

The Value of Apparent Diffusion Coefficient in Differential Diagnosis of Ovarian Cystic Adenoid Tumors

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Abstract: Objective: To quantitatively analyze apparent diffusion coefficient (ADC) value of cystic composition and solid composition in ovarian cystadenocarcinoma, borderline cystadenoma and cystadenoma by 3.0T magnetic resonance imaging (MRI), and to investigate its diagnostic and differential diagnostic values in ovarian cystic adenoid tumors. **Methods:** Retrospective analysis was carried out on 28 patients with ovarian cystic adenoid tumor as confirmed by surgical and pathological examinations. Examination was performed by Siemens 3.0T MRI scanner. Tumor size, margin, composition (cystic or solid), signal characteristic and presence of ascites were observed. Combined with localization using T2WI and diffusion weighted imaging (DWI), ADC value was calculated from ADC mapping using region of interest ROI (the largest surface area of cystic and solid compositions in tumor). Statistical analysis was performed. **Results:** Among the 28 ovarian tumors, there were 13 cases of cystadenomas (5 serous cystadenomas and 9 mucinous cystadenomas), 4 borderline mucinous cystadenomas and 11 cystadenocarcinoma (9 serous cystadenocarcinoma and 2 mucinous cystadenocarcinoma). There was no significant intragroup difference in ADC values of cystic composition and solid composition in ovarian cystadenoma and cystadenocarcinoma respectively ($P>0.05$). The ADC value of solid composition between benign cystadenoma and borderline cystadenoma ($P<0.05$) showed statistically significantly difference. The difference in ADC value of solid composition between benign cystadenoma and cystadenocarcinoma

was also statistically significant ($P<0.05$). There was no significant difference in ADC value of cystic composition between benign cystadenoma, borderline cystadenoma and cystadenocarcinoma ($P>0.05$).

Conclusion: Quantitative analysis of ADC value of solid composition using 3.0T MRI has great value in differential diagnosis of benign and malignant ovarian cystic adenoid tumors. Its combination with conventional MRI method can improve the accuracy of diagnosis of ovarian cystic adenoid tumors.

Keywords: Apparent diffusion coefficient, Magnetic resonance imaging, Ovarian cystadenoma, Cystadenocarcinoma, Borderline cystadenoma

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1 Introduction

Early symptoms of ovarian tumor are not obvious, and most malignant tumors show serious manifestations when diagnosed. Most ovarian cystic adenoid tumors occur in young and middle-aged women^[1], which seriously threaten the health and survival rate of women. Therefore, early accurate and quantitative diagnosis has very important values. At present, MRI has been increasingly applied in imaging examination diagnosis of pelvic diseases due to its advantages of high resolution, non-radiation and multi sequence imaging. With the development of new technologies, DWI scanning technology has been applied for

diagnosis and differential diagnosis of ovarian tumors. It has a strong diagnostic value for preoperative evaluation of ovarian tumors^[2].

ADC value measurement reflects the diffusion degree of water molecules in DWI. Combined with routine MRI method, this study quantitatively analyzed the ADC value of cystic and solid compositions in ovarian cystadenocarcinoma, borderline cystadenoma and cystadenoma. The value of ADC in diagnosis and differential diagnosis of ovarian cystadenocarcinoma was investigated.

2 Data and methods

2.1 General information

This study included 13 patients with ovarian cystadenoma (5 serous cystadenoma and 9 mucinous cystadenoma), 4 borderline mucinous cystadenoma, 11 cystadenocarcinoma (9 serous cystadenocarcinoma and 2 mucinous cystadenocarcinoma) as confirmed by surgical and pathological examinations in our hospital from July 2017 to September 2019. Age ranged from 24 to 75 years old, the average age was (48.9 ± 3.2) years old. Patients with mild clinical symptom showed abdominal distention, pain and discomfort. Patients with severe symptom manifested abdominal pain, abdominal distention, abdominal mass, postmenopausal vaginal bleeding and others.

2.2 Instruments and methods

Patients were placed in supine position. Body movement during scanning was prohibited. Small fluid volume was maintained in bladder. Siemens 3.0T MR scanner was used for routine plain scan and DWI scan of pelvis. Echo planar imaging (EPI) sequence was used in DWI scan, fat-suppressed sagittal and axial T2WI, axial T1WI and non-fat suppressed T1WI and T2WI. Axial scan, fat suppression, layer thickness, layer gap and FOV were kept constant for standardization. The B value selected was 0 and 800s/mm^2 .

2.3 Imaging analysis

All imaging results were analyzed by two senior radiologists in double-blinded manner and mutual agreement was achieved. Analysis contents: (1) observation of presence of space-occupying lesion; (2) MRI manifestations of lesion, including tumor size, margin, composition (cystic or solid), signal characteristic and presence of ascites; (3) ADC value measurement in combination with T2WI and DWI localization, the largest surface areas of cystic and

solid compositions in tumor were selected, center zone of lesion was selected as the region of interest, measurement was taken 3 times for average value.

2.4 Statistical methods

All data were statistically processed by SPSS16.0 software package. All measurement data were expressed in the form of mean \pm standard deviation ($\bar{x} \pm s$). ADC values of different lesions were compared by ANOVA, and difference with $P < 0.05$ was considered statistically significant.

3 Results

3.1 Comparison of MRI diagnosis results with pathological results

Among the 28 cases, there were a total of 31 lesions (3 cases were bilateral lesions). MRI examination detected 31 lesions; the detection rate was 100%. Compared with surgical and pathological results, 3 cases were misdiagnosed. A case of serous cystadenoma was misdiagnosed as simple cyst; 2 cases of borderline mucinous cystadenoma were misdiagnosed as cystadenocarcinoma and cystadenoma respectively. The specificity of MRI was 89.2% [25/28].

3.2 MRI findings of ovarian tumors

3.2.1 Cystadenoma

There were 5 cases of serous cystadenomas (Figure 1). Age ranged from 37 to 75 years old. The average cyst diameter was (9.87 ± 5.14) cm. Four cases were single cyst and 1 case had multiple cysts. Lesions were round or oval, with thin and smooth cyst wall and distinct boundary with the surrounding tissues. Cysts showed homogenous signal, long T1 and T2 water-like signals. DWI showed normal and low signals. ADC mapping showed significantly high signal. ADC value of cystic composition was $2.64 \pm 0.32 \times 10^{-3} \text{mm}^2/\text{s}$. There was a case with cystic wall contained papillary isosignal projections, the ADC value was $2.67 \times 10^{-3} \text{mm}^2/\text{s}$.

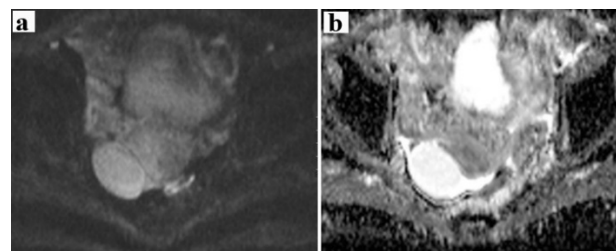


Figure 1. 46 years old, serous cystadenoma at right side ovary. a: DWI showed normal signal. b: ADC mapping showed ADC value of about $3.05 \times 10^{-3} \text{mm}^2/\text{s}$.

There were 9 cases of mucinous cystadenomas (Figure 2). Age ranged from 24 to 66 years old. All were unilateral and multicystic. Average tumor diameter was (17.52 ± 4.94) cm. The cysts were multi-septated, with distinct boundary from the surrounding tissues. Signal was uneven between different cysts. T1WI and T2WI showed hypointense, isointense or hyperintense signals. Signal within each cyst was homogenous. DWI showed slightly high and low signals. ADC mapping showed high signal. ADC value was $2.69 \pm 0.21 \times 10^{-3} \text{mm}^2/\text{s}$.

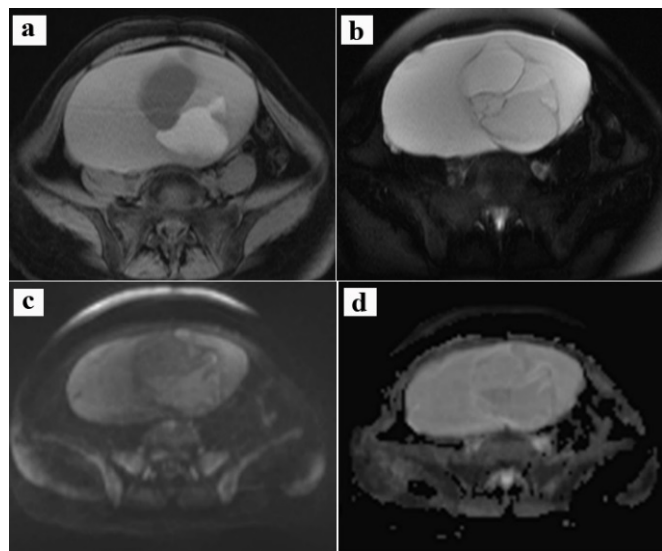


Figure 2. Female, 42 years old, mucinous cystadenoma at left ovary. Multilocular cystic lesion. Mixed signal between cysts. DWI showed low and slightly high signal changes (c). ADC mapping (d) showed cystic composition with ADC value of $2.68 \times 10^{-3} \text{mm}^2/\text{s}$ and intracystic septum with ADC value of $2.73 \times 10^{-3} \text{mm}^2/\text{s}$.

3.2.2 Borderline mucinous cystadenoma

Figures 3 show four cases with age ranged from 39 to 58 years old. All were multilocular cystic lesions. There were 2 cases of honeycomb ovary, 1 case had nodular solid composition (about 1.1cm diameter), and 2 cases with cystic composition showing slightly hyperintense T1 and hypointense T2 signals. The average ADC value of cystic composition was about $2.38 \pm 0.58 \times 10^{-3} \text{mm}^2/\text{s}$, and the average ADC value of solid composition was about $1.36 \pm 0.27 \times 10^{-3} \text{mm}^2/\text{s}$.

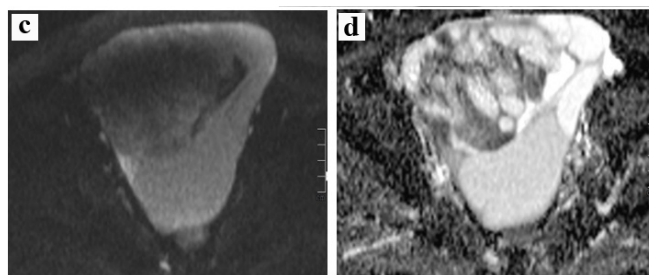
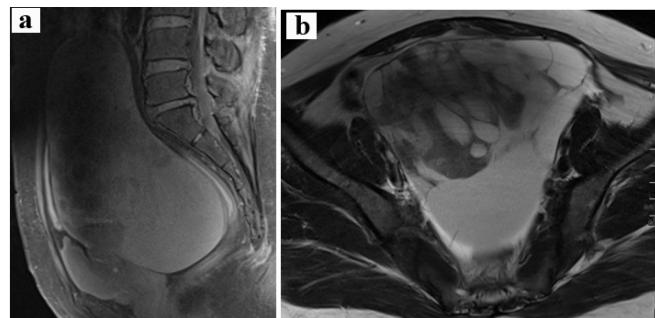


Figure 3. Female, 45 years old, abdominal distention for 4 months accompanied with pain and discomfort. Ovarian multilocular masses on the left side, tumor boundaries were distinct. T2WI showed multiple hypointense signal areas and septum. DWI (c) showed mixed signals. ADC figure (d) showed that ADC value of cystic composition was $1.32\text{--}3.01 \times 10^{-3} \text{mm}^2/\text{s}$, and that of solid composition was $1.06\text{--}1.35 \times 10^{-3} \text{mm}^2/\text{s}$.

3.2.3 Cystadenocarcinoma

There were 9 cases of serous cystadenocarcinoma (Figure 4), age ranged from 42 to 70 years old. There were 2 bilateral cases. The average tumor diameter was (7.48 ± 2.07) cm. Tumors were in irregular shape, most with unclear boundary with the surrounding tissues, and appeared as cystic solid masses. Cystic composition showed long T1 long T2 change, normal and low signals on DWI, normal and high signals on ADC mapping; the average ADC value was $2.51 \pm 0.26 \times 10^{-3} \text{mm}^2/\text{s}$. Solid composition showed isointense T1 and T2 changes, high signal on DWI, and low signal on ADC mapping; the average ADC value was $1.15 \pm 0.19 \times 10^{-3} \text{mm}^2/\text{s}$. One case had clear boundary. Nine cases were accompanied by a large amount of ascites and 1 case showed small amount of ascites.

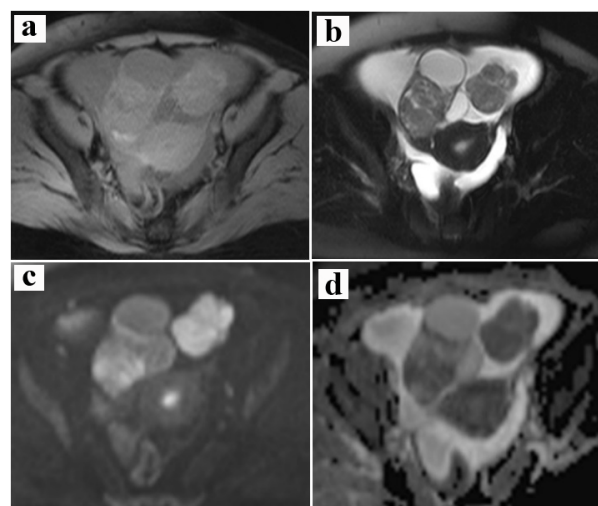


Figure 4. 47 years old, abdominal distention for 1 month. Serous cystadenocarcinoma at bilateral ovaries, cystic solid masses at bilateral adnexa. Cystic composition showed long T1 (a) and long T2 signals (b), small piece of short T1 signal (hemorrhage) could be seen on T1WI. Solid composition showed isointense T1 and isointense T2 signals, high DWI signal (c), and the ADC value (d) was $1.27 \times 10^{-3} \text{mm}^2/\text{s}$. It is accompanied with a large amount of ascites.

There were 2 cases of mucinous cystadenocarcinomas (Figure 5), with age ranged from 42 to 72 years old. All were unilateral, the average lesion diameter was (16.3 ± 5.74) cm. All showed mixed cystic and solid masses, with unclear boundaries with the surrounding tissues. Most cystic compositions showed long T1 and long T2 changes. A few cystic compositions showed hyperintense signal on T1WI, thicker cyst wall and thicker intracystic septa. Cystic compositions showed normal and low signals in DWI, and normal and high signals in ADC mapping. The average ADC value was $2.75 \pm 0.10 \times 10^{-3} \text{mm}^2/\text{s}$. Solid compositions showed isointense T1 and T2 changes, high signal in DWI, and low signal in ADC mapping. The average ADC value was $1.06 \pm 0.11 \times 10^{-3} \text{mm}^2/\text{s}$. There were 3 cases accompanied with ascites.

3.3 Comparison of ADC value in benign cystadenoma, borderline cystadenoma and cystadenocarcinoma

There were no significant intragroup differences in ADC value of cystic composition and solid composition for ovarian cystadenoma and cystadenocarcinoma respectively ($P > 0.05$), as shown in Table 1. Comparison of ADC value of solid composition between benign cystadenoma and borderline cystadenoma showed statistically significant difference ($P < 0.05$). The

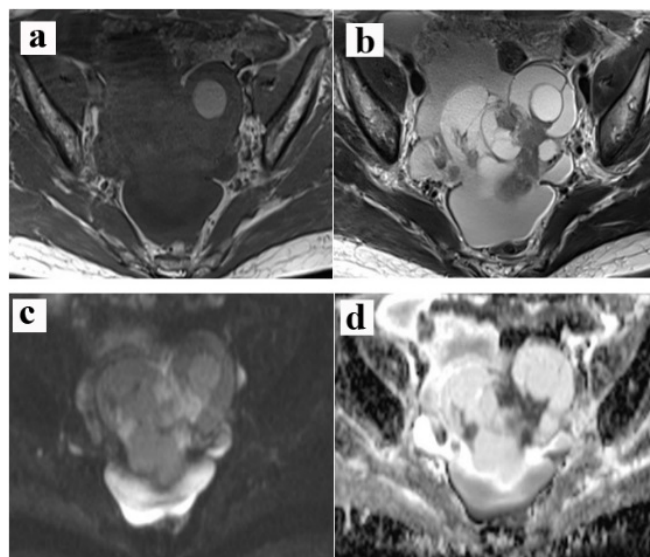


Figure 5. Female, 55 years old, mucinous cystadenocarcinoma at left ovary. Abdominal pain for 5 months, abdominal distention for more than 10 days. Multilocular cystic solid masses. Uneven signal between the cysts. Solid composition of lesion showed high signal in DWI (c). ADC mapping (d) showed low signal. The ADC value was $1.12 \times 10^{-3} \text{mm}^2/\text{s}$, accompanied by ascites and peritoneal thickening.

difference in ADC value of solid composition between benign cystadenoma and cystadenocarcinoma was also statistically significant ($P < 0.05$). There was no statistical significance in cystic composition between benign cystadenoma, borderline cystadenoma and cystadenocarcinoma ($P > 0.05$), as shown in Table 2.

Table 1. Comparison of ADC value between ovarian cystadenoma and cystadenocarcinoma ($10^{-3} \text{mm}^2/\text{s}$)

Intra-group comparison		ADC value of cystic composition	P	ADC value of solid composition	P
Benign cystadenoma	Serous cystadenoma	2.64±0.32	0.75	2.67*	0.82
	Mucinous cystadenoma	2.69±0.21		2.61±0.17	
Cystadeno- carcinoma	Serous cystadenocarcinoma	2.51±0.26	0.25	1.15±0.19	0.54
	Mucinous cystadenocarcinoma	2.75±0.10		1.06±0.11	

Note*: In this study, 1 case of serous cystadenoma had papillary projections on cyst wall.

Table 2. Comparison of ADC value between ovarian benign cystadenoma, borderline cystadenoma and cystadenocarcinoma ($10^{-3} \text{mm}^2/\text{s}$)

Inter-group comparison	ADC value of cystic composition	P	ADC value of solid composition	P
Benign cystadenoma 1	2.67±0.25	Comparison between 1 and 2	2.63±0.12	Comparison between 1 and 2
		0.13		0.01
Borderline cystadenoma 2	2.38±0.58	Comparison between 2 and 3	1.36±0.27	Comparison between 2 and 3
		0.40		0.06
Cystadeno- carcinoma 3	2.56±0.25	Comparison between 1 and 3	1.14±0.18	Comparison between 1 and 3
		0.25		0.01

4 Discussions

DWI observes pathophysiological changes at molecular level by detecting changes of micro free diffusion movement of water molecules in tissue content. It is helpful for qualitative diagnosis of disease. Selection of appropriate diffusion sensitive factor (b value) has an important effect on image quality. The b value of 800 s/mm² not only clearly displays lesions but also has high signal-to-noise ratio^[3]. The b value used in this study was 800 s/mm². Index of diffusion motion of water molecules can be reflected by ADC value measurement. ADC value of tumor is related to cell density and malignant degree of tumor^[4]. The higher the malignancy degree of tumor, the higher the cell density and nucleoplasm ratio, the lesser the extracellular water, the lesser the diffusion of water molecules, and thus the lower ADC value. Results of this study also showed that ADC value of ovarian malignant cystic adenoids was significantly lower than that of benign cystic adenoids.

MRI features of ovarian serous cystadenoma are mainly: single locular, cystic mass with homogeneous signal, clear boundary with surrounding tissues, thin cyst wall, possible compression and displacement signs at adjacent organs with no invasion. Because of mucin content in mucinous cystadenoma, signal is higher than the former in T1WI. Signals in multilocular cystadenoma are also varied due to different protein contents, and lesion volume is generally larger. Tumor with these characteristics is first considered mucinous cystadenoma^[5]. For both groups in this study, small papillary projections (<5mm) could be seen at inner wall, and there was no significant difference in ADC value between the two groups. One case of serous cystadenoma could not be accurately classified due to smaller tumor diameter before surgery, it was misdiagnosed as cyst. Location of cystadenoma was more constant, mainly at adnexa of both sides of uterus. It usually presented as thin-walled water signal cystic lesion with homogenous signal, no septation, clear boundary and diameter less than 5cm^[6].

Borderline cystadenoma is a kind of tumor with low malignancy degree or potential malignancy. Its growth is slow, but it can undergo malignant change. It has a good prognosis with malignant tumor, but imaging diagnosis differentiation between the two types of tumor is difficult at present. It has been reported that MRI manifestations of borderline ovarian mucinous cystadenoma are mostly nodular or papillary projection

(≥ 5mm, 1 case in this study), honeycomb ovary (2 cases in this study), T2WI with low signal cystic fluid (2 cases in this study), irregular thickening of cystic wall or septum (≥ 5mm), and T1WI with high signal cystic fluid (1 case in this study)^[7]. These five signs are of great significance for its diagnosis. In this study, 2 cases were misdiagnosed; 1 case was diagnosed as cystadenocarcinoma due to low ADC value and darkening effect of T2WI was overlooked; 1 case was diagnosed as mucinous cystadenoma with hemorrhage due to hyperintense signal on T1WI and hypointense signal on T2WI. In this study, ADC value of solid part can be used to distinguish benign cystadenoma from borderline cystadenoma.

MRI manifestations of ovarian cystadenocarcinoma are cystic solid or solid mass, irregular shape, unclear boundary with surrounding tissues, wide area involvement, greater and irregular solid composition, uneven thickness of cystic wall in cystic composition, a large number of ascites and omentum. Peritoneal metastasis is a reliable indication of malignancy^[8]. In this study, there was no significant difference in ADC value between serous and mucinous cystadenocarcinoma. This might be related to differences in bleeding condition and protein content, composition of solid composition and region of interest selection. However, ADC value in solid composition could be used to distinguish between cystadenoma and cystadenocarcinoma. ADC value of cystic composition showed no statistical significance in differential diagnosis, which is in agreement with many research results of scholars^[9,10]. However, local and abroad scholars believed that ADC value of cystic composition has statistical significance in differential diagnosis of ovarian benign and malignant lesions^[11,12].

Summarizing the data of this study, authors believe that tumors with clear boundary (mainly cystic), uniform and smooth cystic wall, and with higher ADC value are mostly benign. Those with unclear boundary and wide involvement range (mainly cystic or solid), mixed signals, uneven thickening of cystic wall or septum, and lower ADC value are mostly borderline or malignant. Therefore, quantitative analysis of ADC value of solid composition using 3.0T MRI has an important value in differential diagnosis of ovarian cystic adenoid tumors. Its combination with conventional MRI method can improve accuracy of diagnosis of ovarian cystic adenoid tumors.

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