Multistation Non-Contrast Black Blood Angiography for the diagnosis of Peripheral Arterial Disease

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Introduction: Peripheral arterial disease (PAD) is a common circulatory problem in which narrowed arteries reduce blood flow to the limbs. PAD is a manifestation of systemic atherosclerosis, with implications for cardiovascular events. A major locus of disease in PAD especially in those presenting with intermittent claudication is aorto-iliac and superficial femoral artery (SFA) disease. Current magnetic resonance diagnosis of PAD is based on contrast-enhanced angiography (ce-MRA), which assesses the lumen and lacks information on vascular remodeling and the extent of atherosclerotic plaque burden. Moreover, the recent links between nephrogenic systemic fibrosis disease and gadolinium limits this approach in patients with impaired kidney function. In this work, we evaluate the feasibility of a multistation T1w-SPACE [2] dark blood sequence to assess PAD in the aorto-iliac and superficial femoral artery (SFA) (inflow vessels) and compare its performance (luminal narrowing) with a standard multistation ce-MRA protocol with identical spatial resolution. T1w-SPACE is a highly efficient 3D TSE technique due to its long echo train and very short echo spacing. Blood signal is suppressed in T1w-SPACE by dephasing due to flow in the readout direction. Furthermore, T1w-SPACE may allow for atherosclerotic plaque characterization and burden evaluation as shown by the vessel wall area measurements.

Methods: Four normal volunteers (2 males and 2 females, mean age 43.3±25.3) and 13 patients with PAD and normal kidney function (8 males and 5 females, mean age 60.2±11) were imaged on a 1.5T scanner (MAGNETOM Avanto, Siemens, Erlangen) using two body matrix coils for the abdominal/pelvic area and a peripheral coil for thighs and lower legs. The imaging protocol included localizers and coronal acquisitions of abdominal aorta and SFA using T1w-SPACE, followed by ce-MRA covering the abdomen, thighs and lower legs. Both T1w-SPACE and ce-MRA were acquired with isotropic 1mm resolution. Imaging parameters are listed in Table 1.

T1w- SPACE	ECG trg.	TR/TE (ms)	Echo train	Slices	Scan time (s)	BW (Hz/pixel)	iPAT	NEX
Abd. aorta	Yes	RR/25	180	80	14:30-22:30	587	2	3.5
Thighs (SFA)	No	700/23	72	60	11:36	587	2	1.4
ce-MRA	ECG trg.	TR/TE (ms)	Echo train	Slices	Scan time (s)	BW (Hz/pixel)	iPAT	NEX
Abd. aorta	NA	3/1	NA	88	0:14	445	3	NA
SFA/Lower legs	NA	3/1	NA	66	0:15	445	2	NA

Table 1. Acquisition parameters for T1w-SPACE and ce-MRA

For each subject T1w-SPACE and ce-MRA acquisitions were co-registered (abdominal aorta, and then SFA) on a workstation (FUSION, Siemens Healthcare, Inc.). Three, 1 mm multiplanar images (with 3 mm gap) perpendicular to the arteries were created at each of the following locations: celiac, superior mesenteric, renal, halfway between renal and bifurcation, iliac bifurcation, and at both right and left iliac, internal and external iliac, proximal, medial and distal superficial femoral arterial levels. Two experienced observers measured lumen area at each of these 17 locations on both T1w-SPACE and ce-MRA images, as well as the wall thickness area in T1w-SPACE for plaque burden quantification.

Results: High quality T1w-SPACE images were obtained for all 17 subjects allowing free hand lumen and wall thickness area measurements. Figure 1 shows same patient examples of dark blood (left) and bright blood (right) segments of abdominal aorta with total right iliac occlusion(A) as well as significant stenosis of left iliac and SFA plaque (B). SFA segment images show a normal looking lumen with vessel wall remodeling due to the plaque buildup depicted only by T1w-SPACE sequence. Quantitative comparison of lumen areas with ce-MRA and T1w-SPACE revealed non significant difference and strong correlation between the two techniques (2 samples t-test $p>0.5$, r value>0.9). There was a strong inter-observer agreement between the two imaging methods, as well as between vessel wall area thickness measurements.

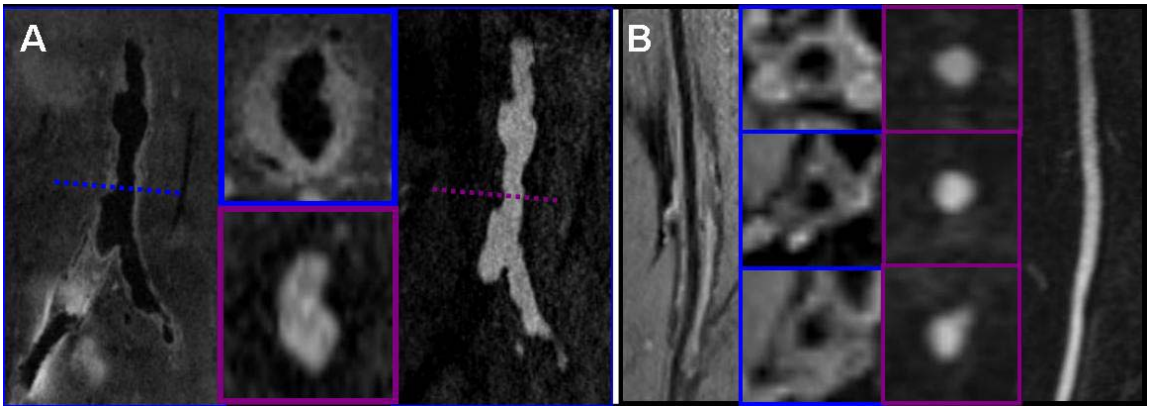

Figure 1. T1w-SPACE (left, A and B) and ce-MRA (right, A and B) images of abdominal aorta (A) and SFA (B) segments showing lumen narrowing and plaque deposition in a 63 years old PAD patient

Conclusion: In this study we demonstrate that dark blood high resolution imaging of arteries can be performed rapidly, with results at least as accurate as ce-MRA in assessing lumen stenosis. In addition, 3D T1w-SPACE imaging of inflow vessels (aorto-iliac and SFA) is an attractive alternative to ce-MRA in patients with PAD and impaired kidney function, and due to its ability to assess atherosclerotic plaque and vascular remodeling offers an additional significant improvement over other non-contrast [2] and ce-MRA techniques.

References: [1] Park J et al., Magn Reson Med, 58(5): p.982, 2007. [2] Miyazaki M et al., J Magn Reson Imaging, 12(5):p.776, 2000.