Evaluation of Chronic Cryo Prostate Lesions by Diffusion-weighted MRI

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Introduction Prostate cancer is the most common cancer among US males, accounting for one out of three cancer diagnoses (1). Cryosurgery has been shown to be a promising treatment method for this disease. Our group has demonstrated that diffusion-weighted MRI (DWI) provides delineation of the acute cryo lesion from normal untreated prostate tissue (2, 3). This is particularly useful because, unlike contrast enhanced imaging, the method is repeatable. In this work, we further investigate the use of DWI to evaluate chronic prostate lesion after cryoablation and compare the result to contrast enhanced MRI and histology.

Method All animal experiments were approved by the Administrative Panel on Laboratory Animal Care. MR-guided cryoablation was performed on 3 dogs to create two distinct cryo lesions in each dog. The lesion in the right lobe of the gland was frozen slowly to ~ -10°C once, while the lesion in the left lobe was rapidly frozen to lower than -40°C. After the procedure, the dogs survived for 4 days (dog #1), 14 days (dog #2) and 53 days (dog #3), respectively. Upon completion of the follow-up MR imaging, the dogs were euthanized, the prostate was sliced and stained with 1% triphenyl, tetrazolium chloride (TTC) solution. MR-guidance and the follow-up imaging were performed on a 0.5T Signa SP open MRI system (GE, Milwaukee, WI). The body coil was used as the transmitter, and an endorectal coil was used as the receiver. Line scan diffusion weighted imaging (LSDI) (4) (TE/TR = 70/120 ms, matrix = 256×63, field of view = 24×6 cm, LSDI inclination angle = 70°, band width = 3.81 kHz, effective slice thickness = 5 mm, b = 10, 380 seconds/mm^2) was used as the DWI sequence. Diffusion trace data were calculated using three orthogonal gradient directions. The total scan time for each slice was 30 sec, acquired within one breath hold. Subsequently, a triple dose of Gd-DTPA was administrated and a high resolution T1-weighted images were acquired.

Results As shown in Figure 1, all acute lesions presented on the ADC trace map as low ADC value and agreed well with the contrast enhanced (CE) images. Interestingly, all lesions on the left (fast freezing to lower temperature) had a lower ADC than lesions on the right (slow freezing to higher temperature).

The follow-up images were more complicated with the general trend of low initial ADC values increasing over time. More specifically, the left lesion of dog #1 (4 days post-treatment) was still visible as low ADC value on the ADC trace map (arrow), and a lack of enhancement region on the CE image. On both images, this lesion appeared to be slightly smaller than the acute lesion acquired right after the treatment. Histological results revealed a large central area of hemorrhage surrounded by a narrow rim of regeneration. For the left lesion of dog #2 scanned 14 days after the cryoablation, the ADC map showed a small area of slightly lower ADC near the cryoprobe (circle) compared to normal untreated prostate tissue. Histological results showed that this lesion had a central region of fibrosis and few glands surrounded by a large area of regeneration. For dog #3 53 days post treatment, the lesion on the left had a slightly elevated ADC compared to normal tissue, with histology revealing fibrosis and regeneration of glands.

Conclusion and Discussion In this work we report an experimental study of evaluating chronic cryo lesions in the canine prostate with diffusion weighted MRI. At different recovery and regeneration stage, the lesion appeared differently on the ADC trace map from low ADC in the acute lesion, to high ADC in the regenerated gland. Thus, the imaging behavior on ADC maps could be used to evaluate the evolution of the tissue following cryoablation. Our future work includes improving the LSDI sequence for higher image resolution and better signal noise ratio, and registering MR image to histologic result for further investigation

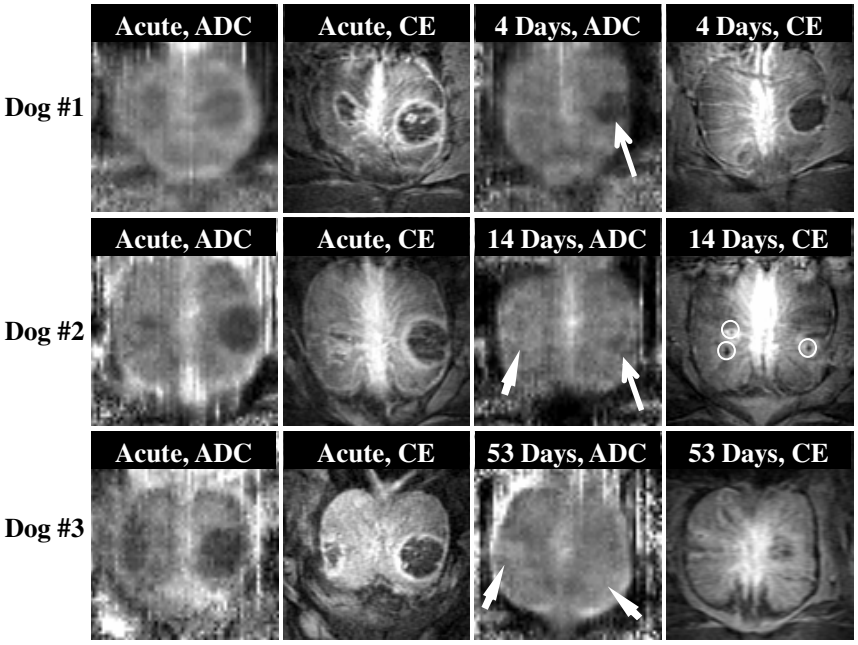

Fig. 1. ADC trace map and T1-wighted CE images from all three dogs at different time post treatment. Each row of images is from one particular dog. The dark dot (circle) showed the previous location of the cryo probes. At different recovery stage, the ADC value increased from lower than normal tissue (arrows) to higher than normal tissue (arrow heads).

Reference

1) American Cancer Society, Cancer Facts and Figures 2006

2) Butts et al, JMRI 2003; 17: 131-5

3) Chen et al, 14th ISMRM 2006, #196

4) Gudbjartsson et al, MRM 1996; 36: 509-19

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