Application of breath-hold spiral tissue phase velocity mapping in a DCM patient

Robin Simpson[1,2], Jennifer Keegan[1,2], and David Firmin[1,2]
[1]*Imperial College, London, England, United Kingdom,* [2]*Royal Brompton Hospital, London, England, United Kingdom*

Target Audience: Those interested in regional myocardial mechanics

Purpose: The assessment of regional myocardial mechanics is a promising research area which could allow better monitoring and follow up of disease. A spiral tissue phase velocity mapping (TPVM) sequence with non-Cartesian SENSE has been developed and used previously to characterise regional myocardial mechanics in healthy volunteers[1]. The technique takes only 13 heartbeats to acquire three directions of myocardial motion in a single image slice and is reconstructed immediately, allowing it to be easily incorporated into a clinical scan. This abstract presents initial experience using this sequence in a dilated cardiomyopathy (DCM) patient.

Methods: As previously described[1], k-space is fully sampled with 8 spiral interleaves (14ms duration, TR 24ms) but only 3 spirals are acquired and reconstructed using non-Cartesian SENSE[2] implemented on the Gadgetron GPU framework[3]. Velocity compensated and encoded (30cm/s through plane, 20cm/s in-plane) data are acquired in consecutive heartbeats, with an initial heartbeat used to collect coil sensitivity information (total breath-hold duration 13 heartbeats). Acquired spatial resolution is 1.7x1.7mm. Retrospective cardiac gating is used to cover the entire cycle (50 reconstructed phases). A mid ventricular short-axis slice has been acquired in a DCM patient (LVEF 21%, EDV 326mL, ESV 258mL, age 58) on a Siemens Skyra 3T scanner. Global peak and time to peak (TTP) velocities were extracted and compared with results from ten healthy volunteers (mean age 32, range 25-57) and in particular with one age-matched volunteer (age 57).

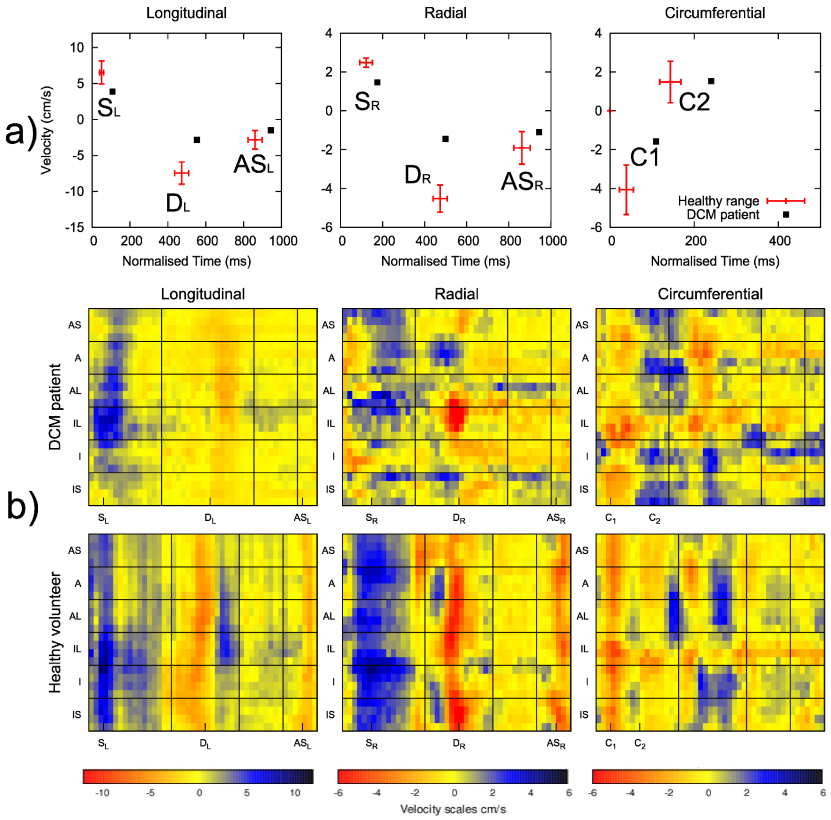

Figure 1: a) Mean +/- SD longitudinal, radial and circumferential peak and time to peak velocity values in 10 healthy volunteers (red) and one DCM patient (black). In the longitudinal and radial directions one systolic (S_L and S_R respectively), one diastolic (D_L and D_R) and one atrial systolic (AS_L and AS_R) peak is seen. In the circumferential direction the peaks are more variable but two early systolic peaks (C1 and C2) are seen consistently. b) Regional colourplots showing regional velocity variation on the y-axis against time on the x axis for the DCM patient and one age matched healthy volunteer for comparison. The positions of the global peak velocities are marked beneath each plot. (AS=anteroseptum, A=anterior, AL=anterolateral, IL=inferolateral, I=inferior, IS=inferoseptum).

Results: Figure 1a shows mid-slice healthy mean (+/- SD) peak and time to peak velocities as well as the patient values. In the patient peak velocities in the longitudinal and radial directions are clearly reduced. The regional motion colour plots for the patient and an age-matched volunteer allow easy comparison of healthy and diseased motion. While systolic longitudinal function in the patient is reasonably well preserved, diastolic function is clearly impaired. In the radial direction asynchronous motion can be seen, particularly in early diastole: while the lateral and septal regions are relaxing, the anterior and inferior regions are still moving towards the centre of the ventricle. There are fewer circumferential velocity peaks when compared with the healthy volunteer and the peaks which are present are prolonged.

Conclusion: Spiral trajectories and non-Cartesian SENSE has allowed acquisition of high temporal resolution TPVM images within a clinically achievable breath-hold. The necessity of using age matched volunteers has previously been shown[4] and allows proper comparison of healthy and diseased motion. This initial clinical example indicates that this technique is capable of characterizing pathological motion and thereby could be used in the future to monitor disease.

References

1.Simpson R, Keegan J, Gatehouse P, Hansen M, Firmin D, “Spiral Tissue Phase Velocity Mapping in a Breath-hold with Non-Cartesian SENSE” JCMR,2013
2. Soerensen T, Atkinson D, Schaeffter T, Hansen M, “Real-Time Reconstruction of Sensitivity Encoded Radial Magnetic Resonance Imaging Using a Graphics Processing Unit” IEEE Trans Med Imaging, 2009
3. Hansen M, Soerensen T, “Gadgetron: An Open Source Framework for Medical Image Reconstruction” MRM,2013
4.Foell D, Jung B, Staehle F, Schilli E, Bode C, Hennig J, Markl M, “Visualization of Multidirectional Regional Left Ventricular Dynamics by High-Temporal-Resolution Tissue Phase Mapping”, JMRI, 2009