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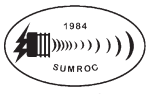

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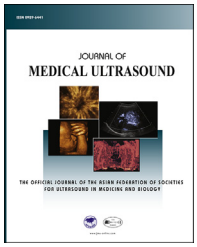

ORIGINAL ARTICLE

Role of Left Atrial Reservoir Strain Rate in Left Atrial Remodeling in Severe Mitral Regurgitation

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Abstract *Background:* Impaired left atrial (LA) reservoir deformation has been found to be associated with poor functional capacity and outcomes in severe chronic mitral regurgitation (MR). Among patients with primary MR (valve incompetence due to mitral valve pathology), we focus on Carpentier II classification (prolapse or flail mitral valve) and aim to investigate determinants for decreased LA reservoir deformation and its impact on LA remodeling in severe MR.

Methods: Among 159 consecutive patients with severe chronic Carpentier II MR (left ventricular ejection fraction $\geq 60\%$), 55 underwent follow-up echocardiography, which was compared with their baseline study. We used the change of LA volume index as the rapidity of LA remodeling, LA eccentricity index as LA sphericity, and peak LA reservoir strain as well as reservoir strain rate ($LASR_R$) derived from two-dimensional speckle-tracking echocardiography as LA reservoir function.

Results: Older age, elongated left atrium, increased LA volume index, as well as reduced left ventricular global longitudinal strain and LA ejection fraction all linked to a poor baseline $LASR_R$ (all $p < 0.001$). A second echocardiography during a mean follow-up of 15.3 ± 8.3 months revealed an enlarged left atrium (increased interval change of LA volume index; $p < 0.001$). In multivariate analysis, only the difference between the baseline and follow-up $LASR_R$ values ($\triangle LASR_R$; odds ratio (OR) 0.037, 95% confidence interval (CI) 0.003–0.496, $p = 0.013$) predicted accelerated LA remodeling. A poor baseline $LASR_R$ was significantly associated with its profound deterioration during the follow-up period ($\beta = -0.424$, $p = 0.002$).

Conflicts of interest: There is no conflict of interest.

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Conclusion: In severe chronic Carpentier II MR, a reduced follow-up $LASR_R$ predicted future accelerated LA remodeling. Patients with a poor baseline $LASR_R$ are at a higher risk of its deterioration.

Introduction

Severe chronic mitral regurgitation (MR) is characterized by excessive volume load, leading to serial cardiac adaptations [1].Among which, left atrial (LA) dilatation arises early, maintaining a balanced LA pressure while prohibiting pulmonary congestion. However, the rapidity of this compensatory process *per se* forecasts dire outcomes. LA volume index (LAVi), signifying LA remodeling, has been well acknowledged as a prognostic indicator with respect to atrial fibrillation (AF), stroke, and congestive heart failure [2—4]. Similarly, in primary MR (characterized by pathology involving mitral leaflets, chordae tendineae, papillary muscle, and annulus), LAVi is a harbinger of increased mortality and more cardiac events, including subsequent occurrence of AF [2,5—7]. As a matter of fact, identifying patients with severe primary MR who are at risk of accelerated LA remodeling is pivotal in guiding patient-tailored therapeutic strategy to improve their survival and restore their quality of life.

By contrast, the association between severe primary MR and impaired LA deformation assessed by two-dimensional (2D) speckle-tracking echocardiography (STE) has been demonstrated [8,9]. Changes of LA deformation mechanics, reflecting LA ultrastructural change, may occur before changes in LA dimension [10]. LA deformation indexes have been utilized in the prediction of functional capacity, future cardiac events, as well as postoperative survival in severe primary MR, suggesting their value in clinical practice [11—13]. It is of interest whether accelerated LA remodeling and LA deformation deterioration are closely interwoven.

Using 2D STE, phasic LA deformation can be evaluated, including the reservoir, conduit, and contractile functions. Notably, the prognostic implication of a reduced LA reservoir function, represented by decreased LA reservoir strain ($LA\varepsilon_R$) and strain rate ($LASR_R$), has been recognized, assuring its value and importance in chronic MR [12—14]. During ventricular systole, LA strain (ε) and strain rate (SR) reflect LA expansibility and stiffness. Our previous studies found that deformation in the reservoir phase is associated with functional capacity and prognosis in severe chronic primary MR, especially for Carpentier II classification (mitral valve prolapse or flail) [12,13]. However, determinants of reservoir deformation have not been elucidated in this group. Hence, the current study aims to explore the (1) determinants of a poor LA reservoir function, (2) determinants of accelerated LA remodeling, and (3) interconnection between LA remodeling and LA reservoir mechanics in patients with chronic severe Carpentier II MR.

Methods

Study population

Figure 1 shows the study flow diagram of this prospective observational cohort study. Patients with chronic severe primary MR undergoing echocardiography in the outpatient clinic were screened between December 2010 and August 2013. We did not enroll patients with: (1) left ventricular ejection fraction (LVEF) $< 60\%$; (2) New York Heart Association (NYHA) functional classification III or IV; (3) ischemic MR; (4) infiltrative cardiomyopathy; (5) coexistent aortic valve disease and mitral stenosis $\geq$ mild degree; (6) prior open heart surgery; and (7) congenital heart disease. Eighteen of 177 patients with chronic severe Carpentier II MR were excluded because of an anticipated mitral valve surgery at the time of the index echocardiography or inadequate image acquisition.

Severe MR was diagnosed using a multiparametric approach via transthoracic echocardiography, including evaluation of the vena contracta width, effective regurgitant orifice area, regurgitant volume, and presence of systolic pulmonary venous flow reversal aligned with the European Association of Echocardiography criteria [15]. Patients were followed up (interval $\leq$3 months), by their original cardiovascular specialists, in the clinic where symptoms and signs of heart failure were carefully evaluated. Follow-up echocardiography was arranged based on the discretion of the care physician. The functional class at enrollment and past history were obtained from the medical records. The study adhered to the Declaration of Helsinki and received approval from the Human Research and Ethics Committee of National Cheng Kung University Hospital (A-ER-102-322).

Echocardiography

Standard transthoracic echocardiography was performed (Vivid 7; GE-VingMed, Horten, Norway) using a 3.5-MHz multiphase array probe in individuals respiring quietly at a left lateral decubitus position. Chamber dimension and wall thickness were measured by the 2D-guided M-mode method, and LVEF was measured by the 2D biplane method of discs [16]. Left ventricular (LV) mass was obtained by the M-mode-derived linear measurements based on modeling of the left ventricle as a prolate ellipse and indexed by the body surface area. The Doppler sample volume was placed at the tips of the mitral leaflets to obtain the LV inflow blood flow velocity waveforms on the apical four-chamber view. Pulse wave tissue Doppler imaging was obtained

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