Targeted Multi-contrast Vessel Wall Imaging of Bilateral Peripheral Artery Disease

N. Balu[1], J. Wang[2], X. Zhao[1], T. Hatsukami[1], and C. Yuan[1]
[1]University of Washington, Seattle, WA, United States, [2]Philips Research North America

Introduction: Peripheral artery disease (PAD) which affects more than a fifth of people over 70 years is associated with high morbidity [1]. Ankle Brachial Index measurement and MR angiography are not sensitive to detect early atherosclerotic changes in the vessel wall [2]. 2D black-blood MRI is highly reproducible for atherosclerotic plaque measurement in the femoral arteries [2]. However current black-blood imaging techniques are time consuming and do not provide adequate coverage of the diffuse disease in PAD [3]. Recent improvements in black-blood imaging provide the opportunity for imaging in planes oblique to the artery and allow for 3D PAD vessel wall imaging [1,3]. Bilateral large coverage of the femoral arteries from the femoral bifurcation to the popliteal artery is required to effectively map the full extent of atherosclerotic disease in PAD. Multi-contrast information is also desirable for adequate plaque component identification. To address the competing demands of large coverage and multi-contrast characterization of atherosclerotic plaque, we propose a time-efficient protocol that allows targeted multi-contrast imaging of arterial segments with large lesion burden and simultaneous lesion burden measurement along the entire length of the superficial femoral artery. **Aims:** 1) To develop and integrate a fast isotropic 3D black blood sequence into a multi-contrast protocol for targeted multi-contrast 2D imaging of the region of maximal disease; 2) To assess the quality of blood suppression and wall delineation in the femoral arteries and veins.

Materials and Methods: Imaging Protocol: A 3D motion-sensitized driven equilibrium prepared rapid gradient echo (3D-MERGE) was implemented with MSDE preparation [4,5] and spoiled segmented FLASH (T1-TFE) readout with centric phase encoding. Sequence parameters were adjusted to obtain isotropic resolution of 1.0mm^3 (zero-interpolated to 0.5mm^3) covering bilateral femoral arteries with an effective longitudinal coverage of 50 cm within 10.5 min (3 stations). Six volunteers were scanned according to local IRB guidelines on a Philips Achieva 3T scanner with combined cardiac and torso phased array coils. The isotropic dataset acquired was examined by interactive multiplanar reformatting to identify the region of interest for centering multicontrast high resolution PDw, T2w and T1w images with MSDE preparation (Table 1). **Image analysis:** Bilateral 3D-MERGE images (12 arteries) were reviewed for image quality (rated on a 3 point scale (Table 2) with 2 and above considered diagnostic) for quality of flow suppression and vessel wall delineation at three locations along the thigh. **Results:** Vessel wall was visualized in all subjects with good flow suppression (fig 1). A lesion of interest was located on 3D-MERGE in two subjects and followed up with multicontrast imaging. Mild venous wall thickening was noted in one subject while extensive deep vein thrombosis was detected in the second subject (fig 2). Average blood suppression quality on 3D-MERGE was 2.8 for arterial segments and 2.1 for venous segments. Wall definition was rated 2.7 for both arteries and veins. **Discussion:** Image quality in all subjects was of diagnostic quality and enabled fast screening for lesions. Outer wall boundaries of both arteries and veins were well visualized at the bifurcation, midthigh and popliteal regions. Femoral artery blood suppression was rated good in all locations. Venous flow suppression was less optimal particularly in veins of small caliber such as popliteal region. Use of higher MSDE gradients can improve blood suppression. The stronger MSDE gradients used for T1w and T2w helped to distinguish thrombosis vs unsuppressed flow in small veins. **Conclusion:** A fast multi-station multi-contrast peripheral artery vessel wall imaging protocol was developed. Isotropic voxels allowed interactive reformatting in arbitrary planes and allowed fast identification of lesions of interest allowing efficient screening of the entire femoral artery from the bifurcation down to the popliteal artery for plaque burden followed by targeting of lesions for high-resolution multi-contrast MRI. Average screening time was 15 minutes and total scan time was 30 minutes for multicontrast imaging.

Table 1: Imaging Parameters

	3D-MERGE	TOF	T1w	T2w
Mode	3D	3D	2D	2D
Acquisition plane	Coronal	Axial	Axial	Axial
Black-blood prep	MSDE		MSDE	MSDE
Resolution, mm^2	1.0	0.7	0.7	0.7
FOV, mm^2	300×360	120x300	120x300	120x300
Slice thickness , mm	1.0	3	3	3
# of slices	150	32	16	16
TR/TE, ms	7.5/3.5	20/4.7	800/8.6	4500/40
Flip angle, °	6	20	90	90
Turbo factor	100		14	10
BW, Hz/pixel	191.6	289.0	208.7	192.7
NSA	1	1	2	1
No of stations	2 (or 3)	1	1	1
Scan time, min:s	6:53 (or 10:20)	2:12	12:48	6:09

Table 2: Image Quality Scoring

Blood Suppression	
3	Excellent blood suppression
2	Some areas of unsuppressed flow; Luminal boundary distinct
1	Unsupressed flow; Luminal boundary indistinct
Outerwall delineation	
3	Distinct outer boundary
2	Outerwall visible with some indistinct areas
1	Outerwall boundary cannot be seen

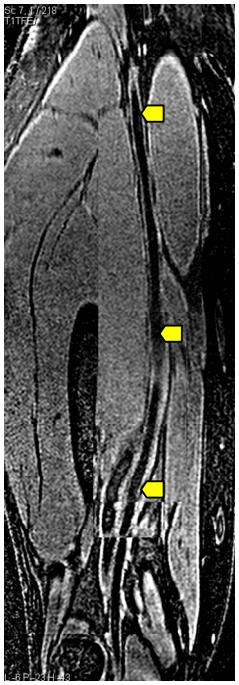

Fig 1: Extent of femoral artery covered from femoral bifurcation to popliteal (montage of images from slices)

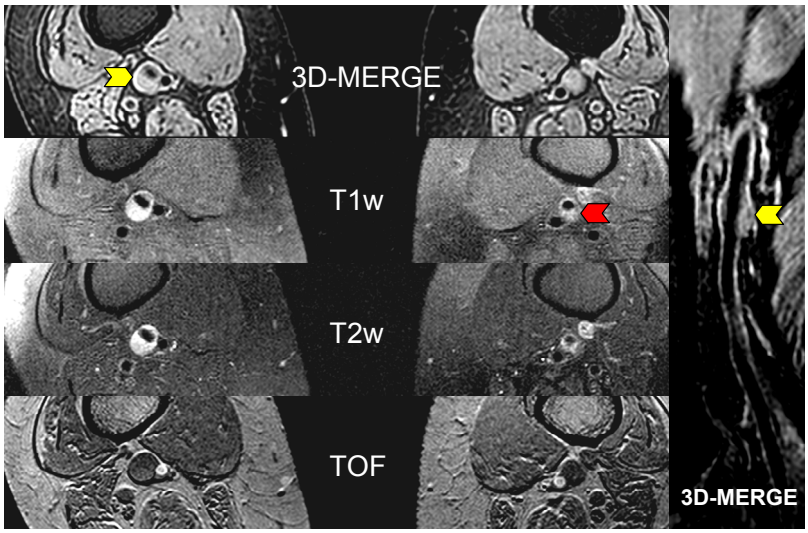

Fig 2: Deep vein thrombosis (DVT) on both sides (arrows). Multicontrast imaging with high diffusion gradients ruled out total occlusion on the left (red arrow). High signal on T1 and T2 is consistent with DVT. Oblique sagittal reformat of right side shows thrombosis can be missed by luminography.

References: [1] Mihai, JMRI 2009; 30:785-93, [2] Isbell, JCMR, 2007; 9:71-76, [3] Zhang, Invest Radiol 2009; 44:619-26, [4] Koktzoglou, Radiology 2007; 243:220-8, [5] Wang, MRM 2007; 58:973-81