High-resolution, vein-suppressed MRA of the lower extremity using MS-325

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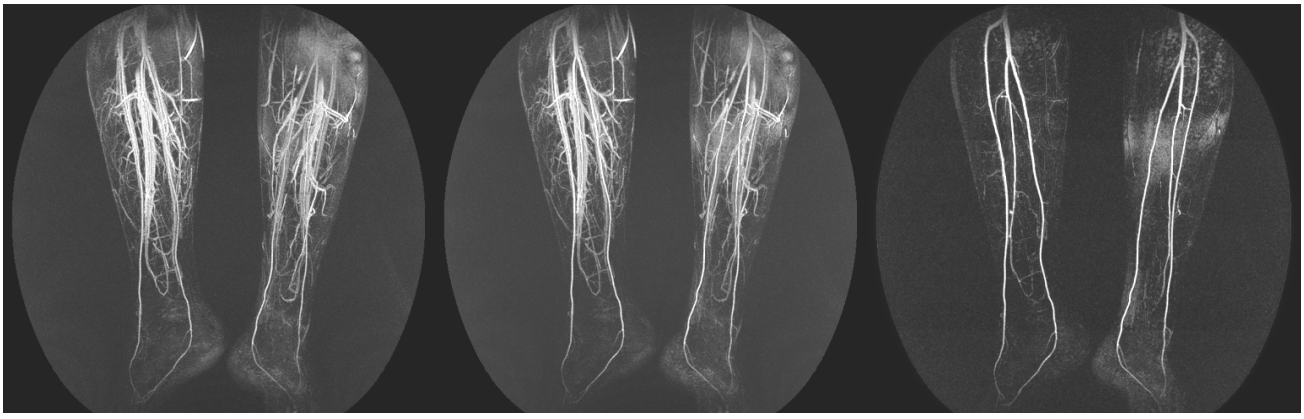
Introduction: The presence of residual gadolinium (Gd) contrast agent in the arterial system following in intravenous injection presents an opportunity and a pitfall in contrast-enhanced MRA. The opportunity exists to acquire data over a longer period of time and therefore improve spatial resolution for contrast-enhanced MRA. However, the venous enhancement associated with equilibrium phase imaging obscures the visualization of the arteries. MS-325 (EPIX Pharmaceuticals, Cambridge, MA and Schering AG, Berlin, Germany) is a Gd contrast agent that is specifically designed to remain in the blood pool for a prolonged period of time, therefore allowing high-resolution images of the arterial system in humans. (1) Our objective is to demonstrate the feasibility of a method to reconstruct high-resolution, vein-suppressed images of the arteries from data acquired during the dynamic and equilibrium phases contrast enhancement.

Methods: The pulse sequence combines dynamic phase and steady state phase acquisitions. (2) The dynamic phase uses the TRICKS technique with under-sampled projection reconstruction to reconstruct time-resolved images at 7 second intervals with submillimeter resolution. (TR/TE/Flip= 7.4/2.6/30, Matrix 512 x 512 x 118, Voxel Volume = 0.63 mm^3) High-resolution data from the equilibrium phase are used to improve spatial resolution and coverage by acquiring additional data for a total scan time of 7 minutes. Delayed equilibrium phase exams were also acquired at 1.0 mm^3, 0.5 mm^3, and 0.15 mm^3 voxel sizes using conventional Fourier-encoded techniques for comparison. We investigated the matched-filter addition of equilibrium phase data to improve SNR. In addition, arteries were segmented using 2D cross-correlation analysis and calculating the Mahalanobis distance relative to a reference curve selected in an artery within the FOV. (3) The lower leg vasculature of seven volunteers and five patients with severe occlusive disease were examined following the intravenous injection of 0.03 mmol/kg MS-325. We computed vessel SNR, CNR and arterial-venous (A/V) ratio on the dynamic, equilibrium, matched filter, and vein-suppressed images. Differences between the measurement mean and standard deviation (+/-) were assessed using the paired t-test.

Results: Matched filter addition of the dynamic and steady state data resulted in a significant improvement in vessel SNR ($p<0.05$), however, venous enhancement obscured visualization of the arteries (when viewed in maximal intensity projection (MIP) format. The cross-correlation segmentation method resulted in nearly complete suppression of the venous enhancement despite the extended acquisition time. Mean A/V ratio was 1.3 (+/- 0.5) for unsuppressed images, and 18.4 (+/-10.0) for vein suppressed images ($p<0.05$).



Equilibrium Phase Image
SNR = 38; A/V ratio = 1.3

Matched Filter (MF)
SNR = 64; A/V ratio = 2.3

Segmented, MF addition
SNR = 69; A/V ratio = 19

Discussion: The proposed method shows significant promise for high-resolution, vein-suppressed MRA using MS-325. It is possible to generate images with voxel volumes as small as 0.63 mm^3, while retaining temporal information about vessel filling available from a time-resolved image acquisition. Additional studies to test the technique in a larger number of patients with vascular disease are warranted.

References: 1. Grist et al Radiology 1998; 207:539-534. 2. Mazaheri et al JMRI 2002;15:291-301. 3. Du et al MRM 2003;49:909-917.**Acknowledgements:** This work was supported in part by NIH Grant HL66488 and a grant from EPIX Pharmaceuticals