Assessment of global and regional myocardial velocities in patients with left ventricular hypertrophy using high temporal resolution MR Tissue Phase Mapping

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Introduction

Magnetic Resonance Tissue Phase Mapping (TPM) allows a detailed evaluation of global and regional myocardial velocities in all spatial directions throughout the cardiac cycle. Using a high temporal resolution, even discrete changes of the left ventricular motion pattern can be detected [1]. As myocardial velocities vary within different segments of the left ventricle, diagnostic accuracy might benefit from a segmental analysis. Experimental studies suggest that regional myocardial relaxation disorders are related to specific cardiac diseases like left ventricular hypertrophy [2]. Our purpose was to determine, whether patients with left ventricular hypertrophy due to systemic hypertension demonstrate changes in global or segmental myocardial motion of the left ventricle as measured by high temporal resolution TPM.

Methods

14 patients with echocardiographic proven left ventricular hypertrophy and arterial hypertension (mean age 52.1 years) and 8 age-matched volunteers (mean age 52.5 years) were assessed with respiratory gated TPM measurements using a 1.5 T system (Siemens Sonata). Three short axis slices (basal, midventricular, apical) were acquired with a black blood prepared gradient echo sequence (TR=6.9ms; temporal resolution 13.8ms; spatial resolution 1.3×2.6mm; *venc*=15cm/s in-plane, 25cm/s through-plane) with prospective ECG-gating, advanced navigator gating [3], view sharing and first-order flow compensation. The acquisition duration of one slice was about 6 minutes.

Data postprocessing includes contour segmentation, correction for translational motion components and a transformation of the measured in-plane velocities to radial and circumferential velocities [4]. The temporal axis was normalized in order to avoid temporal jitter caused by the heart rate [1]. In each slice global velocity time courses as a mean over all pixel of the LV segmentation mask were calculated. Furthermore, systolic and diastolic peak velocities of all three velocity components were assessed, as well as diastolic time to peak radial and longitudinal velocities. A ROI analysis was performed according to the 16-segment model in 6 basal, 6 midventricular and 4 apical segments (see figure 1). The basal longitudinal velocities of all myocardial segments were analyzed in terms of peak velocities and diastolic time to peak velocity.

Results

If global velocities were compared, in the basal slice diastolic longitudinal peak velocities were significantly reduced in patients (p=0.03, t-test) (see figure 2), whereas no significant differences were revealed in midventricular or apical slices. However, the time course of myocardial performance seems altered in all slices of the patients as radial and longitudinal diastolic peak velocities were significantly delayed in the basal and midventricular slices ($p<0.05$). In apical slices only radial time to peak velocity was significantly altered (p=0.001). Furthermore systolic radial peak velocities were significantly increased in apical slices of patients compared to the group of age-matched volunteers (p=0.02).

Figure 3 demonstrates exemplary the differences of regional myocardial motion pattern in the anterior and the inferoseptal left ventricular wall. Regional times to peak longitudinal velocities were delayed in all myocardial segments ($p<0.01$). Noticeable, systolic longitudinal peak velocities were significantly increased in the septal regions, i.e. in the anteroseptal (p=0.04) and inferoseptal (p=0.01) segments. Furthermore these segments demonstrated reduced diastolic longitudinal peak velocities (p=0.04), whereas no significant differences of peak velocities could be found in the other regions of the basal myocardium.

Discussion

Patients with left ventricular hypertrophy demonstrated substantial changes in the temporal evolution of myocardial velocities especially in diastole as indicated by changes in time to peak diastolic expansion. The changes between patients and volunteers of longitudinal peak velocities in the basal slice became only significant as segmental analysis was performed, corroborating the importance of a regional data evaluation.

With three left ventricular slices subdivided in 16 segments including three velocity components, TPM provides a large amount of data. Therefore, the most significant changes in terms of a specific cardiac disease have to be extracted regarding future clinical applications. This leads to a reduction of necessary data to be acquired and might therefore result in a reduced acquisition duration of TPM measurements (e.g. the acquisition of less velocity components). A large number of healthy subjects in at least three different age groups could serve as a clinically valid reference standard to permit a correlation of global and local motion patterns between age-matched volunteers and patients with potentially disturbed myocardial motion.

With its high temporal and spatial resolution TPM is a promising method that might develop as a new diagnostic tool which detects even subtle changes of systolic and diastolic dysfunction in cardiac disease. As myocardial velocities differ within left ventricular regions a careful evaluation of the different myocardial segments, as enabled by TPM, seems essential.

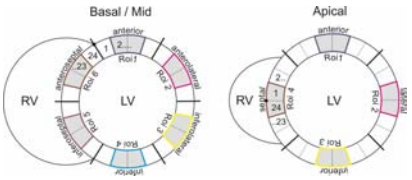

Fig.1: ROI analysis in 16 segments according to AHA/ACC recommendations. Mean velocities were calculated inside every segment.

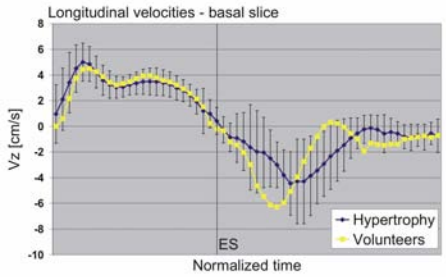

Fig.2: Time course of global longitudinal velocities in the basal slices of patients and age-matched volunteers.

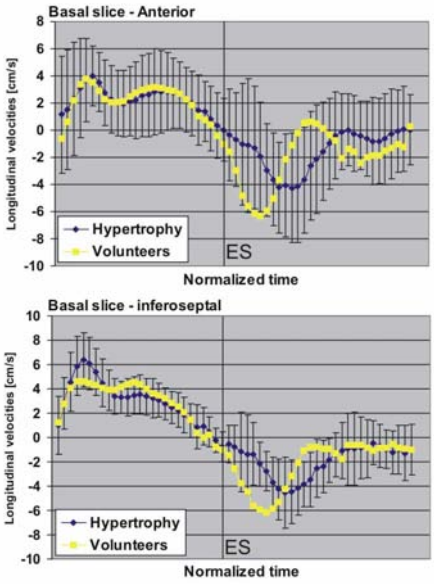

Fig.3: Time course of basal longitudinal velocities in the anterior (upper) and inferoseptal (lower) left ventricular wall of patients and volunteers.

References

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