Fat Saturation Improves Fresh Blood Imaging of Peripheral Vessels in the Calf Station

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Purpose: Non-contrast magnetic resonance angiography (NC-MRA) is an alternative diagnostic tool for assessment of peripheral arterial disease (PAD) in patients with impaired kidney function who are contraindicated for gadolinium-based contrast agent. "Fresh-blood-imaging" (FBI) is a peripheral NC-MRA method based on subtraction of two turbo-spin-echo (TSE) acquisitions at different cardiac phases (i.e., systole and diastole), where the subtraction, in principle, should cancel out the background signal. However, in practice, residual signal after subtraction, even in the absence of obvious motion, obscures visualization of vessels. The purpose of this study was to evaluate the benefit of fat suppression in FBI for suppression of background signal.

Methods: Eight patients with PAD were imaged at 3T (Tim Trio, Siemens) to compare the following two FBI acquisitions with flip angle = 60°, spatial resolution = 1.5 x 1.6 x 2.0 mm and scan time ~ 3 min: (i) without fat suppression (default) and (ii) with "weak" fat suppression. The pulse sequence order was randomized between fat suppression and without fat suppression. For quantitative analysis, we calculated apparent contrast-to-noise ratio (CNR) of the popliteal, anterior tibial, peroneal, and posterior tibial arteries, where apparent CNR is defined as (SI_{artery}-$SI_{background\_Tissue}$)/noise (see Fig 1). Given that the two FBI acquisitions used identical imaging parameters, except for fat suppression, we used the same noise measurement from the diastolic image to calculate apparent CNR values for each subject. While these apparent CNR values do not represent absolute CNR values, they are adequate for comparing with and without fat saturation. The arterial region-of-interest (ROI) was determined by reformatting the images so that the length of the entire artery could be visualized in one 2D plane (Fig 1). For each subject per vessel type, mean arterial signal was defined as the averaged signal within ROI, and mean background signal was defined as the averaged signal within its ROI. Mean signals were then averaged over subjects, and the two groups were compared using paired t-test. For qualitative analysis, images were graded by three radiologists blinded to acquisition type on a Likert scale 1-5 (worst-best) for conspicuity of proximal and distal vessels, and scores were averaged. Mean scores for the two groups were compared using the Wilcoxon rank sum test.

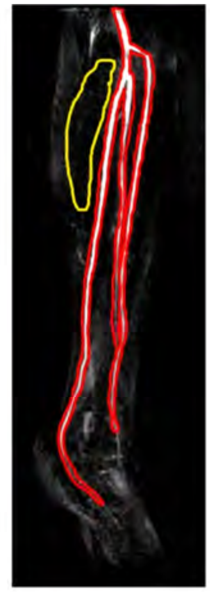

Figure 1: Representative ROIs (red is arterial, yellow is background) for CNR calculation.

Table 1. Measured CNR for right and left legs, without and with fat saturation

	No Fat Sat	Fat Sat	p-value
Right leg CNR	30 ± 8	34 ± 6	0.13
Left leg CNR	24 ± 6	31 ± 6	< 0.05

Table 2. Vessel conspicuity scores for proximal and distal vessels, without and with fat saturation.

	No Fat Sat	Fat Sat	p-value
Proximal	3.6 ± 1.1	4.3 ± 1.1	0.21
Distal	2.8 ± 1.6	3.9 ± 1.4	< 0.05

Results: By visual inspection of MIPs, we observed that FBI with fat saturation suppressed the background signal better than FBI without fat suppression in 7 out of 8 patients. For right legs, CNR was 30 ± 8 and 34 ± 6 for without and with fat saturation, respectively, and the two values were not significantly different. For left legs, CNR was 24 ± 6 and 31 ± 6 for without and with fat saturation, respectively, and the two values were significantly different ($p < 0.05$). Conspicuity score for proximal vessels averaged 3.5 ± 1.1 and 4.1 ± 1.1 without and with fat saturation, respectively, and the two scores were not significantly different. Conspicuity scores for the distal vessels averaged 2.9 ± 1.5 and 4.0 ± 1.2 without and with fat saturation, respectively, and the two scores were significantly different ($p < 0.05$).

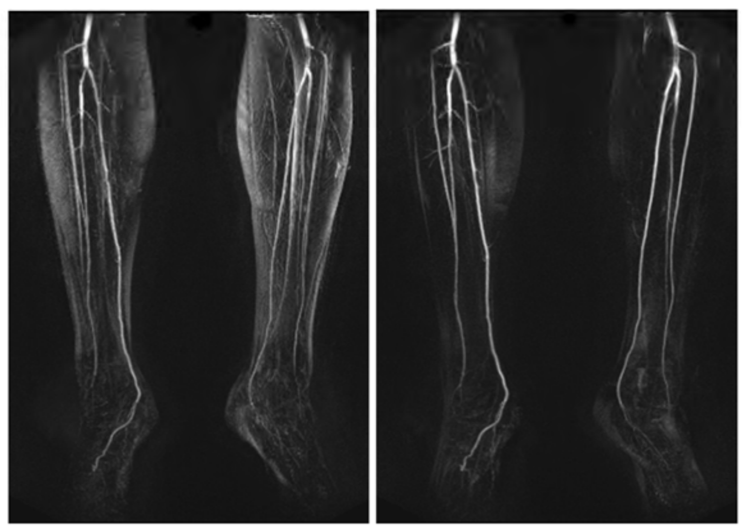

Figure 2: Representative MIPs showing without fat saturation (left) and with weak fat saturation (right).

Conclusions: Our study shows that FBI of peripheral arteries of the calf station can be improved by adding fat suppression. We note that adding fat suppression is inconsequential in terms of specific absorption rate (SAR) and scan time (since only a fraction of heart beat is spent on data readout). Another advantage with fat suppression is that unsubtracted images will have less background signal, such that it will be easier to read them as good backup for diagnosis. A future study is warranted to evaluate fully the clinical utility of FBI with fat suppression, including more patients and testing with other MR vendors.

References: [1] Miyazaki, M, et al., JMRI 2000. [2] Storey, P, et al., JMRI 2011.

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