

Multi-Parametric MR Imaging of Prostate Cancer at 3T

A. P. Chen^{1,2}, J. Oh¹, E. T. Han³, D. Xu^{1,2}, J. Kurhanewicz^{1,2}, D. B. Vigneron^{1,2}

¹Radiology, UCSF, San Francisco, CA, United States, ²Joint Graduate Group in Bioengineering, UCSF/UCB, San Francisco, CA, United States, ³Global Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States

Introduction:

MR imaging and MR spectroscopic imaging utilizing endorectal coil have become important clinical tools for prostate cancer management (1). However, the addition of other type of MR techniques such as diffusion imaging and T2-mapping to provide quantitative and functional information may improve the sensitivity and specificity of MR to characterize prostate cancer (2). Several challenges such as imaging artifacts associated with EPI sampling due to the high susceptibility of the air-filled inflatable endorectal coil, and the long acquisition time required to quantify T2 relaxation have kept these MR techniques from being clinically feasible. In addition, modulation of citrate resonance at 3T prevented acquisition upright spectral pattern for accurate and easy quantification at a reasonable echo time using conventional MRSI pulse sequences (3). By filling the inflatable coil with a susceptibility matched compound and by utilizing recent developments in pulse sequence design, these challenges may be overcome (3-5). In this study, we developed a novel 1-hour clinical protocol combining 3T MRI, MLEV-PRESS, DTI-EPI and magnetization prepared/spiral readout T2 mapping to monitor anatomic, metabolic, and relaxivity changes in prostate cancer.

Methods:

All studies were performed on a GE 3T scanner (GE Healthcare, Waukesha, WI) using body coil for excitation and a Medrad inflatable endorectal coil (Medrad, Pittsburgh, PA) filled with Flutech_T14™ (F2 Chemicals, UK) in conjunction with a pelvic phase array coil for signal reception. Flutech_T14 is a fully fluorinated, colorless, odorless, non-toxic fluid with a magnetic permeability similar to tissue and thus is an ideal substitute for air to inflate the endorectal coil. 3T MRI and MRSI protocols have been described previously (3). The MRI consisted of sagittal localizer, high-resolution T2-weighted FSE oblique axial and coronal images, and T1-weighted SE axial images. MRSI data was acquired with an MLEV-PRESS sequence that allowed the acquisition of completely upright citrate resonance at TE of 85ms with a 0.157cc nominal spatial resolution. A DTI sequence based on EPI with 6 diffusion gradient directions was used. Oblique axial DTI-EPI images were acquired in 2.5 minutes with a FOV = 24 cm, 256 x 128 matrix, 4mm thick slices, and b-value of 600, with 8-10 slices typically to cover the prostate. A magnetization prepared sequence utilized non-selective composite 180 pulses and MLEV phase cycling followed by multi-slice spiral acquisition was used for T2 quantification (5). Images at six different echo times were acquired (TE = 6, 25, 43, 81, 156, and 305 ms) with FOV = 24 cm, 256 x 256 effective matrix, TR = 2s, 4mm thick slices, at identical slice location as the DTI acquisition. Total acquisition time for all six sets of images was 4.5 minutes. Custom developed software was used for the processing of MRSI data, calculation of DTI parameters, and mono-exponential fitting of the six echo times data for calculation of quantitative maps of T2 relaxivity.

Results:

Artifact free, high quality ADC maps and T2 maps were obtained from seven prostate cancer patient MRI/MRSI exams (Fig. 1). Reduced T2 and directionally invariant average diffusivity (D_{av}), as well as reduced citrate and elevated choline were observed in regions of biopsy proven prostate cancer as compared to regions of benign prostate peripheral zone.

Discussion:

Imaging artifacts for EPI based imaging sequence in area of high magnetic susceptibility are particularly undesirable for multi-parametric imaging. Acquisition of artifact free, multiple T2-weighted images for T2 mapping required considerable amount of time since relative long TR needed to reduced T1-weighting. By filling the inflatable endorectal coil with a susceptibility matched fluid and utilizing DTI-EPI sequence and a T2-prepared sequence with fast multi-slice spiral readout, it was demonstrated that artifact free DTI data and high quality T2 maps can be acquired in the prostate at 3T in seven minutes. Along with MRI and MRSI, a multi-parametric MR imaging protocol was shown to be clinically feasible. With the addition of these techniques, quantitative parameters based on tissue structure and cellular environment can be calculated to potentially increase the specificity of MRI/MRSI exam for prostate cancer.

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References:

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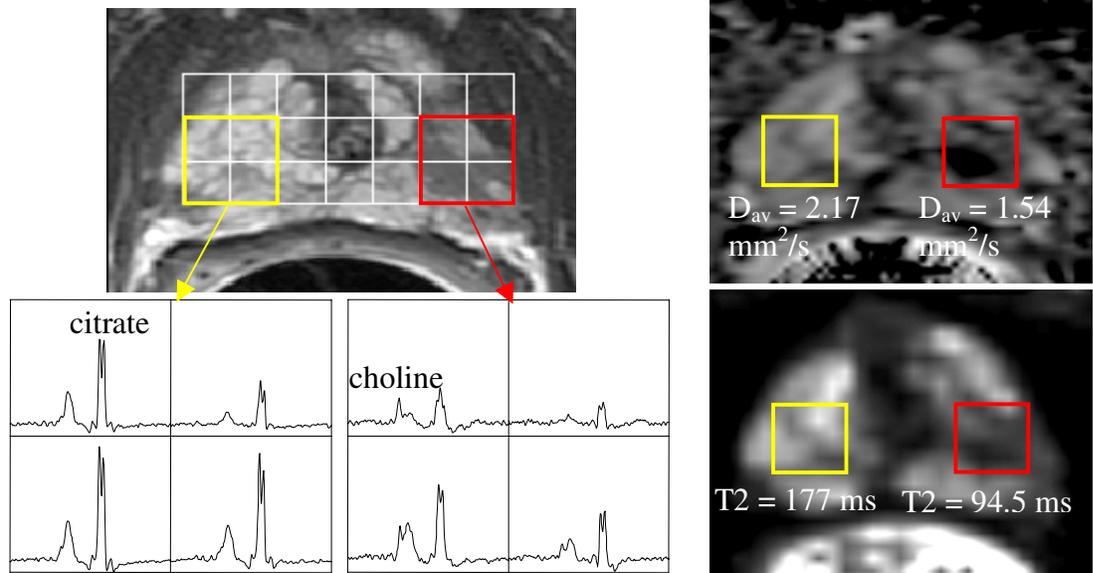


Figure 1. Sixty-one year old prostate cancer patient with biopsy proven cancer (G3+3, Left lobe). High-resolution T2-weighted FSE images (upper left) and MRSI (lower left) showed decrease signal intensity in the T2-weighted image and elevated choline and reduced citrate in region of prostate cancer. D_{av} maps (upper right) and T2 maps (lower right) also demonstrated decreased D_{av} (Cancer: .154 mm²/s vs Healthy: 2.17 mm²/s) and T2 (Cancer: 94.5 ms vs Healthy: 177 ms) relaxation time in region of cancer compared to region of healthy prostate peripheral zone.