

Dark blood fat-water separated cardiac imaging improves delineation of right ventricular myocardium

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Introduction

Fat-water imaging in the heart [1-4] is important for detection of intramyocardial fat and characterizing fibro-fatty infiltration seen in ARVD and chronic MI. It is also useful in characterizing fatty tumors and delineating epicardial and/or pericardial fat. Multi-echo GRE acquisitions provide T1-weighted contrast between the myocardium and blood pool, however, it is often difficult to delineate fine structures such as the RV myocardial wall due to limited contrast. Double inversion recovery (DIR) magnetization preparation is frequently used with turbo-spin echo (TSE) sequences to provide dark blood contrast. A DIR dark blood prepared multi-echo GRE protocol is proposed for cardiac fat-water separated imaging to improve delineation of myocardial structures.

Methods

A multi-echo GRE sequence using gradient flyback for monopolar readout was used to acquire 4 echoes. The VARPRO-GRAPHCUT joint water/fat estimation method [5] was used to reconstruct fat and water images. This method provides good noise performance and robustness to significant field inhomogeneities. ECG triggering was used to acquire a mid-diastolic phase image in a segmented fashion. The DIR preparation used adiabatic inversion pulses. Imaging parameters using the 1.5T Siemens widebore Espree scanner were: bandwidth=977 Hz/pixel, TE=1.64, 4.17, 6.7, and 9.23 ms, TR=11.24 ms, excitation flip angle=10°, matrix=256x150, 15 PE lines per segment (169 ms), FOV=360x270 mm², slice thickness≈8 mm, breath-hold duration = 12 heartbeats including 2 discarded, and 32 channel cardiac array. For comparison, bright blood, multi-echo GRE segmented cine fat/water separated protocol used a 20° flip angle, and rate 2 parallel imaging.

Images were acquired for short axis slices using both dark blood and bright blood fat water imaging protocols in patients that provided written informed consent. Magnetization vs readout flip angle for fat and myocardium was simulated (Fig 1) for bright blood cine protocol using steady state formulation (continuous RF) and for dark blood protocol modeling approach to steady state. Low fat-to-myocardial contrast is desirable for accurate fat quantification [6]. The DB protocol at 10° acquired during approach to steady state reduced the T1-weighting as desired compared to the cine protocol without sacrificing SNR. The T1 contrast for blood (not simulated) is predominately due to inflow of new spins.

Results

Example images for a study to rule out ARVD (negative case) compare the bright blood cine (Fig 2) with the dark blood (Fig 3) protocols. The thin RV myocardium is difficult to discern in the bright blood images due to lack of sufficient contrast between RV myocardium and blood. However, the RV free wall is well depicted in the dark blood prepared images. In this example, the measured T1-weighted contrast of the myocardium-to-blood (water image septal region) was 1:1.5, whereas for the dark blood protocol the contrast was greater than 4:1.

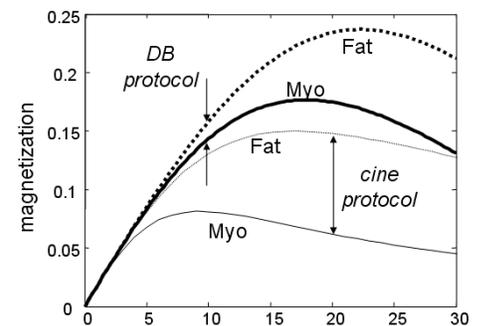


Figure 1. Simulated magnetization vs readout flip angle.

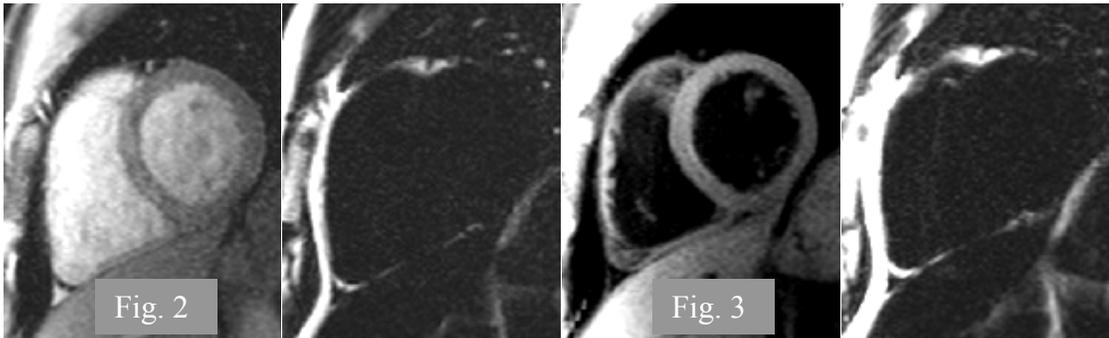


Figure 2. Bright blood cine protocol: water (left) and fat (right) images for short axis slice.

Figure 3. Dark blood prepared protocol: water (left) and fat (right).

Discussion

A dark blood prepared fat/water separated imaging protocol has been developed which provides improved delineation of the myocardium. This should improve the ability to discern fatty infiltration of the RV which has potential in the diagnosis of ARVD. The proposed approach does inherit the limitations of DIR dark blood preparation method, namely, it can lead to posterior wall signal loss due to cardiac motion at higher heart rates or in cases where the timing is not set properly and potential bright rim artifacts due to stagnant blood. With this approach, a reduction in excitation flip angle is possible which reduces the T1-weighting thereby improving fat fraction estimates.

References

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