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Editorial

Magnetic Resonance Imaging-based Right Ventricular Strain Evaluation

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▸ See the article "Right Ventricular Strain Is Associated With Increased Length of Stay After Tetralogy of Fallot Repair" in volume 30 on page 50.

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Cardiac integrity comprises normal morphology and pumping function of the heart's 4 chambers. Evaluation of the heart aims to check the chambers' shape and function. Since the major role of the heart is to pump blood in the circulatory system, cardiac function is typically prioritized over morphology. Echocardiography is an important modality for assessing cardiac function and morphology, although it is more proficient for hemodynamic evaluation. Computed tomography (CT) and magnetic resonance imaging (MRI) joining cardiac imaging has strengthened the evaluation of cardiac morphology and facilitated the objective assessment of cardiac chamber function.

The function of each chamber is influenced by preload, afterload, and its own wall function. If the conditions in and around the chambers provoke dysfunction, the cardiac chambers will begin to adjust their morphology and motion, resulting in remodeling. Chamber volumes and their variations along a cardiac cycle can be measured so that the global function of a single chamber can be estimated, even during the remodeling process. For regional function evaluation, chamber wall motion can be evaluated qualitatively in routine practice. However, detecting chamber dysfunction as early as possible is important, and more sensitive imaging markers have been reported.

Unlike the left ventricle (LV), the right ventricle (RV) has a more complex shape without fixed reference points since it partly wraps around the LV and has a thinner and more compliant myocardium. In healthy subjects, the wall thickness of the RV varies between 2 and 5 mm.[1] To evaluate RV volume and its variability, complete three-dimensional measurements along a compact timeline are critical. The magnetic resonance (MR) cine image could provide a solution in this context. As comparing with MR, the echocardiography could evaluate right ventricle in a simpler and more convenient way. Already several echocardiographic imaging markers for right ventricular function are popular. The tricuspid annular plane systolic excursion, the time–velocity integral, the fractional area change, and the Tei index of the RV feasibly measure global RV function.[2] However, these markers cannot provide regional RV function, and they cannot differentiate active RV motion from passive entrainment by the neighboring LV.

The global and regional strains along promised planes were introduced to evaluate active myocardial motion from the standpoint of the myocardium itself. Since echocardiography

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depicts myocardial motion in real-time and speckle tracking is relatively easier, the echocardiography is an essential modality for strain imaging.[3] Strain presents as myocardial deformation during the chamber motion. Despite the handicaps of RV imaging, echocardiographic strain has been successfully and widely applied on RV function evaluation in diverse pathological situations, including heart failure, ischemic heart disease, valvular heart disease, congenital heart disease, cardiomyopathy, and pulmonary hypertension.[2]

As a gold standard modality for the evaluation of chamber function, cardiac MRI provides three-dimensional information on all 4 chambers without any imaging window limitations. Several techniques were introduced for strain evaluation based on cine MRI data. Initially, a conventional tagged MRI technique was used for strain imaging despite insufficient spatial resolution. Soon, a technical advancement occurred by introducing feature tracking imaging (FTI) operable in an independent post-processing console. FTI has been the most popular option for strain MRI thus far, although features at the endocardial and epicardial borders are the main targets. Actually, measuring strain in the mid-myocardial layer by MR FTI is challenging due to a homogenous mid-myocardial texture without a target feature.[4] Recently an improved tagged MRI technique, strain-encoded (SENC) MRI, was introduced, which showed superior performance to the MR FTI technique.[5]

Since strain MRI is a relatively younger methodology than echocardiography, its clinical application is not as wide as other methodologies. In acute myocardial infarction cases, the longitudinal strain evaluated by MR FTI reliably predicted clinical outcomes during follow-up.[6] Measuring the difference between epicardial and endocardial circumferential strain based on MR FTI permitted early detection of systolic dysfunction in patients with hypertrophic cardiomyopathy, even at the pre-clinical and pre-dysmorphic stages.[4] In cases of arrhythmogenic right ventricular dystrophy, MR FTI successfully and reproducibly evaluated regional strain in the right ventricular myocardium.[7] In patients with pulmonary hypertension, the SENC MR technique revealed decreased longitudinal and circumferential strains compared with those in healthy subjects.[8] However, due to the limited MRI quality of the RV in pediatric patients, strain MRI for congenital heart diseases is still unrecognized.

Tetralogy of Fallot (TOF) is well known as the most common cyanotic congenital heart disease. Due to the high incidence of TOF, initial palliative and corrective surgical treatments are well established. In parallel, postoperative follow-up and prognosis prediction becomes more interesting and meticulous. By correcting the TOF, the RV is exposed to a new environment, from high afterload pressure to volume overload by inevitable pulmonary regurgitation. From the moment of correction, the RV remodels itself over time.[9] Together with the possible improvement of RV hypertrophy, RV dilatation with hindered systolic function is a common postoperative feature. During this remodeling process, medical surveillance is required for pulmonary valvular replacement at a suitable timing. The decision regarding the appropriate time for this correction depends on the patient's clinical expression, RV volume and function, and systemic venous congestion. Meanwhile, RV strain provides more sensitive and accurate information for detection of noticeable stress of the RV as early as possible. Echocardiographic strain evaluation was successfully applied on postoperative TOF cases despite a limited imaging window.[10] Strain MRI will allow more feasible evaluation of RV strain for patients with surgically corrected TOF. In this context, the report by Srinivasan et al.[11] sought to improve the role of strain MRI for pediatric patients with congenital heart disease, including surgically corrected TOF.

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Using MRI, Srinivasan et al.[11] focused on RV myocardial strain immediately after TOF repair for early detection of adverse effects on future RV function. In addition, based on their previous work, they performed strain MRI exams without anesthesia in infants. In this study, early postoperative RV deformation was observed as a decrease in mean RV peak longitudinal strain (median [interquartile range], 16.51 [−19.49, −9.95]). In addition, RV peak radial strain was always available and was significantly associated with an extended hospital stay. These findings were detected prior to the expression of conventional markers, such as changes in RV ejection fraction. A series of postoperative RV strain adaptation processes could not be disclosed in this study; however, MR-based RV strain was adequate as an early prognostic indicator for surgically-corrected TOF patients.

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