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Role of Diffusion Weighted Magnetic Resonance Imaging (DW-MRI) in Assessment of Urinary Bladder Carcinoma

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ABSTRACT

Background: bladder cancer is the fourth most common cancer in males and the tenth most common cancer in females. Urinary bladder cancer occurs three to four times more frequently in men than in women and has a high recurrence rate, necessitating long-term surveillance after initial therapy. Patients with bladder cancer survive longer than those with most other common cancers. For the radiological evaluation of the urinary bladder and prostate gland, magnetic resonance imaging (MRI) is a valuable imaging modality due to high tissue contrast, multiplanar imaging capabilities, and the possibility of tissue characterization. Diffusion-weighted imaging (DWI) has emerged as a diagnostic technique in the evaluation of various abdominal lesions. **Aim of the Work:** to evaluate the role of diffusion weighted magnetic resonance imaging (MRI-DWI) in the diagnosis of urinary bladder carcinoma, with pathological diagnosis was taken as the reference. **Patients and Methods:** this is a retrospective study that included 20 patients in whom bladder cancer had been suspected either clinically or by U/S and confirmed by biopsy and 20 patients in whom bladder cancer had been not suspected and MRI was done because of other pelvic diseases as a control group. The study was conducted in El-Demerdash hospital. The patients will be referred to the radiology department from the urology department for further MRI evaluation with DWIs. **Results:** in this study, 20 patients suspected to have bladder cancer were scheduled for MR imaging. All patients were scheduled for different MR sequences including T2WIs, DWIs and post contrast T1WIs. Regarding the detection of urinary bladder carcinoma the sensitivity, specificity, and accuracy for differentiating superficial from invasive tumors using T2 images alone and combined use of T2 and DW images were 62.5%, 66.7%, 63.2% and 100%, 100%, 100% respectively. The sensitivity, specificity, and accuracy for differentiating superficial from invasive tumors using post contrast MR images alone and combined use of post contrast MR images and DW images were 92.3%, 100%, 93.3% and 100%, 100%, 100% respectively. **Conclusion:** we assume that DW-MRI is a safe and confident method in detection and local staging of urinary bladder carcinoma. In addition, DW images may predict the histological grade of the tumor. Hence DWI may be added to routine imaging protocols of urinary bladder tumors.

Keywords: Diffusion Weighted Imaging, Magnetic Resonance Imaging, Urinary Bladder Carcinoma

INTRODUCTION

Bladder cancer is the fourth most common cancer in males and the tenth most common cancer in females. Urinary bladder cancer occurs three to four times more frequently in men than in women and has a high recurrence rate, necessitating long-term surveillance after initial therapy. Patients with bladder cancer survive longer than those with most other common cancers[(1)]. In Egypt, the condition is worse as a result of Bilharziasis. Bilharziasis is not only endemic in Egypt but also considered to be a historical disease as it has been discovered in the urinary bladder of pharaoh ancestors' mummies. The uncommon aggressive squamous cell carcinoma is frequently associated with Bilharzial bladder [(2)]. For the radiological evaluation of the urinary bladder and prostate gland, magnetic resonance imaging (MRI) is a valuable imaging modality due to high tissue contrast, multiplanar imaging capabilities, and the possibility of tissue characterization [(3)]. Diffusion-weighted imaging (DWI) has emerged as a diagnostic technique in the evaluation of various abdominal lesions. DWI reveals micro-molecular diffusion, which is the Brownian motion of the spins in biologic tissues. This technique can delineate pathologic lesions with high tissue contrast against generally suppressed background signal[(3)]**.** The utilization of diffusion-weighted (DW) magnetic resonance (MR) imaging in the abdomen was attractive in the detection of the malignant tumors, such as malignant hepatic, renal, prostatic, colonic and uterine cervical tumors. However, its application to the abdomen has been hindered by the presence of bulky physiologic motions such as respiration, peristalsis, and blood flow[(4)]**.** To resolve those problems, in ***2017, Barsoum et al.*** [(3)] reported a procedure of body DW MR imaging under free breathing which enables longer scan times. This technique gives more, thin-slice images, with multiple signal averaging, and provides high quality multiplanar display. In this study, the feasibility of DW MR imaging under free breathing for the detection of a urinary bladder carcinoma was

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evaluated. DW images provided useful information for evaluating the T stage of bladder cancer, particularly in differentiating T1 or lower tumors from T2 or higher tumors. The ADC may in part predict the histologic grade of bladder cancer[5]**.** DW images under free breathing enabled the clear detection of the urinary bladder carcinoma. The ADC value of the carcinoma was lower compared with that of the normal bladder wall, the prostate and the seminal vesicles. Based on these results, the DW images may be useful in evaluating the tumor invading the surrounding structures. Moreover, this technique can be applied to differentiate scars and reactive tissue after the biopsy[6]**.**

AIM OF THE WORK

To evaluate the role of diffusion weighted magnetic resonance imaging (MRI-DWI) in the diagnosis of urinary bladder carcinoma, with pathological diagnosis was taken as the reference.

PATIENTS AND METHODS

Patients: This is a retrospective study that included 20 patients in whom bladder cancer had been suspected either clinically or by U/S and confirmed by biopsy and 20 patients in whom bladder cancer had been not suspected and MRI was done because of other pelvic diseases as a control group. The study conducted in El-Demerdash hospital. The patients referred to the radiology department from the urology department for further MRI evaluation with DWIs. **The study was approved by the Ethics Board of Ain Shams University and an informed written consent was taken from each participant in the study. Inclusion Criteria:** Age range, 30-75years. These patients presented with gross (macroscopic) hematuria or had urinary bladder mass, detected on U/S and/or CT examinations. **Exclusion Criteria:** History of urinary tract trauma, contraindications to MR imaging (eg., pacemaker or metallic prostheses), age under 18 years. ***Before MRI examination, all cases were subjected to:*** full history taking with a special emphasis on: age, gross (macroscopic) hematuria 80–90% of the patients, bladder or ureteric stones, infection, kidney disease and vascular malformations, history of systemic disease or anticoagulant therapy. 1. Routine laboratory investigation for all patients including complete blood count, random blood sugar, renal functions test. **Methods:** ***Patient preparation:*** All patients requested to fast for 6 hours before the examination, to moderately distend the bladder, patients were instructed to start drinking water one hour before the MR imaging examination. All patients were prohibited from urinating for at least 1 hour before examination, no special bowel preparation required. **Protocol of MR Imaging:** MRI studies were performed on 1.5 T MRI (Achieva, Philips medical system), using body coil (phased array coil). All the patients were imaged in the supine position with head pointing to the magnet (HFS). Bladder fullness was checked on localizer images, and the examination was delayed if the bladder was not full. ***The standard sequences included:*** Initially, turbo spin-echo **T2-weighted images** were obtained (repetition time msec/echo time msec, 2250–3500/90–100; bandwidth, 20–83 kHz; matrix, 256 x 256; section thickness, 4-6 mm; intersection gap, 1-2 mm; field of view, 20 cm). T2-weighted images were evaluated in the axial planes and in some cases obtained in the sagittal and coronal planes. Then, with the patient free breathing, **DW images** were obtained in the axial plane by using a body coil and a monodirectional gradient multisection fast spin-echo echoplanar sequence (repetition time msec/echo time msec 3500-4500/60-70; bandwidth, 142 kHz; matrix, 256 x 256; section thickness, 4-6 mm; intersection gap, 1-2 mm; field of view, 36 cm; signals acquired with b values of 0, 400 and 800 sec/mm^2). Thirty to 55 sections were obtained in 60–120 seconds to cover the pelvis. **ADC maps** were generated in the tumors that were large enough (> 5 mm) to contain the region of interest (ROI). The ADC values were measured to estimate the degree of diffusion and usually expressed in ($\times 10^{-3}$) square millimeters per second. **T1-weighted** fast field-echo images with a water-selective excitation technique (repetition time msec/echo time msec 400-460/10-15; flip angle, 20°; matrix, 256 x 256; section thickness, 4-6 mm; intersection gap, 1-2; field of view, 36 cm; number of sections, 24–27; acquisition time, 26–30 seconds) were obtained after administration of 0.2 mL per kilogram of body weight gadopentetate dimeglumine (Magnevist). **Image Interpretation & Tumor Staging:** All MR image sets were interpreted independently from all histopathological information. The urinary bladder tumors were classified into the following four categories in accordance with TNM classification from the American Joint Committee on Cancer ***(see Figure 1)*** T1 or lower, T2 (T2a or T2b), T3 (T3a or T3b), and T4. Since the normal bladder wall can be seen as a low SI line on T2-weighted images, the bladder wall was considered to be intact

(stage T1 or lower) when the low SI line was present. The bladder wall was considered to be invaded by the tumor (stage T2 or higher) when the low SI line was disrupted focally in the region underlying the tumor. On contrast-enhanced images, submucosal linear enhancement (SLE) is depicted immediately after the injection of contrast agent, and the SI of the muscle layer remains low. Therefore, an intact SLE adjacent to a tumor was regarded as indicative of stage T1 or lower. When the SLE was disrupted by a tumor but there was no infiltration into the perivesical fat, this was considered to be stage T2. On both T2-weighted and contrast-enhanced images, tumors invading the perivesical fat were classified as T3, and those extending into an adjacent organ or the abdominal wall, as T4. On DW images, bladder cancer has been reported to show high SI, we assumed that a line of intermediate SI outlining the bladder lumen and a low SI area between the tumor and muscle could reflect a muscle layer and a submucosal stalk, respectively. A thin, flat, high SI area corresponding to the tumor or a high SI tumor with a low SI submucosal stalk or a thickened submucosa indicates stage T1 or lower; a high SI tumor without a submucosal stalk and with a smooth tumor margin indicates stage T2; extension into the perivesical fat with an irregular margin indicates stage T3; and extension into adjacent organs indicates stage T4.

The staging criterion for DW imaging as follows: ***(Figure 1)***

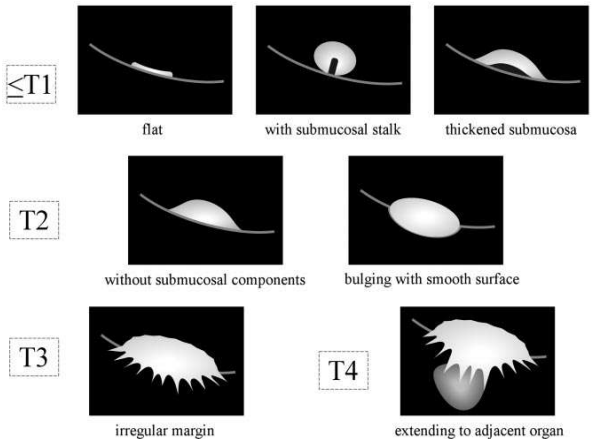

Figure 1: Schematic shows diagnostic criteria for using DW imaging for staging bladder cancer. Cancer component, muscle layer, and submucosa show high, intermediate, and low SI, respectively. Submucosal stalk or thickened submucosa indicates T1 or lower stage; smooth tumor margin without submucosal components, T2; irregular margin toward the perivesical fat tissue, T3; and extension into adjacent organs, T4.[(14)]

Histopathology: Pathological examination was performed for all patients to compare between cases diagnosed as malignant tumor by MRI-DWIs and pathological diagnosis.

RESULTS

Patients characteristics: The included 20 patients ages ranged between 30-75 years (mean age: 52.85±13.81), ≤50 years (45%) and >50 years (55%) of age, also female (20%) and male (80%) of sex.

Table 1: Age (years) distribution of the study group.

	No.	%
Age (years)		
≤50 years	9	45.0%
>50 years	11	55.0%
Range [Mean±SD]	30-75 [52.85±13.81]	
Sex		
Female	4	20.0%
Male	16	80.0%
Total	20	100.0%

Table 2: Presentation and size distribution of the study group.

Presentation	No.	%
Hematuria	18	90.0%
Irregular vaginal bleeding	2	10.0%
Size (cm)		
≤5cm	10	50.0%
>5cm	10	50.0%
Range [Mean±SD]	2-9.8 [5.56±2.30]	

This table shows that the hematuria (90%) and irregular vaginal bleeding (10%) of presentation, while size ≤5cm (50%) and >5cm (50%) of size.

Table 3: T1 post contrast DCE distribution of the study group.

T1 post contrast (DCE)	No.	%
Heterogeneous enhancement	16	80.0%
Without contrast	4	20.0%
Total	20	100.0%

ON T1 post contrast enhancement, heterogeneous enhancement (80%) and without contrast (20%).

Table 4: DWI distribution of the study group.

DWI	No.	%
Not restricted	1	5.0%
Restricted	19	95.0%
Total	20	100.0%

This table shows that the not restricted (5%) and restricted (95%) of DWI. **ON DWI,** lesions in 19 cases were seen restricted only one case was not restricted and **ADC** seen high on only one case proved to be inflammatory pseudotumor on histopathology, however ADC was found to be low on the rest 19 cases proved to be bladder cancer on histopathology.

Table 5: ADC distribution of the study group.

ADC	No.	%
High	1	5.0%
Low	19	95.0%
Total	20	100.0%

This table shows that the high (5%) and low (95%) of ADC.

Table 6: Staging distribution of the study group.

Staging	No.	%
T1	3	15.8%
T2	4	21.1%
T3	8	42.1%
T4	4	21.1%
Total	19	100.0%

This table shows that the T1 (15.8%), T2 (21.1%), T3 (42.1%) and T4 (21.1%) of staging. A total 19 bladder cancer lesions, 3 lesions were stage I, 4 lesions were stage II, 8 lesions were stage III, and 4 lesions were stage IV.

Table 7: Histological grading distribution of the study group.

Histological grading	No.	%
I	1	5.3%
II	7	36.8%
III	11	57.9%
Total	19	100.0%

This table shows that the grade I (5.3%), grade II (36.8%) and grade III (57.9%) of histological grading.

Table 8: Histopathological distribution of the study group.

Histopathological diagnosis	No.	%
Inflammatory pseudo tumor	1	5.0%
Squamous cell carcinoma	5	25.0%
Urothelial carcinoma	14	70.0%
Total	20	100.0%

This table shows that the inflammatory pseudotumor (5%), squamous cell carcinoma (25%) and urothelial carcinoma (70%) of histopathological diagnosis.

Table 9: Comparison between patients and control according to ADC value ($x10^{-3}$).

ADC value (x10-3)	Patients (N=20)	Control (N=20)	t-test	p-value
Mean±SD	0.94±0.16	1.70±0.21	67.168	<0.001**
Range	0.6-1.31	1.31-2.05		

This table shows highly statistically significant difference between patients and control according to ADC value ($x10^{-3}$).

Table 10: Diagnostic Accuracy for Differentiating Stage Tis to T1 Tumors from T2 to T4 Tumors.

	Sensitivity	Specificity	Accuracy
T2WIs	10/16(62.5%)	2/3(66.7%)	12/19(63.2%)
DWI	16/16 (100%)	3/3 (100%)	19/19 (100%)
T2WIs plus DWIs	16/16 (100%)	3/3 (100%)	19/19 (100%)

The specificities and accuracy obtained by using DW images alone or DW plus T2-weighted images were significantly better than using T2-weighted images alone. In addition, the sensitivity achieved by using T2-weighted is high reaching 62.5%. While the sensitivity achieved by DW images alone or DW plus T2-weighted images together is raised reaching 100%.

Table 11: Diagnostic Accuracy for Differentiating Stage Tis to T2 and Tumors from T3 to T4 Tumors.

	Sensitivity	Specificity	Accuracy
T2WIs	7/12 (58.3%)	2/4 (50%)	9/16 (56.3%)
DWI	12/12(100%)	4/4(100%)	16/16(100%)
T2WIs plus DWIs	12/12(100%)	4/4 (100%)	16/16(100%)

The sensitivity, specificities and accuracy obtained by DW images were higher than using T2-weighted images. T2-weighted images together with DWIs showed sensitivity, specificity and accuracy of 100 % for each.

Table (12): Diagnostic Accuracy for Differentiating Stage Tis to T1 Tumors from T2 to T4 Tumors.

	Sensitivity	Specificity	Accuracy
MR contrast	12/13(92.3%)	2/2(100%)	14/15(93.3%)
DWI	13/13 (100%)	2/2(100%)	15/15 (100%)
MR Contrast plus DWIs	13/13 (100%)	2/2(100%)	15/15 (100%)

Table (13): Diagnostic Accuracy for Differentiating Stage Tis to T2 and Tumors from T3 to T4 Tumors.

	Sensitivity	Specificity	Accuracy
MR contrast	9/10 (90%)	2/3(66.7%)	11/13(84.6%)
DWI	10/10(100%)	3/3 (100%)	13/13 (100%)
MR Contrast plus DWIs	10/10(100%)	3/3 (100%)	13/13 (100%)

The sensitivity, specificity and accuracy of DW images plus contrast enhanced MR images each alone or together are raised to 100% for each.

Table (14): Relation between histological grading and ADC value ($x10^{-3}$).

Histological grading	ADC value (x10-3)		ANOVA	
	Mean±SD	Range	F	p-value
G1	1.11±0.00	1.11-1.11	4.071	0.027*
G2	0.97±0.06	0.91-1.06		
G3	0.83±0.14	0.60-1.20		

This table shows statistically significant relation between histological grading and ADC value ($x10^{-3}$).

Case (1)

62-year-old male patient, heavy smoker with no other risk factors for urinary bladder carcinoma. He complained of two attacks of hematuria and deep pelvic pain. The patient was scheduled for U/S and CT examinations with the following findings as reported ***(Figure 2)***: Heterogeneous soft tissue mass lesion along the right lateral wall of the urinary bladder with possible perivesical fat plane invasion.

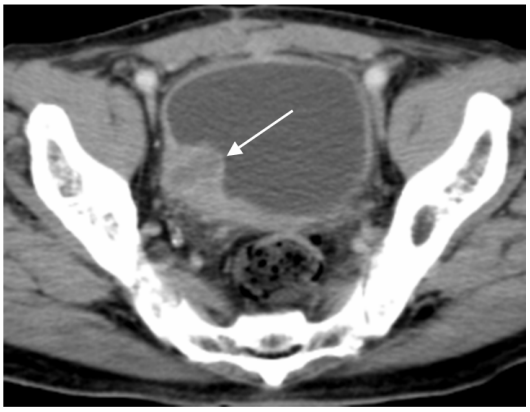

Figure 2: Axial post contrast CT scan.

One week later, the pelvic MRI was requested to assess the local staging of the urinary bladder mass with the following findings: In ***figure 3,*** poorly defined fungating soft tissue mass lesion is seen involving the right lateral wall of the urinary bladder measuring about 5 cm in maximum diameter. The mass lesion displays inhomogeneous hyper-intense signal intensity in T2Ws with indistinct normal low signal intensity line of the bladder wall and evidence of exophytic component invading the perivesical fat planes (stage T3).

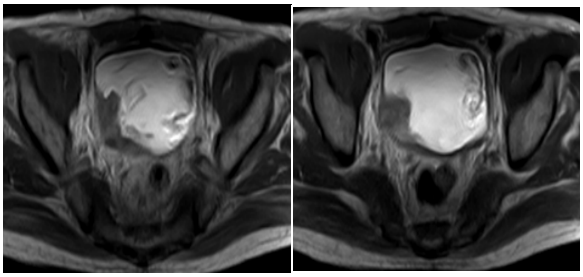

Figure 3: Axial T2WIs.

In ***figure 4,*** the urinary bladder soft tissue mass lesion showed evidence of restricted diffusion evident by high signal intensity in the diffusion weighted images in b400 and b800, with corresponding low ADC values in ADC map. The mass lesion shows irregular outline toward the perivesical fat planes (stage T3). The mean ADC value measures 0.93 x 10^{-3} mm^2/sec.

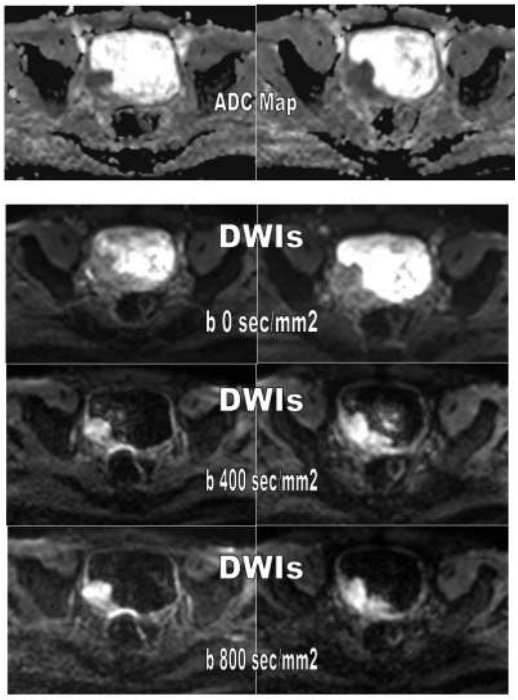

Figure 4: Case 1: Axial ADC map and DWIs in different b values.

Pathological diagnosis: The patient underwent radical cystectomy with pathological findings were reported as: (Squamous carcinoma, Stage T3, Grade II). **Conclusion:** Findings of CT, T2 & DWIs were matched with pathological findings regarding the loco-regional staging of the urinary

bladder mass lesion (stageT3). The ADC value is toward grade III, yet the pathological grade is II.

Case (2)

40-year-old female patient complain of lower abdominal pain, macroscopic hematuria and dysuria for about 2 weeks. She had no fever and symptoms did not improve despite antibiotic therapy. Pelvic CT scan and U/S were performed, smooth filling of the urinary bladder with diffuse mural thickening (6 mm) with focal sessile mass is seen at the dome of the bladder. ***The patient was scheduled to perform pelvic MR examination for better characterization with results as follows:*** In ***figure 5,*** the urinary bladder with diffuse mural thickening (6mm), a focal sessile mass is seen at the dome of the bladder measuring 2x1 cms in TR x AP dimensions. It displays bright signal on T2 with hypointense rim, no diffusion restriction, and diffuse enhancement is seen on post contrast images ***(refer to arrows in images A, B and C)***. No intracavitary lesions, no sizable lymphadenopathy and the other pelvic organs had no signs of disease. The mean ADC value measures 1.31 x 10^{-3} mm^2/sec.

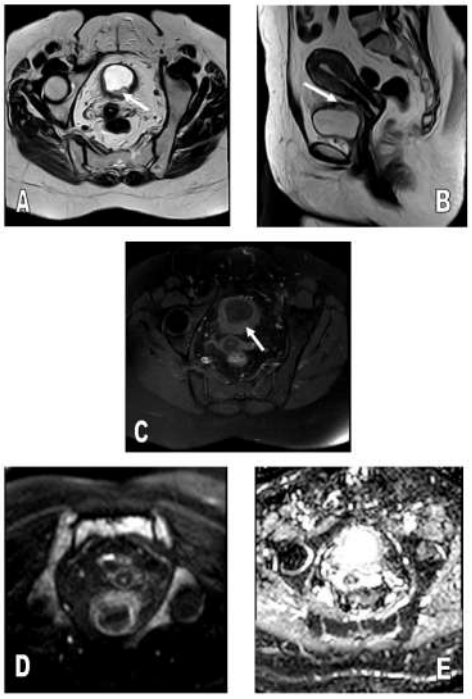

Figure 5: (a) axial T2WI (b) sagital T2WI (c) axial T1WI (d) DWI (e) ADC map.

Pathological diagnosis: Cystoscopy was performed and urinary cytology revealed no neoplastic cells, suggesting nature of the lesion; (Inflammatory pseudotumor). **Conclusion:** Urinary bladder dome with diffuse mural thickening (6mm) and focal mass measuring 2x1 cms in TR x AP dimensions. The diffusion weighted image show no restriction, the high ADC value is matched with the pathological findings as well.

Case (3)

56-year-old male patient complain of deep pelvic pain, attacks of hematuria and dysuria for about 3 months. Pelvic U/S was performed and bladder mass lesion was determined. The patient was scheduled to perform pelvic MR examination with results as follows: In ***figure 6,*** large ill-defined fungating soft tissue mass lesion involving the urinary bladder walls partially sparing its anterior wall. The mass lesion measures about 9.8 cm in maximum diameter. The mass lesion displays mixed low and high signal intensity in T2Ws with large exophytic component projecting posteriorly, infiltrating the left seminal vesicle with obliterated left semino-vesical angle ***(refer to dashed circular arrow in image B)*** (denoting stage T4). The mass lesion is seen engulfing and obliterating the lowermost portion of the left ureter and encroaching upon the right ureteric orifice. Associated two mild discretely enlarged right internal iliac lymph nodes are seen. In DWIs the bladder mass lesion shows evidence of restricted diffusion. The lesion shows similar fore-mentioned exophytic component, infiltrating the left seminal vesicle ***(refer to dashed circular arrow in image F)*** and smoothly indenting the nearby rectal segment.

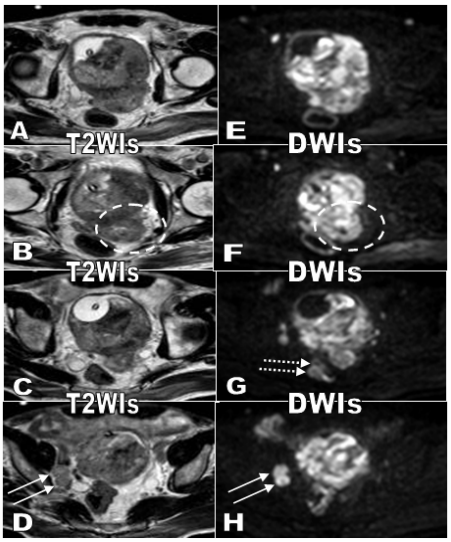

Figure 6: Case 10: Axial DWIs and T2WIs.

In addition, the DWIs added two diagnostic data as follows: The fore-mentioned right internal iliac lymph nodes detected in T2WIs, show evidence of diffusion restriction in the DWIs ***(refer to arrows in image H)***, denoting high

cellularity, therefore neoplastic infiltration and metastatic nature is considered. Two peritoneal nodular lesions of high signal intensity in DWIs are seen along the right ventrolateral wall of the nearby recto-sigmoid colon ***(refer to arrows in image G),*** denoting high cellularity and metastatic lesions as well. These nodular lesions are almost indistinct in the T2WIs. The mean ADC values of the bladder mass lesion measured 0.89 x 10^{-3} mm^2/sec. **Pathological diagnosis:** The patient underwent radical cystectomy with pathological findings were reported as: (Urothelial carcinoma, Stage T4, Grade III). **Conclusion:** The loco-regional staging of the bladder mass lesion was accurately diagnosed in the examined MR sequences. The mass lesion shows exophytic component invading the left seminal vesicle in the T2 and DWIs (stage T4). The DWIs added metastatic spread into the right iliac lymphadenopathy and the peritoneal deposits. The ADC value of the mass lesion is toward grade III according to the results of our study that matched with its histopathological grade.

DISCUSSION

Cancer of the urinary bladder is a common malignant tumor of the urinary tract in both men and women. Accurate preoperative staging is the most important factor in determining the appropriate management of urinary bladder cancer because the therapeutic method chosen and prognosis depend on the clinical findings and radiologic stage at presentation[(7)]. Superficial tumors are treated with transurethral resection (TUR) with or without adjuvant intravesical chemotherapy or photodynamic therapy, whereas invasive tumors are treated with radical cystectomy, radiation therapy, chemotherapy, or a combination[(3)]. Therefore, preoperative imaging studies would play an important diagnostic role if they could be used to precisely differentiate between the two categories of bladder cancer. Contrast agents used in conventional MR imaging can have adverse effects, including nephrogenic systemic fibrosis. Cystoscopy and transurethral endoscopic ultrasonography considered as invasive techniques. Therefore, further improvement of a diagnostic modality may be desirable[(8)]. Hence, the purpose of our study was to assess detection of urinary bladder carcinoma by diffusion-weighted MR imaging (DW-MRI) and determine whether this non invasive technique has supplementary value for preoperative T staging. In addition, we conducted this study to measure the correlation between ADC and histologic grade of the urinary bladder cancer. **Role of DW-MR imaging in detection of urinary bladder carcinoma:** The feasibility of using DW-MR imaging for the detection of a urinary bladder carcinoma has been reported by ***Wang et al.*[(9)].** The sensitivity of DW imaging in that study was 100% for detection of carcinomas. However, that study had several limitations. First, it was a retrospective study of a small number of patients (15 patients). In addition, all patients' MR examinations occurred after biopsy, which may have affected the results. Furthermore, all patients included in the study were known to have bladder tumors, thus there was case selection bias in the report. Similar findings were reported by ***Eman et al.*[(10)],** the sensitivity of DW-MRI was 100% in terms of correctly detecting the bladder carcinomas on 43 patients. In a study published by ***Barrett et al.*** [(11)], on 59 patients referred to the clinic complaining of hematuria were enrolled and evaluated by upper urinary system pathology and then DW-MRI and cystoscopy. The sensitivity, specificity and accuracy values of DW-MR imaging were found, respectively 90%, 93% and 91%. The results of our and previously published studies suggest a high reliability of DW-MR imaging for the diagnosis of bladder and extra-bladder lesions in patients with gross hematuria. In addition, DW-MR images can provide informations regarding lesion size, number, and location to surgeons who perform conventional cystoscopy. The common limitation of our and these studies was lacking follow up after interventional or operative therapy. [(12)] In study published by ***El-Assmy et al.*[(13)]** to study the feasibility of using DW-MRI in bladder cancer follow-up after TUR. In 47 patients, cystoscopy identified 34 bladder lesions in 24 patients and in the remaining 23, the bladder looked normal. The sensitivity, specificity and accuracy of DW-MRI for identifying bladder tumors were 91.6% (22/24), 91.3% (21/23), 91.5% (43/47), respectively. The authors concluded that there was no significant difference between DW-MRI and cystoscopy; therefore DW-MRI has a high reliability in differentiating post-TUR inflammatory changes from bladder tumors, which is similar to that of cystoscopy. In addition, DW-MRI could be a first-line diagnostic test in follow-up of patients after

TUR. **Role of DW-MR imaging in staging of urinary bladder carcinoma:** In a study reported by ***Takeuchi et al.*** [14], on 52 bladder tumors. The sensitivity, specificity, and accuracy for differentiating Tis to T1 tumors from T2 to T4 tumors and for differentiating Tis to T2 tumors from T3 to T4 tumors using T2 images alone and combined use of T2 and DW images were demonstrated in chart 1 and 2. In our study the sensitivity, specificity, and accuracy for differentiating Tis to T1 tumors from T2 to T4 tumors and for differentiating Tis to T2 tumors from T3 to T4 tumors using T2 images alone and combined use of T2 and DW images were demonstrated. ***Hoeks et al.*** [15] reported that 81% of bladder tumors showed a SI similar to that of muscle on T2-weighted images and that overstating was the most common error when evaluating T stage. We also believe that the insufficient SI contrast between tumor and submucosa might cause relatively low accuracy. The results of the ***Huan-jun et al.*** [16] study were matched with our study that concluded sensitivities, specificities and accuracy obtained by using T2-weighted plus DW images were significantly better than that obtained by using T2-weighted images alone. We believe that this was due to the enhanced visibility of the structures of the tumor, muscle layer, and thickened submucosa, all of which showed different signal intensity on DW images. **Role of contrast enhanced MRI in staging of urinary bladder carcinoma:** Study performed ***by Barentsz et al.*** [17] showed that gadolinium enhanced dynamic MRI was slightly more accurate than CT or other MR techniques, although the difference was not statistically significant. According to their results, overstaging occurred in 26% of cases with gadolinium-enhanced imaging. Study performed by ***Kuchynka et al.*** [18] reported that the accuracy was as low as 62% and over-staging was the most common error (32%), but they found that T staging accuracy improved up to 85% in differentiating superficial from invasive tumors. In our study the accuracy of gadolinium enhanced MR study was 93% in differentiating superficial from invasive tumors, which was slightly better than that in previous reports. Moreover the accuracy using the DW imaging was slightly improved up to 100%, suggesting the incremental usefulness of DW imaging. The overall staging accuracy was 100% when contrast-enhanced, and DW images were used together. ***Hoeks et al.*** [15] reported that the tumor and submucosa were of similar signal intensity in 60% of the dynamic contrast-enhanced findings, and submucosal linear enhancement (SLE) was difficult to recognize in these cases. Therefore, contrast-enhanced images might have limitations for use to correctly distinguish T1 tumors with intact SLE from T2 tumors with disrupted SLE. DW imaging could reduce overstaging because of its good contrast resolution. **Can DW-MR imaging predict the histological grading of urinary bladder carcinoma?** The usefulness of diffusion-weighted (DW) MR imaging for depicting malignant tumors, and an apparent diffusion coefficient (ADC) for characterizing tumor grades have been suggested recently. [19] ADCs representing the degree of water molecular diffusion and the degree of restriction to water diffusion in biological tissues are inversely correlated to the tissue cellularity and the integrity of the cell membranes. Several authors had already reported decreased ADC among various malignant lesions due to dense cellularity and large cellular size[20]. In our study, the mean ADC of G1 tumors was higher than that of G2 and G3 tumors. Meanwhile, there is inverse relationship between the mean ADC values and the histological grade of the tumor. Our results were nearly matching with those of the study reported by ***Zytoon et al.*** [21] yet the authors found that all G3 tumors had an ADC less than 1.0×10^{-3} mm^2/sec, while in our study all G3 tumors had an ADC less than 1.2×10^{-3} mm^2/sec. Yet the mean ADC value in our study for G3 tumors was less than 0.97×10^{-3} mm^2/sec. Based on our and prior studies, the ADC could predict the histologic grade of bladder cancer. The limitation of the present study, we included a larger number of advanced stage tumors and large sized lesions (mean 5.56 cm), and this could explain the high sensitivity, specificity and accuracy of DW-MR imaging for differentiating Tis to T2 tumors from T3 to T4 tumors. However, further study is needed to assess whether the use of diffusion weighted imaging improves such diagnoses. We agree with ***Barsoum et al.*** [3] regarding two main disadvantages of DW-MR imaging. First, failure to visualize the lumen of the urethra, as it is routinely seen at conventional cystoscopy. Second, patients with metal prostheses or implants couldn't be adequately examined. In addition, this technique is limited by poor spatial

resolution and the potential risk of image distortion caused by post-biopsy hemorrhage or previous interventional therapy. However, DW-MRI has many advantages such as short acquisition time, non-invasive technique, and does not contain ionized radiation. Also in our study, DWI was performed without breath holding, thus allowing examination of severely ill, old, or obese patients who were unable to hold their breath for a long time. In addition, recently DW-MRI is accepted as an important marker of tumor cellularity, it may be used as an alternative in future diagnosis and follow-up of bladder tumors. DW-MR imaging is emerging as a powerful clinical tool for directing the care of patients with cancer. DW-MR imaging may be added to routine abdominal imaging protocols that add confidence to lesion detection, characterization against suppressed background signal, especially in urinary bladder cancers and determining therapy response[22].

CONCLUSION

In conclusion, we assume that DW-MRI is a safe and confident method in detection and local staging of urinary bladder carcinoma. In addition, DW images may predict the histological grade of the tumor. Hence DWI may be added to routine imaging protocols of urinary bladder tumors.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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