T2-prepared SSFP Improves Diagnostic Confidence in Edema Imaging in Acute Myocardial Infarction Compared with Turbo-SpinEcho

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Introduction

T2-weighted MR imaging of edema in acute myocardial infarction (MI) provides a means of differentiating acute and chronic MI and for assessing the area-at-risk of infarction. Standard T2-weighted imaging of edema uses a turbo-SpinEcho (TSE) readout with dark-blood preparation. Dark-blood TSE methods are subject to artifacts such as posterior wall signal loss due to cardiac motion and bright sub-endocardial rims due to stagnant blood which pose a significant limitation to clinical use. Thus clinical application of T2-weighted CMR is hindered primarily by artifacts. Single-shot imaging with T2-prepared SSFP (true-FISP) readout provides an alternative to dark-blood TSE and may be conducted during free-breathing. This is desirable where patients cannot tolerate breath-holding. We hypothesized that T2-prepared SSFP (1) improves signal homogeneity in normal hearts and (2) increases diagnostic accuracy in characterizing MI-related edema in patients relative to dark-blood TSE.

Methods

The proposed approach uses a T2-prepared single-shot true-FISP readout with parallel imaging. Repeated images were acquired, corrected for respiratory motion, and averaged to enhance SNR. The T2-prepared FISP sequence was compared with dark-blood prepared TSE in both normal volunteers and in 31 patients with MI, 22 acute (within 8 days of acute event) and 9 chronic (> 1 year).

Images were acquired on a Siemens Espree 1.5T widebore scanner. In-plane resolution was typically 1.9x2.5 mm^2 with 6mm slice-thickness. ECG triggering used 2 R-R intervals between readouts. TSE images used a double inversion-recovery dark-blood prep with 300% slice-thickness for selective component, BW=449Hz/pixel, echo-train-length=25, TE=64 ms. Single-shot T2-prepared FISP images used a BW=977Hz/pixel, TE/TR=1.6/3.2 ms, flip angle=90°, T2-prep TE=60ms, 8 repetitions. Parallel imaging (rate=2) was used to obtain the full resolution in a single heartbeat. Delayed enhancement imaging was performed using a segmented turboFLASH sequence.

Results

In normal volunteers (n=8) where uniform T2-weighted signal intensity is expected, the loss in signal intensity of the posterior wall of the LV (mid-ventricular SAX slice) compared to the septal wall was 22.6±13.7% (mean±SD) using TSE, and 0.6%±4.2% using T2-prepared FISP. Both methods had surface coil intensity correction, and TSE images used timing optimized for minimal cardiac motion. A signal loss of 23% would represent a large fraction of the expected difference in signal intensity between acute MI and normal myocardium.

T2-weighted imaging in patients was performed with both methods prior to contrast administration and delayed enhancement imaging of viable myocardium. While the SNR of the edema region for both methods was quite good (Fig 1), the T2-weighted images using TSE were non-diagnostic in 3-of-31 images, while 6 additional cases (Fig 2) rated diagnostic quality but the incorrect diagnosis (incorrect coronary territory). In all 31 cases the T2-prepared FISP was rated diagnostic quality and yielded the correct diagnosis (Fig 3).

Discussion

The proposed bright blood T2-prepared SSFP approach overcomes artifacts such as posterior wall signal loss due to cardiac motion and bright sub-endocardial rims due to stagnant blood (Fig 4) which pose a significant limitation to more widely used dark-blood T2-weighted methods. The TSE method was sensitive to RR variation and image quality suffered at higher heart rates, whereas the single shot T2-prepared FISP approach was robust to such variation and enabled non-breathhold imaging. T2-prepared FISP may be used clinically for reliable T2-weighted imaging in acute MI.

References

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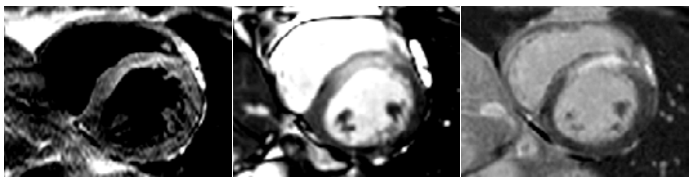

Fig 1. Acute MI patient exhibiting edema in LAD territory and agreement with myocardial infarction (MI): TSE (left), T2-prepared SSFP (center), delayed enhancement (right).

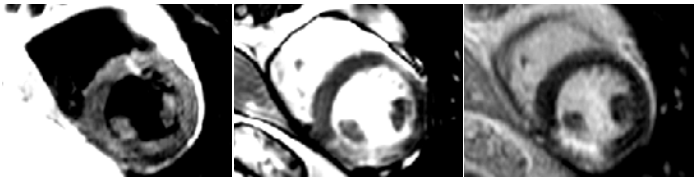

Fig 2. Acute MI patient exhibiting edema: DIR-TSE (left) with apparent elevated T2 in LAD (incorrect) coronary territory, T2-prepared SSFP (center) with elevated-T2 in RCA territory (correct), delayed enhancement (right) with MI in RCA territory. This patient had significant RR-variability.

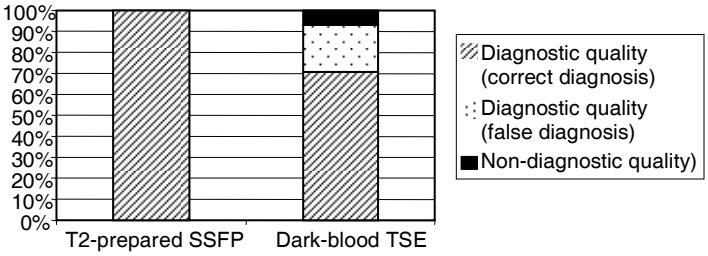

Fig 3. T2-prepared SSFP had better diagnostic accuracy than dark-blood TSE for patients with MI (N=31; acute N=22 and chronic N=9).

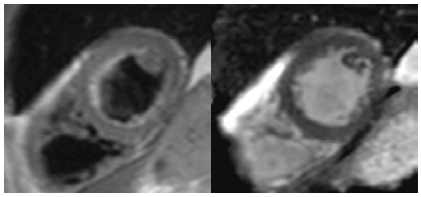

Fig 4. Example illustrating bright blood artifact for dark-blood TSE image (left) resulting from stagnant blood within trabeculae along endocardial wall. The corresponding T2-prepared SSFP image (right) has no blood artifact.