Vessel Wall Imaging of Abdominal Aorta at 3T: Investigation of Plaque-mimicking Flow Artefacts

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Introduction

Vessel wall imaging is important for the non-invasive assessment of atherosclerosis, giving complementary information to angiography. The abdominal aorta is a common area for development of atherosclerosis, but has not been widely studied because of its deep location within the body and because of problems associated with respiratory and peristaltic motion. Our preliminary studies of the vessel wall in this region demonstrated inconsistent image quality, ineffective blood suppression and apparent vessel wall thicknesses which varied between slices in a multislice protocol. These effects can eroneously be interpreted as atherosclerotic plaques. Such 'plaque mimicking flow artefacts' have previously been seen in the carotid bulb, as the result of slow flow which is inadequately suppressed by out-of-slice saturation bands at certain phases of the cardiac cycle [1]. This study aims to investigate the appearance of these artefacts in the abdominal aorta and to discover ways to avoid their appearance.

Methods

The abdominal aortas of 4 healthy volunteers were imaged with a 3T clinical scanner (Philips) using a 6-element array coil, at various delay times following cardiac triggering with either vector-ECG or peripheral pulse (PP) oximetry. A turbo-spin echo sequence was used with TE=70ms, TR=3 heartbeats, with data acquisition for only one slice per heartbeat in a 3-slice interleaved package. Abdominal motion artefacts were reduced using phase-encode artefact reduction [2] and an anterior saturation band. Two blood-suppression methods were compared: double-inversion recovery (DIR) [3] and out-of-slice presaturation using superior and inferior saturation bands [4]. Other sequence parameters were: turbo factor 11, FoV 340×200, matrix 432×232, slice thickness/gap 3 mm/3 mm, 2 signal averages, spectral fat suppression. Measurements were made of mean blood signal-to-noise ratio, apparent vessel wall thickness and subjective quality of vessel wall visualisation (scale 0–5, 5 is best).

Results

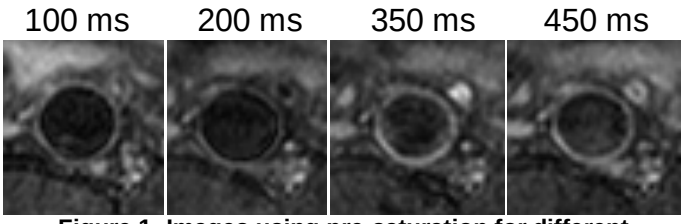

Figure 1: Images using pre-saturation for different delays following PPU trigger (~250 ms after R-wave).

Delay (ms)	Method	Blood SNR	Thickness (mm)	Quality score
150 ECG	PreSat	3.4	1.04	2.2
300 ECG	PreSat	1.9	1.12	3.6
450–470 ECG	PreSat	2.8	1.06	2.8
450–470 ECG	DIR	2.6	0.96	2.1
400–475 PPU	PreSat	5.5	1.52	3.2
400–475 PPU	DIR	2.5	1.17	2.8

Using presaturation, the quality of blood suppression varies with trigger delay, leading to increased apparent wall thickness in diastole (Figure 1). In systole, blood suppression is better but variable image quality is observed. The table lists the blood SNR, apparent vessel wall thickness and subjective quality score for different trigger delays and suppression methods, averaged for three volunteers. Example images are shown in Figure 2.

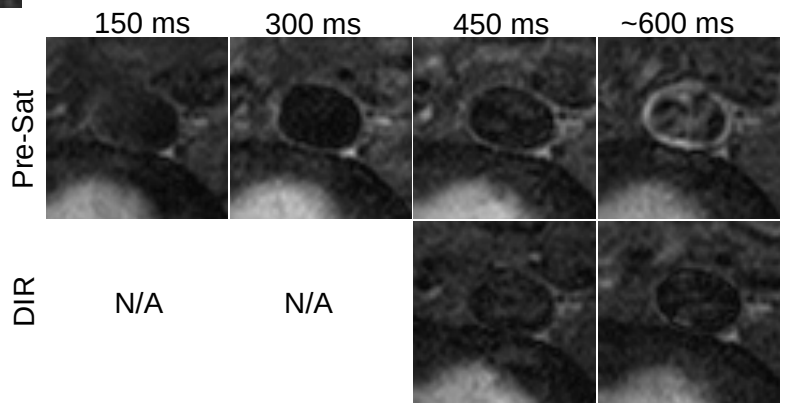

Figure 2: Comparison of presaturation and DIR images for different trigger-delays following the R-wave.

Discussion and Conclusions

Blood suppression using presaturation is effective during systole, but not in mid-late diastole due to slower flow rates; since flow is slowest near the vessel wall, the apparent vessel wall thickness increases. This problem can be reduced by using DIR for blood suppression. However, in each individual the best overall image quality occurred for late-systolic imaging (300 ms after R-wave), at which presaturation leads to good blood suppression but DIR is not applicable (due to the long inversion time). Motion effects reduce the image quality at earlier and later delay-times. These results were obtained in healthy volunteers, and further work is needed to establish the optimum methods in patients, who may have lower flow-rates and reduced vessel wall motion.

This study used a relatively low resolution for speed, to allow for many repetitions. Higher resolution acquisitions, with longer scan-times, may be more appropriate for clinical imaging. The protocols used in this study are relatively slow, as data from only one slice is acquired per heart-beat. Acquisition of multiple slices per heartbeat, at different trigger-delays, leads to substantial variations between slices and may not be reliable, although this problem has been addressed successfully in the carotids [1]. Further investigations of the flow patterns in both healthy and pathological individuals are needed to resolve this issue.

Acknowledgement

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References

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