Segmental Left Ventricular Function Depends on Gender and Age: New Findings by High Temporal Resolution Tissue Phase Mapping

D. Foell[1], E. Schilli[1], F. Staehle[2], B. Jung[2], C. Bode[1], J. Hennig[2], and M. Markl[2]

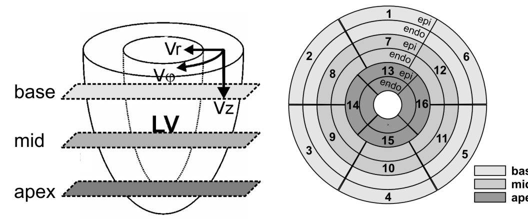
[1]Cardiology and Angiology, University Hospital Freiburg, Freiburg, Germany, [2]Dept. of Diagnostic Radiology, Medical Physics, University Hospital Freiburg, Freiburg, Germany

Introduction: Recent developments in cardiac gated and respiration controlled CINE phase contrast MRI (Tissue Phase Mapping, TPM) permit the quantitative evaluation of myocardial velocities with high spatial and temporal resolution [1]. This exact analysis of myocardial velocities in all spatial directions can be used to evaluate global and local radial, circumferential and long-axis left ventricular (LV) function. Due to the high spatial resolution of TPM a segmental analysis covering the entire LV is possible and as velocities are distributed heterogeneously within the LV, it seems preferable over the investigation of global velocities [2]. The aim of our study was a detailed analysis of the distribution of myocardial velocities in a large cohort of 60 healthy volunteers. Segmental analysis of myocardial velocities was employed to provide reference values and to detect gender and age-related changes of regional LV function.

Methods: 3 short axis slices (basal, midventricular, apical) were acquired using a black blood prepared gradient echo TPM sequence (TR=6.9 ms; 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 (1.5 T, Sonata, Siemens). We examined 60 healthy volunteers in 3 age groups: 20-40 years (n= 21, 11 men), 40-60 years (n= 20, 9 men), > 60 years (n= 19, 10 men). Data post-processing (Matlab, The Mathworks Inc.) included LV contour segmentation, correction for translational motion and a transformation of the measured three-directional motion velocities into a cylindrical coordinate system adapted to the LV anatomy, i.e. radial (Vr), circumferential (Vϕ) and long-axis velocities (Vz) (fig.1). To perform a segmental analysis, the anteroseptal right ventricular connection of the LV was marked manually. Next, the LV was divided according to the 16 segment model (see fig.1) and subdivided into endo- and epicardial regions. For each segment peak and times to peak radial and long-axis velocities in systole and diastole were calculated. Results were presented as bull eyes plots permitting a direct comparison between gender, age and location (fig.2, 3).

Results: Figure 2 and 3 demonstrate the results for peak long- axis velocities in systole and diastole. Systolic lateral velocities were higher in young women than in young men, whereas this difference was reversed with increased age (see fig.2). Women in the oldest age-group revealed lower septal and inferior velocities than age-matched men or younger women. Furthermore, in diastole (fig.3) young women's long-axis velocities were higher in all segments except for the anterior apical region, whereas older women revealed lower velocities than age-matched men. In general, the differences in regional diastolic peak velocities within the left ventricle, e.g. between septum and lateral wall or between apical and basal regions were reduced with aging. Analysis of peak radial velocities demonstrated an increase of lateral radial velocity compared to the septum in aging men, not in women, in whom this velocity rather decreased. Similar to findings for long-axis motion, young women's septal diastolic radial velocities exceeded those of age-matched men, with reversal in the oldest age group. If times to peak velocities were assessed, both velocity components were delayed with aging to various extents. For example times to radial diastolic peak velocities were prolonged in both genders in all segments except in the septum.

Fig.1: Segmental analysis of LV function based on the AHA/ACC recommendations. Mean velocities were calculated in every segment.



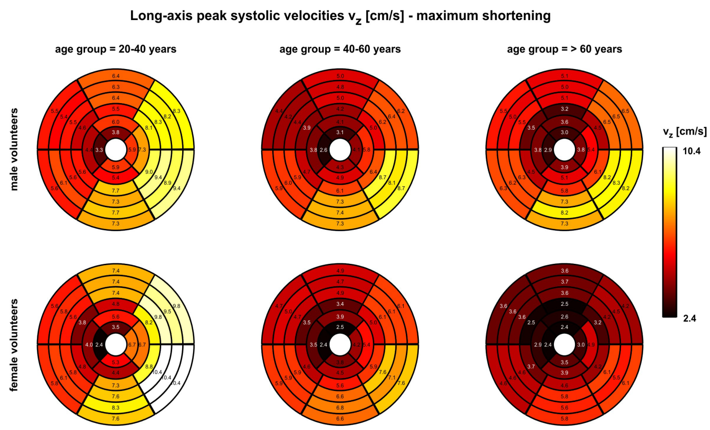


Fig.2: Comparison of peak ***systolic*** *long-axis velocities for different genders (rows) and age groups (columns). Peak systolic velocities are shown as colour coded overly onto an extended AHA 16 segment model.*

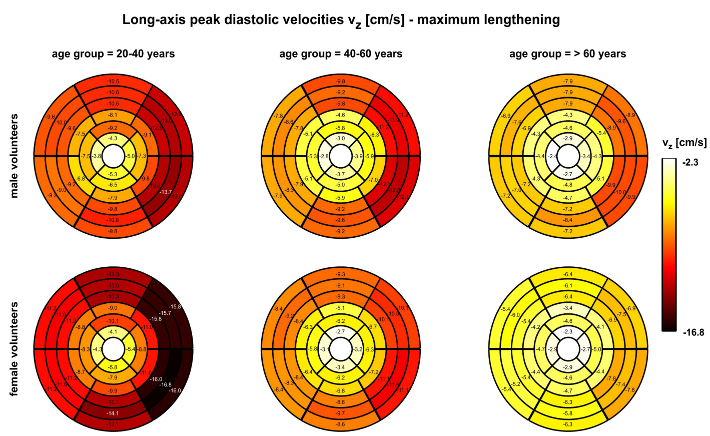


Fig.3: Comparison of peak ***diastolic*** *long-axis velocities for different genders (rows) and age groups (columns). Peak systolic velocities are shown as colour coded overly onto an extended AHA 16 segment model.*

Discussion: The results of this study present, to our knowledge for the first time, a comprehensive evaluation of age and gender specific normal left ventricular function based on a segmental analysis of the dynamics of myocardial velocities. Our findings clearly demonstrate age and, most noticeably, gender related alterations of regional myocardial motion. Overall, we found a reduction of diastolic velocities in women during the process of aging, whereas myocardial velocities of young women exceeded those of age-matched men. Yet, it remains unknown, whether these alterations of myocardial velocities may influence or even cause the higher prevalence of diastolic heart failure in women or the worse prognosis of women for a variety of cardiac diseases [4]. Most of these differences may have been missed, if analysis of cardiac function was solely based on global velocities. But the exact knowledge of the normal myocardial performance is essential and can be used as a reference for future patient studies. In this context, TPM providing full left ventricular coverage offers the base for further investigation and has the potential to become a diagnostic tool that might elucidate the complexity of the performance of the heart muscle as a whole.

Acknowledgements: Deutsche Forschungsgemeinschaft (DFG): Grant # HE 1875/18-1, FO 507/2-1, Bundesministerium für Bildung und Forschung (BMBF), Grant # 01EV0706.**References:** [1] Jung et al. *J Magn Reson Imaging* 2006; 24:1033-39; [2] Bogaert et al. *Am J Physiol* 2001; 280: H610-620; [3] Jung et al. *Magn Res Med* 2006; 55:937-42. ; [4] Kitzman et al. *Heart Fail Clin* 2007; 3(4):437-453.