High spatial resolution MR angiography of peripheral vasculature-iPAT combined with mid-femoral venous compression

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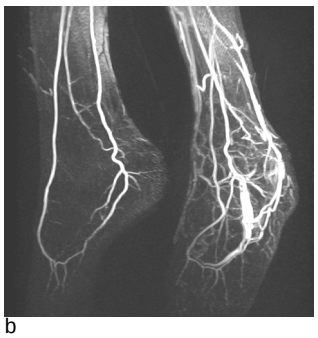
Introduction: Improved delineation of the infrapopliteal arteries and small branch vessels can be crucial for the assessment of the peripheral arterial system of patients requiring surgical grafting. However, arterial visualization of peripheral vasculature in high spatial resolution imaging can be hampered by venous overlay due to prolonged acquisition times.
Purpose of our study was the implementation of mid-femoral venous compression in combination with a parallel acquisition technique (PAT) into the concept of peripheral 3D MRA to increase the spatial resolution using a dedicated peripheral vascular coil.

Methods: Five healthy male volunteers (mean age 31) and five patients (mean age 45) with clinically documented occlusive arterial disease of peripheral vasculature underwent four-station contrast-enhanced three-dimensional peripheral MR-angiography. All imaging was performed on a Siemens Sonata 1.5 T (Siemens, Medical Solutions, Erlangen, Germany) equipped with a dedicated peripheral vasculature coil for signal reception.
The four consecutive 3D data sets were collected in coronal planes during biphasic automatic injection of 0.2 mmol/kg GD-BOPTA. A commercially available floating table MRA software assured the rapid motion from one imaging position to the next. Prior to data acquisition, a cuff was placed at the mid-femoral level of the left leg and remained inflated to 50 mm Hg until the end of the examination. Acquisition time was extended with mid-femoral venous compression while the PAT reconstruction algorithm enabled to increase the spatial resolution. Scanning parameters for the high-resolution protocol were adapted for each station: 3D FLASH: TR 2.4/2.9/2.9/3.8 ms TE 0.9/0.9/1.2/1.4 ms, FOV 375 x 400 mm, interpolated matrix 460x768/422x768/952x1024/757x1024, acquisition time 13/15/24/44 sec. A PAT factor of 2 was used for the last three of four stations. For intraindividual comparison, compression was added only in one leg. SNR and CNR values of arterial enhancement were determined on a segment per segment basis on coronal source images both for the extremity with and w/o compression. All patients underwent catheter-based DSA of the aorto-iliac and lower extremity arteries within 24 - 48 hours of the MRA exam.

Results: All subjects tolerated the examination well without complaints about discomfort or pain due to cuff inflation for venous compression. Quantitative analysis failed to demonstrate any statistically significant difference between SNR and CNR values for arterial segments imaged with and those imaged without venous compression ($p > 0.1$). Mean SNR values were 62.2 with venous compression and 61.2 without compression; mean CNR values were 51.3 without and 52 with venous compression. On MRA, 48 of 220 potentially visible arterial segments (21.3%) were not adequately visualized, largely due to severe venous overlap. In the extremities imaged without venous compression, 42 of 110 arterial segments (38.1%) were not seen, while in the extremities imaged with venous compression only 6 metatarsales arteries (5.4%) were not depicted.
Venous compression allowed the extension of acquisition time without venous overlap while venous contamination in the lower extremities was severe in the extremity without compression. The implemented PAT resulted in increased spatial resolution with an interpolated matrix and voxel size of up to 980x1024, and 0.4x0.4x1 mm^3, respectively. High-resolution MRA showed excellent correlation to DSA in patients with PAD. The Cohen`s kappa value calculated to measure concordance between DSA and MRA was 0.95 and 0.81 for venous compression and without venous compression, respectively.

a



b

Fig.1: Peripheral MR-angiogram of a 32-year-old male healthy volunteer. **a)** high-resolution anterior-posterior 3D MRA of the entire peripheral vascular and **b)** oblique view of inframalleolar vessels including the pedal arch. Implementation of venous compression on right leg leads to improved delineation of arterial morphology, especially in the infrapoliteal vessels down to the pedal arch.

Fig.2: **a)** non selective intraarterial DSA, **b)** 3D MIP obtained with contrast enhanced MRA and dedicated peripheral coil of the lower extremities in a 51 y female patient with PAOD (Fontaine grade IV). Venous compression was applied for MRA to the left leg. Note better depiction of the infrapopliteal arteries including pedal arch compared to DSA in the left leg, while venous overlay hamper visualization of the distal vessels in MRA in the right leg.

Discussion: MRA of the peripheral arteries with a refined data acquisition technique including PAT and mid-femoral venous compression leads to vastly improved display of the peripheral vasculature including the pedal arteries. Data with high spatial resolution can be achieved without relevant venous overlay.