High temporal resolution Tissue Phase Mapping detects age-related segmental changes of myocardial velocities in healthy volunteers

D. Föll[1], E. Schilli[1], M. Markl[2], C. Bode[1], J. Hennig[2], and B. A. Jung[2]

[1]Dept. of Cardiology, University Hospital, Freiburg, Germany, [2]Dept. of Diagnostic Radiology - Medical Physics, University Hospital, Freiburg, Germany

Introduction

Magnetic resonance Tissue Phase Mapping (TPM) enables a quantitative analysis of myocardial wall motion. Subtle changes of the complex diastolic motion patterns of the left ventricle can be detected with high temporal resolution TPM [1]. In contrast to Tissue Doppler Imaging, which is limited by the acoustic window, TPM allows for a segmental analysis of the entire left ventricle. High temporal resolution TPM measurements were performed with three-directional velocity encoding in healthy volunteers in three different age groups. Global and regional motion patterns were analyzed in order to determine, whether different age-groups demonstrate changes in myocardial velocities.

Methods

We examined 32 healthy volunteers by respiratory gated TPM using a 1.5 T system (Siemens Sonata). Three different age-groups (<40 years (mean 28.2 y., n=12), 40-60 years (mean 52.5 y., n=8) and >60 years (mean 63.3 y., n=7) were assessed. Three slices (basal, midventricular, apical / 8 mm thickness) in short axis view of the left ventricle were acquired with a black blood prepared gradient echo sequence (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 [2], view sharing and first-order flow compensation.

Data postprocessing include contour segmentation, correction for translational motion components and a transformation of the measured in-plane velocities to radial and circumferential velocities. The temporal axis was normalized in order to avoid temporal jitter due to different heart rates [1]. Global systolic and diastolic peak velocities in the longitudinal, radial and circumferential direction of the left ventricle were assessed. Furthermore, time to peak of longitudinal and radial diastolic velocities was calculated. In order to assess intraventricular local differences of myocardial motion, we performed a ROI analysis according to the 16-segment model (excluding the pure apex) in 6 basal, 6 midventricular and 4 apical segments (see Fig. 1). The basal longitudinal velocities of all ROI's were compared in the different age groups.

Results

Assessing global systolic velocities only apical radial velocities were significantly increased in the age group < 40y compared to the group >60y and the group 40-60y. Furthermore a reduced peak diastolic radial velocity was demonstrated in midventricular and apical slices in the group >60y compared to the young volunteers (t-test, $p<0.05$). Fig.2 shows the global longitudinal velocities in the basal slice for all three age groups. Peak maximal systolic longitudinal velocity was significantly decreased in the group >60y in apical slices ($p=0.01$). A significant difference ($p<0.05$) in all slice locations in diastolic peak longitudinal velocities was revealed comparing the age group >60y and <40y. Time to peak diastolic longitudinal velocity was not significantly altered, if global velocities of these two groups were compared. In basal global longitudinal velocities no significant changes between <40y and 40-60y or between 40-60 y and >60 y were found.

This was different in a segmental analysis: Fig. 3 demonstrates the time courses of segmental basal longitudinal velocities for the different age groups in the anterior and inferior wall. It shows that changes of myocardial motion in age differ from segment to segment, demonstrated by the dependency of diastolic peak velocity reduction on the myocardial region. The diastolic overshoot after the rapid relaxation, seen in anterior and lateral wall in the young is extremely diminished and delayed in the oldest group. As for global velocities a significant decrease of diastolic longitudinal velocity was found within all basal myocardial regions ($p<0.001$). Furthermore, time to peak diastolic longitudinal velocity was significantly changed with increased age ($p<0.05$) in the anterior, inferior and inferolateral myocardium. In the age group 40-60y the diastolic peak longitudinal velocities in all regions were significantly reduced compared to the younger group (<40y) and significantly increased in the inferior and septal wall compared to the older group (>60 y). Motion patterns during diastole exhibit considerable differences within the different segments of a single slice, as shown for the longitudinal velocities in the basal slice in Fig. 4.

Discussion

High temporal resolution TPM is a promising method for the assessment of global and segmental myocardial motion. The data show that different left ventricular segments exhibit distinctive and different myocardial motion patterns. With a larger number of healthy subjects in the three different age groups the data 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. Furthermore, we demonstrated that the evaluation of diastolic performance depends on segmental analysis. In fact, the diagnosis of diastolic dysfunction often raises difficulties in clinical routine, but relaxation disorders may be an early hint to cardiac disease preceding systolic dysfunction and account for up to a half of the cases with heart failure [3]. TPM has a high potential to overcome this diagnostic problem in future.

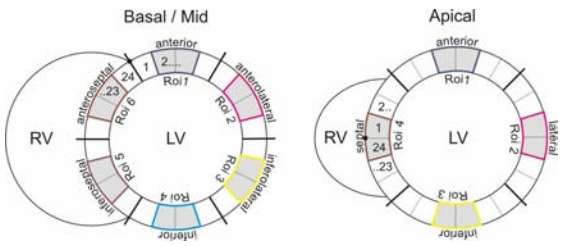

Fig.1: ROI analysis in 16 segments according to AHA/ ACC recommendations. Mean velocities were calculated inside every segment according to the 16-segment model.

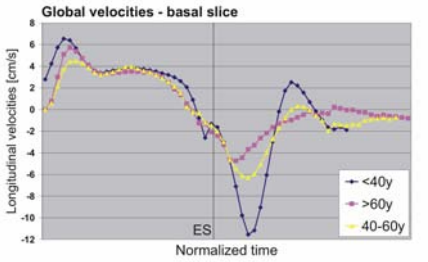

Fig.2: Time courses of global longitudinal velocities in the basal slice for all three age groups. ES=end-systole.

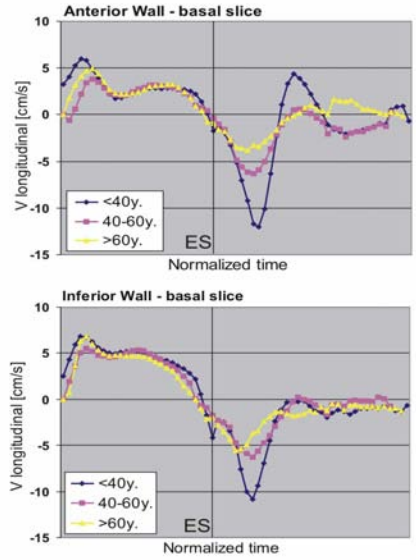

Fig.3: Time courses of basal longitudinal velocities for the three age groups in an anterior region (upper) and inferior region (lower). ES=end-systole.

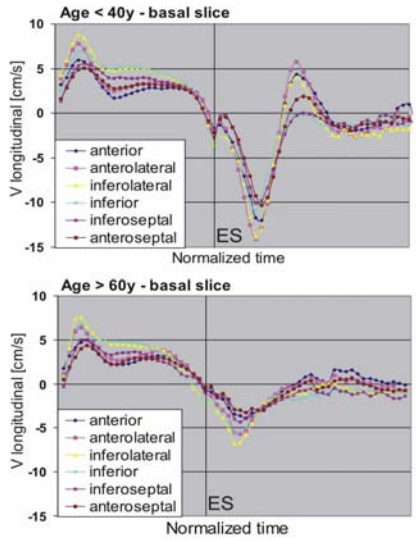

Fig.4: Time courses of regional longitudinal velocities in six ROI's of the basal slice for the younger (upper) and the older (lower) age group.

References

[1] Jung et al. J Magn Reson Imaging 2006; 24:1033-39.

[2] Jung et al. Magn Res Med 2005; 55:937-942.

[3] Owan et al., New Engl J Med 2006; 355:251-259.