

Optimizing flip angle and injection rate for combined first pass and steady state imaging of the supraaortic vasculature using gadofosveset trisodium at 1.5 T MRI – a volunteer study

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Introduction

Recently, the intravascular MR contrast agent gadofosveset trisodium has been clinically approved for use in the European market. The contrast agent has a high reversible affinity to human serum albumin, which leads to a prolonged presence in the blood stream. The prolonged intravascular contrast allows acquiring high-resolution MRA data sets during steady state, but optimized imaging protocols are still under investigation. The aim of this study was to determine the optimal injection rate for first pass imaging studies and the optimal flip angle using high resolution steady state spoiled gradient echo MRA pulse sequence for the supra-aortic vessels.

Methods

Nine volunteers were enrolled in this phase II clinical trial, and underwent four MR-sessions at weekly intervals with fast automatic injection of 0.03 mmol/kg BW of gadofosveset trisodium (Vasovist®, Bayer Schering Pharma AG, Berlin, Germany). Four different injection rates were used: 0.25, 0.5, 1 and 2 cm³/s. During the first pass of the contrast agent, the following time-resolved MRA acquisition was performed: 3D FLASH with view sharing (TWIST), FOV 320x290, Matrix 320x290, TR=2.69ms, TE=0.97. For steady state imaging (i.e., 2-3 min after infusion of the contrast agent) a 3D-MRA-FLASH pulse sequence was used (FOV 270 x 320 mm, spatial resolution: 0.7 mm, TR=12 ms, TE=4.62 ms; TA=4:11 min) using different flip angles from 10° to 50° in steps of 10°. Signal intensities were analyzed in selected ROIs to quantify the contrast-to-noise ratios CNR in the carotid arteries, the jugular vein, using the signal of the surrounding muscle tissue and the mean of the noise signal in air for calculation: $CNR = (S_{vessel} - S_{muscle})/Noise$.

Results

All volunteers were imaged successfully. The highest injection rate of 2 cc/sec provided the highest SNR (Fig. 1) during first pass. In contrast in the steady state phase no significant difference was found between the four different injection rates ($p>0.05$). The ROI-analysis for the median carotid artery and vein presented the highest signal and CNR of 25 at a flip angle of 30° with a nearly three-fold CNR improvement over 10° and 50°. These results are in line with previous predictions about the expected T1 during steady state of 130 ms at 1.5 Tesla, which would result in an optimal (i.e., Ernst) angle for the given TR of 25° [1].

Discussion

These results show that during first pass for the given range of injection rates a nearly linear increase in SNR can be expected with increasing injection rate. Furthermore, the theoretically predicted relaxation enhancement of gadofosveset trisodium is found in the carotid arteries during steady state, and that a nearly optimal excitation flip angle can be estimated a priori using the well-known Ernst angle calculation for spoiled gradient echo imaging. Injection rate has no influence on the steady state signal, as would be expected by the indicator dilution theory. However, steady state MRI particularly of small vascular structures or high grade stenosis is still challenging, and this problem might be overcome by optimized imaging protocols in combination with intravascular blood pool contrast agents.

References

[1] Bock M, et al. Magn Reson Mater Phys 21: 363-368 (2008)

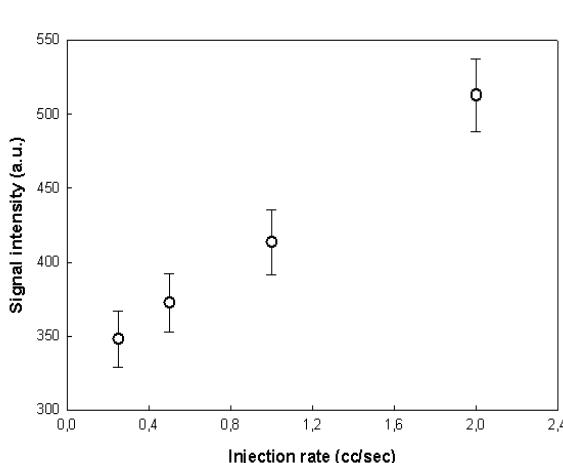


Fig. 1: Maximum first pass signal intensity as a function of injection rate measured in the carotid artery. A nearly linear increase of the signal intensity with injection rate is observed.

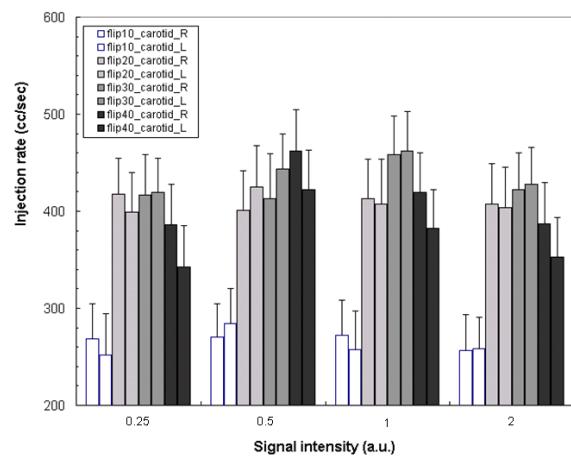


Fig. 2: Signal intensity of the carotid arteries (right and left) versus contrast media injection rate in the steady state phase (0.25, 0.5, 1 and 2 cc/sec). No significant difference was found between the four different injection rates in the steady state phase.