Histologically-validated Bladder Cancer Staging with Magnetic Resonance Imaging at 3T

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Introduction

Accurate diagnosis and staging of bladder cancer is essential to patient management and prognosis [1]. The differentiations among stage T2 or lower, T3 and T4 are the most important to cystectomy, a standard treatment for bladder cancer. High field 3T MRI has the advantages over lower field MRI (such as 1.5T) in the improvement of signal-to-noise ratio and image resolution to delineate the depth of tumor invasion. This study is to investigate the capability of 3T MRI in accurately staging bladder cancer.

Materials and Methods

Subjects: 21 patients (17 males and 4 females) who had cystoscopic confirmation of bladder cancer have been prospectively included in the study. After completing MRI scans, all patients were directed to cystectomy with subsequent histological p-staging.

MRI exams: All patient scans were performed on a 3T MRI system (Achieva, Philips Healthcare, Cleveland, Ohio) upgraded with multi-transmit and using multi-channel (32 or 16-channel) phased-array surface coils.

Axial T2w images were acquired with a Turbo Spin Echo (TSE) sequence: TR/TE = 13850/80 (ms); number of slices = 40; slice gap = 0.3 mm; voxel size (RL/AP/FH) = 0.98/1.03/3.00 (mm); FOV (RL/AP/FH) = 350/251/132 (mm); scan time = 4 minutes; NSA = 3. DCE-MRI was performed with a 3D-spoiled gradient echo (3D-T1w-FFE) sequence: TR/TE/Flip angle = 5ms/2ms/20°; number of slices= 19; voxel size (RL/AP/FH) = 1.70/1.68/5.00 (mm); FOV (RL/AP/FH) = 360/360/90 (mm); temporal resolution = 8.25 (s); scan time = 8.5 minutes; NSA= 1; number of dynamic scans = 60. A single dose (0.2 mmol per kilogram body weight) of Gd-based contrast agent (Magnevist, Bayer) was intravenously injected at a constant flow rate of 0.5 ml/s after the fifth dynamic scan of acquisition, followed by a flush of 25 ml saline at the same flow rate

Data Analysis: DCE-MRI data was processed using proprietary PRIDE software (Philips Healthcare, Cleveland, Ohio) by applying a linear two-compartment pharmacokinetic model [2] to calculate pharmacokinetic parameters: K^{trans}, the volume transfer constant; v_e, the volume of extravascular-extracellular space (EES) per unit volume of tissue; v_p, the volume of the plasma space per unit volume of tissue; and k_{ep}, the exchange rate of the contrast agent between EES and the plasma space. The maps of pharmacokinetic parameters were parameter-coded with the same color table (Figure 1).

An experienced radiologist (Z.K.S., 9 years of experience) blinded to histopathological findings read T2w MR images before DCE data (enhanced T1w images and the maps of pharmacokinetic parameters) to classify tumors in three categories stage T2 or lower, stage T3, or stage T4 in accordance with the TNM system. Radiological read was correlated with histopathological findings.

Staging Criteria: a tumor is in stage T2 or lower when the tumor margin adjacent to surrounding fat tissues is smooth, in stage T3 when the tumor margin is irregular and disrupted with fat signal and not contiguous with any adjacent organ, or in stage T4 when the tumor margin is contiguous with an adjacent organ.

Results

Pathology confirmed 10 cases in stage T2 or lower, 7 in T3, and 4 in T4. The sensitivities, specificities, and accuracies of staging by using T2w MRI and DCE-MRI are summarized in Table 1. Our staging using T2w images over-staged 2 tumors in stage T2 or lower and 1 tumor in stage T3, and under-staged 1 tumor in stage T3 and 2 tumors in stage T4. The staging using DCE-MRI over-staged 1 tumor in stage T2 or lower and under-staged 3 tumors in stage T3. The overall accuracy of bladder cancer staging by using T2w MRI and DCE-MRI were 71% and 81%, respectively.

The accuracies of the differentiation of T2 or lower from T3 or higher by using T2w MRI and DCE-MRI were both 81%. The differentiations of T3 or lower from T4 by using T2w MRI and DCE-MRI had the accuracy of 81% and 95%, respectively.

Discussions and Conclusions

Staging T2 or lower with T2w MRI and DCE-MRI at 3T had high sensitivity, specificity, and accuracy. DCE-MRI increased the sensitivity, specificity, and accuracy of staging T4 by using T2w MRI only.

In conclusion, 3T MRI with the potential to accurately stage bladder cancer can make a major impact on the patient outcome of cystectomy.

	T2wMRI			DCE-MRI		
Tumor Stage	Sensitivity	Specificity	Accuracy	Sensitivity	Specificity	Accuracy
T2/lower	80% (8/10)	82% (9/11)	81% (7/21)	90% (9/10)	73% (8/11)	81% (17/21)
T3	71% (5/7)	71% (10/14)	71% (15/21)	57% (4/7)	79% (11/14)	71% (15/21)
T4	50% (2/4)	94% (16/17)	86% (18/21)	100% (4/4)	100% (17/17)	100% (21/21)

Table 1: Staging of bladder cancer by T2w MRI and DCE-MRI.

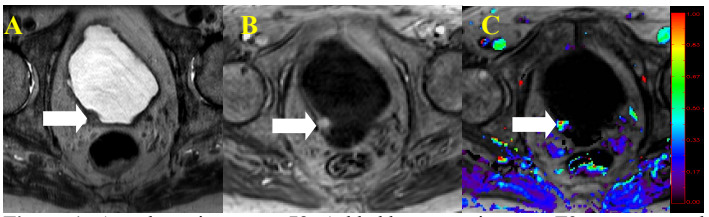

Figure 1: A male patient; age: 78. A bladder tumor in stage T2 was accurately staged by using T2w image (Image A), enhanced T1w image (Image B), and k_{ep} map (Image C). Tumor location (indicated by white arrows): trigone.

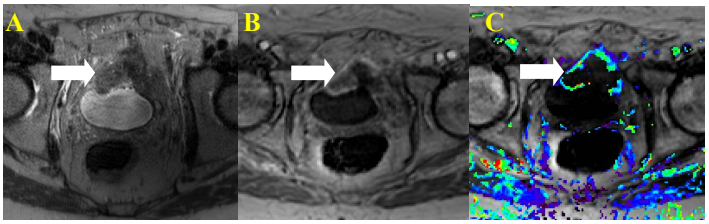

Figure 2: A male patient; age: 83. A bladder tumor in stage T3 was accurately staged by using T2w image (Image A), enhanced T1w image (Image B), and k_{ep} map (Image C). Tumor location (indicated by white arrows): anterior.

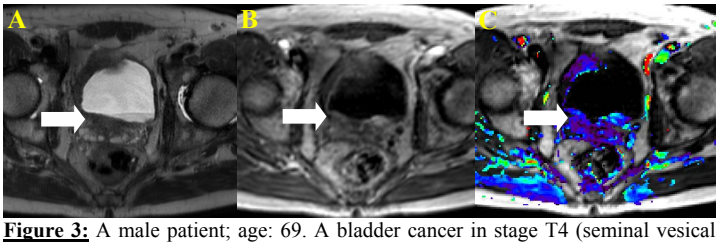

Figure 3: A male patient; age: 69. A bladder cancer in stage T4 (seminal vesical invasion) was accurately staged by using T2w image (Image A), enhanced T1w image (Image B), and k_{ep} map (Image C). Tumor location (indicated by white arrows): right and posterior.

References

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