Contrast Agents Based on Magnetic Nanoparticles and its Interaction with Surrounding Environment During Contrast Imaging

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Abstract. *The paper analyzes properties of commonly used contrast agents, based on gadolinium and different types of iron oxides, like Fe_2O_3, Fe_3O_4. The goal of the study was to investigate the influence of the molecules of interest (NaCl and glucose) to the Resovist contrast agent relaxation properties.*

Keywords: Magnetic Nanoparticles, Contrast Agents, NMR Imaging

1. Introduction

Magnetic resonance imaging (MRI), like another imaging techniques, meets the challenge to distinguish tissue structures, whose signal intensity are overlapped. It is despite to the fact that MRI is currently regarded as imaging techniques with the best resolution ability for the soft tissues [1, 2]. The most commonly used contrast agents are based on particles of gadolinium or different iron oxides, like Fe_2O_3 and Fe_3O_4, which are in the form of colloidal suspension in the carrier liquid [3].
The goal of this study was to observe the influence of the molecules of interest (MOI), like NaCl and glucose, to the relaxivity of Resovist contrast agent.

2. Materials and methods

Resovist is a widely used contrast agent in clinical practice. Its active substance is the superparamagnetic iron oxide, which is coated by the carboxyl-dextran. Resovist increases the spatial resolution between tissues in T_2, T_2^* weight images. This contrast agent is highly effective and generally is a very good tolerated by the cardiovascular system. Concentration of Resovist in our in-vitro experiments was equal to the concentration of contrast agent during in-vivo imaging in humans. Images were acquired by the MR tomograph Varian 4.7 T, with "Spin-echo Multi-slices Imaging sequence" (SEMS). The parameters of imaging sequence includes repetition time TR = 2 s and twelve different echo time (TE = 8.344; 16.688; 25.032; 33.376; 41.72; 50.064; 58.408; 66.752; 75.096; 83.44; 91.784; 100.128 ms). The T_2 values were obtained by the exponential fitting of intensity decrease by the least squares method (VNMRj 2.3A software). The acquired data was compared with the data obtained by the clinical tomograph ESAOTE Opera 0.178 T. Five samples were observed (one as a reference) with the same concentration of Resovist and different concentrations of MOI (NaCl and glucose) are shown in Table 1.

Table 1: Five samples and one as a reference with different concentration of MOI .

Sample number	Basal solution	Concentration molecules of	
		c_{NaCl} [g/l]	c_{Glu} [g/l]
1	distilled water	0	0
2	distilled water + Resovist	9	0
3	distilled water + Resovist	9	0
4	distilled water + Resovist	90	0
5	distilled water + Resovist	0	1
6	distilled water + Resovist	0	10

3. Results and Discusion

In Fig. 1 are showed data obtained by the SEMS sequence at 4.7 T for twelve different echo times.

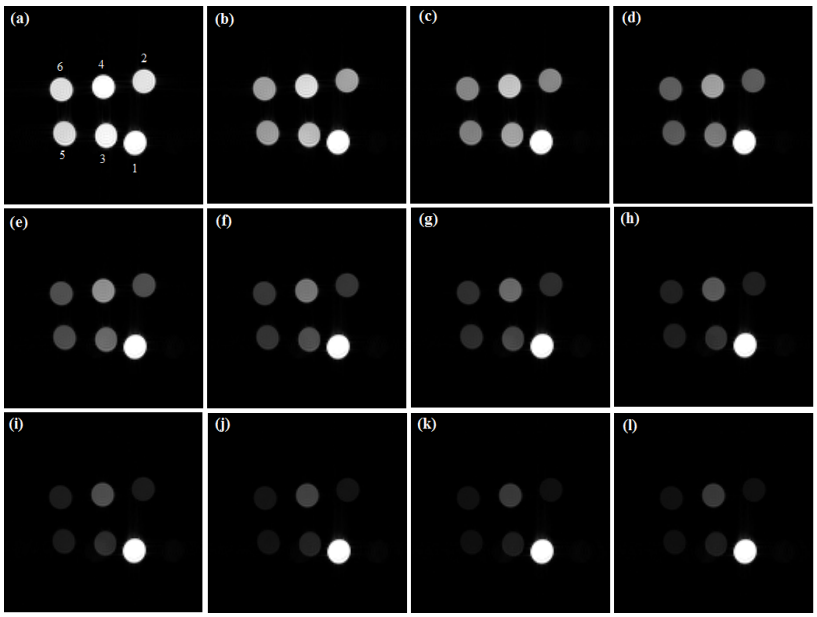


Fig. 1. Six samples with different concentration of MOI obtained by MR tomography with magnetic field strength 4.7 T, TR = 2 s.

The images show, that different MOI with a different concentration, have an influence to the relaxation times of contrast agent. Changes of T_2 relaxation time are shown in Table 2.

Table 2: T2 relaxation time values and standard deviation for each sample measured at 4.7 T, 'std' means standard deviation .

	Sample n.1	Sample n.2	Sample n.3	Sample n.4	Sample n.5	Sample n.6
T_2[s]	0.3205	0.0286	0.0348	0.0463	0.0287	0.0297
[std]+/- [s]	0.009	0.00009	0.00024	0.00017	0.00007	0.00013

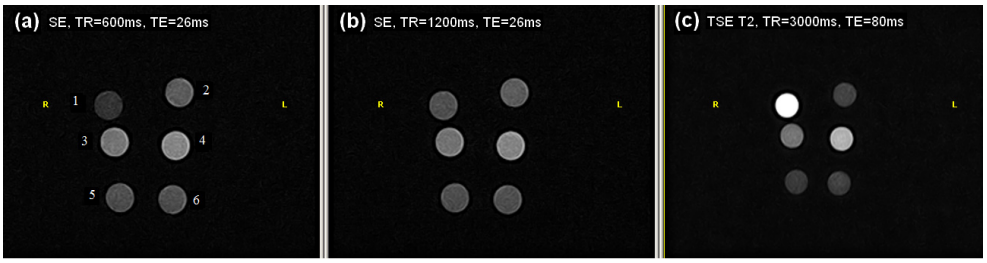


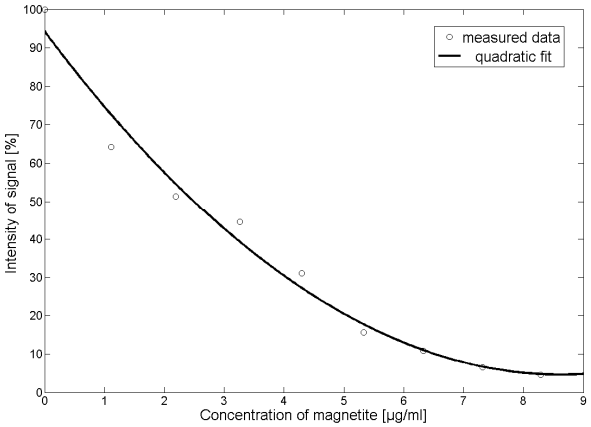
Fig. 2. MR images of six samples with different concentration of MOI, measured by clinical MR tomograph 0.178 T

To compare the influence of the MOI to the relaxation properties of the contrast agent, the samples were imaged by the clinical tomograph ESAOTE Opera 0.178 T (Fig. 2). The images show the change of the contrast for the samples number 1, 3, and 4, when the SE image sequence was used.

For quantification of signal intensity at ESAOTE E-scan Opera XQ, we used custom-made phantoms, which parameters are summarized in Table 3. Decrease in signal intensity with dependence on the concentration is shown in graph (Fig. 3)

Tab.3 Properties description of prepared samples

Sample	Concentration EMG607 [μg/ml]	Susceptibility of sample	T2 relaxation time [ms]
Distilled water	0	$-9{,}04\text{x}10^{-6}$	1800 ±20
Distilled water + EMG607	1.11	$4{,}24\text{x}10^{-5}$	31 ±0.3
	2.19	$3{,}11\text{x}10^{-5}$	15.2 ±0.2
	3.26	$5{,}58\text{x}10^{-5}$	10 ±0.079
	4.3	$1{,}28\text{x}10^{-4}$	8.8 ±0.088
	5.33	$1{,}11\text{x}10^{-4}$	6.4 ±0.073
	6.33	$1{,}33\text{x}10^{-4}$	5.2 ±0.052
	7.32	$1{,}41\text{x}10^{-4}$	4.6 ±0.053



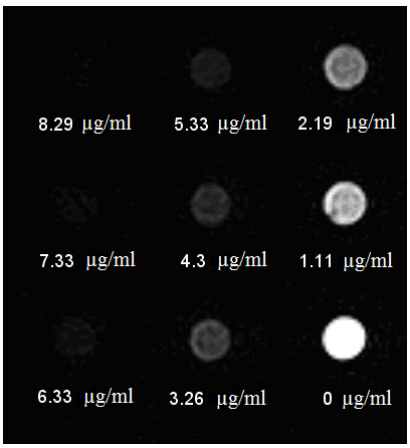


Fig. 3., **Fig. 4.** Dependence of signal intensity on the concentration of magnetite. For a reference value (maximal), the distilled water was chosen. The intensity values are in % range with regard to distilled water value.

4. Conclusions

The decrease of signal intensity in each sample with MOI, with increase of echo time, was expected. However, the changes in T_2 relaxation times for MOI samples are a little bit surprising. These changes, together with variations measured at clinical tomograph are subject of next study.

Acknowledgements

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