Relaxivities of protein-interacting and non-protein-interacting contrast agents at 1.5 and 3 Tesla

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Introduction. Contrast agents that do not interact with albumin have very similar relaxivities at the field strengths above 0.2 T and the decrease of these relaxivities on the magnetic field strength is relatively mild (1). Agents interacting with proteins show longer rotational correlation times and, consequently, are expected to have stronger dependence of their relaxivities on the magnetic field strength (2). As 3 Tesla scanners become common in clinical practice, knowledge of relaxivities of various contrast agents at this field strength is desirable. Our aim was to study the concentration dependence of the longitudinal relaxation rate at two magnetic field strengths, 1.5 Tesla and 3 Tesla, using a standard gadolinium chelate (gadodiamide, Omniscan®), and a contrast agent that interacts with serum proteins (gadobenate dimeglumine, MultiHance®).

Materials and Methods. Series of solutions of the above compounds in human plasma (Octapharma, Vienna) were prepared with concentrations ranging from 0.01 mM to 2 mM. The T1 relaxation times of these solutions and specimens of the pure plasma were determined on a 1.5 T Siemens Vision scanner and on a 3 T Bruker MEDSPEC system at the same temperature (25 ±1 °C) and using the same measurement protocol. On both scanners, the inversion-recovery spin echo images were obtained for 12 different inversion times from 25 ms to 5000 ms. The relaxation delay was kept constant at 6.5 s and the echo time was 30 ms. FOV was 22 cm × 11 cm, slice thickness was 10 mm and the matrix size was 256 × 128 data points.

Results. Single-component effective relaxation times were calculated using a 3-parameter exponential fit accounting for pulse imperfections. The plots of relaxation rates against concentrations of the contrast agents are given in Fig. 1. Dependence of relaxation rates on concentration could be described by a saturation-like expression

$$R_1(c) = R_1(0) + c \cdot r_{1\max} / (1+\alpha \cdot c)$$

wherein $r_{1\max}$ is a maximum relaxivity in $mM^{-1} \cdot s^{-1}$ (more correctly, $\partial R_1/\partial c$), and the plasma relaxation rate $R_1(0)$ was either constrained (2-parameter fit) or optimized (3-parameter fit). Best fit parameter values and apparent relaxivities at 1 mM concentration ($r_{1\text{stand}}$) are given in Table 1.

Table 1. Parameters of the fits of relaxation rates vs. concentration

	gadodiamide, 1.5 T	gadodiamide, 3.0 T	gadobenate, 1.5 T	gadobenate, 3.0 T
$r_{1\max}$	5.74 ± 0.16	5.31 ± 0.15	9.01 ± 0.15	7.75 ± 0.14
α	0.108 ± 0.017	0.090 ± 0.016	0.053 ± 0.009	0.054 ± 0.010
$r_{1\text{stand}}$	5.18 ± 0.16	4.87 ± 0.15	8.55 ± 0.16	7.36 ± 0.15

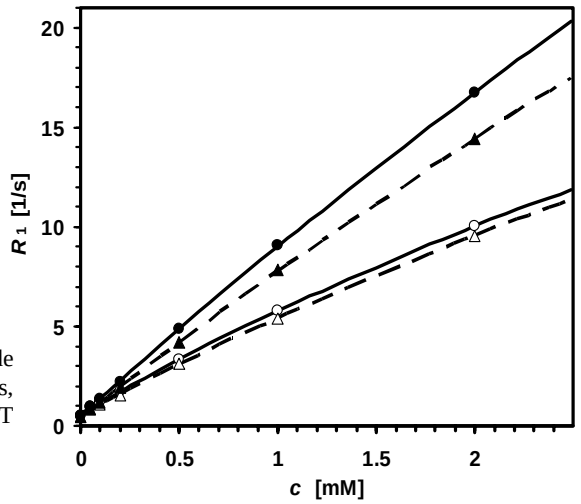

Fig. 1. Plot of the relaxation rates of gadobenate (filled symbols) and gadodiamide (open symbols) plasma solutions at 1.5 T and 3.0 T field strength (circles and triangles, respectively). Curves represent the best fit by 3-parameter functions for data at 1.5 T (solid) and at 3.0 T (dashed).

A small decrease in $r_{1\text{stand}}$ at 3 T, about 14% for gadobenate and about 6% for gadodiamide, was observed in comparison with 1.5 T. The ratio of the $r_{1\text{stand}}$ values of gadobenate and gadodiamide decreased only slightly at 3 T compared to 1.5 T (1.51 vs. 1.65). Notably, the concentration dependences of relaxation rates show small but non-negligible deviations from linearity up to 2 mM for both agents.

Conclusions. The slight reduction of the gadodiamide relaxivity at 3 T is in agreement with previous studies. The decrease in the relaxivity of gadobenate was larger in absolute terms, although the relaxivity of gadobenate in plasma was still significantly higher than that of gadodiamide at either field strength. Together with appropriate considerations on the pharmacokinetics and compartmental distribution of injected contrast agents, the obtained values can be utilized for an appraisal of the signal and contrast characteristics of MR images at 3 Tesla.

References

1. Rinck PA and Muller RN, Eur Radiol. 9:998, 1999.
2. Cavagna FM *et al.* Invest Radiol. 32:780, 1997.