T2 and Dynamic Contrast Enhanced MR (DCE-MRI) Imaging of Prostate Cancer at 3T

A. M. Gharib[1], E. Jung[2], D. Thomasson[1], S. N. Gupta[3], G. Metzger[4], M. Bernardo[2], Y. McKinney[1], J. Coleman[5], C. Menard[6], P. Choyke[2]

[1]Radiology, NIH, Bethesda, MD, United States, [2]NCI, NIH, Bethesda, MD, United States, [3]GE Heathcare, Baltimore, MD, United States, [4]Philips Medical Systems, Bethesda, MD, United States, [5]NCI, Urologic Oncology, NIH, Bethesda, MD, United States, [6]Department of Radiation Oncology, Princess Margeret Hospital, University of Toronto, Toronto, ON, Canada

Introduction

Prostate cancer is the second leading cause of cancer death in American males with an estimated 29,900 deaths annually [1]. No imaging technique has proven wholly satisfactory for imaging the prostate. T2 weighted MRI at 1.5 T using an endorectal coil is a promising method for detecting and staging prostate cancer but cannot detect all cancers. MRI at 3.0 T could improve both speed and image quality of prostate MRI because of its higher signal-to-noise ratio. Dynamic contrast enhanced MR (DCE-MRI) provides additional information that could further improve cancer detection [2]. The purpose of this study is to examine the combined clinical utility of endorectal coil T2 weighted MRI and DCE-MRI at 3T in the evaluation of prostate cancer.

Materials and Methods

T2 weighted and DCE-MRI images were performed on 18 men with biopsy proven prostate cancer using a 3T scanner (Philips Medical Systems, Best, NL) with a pelvic phased-array surface coil and an endorectal coil (ERC). Later studies were performed by replacing the prototype ERC with a modified commercial ERC (MRinnervu; Medrad, Pittsburgh, PA) properly tuned for 3T. Patients were imaged in the supine position. T2 weighted fast spin-echo images were obtained at a resolution of 0.46 x 0.6 x 3.0 mm (FOV 140 mm, matrix 234 x 304, TR/TE 8852/120 msec). DCE-MRI images were acquired during bolus administration of 0.1mmol/Kg of gadolinium chelate at 3cc/sec using a 3D Fast Field Echo with a temporal resolution of 6.1 sec and spatial resolution of 0.86 x 1.18 x 6.0 mm (FOV 220 mm, TR/TE 5.5/2.1 msec, flip angle 15°). SENSE DCE-MRI was also performed in the later patients resulting in improvement of temporal resolution to 3 seconds. For data analysis, the prostate was divided into sextants: [apex, mid, base] for the right and left gland. All 18 patients were analyzed qualitatively for T2 signal characteristics and DCE-MRI. In addition, the DCE-MRI of 11 patients were quantitatively analyzed using regions of interest (ROIs) placed on the external iliac artery (for arterial input data), the site of cancer, and the contralateral normal peripheral zone. The ROI curves were fitted to a 2-compartment General Kinetic Model (GKM) using custom software (Cine Tool, GE Healthcare) to obtain values for K^{trans} and k_{ep}, as well as the following descriptive parameters: wash-in-rate, wash-out-rate, time-to-peak. A total of seven patients were excluded from the GKM analysis due to technical issues with the data (4 patients) or false negative result on the DCE-MRI qualitative analysis (3 patients). Student T-test was used for statistical analysis of the DCE-MRI parameters.

Results

Areas of hypointensity on T2 weighted MR images [Figure 1A] or regions of early contrast enhancement on DCE-MRI [Figure 1B] were interpreted as positive for cancer. Sensitivity, specificity, positive predictive (PPV), and negative predictive value (NPV) for the diagnostic reading of T2 weighted images were 70%, 84%, 76% and 81% respectively when compared to core biopsy reports. For DCE-MRI, these values were slightly higher (73%, 88%, 80%, 82% respectively). The combined diagnostic reading of T2 and DCE-MRI images yielded an overall sensitivity of 77%, specificity of 83%, PPV of 76%, and NPV of 84%. DCE-MRI time-signal curve analysis [Figure 2] demonstrated a higher K^{trans} (p=0.009) and k_{ep} (p=0.002), and a lower time-to-peak (TTP) value (p=0.02) for prostate cancer versus normal prostatic tissue.

Conclusion and Discussion

Localization of prostate cancer is important for staging and directing the appropriate treatment option. Current modalities of tumor localization and staging such as digital rectal exam, CT, and ultrasound all have limitations. T2 weighted MRI at 1.5T is insufficient alone for prostate cancer diagnosis, and the data on the ability to predict stage is variable [3]. We evaluated MRI at 3T to determine if it improves diagnosis and tumor localization. With endorectal MRI at 3T, higher spatial and temporal resolution can be achieved. Combining DCE-MRI with T2 weighted imaging can aid in diagnosis and staging. Our initial results show that the sensitivity and specificity at 3T are better than 1.5T values reported in the literature [4]. We believe this performance can be substantially improved by optimizing the surface and endorectal coil combinations for 3T MRI. Analysis of dynamic contrast parameters, which are objective measures of permeability, show that prostate cancer demonstrated higher K^{trans} and k_{ep}, and lower TTP values when compared to normal tissue. These results may reflect increased microvessel density from angiogenesis in prostate cancer. Dynamic contrast imaging could benefit from higher speed DCE-MRI using SENSitivity Encoding (SENSE) parallel imaging technique. The limitation to our study is that we did not correlate the MRI images with step section histopathology, which is considered the gold standard. Studies are currently underway with radical prostatectomy specimens for comparison. Future 3T MRI studies could also include MR spectroscopy, which improves the accuracy of sextant localization at 1.5 T, and should yield even better results at 3T.
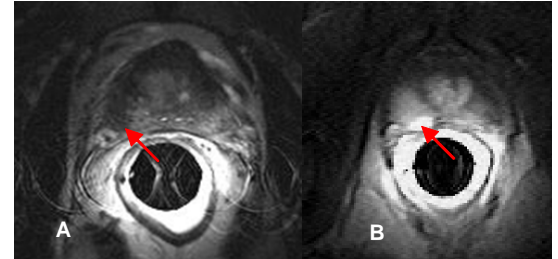

Figure 1: (A) T2 weighted image showing hypointense area in right peripheral zone (arrow). (B) DCE-MRI demonstrating enhancement in same area (arrow).
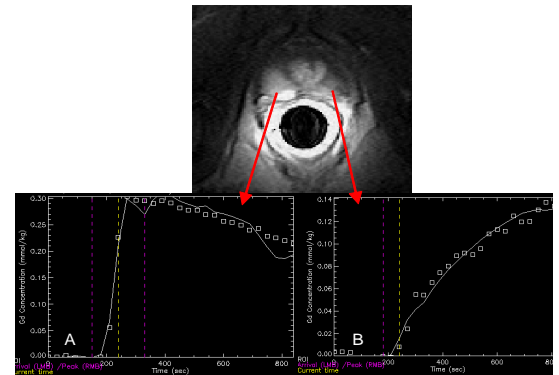

Figure 2: (A) Time intensity curve of cancer area showing rapid early enhancement and rapid wash-out. (B) Time intensity curve of normal peripheral zone showing slow enhancement.

References:

[1] Jemal, A, Tiwari, RC, Murray, T, et al. Cancer statistics, 2004. CA Cancer J Clin 2004; 54:8.

[2] Schlemmer HP et al. Can pre-operative contrast-enhanced dynamic MR imaging for prostate cancer predict microvascular density in prostatectomy specimens? Eur Radiol (2004) 14:309-317.

[3] Purohit RS, Shinohara K, Meng MV, Carroll PR. Imaging clinically localized prostate cancer. Urol Clin North Am. 2003 May;30(2):279-93.

[4] Ito H, Kamoi K, Yokoyama K, Yamada K, Nishimura T. Visualization of prostate cancer using dynamic contrast-enhanced MRI: comparison with transrectal power Doppler ultrasound. Br J Radiol. 2003 Sep;76(909):617-24.