Role of MRI diffusion weighted imaging in differentiation between benign and malignant ovarian masses

Mohammed Abd kadhim *, Lina Saad Jaafer **, Noor Abbas Hummadi Fayadh ***, Mohssin Abd Ali Hussain****

ABSTRACT

Background: Characterization of the ovarian masses preoperatively is important to inform the surgeon about the possible management strategies. MRI may be of great help in identifying malignant lesion before surgery. Diffusion Weighted Imaging (DWI) is a sensitive method for changes in proton of water mobility caused by pathological alteration of tissue cellularity, cellular membrane integrity, extracellular space perfusion, and fluid viscosity.

Objective: to study the diagnostic accuracy of DWI in differentiation between benign and malignant ovarian masses.

Type of the study:Cross-sectional study.

Methods: this study included 53with complex ovarian mass or masses ,Diffusion Weighted Imaging was obtained to all these patient with correlation to the histopathological results; the Signal Intensity (SI) of the solid and cystic part of the lesions was evaluated on T2 and Diffusion Weighted Imaging ,with Apparent Diffusion Coefficient (ADC) values were also obtained .

Results*:* 22 masses out of the total 53 were malignant and 31 were benign .On DWI the high SI intensity observed more frequently in the malignant lesions than the benign lesions (p value 0.0293) .There was significant difference between the mean ADC value of the malignant and benign ovarian lesions, with the mean ADC value for the benign lesions solid component =1.05 x10 $^{-3}$, and the mean ADC value for the malignant lesions solid component =0.91 x10^{-3}. The ROC study reveals that 0.926 x 10 $^{-3}$ may be the optimal cutoff value with sensitivity 54.8 %, specificity 59.1%, NPV 48.15 %, PPV 63.39% , Accuracy 56.6%. With exclusion of the teratoma and endometriomas from statistical analysis the ROC reveals that 0.99 x10 $^{-3}$ may be the optimal cut off value with sensitivity 76.9 % , specificity 77.3% , PPV 66.67% , NPP 85% and accuracy 77.14%

Conclusions*:* Combined with conventional pelvic MRI, DWI is a helpful tool in differentiation between benign and malignant ovarian masses, with high signal intensity on DWI more frequently observed in the malignant than benign ovarian lesions.

Key words: diffusion weighted imaging, MRI, benign and malignant ovarian masses.

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* M.B.Ch.B., F.I.B.M.S.Professor in Medical Collage / Al-Nahrain University.Consultant radiologists at Al-Imamain AL-Kadhmain medical city. Dr_a_mohammed@yahoo.com

** M.B.Ch.B.-Radiology resident in Al-Imamian Al-Kadhimyian medical city

*** M.B.Ch.B., CABHS-Rad., Lecturer at medical College /Al Nahrain University.Senior radiologist at Al-Imamain AL-Kadhmain medical city.noorabbashummadi@gmail.com

**** MRI application specialist in Al-Imamian Al-Kadhimyian medical city.

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Corresponding to: Mohammed Abd kadhim Dr_a_mohammed@yahoo.com,noorabbashummadi@gmail.com

Ovarian masses are very common in pre- and postmenopausal women and 10% of women have an operation during their life for investigation of an ovarian mass [1]. Ovarian tumors are the leading indication for gynecologic surgery, and the preoperative characterization of complex solid and cystic adnexal masses is crucial for informing patients about possible surgical strategies [2]. It is very difficult to distinguish benign ovarian lesions from ovarian cancer preoperatively [3]. Two main problems need answers: discrimination of benign and malignant adnexal masses and choice of the appropriate surgical treatment if necessary [4].Ovarian cancer is the seventh most common malignancy among women worldwide representing 3.7% of all cases of cancer in women and the second most common gynecological malignancy after cancer cervix [5, 6]. Generally ovarian tumors are more prevalent in the upper socioeconomic groups, and account for approximately two-thirds of cancers in the 40-65 age group. The incidence of ovarian tumor starts increasing in the third decade, and progressively increases to peak in the seventh decade, the different subtypes of ovarian neoplasms are more prevalent in different age groups [7]. There is no racial predisposition to ovarian sex cord-stromal tumors or ovarian germ cell tumors. However there is a racial predisposition for ovarian epithelial tumors with higher risks for Caucasians and lower risks for black women. Clear cell adenocarcinoma, a subtype of epithelial ovarian tumors, is more prevalent in Japanese than in Western women [8].The peak incidence of ovarian cancer is coincident with menopause. Menopause results when the supply of ova in the ovaries is exhausted. Follicle development, and thus production of the ovarian steroids estradiol and

progesterone, stops. Hormonal feedback mechanisms then cause elevated secretion of pituitary gonadotropins. In addition to reproductive senescence, age related immunosenescence also occurs. So, the progression of ovarian cancer around the time of menopause likely may result from both reproductive and immune factors [9]. MRI is well known to provide accurate information about hemorrhage, fat, and collagen. It is able to identify different types of tissue contained in pelvic masses, distinguishing benign from malignant ovarian tumors, with an overall accuracy of 88% to 93 %(10)Magnetic Resonance Imaging (MRI) is an essential problem solving tool to determine the site of origin of a pelvic mass and then to characterize an adnexal mass, especially in patients with indeterminate lesions. MRI is also reliable in detecting local invasion. The main advantages of MRI are the high contrast resolution with excellent soft tissue contrast and lack of ionizing radiation exposure, which is particularly important in young female patients (10, 11).In order to obtain anatomic information and to study morphological and signal intensity characteristics of the mass, both T1- and T2-weighted sequences are needed. Fat-saturated T1-weighted images are helpful to detect haemorrhagic areas and fat tissue. The use of intravenous gadolinium improves detection of enhancing septa and solid components within the mass and of peritoneal and omental implants.In the evaluation of adnexal masses indeterminate on ultrasound, unenhanced MRI has shown a sensitivity and a specificity of 76 and 97 %, respectively, in the diagnosis of ovarian cancer; assessment with contrast-enhanced MRI increases sensitivity to 81 % and specificity to 98 % (11).Diffusion-weighted imaging (DWI) reflects changes in proton mobility caused by pathological alterations of tissue cellularity, cellular membrane integrity, extracellular space perfusion, and fluid viscosity [11]. The extent of tissue cellularity and the presence of intact cell membrane help determine the impedance of water molecule diffusion. This impedance of water molecules diffusion can be quantitatively assessed using the apparent diffusion coefficient (ADC) value. This assessment can be done using different b values via changing gradient amplitude [12]. Normal structures, such as the premenopausal uterine endometrium and ovarian mesenchyme, excluding ovarian follicular cysts, show high signal intensity on DWI [13]. For the myometrium and endometrium, the mean ADC values tended to be lower in the menstrual phase than in other phases [13, 14].

Aim of the study: To study the diagnostic accuracy of MRI Diffusion Weighted Imaging (DWI) in differentiating benign from malignant ovarian masses.

Methods: Study Sample: This cross sectional study was conducted in MRI unit of Al -Imamain Al-Kadhimain medical city during 12 months period from September 2014 to September 2015. This study is carried out on 60 patient referred from the gynecological department who are sonographically diagnosed as having complex ovarian mass or masses. Their age ranged from 17 to 71 years (mean 40.5 ±13.6). Their complaints ranged from nonspecific abdominal pain, distention or weight loss. Full history had been taken, abdominal and/ or trans-vaginal US with Doppler study were performed to all these patient to select cases for MRI. MRI Have been done to all these patient , with both conventional MRI and contrast enhancement MRI, in addition to the DWI sequences in pre-contrast images, all patients underwent surgical excision of the tumor and histopathology results were obtained and compared to the MRI results.The exclusion criteria were: general contraindications for magnetic resonance (MR) examination and contrast medium injection, when the histopathology was not obtained, when the patient underwent MRI without DWI, simple ovarian cysts, and overweight patient who cannot fit within the MRI gantry.

MRI protocols: All studies were performed using a 1.5T MR imaging unit (SIEMENS, MAGNETOM, Avanto Germany). All the patients were imaged in supine position using a pelvic array coil, conventional pelvic MRI was performed followed by DWI sequence:

1. T2 axial was obtained (TR/TE 3000-5000/100-120 ms) with slice thickness: 5mm; interslice gap:1mm; FOV (280-500mm); matrix: 320 x320, flip angle 90 ^{o}
2. T2 sagittal and coronal images were obtained with slice thickness:7-10 mm , gap 1mm, FOV: (400-500 mm) matrix 320 x320, flip angle=90 ^{o}
3. T1 axial were obtained with TR/TE (400-700/7-14) ms), slice thickness=5 mm, interslice gap =1mm, FOV 483 mm, flip angle =90 ^{o} matrix 256 x256.
4. T2 axial SPAIR with TR/TE (1300/92), matrix 256 x256 mm, FOV=327mm.
5. DW-MRI was acquired in the axial plane prior to administration of contrast medium by using a single shot echo-planner DW sequences with the following parameters :TR/TE: (5000-70), slice thickness: 5mm inter slice gap:1mm , FOV 483 mm with three *b* values were used (0,500,1000) and applied in three orthogonal (Z, Y, and X) directions .
6. Post contrast axial T1 after manually injection of IV contrast medium (Dimeglumine gadopentate), Magnevist, and dose of 0.1 mmol/kg of body weight.

Image analysis: the acquired images are transferred to work station where DWI was post processed, the apparent diffusion coefficient (ADC) values were automatically calculated by placing ROI well within the confines of the lesions. For analysis, first, the conventional MR images were analyzed to detect the location, signal intensities, morphology, and post contrast enhancement criteria of the lesions. Second, DWI and ADC map were compared with conventional MR findings. High signal intensity in T1 was considered due to fat or blood. Persistence of high signal in fat suppression images indicate its bloody nature. Lesion with high signal on intensity on T2 and DWI with low signal intensity in ADC were considered as restricted diffusion .While lesion with high signal intensity on T2, DWI and ADC was considered facilitated diffusion. The lesions are evaluated for signal intensity on DWI at maximum *b* value (=1000 mm ^{2} / s), T2WI and T2 W post contrast images. At least 3 areas of solid tissue signal changes have been used in the complex masses choosing the highest signal region to evaluate restriction on DWI (b = 1000 mm ^{2} /s). On T2WI, the signal intensity is compared to that of the outer myometium, which corresponds to the outer third of the myometrium

excluding the arcuate veins. For the lesion with heterogeneous signal intensity. The dominant signal intensity (hypo intense or hyper intense) was taken into the consideration. On T1 post contrast image, the enhancement pattern of the lesion is considered marked or mild in comparison to the signal of the myometium. The signal intensity of the cystic and solid component on DWI at *b* value =1000 mm ^{2} /s was classified as intermediate or low compared with that of the urine. The Apparent Diffusion Coefficient (ADC) was used for quantitative analysis of the data. The ADC values of the solid component of each lesion were measured. In order to minimize the variability, the largest possible region of interest (ROIs), which varied from 15 to 150 mm ^{2}, where manually placed in the solid part of the lesion. When the lesion exhibited irregular or heterogeneous solid component, irregular thickened septa, and numerous vegetations, between 3 to 5 ROIs were drown within the targeted component and the mean ADC value was used in the analysis. In cases of teratoma, and endometriomas, the ROIs was placed within the lesion in the area with the lowest ADC value on ADC map and highest intensity on DWI (*b* =1000 mm ^{2} /s).

Statistical analysis: the statistical analysis was performed using the commercially available software SPSS (statistical package for social science) version 22.0; Student t-test was used for statistical analysis for the differences in the mean ADC value between benign and malignant ovarian lesions. A p value <0.05 was considered to be statistically significant. ROC (receiver operating characteristic) curve used for presentation of data and the optimal cutoff value calculation, sensitivity and for specificity. Chi- square and Fisher's exact tests for continuous comparison between the categorical variables.

Results: This study included 60 patients. The statistical analysis included 53 patients , 7 cases were excluded from the statistical analysis, as 2 cases were ovarian mimics, not true ovarian masses; one of these two was hydrosalpinx in the setting of chronic salpingitis, diagnosed as ovarian tumor by MRI, and the other was a broad ligament fibroid; another 2 cases were also excluded because there were purely cystic lesion with very thin septa that ADC value cannot be obtained from them, the last 3 cases due to lake of the histological sample. Their age ranged from 17 to 71 years (mean=40.5 ±13.6); the age range of those patients with benign lesions were 17 -52 (mean=32 years), and that with malignant lesion 25 -71 years (mean=56 years).Fifty -three cases (53) were pathologically proved, the tumors pathologically were classified into: 31 benign, and 22 malignant. The benign tumor incude: 8 serous cystadenomas, 2 mucinous cystadenomas, 3 fibromas, 4 endometriomas, 14 teratomas (13 typical mature cystic teratomas, and one atypical mature cystic teratoma). The malignant tumor include: 9 mucinous cystadenocarcinoma, 4 metastasis (3 from primary colonic CA, and one from primary CA of the cervix), 5 serous cystadenocarcinoams, 1 papillary cystaenocarcinoma, and 3 recurrent ovarian tumors. (Table 1). The tumors varied in there composition from being solid, complex cystic, and mixed solid and cystic. Table (2).

MRI findings: The high signal intensity within the solid component on T2-wieghted MR images was observed less frequently in benign than in malignant ovarian lesions, 29 from 31 of the benign lesions had low signal intensity, 2 from 31 were intermediate signal intensity, on the other hand 18 of 22 of the malignant ovarian lesions had high signal intensity, 3 of 22 were intermediate signal intensity, with only 1 of 22 of the malignant lesion shows low signal intensity as shown in table (3). On post contrast enhancement, 18 of 22 malignant lesion have marked T1 post- contrast enhancement, while marked T1 post contrast enhancement is detected only 8 of 31 case of all benign ovarian lesion (2 mucinous and 4 serous cystadenomas) (P =0,0001), as shown in table (3).

Findings on the DWI: 20 of 22 malignant lesions have restricted diffusion (high signal intensity on DWI, with low signal on ADC map), while 1 of 22 malignant lesions, and has low signal intensity on DWI, while only 1 of 22 of these malignant lesions was iso intense. Regarding the SI of the benign lesion on DWI, 10 showed free diffusion (low SI on DWI with high signal on ADC map), 21 of these benign lesions shows restrictive DWI (high SI on DWI with low signal on ADC map), 3 of them were fibromas, 14 were teratomas, and 4 endometriomas as shown in table (4).This means the higher SI on the DWI (b value =1000 s/mm 2) is noticed in the malignant ovarian lesions more frequently than the benign lesions (p value =0.0293). But the specificity of the hyper intensity on the DWI appears low (not specific) with high sensitivity as shown in table (5).

ADC analysis: The mean ADC values of the solid component of the ovarian lesions were determined for each group, there was much overlap between the ranges of values for malignant and benign lesions, however the mean ADC value for benign lesions was 1.05 ± 0.25 mm² /s, and that for malignant ovarian lesions was 0.91 ±0.15 mm 2/s which was significant (p value is 0.012), as shown in table (6). Regarding the ADC value of cystic component there was no significant difference between benign and malignant ovarian lesions (*p* value of 0.9289), as shown table (6).The ROC curve revealed that 0.926 x10^{-3} mm^2/s may be the optimal cutoff value for differentiating benign from malignant ovarian lesions with sensitivity, specificity, positive predictive value, negative predictive value and accuracy as shown in table (7) and figure (1). On the other hand there was no statistically significant difference between the mean ADC values of the teratomas, endometriomas and fibroams from the mean ADC value of the malignant ovarian lesions *(p* value>0.05), so when we exclude the teratoma and endometriomas from the statistical analysis, (on the base that these lesion can be accurately diagnosed by conventional MRI sequences with and without fat suppression), the sensitivity , specificity, NPV and PPV for the optimal cut off point would be 0.99 mm ^{2} /s as shown table (7). So we find the sensitivity and specificity increase from 54.8 and 59.1 to 76.9 and 77.3 respectively.Figures 2 and 3 show MRI images of some of the cases included in our study.

Table 1: Histology of ovarian masses.

Benign masses (N=31)		Malignant masses (N=22)	
histology	Number	histology	Number
Serous cystadenoma	8	Mucinous csystadenocarcinoma	9
fibroma	3	Metastasis from primary colonic carcinoma	3
endomemtrioma	4	Metastasis from primary cervical carcinoma	1
Typical Mature cystic teratoma	13	Serous cystadenocarcinoma	5
Atypical Mature cystic teratoma	1	Papillary cystadenocarcinoma	1
Mucinous cystadenoma	2	Recurrent ovarian tumor	3

Table 2: Difference between benign and malignant ovarian lesions regarding the tumor composition.

Presence of cyst	Benign (N=31)		Malignant (N=22)		P value
	No.	%	No.	%	
Complex cystic	2	6.45	0	0	0.3564
Purely solid	3	9.68	1	4.55	
Mixed	26	83.87	21	95.45	

Table 3: Difference in signal intensity of solid component in T2 WI MRI and degree of enhancement on T1 post contrast images between benign and malignant ovarian lesions.

T2 Signal intensity	Benign (N=31)		Malignant (N=22)		*P* value
	No.	%	No.	%	
Signal intensity of the solid component in T2 WI					
Low (hypo intense)	29	93.55	1	4.55	< 0.001
High (hyper intense)	0	0	18	81.82	
Intermediate (Iso intense)	2	6.45	3	13.63	
Degree of enhancement T1 post contrast images					
Mild enhancement	23	74.19	4	18.18	< 0.0001
Marked enhancement	8	25.81	18	81.82	

Table 4: Difference in SI on DWI (b value = 1000 s /mm 2) between benign and malignant ovarian lesions.

Signal intensity	Benign (N=31)		Malignant (N=22)		*P* value
	No.	%	No.	%	
Low (hypo intense)	10	32.26	1	4.55	0.0293
High (hyper intense)	21	67.74	20	90.90	
Intermediate (Iso intense)	0	0	1	4.55	

Table 5: Sensitivity, specificity, NPV, PPV and accuracy of hyperintensity on DWI.

Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
90.91%	32.26%	48.78%	83.33%	56.6%

Table 6: Comparison of the ADC values in solid and cystic components in benign and malignant ovarian lesions (ADC (*10-3) mm² /s).

		Minimum	Maximum	mean±SD	*P* value
Solid component	Malignant	0.72	1.23	0.91±0.15	0.012
	Benign	0.75	1.56	1.05±0.25	
Cystic component	Malignant	2.12	3.40	2.77±0.32	0.9289
	Benign	2.20	3.10	2.76±0.27	

Table 7: Cut off value, sensitivity and the specificity of ADC values in the solid and cystic components of the benign and malignant ovarian lesions:

	With enometriomas and teratoms			After exclusion of the enometriomas and teratoms	
	Solid	Cystic		Solid	Cystic
Sensitivity	54.8%	50.0%		76.9%	61.9%
Specificity	59.1%	52.4%		77.3%	80.0%
Positive predictive	65.39%	55.0%		66.67%	86.67%
Negative predictive	48.15%	50.0%		85.0%	50.0%
Accuracy	56.6%	52.38%		77.14%	67.74%
Cutoff value	0.926	2.795		0.99	2.765

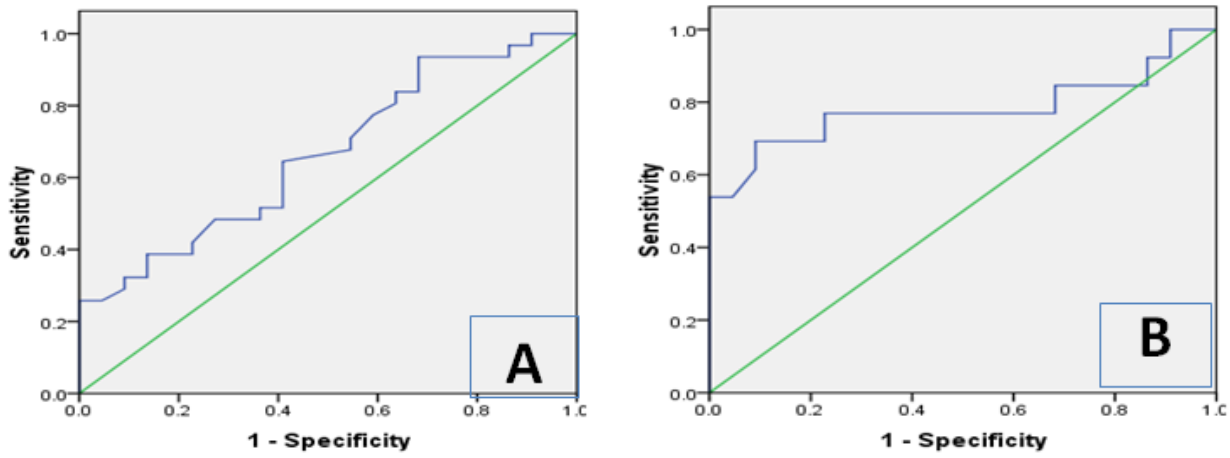

Figure (1): A: ROC comparative diagnostic values of quantitative ADC value parameter of the solid component for discriminating between benign and malignant ovarian lesions, B: the same curve in A after teratomas and endometriomas were excluded.

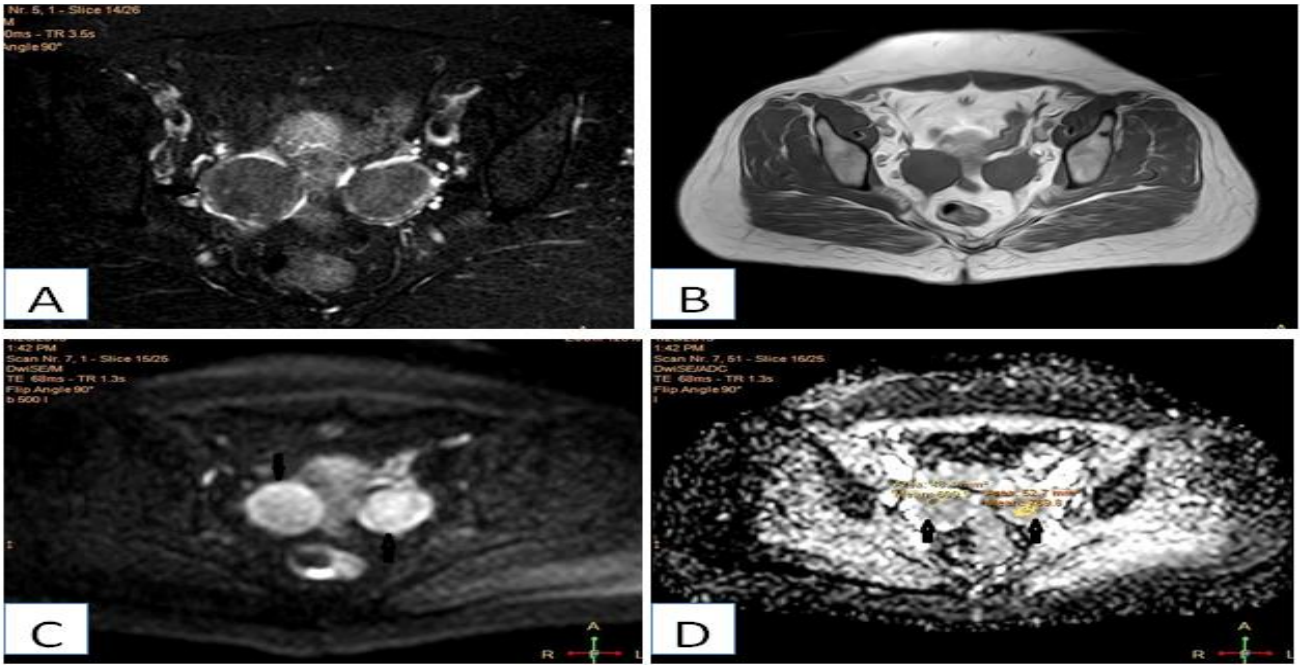

Figure (2): 33 years old female with bilateral ovarian fibromas (a) coronal T2 wiegthed image. (b) Axial T1 post contrast - weighted image post contrast. (c) Axial DWI on b value 1000 mm 2 /s shows hyper intensity (d) axial ADC shows low signal intensity with mean ADC value 0.759 $x10^{-3}$

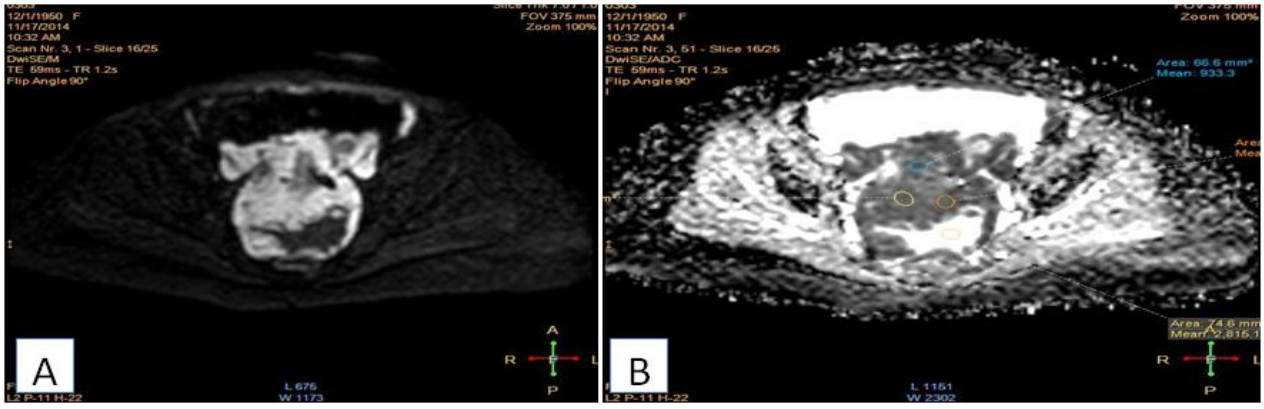

Figure (3): 71 years old female with RT ovarian mucinous cysts adenocarcinoma (a)axial DWI obtained at b value 1000 s/mm 2 reavel the solid component hyper intense (b)shows that the tumor had hypoinsity within the solid component with low ADC value =0.93 $x10^{-3}$ mm^2 /s.

Discussion: Ovarian masses present a special diagnostic challenge when imaging findings cannot be categorized into benign or malignant pathology [15]. Characterization of the ovarian masses is frequently carried out by US, however if the mass is complex, large, or remain indeterminate on US, MRI of the pelvis is indicated for further assessment [16]. Some pelvic MR imaging features of ovarian masses are suggestive of malignancy: size over 6cm, bilateral tumors, tumor with solid and cystic components, presence of vegetations more than 5mm thickness and irregular internal septations. The presence of adenopathy, pelvic side wall, peritoneal disseminations and adjacent organs involvement are strongly indicative of malignancy [17]. MRI can reveal morphologic characteristics such as papillary projections, nodularity, septa, solid portions and signal intensity on T1- and T2-weighted images, but none of these criteria reliably distinguish between benign and malignant tumors. The use of magnetic resonance (MR) diffusion-weighted imaging (DWI) may improve MR characterization of ovarian lesions. Diffusion-weighted imaging is sensitive to changes in the microdiffusion of water into both intracellular and

extracellular spaces. Differences in the apparent diffusion coefficient (ADC) of benign and malignant complex adnexal masses have been reported [18-20].Our findings demonstrate that the presence of high SI in the solid component of an ovarian lesion on DWI and T2 -weighted imaging combined with low ADC values can be used to distinguish malignant from benign ovarian lesions. A matched study done by Ping Zhang et al 2012 [21], the study is carried out on 202 patient with ovarian masses 74 were benign and 128 were malignant, the results suggested the potential role for DWI with quantitative analysis of ADC values in improving the diagnostic performance of ovarian MRI and yielding functional measures of the tumor microenvironment. ADC values are largely proportional to the ratio of the extracellular and intracellular component, cell density, matrix fibers, and soluble macromolecules [2]. Although much overlap in the ADC values between the benign and malignant ovarian lesions, in our study the mean ADC value of the 22 malignant ovarian tumors was significantly lower than that of the 31 benign group (p value <0.05), our result suggest that an ADC value of 0.926 $x10^{-3}$ may be the optimal cutoff value for differentiating benign from malignant ovarian lesions with sensitivity 54.8 %, specificity 59.1 %, PPV 65.39 %, NPP 48.15%, and accuracy 56.6%. Our study is consistent with the study done by Ping Zhang et al 2012 [21] who found that there is significant difference between mean ADC value between benign and malignant ovarian lesion with 1.20 x 10^{-3} may be the optimal cutoff value for differentiating benign from malignant ovarian masses with a sensitivity 66.7 %, specificity 90.9 %, PPV 81.4 %, NPV 82.1%; this apparent discrepancy in the sensitivity and specificity because they exclude terratoma and endometriomas from their study so they induce selection bias, so when we exclude the teratomas and endometriomas from our statistical analysis the sensitivity, specificity, PPV, NPV, and accuracy increased respectively to: 76.9 %,77.3%, 66.7 %, 85.0% with 0.99 mm^2 /s cutoff value. A study carried by Fugii et al 2008 [22], the authors evaluated the contribution of DWI in combination with quantitative ADC analysis to the characterization of 123 ovarian lesions, which included 42 malignant and 81 benign lesions (including 18 mature cystic teratomas, 24 endometrioma, and 7 fibromas); the results suggested that the DWI and ADC value of the solid component of the ovarian lesions were not useful for differentiating benign from malignant ovarian masses. This difference in the results may be due to the pathological architecture of the benign lesions because main location of the abnormal signal intensity located within solid component of the malignant tumor, in the rokitansky protuberance in the mature cystic teratomas, and in the intracystic clot in endometriomas, which causes diffusion restriction while in the fibroma, the abundant collagen -producing fibroblastic cells and dense network of the collagen fibers within the extracellular matrix which causing restriction of the Brownian motion of the water molecule. A study done by Bakir et al 2011[23] evaluated the contribution of DWI of solid or predominantly solid gynecological adnexial masses and its usefulness in the differential diagnosis, their study carried out on 51 patients and statistical analysis carried on 37 patients with adnexail masses (15 benign and 22 malignant), they observed that no statistical significant between the ADC values of the benign and malignant lesions, with significant difference in the SI of the benign and malignant ovarian lesions when evaluated on DWI with high SI observed more frequently in the malignant than benign lesions and they concluded that the SI on DWI of benign and malignant lesions differed significantly, these results again are consistent with ours.Another study carried by Takeuchi et al 2012 [24] on 49 patients with ovarian masses (10 benign and 39 malignant and/or borderline malignant), the authors found that the mean ADC value of the malignant lesions significantly lower than the mean ADC value of the benign lesions, and they concluded that low SI on the DWI with high ADC value may suggests benign lesions and was difficult to differentiate benign from malignant ovarian lesions on the base of DWI alone, again our study suggest the low signal intensity on T2 and DWI in favors of benignity.DWI (*b* value =1000 mm^2/s) appear to be complementary to other conventional sequences and should probably be added to the routine MRI evaluation of the ovarian lesions, the SI on the DWI sequences may be an extra argument in the evaluation of a mass as benign or malignant, when other conventional sequences already suggestive of one over the other, or provide deciding element towards benign or malignant when other sequences are indeterminate. In our results the presence of hyper SI within the solid component of an ovarian lesion on DWI *b* value 1000 should alert the radiologist to the possibility of malignant pathology, however this finding is not specific since some benign ovarian lesion may also be hyper intense on DWI and our results suggesting that the specificity of the hyper intense signal on DWI b value 1000 mm ^{2}/s appear low 32.26 % and the sensitivity was 90.91%, so the absence of hyper-intensity on DWI strongly support a benign pathology. This result matched a study carried by Rousssel A. 2009 [16], the author reported that the hyperintensity within the solid component of adnexal masses, the possibility of malignant tumor and reported that this finding is not specific since some benign tumor also hyperintense on DWI, and found that T2 hypo-intensity or the absence of hyper intensity on DWI strongly suggest benign pathology. Regarding the cystic component of the malignant and benign ovarian lesions there was no significant difference between the mean ADC values *p* value (0.9289) this consistent with the results of the above mentioned studies. There are several limitations to our study: the small sample size, drawing the ROI on the DWI while viewing T2-weighted or T1-post contrast images may have resulted on information bias, as DWI has poor spatial resolution. Another bias in our study with regard to the ADC measurements on the ADC maps due to small size of the ROI on small vegetations, with non negligible risk of partial volume artifacts with surroundings structures that could result in inaccurate ADC values.

Conclusions: Combined with conventional MRI sequences, DWI appears to provide additional information in the characterization of ovarian masses and is a helpful tool in differentiation between benign and malignant ovarian masses, with high signal intensity on DWI more frequently observed in the malignant than benign ovarian lesions. When the solid component in the ovarian mass exhibits low signal intensity on T2 and DWI, is mostly benign; however there is much overlap between the ADC values of the benign and malignant ovarian lesions, and some overlap between the SI on DWI b value =1000 mm ^{2}/s where some malignant tumors are hypo-intense in the DWI, while some of the benign lesions were hyper intense indicating that DWI is helpful but not able to make a consistent distinction.

References:

1. M. Yeoh. Investigation and management of an ovarian mass. 2015, 44 (1), 48-52
2. P. Zhang, Y. Cui, W. Li, et al. Diagnostic accuracy of diffusion-weighted imaging with conventional MR imaging for differentiating complex solid and cystic ovarian tumors at 1.5T. World J Surg Oncol. 2012; 10: 237.
3. M. Yildirim, B. Cendek, and A. AVSAR. Differentiation between benign and malignant ovarian masses in the preoperative period using neutrophil-to-lymphocyte and platelet-to-lymphocyte ratios. Mol Clin Oncol. 2015; 3(2): 317-321.
4. H. Marret, M. Cayrol. Sonographic diagnosis of presumed benign ovarian tumors. jgyn. 2013, 42(8), 730-743
5. Mohaghegh.P, Rockall. A.G. Imaging strategy for early ovarian cancer: characterization of adnexal masses with conventional and advanced imaging techniques, Radiographics, 32 (6) (2012), pp. 1751-1773
6. Chu.C, Kim. S, June .C, et al. Expert immunotherapy opportunities in ovarian cancer. Expert Rev Anticancer Ther. 2008; 8(2):243-57
7. Kiechle-Schwarz M, Bauknecht T, Karck U, et al. Recurrent cytogenetic aberrations and loss of constitutional heterezygosity in ovarian carcinomas Gynecologic oncology. 1994; 55 (2): 198-205.
8. Glund M, Gisselsson D, Hansen GB, Mitelman F. Ovarian carcinoma develops through multiple modes of chromosomal evolution. 2003; 63 (12): 3378-3385.
9. Andrew E Green. Ovarian Cancer, updated November 26, 2014. Available from: p://emedicine.medscape.com/article/255771-overview.
10. J. A. Spencer, R. Forstner, T. M. Cunha, and K. Kinkel, "ESUR guidelines for MR imaging of the sonographically indeterminate adnexal mass: an algorithmic approach," European Radiology, 2010, 20(1): 25-35.
11. M. Bazot, E. Daraï, J. Nassar-Slaba, et al, "Value of magnetic resonance imaging for the diagnosis of. ovarian tumors: a review," Journal of Computer Assisted Tomography, 2008, 32(5): 712-723.
12. Thomassin-Naggara., Daraï, Cuenod, et al. Dynamic contrast-enhanced magnetic resonance imaging: a useful tool for characterizing ovarian epithelial tumors, J Magn Reson Imaging. 2008, 28 (1): 111-120
13. Padhani AR, Liu G, Koh DM, et al. Diffusion-weighted magnetic resonance imaging as a cancer biomarker: consensus and recommendations. Neoplasia.2009; 11:102-125.
14. Charlotte, Andy, Linda, et al. Diffusion-weighted MR imaging of female pelvic tumors: a pictorial review RadioGraphics, 2009, 29: 759-778
15. N. Pierce, Narayanan, Sahdev, et al. "Ovarian lesions pose diagnostic dilemmas," Diagnostic Imaging Europe, 2008, 24(3): 14-18.
16. Russel, Value of diffusion -weighted imaging in the evaluation of adnexal tumors .Journal of radiology.2009, 90: 112-117.
17. Hricak, Chen, Coakley FV, et al. Complex adnexal masses: detection and characterization with MR imaging -multivariate analysis. Radiology 2000; 214:39-46.
18. Katayama M, Masui T, and Kobayashi S, et al. Diffusion-weighted echo planar imaging of ovarian tumors: is it useful to measure apparent diffusion coefficients? J Comput Assist Tomogr. 2002; 26:250-256.
19. Li WH, Chu CT, Cui YF, et al. Diffusion-weighted MRI: a useful technique to discriminate benign versus malignant ovarian surface epithelial tumors with solid and cystic components. Abdom Imaging. 2012; 37:897-903.
20. Moteki, Ishizaka. Evaluation of cystic ovarian lesions using apparent diffusion coefficient from turbo on FLASH MR images. Br J Radiol. 1998; 71:612-620.
21. 21.Ping Zhang, Yanfen Cui, Wenhua Li, et al. Diagnostic accuracy of diffusion -weighted imaging with conventional MR for differentiating complex solid and cystic ovarian tumors at 1.5 T. World Journal of Surgical Oncology, 2012, 10:237
22. Fugii.S et al. Diagnostic accuracy of diffusion weighted imaging in differentiating benign from malignant ovarian lesions. J Magn Reson imaging 2008, 28:1149-1156.
23. Bakir.B, Bakan. S, et al .Diffusion -weighted imaging of solid or predominantly solid adnexial masses: is it useful in the differential diagnosis? Br J Rdiol. 2011, 84(1003):600-611.
24. Takeuchi M et al .Diffusion -weighted magnantic resonance imaging of ovarian tumors: Diffrentiation of bengin and malignant solid components of ovarian masses. J comput assist tomgr 2012, 36:46-53.