Aims and objectives

**Purpose:** To evaluate the ability of diffusion-weighted imaging (DWI) in T staging of bladder cancer and the correlation between the apparent diffusion coefficient (ADC) and tumor grading.
Methods and materials

In this study 40 patients (28 males and 12 females) sonographically diagnosed with bladder mass, in the period between October 2012 to April 2014. Their ages ranged from 52 to 70 years. A full history was obtained from all patients with special attention to haematuria, pain, passage of blood clots or necroturia, dysuria, frequency and urgency. A thorough clinical examination with special attention to digital rectal and bimanual examination and a full laboratory investigation.

Referral to Radiodiagnosis Department, from Urology department, after obtaining institutional review board approval from our hospital and informed consent from the patients before the study. The Patients exclusion criteria were patients with impaired renal function (serum creatinine > 2 mg/dl), claustrophobia and metallic implants.

Imaging techniques:

The Patients were instructed to start drinking water 30 minutes before the MRI study and arrive for their examination with a full bladder. In 5 patients with a urethral catheter; it was closed one hour before examination and asking the patient to drink water at least 30 minutes before study. During the imaging procedure, fullness of the bladder was checked at localizer images and the examination was delayed if the bladder was not full.

MR imaging was performed with a 1.5-T Philips Achieva system by using a pelvic phased-array coil with the patient in supine position. MR imaging examination included: T2WI, DWI and T1WI post contrast.

After localizer images, T2-weighted spin-echo MR images were obtained from the aortic bifurcation to the symphysis pubis with the following parameters: repetition time msec/echo time msec, 4400/120, section thickness, 4 mm; intersection gap, 0.4 mm; field of view, 23 cm; matrix, 256X190. T2-weighted images were done in the axial and sagittal planes.

Diffusion-weighted images were obtained by using single shot spin-echo echo-planar imaging with a pair of rectangular gradient pulses along three orthogonal axes. The imaging parameters were as follows: TR /TE= 2800/74; field of view 25 cm, section thickness, 3 mm; intersection gap, 1 mm. Images were zero-filled to a 256X256 matrix. The orientation and location of these images were prescribed identically to the axial T2-weighted images. The b values were 0, 500 and 1000 s/mm. To gain better signal-to-noise ratios, a larger field of view was used for DW imaging than for T2-weighted imaging, and a thicker section was used for T2-weighted and DW imaging than for T1-weighted fast field echo imaging. DW images were obtained in the axial and sagittal planes.

ADC maps were formed automatically by the device, circular regions of interest (ROI) was set to be at least 20 mm2 in order to minimize the influence of potential motion artifacts.
ranging from 10 to 40 mm$^2$ according to the size of the mass, it were placed in the center of the lesion in cases of large masses. ADC value was obtained with b values 500 and 1000 s/ mm$^2$. The ADC values are expressed in square millimeters per second.

T1-weighted fast field-echo images with and without fat suppression technique; TR/TE= 500/ 20; matrix, 224 X214; section thickness, 3 mm; gapless; field of view, 35 cm; were obtained before and after administration of 0.2 mL per/ Kilogram of body weight gadopentetate dimeglumine.

The patients were referred again to Urology department. Diagnostic cystoscopy and transurethral resection of bladder tumor (TURBT), examination under anaesthesia before and after TURBT were done for all patients and radical cystectomy was done for 28 patients.

**Image Interpretation**

Imaging sequences sets (T2-weighted images, DW images and T1 post contrast-enhanced images) were randomly reviewed by two radiologists (H M and I M with 10 years' experience) who were blinded to cystoscopic and histopathological results.

**T staging depends on criteria shown on table (1).**

**Table (1)**

<table>
<thead>
<tr>
<th></th>
<th>T2WI</th>
<th>DWI</th>
<th>T1WI post contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ T1</td>
<td>Intact low SI muscle-layer at the base of the tumor</td>
<td>a thin, flat, high SI tumor or a high SI tumor with a low SI submucosal stalk or a thickened submucosa</td>
<td>Intact submucosal linear enhancement (SLE) adjacent to the tumor</td>
</tr>
<tr>
<td>T2</td>
<td>a lesion with focally disrupted muscle-layer without perivesical infiltration</td>
<td>a high SI tumor without a submucosal stalk and with a smooth tumor margin</td>
<td>SLE was disrupted by a tumor but there was no infiltration into the perivesical fat</td>
</tr>
<tr>
<td>T3</td>
<td>a lesion extending into the perivesical fat</td>
<td>extension into the perivesical fat with an irregular margin</td>
<td>tumors invading the perivesical fat</td>
</tr>
</tbody>
</table>
Correlation between MR findings and histopathological results (after TURBT or radical cystectomy) was done.

**Statistical analysis**

Data were checked, entered and analyzed using SPSS version 13 for data processing and statistics.

| T4          | A lesion extending into the adjacent Organs | Extension into adjacent organs. | Tumor extended to the adjacent organs. |
Results

Results: Of all forty patients; 14 patients (35%) were T1, 18 (45%) patients were T2, and 8 (20%) patients were T3. Thirty four patients (85 %) had transitional cell carcinoma, 4 patients (10%) had squamous cell carcinoma and 2 patients (5%) had adenocarcinoma regarding to the histopathology. The overall accuracy of T2WI, DWI and post contrast T1WI sequences in differentiating superficial from invasive tumor was 60%, 85% and 75% respectively. The overall accuracy of T2WI, DWI and post contrast imaging sequences in differentiating organ confined from non-organ confined tumor was 80%, 90% and 70% respectively. The mean ADC value was 0.95 ± 0.13 x10^-3 mm^2/s in low grade tumors and 0.69 ± 0.12 x10^-3 mm^2/s in high grade tumors. The ADC cut off value between high and low grade tumors was 0.82 x10^-3 mm^2/s.

The following tables show T2WI, DWI and post contrast T1WI staging results on a stage-by-stage basis compared with histo pathological staging.

<table>
<thead>
<tr>
<th>T2 WI stage</th>
<th>Histopathology stage</th>
<th># T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td># T1</td>
<td></td>
<td>4</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td>8</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>T3</td>
<td></td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>T4</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>14</td>
<td>18</td>
<td>8</td>
<td>0</td>
<td>40</td>
</tr>
</tbody>
</table>

Normal 0 false false false EN-US X-NONE AR-SA

<table>
<thead>
<tr>
<th>DWI stage</th>
<th>Histopathology stage</th>
<th># T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td># T1</td>
<td></td>
<td>12</td>
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<tr>
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<td>20</td>
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<tr>
<td>T3</td>
<td></td>
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<td>0</td>
<td>4</td>
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</tr>
<tr>
<td>Total</td>
<td></td>
<td>14</td>
<td>18</td>
<td>8</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Post contrast T1WI stage</td>
<td>Histopathology stage</td>
<td># T1</td>
<td>T2</td>
<td>T3</td>
<td>T4</td>
<td>Total</td>
</tr>
<tr>
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<td>-----</td>
<td>-----</td>
<td>-------</td>
</tr>
<tr>
<td># T1</td>
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<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>T2</td>
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<td>8</td>
<td>10</td>
<td>6</td>
<td>0</td>
<td>24</td>
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<tr>
<td>T3</td>
<td></td>
<td>0</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>T4</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>14</td>
<td>18</td>
<td>8</td>
<td>0</td>
<td>40</td>
</tr>
</tbody>
</table>
Fig. 1: Case(1, Fig. 1-5) 56 old male histopathologically confirmed transitional cell carcinoma T1, G1 tumor: Sag. T1WI shows small fungating mass lesion disrupting hypointense muscle layer at base of the mass, over staged as stage T2a.

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**Fig. 2:** Axial T1WI shows small fungating mass lesion disrupting hypointense muscle layer at base of the mass, over staged as stage T2a.
**Fig. 3:** Post contrast T1 WI the mass is showing heterogeneous contrast enhancement with almost indistinct urinary bladder wall, over staged as stage T2.

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**Fig. 4:** DWI the mass shows restricted diffusion evident by C-shaped high signal intensity with a low SI stalk connecting to left bladder wall (b500 & b 1000) denoting stage T1 representing accurate staging.

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**Fig. 5:** ADC value measured within the ROI was $0.98 \times 10^{-3}$ mm$^2$/s denoting low grade (G1) tumor.

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Fig. 6: Case 2, (Fig.6-9) 64 old male histopathologically confirmed Transitional cell carcinoma staged T2 b, high grade (G3) Sagital T2-weighted image shows poorly defined endophytic fungating large soft tissue mass lesion in the dome and anterior wall of the bladder and high signal intensity blood clots seen in the lumen. The mass extends into perivesical fat with an irregular contour, over-staged as Stage T3b.

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**Fig. 7:** axial T1 post contrast-enhanced T1 WI shows heterogeneous contrast enhancement of the mass with evidence of focal invasion into the perivesical fat planes, over-staged as Stage T3.

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Fig. 8: DWI (b1000) shows evidence of restricted diffusion with a smooth bulging, accurately-staged as Stage T2.

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Fig. 9: ADC value was 0.68 x10^-3 mm2/s denoting high grade tumor (accurate grading).

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Conclusion

Conclusion:

DWI has a higher overall accuracy compared to both T2WI and post contrast T1 WI in T staging of bladder cancer, also ADC map can predict the tumor grade. So DWI can be recommended as promising MRI sequence in urinary bladder T staging and grading.
References


6. Sylvester R, van der Meijden APM, Oosterlinck W, . Predicting recurrence and progression in individual patients with stage Ta T1 bladder cancer using EORTC risk tables: a combined analysis of 2596 patients from seven EORTC trials. Eur Urol 2006;49,466-77


