Longitudinal Study of T2* Maps in Rat Kidneys at 3.0T

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INTRODUCTION

MRI maps of the effective spin-spin relaxation constant T_2* (or rate R_2*) have been shown to provide a new method for detecting and tracing renal changes caused by furosemide and water load [1, 2]. This technique may provide a tool for monitoring renal disease progression and treatment. To be useful for these types of longitudinal studies, the T_2* values must remain stable over time. In this study we tested the stability of BOLD- MRI T2* mapping at 3T with a multiple gradient-echo sequence [3] in four rats over a period of two weeks.

METHODS

Four 16-week old male Sprague-Dawley rats were studied three times, over a period of two weeks. After induction of anesthesia, maintained through a breathing mask (2% isoflurane, 1ltr/min in 100% oxygen) each rat was placed supine on a custom-built platform with an external plastic kidney cup [4] that was used to hold the left kidney still and isolate it from the intestines and other internal organs. Animal core body temperature, using a YSI Inc. rectal probe, respiration, using an infrared motion detector, and oxygen saturation (%StO2), using a Hutchinson InSpectra NIRS system, were monitored during the experiments. All studies were performed on a 3.0T scanner (GEMS) using a standard quadrature transmit/receive extremity coil. The multiple gradient echo (mGRE) sequence (TR/FA/BW=100ms/30/32kHz, FOV=12mm x 9mm, slice thickness=3mm, matrix=256 x 192) was employed to acquire eight T_2* weighted images at TE values starting at 3.8ms, incrementally increasing by 4.46ms to 35.1ms. Five oblique slices oriented perpendicular to the axis of the kidney were selected to provide complete kidney coverage. Then T_2* maps were calculated by using a linear fit to the natural log of the signal for each pixel (MATLAB, Mathworks, Inc). Mean T_2* values were measured in three regions of interest: posterior cortex, anterior cortex, and medulla.

RESULTS

A representative mGRE image at TE=3.8ms is shown in Figure 1. The isolating plastic external cup effectively isolated the kidney. Cine movies of the slices demonstrated that there was no movement during the imaging. Animal physiology also remained stable. The mean T_2* values were posterior cortex T2*= 30.43 +/-1.87ms, medulla T_2*= 28.23 +/-4.1ms. The susceptibility artifact caused by the cup altered the anterior cortex values of T_2*, anterior cortex T_2*= 17.4 +/-3.63ms, reducing them by almost 50% as compared to the posterior values. Values for the two regions of the cortex and the medulla are plotted including the inter-animal standard deviations in Figure 2. The T_2* variations were dominated by intra-animal differences caused by tissue heterogeneity; within each region of interest the standard deviation in T_2* ranged from 3ms to 9ms. The posterior values are in agreement with those previously published at 1.5T and remained stable over three different imaging experiments.

CONCLUSIONS

At 3T using mGRE, in rat kidneys, we observed that the T_2* values are stable to better than 10%. The plastic holder provided good isolation from the intestines and held the kidney still. This is critical as the animals cannot breath-hold and ventilation or pacing would alter renal hemodynamics. T_2* values are unaffected in the renal medulla and posterior cortex away from the cup.

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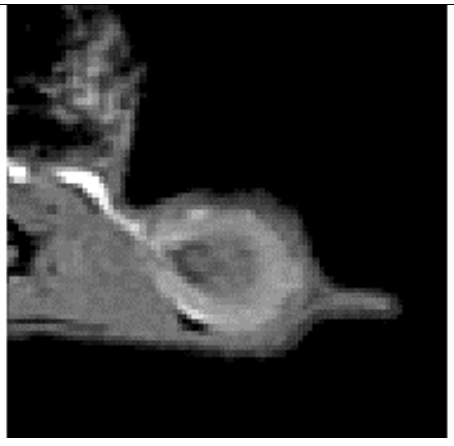

Figure 1: An mGRE image of rat kidney.

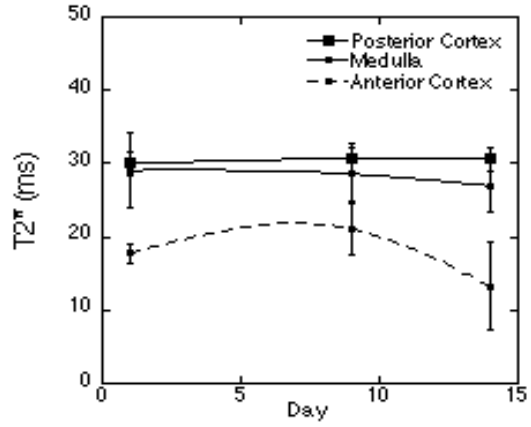

Figure 2: Plot showing T_2* stability over time.

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