Rapid 5-minute Echo-Planar Spectroscopic Imaging of Prostate Cancer Patients at 3T

G. D. Reed[1,2], P. E. Larson[1], J. Kurhanewicz[1,2], and D. B. Vigneron[1,2]
[1]Radiology and Biomedical Imaging, University of California, San Francisco, San Francisco, California, United States, [2]Joint Graduate Group in Bioengineering, UCB / UCSF, Berkeley, California, United States

Introduction

Proton spectroscopic imaging of the prostate has become a valuable clinical tool due to its effectiveness in detecting the presence and aggressiveness of prostate tumors [1]. However, the long acquisition times (typically 15-20 minutes) for the 3D phase encoding traditionally employed can be prohibitively long. A flyback echo-planar readout sequence has been developed and recently implemented for our clinical cases at UCSF. This sequence necessitates only 2 dimensions of spatial phase encoding, thus drastically reducing minimum scan time. This reduction in scan time facilitates greater flexibility in acquisition, since the shortened scan time allowing for longer repetition times (to avoid metabolite saturation) and increased encoding matrix sizes. Comparison with a 1.5T 3D phase-encoded sequence showed that the flyback sequence can achieve comparable spatial resolution (7mm isotropic), improved spectral resolution, and significantly improved SNR in a 5-minute 3T exam as compared to a 17-minute scan at 1.5T.

Methods

The sequence uses a spatially selective excitation followed by a train of dual-band spectral-spatial refocusing 180s for partial water suppression [2] and an MLEV phase-cycling pulse train for upright citrate resonances with reduced transit gain sensitivity [3]. For X-axis localization, an interleaved flyback echo-planar readout was implemented [4,5]. Using TE = 85 ms, TR = 2s, a 16×10×8 matrix could be acquired in 5.5 minutes. Two methods were independently evaluated on a 3T GE MR scanner in prostate cancer patients. First, the resolution was increased isotropically from 5.4 mm to 7.0 mm (approximately doubling the voxel volume). A second acquisition over the same volume with 5.4 mm resolution using 2 averages was also acquired (resulting in an 11 minute scan). Two spectroscopic acquisitions (one for each method) were acquired on 14 prostate cancer patients, and the data was assessed for spectral quality and diagnostic value. Flyback spectroscopy data was also compared to conventional 1.5T 3D MRSI acquisitions for the 3 of the 14 patients.

Results

All foci of abnormal metabolism, when present, were clearly visible at both the 0.16 cc (11 minute scan) and 0.34 cc (5 minute scan) resolutions. Peripheral zone voxels showed similar citrate and choline SNR for both acquisitions, and both acquisition schemes showed similar diagnostic usefulness. Patients scanned at both 1.5T using 3D phase encoding and at 3T using the flyback scan, each with 0.34 cc voxels, exhibited improved spectral resolution and a significant ($p<10^{-6}$) increase in SNR by a factor of 3.5 for both choline and citrate resonances in peripheral zone voxels. The flyback spectroscopic data was comparable or superior in diagnostic utility compared to the 1.5T data.

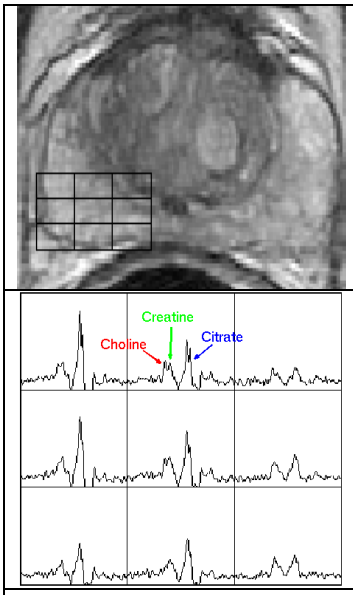

Figure 1a: 1.5T axial T2 FSE (top) and spectroscopic data (bottom) using 3D phase encoding acquisition with 7mm isotropic resolution. Scan time is 17 minutes.

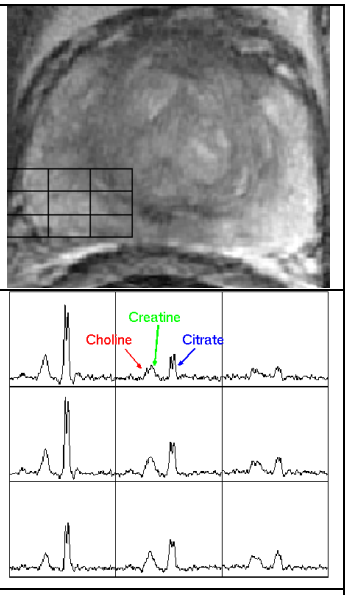

Figure 1b: 3T flyback spectroscopy data from the same patient in roughly the same location shows improved SNR and citrate splitting. Scan time is 5.5 minutes.

Conclusion

3T echo-planar spectroscopic imaging of the prostate demonstrated the ability to provide fast 5-minute acquisition times without compromising data quality. This acquisition technique greatly improves the clinical applicability of prostate MRSI and is now applied to all 3T clinical patients at UCSF.

Acknowledgements: We acknowledge funding support from NIH RO1 CA111291 and CA059897.

References:

[1] J. Kurhanewicz, et al., Radiology 198(3), 795 (1996).
[2] C. Cunningham, et al., Magnetic Resonance in Medicine 53(5), 1033 (2005).
[3] A. P. Chen, et al., Magnetic Resonance Imaging 24(7), 825 (2006).
[4] A. P. Chen, et al., Magnetic Resonance Imaging 25(6), 1288 (2007).
[5] C. H. Cunningham, et al., Magnetic Resonance in Medicine 54(5), 1286 (2005).