Intersequence variability in multiparametric-derived 3D prostate tumor volumetrics at 3.0T

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Introduction: Prostate cancer treatment has traditionally been a global "whole gland"-directed therapy. Newer approaches to treatment are being increasingly directed to focal (subtotal) therapy. These approaches mandate improvements in Magnetic Resonance (MR) imaging to allow for accurate index lesion detection and display, necessary for image-guided biopsy or focal treatment with ablative methods such as-radiofrequency ablation, cryoablation, laser therapy, or high intensity focused ultrasound techniques. The current shift to higher field strength magnets and multiparametric magnetic resonance (mpMR) imaging for prostate cancer should allow for a more comprehensive approach to tumor localization and tumor volumetrics. However, considering the different physiological tissue properties upon which the mpMR sequences, such as T2 weighted imaging (T2WI), diffusion weighted imaging (DWI) and dynamic contrast-enhanced (DCE) imaging are based, it is likely that there will be variability in inter-parameter tumor location/mapping and volumetrics, which would be of importance for focal prostate therapy planning and guidance.

Methods: In this preliminary study, patients with biopsy-proven prostate cancer underwent a mpMR endorectal coil (Medrad Inc.) exam using a 3.0T scanner (General Electric Medical Systems, Milwaukee, WI) for tumor staging prior to therapy. The inclusion criteria for this study included MR demostrating a well defined index lesion on T2WI, the location of which correlated with pathology at either biopsy or prostatectomy. A 2D fast spin echo (FSE) sequence was used for T2WI (TR/TE: 3000/102msec; FOV:14-18cm; slice thickness: 3mm; spacing: 3mm; 384x256; NEX=3). For diffusion, a single-shot spin-echo echo-planar imaging (EPI) sequence (TR/TE 2500/67 msec; FOV 16x12 cm; slice thickness 3mm; spacing 3mm; 128x96) was employed to acquire images with a b-value of 500 s/mm^2, and with 3 diffusion sensitization directions to obtain ADC-maps. A Gd-DTPA contrast-injection (injection rate 3ml/s) multi-phase 3D-fast spoiled gradient-echo sequence was used for T1WI and DCE-maps (TR/TE: 3.67/1.3 msec; flip angle: 15 degrees; FOV: 26 cm; slice thickness 6mm; spacing 6mm; 256x160, 16-20 slices, 5 sec/volume, 60 temporal phases, 5 minute total scan time) . DCE subtraction imaging was based on the second dynamic arterial phase. Using 3D Slicer (www.slicer.org), the outer contour of the prostate gland was manually countoured on each corresponding parametric map and used to manually align the maps to account for possible inter-sequence gland deformation or motion. This software allowed us to manually segment and produce 3D models of the tumor and its margins (outlined according to the different mpMR sequences) and was also used to calculate tumor volumes for each of the three sequences.

Results and Discussion: Manual segmentation of tumor and entire prostate was performed in 9 cases who had eligible data sets. The 3D slicer (www.slicer.org) allowed for 3D tumor visualization with respect to the gland (Figure 1), and mpMRI data display in a single framework. It also provided automatic volume measurements: mean (± std dev) tumor volumes outlined according to T2WIs, ADC maps and DCE subtraction images were 2.45 ±1.93, 2.03 ± 1.64, and 2.77 ± 1.96 cc's respectively (Figure 2). As expected, there was a significant correlation (using Pearson's correlation coefficient) between T2WIs and ADC (r=0.931), between T2WI and subtraction DCE (r=0.997), and between ADC maps and subtraction DCE (r=0.923). Using a paired t-test, volume measurements based on DCE maps were significantly greater than those based on ADC maps (p=0.011), and also significantly greater than those based on T2WI (p=0.001). These results demonstrate that even in a small group of patients (n=9), there is variation in multiparametric-derived tumor volumetrics, with DCE-based volumes being significantly greater. These preliminary findings may reflect the differing underlying physiological properties of tumor assessed with mpMR imaging, and need to be taken into consideration for tumor mapping in focal therapy planning.

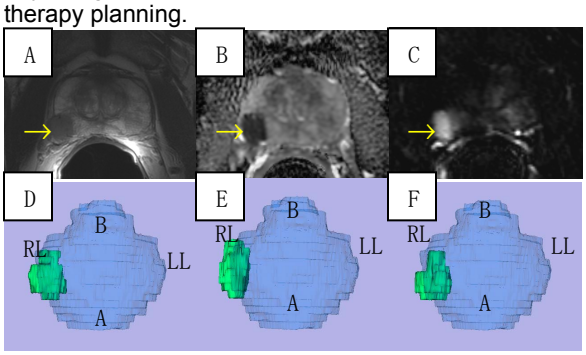

Figure 1: Top row: Axial T2 WI (A), ADC map (B) and subtraction DCE map (C) depicting tumor in the right mid gland (yellow arrows) of patient no. 1. Bottom row: D, E and F represent the corresponding 3D Slicer segmentations (A-D, B-E and C-F) of the entire outlined tumor (green) and of the entire prostate gland (blue). [B=prostate base; A=prostate apex; RL = right lateral gland; LL=left lateral gland].

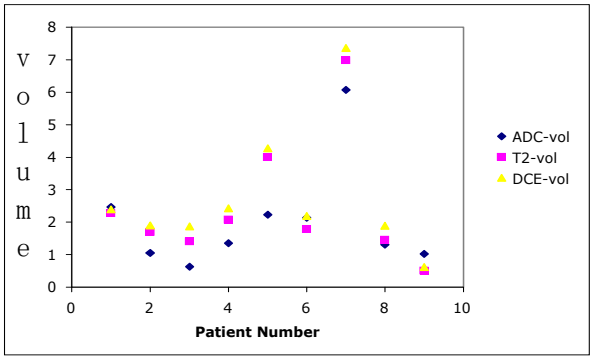

Figure 2: Tumor volumetrics (in cc's) as measured in 3D Slicer from nine patients using the T2, ADC and DCE data. Tumor DCE volumetrics were significantly greater than those contoured according to ADC maps (p=0.011) and T2WIs (p=0.001).