Reproducibility of MR arteriography and cine phase-contrast flow measurements in peripheral arterial disease

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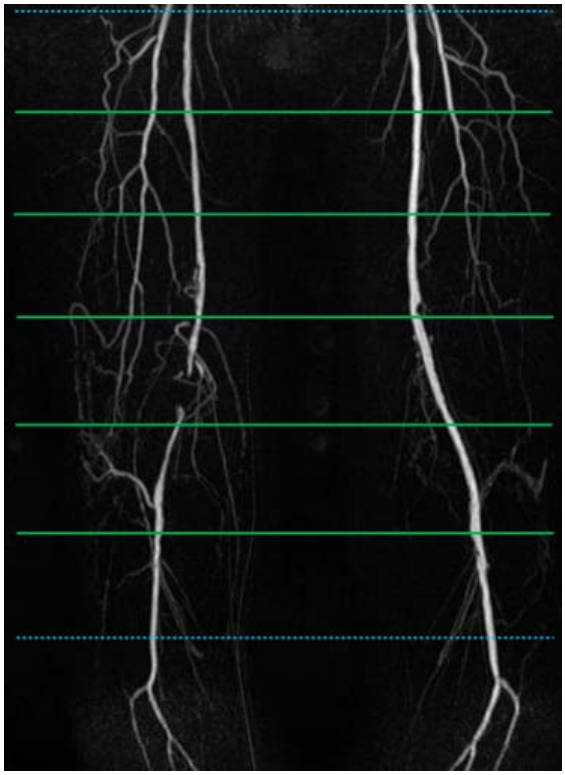
Introduction: Recovery of peripheral arterial disease (PAD) is thought to be the result of vascular adaptations. Changes in macrovascular morphology and functionality may represent early in vivo markers to signal whether patients will benefit from physical exercise training and future therapeutic neovascularization programs. At the macrovascular level, such adaptations may include the formation of collateral vessels and/or increase in flow. The aim of the current study was to assess the reproducibility of MRI for the quantification of the number of arteries and flow in conduit arteries of the thigh by using contrast-enhanced MR arteriography (CE-MRA) and MR cine phase-contrast angiography (PCA) measurements.

Methods: Ten patients with proven PAD (Fontaine stage II) and collateral formation of the upper leg and ten healthy volunteers were included. All scans were performed on a 1.5T Gyroscan ACS-NT (Philips Medical systems, Best, NL). All examinations were performed with a dedicated three station 12-element phased-array peripheral vascular coil, a coil (4 elements/station; Philips Medical Systems). Subjects underwent 3D CE-MRA of the entire upper leg as described before[1] (parameters were: matrix/TR (msec)/TE (msec)/flip angle (°)/SENSE reduction factor (R-L): 512 x 334-436/4.8/1.45/40/2). MRA was followed by ECG-triggered 2D cine PCA flow measurements of the superficial femoral artery (SFA) and popliteal artery (PA) in the same session. Parameters were: matrix/TR (msec)/TE (msec)/flip angle (°)/venc (cm/s): 256 x 256/7.9/4.7/30/100. 20 images were reconstructed within the R-R interval. All subjects underwent an identical MRI exam within one week.

The mean number of arteries for per plane was determined by two independent readers, who manually counted the total number of arteries intersecting five transverse planes spaced at 5-cm intervals (figure). Flow wave forms were acquired and analyzed as described before[2]. Regions of interest were drawn in the SFA and PA by two independent readers.

Inter- and intra-observer reproducibility was expressed by intra-class correlation coefficients (ICC) and repeatability coefficient (RC), where RC quantifies the smallest detectable change.



Occluded SFA (left) and normal SFA (right) of one patient, green lines represent counting levels, blue lines the location of flow measurements

Results: The number of arteries per plane was significantly higher in patients (15.7±3.5) compared to volunteers (12.9±2.5, $p<0.01$), reflecting collateral formation. Intra-observer reproducibility (i.e. artery count based on the two separate acquisitions) showed high ICC (95% CI) of 0.98 (0.95-0.99) and 0.97 (0.93-0.99) for both patients and volunteers. Inter-observer reproducibility was 0.85 (0.56-0.96) in patients and 0.72 (0.42-0.88) in volunteers. The RC in patients was 1.1 and 1.7 vessels in volunteers.

Peak systolic flow was significantly lower in patients (SFA, 8.7±3.6; PA, 4.7±2.8 mL/s) compared to volunteers (SFA, 16.8±2.4; PA, 8.4±2.3 mL/s, $p<0.01$). ICC of flow was 0.97 (0.90-0.99) and 0.96 (0.90-0.99) in patients for SFA and PA respectively and 0.94 (0.86-0.98) and 0.91 (0.79-0.96) in volunteers. RC in patients (1.7 mL/s (SFA) and 1.5 mL/s (PA)) was in line with volunteers (1.6 mL/s and 1.9 mL/s respectively). Inter-observer reproducibility was 0.98 (0.94-1) and 0.99 (0.98-1) in patients for SFA and PA, 0.91 (0.78-0.97) and 0.94 (0.86-0.98) in volunteers.

Conclusion: Arterial vessel counts based upon 3D CE-MRA and flow quantification using 2D MR cine PCA are reproducible measurements to quantify the morphological and functional macrovascular status and adaptations in both volunteers and PAD patients.

Reference.

1. De Vries et al. J Magn Reson Imaging 2005;21:37-45
2. Mohajer et al. J Magn Reson Imaging 2006;23:355-360