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Enhancement Effect of Superparamagnetic Iron Oxide Nanoparticle-Based MRI Contrast Agent at Different Concentrations and Magnetic Field Strengths

Authors : Bimali Sanjeevani Weerakoon, Toshiaki Osuga, Takehisa Konishi

Abstract : Magnetic Resonance Imaging Contrast Agents (MRI-CM) are significant in the clinical and biological imaging as they have the ability to alter the normal tissue contrast, thereby affecting the signal intensity to enhance the visibility and detectability of images. Superparamagnetic Iron Oxide (SPIO) nanoparticles, coated with dextran or carboxydextran are currently available for clinical MR imaging of the liver. Most SPIO contrast agents are T2 shortening agents and Resovist (Ferucarbotran) is one of a clinically tested, organ-specific, SPIO agent which has a low molecular carboxydextran coating. The enhancement effect of Resovist depends on its relaxivity which in turn depends on factors like magnetic field strength, concentrations, nanoparticle properties, pH and temperature. Therefore, this study was conducted to investigate the impact of field strength and different contrast concentrations on enhancement effects of Resovist. The study explored the MRI signal intensity of Resovist in the physiological range of plasma from T2-weighted spin echo sequence at three magnetic field strengths: 0.47 T (r1=15, r2=101), 1.5 T (r1=7.4, r2=95), and 3 T (r1=3.3, r2=160) and the range of contrast concentrations by a mathematical simulation. Relaxivities of r1 and r2 (L mmol-1 Sec-1) were obtained from a previous study and the selected concentrations were 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 2.0, and 3.0 mmol/L. T2-weighted images were simulated using TR/TE ratio as 2000 ms /100 ms. According to the reference literature, with increasing magnetic field strengths, the r1 relaxivity tends to decrease while the r2 did not show any systematic relationship with the selected field strengths. In parallel, this study results revealed that the signal intensity of Resovist at lower concentrations tends to increase than the higher concentrations. The highest reported signal intensity was observed in the low field strength of 0.47 T. The maximum signal intensities for 0.47 T, 1.5 T and 3 T were found at the concentration levels of 0.05, 0.06 and 0.05 mmol/L, respectively. Furthermore, it was revealed that, the concentrations higher than the above, the signal intensity was decreased exponentially. An inverse relationship can be found between the field strength and T2 relaxation time, whereas, the field strength was increased, T2 relaxation time was decreased accordingly. However, resulted T2 relaxation time was not significantly different between 0.47 T and 1.5 T in this study. Moreover, a linear correlation of transverse relaxation rates (1/T2, s–1) with the concentrations of Resovist can be observed. According to these results, it can conclude that the concentration of SPIO nanoparticle contrast agents and the field strengths of MRI are two important parameters which can affect the signal intensity of T2-weighted SE sequence. Therefore, when MR imaging those two parameters should be considered prudently.

Keywords : Concentration, resovist, field strength, relaxivity, signal intensity
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