Time-Resolved 3D MR-Angiography of the Thoracic Aorta at 3 Tesla: Comparison of First-Pass Imaging Characteristics of a Low Albumin-Binding and a Blood-Pool Contrast Agent.

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Introduction: Gadofosveset trisodium (Vasovist®, Bayer Schering Pharma, Berlin, Germany) has been approved for diagnostic use in Europe. Its advantages are related to the prolonged decrease of the T1 time which allow for extended imaging times. Further, its increased relaxivity compared to standard low-albumin-binding agents offers a high signal at low molecular concentrations not solely for angiographic MR imaging [1]. Since time-resolved contrast-enhanced 3D MRA (tr-CE-MRA) gathers information about arterial and venous vessels in the first phase of a single application of contrast agent (CA) it can thus be easily added to any imaging protocol that requires CA [2]. However, no direct in-vivo comparison of first pass time-resolved MRA using blood pool agent with a standard extra-vascular contrast agent has been presented to date. The motivation to conduct this study was further supported by the fact that relaxivities of standard and blood-pool CAs will change differently if exposed to 3 Tesla which will also have an impact on first-pass imaging characteristics. Further, it has to be tested whether blood-pool agents are equally acceptable for first-pass imaging in addition to later high resolution imaging. Therefore, it was the aim of this volunteer study to evaluate whether there is a difference in the first pass imaging characteristics at 3 Tesla between a standard low albumin-binding first-pass CA and a blood-pool contrast agent based on qualitative and quantitative image evaluation.

Methods: 20 healthy volunteers were included in the study after approval of the local ethics committee and written informed consent. Time-resolved 3D MR-angiography was performed with a standard 8-chanel phased-array surface coil on a 3T scanner (Magnetom Trio, Siemens AG, Erlangen, Germany, maximum gradient strength=40 mT/m, rise time=200µsec) using a rf-spoiled gradient echo sequence. Imaging parameters were adapted to the individual volunteer's anatomy and specific absorption rate (SAR) limits: flip angle (FA)=8-25°, TR=2.08–3.44ms, TE=0.78–0.88 ms, FOV 400x400 mm², Matrix 320x320, number of phase encoding steps=179, slice thickness = 1.5–1.7 mm, actual inplane resolution (2.22–2.24x1.25) mm². A total of 20 data volumes were consecutively acquired. For spatial and temporal image acceleration multiple acquisition strategies were combined: parallel imaging (GRAPPA reconstruction [3]): acceleration factor = 4 along the phase encoding direction and 32 reference lines, partial Fourier acquisition: along phase and slice encoding direction (for both, partial Fourier factor = 6/8), view sharing: along the temporal domain (TREAT [4]) based on elliptical centric view ordering [5]. Double update rate of central k-space and sharing of outer k-space regions was employed.
Contrast agent was administered at a rate of 3.5 mL/s directly after the second 3D data volume was acquired which served later as the reference scan. Of all 20 volunteers, 10 received the standard contrast-agent (SCA, gadobenate dimeglumine, Multihance®, Bracco, Germany, single dose=0.1mmol/kg) and 10 underwent MR imaging using the blood-pool contrast agent (BPA, gadofosveset trisodium, Vasovist®, Bayer Schering Pharma, Germany, single dose = 0.03 mmol/kg), respectively.
A blinded evaluation of image quality on a 0-3 scale (0=poor, 3=excellent diagnostic quality), relative signal-to-noise (SNR) and contrast-to-noise-ratio (rel. CNR) versus fat and muscle was performed. For the estimation of local noise, the last two time frames were subtracted, for estimation of the relative signal, the last two timeframes were averaged.

Results: Results for rel. CNR are given in fig 1, for SNR in fig. 2. Good to excellent image quality was confirmed for all MRA examinations using either a BPA or a SCA with a trend towards superior quality for SCA (arteries: SCA 2.82±0.15 vs. BPA 2.58±0.39, veins: 2.52±0.29 vs. 2.23±0.39, artifacts: 2.40±0.18 vs. 2.33±0.08, see also fig. 3). Quantitative SNR and CNR analysis further specified these findings and revealed a non-significant superiority of SCA in arterial imaging and of BPA in venous imaging. SCA showed superior vs. BPA for averaged overall arterial values with respect to rel. CNR vs. fat (SCA: 0.91±0.26 vs. BPA: 0.39±0.02, $p<0.05$) and SNR averaged for all arteries (SCA: 24.46±61.78 vs. BPA: 18.37±15.61, $p<0.05$), see also fig. 3.

Discussion: First-pass imaging characteristics of a blood-pool agent are equally well suited for tr-CE-MRA at 3T (see fig. 4). In comparison, BPA demonstrated enhanced venous signal and superior venous image quality and non-significantly altered arterial imaging properties.

References: 1. Parmelee, Invest Radiol 1997; 2. Frydrychowicz, MAGMA 2006; 3. Grsiwold, MRM 2002; 4. Fink, Invest Radiol 2005; 5. Wilman, MRM 1997

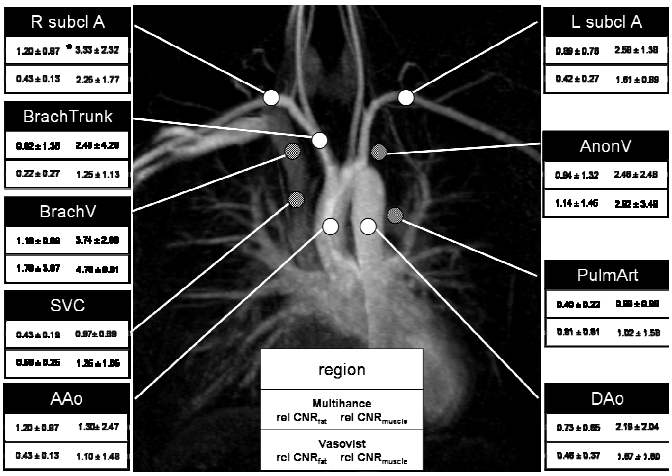

Fig. 1: MIP of the maximum arterial enhancement in time-resolved MR-angiography at 3t. The localization of the regions of interest for quantitative evaluation of SNR are displayed.

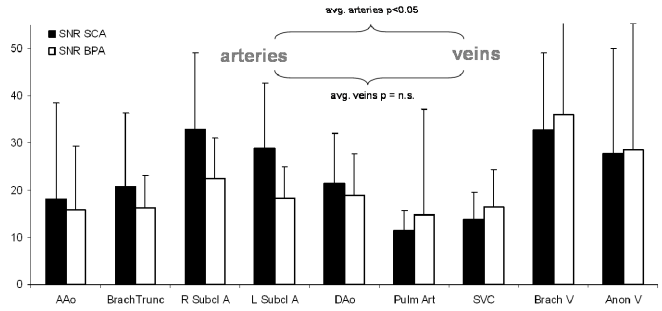

Fig. 2: Comparison for local SNR between the low-albumin bind contrast agent (SCA) and the blood-pool agent (BPA) Only if values for arteries and veins are averaged, the SCA is significantly superior to BPA in arteries (see also fig. 3).

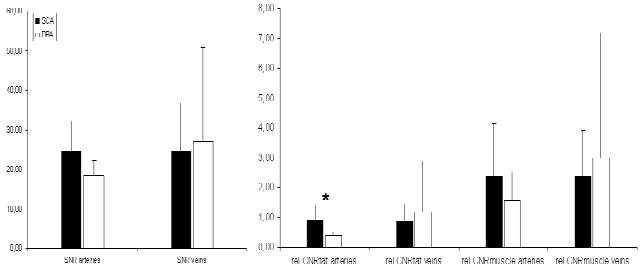

Fig. 3: Averaged SNR and local CNR values for SCA and BPA.

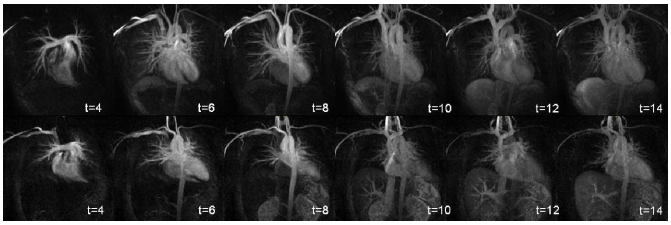

Fig. 4: Series of images from time-resolved MR angiography performed with a low-albumin-binding contrast agent (top row) and a blood-pool agent (lower row). Obviously, both agents enable for high quality MRA.