Improved Outer Volume Suppression for Prostate MR Spectroscopic Imaging

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INTRODUCTION:

A key component in the robust clinical utility of magnetic resonance spectroscopic imaging (MRSI) of the prostate (Ref.1) is effective suppression of periprostatic lipid signal. We present the use of conformal voxel MRS (CV-MRS) (Ref.2) for application in prostate MRSI to improve the effectiveness and consistency of outer volume lipid suppression. This method utilizes up to twenty Very Selective Saturation (VSS) pulses, automatically positioned and angled in three dimensions, to "conform" the excitation voxel to the shape of the prostate, effectively nulling signal from outside the prostate. To account for the rapid regrowth of lipid signal due to its short T_1 relaxation time, the flip angles of the VSS pulses are re-calculated based on their temporal distance from the PRESS excitation sequence. Finally, to account for the negative effect of overlapping spatial saturation bands, temporal re-ordering of the spatial saturation pulses to minimize residual signal based on 3D modeling has also been implemented.

METHODS;

All scans were performed on a General Electric 1.5T Signa MR scanner equipped with Echospeed gradients. A standard quadrature head coil was used for all phantom experiments and an endorectal coil (Medrad Inc.) in combination with a torso phased array coil was used for all human experiments. A water/oil phantom was designed to simulate the prostate and surrounding lipid signal. The product PRESS pulse sequence was modified to include a user-selectable number of spatial saturation pulses with offsets and rotations defined from a text file, rather than graphic prescription. The text file was generated in a separate program which took the prostate MR images as input and output the size and position of the excitation voxel as well as the offsets and rotations of the spatial saturation pulses. Flip angles were re-calculated to account for T_1 regrowth. Temporal ordering of the spatial saturation pulses was re-calculated to minimize the impact of overlapping spatial saturation bands on the magnitude of the residual lipid signal.

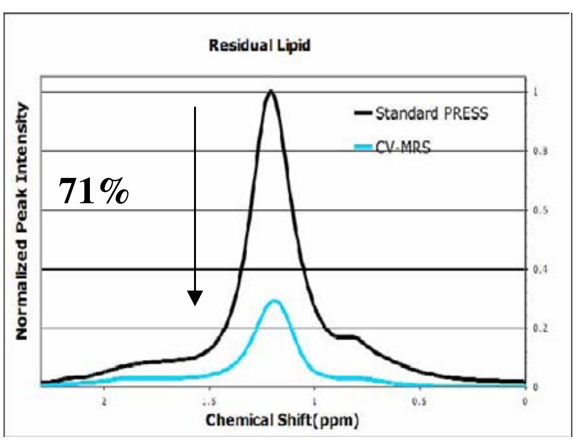
RESULTS:

3D MRSI and single voxel spectra were acquired with four different acquisitions. A standard PRESS voxel encompassing the irregularly-shaped water phantom (simulating the prostate) gave rise to the spectrum shown in Fig.1 where the spectrum is zoomed to show the contaminating lipid signal at 1.2 ppm and normalized to a height of 1.0. The second acquisition utilized the CV-MRS technique, resulting in a 71% reduction in the lipid signal. Further reductions in the lipid signal were observed in the third acquisition where the flip angles were modified to account for T_1 regrowth (76% reduction) and finally the fourth acquisition where the temporal re-ordering of the pulses was introduced (79% reduction). Results on human subjects show consistently improved lipid suppression with this new technique.

DISCUSSION AND CONCLUSION:

A 79% reduction in contamination lipid signal was observed when combining the conformal voxel acquisition with T_1-dependent flip angles and temporal re-ordering of the spatial saturation pulses to account for overlapping spatial saturation bands. 3D modeling of the successive application of up to 20 spatial saturation pulses revealed that 68% of the saturation volume was affected by two or more saturation pulses, with some regions being saturated as many as seven times. This overlap effect worked against the flip angle optimization since this latter optimization assumed a single RF pulse was affecting the lipid magnetization. The 3D model enabled the temporal reordering of the pulses to minimize this overlap effect. In summary, we have developed an improved outer volume suppression technique which reduces the problem of periprostatic lipid signal contamination in prostate MRSI.

References: 1. Kurhanewicz J et al, Radiology 198:795-805, 1996. 2. Ryner LN et al, ISMRM Abstracts: 350, 2005.



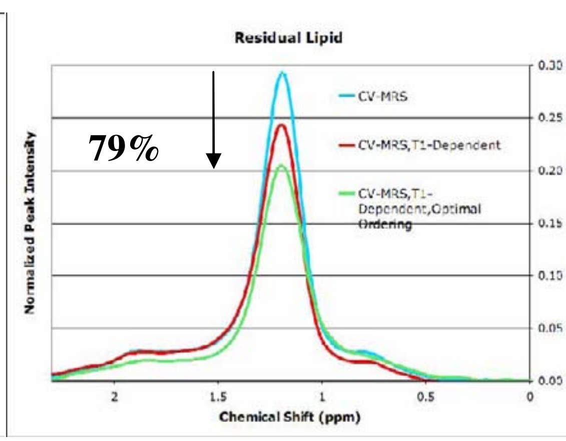


Figure 1. Left, single voxel spectra showed a 71% percent reduction in residual lipid when comparing the standard PRESS, with the inclusion of the CV-MRS technique. On the right, a total reduction of 79% is achieved when using all three optimizations. All spectra have been normalized to the Standard PRESS acquisition.