MR Tissue Phase Mapping in Patients with Transposition of the Great Arteries

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Introduction

Although the long-term outcome is favorable for patients that have undergone atrial switch procedures, this growing population of adults is at risk for progressive myocardial failure of the systemic right ventricle (RV) and arrhythmia during follow-up [1]. Therefore, it would be beneficial to identify functional parameters that assess the need for surgical interventions or drug therapies prior to the event of heart failure. Previous studies of regional motion in the right ventricular wall of such patients have been conducted with MR tagging [2], and tissue Doppler and conductance catheters [3]. MR tissue phase mapping (TPM) presents an alternative approach for the evaluation of segmental myocardial wall motion [4]. Compared to MR tagging, TPM offers the advantages of a higher spatial resolution, less demanding post-processing, and consistent image quality throughout the cardiac cycle. In this study, we present our initial results in the evaluation of regional function of the systemic ventricle in patients that had undergone a Senning procedure.

Methods

Phase contrast measurements with in-plane velocity encoding were performed in short axis views of 5 patients (15-22 years) who each had a Senning operation as a newborn. A spoiled gradient echo sequence with black blood preparation and first-order flow compensation in read- and phase encoding direction for the reduction of flow artifacts was implemented on a 1.5 T Sonata system (Siemens Medical Solutions, Erlangen, Germany) Image acquisition parameters were as follow: TE/TR = 4.5/6.2 ms, flip angle = 15°, FOV = 300 mm × 400 mm, acquisition matrix = 256 × 96, venc = 20 cm/s. A temporal resolution of 49-87 ms was achieved with view sharing such that full in-plane velocity information of the beating heart was obtained in 13-22 heartbeats within a single breath-hold measurement. These breath-hold periods were well tolerated by all patients. The right ventricular wall was manually segmented from the magnitude images and radial and tangential velocities were calculated for each pixel in the wall. The segmented right ventricle was divided into 24 angular areas for which radial velocities were averaged and correlated to a reference time course derived from the mean velocity of the complete segmented right ventricle [4]. Positive correlation values correspond to similar or hypokinetic motion patterns, values near zero describe akinetic motion, and negative values express dyskinetic RV waveforms. The flow analysis and visualization was perfomed with a customized software tool written in Matlab (The Mathworks, Natick, MA).

Results

All five patients showed a dyskinetic motion pattern of the ventricular wall. Fig. 1 contains data from a representative example displaying the radial velocities of a mid-ventricular slice where red color represents contraction of the myocardium and blue color the expansion. The septum moves toward the LV wall while the RV free wall contracts during systole (a) and moves back during early diastole (b) while the RV free wall expands. Fig. 1c shows the differences in the temporal evolutions of the radial velocities in the segments of the RV free wall (thick) and the septum (thin). This dyskinetic motion is also displayed in the color-coded correlation plots of radial velocities for various slice locations (Fig. 2a-d) and the summarizing bullseye plot in Fig. 2 e, covering the results in each slice of the heart from base to apex.

Discussion

In this pilot study, we presented our initial results using TPM for the analysis of regional RV function in patients with transposition of the great arteries. It was observed, in agreement with [2], that the motion patterns of the systemic RV in Senning patients differ significantly from those of the normal human LV, where the contraction of the ventricular wall and the septum occur simultaneously. Further investigations with more patients in various stages of the remodeling process of the right ventricle are warranted in order to understand the significance of these abnormalities and to assess potential benefits for therapeutic decisions. We are also currently investigating the direct derivation of strain maps from the obtained MR velocity fields [5] in comparison to 1D strain measurements obtained with ultrasound [6].

References

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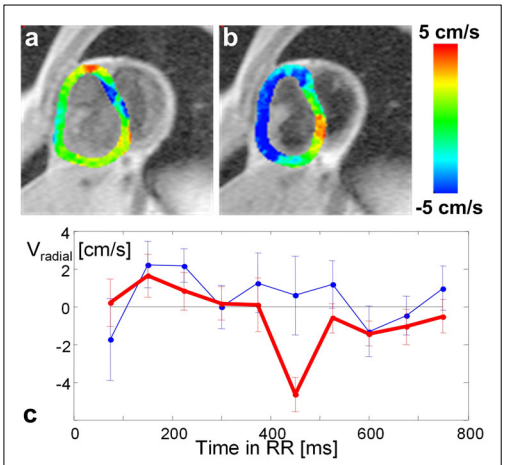

Fig 1: Patient 2: Color-coded radial velocity maps in a mid-ventricular slice during systole (a) and diastole (b) and the mean radial velocities over the cardiac cycle in segments of the RV free wall (thick) and septum (thin).

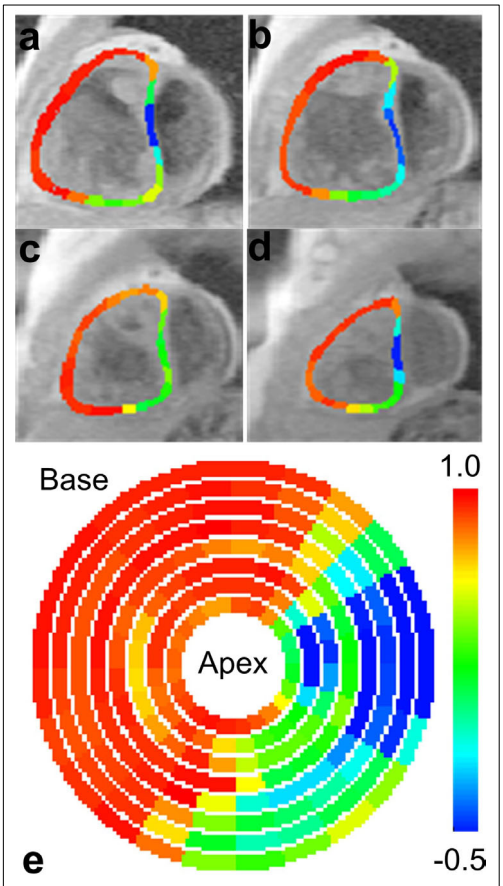

Fig 2: Patient 5: Color-coded correlation coefficients superimposed onto the anatomical images of every other slice (a-d) and a bullseye plot representing all acquired slices from base to apex (e).