# Characterising global and regional myocardial motion patterns for the whole cardiac cycle using retrogated spiral phase velocity mapping

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***Target audience:*** Scientists and clinicians interested in regional myocardial mechanics – visualisation of normal motion, atrial systole.

***Purpose*:** One of the available methods for measuring regional myocardial motion with MR is phase velocity mapping (PVM). Current high resolution PVM sequences with use Cartesian k-space coverage in combination with respiratory navigator gating, leading to long acquisition times [1,2]. Also, prospective ECG-gating means that the analysis of the full cardiac cycle has not previously been possible. In this study, a high temporal and spatial resolution PVM technique using efficient spiral k-space coverage and retrospective ECG-gating is presented which allows detailed analysis of the entire cardiac cycle in ten healthy volunteers. Analysing and visualising the complicated 3D motion patterns of the LV is a challenge – a new method of presenting the data using 2D colour maps is also introduced.

***Methods***: The sequence covers k-space with 13 spiral interleaves (12ms duration, TR 21ms). Navigator-gated reference and 3-directional velocity-encoded data (15cm/s in-plane, 25cm/s through-plane) are acquired in consecutive cardiac cycles following a dummy cycle (nominal duration 53 cardiac cycles). Acquired spatial resolution is 1.4x1.4x8mm (reconstructed 0.7x0.7mm). Retrospective gating allows full coverage of the cardiac cycle with 60 phases per RR-interval (reconstructed temporal resolution 14-20ms depending on heart-rate). Basal, mid and apical short-axis slices were acquired in 10 healthy volunteers on a Siemens Skyra 3Tesla scanner. Radial, circumferential and longitudinal peak and time-to-peak velocities were measured (the main peaks in all three directions can be seen in Figure 1). Of particular note is the late diastolic peak which has not previously been seen with prospectively gated PVM studies and which occurs due to passive movement as the atria contract, producing a velocity peak in radial and longitudinal directions. The data averaged over the volunteers is also shown in 2D colour-plots allowing regional differences in velocities and their timings to be easily assessed.

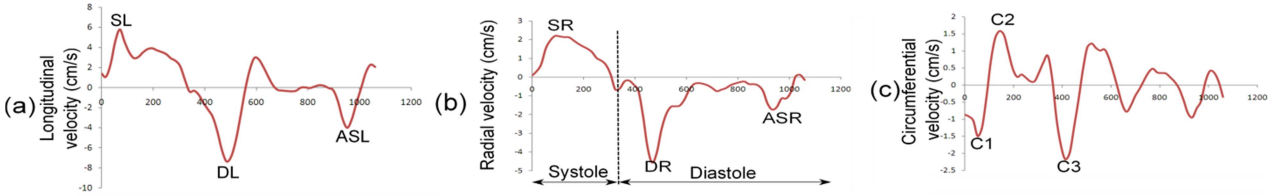


***Figure 1***: *Example basal curves for longitudinal (a), radial (b) and circumferential (c) directions. End systole is marked by a vertical dotted line on the radial curve. The main peaks (systole (S), early diastole (D) and atrial systole (AS) for longitudinal and radial velocities and the three circumferential peaks (C1, C2 and C3)) are marked.*

***Results*:** The high temporal resolution allowed consistent visualisation of fine features of motion, while high spatial resolution allowed the detection of statistically significant regional and transmural differences in motion. Figure 1 shows example data and highlights the main velocity peaks throughout the cardiac cycle, while Figure 2 shows the mean peak and TTP velocity values +/- standard deviation for those peaks. TTP values are shown normalized to a fixed systolic (350ms) and diastolic (650ms) length. This reduces the effect of differences in heart rates (mean RR-interval = 994 +/- 121ms) between volunteers, leading to small SDs in TTP values throughout the cardiac cycle (16.1ms, 20.2ms and 29.9ms for early systolic, early diastolic and late diastolic radial TTPs respectively in the mid slice). Peak velocity values similarly show small standard deviations. Figure 3 shows basal, mid and apical short-axis colour-maps displaying regional velocities against time after the R-wave, averaged over the 10 volunteers.

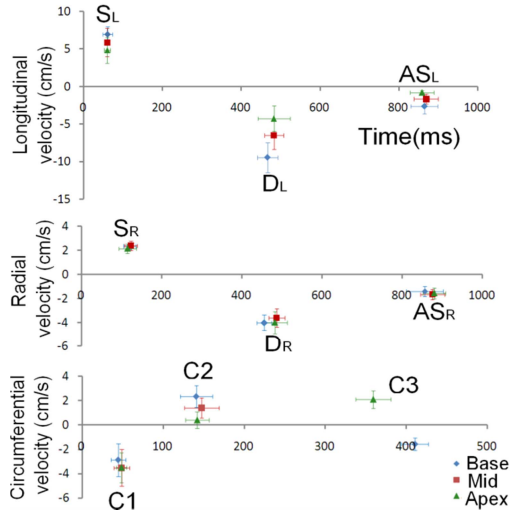


***Figure 2***: *Mean+/-SD values of peak and TTP velocities for the peaks shown in Figure 1. Peak and TTP values show low standard deviations throughout the cardiac cycle. C3 is not present in the mid slice.*

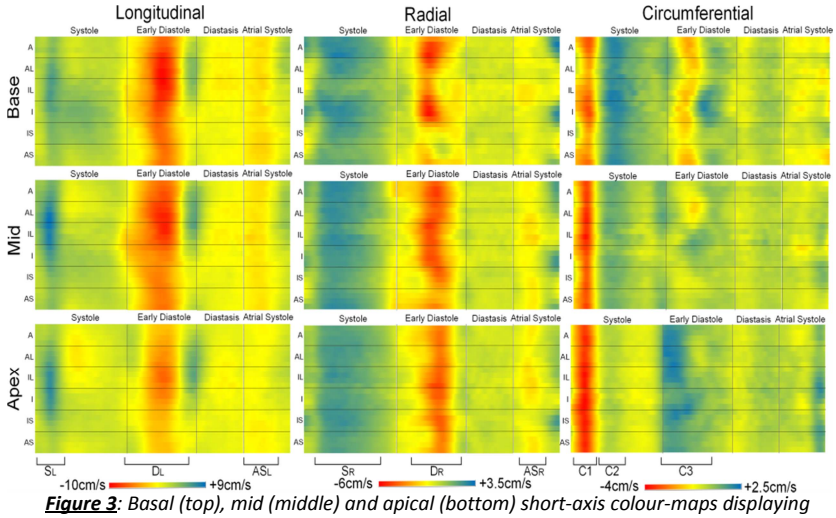


***Figure 3***: *Basal (top), mid (middle) and apical (bottom) short-axis colour-maps displaying regional longitudinal (left), radial (middle) and circumferential (right) velocities (from anterior wall through to lateral, inferior and septal walls on the vertical axis) against time after the R-wave (horizontal axis), averaged over the ten healthy volunteers. Complicated motion patterns can be rapidly visualized.*

**Conclusion and Discussion**: The use of spiral imaging has allowed the acquisition of high resolution PVM images in a relatively short acquisition time (95 ± 16 cardiac cycles per slice), while retrospective cardiac gating has enabled the analysis of the entire cardiac cycle including late diastole (atrial systole). The newly introduced colour plots allow easy interpretation of complicated regional motion patterns and make use of the high spatial resolution acquired. Future work will include implementing parallel imaging to further speed up the acquisition.

***References:*** *[1]Jung,2006,JMRI;[2]Delfino,2006,JMRI*