Characterising a coil/sample system for monitoring gastrointestinal transit using fluorine markers

E. Placidi[1], R. C. Spiller[2], and P. A. Gowland[1]
[1]SPMMRC, School of Physics and Astronomy, University of Nottingham, Nottingham, United Kingdom, [2]Nottingham Digestive Diseases Centre Biomedical Research Unit, University of Nottingham, Nottingham, United Kingdom

Introduction

There is a need for markers that can be used to study transit in the gastrointestinal (GI) tract. Fluorinated agents have particular advantages in this application: there are negligible amounts of fluorine in biologic tissues so no background noise is present, ^{19}F is the only naturally occurring isotope of fluorine, fluorine has the highest MR sensitivity after proton and finally if the marker is absorbed, then since it has a large range of chemical shifts, metabolic changes are easily resolved in vivo. We are developing methods to use ^{19}F MRI to monitor the GI transit and currently plan to use encapsulated fluorine containing liquids. Perflubron (perfluorooctylbromide, PFOB, $C_8F_{17}Br$) has been proven to be a relatively safe and effective gastrointestinal MR contrast agent in the past [1-2]. If the agent is to be used to study GI transit it will be encapsulated and swallowed and will then need to be tracked through the GI tract. This abstract aims to characterise a fluorine coil /sample combination for monitoring transit through the GI tract.

Methods

Fluorine coil All scanning was carried out on a 3T Philips Achieva scanner using a PulseTeq surface coils consisting of two 20 cm diameter loops to be placed on either side of the abdomen. If the fluorine containing capsules are to be tracked through the GI tract the coil must have good sensitivity across the field of view. B1 maps were formed to characterise the performance of the coil: large volumes of PFOB were not available so instead a 20 cm NMR tube was scanned in 3 different positions in the FOV (Fig 1). A FFE sequence (TR=1000 ms, 2.4 mm x 2.4 mm voxel size, 1 slice of 50 mm thickness) was used to acquire images at multiple flip angles α (α= 40º, 70º, 90º, 110º, 130º and 150º). A 20 cm grid of small (1 ml) samples were scanned to determine the variations in sensitivity across the field of view.

NMR measurements: If the agent is to be encapsulated it is important that its susceptibility is not too different from water or it will cause large field gradients and the signal from the agent may be dephased. Therefore the susceptibility [3] and T1 of PFOB were measured. To measure susceptibility the sample was placed in a medium-walled NMR tube of 20 mm diameter, which was inserted in a collar on the top of a 500 ml spherical flask. This phantom was placed in the centre of the bore with the long axis of the tube perpendicular to the main magnetic field. An FFE sequence was used to acquire phase images in the coronal plane (TR=100 ms, rec. res. = 0.48 mm x 0.48 mm, 10 slices of 1 mm thickness), for TE =10, 25 and 50 ms in order to calculate the field shift from the relation $\varphi=\gamma\,\Delta B\,\Delta T$. A second phase map was acquired after replacing the sample with water without moving the phantom. The difference between the two phase maps is due to the difference in susceptibility between PFOB and water, and susceptibility can be calculated from:

$$\Delta B = B_0 \frac{\Delta\chi}{2}\left[\frac{R}{r}\right]^2 \cos(2\alpha) \qquad (1)$$

where R is the radius of the tube, r is the distance from the centre of the tube, θ is the angle around the coronal plane (defined relatively to B_0) and $\Delta\chi$ is the susceptibility difference between the PFOB and the water. In order to calculate the T_1 of the PFOB an IR-TSE sequence (TR=6000 ms, 2.1 mm x 2.1 mm, 1 slice of 50 mm thickness) has been acquired with multiple values for TI (TI=100, 250, 500, 100, 1500, 2000, 3000, 5000 ms).

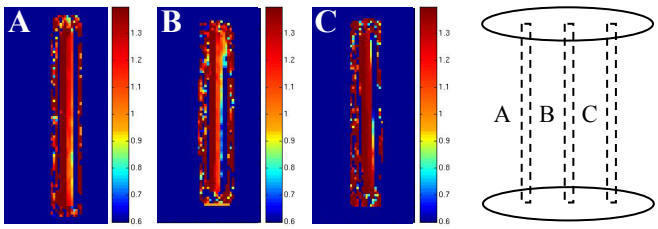

Fig 1 Spatial distribution of the B1 magnetic field generated by the RF pulse on the transverse plane: A left lateral, B central and C right lateral.

Results

Figure 1 shows the B1 field is uniform across the field of view and the grid of phantoms showed good sensitivity across the field of view. Figure 2 shows the images used to calculate the susceptibility of the PFBO which was found to be 7.0 ± 0.3 10^{-7}. The T1 for the PFOB was found to be 1009±10 ms.

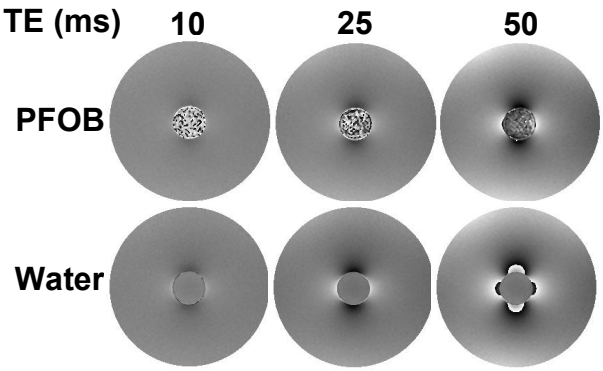

Fig 2 Phase images for PFOB and water at different TEs.

Conclusion

The fluorine coil will provide good coverage across the abdomen at least in subjects that are not too large. The PFOB agent has suitable susceptibility and T1 for encapsulation and in vivo imaging. Current efforts are focused on finding a safe way to encapsulate the PFOB for delivery to subjects.

References

[1] Anderson et al. JMRI **4**: 491-496 (1994)
[2] Mattrey et al. AJR **148**:1259-1263 (1987)
[3] Weisskoff et al Magnetic Resonance in Medicine **24** (1992) p.375-383