Ultrasound in Med. & Biol., Vol. 41, No. 2, pp. 407–417, 2015

0301-5629/$ - see front matter

http://dx.doi.org/10.1016/j.ultrasmedbio.2014.09.025

● *Original Contribution*

GLOBAL AND REGIONAL LEFT VENTRICULAR STRAIN INDICES IN POST-MYOCARDIAL INFARCTION PATIENTS WITH VENTRICULAR ARRHYTHMIAS AND MODERATELY ABNORMAL EJECTION FRACTION

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(*Received* 9 *June* 2014; *revised* 15 *September* 2014; *in final form* 19 *September* 2014)

Abstract—The aim of the study described here was to compare myocardial strains in ischemic heart patients with and without sustained ventricular tachycardia (VT) and moderately abnormal left ventricular ejection fraction (LVEF) to investigate which index could better predict VT on the basis of the analysis of global and regional left ventricular (LV) dysfunction. We studied 467 patients with previous myocardial infarction and LVEF >35%. Fifty-one patients had documented VT, and 416 patients presented with no VT. LV volumes and score index were obtained by 2-D echocardiography. Longitudinal, radial and circumferential strains were determined. Strains of the infarct, border and remote zones were also obtained. There were no differences in standard LV 2-D parameters between patients with and those without VT. Receiver operating characteristic values were −12.7% for global longitudinal strain (area under the curve [AUC] = 0.72), −4.8% for posterior-inferior wall circumferential strain (AUC = 0.80), 61 ms for LV mechanical dispersion (AUC = 0.84), −10.1% for longitudinal strain of the border zone (AUC = 0.86) and −9.2% for circumferential strain of the border zone (AUC = 0.89). In patients with previous myocardial infarction and moderately abnormal LVEF, peri-infarct circumferential strain was the strongest predictor of documented ventricular arrhythmias among all strain quantitative indices. Additionally, strain values from posterior-inferior wall infarctions had a higher association with arrhythmic events compared with global strain. (E-mail: vitar@tiscali.it) © 2015 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Speckle tracking echocardiography, Ventricular arrhythmias, Sudden cardiac death, Myocardial infarction.**

INTRODUCTION

Depressed left ventricular ejection fraction (LVEF) is currently the major indication for implantation of a cardiac defibrillator (ICD). LVEF ≤35% serves as the threshold for identifying individuals at high risk for sudden cardiac death (SCD). However, in the general population, the majority of SCDs occur in patients with moderately abnormal LV function (>35%), and there is currently a lack of routinely recommended screening tools for SCD risk stratification even though a number of diagnostic tests have been proposed (Buxton et al. 2007; Epstein et al. 2013; Passman and Kaddish 2007; Rosenbaum 2008).

Myocardial strain by speckle-tracking echocardiography (STE) accurately quantifies subtle contraction delay and reduction indicating dysfunctional myocardium (Korinek et al. 2005; Amundsen et al. 2006; Vitarelli et al. 2013). Prior studies in patients with LV myocardial infarction and cardiomyopathies with reduced ventricular function (Ersbøll et al. 2013a, 2013b; Haugaa et al. 2010b, 2012, 2013; Sarvari et al. 2011) found that global longitudinal strain and mechanical dispersion are promising markers of arrhythmias and predicted arrhythmic events independently of LVEF.

The area of a previous myocardial infarction (MI) may represent an anatomic and electrophysiologic substrate (Moss et al. 2002) for malignant ventricular arrhythmias (VAs). In fact, tissue heterogeneity between infarcted and normal myocardium creates areas of slow conduction and electrical dispersion, including both activation time and refractoriness, which are known

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Conflicts of Interest: We have no conflicts to disclose.

arrhythmogenic factors (Bardy et al. 2005). The scar areas of the infarct zone are generally highly fibrosed, whereas peri-infarct zones comprise heterogeneous areas with intermediate degrees of non-transmural fibrosis. The tissue heterogeneity of the peri-infarct zone may be electrically unstable (Verma et al. 2005) and represent a substrate for re-entrant ventricular tachycardia (VT). Recently, magnetic resonance imaging (MRI) studies have reported the identification of myocardial scar tissue, as well as a strong relationship between peri-infarct zone heterogeneity and monomorphic VT inducibility (Fernandes et al. 2007; Roes et al. 2009a, 2009b; Wong et al. 2012). Longitudinal peak systolic strain of the peri-infarct border zone was also found to be strongly associated with monomorphic VT inducibility in patients with chronic ischemic cardiomyopathy (Bertini et al. 2010; Ng et al. 2010; Roes et al. 2009a, 2009b), and impaired peri-infarct zone function determined the occurrence of appropriate ICD therapy on follow-up (Bertini et al. 2010).

Although analysis of LV global longitudinal strain, mechanical dispersion and infarct border zone has been used for quantitative assessment of LV myocardial deformation and prediction of VAs, a comparison of various quantitative strain indices has not been performed to date. Accordingly, we aimed to compare myocardial strains in patients with a history of ischemic heart disease with and without VAs and moderately abnormal LVEF to investigate which index could better predict VAs on the basis of the analysis of global as well as regional LV dysfunction.

METHODS

Study population

A total of 467 patients were recruited from two university hospitals (Cedars–Sinai Medical Center, University of California at Los Angeles, Los Angeles, CA, USA; Umberto I University Hospital, Sapienza University, Rome, Italy). Inclusion criteria were an EF >35% at least 60 d after MI. All patients underwent coronary angiography soon after myocardial infarction. Percutaneous coronary intervention was performed in 418 patients. In 49 patients, the coronary lesions were ineligible for revascularization. The beginning of the study was defined by the date of the echocardiographic examination. Patients were followed for ≥12 mo or to the date of defined endpoints such as mortality, documented sustained ventricular tachycardia and sudden cardiac arrest. Pharmacologic treatment was reported. Exclusion criteria were unstable clinical condition, atrial fibrillation, left bundle branch block, greater than moderate valve regurgitation and more than mild valvular stenosis. The study was approved by the institutional medical research committees. Written informed consent was obtained.

Electrocardiography

Electrocardiograms were obtained in all participants. The QT interval was heart rate corrected with Bazett's (1920) formula. The 12-lead electrocardiography (ECG) morphology of the VAs was recorded. QRS durations and QT intervals were measured on tracings recorded at 50 mm/s. The longest QRS duration was selected as the QRS duration. QRS dispersion was calculated as the difference between the longest and shortest QRS durations and as the standard deviation from the 12 QRS durations. No patient underwent ventricular pacing during electrocardiographic or echocardiographic recordings. Electrophysiology was performed to induce VAs in patients with non-sustained VT.

Electrocardiographic data and echocardiographic data were analyzed by independent observers blinded to clinical data.

Echocardiography

All patients underwent transthoracic echocardiography with a commercially available cardiovascular ultrasound system (Vivid E9, GE Vingmed Ultrasound, Horten, Norway). Measurements of cardiac chambers were made by transthoracic echocardiography according to established criteria (Lang et al. 2005). LV ejection fraction by the modified Simpson method and mass index were estimated. Peak early and late diastolic velocities, deceleration time, left ventricular isovolumic relaxation time, myocardial performance index and right ventricular systolic pressure were obtained using standard Doppler practices. Segmental wall motions were evaluated and scored as 1 = normal, 2 = hypokinesia, 3 = akinesia and 4 = dyskinesia. Global wall motion score index was calculated using the sum of the segmental scores divided by the number of segments analyzed, as recommended by the American Society of Echocardiography (Lang et al. 2005). Segments were divided into three categories: an infarct zone, defined as segments with abnormal scores (2 or 3); a border zone, defined as segments with scores of 1 but adjacent to infarct segments; and a remote zone, defined as segments having no common border with an infarct segment.

Two-dimensional strain was measured as previously described (Amundsen et al. 2006; Korinek et al. 2005; Vitarelli et al. 2013). After tracing endocardial border at an end-systolic frame, the operator could validate the tracking quality and adjust the endocardial border or modify the width of the region of interest. The software automatically tracks the myocardium, accepting segments of good tracking quality and rejecting poorly tracked segments, and allows the operator to manually