Investigation of DWI to Evaluate Prostate Thermal and Cryo Lesions

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Introduction An estimated 232,090 new prostate cancer cases present in the U.S. during 2005, with an estimated 30,350 deaths (1). Options for minimally invasive therapy of the prostate includes thermal therapy and cryosurgery. MRI has been shown particularly useful as the treatment guiding modality (2) with the ability to localize prostate tumor (3), to guide the positioning of treatment applicator and to measure the temperature *in vivo* (4, 5). Moreover, diffusion-weighted imaging (DWI) has been shown promising to evaluate the acute cryolesion *in vivo* (2). The goal of this work is to further investigate the use of DWI to estimate the cell viability immediately after the treatment.

Method All animal experiments were approved by the Administrative Panel on Laboratory Animal Care. Diffusion weighted imaging was performed in six canine prostates with MRI-guided high intensity ultrasound thermal therapy (3 cases) or cryoablation (3 cases). All MR imaging were acquired on the 0.5T Signa SP open MRI system (GE, Milwaukee, WI). The body coil was used as the transmitter. A 2-channel phase array coil consisting of an anterior surface coil and an endorectal coil was used as the receiver. Line scan diffusion weighted images (LSDI) (TE/TR = 70/150 ms, matrix = 256×63, field of view = 24×6 cm, LSDI inclination angle = 70°, band width = 7.91 kHz, slice thickness = 5 mm, b = 10, 360 seconds/mm^2) were acquired before the therapy and after the prostates returned to body temperature, as determined by implanted thermocouples. Diffusion trace data were calculated using three orthogonal gradient directions. Later, the dogs were euthanized and sliced prostate samples were incubated in a 1% triphenyl tetrazolium chloride (TTC) solution. According to the TTC staining result, regions of interest (ROI) were chosen completely within the necrotic tissues and viable tissues. The ADC values of these two types of tissue were measured.

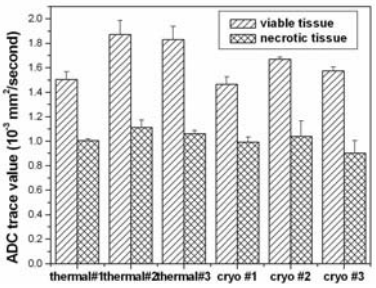

Fig.2 ADC trace value of canine prostate tissue before and after thermal or cryo treatment. The necrotic tissue has an ADC value of approximately 1.0×e-3 mm^2/second.

Results Both thermal/cryo necroses (arrow and arrow heads) appear as low ADC after the whole prostate returned to body temperature as shown in Fig.1. The results from the six dog experiments was summarized in Fig.2. The viable canine prostate had an ADC value of (1.68±0.175) ×10^{-3} mm^2/second, while the necrotic tissue ADC decreased to (1.02±0.094) ×10^{-3} mm^2/second. A transition area was seen between the two parts on a cross-section plot of the ADC trace map as illustrated in Fig.3. In general, the ADC decreased about 39% in the core of the lesions after the treatment. There was no significant difference between thermal and cryo lesions in ADC trace value.

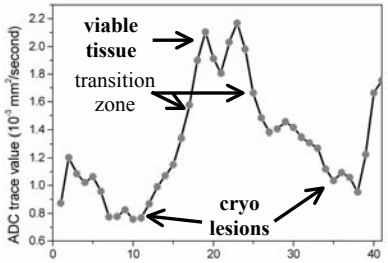

Fig.3 A cross-section ADC trace plot of the cryolesions of Fig.1 (e). The difference in the ADC value between viable tissue and the cryo lesions is distinct.

Conclusion and Discussion In this work we report an experimental study of *in vivo* canine prostate tissue damage with high intensity ultrasound thermal therapy or cryoablation using line scan diffusion imaging. A significant reduction of ADC trace value was observed immediately after the tissue returned to body temperature, and the tissue necrosis in that area was confirmed by histological analysis. However, the absolute ADC trace value should be carefully interpreted. The variation of ADC in the viable prostate samples is larger than the variation in the necrotic samples. The reason might be due to fibrosis in some part of their prostates, which also showed as lower signal than normal prostate tissue in the pre-treatment ADC trace map. The transition zone between the viable and necrotic parts demonstrates a gradual change in the ADC value. However, since the LSDI image is blurred in the line scan direction (6), the actual change could be sharper than shown in Fig.3.

Although the shape of prostate tissue changed during the histological processing, the correlation between the DW images and the TTC images is evident. For example, the angular lesion shape is similar in Fig.1 (e) and (h) (dashed arrows), but the T1 weighted images acquired during the freezing instead show a more round shape to the iceball. With the ability of immediate, accurate and repeatable lesion evaluation, DWI could be a promising method to monitor cell viability for prostate therapies.

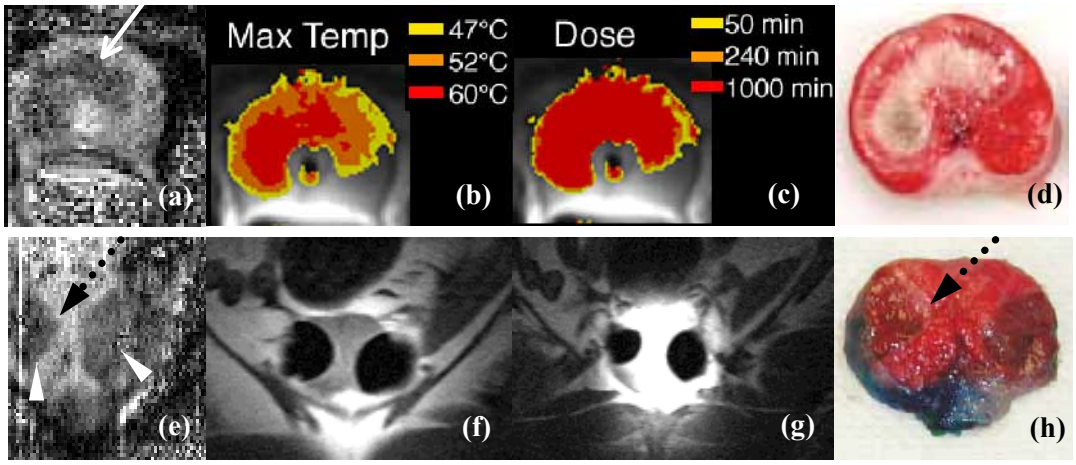

Fig.1 ADC trace map (a,e), therapy images (b, c, f, g) and TTC staining (d, h). (a-d) display the axial view of the thermal lesion (arrow) resulting from high intensity ultrasound heating. The shape of the lesion corresponds to the treatment dose. (e-h) depict two cryolesions in the coronal plane. T1 weighted FSE images of two slices (f, g) show similar round icesballs. The cryo lesion (arrow heads) completely lies in the previously frozen tissue. The angular shape of the cryolesion on the ADC map (dashed arrow) is consistent with that seen in the TTC image

Reference

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