Comparison of concentration-dependent signal intensities of MRI contrast media solutions obtained at different pulse sequences at 3T and 7T

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Purpose: An increase in signal intensity (SI) in contrast enhanced MRI depends on the contrast media (CM) relaxivity [1,2], the tissue concentration (i.e. the CM-dilution within the body), the field strength and the pulse sequence used. In this phantom study, the concentration dependence of relative SIs for all commercially available CM were determined at 3T and 7T using common clinical pulse sequences with typical parameters.

Methods: The CM (non-protein binding: Gadobutrol, gadoteridol, gadoterate, gadopentetate, gadodiamide, gadoversetamide; protein-binding: gadoxetate, gadobenate, gadofosveset) were investigated in human plasma (healthy donors pool) at physiological temperature (37°C) maintained by a temperature control system. Imaging was performed at 3T and 7T (both Siemens Healthcare) using SE, TSE, FLASH 2D and 3D and VIBE sequences. The SIs were determined from ROIs of the central slice of the test vials (see Fig 1).

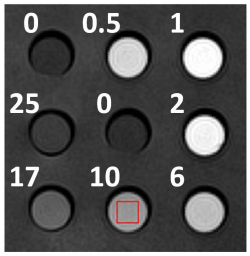

Fig. 1: ROI-based image analysis. Conc. in mmol/L

Results and Discussion: For the comparison of different pulse sequences the different approved dosages and CM formulations (0.25 / 0.5 / 1.0 mol/L) were taken into account and the SIs were plotted vs. molar concentration (mM) and dilution of the ready-to-use products (mL/L), visualizing the influence of the product concentration on the T1-shortening (Fig. 2). A nearly linear correlation between Gd-concentration and SI was observed only for very low concentrations (<1mM for spin-echo, 2-3mM for gradient echo sequences) and this range was even lower at 7T than at 3T. Almost stable or slightly increasing (FLASH 3D, VIBE) or strongly decreasing SIs (SE,TSE, FLASH 2D) were observed at higher concentrations. At 7 T and with spin-echo sequences this decrease was most prominent especially for protein binding CM, leading to SIs significantly below baseline. This decrease in SI started already at concentrations < 1 mM for protein binding CM. Under the given conditions, at 3 Tesla protein binding moderately increased the SI of the FLASH 3D sequence at lower concentrations, compared to non-protein binding agents.

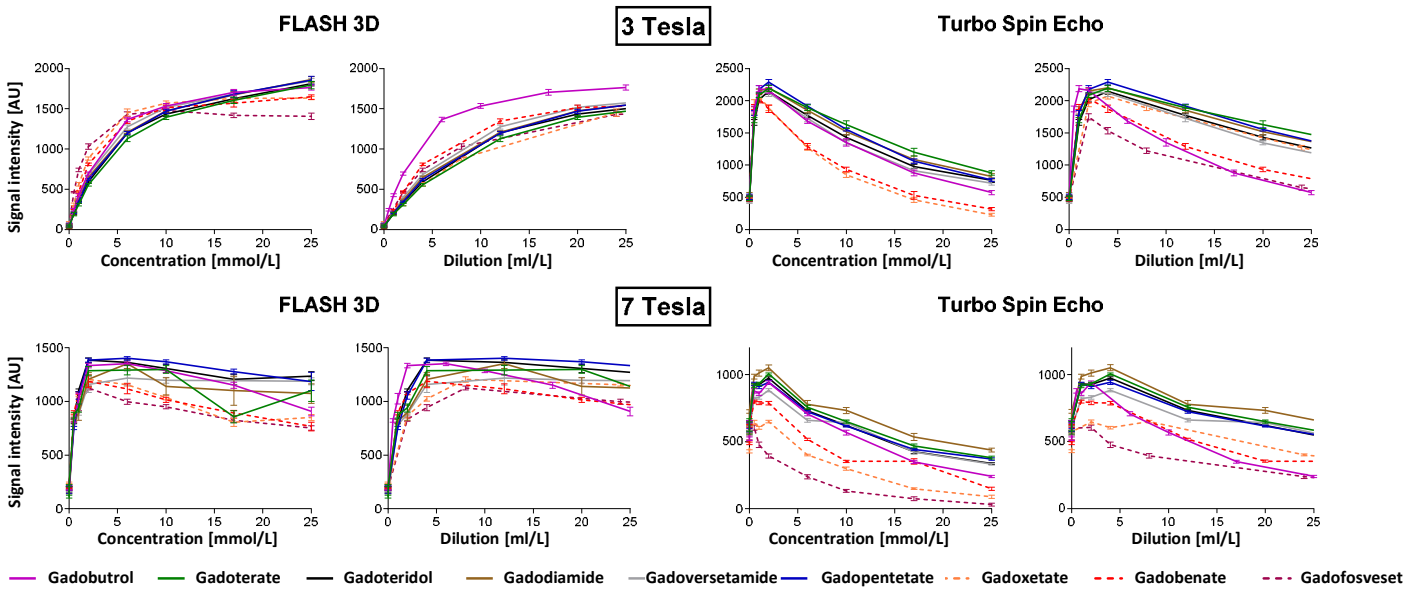

Fig 2. SI in dependence of CM concentration and dilution acquired with FLASH 3D (left) and Turbo Spin Echo (right), at 3T and 7T

At 7 Tesla this influence of protein binding was strongly reduced. The observed SIs can be approximated and understood by well-known dependencies of MRI SIs on T1- and T2-relaxivities. This holds true for constant T1- and T2-relaxivities , which is not given for protein-binding CM where concentration-dependent relaxivities as well as field-dependent influences such as rotational correlation times need to be considered [3,4]. Hence, a straightforward prediction of SI becomes more difficult, resulting in a need for additional experimental data such as presented in this study.

Conclusions: The CM relaxivity, its in vivo concentration, the pulse sequence and the concentration of the commercial products have considerable impact on SI. This has to be considered in contrast enhanced MRI, especially for (semi-) quantitative image evaluation.

References:

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