Cardiovascular MRI Symposium ll_Recent updates of CMR Quantification

SY20-1

CMR techniques: Recent updates and future direction

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Cardiac MRI provides complementary information on left ventricular function, local perfusion, myocardial viability, metabolic changes and direction of origin. Current cardiac MRI has dramatically reduced scan times and improved overall image quality with advances in hardware and reconstruction algorithms. Cine MRI provides a dynamic image of cardiac wall motion, allowing more accurate assessment of the wall motion. Left ventricular function and mass, measured with cine MRI, are used in clinical practice as an endpoint in clinical trials. While MRI has become accepted as the “gold standard” method for assessment of global function, there exists the substantial potential for it to provide much more detailed and quantitative information on cardiac function. Delay enhanced MRI (DE-MRI) is also a way to measure myocardial viability with high spatial resolution. This is good for observing focal scars, but it is better to use T1 mapping to observe diffuse fibrosis. T1 mapping is a measure of T1 relaxation time in the myocardium. Modified look-locker inversion recovery (MOLLI) and saturation recovery single shot (SASHA) methods are representative. Detection of myocardial edema has previously been shown to allow early detection of acute coronary syndromes. A quantitative T2 mapping is superior to T2-weighted images in identifying tissues with interstitial edema. Diffusion MRI provides information regarding microscopic tissue structure through encoding random motion of water molecule. The information includes apparent diffusion coefficient (ADC), mean diffusivity(MD), fractional anisotropy (FA), Helix angle(HA) and fiber tracking of the LV wall.

Keywords : Cardiovascular, Magnetic Resonance Imaging, Quantitative

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Parametric mapping (T1, T2 and ECV) in CAD and non-ischemic heart disease

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The main advantage of CMR is its potential for characterization of the myocardial tissues. However, conventional CMR techniques have well-known limitations. The signal intensity (SI) of CMR cannot be quantified or compared among subjects and its comparison depends on the contrast between the normal and abnormal myocardium.

Rapid technological innovations in MRI in the recent times have resulted in the development of new techniques for cardiac MRI. Hence, T1 and T2 mapping techniques are emerging as useful tools for the quantitative evaluation of ischemic or non-ischemic cardiomyopathies.

The major advantage of mapping sequences is their potential for quantitative objective assessment of myocardial abnormalities. To enable direct quantification of the myocardium, four powerful parametric parameters that may be used are the native T1 value, post-T1 value, ECV fraction, and T2 value, leading to the progressive integration of these sequences into routine CMR settings. T1 quantification has been the basis for diagnostic methods since the beginning of magnetic resonance imaging in the early 1970s. The earliest studies looking at changes in T1 in the heart were performed in vitro using samples from dog hearts. These showed that T1 increased with ischemia, and that the magnitude of increase was related to the duration and severity of ischemia. Nowadays, various T1 mapping technique using inversion recovery sequence or saturation recovery sequence are available and they could provide acceptable T1 values of beating heart pixel by pixel. By using T1 mapping sequence, we can obtain native T1 map without contrast material, and post T1 map after contrast injection. And then ECV fraction could be calculated pixel by pixel. ECV fraction is robust surrogate marker of interstitial components of myocardium and it is well known that Post-contrast T1 values are known to vary depending on the gadolinium dosage and clearance rate, scanning time, body composition, and hematocrit levels. However, ECV fraction is known to be a more stable and biologically significant biomarker. By using T2-prepared bSSFP or GRE, T2 map provides pixel by pixel T2 value which is tissue specific parameter. These quantitative mapping sequences are useful in the evaluation of ischemic cardiomyopathy or non-ischemic cardiomyopathies in various ways, including the detection, diagnosis, stratification and prognostication.

In this lecture, we will discuss various cases with ischemic cardiomyopathy or non-ischemic cardiomyopathies wherein the T1- and T2-mapping sequences of cardiac MRI were helpful for the diagnosis and treatment.

Keywords : CMR, T1 map, T2 map, ECV, CAD

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4D flow: Visualization and Quantification

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Characteristics of blood flow may have an important clinical implication in various cardiovascular diseases involving cardiac valves, great vessels, and cardiac chambers. Phase-contrast magnetic resonance imaging (PCMRI) has been used at various clinical settings for evaluating blood flow and pattern. Although conventional two-dimensional PCMRI has been validated extensively as accurate, evaluation of blood flow using the 2D PCMRI has some limitations [1]. One of the most important limitations of 2D PCMRI is that flow evaluation is only possible on single, pre-determined imaging plane. Recently time-resolved three-dimensional PCMRI, also known as four dimensional flow cardiovascular magnetic resonance (4D flow CMR), allows a volumetric assessment of blood flow in the great vessels or even in the cardiac chambers [2-4]. Based on the volumetric velocity data of 4D flow CMR, various flow parameters including flow velocity, flow rate, wall shear stress, vortex, turbulent kinetic energy, and relative pressure could be obtained [5]. In this lecture, experimental studies of 4D flow MRI using 3D-printed phantom model will be presented [2, 3, 5]. In addition, an early clinical application of this technique will be introduced.

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Keywords : 4D Flow MRI, Flow

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SY20-4

Myocardial Strain: Quantification and Application

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Myocardial strain is a measure of the deformation in shape and dimension of the heart muscle during the cardiac cycle. In echocardiography, myocardial strain can be measured by tissue Doppler imaging (DTI) or by speckle-tracking echocardiography (STE). It is used to describe local shortening, thickening and lengthening of the myocardium as a measure of regional LV function. A number of investigations on identifying best reliable parameters for clinical heart diseases and developing technological advances for more reliable measurements have been being conducted.

Similarly, the recent technical advance enables to measure myocardial strain by MRI. Nowadays, dedicated MR softwares for myocardial strain are commercially available and measures of myocardial strain using routinely acquired cine images can be possible without any cumbersome preparation. Mathematically speaking, Lagrangian strain tensor is usually used and the deformation is measured with respect to the diastolic phase: various parameter including radial, circumferential and longitudinal peak strains, time to peak strain, strain rate, peak diastolic strain rate, peak systolic strain rate, peak displacement, time to peak displacement, velocity, peak diastolic velocity, peak systolic velocity, torsion, and torsion rate can be generated in both 2D or 3D directions.

Previous echographic studies showed that the best-reliable strain parameter is global longitudinal strain which is more sensitive than left ventricular ejection fraction as a measure of systolic function. Strain imaging may be applied to diagnose myocardial ischemia or subclinical left ventricular dysfunction in cardiomyopathies, and useful in clinical decision making. Strain imaging for the right ventricle by MRI may be promising. The strain imaging technology is still being developed, and not sufficiently standardized to be recommended as a routine clinical use. Despite this limitations, myocardial strain may be applied clinically as a supplementary diagnostic tool.

Reference

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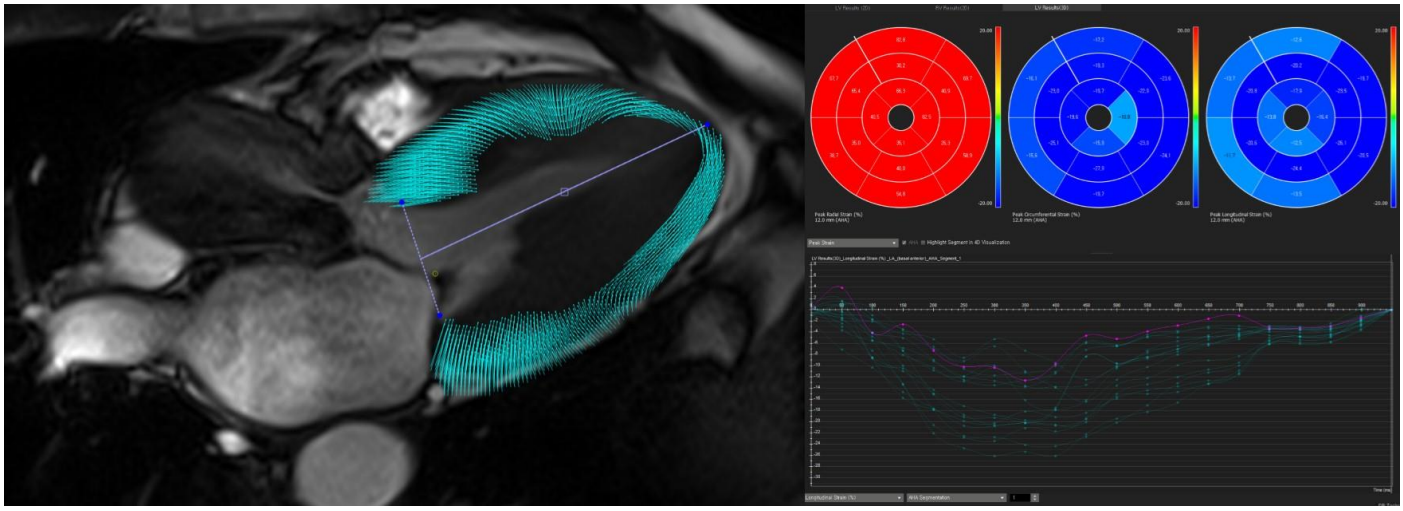

Fig. 1. Myocardial points at each slice are connected visualizing motion lines from end-diastolic to end-systolic phases after defining the axis of LV and drawing endocardial and epicardial contours. Global and segmental strain values (polar maps) and phasic graphs are obtained.

Keywords : Myocardial strain