ORIGINAL ARTICLE

Can diffusion weighted imaging distinguish between benign and malignant solid or predominantly solid gynecological adnexal masses?

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DWI; Solid; Gynecological; Adnexal; Masses

Abstract Objective: To determine the benefit of DWI in diagnosis of benign and malignant solid or predominantly solid gynecological adnexal or ovarian masses.

Material and Methods: This study is carried out on 23 patients with histologically proven solid or predominantly solid adnexal or ovarian masses out of which 5 cases (21.8%) have benign and 18 cases (78.2%) have malignant neoplasms. Among these 19 cases (82.6%) have unilateral disease and 4 cases (17.4%) have bilateral disease which was metastatic ovarian carcinoma.

Result: On DWI, high signal intensity is noted in malignant lesion more frequently than in benign lesion. \(P < 0.001\) in adnexal lesions, while in ovarian lesions \(P = 0.001\).

The differentiation between benign and malignant adnexal lesions revealed no significant difference in the apparent diffusion coefficient (ADC) value \(P = 0.22\).

Conclusion: DWI is a helpful tool in differentiation between predominantly solid and solid benign and malignant adnexal lesions because there is an increased frequency of higher signal intensity (diffusion restriction) in malignant lesions.

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1. Introduction

MRI plays an increasingly important role in the evaluation of the patients with adnexal disease. Accurate tissue characterization often allows definitive diagnosis not possible with other imaging modalities (1). Studies have looked at the utility of MRI in the differential diagnosis of benign and malignant lesions using some morphological and signal intensity features of the lesions (2–5). The use of DWI and ADC mapping in
the radiologic differential diagnosis of neoplasms was first suggested for the central nervous system (CNS) and the head and neck regions (6). But over time DWI became recognized and accepted in body imaging for detection and characterization of focal lesion (7–11). Our goal in this study was to evaluate the role of DWI and ADC in discrimination between benign and malignant solid or predominantly solid adnexal or ovarian masses.

2. Materials and methods

The study is carried out on 23 patients, collected from gynecological department in the Zagazig University Hospitals during the period from February 2010 to February 2011. These patients are classified into two groups.

First group consists of 5 patients with pathologically proved benign adnexal lesions. Their age ranged from 20 to 60 years. Second group consists of 18 patients with pathologically proved malignant adnexal lesions. Their age ranged from 30 to 70 years.

Among these 23 patients, 19 patients have unilateral lesions and 4 cases have bilateral lesions which were metastatic ovarian carcinomas. All these cases were diagnosed by transabdominal (TA) and transvaginal (TV) ultrasound as adnexal masses having solid or predominantly solid lesions.

2.1. MRI Protocol

MRI machine, 1.5 Tesla with phased-array body coil.

Imaging sequences and parameters are:

- Sagittal T1 – HASTE-T2 – T2-FSAT WIs.
- Axial T1 – HASTE-T2 – T2-FSAT WIs.
- Coronal HASTE-T2.

Axial Diffusion WI (DWI): single shot echo planar during normal respiration. TR/TE = 7006/86; section thickness 6 mm; intersection gap 1 mm; matrix size 128 × 128; FOV 360 × 360 mm; partial Fourier factor 6/8; band width 1158, five excitations, b0, b400, b800 with fat saturation.

Apparent Diffusion Coefficient (ADC) axial image.

Sagittal – axial-coronal VIBE pre and post contrast.

2.2. Image analysis

The acquired images are transferred to a work station, on which all ADC maps are performed. The mean ADC volume is determined and the signal intensity of the lesions is measured.

2.2.1. Qualitative analysis

The lesions are evaluated for signal intensity on DWI at maximum b value (b = 800 s/mm²), T2WI and post contrast images.

At least 3 areas of solid tissue signal changes are used in complex masses choosing the highest signal regions to evaluate restriction on DWI (800 s/mm²).

On DWI, the signal intensity of each lesion is evaluated as hyper, hypo or iso-intense relative to the myometrium. None of our cases had hysterectomy; however, in case of hysterectomy or abnormal myometrial signal we can use the pelvic muscles as a reference but this needs further study.

On T2 WI, the signal intensity of each lesion is evaluated by comparison with signal intensity of the outer myometrium.

On T1, post contrast image, the enhancement pattern is divided into:

- First group: Marked enhancement; for the lesions whose signal intensity was equal to or higher than the myometrium.
- Second group: Mild enhancement; for the lesions with lower signal intensity than the myometrium.

2.2.2. Quantitative analysis

The (ROI) region of interest is placed within the lesions in the area with the Lowest ADC volume on ADC map and highest intensity on DWI (800 s/mm²) and mean value is calculated.

For adnexal lesions, we compared benign with malignant lesion.

For ovarian lesions we compared benign with malignant lesions and malignant lesions of ovarian origin with those of metastatic origin.

2.2.3. Statistical analysis

Final diagnosis is performed by biopsy and histopathology (Table 1).

3. Result

3.1. Adnexal lesions

3.1.1. Qualitative analysis

Fifteen cases of the total 23 cases (15 of 18 malignant lesions) have higher signal intensity on DWI. This means that the higher signal intensity is noted more frequently in malignant than in benign adnexal lesions (P < 0.001). Two cases of malignant lesions have iso-intense signal on DWI and 1 benign lesion has iso-intense signal on DWI (P 0.53).

Four cases of the benign lesions have hypointense signal on DWI and 1 malignant lesion was hypointense (P 0.002). (Table 2).

Leiomyoma had low signal intensity on DWI.

Leiomyosarcoma appears heterogenous with the main component appearing mildly hyperintense on DWI. Eleven cases of 23 patients (11 of 18 malignant lesions) have hyperintense signal on T2 WI of its solid component (Table 3), while solid components of benign lesions in this study show hypointensity on the T2 WI in only one case (excluding fat containing lesions or cystic components). So that, hyperintense signal on T2 WI is noted more in solid parts of the malignant lesions (P < 0.0001). On the other hand, low signal intensity is noted more in the solid parts of benign lesions than in malignant lesions (P = 0.000). On post contrast T1 WI (Table 4), 16 of the total 23 cases (14 from 18 malignant lesions and 2 from 5 benign lesions) show marked post contrast enhancement. This means, there is a significant difference between benign and malignant adnexal lesions on T1 post contrast images (P = 0.14).
3.1.2. Quantitative analysis (Table 1)

The was no significant difference in ADC values of the benign and malignant lesions, however, the signal intensity or DWI is higher in malignant lesions in comparison with the benign lesions.

3.2. Ovarian lesions

There are 3 benign ovarian lesions (Figs. 1 and 2) and 16 malignant ovarian lesions (Figs. 3–5).

3.2.1. Qualitative analysis

Three benign lesions have low or iso-intense signal intensity on DWI in comparison with malignant lesions (Figs. 1 and 2). Fifteen of 16 malignant lesions have higher signal intensity on DWI (Figs. 3–5). Only one malignant ovarian lesion was iso-intense on DWI (Table 5).

This means the malignant ovarian lesions have higher signal intensity on DWI than the benign lesions (Table 5) ($P = 0.001$).

Twelve of 16 malignant ovarian lesions have hyperintense signal of its solid component on T2 WI (Table 6), while hyperintensity detected on T2 WI is seen only in one case of benign ovarian lesions (struma ovarii Fig. 1).

Twelve out of 16 malignant ovarian lesions have marked T1 post-contrast enhancement (Figs. 3 and 4), while marked post contrast T1 enhancement is detected in one case only of all benign ovarian lesions ($P = 0.22$) (Table 7).

3.2.2. Quantitative analysis (Table 1)

There is no significant difference in ADC value between benign and malignant adnexal lesions ($P = 0.22$).

4. Discussion

DWI gives information about the biophysical properties of the tissue, so that it is useful in body imaging as it helps in the detection and characterization of focal lesions. On the other hand, ADC value is related to the cellularity or cell density. When the tissue cellularity or cell density increased, the ADC value decreased and this might indicate malignancy with large cell diameter and cell density which restricts water diffusion. While a decrease in tissue cellularity and density results in increased ADC value which reflects the benign process (9). Nakayama et al. (7) stated that malignant and benign ovarian cystic fluids cannot be differentiated based on the findings on EPDWI or the ADC value, according to this we use the DWI and ADC map changes.

The result of our study shows that, there was no significant difference noted between benign and malignant solid adnexal lesions on ADC value. Furthermore, the ADC values of primary malignant ovarian neoplasm, metastatic ovarian lesion and recurrent ovarian neoplasm were overlapped.

Bakir et al (12), and Fujii et al (13), agree with our study because they reported that ADC value did not differ significantly between benign and malignant lesions with many overlaps between ADC values of both categories. This overlap which was explained by Fujii et al is due to increased mean ADC values in the malignant lesions and the decreased ADC values in benign lesions as the desmoplastic reaction in the stroma may cause increased mean ADC values in malignant tumors (13).

A significant difference in signal intensity between benign and malignant solid adnexal lesions is noted on DWI when compared to ADC values, high signal intensity was observed more frequently in malignant lesions when evaluated on DWI quantitatively or qualitatively than benign lesion.

Fujii et al, also reported that the solid malignant ovarian tumors show high signal intensity on DWI. In our study, 15 of 16 malignant ovarian lesions demonstrated high signal intensity on DWI, one malignant ovarian lesion was isointense which pathologically was serous cyst adenocarcinoma, one adnexal lesion was hypointense which proved pathologically to be a broad ligament leiomyosarcoma, the other adnexal

| Table 1 | Shows the number of pathologically proven solid benign and malignant adnexal lesions, the measured ADC range and the mean ADC value. |
|---|---|---|
| Lesions | No. of lesions | ADC (mean ± SD) |
| **A. Benign** | | |
| 1. Adnexal | | |
| a. Broad ligament leiomyoma | 2 | 0.69 ± 0.42 |
| 2. Ovarian | | |
| a. Fibroma | 1 | 0.72 |
| b. Struma ovarii (Fig. 1) | 1 | 0.90 |
| c. Fibrothecoma (Fig. 2) | 1 | 0.85 |
| Total | 5 | |
| **B. Malignant** | | |
| 1. Adnexal | | |
| a. Broad ligament leiomyosarcoma | 1 | 0.86 ± 0.86 |
| b. Papillary serous adenocarcinoma of fallopian tubes | 1 | 1.20 |
| 2. Ovarian | | |
| a. Granulosa cell tumor (Fig. 5) | 4 | 1 ± 0.12 |
| b. Dysgerminoma | 4 | 0.70 ± 0.15 |
| c. Serous cyst adenocarcinoma (Fig. 3) | 3 | 0.76 ± 0.1 |
| d. Recurrent ovarian carcinoma | 1 | 0.98 |
| e. Metastatic ovarian carcinoma (Fig. 4) | 4 | 0.97 ± 0.11 |
| Total | 18 | |
A malignant lesion was isointense and was pathologically a papillary serous adenocarcinoma of fallopian tubes. Our observation was in concordance with Fujii et al. and Bakir et al, who reported that higher signal intensity is observed in malignant ovarian lesions than in benign lesions.

In our study, there is no significant difference seen on DWI between signal intensities of primary, secondary and recurrent ovarian tumors. However, there is a significant difference in ADC value between primary, secondary and recurrent ovarian tumors but there was an overlap between the two groups suggesting that DWI cannot be used to differentiate primary malignant and metastatic ovarian lesions.

We observed that the benign lesion demonstrated a hypointense signal in DWI more than malignant lesions, one case was isointense which proved to be struma ovarii. Our observation was in concordance with Fujii et al. and Bakir et al, who reported that higher signal intensity occurred less in benign ovarian lesions than in malignant lesions considering that benign lesion in our study was less than malignant lesions.

In our study, the malignant ovarian lesions had marked enhancement on T1 post contrast image while only one case of the benign ovarian lesions (struma ovarii) had marked enhancement.

In our study, the malignant adnexal and ovarian lesions demonstrate on T2 WI higher signal intensity while benign lesions demonstrate low signal intensity except in one case only (struma ovarii) which shows higher signal intensity, and the difference was statistically significant.

In addition, higher signal intensity on T2 WI associated with more enhancement on post contrast T1 WI, reflects the malignant nature of the lesion, while low signal intensity on T2 WI associated with mild post contrast enhancement reflects the benign nature of the lesion except in struma ovarii which

### Table 2

<table>
<thead>
<tr>
<th>Signal intensity</th>
<th>Benign lesion (No. = 5)</th>
<th>Malignant lesion (No. = 18)</th>
<th>P value</th>
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<tbody>
<tr>
<td>Hyperintensity</td>
<td>0</td>
<td>15 (83%)</td>
<td>0.001</td>
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<tr>
<td>Hypointensity</td>
<td>4 (80%)</td>
<td>1 (6%)</td>
<td>0.002</td>
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<tr>
<td>Iso-intensity</td>
<td>1 (20%)</td>
<td>2 (11%)</td>
<td>0.53</td>
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### Table 3

<table>
<thead>
<tr>
<th>Signal intensity</th>
<th>Benign lesion (No. = 5)</th>
<th>Malignant lesion (No. = 18)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperintense</td>
<td>1 (20%)</td>
<td>11 (61%)</td>
<td>0.15</td>
</tr>
<tr>
<td>Hypointense</td>
<td>3 (60%)</td>
<td>1 (6%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Iso-intense</td>
<td>1 (20%)</td>
<td>6 (33%)</td>
<td>1.0</td>
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### Table 4

<table>
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<tr>
<th>Degree of enhancement</th>
<th>Benign lesions (No. = 5)</th>
<th>Malignant lesions (No. = 18)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marked</td>
<td>2 (40%)</td>
<td>14 (78%)</td>
<td>0.14</td>
</tr>
<tr>
<td>Mild</td>
<td>3 (60%)</td>
<td>4 (22%)</td>
<td>0.14</td>
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</table>

**Fig. 1** Pathologically proven struma ovarii of right ovary. (a) Coronal HASTE image shows right side hyperintense lesion. (b) Axial post contrast image shows evident enhancement of the lesion. (c) DWI-b800 of the lesion shows isointense signal with no evidence of restriction. (d) ADC image with the lesion hypointense in signal.
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Fig. 2 Pathologically proven fibrothecoma. (a) Axial HASTE image shows globular hypointense mass in the pelvis with ascites. (b) Axial post contrast study shows mild enhancement of the lesion. (c) DWI-b800 shows hypointense signal with no restriction. (d) ADC image with the lesion hypointense in signal.

Fig. 3 Pathologically proved cystadenocarcinoma. (a) HASTE coronal shows mixed solid and cystic component lesion with solid parts appearing as isointense signal. (b and c) Post contrast axial and coronal images showing enhanced solid nodular part. (d) DWI b800 shows diffuse restriction with hyperintense signal.
shows high signal intensity on T2 WI and marked T1 post contrast enhancement. These are considered as valuable information to help in decision making.

So, in our study, most of the malignant lesions showed evidence of diffusion restriction with hyperintense signal in $b = 800$, hyperintense signal in T2WI with significant post
contrast enhancement. While the benign lesions showed lower signal intensity in the same $b = 800$ level with less signal in T2WI and mild post contrast enhancement. ADC map was inconclusive to differentiate the benign from malignant lesions.

5. Conclusion

Diffusion weighted image is helpful in differentiation between benign and malignant adnexal as well as ovarian lesions, where a higher signal intensity is observed more frequently in malignant lesions. Lesions with low signal intensity on DWI with $b$-value 800 or more are almost always benign, however there is some overlap where a small number of malignant cases were isointense and hypointense indicating that DWI is helpful but not able to make a consistent distinction. ADC value cannot significantly differentiate between benign and malignant adnexal and ovarian lesions because there is an overlap between both. Accordingly, DWI, ADC maps are valuable sequences to add to the routine pelvic MRI to help differentiate the benign from malignant lesions, aiding the surgeon’s decision and management. However, a post contrast study cannot be replaced as it helps in the decision of vascularity and integrity of the lesions.

References