Interleaved spiral phase velocity mapping of left and right coronary artery blood flow: correction for through-plane motion using selective fat-only excitation

J. Keegan[1], P. Gatehouse[1], G-Z. Yang[2], D. Firmin[1]

[1]Cardiovascular MR Unit, Royal Brompton Hospital, London, United Kingdom, [2]Department of Computing, Imperial College of Science, Technology and Medicine, London, United Kingdom

Introduction: Interleaved spiral phase velocity mapping has recently been used to acquire high temporal resolution velocity maps in both left (lca) and more mobile right (rca) coronary arteries (1). However, whereas the flow velocities in the lca may be corrected for the through-plane motion of the vessel by subtracting the velocity of an area of adjacent myocardium, the right ventricular wall is too thin to allow such a correction for the rca. Although this is unimportant when looking at the mean flow velocity throughout the cardiac cycle, it is an issue when looking at the temporal details in the flow profiles which are known to change with atherosclerotic disease state. The purpose of this work therefore, is to develop a method of through-plane correction applicable to both left and right arteries. The approach implemented has been to selectively excite and velocity map the surrounding epicardial fat.

Materials and Methods: Navigator gated coronary blood flow velocity mapping (TE = 6.1ms, TR = 22ms) may be achieved using a water-excitation pulse, a 10ms spiral readout gradient and a bi-polar velocity encoding gradient which alternates on consecutive cardiac cycles (1). The water-excitation pulse enables the vessel to be seen with good contrast throughout the cardiac cycle and reduces echo-time dependent partial volume effects at the vessel boundary. Two methods of through-plane motion correction were investigated. In the first, a separate velocity mapping acquisition was performed with the same imaging parameters but using fat-excitation, rather than water-excitation. In the second method, water- and fat-excitations were interleaved throughout the cardiac cycle, reducing the temporal resolution to 44ms, but allowing the acquisition to be completed without extending the study duration. Studies were performed in 10 right and 6 left arteries on a Siemens Sonata 1.5 Tesla scanner. Velocity through the cardiac cycle was plotted (i) without correction, (ii) with correction derived from the separate fat-excitation acquisition and (iii) with correction derived from the interleaved fat-excitation/water-excitation acquisition. For the lca studies, velocity was also plotted after correction with an area of adjacent myocardium. Paired t-tests were used to compare the data corrected with the separate fat-excitation acquisition and that corrected with the shorter duration but poorer temporal resolution fat-excitation/water-excitation interleaved acquisition.

Results: Figure 1 shows the mean (+/-SD) velocities measured in the 10 right and 6 left coronary arteries both before (a) and after (b) correction for through-plane motion using the separate fat-excitation acquisition (solid circles) and the interleaved fat-excitation/water-excitation acquisition (open circles). For comparison, typical Doppler Flowire tracings from normal right and left arteries are shown in (c). For the rca, the through-plane motion correction reduces the systolic velocity peak, resulting in a mean diastolic/mean systolic velocity ratio of 1.30 (+/-0.21). As expected, for the left arteries, the through-plane correction removes the systolic flow component, leading to strongly predominant diastolic flow. For both left and right arteries, there are no significant differences between the separate fat-excitation acquisition and the interleaved fat-excitation/water-excitation acquisition when looking at mean systolic and mean diastolic flow velocities.

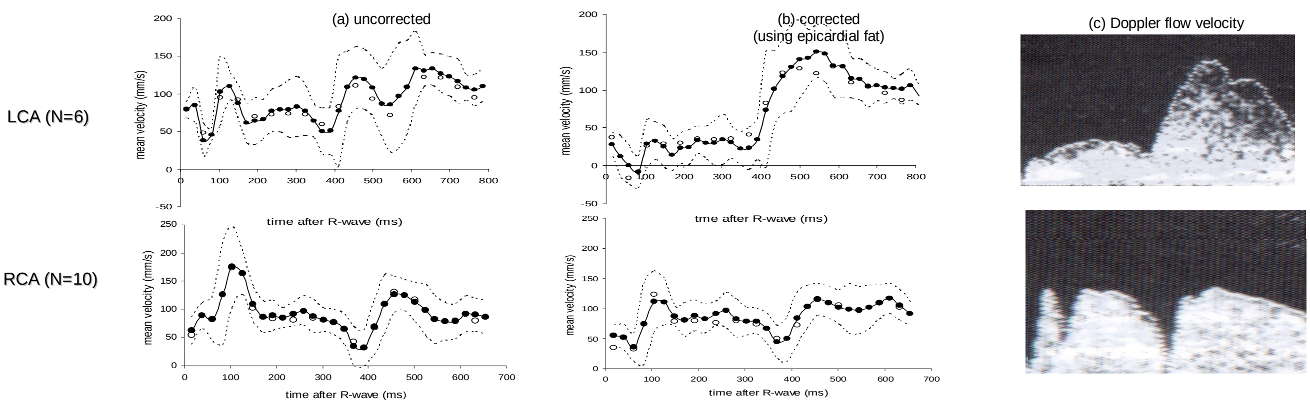

Figure 1: mean (+/-SD) flow velocities in 6 left (top) and 10 right (bottom) coronary arteries before (a) and after (b) correction for through-plane motion. (Solid circles = data from separate water-excitation and fat-excitation acquisitions (TR=22ms), open circles = data from interleaved fat-excitation/water-excitation acquisition (TR=44ms)). For comparison, Doppler Flowire recordings in normal left and right coronary arteries are shown in (c).

For the left arteries, the correction derived from epicardial fat reduced the mean systolic flow velocity more than the correction derived from the adjacent myocardium (21.6mm/s vs. 40.0mm/s, $p < 0.05$; Figure 2(a)). The water-excitation velocity map (Figure 2(b)) shows that the material surrounding the coronary artery has a large range of velocities in systole and demonstrates the need for a more local correction.

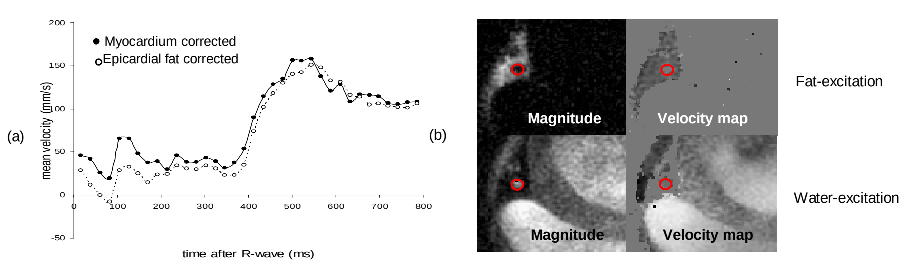

Figure 2: Left coronary artery (N=6) flow velocities corrected with adjacent myocardium (solid circles) and epicardial fat (open circles) (a). Magnitude images (left) and velocity maps (right) from separate water-excitation (top) and fat-excitation (bottom) acquisitions in early systole showing a wide range of velocities around the coronary vessel.

Conclusion: Selective excitation of the surrounding epicardial fat enables through-plane correction of coronary artery flow velocities, enabling the temporal details of the flow profiles to be studied for both left and right arteries. The lower velocities obtained when correcting the left coronary artery with the surrounding epicardial fat are due to the area selected for correction being more local to the coronary artery.

References: (1) Keegan et al., JMRI (in press).