Preliminary Rat Myocardial Tissue Characterisation at 4.7T

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INTRODUCTION: T_2^* mapping is most commonly used for tracking of super-paramagnetic iron oxide (SPIO) contrast agents, assessment of tissue iron content or functional imaging of blood oxygen dependence[1]. The purpose of this study was to establish an MRI protocol suitable for tracking ultra-small SPIOs (USPIOs) which are phagocytised by activated inflammatory cells leading to high concentrations of USPIOs in areas of inflammation. This causes localised signal reduction in T_2 and T_2^* images due to the field inhomogeneity. This method has been shown to be effective in detecting infarctions in rat myocardia *in-vivo*[2]. The images collected here were intended as a normal data set of healthy myocardia which could be later used to compare with diseased hearts.

METHODS: Four healthy female Sprague Dawley Rats between 2 and 5 months old, with mean weight 264g (range 229-293g) were imaged on a 4.7T horizontal magnet (Magnex, UK) equipped with a 120 mT/m gradient system (AE Techron, USA). Procedures were carried out in accordance with a Home Office project licence and institutional guidelines. Animals were placed prone on an in-house designed MR compatible bed which incorporated physiological monitoring (SA Instruments, USA), thermoregulation and an anaesthetic mask that delivered 3% Isoflurane in 3L/min O_2. The bed was positioned inside a 110 mm transmit-receive 16 rung birdcage coil. Image acquisitions were controlled using an EVO spectrometer (MR Solutions, UK), and were prospectively respiration and ECG gated. After globally shimming the FID signal from the rat, single average gradient echo images were acquired with a 50x50 mm FOV, a matrix of 130x130 zero filled to 256x256 with a slice thickness of 2 mm, bandwidth = 133 kHz, flip angle=45°, and 0.75 ms gradient ramp times. 14 short axis images were acquired of a mid-ventricular slice with *TE* values of 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 25, 30 ms. Total sequence time was 10 minutes. The images were analysed using ImageJ (NIH, Bethesda, USA). A region of interest (ROI) was positioned in the septum and the mean signal intensity was obtained for each image. Data were plotted against *TE* in Matlab R2013a (The Mathworks Inc., Natick, MA) and an exponential curve with the equation $y = a\, e^{-TE/T_2^*} + c$ fitted to give T_2^* [3], where *y* is the signal intensity, *a* is a constant representing the initial signal value and *c* is the noise offset. Additional images were acquired with a 35 mm surface coil under the rat's chest to compare the SNR between surface and volume coils.

RESULTS: The T_2^* value obtained from the four rats was 10.12 ± 4.40 ms (mean ± SD). Figure 1 is an example of the first ten images from a sequence. The surface coil comparison images showed a 3.6 fold increase in SNR.

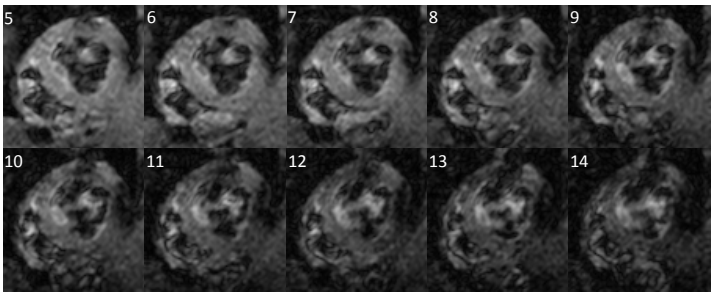

Figure 1: Example *T2 images with *TE* varying as shown (ms)**

DISCUSSION: This value of T_2^* is shorter than the 21.8 ± 1.4 ms reported in a similar 4.7 T study[4]. In future, using the surface coil for this investigation may have the effect of increasing estimated T_2^* values, as images at longer *TE* would be less prone to noise and a narrower shim would be possible over localised volumes. However the volume coil has more uniform image sensitivity over the entire FOV. The prospectively gated acquisition acquired one line of *k*-space for each R-wave, but disabled the pulse sequence during respiratory periods when the chest wall was moving rapidly. This will have effectively increased *TR* for acquisitions immediately following respiratory events, which will have caused variations in T_1 weighting and thus signal strength. In future, the method could be improved by using dummy scans during respiratory periods, where rf pulses are still applied after each ECG trigger but k-space is not filled. This may alleviate the issue of signal variation, as it would help to maintain a constant level of magnetisation[5].

CONCLUSION: We have successfully acquired a normal data set of T_2^* times in healthy rat myocardia and demonstrated its dependence on the type of coil used to receive the RF signal. This will be used in future to compare with myocardial pathologies such as infarction or inflammation. It would also be useful comparison data for other centres operating at this field strength.

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