Magnetic Resonance Spectroscopic Imaging and Dynamic Contrast Enhanced Prostate MRI: Correlation with Histopathology

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Introduction

It is well established that the accuracy in detecting prostate cancer improves when MRI is used along with magnetic resonance spectroscopic imaging (MRSI) and an endorectal coil (1). In recent years several new MRI techniques such as DCE-MRI and diffusion tensor imaging (DTI) have shown to be useful in detecting and providing the status of the prostate tumors. These techniques combined with high resolution imaging have the potential to improve the accuracy in detecting prostate cancer non-invasively while still in its early stages. In this project we performed 3D-MRSI, DCE-MRI along with traditional T2-weighted MRI image acquisition on patients who opted for radical prostatectomy and compared the results with step section histopathology.

Materials and Methods

Subjects: Fourteen patients who had biopsy-proven prostate cancer and elected to have radical prostatectomy were screened as volunteers for this study. The average age of the patients was 58 (42-73, standard deviation 8). Average PSA was 9.4 (0.5-29.0).

MRI data acquisition: Data acquisition was conducted on a 1.5T Magnetom Avanto MRI scanner (SIEMENS Medical Solutions). The following images were acquired: (a)T2-weighted images with TR/TE = 4030/97 ms, FOV=180X180, matrix 256X256, and slice thickness 3mm; (b) 3D-MRSI covering the entire prostate using PRESS localization with 0.22cc resolution; (c) DCE-MRI following a 20ml GD-DTPA injection at 4ml/s at a temporal resolution of 2.88s, 5 precontrast and 65 post contrast, TR/TE = 61/2.4ms, FOV=200X200 and slice thickness of 6mm with slices matching the spectroscopic acquisition.

Histology data acquisition: After radical prostatectomy, the prostate specimen was fixed overnight in a 10% formalin bath. Three millimeter axial sections from the specimen were made using a home built prostate slicer. H&E staining was performed on 50 micron sections from each of the slides. Digital images of both the slice specimens and the pathologic slides were obtained.

Data processing: Tofts model was used for the kinetic analysis of perfusion data and the model included the duration of contrast injection to obtain K^{trans} values (2). The metabolite ratio of Cho+Cr/Cit was computed from MRSI data. A pathologist reviewed all the pathologic slides, marked cancerous regions on each slide and graded them with Gleason score. A region with Gleason score of 4 to 9 was considered as tumor. All in-vivo MRI data was compared with the gold standard of histopathology. Receiver operating characteristic (ROC) based analysis was performed to compute the sensitivity, specificity, positive and negative predictive values and detection accuracy of each of the imaging techniques.

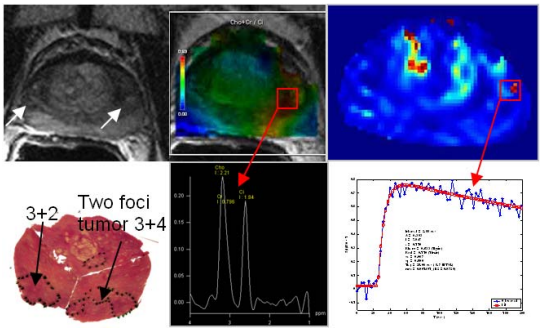

Figure 1: Representative results from a patient (59, male) with biopsy proven multifoci cancerous prostatitis. A) T2-weighted image. The two dark regions in PZ identify the cancerous regions (as marked by arrows). B) The ratio of Cho+Cr/Cit map. The voxel marked by a red box has a ratio of 1.64 indicating a cancerous region and its spectra are shown in E. C) K^{trans} map. The Ktrans value in the region of interest (marked by red box) is 0.53 min-1, as shown in the fitting curve in F. D) Picture of pathologic slide. The cancerous regions are marked by black dotted lines.

Results

Figure 1 shows a representative case from a patient (age 59, male) with bilateral multifocal cancer and prostatitis. Cancerous regions in pathologic slices noted by the pathologist were manually aligned to the in vivo images and comparisons were made between the in vivo findings and the histopathology. The mean ratio of Cho+Cr/Cit for normal tissue and tumors of grade 6, 7, 8 were found to be 0.6 ±0.25, 1.61±0.88, 1.47±1.12, 2.20±2.22, respectively. The Cho+Cr/Cit ratio of tumors is significantly greater than that of normal tissue ($p<0.001$). No significant difference was found among tumors with different grades. The K_{trans} (min^{-1}) value for normal tissue and tumors of grade 6, 7, 8 are 0.14±0.11, 0.28±0.34, 0.36±0.46, 0.27±0.37, respectively. The Ktrans values also differentiated between the normal and cancerous tissues but was unable to differentiate different grades of tumor.

Figure 2 shows the ROC curve for both spectroscopy and contrast enhanced study. The areas under curve (A_z) for K^{trans}, and Cho+Cr/Cit are 0.65 and 0.79 respectively. Based on the ROC curve, the threshold for determining cancer based on the Cho+Cr/Cit was found to be 0.9 and based on K^{trans} it was found to be 0.2 min^{-1}. The thresholds, corresponding sensitivity, specificity, positive and negative predictive values, and accuracy are listed in the table.

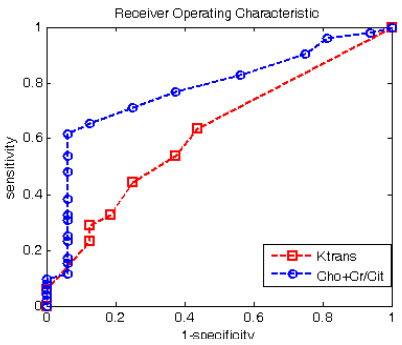

Figure 2: ROC curves for K^{trans} and Cho+Cr/Cit

Discussion and Conclusion:

The preliminary results demonstrate that MRSI and DCE-MRI are able to differentiate tumor from normal tissue but unable to determine tumor grade. The ROC analysis indicates that MRSI is superior to DCE-MRI in prostate cancer detection as it has better sensitivity, specificity and diagnostic accuracy.

	Threshold	Sensitivity	Specificity	PPV	NPV	ACC
MRSI (Cho+Cr/Cit)	0.9	0.68	0.85	0.95	0.45	0.72
DCE-MRI (K^{trans}, 1/min)	0.2	0.65	0.6	0.94	0.36	0.65

References:

1. Kurhanewicz J, et al., J Magn Reson Imaging 2002;16:451-463.
2. Jia G, et al, Proc. Intl. Soc. Mag. Reson. Med. 2006 14:177.