Value of Diffusion Weighted Magnetic Resonance Imaging in Diagnosis of Cervical Carcinoma

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Abstract

Background: Carcinoma of the uterine cervix is the third most frequently diagnosed malignancy in women worldwide. It remains a leading cause of cancer-related death for women in developing countries. Conventional MRI has an established role in gynecologic imaging. However, increasing clinical demand for improved lesion characterization and disease mapping to optimize patient management has resulted in the incorporation of newer sequences, such as diffusion-weighted imaging (DWI).

Aim of Study: The aim of this study is to evaluate the role of DW-MRI in the diagnosis of cervical carcinoma.

Patients and Methods: This is a descriptive exploratory (case-series) study that included 20 female patients diagnosed with cervical cancer. Pelvic MR, DWI and DCE-MR were done for all patient. The study was conducted in El-Demerdash Hospital from March 2019 – Feb. 2020.

Results: This study group consisted of 20 female patients diagnosed with cervical cancer, Pelvic MR, DWI and DCE-MR were done for all patient. Lesions in all cases were seen restricted on DWI (high signal intensity in DWI with low ADC map) with heterogeneous patterns was seen in (17/20, 85%) cases, homogenous patterns was seen in (2/20, 10%) and mural pattern in (1/20, 5%) case. All lesions showed low ADC maps from 0.6 to 1.2 (x10^-3 mm^2/sec), <0.8 x10^-3 mm^2/sec was seen in 5 cases (25%) and ≥0.8 x10^-3 mm^2/sec was seen in 15 cases (75%). A total 20 cervical cancer lesions, 5 lesions were stage IIA (25%), 10 lesions were stage IIB(10%), 4 lesions were stage IVA (20%) and 1 lesion was stage IVB (5%) of FIGO classification.

Conclusion: DWI is a potentially useful adjunct to conventional MRI in the evaluation of gynecologic tumors, thus improving the overall diagnostic accuracy, tumor staging.

Key Words: MRI – DW-MRI – Cervical cancer.

Introduction

CEVICAL cancer is the third most common cancer in women worldwide [1]. It remains a leading cause of cancer-related death for women in developing countries [2].

Conventional MRI has an established role in gynecologic imaging. However, increasing clinical demand for improved lesion characterization and disease mapping to optimize patient management has resulted in the incorporation of newer sequences, such as diffusion-weighted imaging (DWI) [4].

DWI is a noninvasive technique that enables the assessment of morphologic and physiologic changes in a single examination. It also allows for a quantitative evaluation of ADC from images with different b-values [5].

This technique is a functional tool that relies on tissue water displacement to create a contrasted image. For correct evaluation and avoidance of pitfalls, the generated images must be interpreted alongside anatomical sequences. The apparent diffusion coefficient (ADC) map is also needed to reduce image misinterpretation [6].

DWI can provide excellent tissue contrast, making it an excellent choice in cases where contrast administration is not possible. Furthermore, the additional scanning time is relatively short [7].

DWI is a potentially useful adjunct to conventional MRI in the evaluation of gynecologic tumors, thus improving the overall diagnostic accuracy, tumor staging, prediction of response to therapy, and treatment follow-up [8].

DWI and ADC map help in differentiation of benign from malignant zones of cervix without exogenous contrast [8]. The measurement of ADC value in patient with cervical cancer is an important factor for assessing response to chemoradiotherapy [9].

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Aim of the work:
To evaluate the role of diffusion weighted magnetic resonance imaging (DW-MRI) in the diagnosis of cervical carcinoma.

Patients and Methods

The study group consisted of 20 female patients diagnosed with cervical cancer radiologically. Pelvic MR, DWI and DCE- MR were done for all patient. The patient's age ranged from 30 to 87 years old. The study was conducted in Radiology Department at Ain Shams University Hospitals. While, patients with contraindications to MRI were excluded from the study.

MRI imaging:
MR imaging were performed on 1.5 T machine (Achieva, Philips medical system, Eindhoven, Netherlands) using phased array pelvic coil. All the patients were imaged in the supine position with head first and were asked not to move during examination.

Imaging protocol:
T2 -weighted image in axial, sagittal and coronal planes. DW-MRI will be acquired in the axial plane prior to administration of contrast medium. Dynamic contrast-enhanced MRI: Post contrast T1 fat sat images will be obtained immediately after manually injected gadolinium.

Statistical analysis:
Data were analyzed using Statistical Program for Social Science (SPSS) version 20.0. Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

Results

The included 20 patients ages ranged between (30-87) years (mean age: 54.55±15.49), 50% of patients were ≤55 years and 50% of them were >55 years.

The irregular vaginal bleeding (35%), postmenopausal bleeding (65%) were the presentation of the study.

The size of lesion ranged between 2cm to 5cm (70%) and >5cm (30%) of size lesion (cm²).

Table (1): Signal intensity of T1 and T2 in conventional MRI.

<table>
<thead>
<tr>
<th>Signal intensity</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isointense</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Low</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>High</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

On T1 weighted images, isointense signal intensity was found in 3 cases (15%), low signal intensity was found in 17 cases (85%). On T2 weighted images, hyperintens signal intensity was found in 5 cases (25%), isointense signal intensity was found in 14 cases (70%), low intense signal intensity was found in 1 cases (5%). On T1 post contrast enhancement, heterogeneous enhancement was found in 17 cases (85%), homogenous enhancement was found in 2 cases (10%) and mural enhancement was found in 1 case (5%).

Lesions in all cases were seen restricted on DWI (high signal intensity in DWI with low ADC map) with heterogenous patterns was seen in (17/20, 85%) cases, homogenous patterns was seen in (2/20, 10%) and mural pattern in (1/20, 5%) case.

Table (2): DWI signal intensity distribution of the study group.

<table>
<thead>
<tr>
<th>DWI</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

Table (3): Quantitative ADC value (x10^-3 mm²/sec) distribution of the study group.

<table>
<thead>
<tr>
<th>ADC Value (x10^-3 mm²/sec)</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.8 x10^-3 mm²/sec</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>≥0.8 x10^-3 mm²/sec</td>
<td>15</td>
<td>75</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

Range (Mean±SD) 0.6-0.9 (0.79±0.08)

All lesions showed low ADC maps from 0.6 to 1.2 (x10^-3 mm²/sec) and the mean was 0.6-0.9 (0.79±0.08).

All lesions extended to the upper 1/3 of vagina (100%) and (10%) of cases extended to lower 1/3 of vagina.

The parametial invasion was seen in 15 cases (75%).

Lymp nodes involvement was seen in 17 of cases (85%).

A total 20 cervical cancer lesions, 5 lesions were stage IIA (25%), 10 lesions were stage IIB (10%), 4 lesions were stage IVA(20%) and 1 lesion was stage IVB (5%) of figo classification.

A Female patient 67 years old presenting with vaginal bleeding of two months duration (Fig. 1).
Fig. (1): DWI image in Fig. (E,F) revealed the presence of ill defined soft tissue mass lesion measuring 2.8x3.3x4.3cm extending downwards into the upper 2/3 of the vagina, no parametrial invasion. It shows high signal on DWI with homogenous pattern and low signal on the corresponding ADC maps (Fig. F). ADC value was $(0.836 \times 10^{-3} \, \text{mm}^2/\text{s})$. The patient was diagnosed as cancer cervix with extensions as described, stage IIa with lymph nodes.
A female patient 39 years old presenting with vaginal bleeding (Fig. 2).

Fig. (2): DWI image Fig. (E,F) revealed the presence of ill defined soft tissue mass lesion measuring 4.2x4.8x5.4 cm, extending to upper one third of vagina with bilateral parametrial extension. The cervical lesions show high signal on DWI with homogenous pattern, and low signal on the corresponding ADC maps (Fig. F). ADC value was \(0.7 \times 10^{-3}\) mm/s. The patient was diagnosed as cervical carcinoma with extensions as described, stage IIb.
A female patient 49 years old presenting with vaginal bleeding (Fig. 3).

DWI images Fig. (E,F) revealed the presence of ill defined soft tissue mass lesion measuring 7x7.2x5.1cm, extending to lower 1/3 of vagina and it infelterate the Urinaruy bladder and rectum with bilateral parametrial invasion, Bilateral external iliac lymph nodes are seen. The cervical lesions show high signal on DWI with homogenous pattern, and low signal on the corresponding ADC maps (Fig. F). ADC value was (0.6 x10^-3 mm^2/s). The patient was diagnosed as cancer cervix with extensions as described, stage IVA.

Fig. (3): DWI images Fig. (E,F) revealed the presence of ill defined soft tissue mass lesion measuring 7x7.2x5.1cm, extending to lower 1/3 of vagina and it infelterate the Urinaruy bladder and rectum with bilateral parametrial invasion, Bilateral external iliac lymph nodes are seen. The cervical lesions show high signal on DWI with homogenous pattern, and low signal on the corresponding ADC maps (Fig. F). ADC value was (0.6 x10^-3 mm^2/s). The patient was diagnosed as cancer cervix with extensions as described, stage IVA.
Cervical cancer is the third most common cancer in women worldwide [1]. In Egypt, cervical cancer ranks as the second most frequent cancer after breast cancer [3].

This study was conducted at the Radiology Department in Ain Shams University Hospitals. This study group consisted of 20 female patients diagnosed with cancer cervix. Pelvic MR with DWI and DCE-MR were done for all patients. The patient’s age ranged from 30 to 87 years old. Ten patients (50%) were <55 years and 10 (50%) were >55 years with mean age 54.5 years. The clinical presentations of women with cervical cancer are abnormally vaginal bleeding, vaginal discomfort, malodorous discharge and dysuria [10]. In our study, the clinical presentations were postmenopausal bleeding (13/20, 65%), vaginal bleeding (7/20, 35%).

Cervical carcinoma is isointense in T1 compared with pelvic muscles and high signal in T2 relative to the low signal of the cervical stroma [11]. Regarding the signal intensity of the cervical lesions at T1WIs in this study, hypointense T1 signal was seen in 17/20 (85%) cases and iso-intense signal in 3/20 (15%) cases. Hyper intense T2 signal was seen in (5/20, 25%) cases, intermediate signal intensity in (14/20, 70%) and low signal intensity T2 in (1/20, 5%). This was in agreement with Patel et al., 2010 who reported cervical tumors to give iso to high signal compared to cervical stroma on T2. However, delineation of the tumor can be challenging in young patients with intermediate signal cervix, especially in those with small tumors [12].

In Dynamic contrast-enhanced MRI (DCE-MRI) showed heterogeneous post-contrast enhancement in 17/20, (85%), homogenous post-contrast enhancement in 2/20 (10%) and mural enhancement in 1/20 (5%) cases. In Abdelsalam et al. [18], study The hypointense T1 signal was seen in 34/70 (48.5%) cases, iso-intense signal in 28/70 (40%) cases, hyper-intense T1 signal was seen in 6/70 (8.5%) cases.

T2WIs showed hyper-intense signal in 62/70 (88%) cases and intermediate signal in 2/70 (2.8%) cases and heterogeneous signal intensity in 6/70 (8.5%). Heterogeneous post-contrast enhancement was seen in 40/70, (57%), homogenous post-contrast enhancement in 20/70 (28.5%) and mural enhancement in 4/70 (9%) cases.

In qualitative analysis of DWI, the tumors cells appeared hyperintense (bright) at high b-value as water movement is restricted and hence reduced ADC values in ADC maps [14]. In this study all lesions showed diffusion restriction (high signal intensity in DWI and low signal intensity in ADC maps) with heternogenous patterns was seen in (17/20, 85%) cases, homogenous patterns was seen in (2/20, 10%) and mural pattern in (1/20, 5%) case. DWI can yield quantitative information that provides unique tumor characteristics. To our knowledge, the performance of DWI in the characterization of cervical carcinoma has been investigated only in a few studies. Naganawa et al., 2008 applied DWI to cervical carcinoma and found that the mean ADC value of cervical cancer lesions (1.09±0.20 x10^{-3} mm³/sec) was lower than that of normal cervix (1.79±0.24 x10^{-3} mm³/sec). Although the cohort used in that study contained a very small population (n=12) of cervical carcinoma, the result showed the potential ability of measuring the ADC value to differentiate between normal cervix and cervical cancer.

In a study of Hoogendam et al. [8] where the mean ADC of uterine cervical cancer of 20 cases was (0.9 ± 10^{-3} mm³/sec). In a study conducted by Kuang et al., 2019 to evaluate the potential value of apparent diffusion coefficient (ADC) measurement in the assessment of cervical cancer on 112 patients with cervical cancer underwent DWI in addition to routine MR imaging at 3.0-T MRI, the ADCs of cervical cancer were significantly lower than those of normal cervix (1.7 x 10^{-3} mm³/sec). In a study carried out by McVeigh et al. [16], diffusion-weighted MRI was performed in 47 patients with cervical carcinoma a 1.5-T system with a b-value of 600s/mm², the mean ADC (mADC) of cervical carcinomas (0.89 ± 10^{-3} mm³/sec) was significantly lower than normal cervix (1.6 ± 10^{-3} mm³/sec). A study carried out by J. Magn et al., 2017, the mean ADC values for cervical carcinoma were (0.916 ± 0.15 SD mm²/sec), Nakamura et al., 2012 studied 80 cervical cancer patients who underwent pelvic MRI within the 2 to 4 weeks before radical hysterectomy. They reported that the mean ADC value was (0.852 ± 10^{-3} mm³/sec). They also found that well differentiated tumors had higher ADC values than poorly differentiated tumors (1.2 ± 10^{-3} mm³/sec vs. 1.1 ± 10^{-3} mm³/sec) (p=0.01). While vast majority of studies have imaged early stage tumors with ADC values ranging between (0.86-1.38 x10^{-3} mm³/sec). In our study we measured the ADC values of cervical carcinoma was (0.6-0.9 x10^{-3} mm³/sec). We found that the mean ADC value of cervical carcinoma was lower than that of normal cervical tissue, which was in agreement with previous studies.
Accurate assessment of parametrial infiltration is essential for the decision making in management of cervical cancer. Clinical assessment of parametrial and pelvic side wall invasion has a reported accuracy of only 29-53%. While an experienced clinician can usually detect gross parametrial invasion, early invasion usually goes undetected [6].

DWI is a very promising technique that can help with detection and staging of cervical cancer. Most authors agreed that by using conventional MRI, a visible cervical tumor indicates stage Ib or IIb, and presence of a positive node indicates poor prognosis in each stage [20]. Although pelvic lymph nodes involvement was seen in (17/20, 85%). Although pelvic lymph node metastasis is not considered in FIGO classification was FIGO IIa was seen in (1/20, 5%) cases and to the lower 1/3 was seen in (20, 10%) cases. Also parametrial invasion was seen in (15/20, 75%), And lymph nodes involvement depends on the stage, surgical treatment is the preferred modality for the treatment of small, early stage Ib1/ Ib2 and Ia1A lesions. More advanced lesions (eg Ib3 and higher) are treated with chemo/radiation therapy so imaging provides valuable clinical information during treatment Planning [24].

In the present study, the staging of cancer cervix according to figo classification was figo IIa was seen in (5/20, 25%), figo IIb was seen in (10/20, 40%), figo IVa was seen in (4/20, 20%), figo IV was seen in (1/20, 5%).

Conclusion:

DWI is a potentially useful adjunct to conventional MRI in the evaluation of gynecologic tumors, thus improving the overall diagnostic accuracy, tumor staging.

References


دور الرنين المغناطيسي بالانتشار الجزئي في تشخيص سرطان عنق الرحم

يعد الرنين المغناطيسي وسيلة مثالية للتشخيص، رصد أثبتت قوةً على الوسائل الأخرى للتشخيص بالنسبة لأمراض منطقة الحوض. يظهر الرنين المغناطيسي العلاقة التشريحيّة للأحماء الدخيلة بالحوض ومنها عنق الرحم. يلعب الرنين الوظيفي دوراً هاماً في التفريق بين الأنسجة السرطانية والغير سرطانية في حالات سرطان الرحم وعنق الرحم وكذلك تحديد نوع التدخل الجراحي ودرجة الاستجابة للعلاج.

مع تطور التقنيات الحديثة في التشخيص، تم استخدام تقنيات جديدة للتصوير الوظيفي، منها الرنين المغناطيسي بالانتشار الجزئي والرنين المغناطيسي متعدد المراحل والتي أصبحت تستخدم الآن في فحوصات البطن والحوض.

تعتبر فكرة الرنين المغناطيسي بالانتشار الجزئي أن جزيئات الماء تنتشر بحرية في البيئات منخفضة الخلوية، في حين أن البيئات ذات الخلية المرتفعة تؤدي إلى إعاقة تدفقها أو تقييدها في ظاهرة تسمى (الحركة البراونية). ولذلك تظهر الأورام الخبيثة تقييد لجزيئات الماء وذلك لارتفاع خلوتها على المكس من الأورام الحميدة.

هذه التقنية لا تعتمد على حقن الصبغة وبالتالي يمكن استخدامها خاصة في الحالات التي يتسبب فيها استخدام الصبغة كما هو الحال في حالة الحمل.

وقد أظهرت نتائجنا أن أضافة الرنين المغناطيسي بخصائص الانتشار الجزئي إلى التصوير التقليدي أدى إلى زيادة دقة التشخيص وجعله أكثر خصوصية لتحديد نوع الورم وتحديد درجة انتشار الأورام وبالتالي تحديد نوع العلاج المناسب ويمكنه المساعدة في تحديد مدى الاستجابة للعلاج وفي اكتشاف رجوع المرض مرة أخرى وكذلك في التخطيط للعلاج الشعاعي.