Citrate Magnetic Resonance Spectroscopy at 3 T

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Introduction

Citrate is an important metabolite often used in Magnetic Resonance Spectroscopy (MRS) and MR Spectroscopic Imaging (MRSI) to aid the detection of Prostate Cancer (PCa) along with the Choline and Creatine metabolites. In these exams, the level of (Choline + Creatine)/Citrate is often investigated as a marker for PCa. To date, MRS/MRSI protocols for PCa detection have been well established at the field strength of 1.5 Tesla (T) [1].

The advent of higher field strength scanners provide many new extensions from previous 1.5 T systems due to the inherent increase in signal to noise ratio (SNR). For PCa exams, this advantage can be exploited in various forms, for example using higher resolution acquisitions, which can increase the accuracy of localizing cancerous tissues. Also, for the given SNR, scan times can be made shorter compared to 1.5 T thereby reducing the overall MR exam time. The extension of 1.5 T MRS/MRSI protocols for usage in 3 T PCa would therefore have potential merits.

However, the application of higher field strengths for Citrate resonance detection accompanies several considerations. For example, at 3 T, the B_1 inhomogeneity can be problematic causing difficulties in the detection of the metabolites of interest. The Citrate signal is especially vulnerable to changes in B_1 field due to strong coupling effects. Another important factor to consider is the effect of echo time (TE).

In this abstract, the different spectral patterns of the Citrate resonance at 3 T are explored. We show the sensitivity of the Citrate metabolite as a function of the B_1 field and the resonance pattern for different TEs. The study is intended to provide a guideline for PCa detection using metabolite concentrations via MRS and MRSI at 3 T.

Methods

Simulations were performed on the Citrate metabolite using the gamma software [2] for different echo times assuming a PRESS excitation scheme. We used J-coupling value of 15.1 Hz and a chemical shift of 0.12 ppm (=16.6 Hz) for simulations at 3 T [3]. The T_2 value was assumed to be 200 ms with a line width of 8 Hz. Also, experiments using a Citrate phantom were conducted at 3 T using the PRESS sequence with different TEs (TR = 3 sec). To evaluate the influence of B_1 inhomogeneity on the Citrate resonance, data from a phantom comprised of Citrate, Creatine, and Choline was acquired at various transmitter gain (TG) values. In this case, the echo time was set to 95 ms to highlight the effects. One unit change in TG corresponds to a 0.1 dB power change in the RF coil. Finally, data were acquired in vivo with PRESS using an endorectal coil at 3 T at 95 ms TE. A single voxel of size 1.5 cc from a suspicious PCa region was acquired in 8 minutes.

Results and Discussion

Figure 1 shows the Citrate resonance behavior at different echo times obtained from the simulation. Unlike 1.5 T, due to the strong coupling, very different resonant behavior can be observed at 3 T. Figure 2 quantifies the simulation result by calculating the relative peak integral and the relative peak value at 2.6 ppm (top) followed by experimental data from the Citrate phantom (bottom). In Fig. 3, the influence of the RF field inhomogeneity is shown where the sensitivity of the Citrate is shown compared with other metabolites of interest in PCa. Finally, an in vivo spectrum is shown in Fig. 4 where the inverted Citrate peak is well demonstrated (TE = 95 ms).

The successful application of PCa detection using MRS/MRSI at 3 T depends on the knowledge of the Citrate resonance behavior. As seen from the results, to maximize the resonance amplitude, good choices of TE would be 35 ms or 95 ms. In the former case, good saturation pulses to minimize lipid contamination as well as hardware stability at short echo time needs to be established. Meanwhile, at TE of 95 ms the amount of lipid suppression would be similar to the case of 1.5 T. But the resonance peak of the Citrate is inverted causing quantification difficult. Also, in the case of poor B_0 and B_1 field homogeneity, the resonance at this echo time will be highly degraded due to line broadening and sensitivity to TG, respectively.

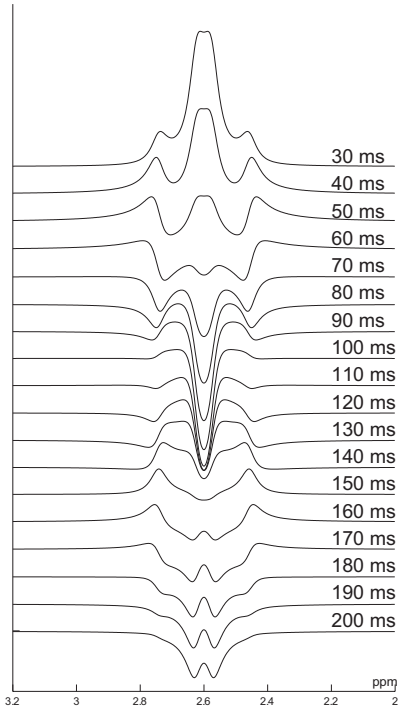

Figure 1. **Citrate resonance simulation at different echo times**

Conclusion

The potential for Citrate detection for PCa at 3 T has been evaluated with simulation, phantom, and in vivo experiments.

Acknowledgements

Lucas foundation, NIH CA48269, RR09784, 1R01CA098523-01A1.

References

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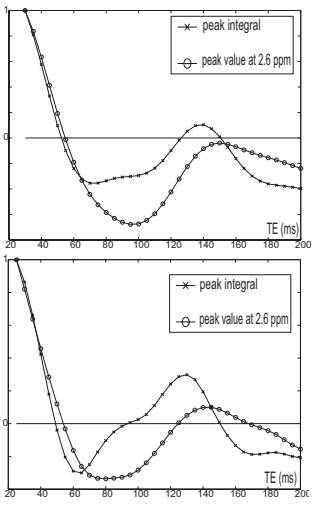

Figure 2. simulation (top) and experimental (bottom) results

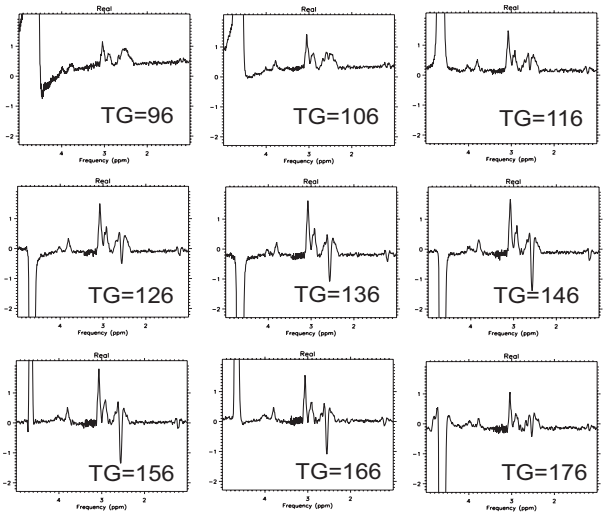

Figure 3. Citrate resonance at different flip angles

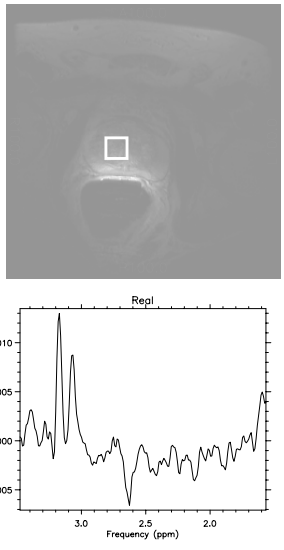

Figure 4. In vivo prostate exam