Manganese Liposomes as Molecular Probes using Fast Field-Cycling MRI

Dara Ó hÓgáin[1,*], Simona Baroni[2], Silvio Aime[3], Gareth R. Davies[1] and David J. Lurie[1]

[1]Aberdeen Biomedical Imaging Centre, University of Aberdeen, Aberdeen, AB25 2ZD, UK;

[2]Invento S.r.l., Torino, Italy; [3]Department of Chemistry, University of Torino, Torino, Italy

*e-mail: r01do7@abdn.ac.uk

Purpose:

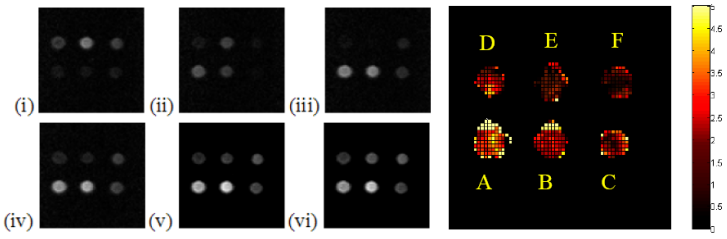
Fast Field Cycling (FFC) MRI is able to switch between magnetic fields during the application of a pulse sequence. In this way it is potentially able to exploit the different T_1 dispersion behaviour of tissue and contrast agents to optimise contrast between normal and pathological tissues. In particular, FFC-MRI allows access to a new contrast mechanism known as ΔR_1 imaging in which contrast depends on the change in R_1 between different fields [1]. In this work, a proof-of-principle study has been carried out using contrast agents designed specifically for use with FFC-MRI which show large changes in R_1 between different magnetic fields. These contrast agents are detected with much greater sensitivity in a ΔR_1 image compared with standard T_1 weighted images.

Materials and Methods:

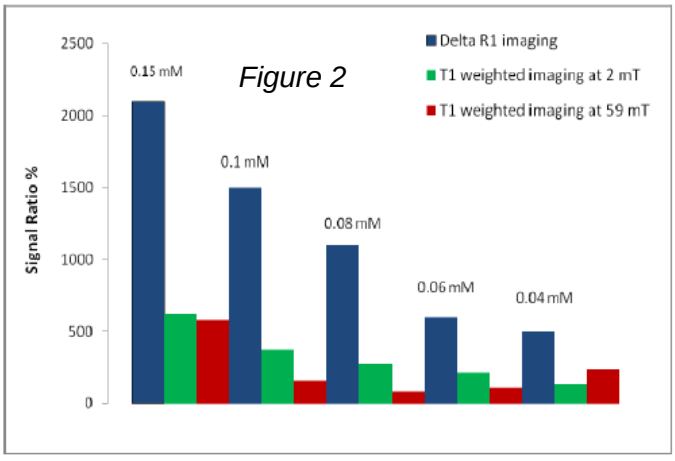
A new contrast agent consisting of Mn[II] ions surrounded by POPC:PEG (95:5) liposomes diluted in a HEPES buffer solution was designed for use with FFC-MRI. The solution was first diluted to five different concentrations; A: 0.15 mM, B: 0.1 mM, C: 0.08 mM, D: 0.06 mM, and E: 0.04 mM respectively. Sample F containing 1.0 mM $CuSO_4$ was also prepared in de-ionised water in order to provide comparison with the Mn[II] contrast agent, as $CuSO_4$ unlike Mn[II] shows almost no change in R_1 between field strengths. The samples were imaged using a home-built, whole-body FFC-MRI scanner with detection at B_0 = 58.7 mT (2.499 MHz) [2].

Results:

T_1 weighted images were acquired initially at 58.7 mT with evolution times of 10 ms, 100 ms, 220 ms, 330 ms, 440 ms and 600 ms (Figure 1A, images (i – vi) respectively). The images were then acquired at 2 mT using the same evolution times. Using these data, maps of R_1 values were calculated using a program written in MATLAB (MathWorks, MA, USA), for each pixel in a set of images. R_1 maps at 59 mT and 2 mT were then subtracted to give a ΔR_1 value for each pixel. Figure 1B shows a ΔR_1 map for each of the samples (A – F) in the imaging phantom. Figure 2 shows the ratio between the image intensities of the Mn[II] samples and the $CuSO_4$ sample, comparing the ΔR_1 values to T_1 weighted images at 2 mT, and at 59 mT.



A) *Figure 1* B)



Conclusions:

The FFC-MRI ΔR_1 mapping technique takes advantage of the R_1 dispersion of the Mn[II] liposomal contrast agent, resulting in higher contrast between the Mn[II] and the 1.0 mM $CuSO_4$ samples compared with T_1 weighted imaging. Typically normal tissue exhibits only a small change in R_1 between 2.5 and 10 MHz [3], and as such, ΔR_1 mapping could be used to enhance contrast between regions containing contrast agent and surrounding areas of normal tissue.

References:

[1] Alford *et al.*, Magn. Reson. Med., **61**, 795 (2009).

[2] Lurie *et al.*, Phys. Med. Biol., **43**, 1877 (1998).

[3] Bottomley *et al.*, Med. Phys., **11**, 425. (1984).