Hexamethyldisiloxane (HMDSO), a novel reporter molecule for in-vivo oximetry using ^{1}H MRI

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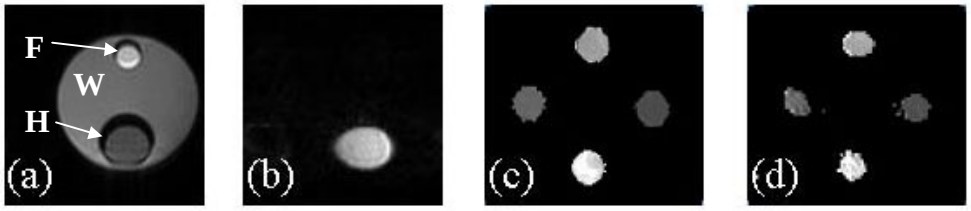
Introduction

There is increasing evidence for the importance of tissue oxygenation in development, progression, and response to cancer therapy. Oxygen is required for efficient function by most tissues and hypoxia leads to rapid cellular dysfunction and damage. In addition, hypoxic tumor cells are refractory to radiotherapy. Thus, the opportunity to measure tissue oxygen tension (pO_2) non-invasively may be significant in understanding mechanisms of tissue function and in clinical prognosis. The linear dependence of R_1 of fluorocarbon ^{19}F resonances on pO_2 is well known and has been studied extensively[1]. We have studied the potential of HMDSO as a ^{1}H based pO_2 reporter molecule. In a related study (submitted to ISMRM 2004) data is presented for the linear dependence of R_1 of HMDSO on pO_2 (R_1= 0.13+ 0.00175*pO_2[torr] at 37^{o}C) and NMR spectroscopic evaluation of tumor oxygenation. Here, we implement an imaging protocol on phantoms demonstrating the potential for future in vivo studies.

Materials and Methods

The data were acquired on a Varian 4.7T scanner. A spin-echo EPI based pulse sequence was used for imaging and measuring T_1 values. The sequence consisted of a) a train of 20 non-selective 90^o pulses for saturation of signal followed by a delay *tau* for magnetization recovery, b) 3 CHESS[2] pulses for frequency selective saturation of water and fat immediately followed by c) spin-echo EPI detection with a slice selective 90^o pulse and a frequency selective 180^o pulse. T_1 maps were obtained using this sequence with the ARDVARC (*A*lternating *R*elaxation *D*elays with *V*ariable *A*cquisitions for *R*eduction of *C*learance effects) protocol[1], by varying *tau*. For comparison, reference images were obtained using a spin echo sequence. T_1 maps were made using the Varian Image Browser software.

Results and Discussion



a) *T_1 weighted spin-echo image of phantom with smaller tubes containing mineral oil (F) and HMDSO (H) inside a tube containing water (W) and* ***b)*** *proton density weighted EPI image of the same phantom with fat and water suppression. T_1 maps of a phantom containing HMDSO saturated with gases with different concentrations of oxygen obtained by* ***c)*** *spin-echo sequence and* ***d)*** *the spin-echo EPI sequence.*

HMDSO has a single proton resonance with a chemical shift of –5ppm relative to water. Since our application is oriented towards T_1 relaxometry, our approach to suppression involves frequency selective pulses. The EPI based sequence with frequency selective excitation and suppression was demonstrated to effectively suppress signals from mineral oil (to simulate fat) and water. The choice of a long echo time (>100ms) enabled suppression of any residual fat signal, resulting from its proximity to the HMDSO resonance. The entire T_1 data set with 14 *tau* values (spanning 0.05 to 20 s) was obtained within 2 and half minutes. This approach is tailored towards future in vivo applications and the short total acquisition time can allow us to monitor dynamic response to intervention. Minimal toxicity and wide availability add to the promise of HMDSO as a pO_2 reporter molecule.

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References

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