Proton Resonant Frequency Shift and R2* in Frozen Ex Vivo Renal Tissue at 7T.

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Introduction

Image-guided cryoablation is a minimally invasive therapy for renal cancer. Temperature monitoring is desired to ensure treatment with adequately low temperatures. To this end, MR parameters of frozen tissue have been measured with ultrashort TE MR imaging on a low field interventional system [1,2]. In addition, phase changes have been observed as tissue freezes [3], but understanding of the contribution of the proton resonant frequency shift to the phase changes have been limited by the SNR of the frozen tissue at low field. The purpose of this study was to measure the MR parameters of frozen tissue (PRF shift and R2*) on a high field spectrometer.

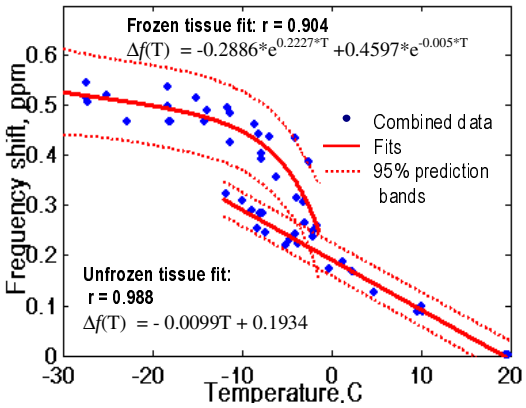

Figure 1. Frequency shift vs temperature

Methods

Freshly excised kidney samples (porcine n=1, sheep n=2) were placed into a 10 mm diameter tube. A 100 ml acetone solution (80% $(CH_3)_2CO$, 20% $(CD_3)_2CO$) was used as internal reference, placed in a 3 mm tube, and inserted into the larger tube with the tissue. The Varian INOVA 300 MHz NMR system was locked to the deuterium resonance of the acetone reference for the duration of the experiment to account for magnetic field drift during the experiment. The spectral width/flip angle/pulse length were 8 kHz/30°/3.4 µs, and 16000 complex points were acquired over 2s. Tissue temperature was decreased to –30°C in steps. A fiber-optic temperature sensor (Luxtron, Santa Clara, CA) measured the sample temperature during imaging. The observed temperature dependence of acetone's chemical shift, 0.0025 ppm/°C, was taken into account. The ^{1}H frequency at room temperature was used as a baseline. To calculate ^{1}H frequency shift with temperature $\Delta f(T)$ the baseline was subtracted from the ^{1}H frequency at every temperature. The linewidth ($\Delta\nu_{1/2}$) of the water ^{1}H peak was recorded at different temperatures of the tissue and T2* was calculated as $1/(\pi\Delta\nu_{1/2})$.

Results

In our study we observed that the ^{1}H frequency as a function of temperature has a discontinuity at the freezing point: the tissue samples follow the known PRF shift until -9°C. As tissue water freezes, there is a temporary increase in temperature and decrease in the frequency shift. Following the transition to the solid phase, the behavior of the ^{1}H frequency with temperature changed from linear to exponential. An exponential fit given in Figure 1 describes the temperature dependence of the frequency shift below freezing.

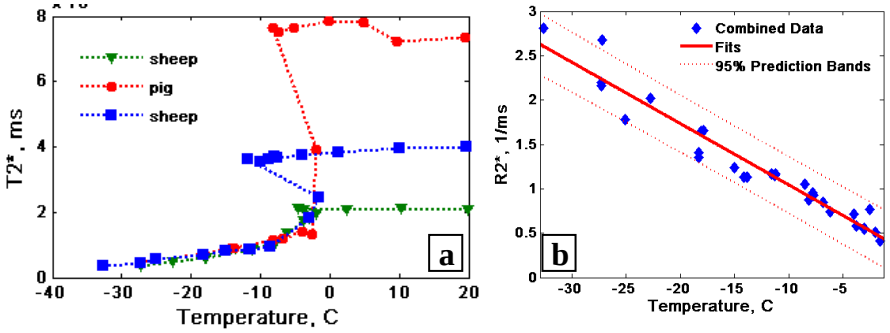

Figure 2. a) T2* vs T for 3 experiments. b) R2* vs T for combined frozen tissue.

In unfrozen tissue, the T2* ranged from 2ms to 8ms in the different tissue samples (Figure 2a). However, once the tissue froze, the T2* in all the tissues abruptly decreased to about 1 ms and continued to decrease with decreasing temperature. Combined R2* values in frozen tissue are shown in Figure 3b. R2*(T) was linearly fit and had a slope of -0.069, agreeing with a previously reported [3] R2*(T) slope of 0.07 for *ex vivo* renal tissue at 0.5T.

Discussion

In this study we report on the ^{1}H frequency shift and R2* of frozen *ex vivo* renal tissue. In frozen tissue, the ^{1}H frequency does not appear to follow the linear PRF shift with temperature, but an exponential decay. The behavior resembles published results [4]. R2* values measured in frozen renal tissue at 7T correlate well to those seen at 0.5T.

References:

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[4] EW Hansen, A Ninequillibrium Phase Diagram of the System HCl-H_2O Determined by ^{1}H NMR. J.Chem.Eng.Data 1988, 33,99-104. **Acknowledgements**: Christina Alarcon, RO1 CA09061, P41 RR009784