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Clinical Utility of Longitudinal Strain to Predict Functional Recovery in Patients With Tachyarrhythmia and Reduced LVEF

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ABSTRACT

OBJECTIVES This study sought to assess the time course of presumptive tachycardia-induced cardiomyopathy and the predictors of left ventricular (LV) functional recovery in such patients.

BACKGROUND Tachycardia-induced cardiomyopathy is a potentially reversible cardiomyopathy with effective treatment of the tachyarrhythmia. However, cases without improvement of LV systolic function were found occasionally. The diagnosis of tachycardia-induced cardiomyopathy can be challenging, and the role of echocardiographic imaging in the prediction of LV functional recovery is limited.

METHODS LV segmental longitudinal strains (LS) were evaluated by 2-dimensional speckle tracking in 71 consecutive patients (65 $\pm$ 16 years; 61% men) with tachyarrhythmia and reduced left ventricular ejection fraction (LVEF) without any other known cardiovascular disease, and 30 age and sex-matched control subjects. Relative apical LS ratio (RALSR) was defined using the equation: average apical LS / (average basal LS + average mid LS) as a marker of strain distribution.

RESULTS Compared with control subjects, patients with tachyarrhythmia had significantly lower global LS. Improvement in LVEF within 6 months after treatment of index arrhythmia was observed in 41 patients, and LVEF did not improve in 30 patients. In univariate analysis, lower LVEF at baseline (hazard ratio: 0.59 per 1 SD; $p = 0.04$) and higher RALSR (hazard ratio: 11.2 per 1 SD; $p < 0.001$) were associated with no recovery in LVEF during follow-up. In a multivariate logistic regression model, the significant predictor of LV systolic functional recovery was RALSR (hazard ratio: 22.9 per 1 SD; $p = 0.001$). A RALSR of 0.61 was sensitive (71%) and specific (90%) in differentiating LV systolic functional recovery (area under the curve: 0.88).

CONCLUSIONS The RALSR was associated with LV systolic functional recovery. This information might be useful for clinical evaluation and follow-up in patients with reduced LVEF. (J Am Coll Cardiol Img 2016;■:■-■) © 2016 by the American College of Cardiology Foundation.

Long-standing tachycardia is a well-known cause of left ventricular (LV) dysfunction and heart failure. This type of LV dysfunction is called tachycardia-induced cardiomyopathy (TIC) (1). TIC is an acquired, potentially reversible form of cardiomyopathy characterized by atrial and/or ventricular myocardial dysfunction resulting from increased atrial and/or ventricular rate (2-5). The diagnosis is

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ABBREVIATIONS AND ACRONYMS

CMR = cardiac magnetic resonance

EF = ejection fraction

GLS = global longitudinal strain

LGE = late gadolinium enhancement

LS = longitudinal strain

LV = left ventricular

PVC = premature ventricular contraction

RALSR = relative apical longitudinal strain ratio

TIC = tachycardia-induced cardiomyopathy

TR-PG = tricuspid regurgitant pressure gradient

usually made after demonstrating recovery of LV function with treatment of arrhythmia in the absence of other identifiable etiologies (6). However, cases without improvement of LV systolic function were found occasionally in the clinical setting. The incidence of TIC is not well characterized, but it is estimated that approximately 50% of patients in tachyarrhythmia have impairment of LV systolic function (7). Some previous studies showed that risk factors for the development of TIC were older age and higher premature ventricular contraction (PVC) burden compared with control subjects (8). A better understanding of the mechanism and improved recognition of its presence can be clinically relevant to the prognosis of patients with tachyarrhythmia.

Quantitation of myocardial deformation is an emerging field of clinical cardiac imaging. In addition, recent clinical work using speckle tracking imaging shows that there are significant differences in regional strain in several cardiomyopathies, even in the absence of ischemia. Knowledge of the characteristic LV strain distribution pattern facilitates diagnosis for constrictive pericarditis, cardiac amyloidosis, hypertrophic cardiomyopathy, and hypertensive heart disease (9–13). Characteristic of strain distribution may help in the differential diagnosis of individual patients. In our previous study, longitudinal strain (LS) slightly increased from base to apex in control subjects. In contrast, decreased LS was more profound in the apex in animal models of rapid pacing-induced cardiomyopathy (14). Thus, this "reverse" distribution of LV strain may help to understand LV dysfunction in the presence of tachyarrhythmia.

The aim of this study was to investigate incidence, time course, and echocardiographic predictors of functional recovery in LV systolic function in a prospective and consecutive group of patients with reduced left ventricular ejection fraction (LVEF) and tachyarrhythmia.

METHODS

STUDY POPULATION. We designed a prospective study to assess the LV functional recovery in patients with tachyarrhythmia. A total of 304 consecutive patients having supraventricular/ventricular tachyarrhythmia were referred to our echocardiographic examination center between January 2013 and February 2016. Reasons for referral included tachyarrhythmia (heart rate >100 beats/min) noted on resting 12-lead electrocardiogram, telemetry monitoring, or 24-h Holter monitor. Patients were excluded because of the following criteria: preserved LVEF (>50%; n = 160), incomplete echocardiographic follow-up (n = 55), coronary artery disease (≥70% stenosis of any major epicardial vessel; n = 18), hypertension (n = 12), diabetes mellitus (n = 4), hypertrophic cardiomyopathy (n = 3), moderate or severe valvular disease (n = 2), end-stage renal disease (n = 4), and stress-induced cardiomyopathy (n = 5). There were no patients with New York Heart Association functional class III or IV symptoms. After exclusions, 71 patients remained for final analysis who had LVEF ≤50% and who were diagnosed as presumptive TIC (**Figure 1**). Thirty age- and sex-matched control patients were selected from our healthy volunteer database based on a comprehensive history and physical examination. The Institutional Review Board of the Tokushima University Hospital approved the study protocol and written informed consent was obtained from all subjects.

DATA ACQUISITION. A detailed medical history was obtained in all patients. Every patient had 12-lead electrocardiogram during his or her index clinical arrhythmia. Twenty-four-hour Holter monitoring was performed to evaluate the frequency of arrhythmia (arrhythmia burden: the ratio of total number of premature atrial/ventricular contractions to total heartbeat). Patients were classified into 3 groups according to the index arrhythmia: 1) atrial fibrillation; 2) paroxysmal supraventricular tachycardia including atrioventricular re-entry tachycardia and AV nodal re-entry tachycardia; and 3) monomorphic PVCs or nonsustained ventricular tachycardia. In patients undergoing initiation of medical antiarrhythmic therapy or cardiac catheter ablation, echocardiographic measurements were repeated within 6 months of index clinical arrhythmia. The primary endpoint was LV functional recovery during follow-up, defined as improvement of LVEF ≥15% or improvement of LVEF ≥10% to more than 50% after effective treatment of index clinical arrhythmia (6).

STANDARD ECHOCARDIOGRAPHIC ASSESSMENT. Transthoracic echocardiography was performed by experienced sonographers/doctors using a commercially available ultrasound machine (iE33, Philips Healthcare, Amsterdam, the Netherlands; Vivid E9, GE Healthcare, Waukesha, Wisconsin; and SSA-770A, Toshiba Medical, Otawara, Japan). Measurements and recordings were obtained according to the American Society of Echocardiography recommendations (15). LV end-diastolic volume, LV end-systolic volume, left atrial volume, and LVEF were calculated by the biplane method of disks using