Ultra-High-Resolution whole-body MRA using parallel imaging on a 32-channel MR system and a blood pool contrast agent: Protocol optimization and clinical implementation

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Background:

Earlier work has shown the value of whole-body MRA for the comprehensive evaluation of systemic atherosclerotic disease (1). In consecutive studies on whole-body MRA implemented on new MR scanners with matrix coils, coverage of the whole vasculature without the need of re-positioning the patient has been demonstrated (2). Still, all studies described limitations and compromises in either spatial resolution or anatomic coverage due to the limited time-frame during first-pass of the contrast agent. With the introduction of blood pool contrast agents, these limitations might be overcome (3).

Introduction:

The aim of this study was the optimization of a whole-body MRA protocol with implementation on a new generation of MR scanners with matrix coils and with application of a blood pool contrast agent to assess its clinical utility for the evaluation of systemic atherosclerotic disease.

Anatomic area	Dynamic Phase	Steady-State
Carotid Arteries	1000 μm^3	216 μm^3
Thorax		1000 μm^3
Abdomen		1000 μm^3
Thigh		216 μm^3
Knee		125 μm^3
Calf	1000 μm^3	75 μm^3

Table 1:
Spatial resolution in various anatomical areas applying a whole-body MRA protocol with intravascular contrast agent during the dynamic phase and during steady-state imaging.

Methods and Materials:

10 healthy volunteers and 5 patients with proven atherosclerotic disease underwent whole-body MRA on a 32-channel 1.5T MRI scanner with matrix coils and parallel imaging (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany). For contrast-enhanced MRA, a strongly albumin-binding gadolinium chelate (gadofosveset trisodium, MS-325, EPIX Pharmaceuticals, Cambridge, MA and Schering AG, Berlin, Germany) with a half-life time of about 15 hours, was injected with a flow rate of 1 cc/s. In the dynamic phase, angiograms of the carotid arteries and calves were obtained during first pass of MS-325, with 1mm^3 isotropic spatial resolution. In the steady-state, a spatial resolution of up to 75 μm^3 was realized **(Table 1)**. In the patients, all results were compared to state-of-the-art MRA protocols using conventional Gd-chelates.

Results:

In the dynamic phase, MR angiograms with pure arterial contrast were consistently obtained without venous overlay. For the thorax and abdomen, MR angiograms were obtained with 1 mm^3 isotropic spatial resolution within a single breath-hold during the steady-state phase of MS-325. In the thigh, knee and calf station of the lower extremity, the ultra-high resolution MRA datasets with voxel sizes between 75 and 130 μm^3 revealed excellent vessel contrast and high signal-to-noise **(Figure 1)**. In patients, MRA data obtained with this protocol showed excellent agreement with the conventional reference MR angiograms.

Conclusion:

The combination of a whole-body MRI scanner and a blood pool imaging agent allows acquisition of a whole-body MR angiogram without compromises in spatial resolution or anatomic coverage.

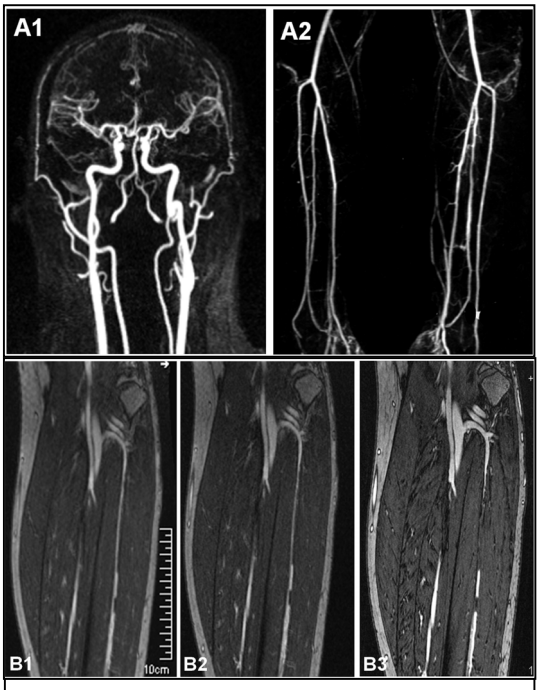

Figure 1: First-Pass and Steady-State Imaging:
A) First pass Imaging: During arterial first-pass of MS-325, pure arterial phase images of the carotid arteries (A1) and the calves (A2) can be obtained, with an isotropic spatial resolution of 1000μm^3.
B) Steady-State Imaging: During steady-state imaging of the calf, increasing spatial resolutions of 1 mm voxel length (B1, 1000 μm^3), 0.8 mm voxel length (B2, 512 μm^3), and 0.42 mm voxel length (B3, 75 $\mu m3$) were acquired. The dataset with highest spatial resolution (B3) displays smallest vessels of the calf in great detail, maintaining a very high signal-to-noise ratio.

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