Continuous Epicardial Fat Suppression for Coronary MRA using Balanced FFE with Long Cardiac Acquisition Windows - A Comparison of Two Techniques

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Introduction

In coronary MRA, suppression of epicardial fat is an essential step to improve the depiction of the coronary vessels. For this purpose, spectrally selective inversion recovery (SPIR) pulses are commonly applied prior to signal sampling. However, if long cardiac acquisition windows are used for increased scan efficiency, fat signal recovery during sampling will cause image quality losses. This work investigates two continuous fat suppression techniques for balanced FFE sequences with long cardiac acquisition windows applied in coronary MRA. The first method, [A], is based on multiple SPIR pulses during sampling, while the second technique, [B], locates and eliminates fat voxels retrospectively. The achieved fat suppression and image quality of the investigated methods are compared.

Methods

Experiments were performed on seven healthy volunteers (age range 27-47 years, 7M). The examinations were performed on a whole body 1.5T MR system (Gyroscan INTERA, Philips Medical Systems) equipped with a five-element cardiac synergy receive coil. The image acquisition was ECG-triggered with an appropriate trigger delay T_D (1) and respiratory-gated (navigator on right hemi-diaphragm, gating window 5mm) (2). Respiratory navigator, REST-slab and initial SPIR pulse were applied prior to sampling (2). A balanced FFE sequence with radial stack-of-stars sampling was used. The following sequence parameters were used: α=60°, TR=4.4ms, FOV 330x330x30mm³, measured voxel size 1.12 x 1.12 x 3.00mm³, reconstructed voxel size 0.7 x 0.7 x 1.5mm³. For the retrospective fat elimination method, the T_R was slightly increased to T_R=4.6ms to obtain an opposite phase between water and off-resonant fat voxels (3). To track the epicardial fat signal recovery, the sampling window (T_{AQ}=260ms) was subdivided into n=4 temporal segments (segment length T_{SEG}= 60ms), and the segments were reconstructed into a time series. The employed techniques for continuous epicardial fat suppression were as follows: using method [A], the steady state is suspended by $\alpha/2$-$T_R/2$ rundown and startup sequences (4, 5), and a SPIR pulse is employed during the interruption (Fig 1). For retrospective fat suppression, [B], epicardial fat voxels are located and eliminated from the complex image by evaluating the voxel phases (3). Additionally, a conventional protocol using only one SPIR pulse during magnetization preparation was performed for comparison. Two reviewers scored the achieved image quality and fat suppression independently. For final presentation, the 3D data sets were reformatted.

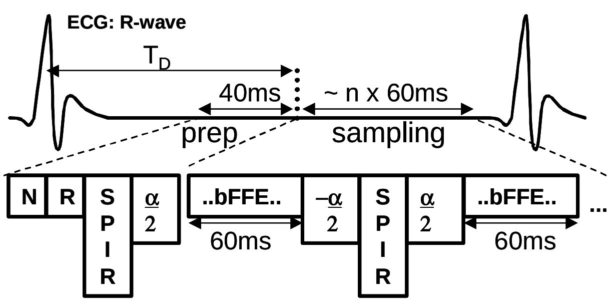

Fig. 1. Scheme of sequence [A] for continuous fat suppression

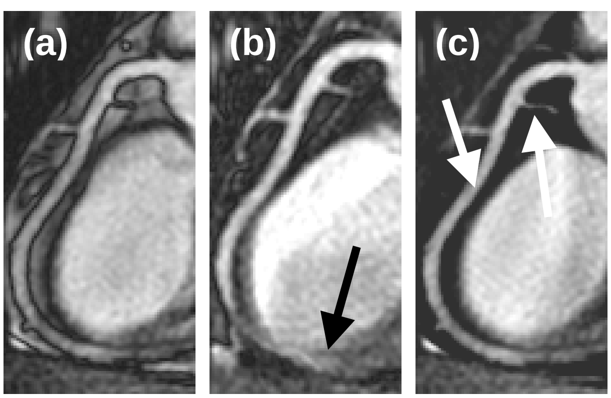

Fig. 2. Reformatted RCA images of a healthy volunteer for a conventional protocol (a), and techniques [A] and [B] (b and c)

Results

An exemplary image for a late temporal segment (~200ms delay to preparation) for one volunteer is shown in Fig. 2. In Fig. 2(a), a conventional protocol comprising one SPIR pulse during preparation was used. A strong signal from epicardial fat is visible due to fat relaxation. In Fig. 2(b), SPIR pulses were applied between the sampling segments (cf. Fig. 1), resulting in a significantly improved fat suppression over the prolonged sampling interval. However, artifacts related to the interruption of the steady state resulted in a pronounced image blur (black arrow), especially at the outer bounds of the FOV. The retrospective fat elimination, Fig 2(c), yielded a superior fat suppression in all volunteers, making additional fat suppression pulses superfluous. Furthermore, artifacts as a consequence of interruptions of the steady state were eliminated, as the steady state was maintained during the cardiac acquisition window. However, an apparent vessel diameter decrease was observed, which may mask especially small branches of the coronary arteries (white arrows).

Conclusion

Prolonged cardiac acquisition windows, e.g. for increased scan efficiency in coronary MRA, require continuous fat suppression. An acceptable suppression of epicardial fat over a prolonged sampling period was achieved with both methods [A] and [B]. However, method [A], comprising multiple SPIR pulses during sampling, is currently limited by image quality losses resulting from the interruptions of the steady state in balanced FFE sequences. This drawback could be overcome by more robust startup/rundown cycles (6) as a future refinement. The retrospective removal of fat voxels from the complex images, [B], has proven to be a reliable tool for efficient epicardial fat suppression in coronary MRA. However, the apparent narrowing of the coronary arteries is a drawback that may be a result of partial volume effects, and requires further investigation.

References

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