Dynamic and static MR angiography of the supraaortic vessels at 3.0 T: intraindividual comparison of Gd-based contrast agents at single dose

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Target audience: The presented work will be of interest for clinical scientists and Radiologists aiming to optimize acquisition protocols for carotid MRA.

Purpose: Several different contrast agents exist for MRI. Despite the fact that these are all Gadolinium (Gd) based, some of them feature dedicated characteristics, e.g. high GD concentration or protein interaction, which make them favorable for MRA [1-3]. Purpose of the study was to intraindividually compare a 1.0 molar Gadolinium (Gd) based contrast agent (GBCA) and two 0.5 molar GBCA with weak / no protein binding using equimolar doses in dynamic and static Magnetic Resonance Angiography (MRA).

Methods: In this IRB approved study a total of 20 healthy volunteers (29±6y) underwent three MRA exams on a 3T MR system (Table 1). Exams with the different GBCA (Gadobutrol, Gadobenate dimeglumine, Gadoterate meglumine) were performed in a randomized fashion with a minimum of 48h in between exams to exclude any effects resulting from a prior GBCA injection. Prior to and 45 minutes after each exam circulatory parameters were recorded. Total GBCA dose per MRA exam was limited to 0.1mmol/kg ("single dose") with a 0.03/0.07mmol/kg split for dynamic and static MRA respectively and a standardized injection rate of 2ml/s. Qualitative assessment of image quality was performed by two blinded readers separately with pairwise rankings (superior, inferior, equal). Quantitative analysis was performed by SNR and CNR measurements as well as in regard to vessel sharpness with an in-house developed semi-automated tool at a pre-defined vascular level (Figure 1). Statistical analysis was done using Cohen's kappa, Wilcoxon rank tests as well as mixed effects models.

Results: There were no significant differences in hemodynamic parameters between MRA exams. Gadobutrol qualitatively was rated superior to Gadoterate meglumine (p 0.0002) and equal to Gadobenate dimeglumine (p 0.057) with good to excellent interreader agreement (kappa 0.663 – 0.83). SNR and CNR were significantly higher with Gadobutrol as compared to both other agents (CNR p 0.0431 / 0.0258, SNR p 0.0458 / 0.0325). Quantitative assessment of vessel sharpness did not show significant differences between GBCAs ($p > 0.05$).

Discussion: At equimolar doses 1.0 molar Gadobutrol demonstrates superior SNR / CNR to Gadobenate dimeglumine and Gadoterate meglumine with subjectively higher image quality as compared to Gadoterate meglumine in dynamic and static carotid MRA. The decrease injected volume and by that shortened bolus with Gadobutrol does not result in significantly different edge blurring of vessels. Since we could not confirm the finding that contrast agents with an at least temporary binding to blood components are beneficial for morphologic imaging for MRA applications, it appears that the high relaxivity of these agents due to concentration differences of contrast agent molecules and human albumin in the first pass bolus is reached after some time of interaction with blood components but not directly after injection.

Conclusion: This study indicates that in static and dynamic MRA of the carotid arteries a contrast agent that features a higher Gd-concentration shows higher qualitative image quality as well as higher SNR and CNR as compared to 0.5 molar agents, no matter if they feature protein interaction / binding or not. Our results reflect findings in carotid MRA and the evaluated characteristics might be different in other vascular territories that are imaged with an extended delay after injection.

References: [1] Rohrer M et al., Comparison of magnetic properties of MRI contrast media solutions at different magnetic field strengths. Invest Radiol. 2005 [2] Achenbach M et al., Prospective comparison of image quality and diagnostic accuracy of 0.5 molar gadobenate dimeglumine and 1.0 molar gadobutrol in contrast-enhanced run-off magnetic resonance angiography of the lower extremities. J Magn Reson Imaging. 2010 [3] Nikolaou K et al., High-spatial-resolution multistation MR angiography with parallel imaging and blood pool contrast agent: initial experience. Radiology. 2006

	static MRA	dynamic MRA
acquisition time [sec]	21.6	98
temp. resolution [sec]	-	1.85; interp. 0.925
parallel imaging factor	4	3
spatial resolution [mm3]	0.8 x 0.8 x 0.8	1.4 x 1.4 x 1.4
TR (repetition time) [ms]	3.25	2.46
TE (echo time) [ms]	1.26	0.92
flip angle [º]	21	18
matrix	576x342	256x176
FOV [mm2]	450x267	350x240
bandwidth [Hz]	620	810

Table 1: Dedicated sequence parameters

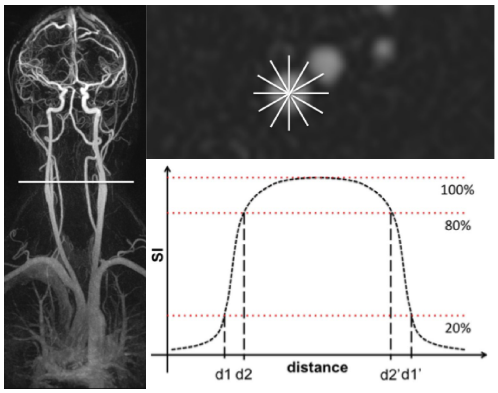

Figure 1: Example of static MRA of the carotid arteries showing the level of the vessel sharpness evaluation as well as the reconstructed axial slice including vessel profile lines. Graph shows an exemplary vessel signal profile with d1 and d1' representing 20% of the maximal signal, d2 and d2' 80% of the maximal signal as well as FWHM level.