; right or left bundle branch block; paced rhythm; history of hypothyroidism or hyperthyroidism; creatinine >1.5 mg/dL; hepatic failure; type 1 diabetes mellitus; and poor quality of echocardiography views. During the study period, 1128 coronary angiographic procedures was performed. Approximately 408 patients had near-normal coronary angiography. A total of 314 patients were excluded from study, and 94 patients were included in the study. Venous samples after 12 h fasting were obtained for the evaluation of cell blood count, blood sugar, lipid profile and biochemistry study. Diabetes was defined as insulin or oral antidiabetic agent usage or fasting blood sugar >126 mg/dL in two examinations, pre-diabetes was defined as fasting blood sugar between 100 and 125 mg/dL and HbA1c between 5.7 and 6.4% and non-diabetes was defined as fasting blood sugar <100 mg/dL and HbA1c < 5.7%. Finally, 33 normal control patients, 31 pre-diabetic patients and 30 diabetic patients were enrolled in the study. Our research proposal was approved by our institutional review board, and informed consent was obtained from all the participants at the time of admission.

Standard echocardiography

Transthoracic echocardiography was performed for the patients in the left lateral decubitus position before discharge using a commercial EKO 7 setting (Samsung Medison, Seoul, South Korea). The LV volumes were measured in the apical two- and four-chamber views according to the American Society of Echocardiography guideline (Lang et al. 2005). The left ventricular ejection fraction was calculated *via* the Simpson method. The RV diameters at end diastole in the mid-RV cavity, RV end-diastolic and end-systolic areas, RV fractional area change (RV end-diastolic area–RV end-systolic area/RV end-diastolic area) and TAPSE were measured according to American Society of Echocardiography guidelines (Lang et al. 2005). The tricuspid flow velocities in early and late (E and A waves) diastole and the deceleration time of the E wave were obtained by pulse-wave Doppler in the apical four-chamber view according to the American Society of Echocardiography guideline (Lang et al. 2005). Tricuspid E and A waves and the deceleration time of E wave were measured in five consequent cardiac cycles, and the mean of these measurements was recorded (Rudski et al. 2010).

Tissue Doppler echocardiography

Lateral tricuspid annular velocities were obtained by pulse-wave tissue Doppler in the apical four-chamber view with maximal effort for the alignment with the RV walls. The sample volume (2–4 mm) was used. Gain was adjusted to obtain optimal view for measurement. A horizontal sweep rate of 100 mm/s and a velocity range of −20 cm/s and 20 cm/s were adopted. There were one positive systolic wave (s′), one negative early diastolic wave (e′) and another negative late diastolic wave (a′). Peak velocity was defined as the peak of the outer edge of the dense envelope of the spectral recording (Fig. 1). Peak velocities in five consecutive cardiac cycles were manually measured and averaged.

2-D speckle tracking echocardiography

Echocardiographic images were obtained from the apical four-chamber view at end expiration and three consecutive cardiac cycles with a rate of 60–80 frames per s stored in the echocardiography setting for analysis. End of systole was automatically determined by software (Sumsong Medision software for two dimensional speckle tracking echocardiography, Sumsong Medison, Seoul, South Korea). The endocardial border of the RV, at end diastole, was traced manually, and the epicardial border was determined automatically. The following of the endocardial and epicardial border from the traced lines was checked. If there was failure of following (appearance of myocardium out of traced lines or appearance of space between traced lines and endocardial and epicardial border) in the cardiac cycle, the traced borders were manually adjusted by one of the researchers. The RV free wall (RVFW) was divided automatically into three segments: base, mid and apex. Each RVFW segment was evaluated individually. 2-D