Improved prostate MRSI employing a conformal voxel technique

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INTRODUCTION:

In prostate magnetic resonance spectroscopic imaging (MRSI) placing the region of interest (ROI) over the entire prostate gland results in unwanted contamination artifacts from periprostatic lipid [1]. Conversely, limiting the ROI within the prostate gland excludes tissue in the peripheral zone of the prostate where 80% of cancers are detected (see figure 1a). In light of this challenge, we present an outer volume suppression technique which conforms to the shape of the prostate and reduces lipid contamination for short TE prostate MRSI. We present the first application of the conformal voxel MRS (CV-MRS) [2] technique for *in vivo* short TE prostate spectroscopy. This method calculates the three dimensional positions and angles of up to twenty Very Selective Saturation (VSS) pulses, which "conform" the excitation voxel to the anatomical shape of the prostate, in effect nulling the signal from surrounding tissue. 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. Additionally, 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. Lastly, the standard 90 degree excitation pulse of the PRESS sequence is replaced with a spatial/spectral excitation pulse to further reduce lipid contamination for short TE prostate MRSI.

METHODS;

All subjects were recruited in accordance with the dictates of the regional ethics board. Subjects were scanned on a General Electric 1.5T Signa MR scanner equipped with Echospeed gradients. A standard endorectal coil (Medrad Inc.) in combination with a torso phased-array coil was used. The PRESS pulse sequence was modified to include the optimized CV-MRS technique. Using an offline application, the CV-MRS algorithm uses the acquired prostate MR images to calculate the offsets and rotations of the VSS pulses. In addition, the application performs two further optimizations: (1) modification of the flip angle of each VSS pulse to account for T1 regrowth, and (2) temporal re-ordering of the VSS pulses to minimize the impact of overlapping VSS pulses. In vivo prostate spectra were obtained using this optimized technique.

RESULTS:

To facilitate a comparison between currently available scan techniques and this newly optimized technique, three separate 3D MRSI acquisitions were obtained during each study. The first acquisition utilized manual placement of the VSS pulses, which were followed by the standard PRESS excitation with TE/TR =130/1100ms. The second acquisition employed the optimized CV-MRS technique followed by the standard PRESS excitation with TE/TR =130/1100ms. Lastly, a third acquisition was obtained using the optimized CV-MRS technique, followed by a modified spatial/spectral PRESS excitation with a shortened TE=40ms and TR=1100ms. Each 3D MRSI acquisition used a 16x8x8 phase encode matrix, with a voxel size of 0.42 cm^3. The spectra obtained from each acquisition can be seen in Fig. 1(b-d). All spectra are at the same voxel position and zoomed between 4ppm and 0ppm to visualize the contaminating lipid signal at 1.2ppm. Using an optimized CV-MRS outer volume suppression technique reduces lipid contamination by an average of 75% over all subjects. Reducing the TE increases the amount of total citrate peak area by 76%, averaged over the entire prostate.

DISCUSSION AND CONCLUSION:

In previous phantom studies [3], an ~80% reduction in contamination lipid signal was observed when combining the conformal voxel acquisition with T1-dependent flip angles and temporal re-ordering of the spatial saturation pulses to account for overlapping spatial saturation bands. Results from the human study show consistently improved lipid suppression, with an observed reduction as high as ~90-95% over the entire prostate. These results led to an improved baseline and easily visualized spectra throughout the prostate. As seen in Fig. 1 (c), a large reduction in contaminating signal at the periphery has resulted in improved identification of metabolite peaks. Furthermore, when TE is reduced, we observed a significant increase in the citrate peak height in the peripheral zone, a region where cancers are dominant (Fig. 1(d)). In summary, we have developed an effective outer volume suppression technique, which has significantly improved the diagnostic quality of spectra throughout the prostate.

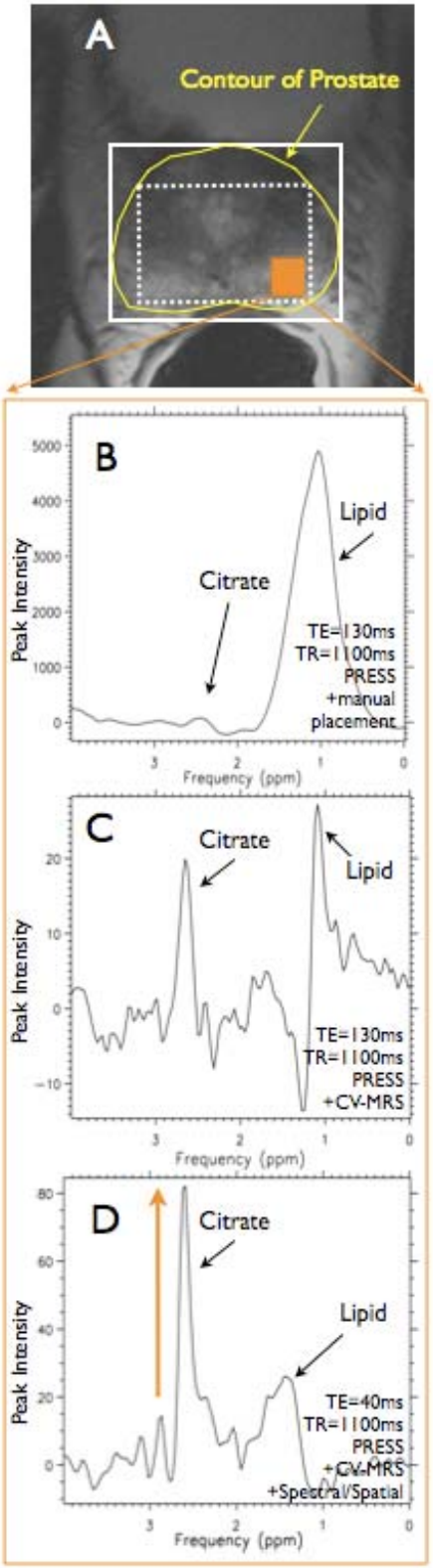

Figure 1: In (A), if the ROI of is taken over the entire prostate (solid white line) including some peripheral tissue, the resulting spectrum will contain unwanted contaminating lipid, as seen in (B). To avoid contamination, an ROI would be placed well within the prostate (dashed white line), but a considerable amount of peripheral prostate tissue is excluded. Three separate 3D MRSI acquisitions were obtained during each study. Since most cancers lie along the peripheral zone of the prostate gland it is of particular interest to obtain high quality spectra in that region. In (B) manual placement of the VSS pulses results in spectra with large lipid contamination. In (C), we present spectra from the same voxel location, but employ the optimized CV-MRS technique. We observe a greater than 95% reduction in contaminating lipid. Lastly, in (D) we reduce the TE to 40ms and employ a spectral/spatial 90^0 excitation pulse to help further reduce the lipid contamination. In this spectrum collected along the periphery, there is a large increase in citrate peak intensity.

Reference:

1. Casciani, E. et al. Abdominal Imaging, 2006.
2. Ryner, L., et al. ISMRM 13th Annual Scientific Meeting, 2005.
3.Venugopal, N., et al. AAPM 49th Annual Scientific Meeting, 2006.