ORIGINAL ARTICLE

Diffusion-Weighted Magnetic Resonance Imaging (DWI) Parameters in Benign and Malignant Ovarian Tumors with Solid and Cystic Components

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ABSTRACT

Objective: To determine the values of diffusion-weighted magnetic resonance imaging (DWI) parameters on differential diagnosis of benign and malignant ovarian tumours with solid and cystic components.

Study Design: An observational study.

Place and Duration of Study: Department of Radiology, Obstetrics and Gynecology Hospital of Fudan University, China, from January to December 2017.

Methodology: Forty-four cases of malignant and benign ovarian tumours were selected as respective groups. Inclusion criteria were ovarian masses found by pelvic and abdominal imaging examination. Exclusion criteria of two groups were endometriosis and pelvic inflammatory diseases found by relevant examination, those with chronic diseases, tumors in other organs found by relevant examination, and those with family cancer history. Conventional MRI plain scans, enhanced scans and DWI scans, were performed after admission. Apparent diffusion coefficient (ADC) and exponential apparent diffusion imaging (eADC) of solid lesions of two groups were recorded and compared.

Results: Solid ADC in malignant group was lower than that in benign group ($p<0.001$). Solid eADC in malignant group was higher than that in benign group ($p<0.001$).

Conclusion: Diffusion-weighted magnetic resonance imaging is of high application value in the differential diagnosis of benign and malignant ovarian tumours with solid and cystic components, and it is worthy of promotion and application.

Key Words: *Diffusion-weighted magnetic resonance imaging (DWI), Ovarian cyst, Tumour, Benign and malignant, Apparent diffusion coefficient, Diagnosis.*

INTRODUCTION

Ovarian cancer is one of the most common female genital cancers. The incidence is second only to cervical cancer and endometrial cancer, with the highest mortality.[1,2] With the development in medical imaging, magnetic resonance imaging (MRI) has been used gradually in the diagnosis of ovarian diseases. Nishio *et al*. found that the MRI findings, which suggested malignant transformation, were emergence of a solid portion and increase in cyst size.[3] But sensitivity of MRI is relatively low in the identification of benign and malignant tumours.[4]

Diffusion-weighted magnetic resonance imaging (DWI) non-invasively reflects the characteristics of molecular diffusion.[5,6] DWI is mainly used for the diagnosis of neurological diseases. With the development of magnetic resonance hardware and software, the application of DWI has been extended to abdominal diseases.[7] Razik *et al*. pointed out that assessment of the morphology of the reactive tumor stalk on DWI has better diagnostic performance in predicting muscle invasion in urinary bladder cancer than conventional MRI.[8] Because DWI is very sensitive to water molecular movement, it is not subject to respiratory movement, heartbeat and pulse, peristalsis and other effects, and has been successfully used in abdominal and pelvic imaging examinations, enhancing the role and potential of MRI in the evaluation of female pelvic lesions.[9] Duarte *et al*. revealed the most relevant physiological and benign pathological conditions of the female pelvis that could show restricted diffusion on DWI.[10]

The objective of this study was to determine the values of diffusion-weighted magnetic resonance imaging (DWI) parameters on the differential diagnosis of benign and malignant ovarian tumours with solid and cystic components.

METHODOLOGY

This study was done in the Dapartment of Radiology, Obstetrics and Gynecology Hospital of Fudan University, China, from January to December 2017. Forty-four patients with malignant ovarian tumours confirmed by clinicopathology were selected as a malignant group. At the same time, 44 cases of benign ovarian tumours confirmed by clinic pathology were selected as a benign

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group. Inclusion criteria of malignant group and benign group in this study were ovarian masses found by pelvic and abdominal imaging examination. Exclusion criteria of two groups were endometriosis and pelvic inflammatory diseases found by relevant examination; those with chronic diseases such as complicated primary hypertension, diabetes, *etc*., as well as those with abnormal liver, kidney and heart functions, tumors in other organs found by relevant examination, and those with family history of cancer. The study was approved by the hospital ethics committee, and all patients volunteered to participate in the study.

All patients were scanned before surgery. The patients were told to keep a stable breath before examination, and then conventional MRI plain scans, enhanced scans and DWI scans were performed. MR scanner adopts Signa 1.5T superconductive MRI, and coil uses 8-channel phased array coils. The conventional cross section T1WI scan parameters with TR:TE at 220/8 ms, scan matrix 320x224, field of view 80 cm. T2WI fat suppression scan parameters were TR:TE 6666/88 ms, scan matrix 320×224, field of view 80 cm. Coronal plane T2WI fat suppression scan parameters were TR:TE 6666/1100 ms, scan matrix 320×224, field of view 1000 cm. Gadopentetate dimeglumine was administered through the cubital vein based on the dose of 0.1 mmol/kg, and then enhanced scans were performed from the above three views. DWI scan parameters were TR:TE 3000/55 ms, matrix 128×128, field of view 100 cm, cross-sectional slice thickness 8mm, slice gap 1mm; the slice thickness was adjusted to 6mm during the scanning from the sagittal view. All images were analysed by two experienced radiologists. The relevant data were transferred to the workstation and the threshold was adjusted so that both the normal and the diseased ovaries were within the threshold. The apparent diffusion coefficient and the exponential apparent diffusion coefficient of solid and cystic lesions were reconstructed. In the malignant group, the centres of solid and cystic lesions were taken as regions of interests (ROI) with a size of 100-200 mm^2 and these regions were measured three times. Apparent diffusion coefficient (ADC) and exponential apparent diffusion imaging (eADC) of solid lesions of two groups were recorded.

The minimum sample size of statistical test was estimated by Ssize software. All experimental data in this study were statistically analysed with SPSS version 22. Quantitative variables, such as ADC, eADC etc. were expressed as mean ± standard deviation, and independent samples t-test was used. Qualitative variables were expressed as frequencies with percentages. Results were considered significant at $p<0.05$.

RESULTS

In the malignant-tumors group, the age ranged from 37 to 66 years with a mean age of 53.61 ±1.75 years; the number of lesions was 1 to 3 lesions, mean 1.38±0.26 lesions. The pathological types were 20 (45.45%) cases of serous cystadenocarcinoma, 7 (15.91%) cases of mucinous cystadenocarcinoma, 5 (11.36%) cases of ovarian epithelial carcinosarcoma, 4 (9.09%) cases of ovarian endometrioid adenocarcinoma, and 8 (18.18%) cases with metastatic carcinoma.

In benign-tumor group, the age ranged from 36 to 67 years with a mean age of 54.05 ±1.96 years. Pathological types were 6 (13.64%) cases with thecomas, 8 (18.18%) cases with endometriosis, 16 (36.36%) cases with corpus luteum cysts, 7 (15.91%) cases with serous cystadenoma, 4 (9.09%) cases with mucinous cystadenoma, and 3 (6.82%) cases with mature teratomas.

In malignant group, the T1WI sequence showed that 35 (79.55%) cases of solid lesions were equal signals (Figure 1-a); 4 (9.09%) cases were equal and slightly higher mixed signals (Figure 2-a); 3 (6.82%) cases were slightly higher signals, and 2 (4.55%) cases were high signals. T2WI fat suppression sequence showed that 33 (75.00%) cases of solid lesions were slightly higher signals (Figure 1-b) and 11 (25.00%) cases were equal and high mixed signals (Figure 2-b). The DWI showed that 41 (93.18%) cases of solid lesions were high signals (Figure 1-c) and 3 (6.82%) cases were high and low mixed signals (Figure 2-c). The T1WI showed that 39 (88.64%) cases of cystic lesions were low signals (Figures 1-a and 2-a) and 5 (11.36%) cases were slightly higher signals and low mixed signals. The T2WI fat suppression sequence showed that 36 (81.82%) cases of cystic lesions were significant high signals (Figures 1-b and 2-b) and 8 (18.18%) cases were high signals and slightly higher mixed signals. DWI showed that 28 (63.64%) cases of cystic lesions were slightly higher signals (Figure 2-c) and 16 (36.36%) cases were low signals (Figure 1-c).

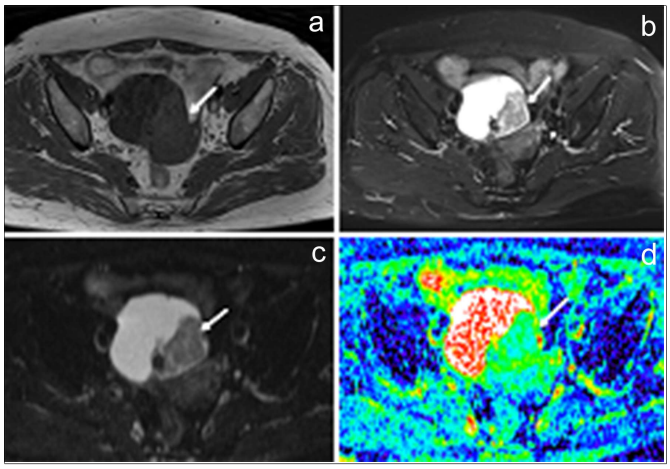

Figure 1: (a - d) Typical case 1: A female patient, 54 years old, ovarian serous cystadenocarcinoma. (a) Solid and cystic masses in the right appendage area, with equal signals (arrows) on the T1WI. (b) The T2WI fat suppression sequence showed solid and cystic lesions. (c) Solid lesions on the DWI were significant high signals. Cystic lesions on the DWI were equal signals and slightly higher mixed signals. (d) The ADC of solid lesions in the ROI was approximately (1.15 ±0.14) × 10^{-3} mm^2/s.

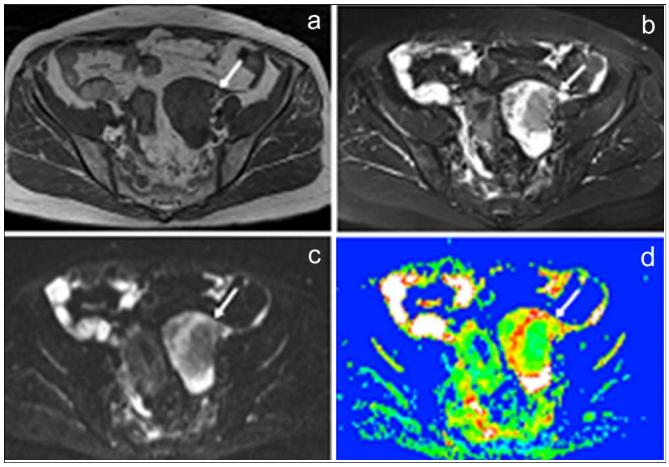

Figure 2: (a - d) Typical case 2: A female patient, 52 years old, ovarian metastatic carcinoma. (a) Solid and cystic masses in the right appendage area, with low signals (arrows) on the T1WI. (b) The T2WI fat suppression sequence showed solid and cystic lesions. (c) Solid lesions on the DWI were high signals. Cystic lesions on the DWI were equal signals and high mixed signals. (d) The ADC of solid lesions in the ROI was approximately (1.39 ±0.21) × 10^{-3} mm^2/s.

Table I: Comparison of ADC and eADC values of solid space-occupying lesions in benign and malignant tumours (×10^{-3} mm^2/s).

Groups	n	Solid ADC		Solid eADC	
		Mean ±SD	p-value	Mean ±SD	p-value
Benign group	44	1.49 ±0.39	<0.001	189.67 ±38.58	<0.001
Malignant group	44	0.95 ±0.13		261.48 ±43.40	

In benign group, the T1WI sequence showed that 42 (95.45%) cases of solid lesions were equal signals and 2 (4.55%) cases were slightly higher signals. The T2WI fat suppression sequence showed that 39 (88.63%) cases of solid lesions were low signals and 5 (11.36%) cases were slightly higher signals. The DWI showed that 38 (86.36%) cases of solid lesions were equal signals and 6 (13.64%) cases were slightly higher signals and equal mixed signals. The T1WI showed that 36 (81.82%) cases of cystic lesions were low signals and 8 (18.18%) cases were slightly higher signals and low mixed signals. The T2WI fat suppression sequence showed that 42 (95.45%) cases of cystic lesions were significant high signals and 2 (4.55%) cases were high signals and slightly higher mixed signals. The DWI showed that 30 (68.18%) cases of cystic lesions were slightly higher signals and 14 (31.82%) cases were low signals.

Solid ADC in malignant group was lower than that in benign group and the difference was statistically significant ($p<0.001$). Solid eADC in malignant group was higher than that in benign group and the difference was statistically significant ($p<0.001$, Table I).

DISCUSSION

Ovarian cancer easily undergoes necrosis, haemorrhage and other severe complications, endangering the lives of patients.[11,12] It has no specific symptoms at the beginning of the disease and is easily overlooked on clinical examinations. Therefore, most diagnosed patients with ovarian cancer are in an advanced disease stage, and the prognosis and life quality of patients are seriously affected.[13] Ovarian surface epithelial tumours can be divided into four types: pure cystic, cystic component, mixed, and solid.[14,15] MRI is a common clinical imaging examination method that shows changes in ovarian morphology and changes in the internal structure of the mass, and has a high application value in the early diagnosis of ovarian diseases.[16] Some studies have shown that ovarian size and structure were assessed noninvasively using pelvic MRI.[17,18] However, MRI cannot determine the nature of malignant solid and cystic tumours, serous cystadenoma and other ovarian diseases.[19]

Previous clinicopathological and radiographic findings showed that the masses meeting the following situations could be determined as malignant tumours: ovarian surface epithelial tumours with a diameter greater than 6cm, visible papillae in the cyst, a cyst wall gap greater than 3 cm, solid components in the cyst, enhanced images in the solid parts under enhanced scans, and a complication of enlarged lymph nodes.[20] A study showed that the differential diagnosis of benign and malignant tumours was difficult in ovarian tumours with multiple gaps and insufficient solid components, which may affect clinical treatment.[21]

DWI is an imaging method that uses a special sequence of MR imaging to observe the microscopic diffusion motion of water molecules in living tissues. The principle is to add a gradient field respectively in front and at the back of a 180° focused radiofrequency pulse on the basis of conventional SE sequences, and the two gradient fields are symmetric in position but have opposite polarities. When the water molecules disperse under the action of the gradient fields, the protons affected by transverse magnetisation are dispersed in phase and cannot be completely reaggregated, which in turn leads to signal attenuation, and abnormal signals are formed on the DWI. The diffuse image contains the comprehensive information on the changes of T2, protons and ADC values. The ADC values can quantitatively reflect the size of the water molecular expansion movement. Different tissues and different pathophysiological processes have different ADC values. The difference in ADC values can reflect the changes in the general and microscopic structures of the disease.[22] A study found that ADC histograms of solid tumor components facilitated the distinction between borderline ovarian tumors and carcinoma.[23]

In this study, the authors found that solid ADC in malignant group was lower than benign group, and solid eADC in malignant group was higher than benign group, and the differences were statistically significant. The results of this study were consistent with those reported

by Ahmad *et al*.[24] The reason may be that the malignant cells had a faster proliferation rate and the cell gap was relatively small; the water molecular activity was limited, so the ADC levels were significantly lower than the normal levels. It showed that DWI could be used as a differential diagnostic method for malignant solid and cystic ovarian tumours.

Although this research was carefully carried out; but the authors are still aware of its limitations and shortcomings, as the sample size was small.

CONCLUSION

DWI, with its short scan time, is a fast, accurate and non-invasive means of examination and can be used as a basis for the clinical diagnosis of benign and malignant ovarian tumours with solid and cystic components. It has a high clinical application and promotion value.

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