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Coronary MRA at 3 T using 3d multi-interleaved multi-echo acquisition with varpro fat-water separation

Saurabh Shah*[1], Xiaoming Bi[1], Diego Hernando[2], Peter Weale[1], Sonia Nielles-Vallespin[3], Peter Kellman[4] and Sven Zuehlsdorff[1]

Address: [1]Siemens Healthcare, Chicago, IL, USA, [2]University of Illinois at Urbana-Champaign, Urbana, IL, USA, [3]Royal Brompton And Harefield NHS Foundation Trust, London, UK and [4]National Institutes of Health/NHLBI, Bethesda, MD, USA

* Corresponding author

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Introduction

Coronary MR Angiography is a valuable tool for non-invasive assessment of coronary arteries. Presently, contrast-enhanced, fat-saturated, ECG-triggered and navigator-gated 3D spoiled gradient-echo sequence is employed for whole-heart Coronary MRA at 3 T[1]. However, large static field variations at 3 T frequently result in non-uniform fat-suppression over the field-of-view (FOV), obscuring the delineation of coronary arteries. Multi-echo Dixon approaches utilizing iterative decomposition have been shown to provide robust fat-water separation even in the presence of large field inhomogeneities. In this study, an ECG-triggered navigator-gated 3D spoiled gradient-echo multi-interleaved multi-echo (GRE-MEMI) pulse sequence is introduced which utilizes VARPRO[2] fat-water separation to achieve reliable fat-suppression and provides enhanced visualization of coronary arteries.

Methods

A 3D GRE-MEMI sequence (Fig. 1) was implemented on a 3 T whole-body MR scanner (MAGNETOM Trio, Siemens AG) with support for navigator-gating and ECG-triggering. Water-only and fat-only images were reconstructed using VARPRO. Four healthy volunteers were imaged pre- and during contrast agent administration targeting right coronary artery (RCA). Typical imaging parameters for pre-contrast GRE-MEMI scan are listed in Table 1. Additionally, a conventional single-echo fat-saturated GRE scan was acquired for comparison. Thereafter, 0.2 mmol/kg Gd-DTPA (Magnevist®, Bayer Healthcare) was slowly injected at a rate of 0.3 ml/s followed by 20 ml of saline solution injected at the same rate. GRE-MEMI acquisition with inversion preparation (TI = 300 ms) was started 30 s after injection.

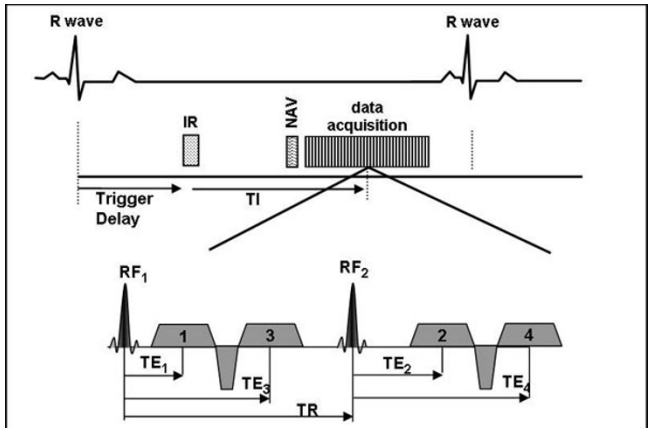

Figure 1
Pule Sequence Diagram for 3D ECG-triggered, navigator gated, spoiled gradient echo sequence with multi-echo multi-interleave readout (GRE-MEMI). Multiple echoes are used during reconstruction by VARPRO for iterative water-fat decomposition. No fat-saturation pre-pulse is applied separately. Multi-interleaved scheme achieves shorter echo time increments between multiple echoes, which improves the fat-water separation.

Table 1: Typical imaging parameters for conventional 3D fat-saturated GRE and 3D GRE-MEMI measurements.

Paramater name	Fat-saturated GRE	GRE-MEMI
No. of Echoes	1	4
TE	1.54 ms	1/2/3/4 = 1.35/2.47/3.6/4.7 2 ms
TR	3.4 ms	5.42 ms
Flip angle	18°	18°
Resolution	1.3 mm × 1.3 mm × 1.5 mm	1.3 mm × 1.3 mm × 1.5 mm
No. of Slices	32	32
Parallel acquisition/acceleration/reference lines	GRAPPA/2/24	GRAPPA/2/24

Results

Targeted RCA images were successfully acquired in all volunteers with effective fat-water separation. The average total imaging time was 8.93 ± 1.2 min with navigator efficiency of 33.8 ± 4.6%. Fig. 2 shows pre-contrast coronary artery images from a healthy volunteer. Conventional fat-saturation yields suboptimal fat-suppression whereas robust fat-suppression is evident in water-only images which provide clear depiction of coronary artery. Fig. 3 illustrates enhanced contrast-to-noise with the use of contrast agent.

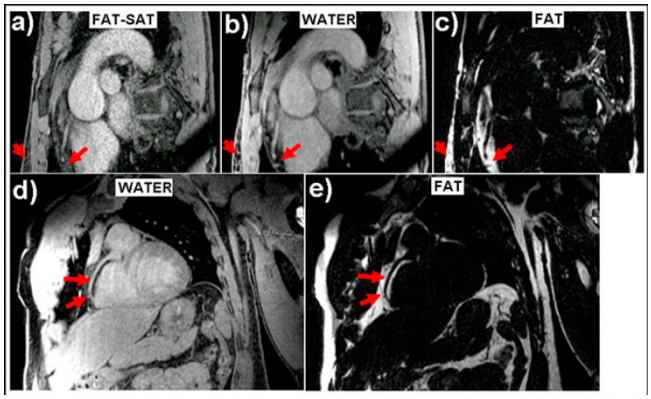

Figure 2
Conventional fat saturation (chemical selective saturation) image (a) and fat-water separated images (b, c) from a targeted right coronary artery (RCA) measurement at 3 T in a healthy volunteer without any contrast agent administration. Conventional fat saturation yields suboptimal results in some areas (a - red arrows), however, robust fat suppression is achieved over the entire FOV using the proposed technique. Moreover, the use of multiple echoes increases the signal-to-noise ratio (SNR). Water-only (d) and fat-only (e) pre-contrast images from another health subject demonstrate excellent fat suppression and clearly depict RCA (red arrows).

Conclusion

3D GRE-MEMI sequence was successfully utilized for targeted fat-water separated coronary artery imaging in healthy volunteers. VARPRO fat-water separation provides reliable fat-suppression at 3 T and improves the delineation of coronary arteries. Moreover, without the use of a fat-saturation prepulse, readout duration within a heartbeat can be extended to cover the entire quiescent period without any degradation in fat-suppression. Multi-echo acquisition results in increased acquisition time, however, the resulting water-only image provides the benefit of increased SNR due to intrinsic averaging effect of fat-water separation. Further improvement in acquisition

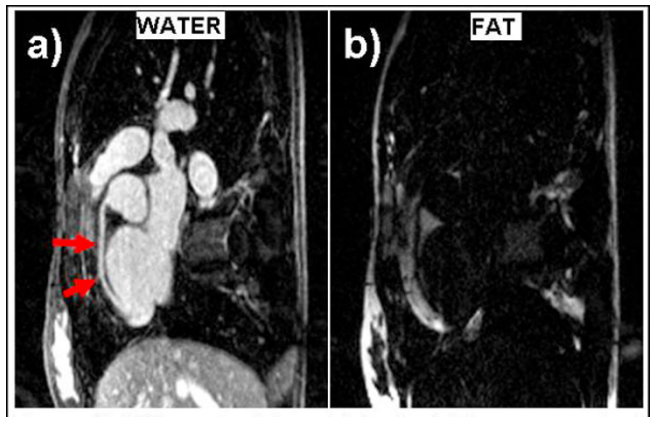

Figure 3
Water-only (a) and fat-only (b) images acquired from a healthy subject during slow infusion of contrast media. Note that water and fat signals are effectively separated and the RCA (a - red arrows) is sharply delineated. Compared to pre-contrast GRE measurements, use of contrast agent increases contrast-to-noise ratio between blood and background tissues.

speed using higher parallel imaging factors is required to achieve 3D whole-heart coverage.

References

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