An improved magnetization preparation scheme for navigator SSFP 3D coronary MR angiography

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INTRODUCTION

Balanced steady-state free-precession (SSFP) imaging provides short TR and high SNR for 3D coronary MRA but requires preparatory ("dummy") RF pulses to drive spins into steady state prior to imaging (1). Since an interruption in these dummy RFs may perturb the steady state, current navigator SSFP coronary sequences execute the navigator before the dummy RFs (2). The separation between the navigator echo and the first image echo may lead to inaccurate motion information and therefore ineffective motion suppression (3). Consequently, the number of dummy RFs is limited, which reduces SSFP signal contrast. To solve these problems, we investigate a new magnetization preparation scheme that minimizes this separation.

METHODS

Fig. 1 illustrates our magnetization preparation. The navigator and fat saturation pulses are executed during steady state after the dummy RFs. The α/2 pair is used to conserve the steady state (4). The separation between the navigator echo and the first image echo is ~20 ms (compared to ~100 ms in current sequences), providing accurate motion information. The number of dummy RFs is only limited by the trigger delay, allowing 60 dummy RFs (30 linear ramp-ups and 30 constant flip angles) to be used to establish steady state (compared to 20 linear ramp-ups in current sequences).

The PAWS navigator gating algorithm (5), which optimizes gating window selection and minimizes residual motion artifacts within the gating window, was implemented on a Sun workstation that controlled data acquisition in real time. Motion bin size was 1 mm, corresponding to a gating window of 3 mm.

Experiments were performed on healthy volunteers (n=7) using a 1.5 T GE Signa CV/i scanner and a four-element phased-array cardiac coil. Imaging parameters were as follows: TR/TE/FA/rBW = 4.2 ms/1.4 ms/60°/±62.5 kHz, 3 mmx16 slices, in-plane resolution = 1.0x1.0 mm^2, sequential view ordering along k_z, 16 echoes per heartbeat during mid-diastole, pencil-beam diaphragm navigator echo. Both the current scheme (navigator before dummy RFs) and the new scheme (Fig.1) were performed in random order for comparison.

Blood and myocardium signals were measured in adjacent areas of left-ventricular (LV) blood pool and LV wall. Noise (σ_n) was estimated from the background air above the anterior chest wall. The SNR and CNR were defined as follows: SNR = S_{blood}/σ_n, CNR = $(S_{blood}-S_{myocardium})/\sigma_n$. Overall image quality was assessed by two independent readers.

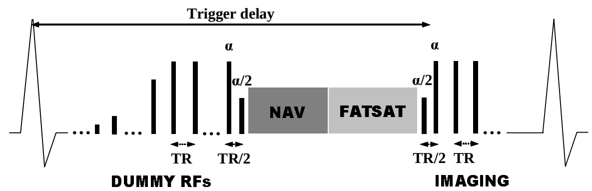

Fig. 1. A new magnetization preparation scheme for navigator SSFP 3D coronary MRA.

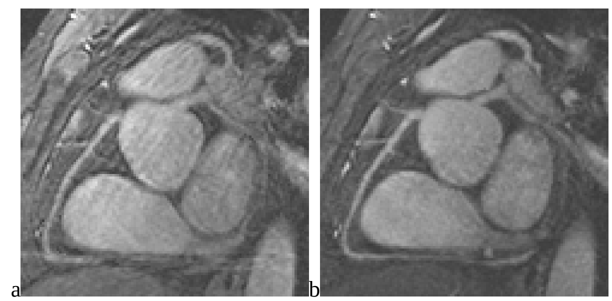

Fig.2. RCA acquired with a) the current and b) the new scheme.

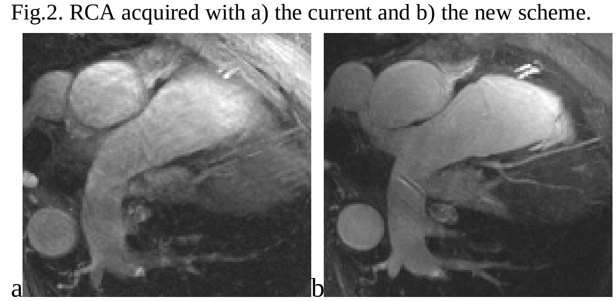

Fig.3. LAD acquired with a) the current and b) the new scheme.

Prep scheme	current	new
SNR	53±13	52±9
CNR	24±10	35±8

Table1. Comparison of SNR and CNR of coronary images acquired with the current and new preparation schemes.

RESULTS

The measured SNR and CNR are summarized in Table 1, which demonstrates that the new preparation scheme had superior CNR at slight SNR cost. No serious off-resonance artifacts were observed in the new scheme. Examples of RCA and LAD MIP images are shown in Figs.2&3 (same window levels for display), which demonstrate reduced motion artifacts and improved blood-myocardium contrast. Over 11 acquired coronary arteries (7 RCA and 4 LAD), the new scheme was judged to provide substantial improvement in 3 cases, modest improvement in 2 cases, and marginal or no improvement in 6 cases (p=0.05, Wilcoxon paired sample signed rank test).

DISCUSSION

Our preliminary data demonstrate that the proposed magnetization preparation scheme is more effective than the current scheme in reducing motion artifacts and improving image contrast for high-resolution navigator SSFP 3D coronary MRA.

REFERENCES

1. Deshpande VS, et al. MRM 2001;46:494-502. 2. Spuentrup E, et al. Invest Radiol 2002;37:637-42. 3. Spuentrup E, et al. MRM 2002;47:196-201. 4. Scheffler K, et al. MRM 2001;45:1075-1080. 5. Jhooti P, et al. MRM 2000;43:470-480.