Improving Myocardial Perfusion Imaging with B0- and B1-Insensitive Saturation RF Pulse at 3T

W. Sun[1], Y. He[2], G. Cao[3], T. Foo[4], and Z. Zhang[2]

[1]GE Healthcare, Waukesha, WI, United States, [2]Beijing Anzhen Hospital, Beijing, China, People's Republic of, [3]GE Healthcare China, China, People's Republic of, [4]GE Global Research Center, Niskayuna, NY, United States

Introduction: First-pass myocardial perfusion MRI is a potential noninvasive method for assessing the severity of coronary artery disease [1]. The accuracy of assessing myocardial perfusion with MRI mainly depends on contrast-to-noise (C/N) and peak contrast enhancement (pCE). Recent study showed that the longer pre-contrast myocardial T1 at 3T leads to more pCE and C/N than at 1.5T [2]. However, the incomplete saturation of magnetization due to the static magnetic field (B_0) and radio-frequency field (B_1) inhomogeneities becomes more problematic on 3T which hence impair the robustness of 3T perfusion imaging. The former study demonstrated that the BIR-4 RF pulse [3] can improve the saturation performance at 1.5T [4]. The purpose of this study was to compare the BIR-4 pulse with the typically used HARD RF pulse on 3T and evaluate the perfusion sequence on human subjects.

Methods: A gradient echo sequence with cardiac gating and a nonselective saturation RF preparation was employed for the first-pass imaging. The imaging parameters were field of view = 370x296 mm^2, acquisition matrix = 128x96, in-plane resolution = 2.89x3.08 mm^2, slice thickness = 8mm, TE/TR = 1.3/3.3ms, flip angle = 10^o, bandwidth = 976.6 Hz/pixel. Two saturation pulses were implemented: nonselective HARD 90^o and nonselective BIR-4 90^o. The pulse durations for HARD 90^o and BIR-4 90^o were 1ms and 8ms respectively. A proton density weighted (PDW) image without saturation RF was also acquired as a reference. The inhomogeneities caused by the transmit RF, dielectric and receive coil can be corrected using the PDW image. The experiments were performed on a 3T Signa Excite HD scanner (GE Healthcare, Milwaukee, USA) with an 8-channel torso phased array RF coil 7 human subjects (4 volunteers and 3 patients) were imaged with3 short-axis views (apical, mid-ventricular, basal) and 2 long-axis views (2-Chamber, 4-Chamber). A single dose (0.1mmol/kg) contrast was injected at 5mL/s for the three patients. The myocardial delay enhancement (MDE) study was also performed at the same anatomic locations. The residual magnetization (M_R) was calculated by S_{SAT}/S_{PDW}. Two ROIs were selected in apical and basal myocardium respectively from the 4-Chamber plane image as Fig. 1. shows. The ratio of S_{ROI1}/S_{ROI2}, which reflects the saturation uniformity, were calculated and corrected using the PDW image.

Results: Fig. 1 shows example images of M_R in a 4-chamber view heart. In all seven human subjects, the mean M_R was significantly different between the BIR-4 and HARD RF pulses ($M_{R,HARD}$=0.21±0.06; $M_{R,BIR\text{-}4}$=0.14±0.03; $p<0.001$). Besides this, the mean ratio of S_{ROI1}/S_{ROI2} was also significantly different ($S_{1,HARD}/S_{2,HARD}$=1.57±0.05; $S_{1,BIR\text{-}4}/S_{2,BIR\text{-}4}$=1.06±0.05; $p<0.001$). The perfusion imaging using BIR-4 saturation successfully identified perfusion defect in 2 patients which were verified by MDE. Fig. 2 shows the first-pass myocardial perfusion images (A-D) and the corresponding MDE image (E) of one case.

Conclusion: This study demonstrates that the saturation performance of BIR-4 RF pulse is much better than HARD RF pulse when there are B_0 and B_1 inhomogeneities. BIR-4 saturation pulse together with gradient echo acquisition sequence can provide satisfactory image quality for perfusion study at 3T and is feasible to detect ischemia heart disease.

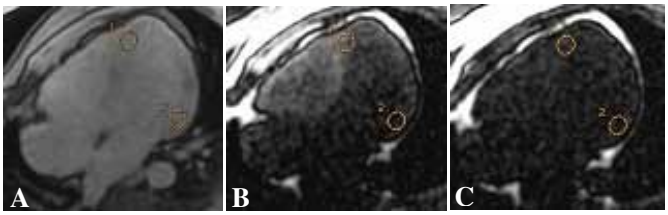

Fig. 1. Example images of residual magnetization in a heart of the 4-chamber view, comparing the performance of the two saturation pulses: (a) PDW, (b) HARD 90^o, (c) BIR-4 90. (b) and (c) are displayed with same WW and WL.

Reference: 1. Wilke, N et al. Radiology 1997; 204:373-84. 2. M. Jerosch-Herold et al. Proc. Intl. Soc. Mag. Reson. Med. 13 (2005): 1623. 3. Staewen, RS et al. Investigative Radiology 1990; 25:559-67. 4. D. Kim et al. Proc. Intl. Soc. Mag. Reson. Med. 13 (2005): 520.

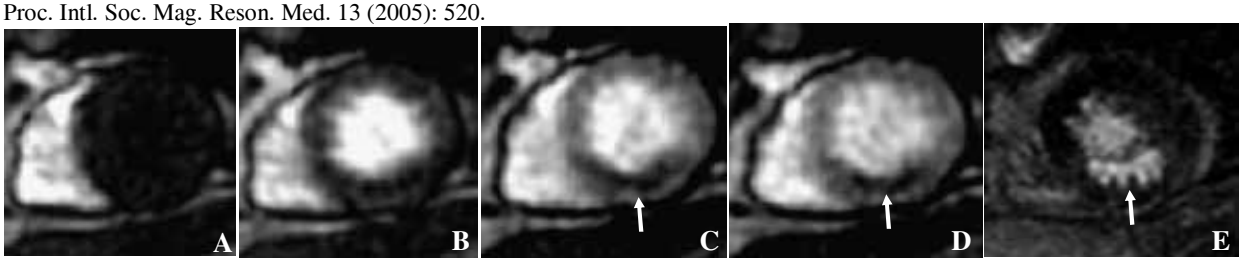

Fig. 2. First-pass myocardial perfusion with BIR-4 90^o saturation RF of one patient. (A)-(D) are the perfusion images from different phases after the contrast injection. (E) is the corresponding image from myocardial delay enhancement study.