ORIGINAL ARTICLE

Role of Diffusion Weighted MR Imaging (DWI) In Characterization of Complex Adnexal Masses

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Abstract

Background: ***The primary reason for gynecologic surgery is still adnexal masses. With the use of imaging techniques, we hope to decrease the number of women who needlessly undergo cancer surgeries, help young women maintain their fertility (through the use of laparoscopy), and, if needed, refer patients to tertiary referral centers that have specialist gynecologic oncologists so that they can receive the best primary surgical treatment possible.***

Aim and objectives: ***Bringing attention to the use of diffusion weighted imaging(DWI) in the description of complex adnexal masses.***

Subjects and methods: ***This prospective diffusion MRI study included 50 participants, whose ages ranged between 20 and 68 years, with a mean age of 39.5 39.5-years. The study was conducted on patients who were referred from gynecological departments to the Department of Radiodiagnosis of Al-Zahraa University Hospital, and other private places during November 2017 to May 2023.***

Results: ***When endometrioma, mature cystic teratoma, and tubo-ovarian abscess cases are excluded from the study, DWI is associated with high sensitivity and specificity and appears to be an effective approach for discriminating between benign and malignant adnexal lesions.***

Conclusion: ***By employing a method that does not involve any radiation and is entirely noninvasive. It is worth considering DWI as a substitute for contrast administration in cases where it is best to avoid it, such as during pregnancy. Efficient method (no extra expense to MRI scan), simple to incorporate into MR study protocols, and does not significantly increase scan duration. In order to distinguish between benign and malignant adnexal lesions, DWI is crucial for the Adnex MR score.***

Keywords: Weighted MR imaging(DWI);Adnexal masses

1. Introduction

The primary reason for gynecologic surgery is still adnexal masses. Imaging procedures aim to decrease the number of women having cancer surgeries that aren't necessary, keep young women's fertility(through laparoscopy), and, when needed, refer patients to tertiary referral centers with gynecologic oncologists for the best possible primary surgical treatment.[1]

In challenging circumstances, pelvic magnetic resonance imaging can help establish a more conclusive diagnosis. If an ultrasound cannot diagnose a cystic or solid adnexal or ovarian mass, or if the ultrasound findings are inconclusive, an MRI may be ordered. The location and kind of mass (cystic, solid, or both) can be shown using magnetic resonance imaging. When it comes to distinguishing between benign and malignant tumors, MRI is very accurate.[1]

A noninvasive imaging technique, diffusion weighted imaging aids in the differentiation of benign from malignant lesions, raises contrast between lesions and surrounding tissues, and enhances the identification and delineation of peritoneal implants during initial staging and follow-up. In addition, DWI offers quantitative data on tissue cellularity, which can be utilized to differentiate between live tumors and alterations caused by treatment.[2]

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Areas with low apparent diffusion coefficient values or "restricted" diffusion tend to correspond with hypercellularity foci when DWI is applied in gynecologic applications. When looking for a return of a tumor, DWI can be helpful. On DW pictures, tumor recurrence areas seem brilliant, yet on ADC maps, the signal strength is low.[3]

The primary objective of this research was to demonstrate how DWI can be used to characterize intricate adnexal masses.

2. Patients and methods

This prospective diffusion MRI study included 50 participants, whose age ranged between 20 and 68 years, with a mean age of 39.5 39.5-years. The study was conducted on patients who were referred from gynecological departments to the Department of Radiodiagnosis of Al-Zahraa University Hospital, the Department of Radiodiagnosis of Nasr City Specialized Hospital, and Misr Scan Radiology Center during November 2017-May 2023.

Inclusion criteria:

Cystic lesions with solid component/septations, pure solid lesions, solid lesions with cystic component, and large masses.

Exclusion criteria:

Completely non-cystic lesions, as well as situations including common MRI contraindications such as cardiac pacemakers, ferromagnetic aneurysm clips, and metallic objects.

Ethical consideration:

All research subjects provided their informed consent after the institutional ethical committee had given its permission. The names of the subjects were obscured on any images used in the study or published in the research report, and all data and investigations of the subjects kept in strict confidence with a private file for each subject.

Methodology:

Participants in this study were required to undergo the following procedures:

Patients' ages, symptoms reported, and medical history are all part of the data set. Common complaints include: fever and abdominal discomfort(n=2), infertility, dysuria, weight loss, and chronic abdominal pain(n=23). Transabdominal pelvic ultrasound examinations and other investigations for various pathologies can sometimes lead to the unintentional discovery of adnexal lesions. Medical history, including any procedures or medications that may have increased the risk, such as oral contraceptives

Diagnostic assessment:

Preliminary transabdominal/transvaginal pelvic US exams were performed on all patients utilizing 3-4MHz abdominal convex probes and 7-8MHz transvaginal probes. In order to identify vascularity, Color Doppler was overlay on masses.

MR imaging: A 1.5-T magnet was used to do MR imaging on a medical system manufactured by Philips. Supine imaging was performed on all patients using a pelvic phased-array coil (16 channels) from SENSE XL Torso.

MR Imaging analysis:

The following were examined in the MR images:

The included mass's MR appearance and the intensity of its pre-contrast signal. Improvement of the solid part. Wall thickness, presence of vegetation, and mural augmentation are all factors in cystic tumors. Having ascites and having one or both ovaries affected. Pathologically enlarged para-aortic or pelvic lymph nodes, infiltration of other pelvic organs by soft tissue, and, if present, peritoneal or omental deposit.

Interpretation of DWI regarding the signal intensity:

The post enhancement criteria, lesion location, morphology, and signal intensity were determined by analyzing the conventional MR images. Next, we compared the results of the DWI and ADC maps to those of the traditional MR scans. The signal intensity of cystic tumors is low in T1-weighted images and high in T2-weighted images. It was thought that a high T1 signal could be caused by blood or fat, such as in dermoid cysts and endometriomas. The fact that the high signal remained in the fat-suppressed photos proved that it was bloody.

It was determined that lesions had restricted diffusion when their T2 signal was high, their DWI signal was high, and their ADC signal was low. T2 shine-through effect, rather than real diffusion restriction, was deemed to be the cause of lesions with strong signal on T2, DWI, and ADC maps. Facilitated diffusion was deemed to have occurred in lesions with a low DWI signal and a high ADC signal. Ovarian fibroma, Brenner tumor, pedunculated subserous fibroid, and other fibrous tumors are characterized by lesions with extremely weak signal intensity on T2WI(T2 blackout effect), DWI, and ADC maps.

Malignant criteria included:

Considerations for staging include a wall thickness of at least 3mm, solid vegetations of more than 1 cm, thick septa measuring more than 3mm, areas of necrosis and breakdown, and indications of tumor dissemination. Omental deposits, peritoneal fluid, ascites, and swollen lymph nodes.[4]

The DWI-MRI signals were low, suggesting that the lesion signals were comparable to those of the pelvic bone and that the intermediate values were comparable to those of the outer myometrium. Similar to endometrial, there are strong signals on DWI-MRI.

We excluded DW photos with a b-value of 0 and 500 seconds/mm2 from our analysis for two reasons:1):they had a smaller diffusion effect and 2):they had a higher T2 shine-through effect. These images were used exclusively for calculating the ADC values. For accurate solid-tissue localization of the studied masses, fusion-merged T2- and DW images were processed utilizing Phillips Advantage Windows workstation with functional tool software.

Quantitative analysis:

Each lesion had a maximum of three regions of interest(ROI) that were manually drawn in both solid and cystic portions. Circular or elliptical shapes with an area ranging between 140 and 220 mm2 were positioned in the middle of the study area.

Analysis was conducted using the mean ADC value after ROIs were drawn within the targeted components in cases of irregular tiny or solid components, abundant flora, or thicker irregular septa. The ADC value that differentiates benign pelvic masses from malignant ones is ≥1.25x10-3mm2/s, as stated earlier in the literature.

Statistical Analysis:

The conventional MRI and DWI suggested pathologies were compared to determine whether they were benign or malignant in correlation with surgical pathology specimens, which are the gold standard of reference. For quantitative variables, mean(as a measure of central tendency) and SD(as a measure of variability) were presented. Frequency and percentages were presented for qualitative variables, sensitivity, and specificity; positive predictive value(PPV), negative predictive value(NPV), and accuracy were all calculated for the conventional MRI and for the DWI.

3. Results

The patients were between the ages of 20 and 68 (mean age: 44.35). The age range for benign tumor cases was 20–53 years old (mean age: 44). Malignant tumor patients, on the other hand, ranged in age from 23 to 68 years (mean age 47.5). Twelve hemorrhagic cysts, eleven endometriomas, three tubo-ovarian abscesses, one ectopic pregnancy, thirteen benign tumors, one borderline, and nine malignant tumors were among the masses whose histology was examined,(table 1;figure 1).

Table 1. The investigation included adnexal masses of a pathological nature.

PATHOLOGY	NUMBERS	FREQUENCY %
HEAMORRAHGIC CYST	12	24%
ENDOMETRIOMA	11	22%
TUBO-OVARIAN ABSCESSES	3	6%
ECTOPIC PREGNANCY	1	2%
BENIGN	13	26%
MATURE CYSTIC TERATOMA	5	10%
SEROUS CYSTADENOMA	2	4%
MUCINOUS CYSTADENOMA	1	2%
FIBROIDS	4	8%
FIBROMA	1	2%
BORDERLINE	1	2%
MALIGNANT	9	18%
GRANULOSA CELL TUMOR	1	2%
PAPILLARY SEROUS CYSTADENOCARCINOMA	2	4%
ENDOMETRIOD ADENOCARCINOMA	1	2%
CLEAR CELL CARCINOMA	2	4%
MUCINOUS CYSTADENOCARCINOMA	2	4%
METASTATIC OVARIAN CARCINOMA	1	2%
TOTAL	50	(100%)

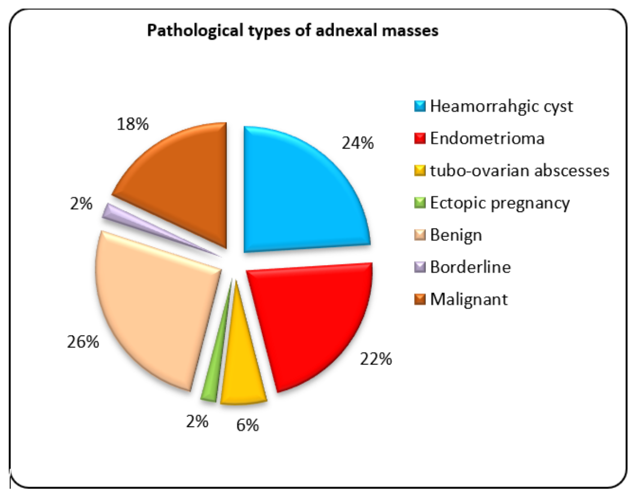

Figure 1. Different pathological types of adnexal masses.

The maximum dimensions of benign and malignant lesions are represented in table 2; figure 2.

Table 2. Minimum and maximum diameters of lesions in cm.

DIMENSION	BENIGN LESIONS	MALIGNANT LESIONS
MINIMUM	3	7
MAXIMUM	17	20
MEAN+/-SD	10 +/- 3.5	13.5 +/- 4.3

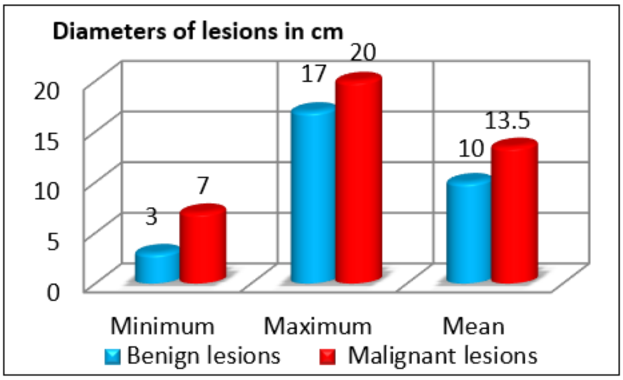

Figure 2. Minimum and maximum diameters of lesions in cm.

Most of the benign and malignant tumors (10/13) displayed low/equal intensity on T1WI and hyper intensity on T2WI, while the majority of ovarian hemorrhagic cysts (10/12) displayed high intensity on T1WI and high/intermediate signal on T2WI. The majority of endometriomas (9/11) appeared as high/equal intensity on T1WI and hypo intensity on T2WI,(table 3).

Table 3. A summary of the MRI signal characteristics for each of the four groups is provided.

PATHOLOGICAL TYPE	T1WI SIGNAL INTENSITY	T2WI SIGNAL INTENSITY
HEMORRHAGIC CYST	High and/Equal intensity(n=10). Mixed intensity(n=2)	High intensity(n=9) Mixed intensity(n=3)
ENDOMETRIOMA	high/equal intensity(n=9) low intensity(n=2)	hypo intensity(n=7) mixed(n=4)
BENIGN TUMOR	Low and/Equal intensity(n=10). high/equal intensity(n=3)	high intensity(n=10) Intermediate intensity(n=3)
MALIGNANT TUMOR	Low and/Equal intensity(n=8) Mixed intensity(n=1)	Intermediate intensity(n=7) mixed(n=2)

Cystic, solid, cystic with septum, cystic with solid, and cystic with solid and septum were the several types of adnexal lesions. We found that the adnexal lesions in our investigation had varying compositions. The majority of endometriomas and hemorrhagic cysts manifested as cystic lesions. The majority of the benign tumors were solid or septally-cylindrical lesions. The most prevalent form in the malignant group was a solid nodule with a cystic component. Three solid lesions were found in the benign group, while one solid lesion was found in the malignant group. The MRI elements in 50 adnexal lesions throughout the 7 categories, (table 4; figure 3).

Table 4. MRI elements in adnexal lesions across seven groups.

PATHOLOGY TYPE	CYSTIC	SOLID	CYST WITH SEPTUM	CYST WITH SOLID	CYST WITH SEPTUM AND SOLID	TOTAL
HEAMORRAHGIC CYST	12(52.2%)					12
ENDOMETRIOMA	11(47.8%)					11
TUBO-OVARIAN ABSCESSES			3(30%)			3
ECTOPIC PREGNANCY				1(10%)		1
BENIGN		5(71.4%)	6(60%)	2(20%)		13
BORDER LINE				1(10%)		1
MALIGNANT		2(28.6%)		6(60%)	1(100%)	9
TOTAL	23	7	10	10	1	50

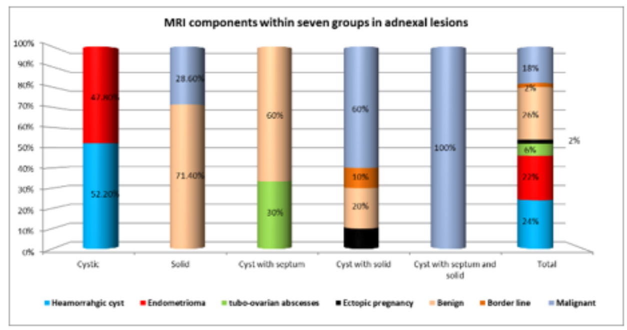

Figure 3. MRI components within the adnexal lesions.

Different adnexal lesions had varying patterns of enhancement on T1 post contrast pictures, according to our findings. Endometrioma did not exhibit any significant enhancement, whereas hemorrhagic cysts did. In contrast to benign lesions, which occasionally had weak enhancement, malignant lesions were shown to exhibit substantial contrast enhancement.

On DWI-MRI, the majority of the adnexal lesions (35/50) had hyperintensity. In this series, the majority of the malignant tumors (7/9) displayed a strong signal. With the exception of endometrioma and malignant tumor, all group differences in DWI-MRI signals were statistically significant. Nonetheless, there were notable differences in the DWI-MRI signals of the lesions between the malignant and non-malignant groups. The seven groups' DWI-MRI signals,(table 5 ; figure 4).

Table 5. Seven sets of DWI findings in fifty adnexal lesions.

PATHOLOGY TYPE	LOW	INTERMEDIATE	HIGH	MIXED	TOTAL
HEAMORRAHGIC CYST			12(34.3%)		12
ENDOMETRIOMA		3(50%)	7(20%)	1(33.3%)	11
TUBO-OVARIAN ABSCESSES			3(8.6%)		3
ECTOPIC PREGNANCY			1(2.8%)		1
BENIGN	6(100%)	3(50%)	4(11.4%)		13
BORDER LINE				1(33.3%)	1
MALIGNANT			8(22.9%)	1(33.3%)	9
TOTAL	6	6	35	3	50

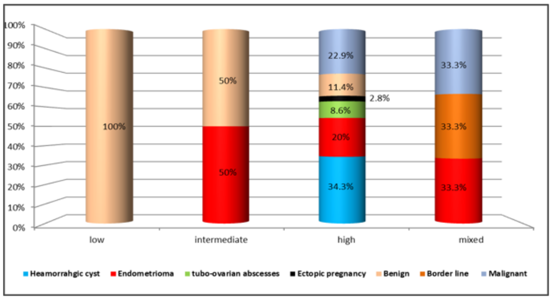

Figure 4. DWI signals within different adnexal lesion.

The malignant tumor, endometrioma, mature cystic teratoma, and tubo-ovarian abscess had the lowest ADC values, whereas serous cystadenoma had the highest, 2.83±0.93. There were no discernible variations in the ADCs between benign and endometrioma, however there was a discernible difference between benign and malignant tumors,(table 6).

Table 6. Different ADC values of the included masses.

PATHOLOGY	ADC VALUES (10-3/MM²/S)
HEAMORRAHGIC CYST	2.31±0.83
ENDOMETRIOMA	1.32±0.71
TUBO-OVARIAN ABSCESSES	1.18±0.167
BENIGN	
MATURE CYSTIC TERATOMA	0.6±0.17
SEROUS CYSTADENOMA	2.83±0.66
MUCINOUS CYSTADENOMA	2.30±1.02
FIBROIDS	1.58±1.09
FIBROMA	1.9
BORDERLINE	1.71
MALIGNANT	
PAPILLARY SEROUS CYSTADENOCARCINOMA	1.12±0.42
MUCINOUS CYSTADENOCARCINOMA	1.21±0.30
ENDOMETRIOID ADENOCARCINOMA	0.75
CLEAR CELL CARCINOMA	1.2±0.37
METASTATIC OVARIAN CARCINOMA	1.14

Using DWI high b-values (800 and 1.000) and corresponding ADC maps, we evaluated the signal intensity of the various ovarian lesions. We discovered that 26 out of 50-lesions (52%), which had a restricted diffusion signal (hyper-intense in DWI and hypo-intense in ADC map), while 30-lesions (48%), which had facilitated diffusion, also showed restricted diffusion, while all borderline (n=1, 100%) and malignant (n=9, 100%) showed restricted diffusion, (figure 5).

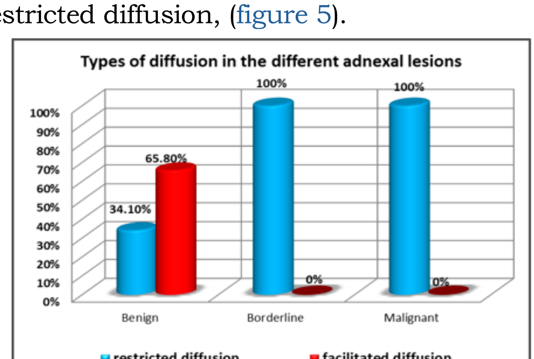

Figure 5. Types of diffusion in the different adnexal lesions.

Case presentation:

Case one:

Forty-five years old female patient with dysuria and abdominal enlargement of about seven-month duration. US showed huge pelvi-abdominal multi-loculated mass. No vascularity was detected on the color Doppler study. MRI was done.

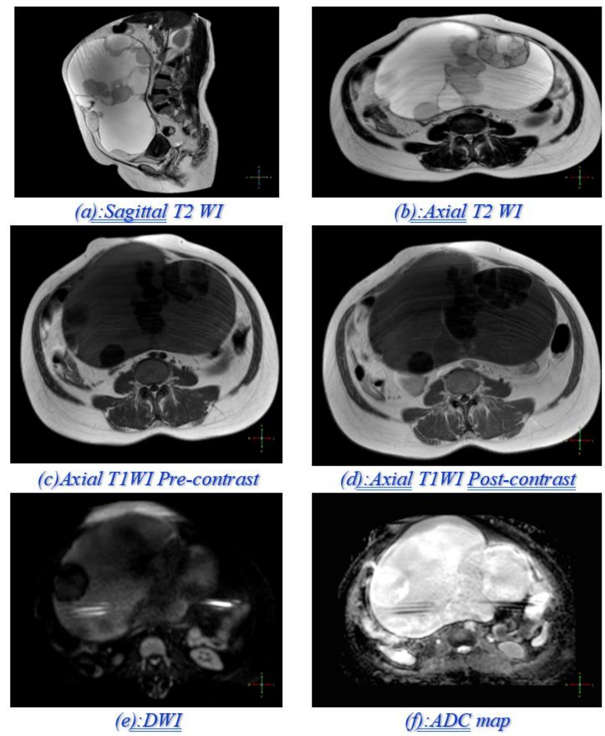

Figure 6. Conventional MRI.

Conventional MRI based Diagnosis:

(a)-Sagittal. (b)-Axial T2WI showed midline large multi loculated adnexal lesion mainly confined to right. It contains multiple locules of variable high signal intensities. (c)-Axial T1WI, showed the lesion of iso and low signal intensity.(d)-Axial post contrast T1WI show no enhancement of the tumor is observed.

It is very indicative of a mucinous cystadenoma, a benign cystic ovarian tumor with varying degrees of signal intensity and no solid component.

DWI:

(e)-axial DWI shows the lesion of Low signal intensity. (f)-ADC maps show high signal intensity(image that could be indicative of a benign tumor lesion in the adnexa). ADC value of the tumor was 2.59x10-3mm2/s(+/-SD 44.4).

Pathological diagnosis: Mucinous cystadenoma.

Case two:

Female patient 52-year-old complaining of abdominal enlargment.US showed large right adnexal cystic lesion with left mural nodule shows vascularity on Doppler examination. MRI was done without contrast(the patient refuses the contrast).

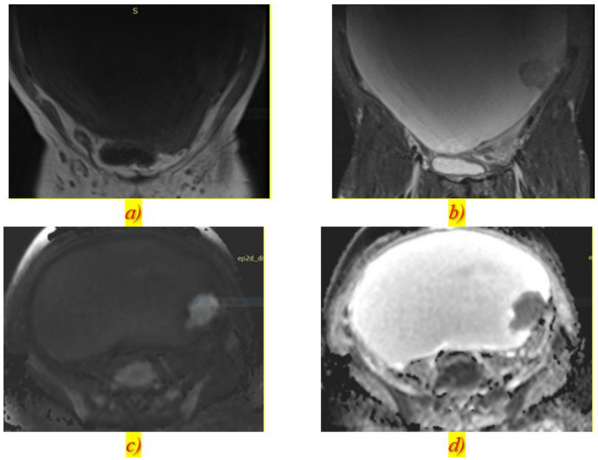

Figure 7. a) Coronal T1 WI;b) Coronal T2WI;c) DWI;d) ADC

Conventional MRI based Diagnosis:

(a) Coronal T1WI and (b) Coronal T2WI, confirmed the presence of right adnexal large cystic lesion with internal mural nodule. The cystic lesion elicits low signal in T1, high signal in T2(fluid signal), however the nodule shows intermediate signal on T1 and low signal in T2WI. No definite lymph nodal affection.

DWI:

(c) DWI, the cyst shows iso to low signal, however the mural nodule shows restricted diffusion with high signal intensity. (d) the corresponding ADC maps shows The cyst of high signal intensity while the nodule of low signal with ADC value of the tumor was 1.12x10-3mm2/s(+/-SD 74.8).

Pathological diagnosis:

Papillary serous cystadenocarcinoma

4. Discussion

The difficulty in diagnosing ovarian tumors with imaging alone is common because biopsy is not always an option.[5]

DWI is a new functional imaging method that shows promise. The current success in differentiating benign from malignant adnexal masses using DWI interpretation is contingent upon its integration with conventional MR imaging and the awareness of its potential limitations.[4]

Sahin et al.,[5] found that, by the use of traditional imaging methods, ovarian tumors had a higher frequency of complex structures and a greater degree of morphological overlap between benign and malignant tumors.

The present investigation found no correlation between lesion size and the ability to distinguish benign from malignant lesions.

This study's solid component findings (7 out of 40-benign cases and 9 out of 9-malignant cases) were in line with El-Wekil et al.,[6] research found that solid components were present in 22.7% of benign cases and in 62.5% of malignant cases out of a total of 9.

Serous cystadenoma had the highest ADC value(2.83±0.66) in the current investigation, followed by endometrioma(1.32±0.71), mature cystic teratoma(0.6±0.17), tubo-ovarian abscess(1.8±0.167), and malignant tumor(0.7±0.62). The benign tumor(2.83±0.66) and the malignant tumor(0.7±0.62) were found to be significantly different.

Similarly, Van et al.,[7] According to researchers who looked at ovarian lesions, DWI revealed a strong signal from most cancerous ovarian tumors and even some advanced cystic teratomas.

The researchers also found that the average ADC value of the solid part in cancerous tumors was 1.41±0.34(x10-3mm2/s), which was not substantially different from the average ADC value in benign lesions(1.47±0.42 for the benign lesions and 1.41±0.34 for the malignant lesions). This discovery was explained by the presence of sex cord stromal tumors, Brenner's tumor, and cyst-adenofibroma. These tumors share low ADC values with malignant lesions because of their extensive collagen fiber networks.[7]

In contrast Alahwal et al.,[8] discovered that malignant lesions had considerably different mean ADC values. Although there were some similarities in which the mean ADC values of benign and malignant lesions were 1.03±0.19 and 1.38±0.30(x10-3mm2/S) respectively.

Similarly, El-Wekil et al.,[6] found no statistically significant difference between benign and malignant tumors in terms of the mean ADC value assessed for the cystic component. The solid component measurement, on the other hand, varied considerably between benign and malignant tumors. The benign lesions had an average ADC value of 1.69x10-3±0.25 SD mm2/s, while the malignant ones had an average ADC value of 1.03x10-3±0.22 SD mm2/s. There was a statistically significant correlation between the lower ADC levels and the malignant group. In order to differentiate between benign and malignant ovarian tumors, their findings indicate that an ADC value of 1.25x10-3mm2/s could be the best cutoff.

Shebreya et al.,[9] examined 69 people in a case-cohort study to better understand tubo-ovarian abscesses(TOA), which can present with symptoms similar to those of ovarian cancer. The cystic component of all tubo-ovarian abscess patients exhibited hypointensity on corresponding ADC maps, suggesting limited water diffusion. On DWI, the cystic part of every cancerous tumor was quite faint. The average ADC value of the cystic component in malignant tumors was 2.42±0.38×10-3mm2/s, and in TOAs it was 1.04±0.41×10-3mm2/s.

A mature cystic teratoma was one of the difficult examples in our investigation; the fat part of the tumor gave a significant signal on the DWI but had low ADC values(0.6x10-3mm2/s) in the ADC maps, making it look like a cancerous tumor. Fortunately, conventional imaging techniques, when combined with fat-suppressed pictures, can reliably diagnose the majority of teratomas.

Out of all the tumors included in this investigation, only one borderline tumor-a papillary mucinous neoplasm with low malignant potential-exhibited consistent high signal intensity on DWI, intermediate signal intensity on the ADC map, and a relatively high ADC value(1.9x10-3 mm2/s).

We found that DWI's specificity was poor at 69.76%, but its sensitivity was 100% when we evaluated the included adnexal masses individually.

The mean ADC values for malignant lesions in the quantitative assessment were 1.39x10-3±0.62 SD mm2/s, whereas the mean values for benign lesions were 2.03x10-3±0.94 SD mm2/s.

We found 19 benign masses that looked like cancer on DWI. This includes 11-endometriomas, 3-tubo-ovarian abscesses, and 5-mature cystic teratomas. Their misleading signal intensities of restricted diffusion and low ADC values explain why our results are so vague.

Recommendations: Recommendations for MRI of the sonographically indeterminate adnexal mass integrating functional techniques are provided.

An algorithmic approach using sagittal T2 and a set of transaxial T1 and T2WI allows categorization of adnexal masses into one of the following three types according to their predominant signal characteristics.

T1 'bright' masses due to fat or blood content can be simply and effectively determined using a combination of T1W, T2W and FST1W imaging.

When there is concern for a solid component within such a mass, it requires additional assessment as for a complex cystic or cystic-solid mass.

For low T2 solid adnexal masses, DWI is now recommended.

Such masses with low DWI signal on high b value image(e.g.>b 1000 s/mm2) can be regarded as benign.

Any other solid adnexal mass, displaying intermediate or high DWI signal, requires further assessment by contrast enhanced T1W imaging, ideally with DCE MR, where a type 3 curve is highly predictive of malignancy.

So, for complex cystic or cystic-solid masses, both DWI and CET1W-preferably DCE MRI-is recommended.

4. Conclusion

The combination of DWI to conventional MRI implies:

Using a completely noninvasive technique with no radiation exposure. DWI might be an alternative for contrast administration, especially for those for whom contrast intake is better avoided, such as during pregnancy. Cost-effective technique (no additional cost to MRI examination), easily added to the MR study protocols with no marked lengthening of examination time. DWI is important for the Adnex MR scoring of any adnexal lesion to differentiate benign from malignant lesions. It improves the specificity of MRI and thus increases the radiologist's confidence in image interpretation, which finally reflects on the patients' outcome and prognosis.

Disclosure

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Authorship

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Conflicts of interest

There are no conflicts of interest.

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