Assessment of Prostatic Ductal Volume Using Combined Dynamic Contrast-Enhanced MRI and Diffusion MRI

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Synopsis
Prostatic ductal volume decreases with cancer grade. To assess whether Gadolinium-DTPA can reach the ducts, MRI, 3D-MRSI, dynamic contrast-enhanced MRI and diffusion were performed on nine prostate cancer patients. Using peak enhancement and ADC, the ductal tissues (normal peripheral zone and glandular BPH) were well separated from the less-ductal tissues (central gland and stromal BPH). This indicates that Gd-DTPA does not reach the ducts; DCE-MRI doesn't seem to reflect the intact ductal volume whereas ADC seems to. Cancer spanned a range of peak enhancement and ADC values. Combining DCE-MRI and ADC yields ductal volume and may help characterize prostate cancers.

Introduction
Dynamic contrast-enhanced MR imaging (DCE MRI) and diffusion imaging have each shown an ability to differentiate cancer from normal prostatic tissues. In particular, DCE MRI has shown higher enhancement and greater washout in cancer versus normal tissues (1). The greater enhancement has been attributed to a larger extravascular, extracellular space in which the contrast agent can accumulate. The apparent diffusion coefficient (ADC) has been shown to be lower in cancer than in normal (2,3). This has been postulated to be due to increased cellularity of cancer, resulting in less free space. The hypotheses to be tested in this work are that Gd-DTPA will not accumulate in prostatic ducts and thus, DCE MRI will not reflect ductal volume, whereas diffusion weighted imaging is hypothesized to reflect ductal volume. Obtaining both DCE MRI and ADC in the same patients should help determine these effects. This study compares these different measurements in untreated prostate cancer patients. The ability to assess ductal volume is important because pathology has shown that ductal volume decreases in higher grade cancers, which have greater metastatic potential.

Methods
Nine patients with no prior treatment were studied using a combined endorectal probe (MedRad) and a pelvic phased array on a GE 1.5T Signa Imager. Anatomic imaging included axial T1 and fast spin-echo T2 images. The 16x8x8 3DMRSI used BASING pulses and PRESS to acquire 7x7x7 mm3 voxels (0.3cc) with TR/TE = 1000/130. The dynamic contrast-enhanced imaging was performed using a 2D FSPGR sequence (flip=13°) with a single-dose bolus injection of Gadolinium DTPA. TR/TE = 12/2, 256x128 matrix (8sec per stack), 26 FOV, 5/2 mm thick slices, and typically 70 time points for 5 locations were acquired, totaling 350 images over 9 minutes. The diffusion sequence was a single shot FSE sequence with 256x128 matrix, 240FOV, 4mm/skip 2 mm slices, RBW=62.5KHz, b-value=600, TE =67 with typically 7-9 axial slices covering the prostate in 2.5 minutes (3).

Motion was assessed and corrected between the imaging sequences and within the DCE sequence. ROIs were drawn on the coil corrected, aligned, T2 images in normal peripheral zone, cancerous peripheral zone, central gland, stromal benign prostatic hyperplasia (BPH), glandular BPH and muscle, as determined by MRI, MRSI and, when available, biopsy. Peak enhancements, normalized to baseline intensity (average of points 3-10), and the ADC were calculated for all the ROIs.

Results
When studied separately, the DCE MRI and the ADC results confirm previous findings, showing an increase in peak enhancement and a decrease in ADC in cancer versus normal tissues. The peak enhancement values were compared to the ADC values for the tissues as shown in Fig 1. Normal peripheral zone and glandular BPH tissues (ductal tissues) were well separated from the central gland and stromal BPH tissues (low-ductal tissues) When compared within patients, central gland always had a higher peak and lower ADC vs. normal peripheral zone. Cancer spanned the measured values.

Discussion
The increase of peak enhancement and decrease of ADC in cancer can possibly be explained by the presence of ducts in the normal prostate. In normal tissue, the ducts are surrounded by an epithelial cell layer. The contrast agent likely cannot penetrate this layer. However, the ducts are large and would contribute to the diffusion measurements. This theory is supported by this study, in which the highly ductal tissues had higher ADC for given peak enhancements as compared to the low-ductal tissues. A similar argument would likely hold for breast tissue, which also shows an increase in enhancement and decrease in ADC with cancer. Thus, the DCE MRI assesses contrast agent in the vasculature and the interstitium, but not in the cells or the normal ducts. ADC, on the other hand, may measure signal in these spaces and in the ducts. Cancer spanned a range of peak enhancement and ADC values, perhaps indicating a difference in ductal volumes. As higher grade cancers have less ducts, this parameter may yield clinically relevant information about the cancer’s aggressiveness. In addition to the complementary information, DCE MRI and diffusion may be able to confirm both cancer presence and characterization as each can identify cancer and as both indices would presumably decrease as the cells become more densely packed. Combining DCE MRI and diffusion imaging in the prostate should be very valuable for identifying and characterizing prostate cancers.

References

Fig 1 Peak Enhancement & ADC separate highly ductal tissues from less ductal tissues. PZ=peripheral zone, BPH=benign prostatic hyperplasia, CG=central gland.