First-Pass Resting Myocardial Perfusion at 3.0 Tesla

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Introduction: First-pass myocardial perfusion imaging at 1.5 Tesla is increasingly being used to assess coronary artery disease. With current techniques, at least 3 slices are acquired per heartbeat during the first pass of a contrast bolus. In order to image this rapidly, spatial resolution and signal-to-noise ratio (SNR) must be sacrificed. This can result in significant reductions in image quality and is the major limitation of current perfusion strategies. The recent introduction of whole body 3.0T scanners offers up to a two-fold increase in SNR compared to 1.5T. This theoretic doubling of SNR at 3T may be particularly beneficial for myocardial perfusion imaging and could potentially result in significant improvements in image quality.

Purpose: To compare resting myocardial perfusion in normal subjects and patients at 1.5T and 3.0T.

Methods: 4 healthy volunteers and 4 patients with known history of myocardial infarction, proven on delayed enhancement viability imaging, underwent resting first-pass perfusion imaging using saturation-recovery TurboFLASH sequences (SR-TFL) on 1.5T MAGNETOM Sonata and 3T MAGNETOM Trio scanners (Siemens, Erlangen, Germany). Similar imaging parameters were used for healthy volunteers and patients at 1.5T and 3T (TR/TE/TI= 168 ms/1.27 ms/TI 100 ms, slice thickness 8mm, FOV =285 x 380 mm, matrix =86 x 193, α=12^o and iPAT acceleration rate of 2). For all subjects, 3 short axis slices (base, mid-ventricle and apex) were obtained in the same positions on each scanner. 8-channel phased array coils were used on both systems, although specific coil design varied between the 1.5T and 3.0T systems. Gadolinium-DTPA (0.075 mmol/kg) was administered at 4 ml/sec for the healthy volunteers and patients. The 1.5T and 3T studies were performed within 4 weeks of each other. Using a segmentation model of the left ventricle described by the American Heart Association[1], the maximum relative signal-to-noise (SNR) measured at peak signal myocardial signal enhancement, and contrast-to-noise (CNR) values (of myocardium at maximal enhancement vs. pre-contrast) were calculated for sixteen myocardial segments across the three slice positions[2]. The randomized perfusion images in the patient group were evaluated in a blinded fashion for overall image quality and conspicuity of any identified infarcts.

Results: In the volunteer group, relative SNR increased by 113% while CNR increased by 146% when imaged on at 3T compared to 1.5T. In the patient group, relative SNR and CNR gains of 76% and 65%, respectively, were attained. The pooled data yielded a 90% increase in relative SNR and a 96% increase in CNR (all p-values less than 0.001). In the patient group, perfusion images at all slice levels (n=24) were evaluated for overall image quality on a 5-point scale, in addition to conspicuity of myocardial scarring. The 1.5T images scored a 3.1 ("average") while the 3.0T images scored a 4.0 ("good") in overall image quality. Infarcts were identified in 9/12 slice levels based on viability image correlation. Seven of the twelve regions of infarction showed corresponding perfusion defects at 3.0T, while only four of the infarcts were visible during first-pass imaging at 1.5T. The conspicuity of these defects was higher at 3T, scoring a 3 ("moderately conspicuous") compared with a 2.5 (between "subtle" and "moderately conspicuous") at 1.5T.

Conclusion: Resting first-pass perfusion imaging using SR-TFL sequences resulted in a significant increase in both quantified relative SNR and CNR and in overall image quality evaluation when studied at 3.0T compared to 1.5T. Perfusion defects corresponding to regions of infarction in four patients were detected more reliably at 3T. These preliminary results suggest that myocardial perfusion with MRI may benefit directly from the higher SNR provided by 3T compared to 1.5T. With further pulse sequence optimization, it may be possible to trade this increase SNR for higher spatial and/or temporal resolution. Further patient studies are required at 3T with adenosine vasodilation for the detection of myocardial ischemia.

References

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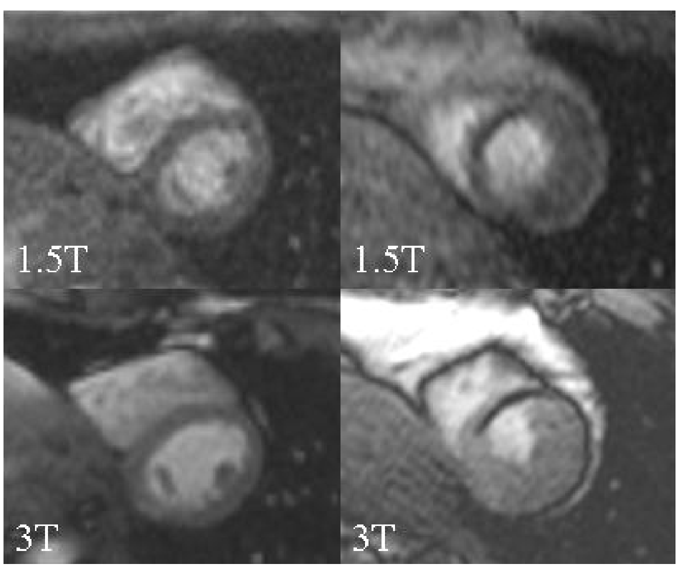

Figure 1. Resting perfusion images at 1.5T and 3T in a healthy volunteer (left) and a patient with an apical septal infarct (right). Note the greater overall image quality and conspicuity of the perfusion defect in the patient at 3T.

	Volunteer (n=4)		Patient (n=4)		Vol + Patient (n=8)	
	Avg. SNR	Avg. CNR	Avg. SNR	Avg. CNR	Avg. SNR	Avg. CNR
1.5T	4.08	2.45	6.53	4.21	5.29	3.31
3T	8.68	6.03	11.48	6.94	10.06	6.48
% Increase	**112.7**	**146.1**	**75.8**	**64.8**	**90.2**	**95.8**

Table 1. Quantitative results showing the respective increases in relative SNR and CNR at 1.5T and 3T. At each magnetic field strength, 16 data points were measured for each subject according to the AHA left ventricular segmentation model, resulting in a total of 128 data pairs analyzed.