Diffusion-Weighted MRI and Dynamic Contrast-Enhanced MRI of Bladder Cancer at 3T

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Introduction

The primary purpose of this on-going study is to evaluate the ability of Diffusion-Weighted Magnetic Resonance Imaging (DWI) and Dynamic Contrast-Enhanced MRI (DCE-MRI) in the diagnosis of the bladder cancer in patients before surgery. Combined with the conventional DWI, high b-factor DWI has been optimized to suppress the tumor's background signal in order to achieve a supportive method of the tumor delineation. The secondary purpose of this study is to assess the consistency of the two sequences in localizing bladder tumors.

Materials and Methods

Subjects: 13 patients (11 men and 2 women, age: 57-84) with cystoscopic confirmed diagnosis of bladder carcinoma have been included in this study.

All the patients were scanned on a 3T MRI system (Achieva, Philips Healthcare) with a dedicated 32-channel phased-array surface coil.

DWI: was performed with a Diffusion-weighted Echo Planar Imaging (DW-EPI) sequence: TR/TE=6000/87ms; b-values= 0, 333, 667, 1000s/mm^2; number of slices=10; slice thickness/gap=3mm/0.3mm. Post-scan processing was employed with IDL (ITT) based software to acquire Apparent Diffusion Coefficient (ADC) maps that show the degree of water diffusion in tissues. ADC values of bladder tumors, normal bladder wall, and the central bladder were compared in regions of interest (ROIs).

DCE-MRI: was implemented with a 3D-spoiled gradient echo (3D-T1w-FFE) sequence: TR/TE/Flip=5ms/2ms/20^o; number of slices=18 or 19; slice thickness=5mm. The intravenous injection of a body weight-adjusted single dose of Gd-based contrast agent (MAGNEVIST, Bayer) was performed with an injection rate of 0.5ml/s. For the analysis of the DCE-MRI images, a two-compartment pharmacokinetic model was applied to obtain the maps of pharmacokinetic parameters including signal enhancement amplitude (Amp), exchange rate constants (k_{ep} and K_{trans}) and elimination factors (k_{el}). The dynamic characteristics of signal intensities in the tumor and other ROIs were further compared by using fitted curves that show the time-dependent change of the ratio of contrast-enhanced signal to the unenhanced signal (Figure 4).

Results

DWI: In 9 out of 13 patients (DWI could not be used for 1 patient because of the low-quality images caused by an implant in their body), a tumor(s) could be identified on grey-value ADC maps. The tumor locations were even better delineated with colored ADC maps (Figure 1). Compared with the normal bladder wall, the tumor always had a significantly lower ADC value. Tumor ADC values varied from 1.58–2.77($\cdot 10^{-3}$) (mm^2/s) with the average of 2.318$\cdot 10^{-3}$ (mm^2/s). The difference between the tumor ADC and the normal bladder wall ADC in each case ranged from 1.32–10.53($\cdot 10^{-4}$) (mm^2/s). Remarkably, the normal bladder wall ADC values were on average 35% higher than tumor ADC values. The images obtained from DWI with a b-factor of 1000 showed a bright tumor signal on the dark surroundings (Figure 2). DWI images from the other cases (the three patients) showed an irregular thickening of the bladder wall in DWI.

DCE-MRI: 12 out of the 13 patients were imaged with DCE-MRI and 9 patients were found with a tumor(s). The results of the tumor locations obtained from DCE-MRI show a complete agreement with those acquired from DWI. On DCE-MRI images, tumor regions with brighter signal intensities on T1w images showed a stronger enhancement than the normal bladder wall (Figure 3, the right image). These strong enhancements were also illustrated on the fitted curve (Figure 4) with a steep slope and a large signal increase right after the time t_{lag} (the time for the contrast agent to flush in the tissues). Tumor Amp values were on average five times larger than those of normal bladder walls. As a result, there was a significant difference between pharmacokinetic parameters of localized tumors and those of normal bladder regions that was explicitly shown on the color map of both Amp and k_{ep} (Figure 3) to efficiently delineate tumor locations.

Discussions and Conclusions

DWI and DCE-MRI can differentiate bladder tumor tissues from normal bladder wall and are effective sequences in the diagnosis of bladder cancer. In addition, DWI performed with high b-factors can be supportive to the differentiation of bladder tumors from surrounding tissues. The consistency of the two sequences helps prove their accuracy in tumor localization. Therefore, their combination can be useful in quantitative imaging analyses of tumors. With these promising preliminary results, the combination can be continued to study the alteration of tumor characteristics after neoadjuvant therapy and the most importantly to help stage bladder tumors.

References

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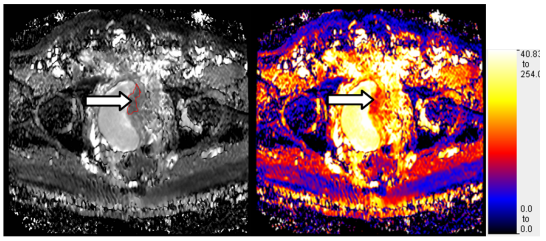

***Figure 1**: Left: Grey-value ADC map; Right: Color ADC map with the ADC color table The tumor locations are indicated by arrows.*

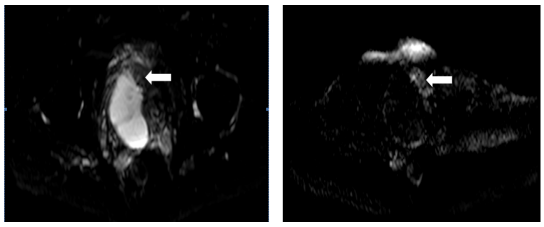

***Figure 2:** Left: DWI image with zero b-factor. Right: DWI image with b-factor of 1000 shows the bright signal in tumor regions on the dark surroundings.*

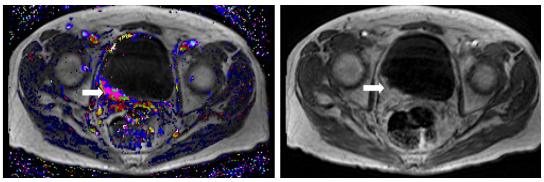

***Figure 3:** Left: Color map of exchange pharmacokinetic parameters Amp & Kep; Right: DCE-MRI image depicts the signal enhancement in the tumor region on a T1-weighted post-constrast image. The tumor is indicated by the arrows.*

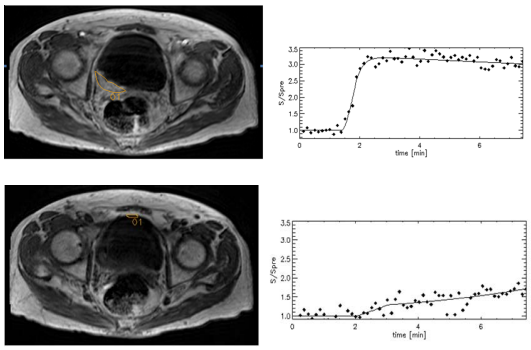

***Figure 4:** ROI placement (left) and corresponding fitted signal intensity ratio vs time curves (right) in tumor tissue (top) and normal bladder wall (bottom).*