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Exercise Capacity Correlates With Left Atrial Structural Remodeling as Detected by Late Gadolinium-Enhanced Cardiac Magnetic Resonance in Patients With Atrial Fibrillation

Kamran A. Rizvi, MD,[a] Nathan S. Burgon, MBA,[b] Jordan B. King, PharmD, MS,[b,c] Nazem Akoum, MD,[b,d] Gaston Vergara, MD,[e] Paul A. Anderson, BSc,[b] Gregory P. Gardner, BSc,[b] Christopher J. McGann, MD,[b] Brent Wilson, MD,[b] Eugene G. Kholmovski, PhD,[b] Robert S. MacLeod, PhD,[b,f,g] Mihail G. Chelu, MD, PhD,[b] Nassir F. Marrouche, MD[b]

ABSTRACT

OBJECTIVES This study hypothesized that left atrial structural remodeling (LA-TR) correlates with exercise capacity (EC) in a cohort of patients with atrial fibrillation (AF).

BACKGROUND Late gadolinium-enhanced cardiac magnetic resonance (LGE-CMR) imaging provides a method of assessing LA-TR in patients with AF.

METHODS A total of 145 patients (32% female, mean age 63.4 ± 11.6 years of age) with AF (66 paroxysmal, 71 persistent, 8 long-standing persistent) presenting for catheter ablation were included in the study. All patients underwent LGE-CMR imaging as well as maximal exercise test using the Bruce protocol prior to catheter ablation of AF. EC was quantified by minutes of exercise and metabolic equivalent (MET) level achieved. LA-TR was quantified from LGE-CMR imaging and classified according to the Utah classification of LA structural remodeling (Utah stage I: <10% LA wall enhancement; Utah II: 10% to <20%; Utah III: 20% to <30%; and Utah IV: >30%). AF recurrence was assessed at 1 year from the date of ablation.

RESULTS The average duration of exercise was 8 ± 3 min, and the mean MET achieved was 9.7 ± 3.2. METs achieved were inversely correlated with LA-TR ($R^2 = 0.061$; $p = 0.003$). The duration of exercise was also inversely correlated with LA-TR ($R^2 = 0.071$; $p = 0.001$). Both EC and LA-TR were associated with AF recurrence post ablation in univariate analysis, but only LA-TR and age were independently predictive of recurrence in multivariate analysis ($p = 0.001$). For every additional minute on the treadmill, subjects were 13% more likely to be free of AF 1 year post ablation ($p = 0.047$).

CONCLUSIONS EC is inversely associated with LA-TR in patients with AF and is predictive of freedom from AF post ablation. (J Am Coll Cardiol EP 2016;■:■–■) © 2016 by the American College of Cardiology Foundation.

From the [a]Denton Regional Medical Center, Denton, Texas; [b]Comprehensive Arrhythmia and Research Management Center, Division of Cardiology, University of Utah Health Sciences Center, Salt Lake City, Utah; [c]Pharmacotherapy Outcomes Research Center, Department of Pharmacotherapy, University of Utah College of Pharmacy, Salt Lake City, Utah; [d]Division of Cardiology, University of Washington, Seattle, Washington; [e]Heart Center of Nevada, Las Vegas, Nevada; [f]Scientific Computing and Imaging Institute, University of Utah School of Medicine, Salt Lake City, Utah; and the [g]Bioengineering Department, University of Utah School of Medicine, Salt Lake City, Utah. This study was supported by U.S. National Institutes of Health National Center for Research Resources Center for Integrative Biomedical Computing grant P41-RR12553-10. Dr. Rizvi has received consulting fees and honoraria from Medtronic, Biosense Webster, Boston Scientific. Dr. Burgon consults for and holds stock options in Marrek, Inc. Dr. Kholmovski consults for, holds stock options in, and has received research support from Marrek Inc. Dr. Marrouche has received research support from National Institutes of Health, MRI Interventions, Sanofi, Biosense Webster, Biotronik, Marrek Inc., Medtronic, Boston Scientific, Catheter Robotics Inc.; and consults for, has received honoraria from, and hold stock options in Biosense Webster, Sanofi Aventis, MRI Interventions, Boehringer-Ingelheim, Biotronik, Ecardio, St. Jude Medical, Medtronic, Arapeen Med, Marrek, Inc., Daiichi Sankyo, Cardiac Designs, and VytronUS. All other authors report that they have no relationships relevant to the contents of this paper to disclose.

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ABBREVIATIONS AND ACRONYMS

AAD = antiarrhythmic drug

AF = atrial fibrillation

BB = beta-blocker

CAD = coronary artery disease

CCB = calcium-channel blocker

CHF = congestive heart failure

LGE-CMR = late gadolinium-enhanced cardiac magnetic resonance

DM = diabetes mellitus

EC = exercise capacity

LA = left atrium

LA-TR = left atrial structural remodeling

LV = left ventricle

LVEF = left ventricular ejection fraction

MET = metabolic equivalent

PV = pulmonary vein

Exercise capacity (EC), a robust predictor of cardiovascular outcomes, is associated with cardiac morbidity and mortality (1). The relationship between atrial fibrillation (AF) and EC is complex and often related to left ventricular (LV) function. However, even in patients with preserved LV function, AF is associated with diminished EC. Successful cardioversion or catheter ablation can improve EC by restoring normal sinus rhythm (2–5).

Abundant evidence has linked left atrial structural remodeling (LA-TR) with the pathophysiology of AF (4). The severity of AF's impact on a patient's EC may be dictated in part by the extent of LA-TR (6). Patients with AF have decreased regional LA function, manifested as lower strain and strain rate (7), and are more likely to have LA enlargement (8,9). Catheter ablation, conversely, has been shown to result in improved LA function with the restoration of sinus rhythm (10). Moreover, regression of dilated chambers can be achieved with sinus rhythm (11).

Late gadolinium-enhanced cardiac magnetic resonance (LGE-CMR) imaging can be used for assessment and quantification of LA-TR (12). LA-TR by LGE-CMR imaging has been shown to strongly predict the success of and aid in patient selection for AF ablation (13). LA-TR is also inversely related to echocardiographically determined LA strain and strain rate (14). As LA-TR progresses, LA active transport function decreases. This decrease in LA transport has been closely associated with functional capacity, although the strength of this relationship remains unclear (2,15).

We hypothesized that there is an inverse relationship between the extent of LA-TR and EC determined by a maximal treadmill test. We also hypothesized that patients with greater baseline EC were more likely to achieve freedom from AF after catheter ablation.

METHODS

We conducted a retrospective review of patients who presented to the University of Utah for treatment of AF between December 2006 and October 2010. The database study protocol was reviewed and approved by the University of Utah Institutional Review Board and was HIPAA compliant. The two inclusion criteria for this study were patients with AF and LGE-CMR evaluation to assess the extent of LA-TR, a maximal exercise treadmill test using the Bruce protocol (16). All patients were asymptomatic at rest. A total of 145 patients met the inclusion criteria and were included in the analysis. Recurrence rates were assessed at 1 year (365 days), including a blanking period of 90 days.

CMR IMAGE ACQUISITION. All LGE-CMR scans were obtained using either a 1.5-T Avanto or a 3-T Verio clinical scanner (Siemens Medical Solutions, Erlangen, Germany), using a total imaging matrix phased-array receiver coil. Each scan was acquired approximately 15 min after contrast agent injection (0.1 mmol/kg Multihance [Bracco Diagnostic Inc., Princeton, New Jersey]), using a 3-dimensional (3D) inversion recovery, respiration-navigated, electrocardiographically (ECG)-triggered gradient echo pulse sequence. Inversion preparation was applied every heartbeat, and fat saturation was applied immediately before data acquisition. Data acquisition was limited to 15% of cardiac cycle and was performed during LA diastole. The time interval between the R peak of the ECG and the start of data acquisition was defined by using cine images of the LA. Typical acquisition parameters were free-breathing using navigator gating, a transverse imaging volume with a voxel size of 1.25 × 1.25 × 2.5 mm (reconstructed to 0.625 × 0.625 × 1.25 mm), and inversion time (TI) of 270 to 310 ms. The other scan parameters for 3D LGE of LA at 3-T were: repetition time (TR) = 3.1 ms, echo delay time (TE) = 1.4 ms, and a flip angle = 14°. Scan parameters for 3D LGE of LA using the 1.5-T machine were TR/TE = 5.2/2.4 ms and a flip angle = 20°. The TE for the scans was chosen such that fat and water were out of phase and the signal intensity of partial volume fat-tissue voxels was reduced, allowing improved delineation of the LA wall boundary. The TI value for the LGE-CMR scan was identified using a TI scout scan acquired in short-axis view of the left ventricle. TI was selected based on nulling of LV myocardium. Typical scan time for LGE study was 7 to 12 min at 1.5-Tor 5 to 9 min at 3-T, depending on patient respiration.

LGE-CMR QUANTIFICATION OF LA-TR. LA wall volumes were manually segmented by expert observers from the LGE-CMR images, using Corview image processing software (Marrek Inc., Salt Lake City, Utah). The protocol for segmentation proceeded as follows. First, the endocardial border of the LA was defined, including an extent of pulmonary vein (PV) sleeves, by manually tracing the LA-PV blood pool in each slice of the LGE-CMR volume. Next, the endocardial segmentation was morphologically dilated and then manually adjusted to create an assessment of the boundary of the epicardial LA surface. Finally, the endocardial segmentation was subtracted from