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Clinical evaluation of MRI in the differential diagnosis between benign and malignant ovarian tumors

Tao Zhang[1], Xin Yi[2], Jian Lu[1], Aiyan Fu[3]

[1] Department of Radiology, Nantong Third People's Hospital, Nantong Uniiversity, Nantong; [2] Department of Human Anatomy, Medical College, Nantong University, Nantong; [3] Department of Radiology, the Tumor Hospital of Nantong, Nantong (China)

Summary

Ovarian tumors present a special diagnostic challenge when imaging findings cannot be categorized into benign or malignant pathology. Magnetic resonance imaging (MRI) is currently used to evaluate ovarian tumors. The aim of this study was to evaluate the diagnostic performance of MRI in patients with benign or malignant ovarian tumors and enhance its diagnostic accuracy. The MRI findings of 48 cases of ovarian tumors, which were confirmed by surgery or pathology from September 2009 to July 2011, were analyzed retrospectively. T1-, T2-, and fat-suppressed T2-weighted sequences were performed and dynamic contrast-enhanced T1-weighted gradient-echo images were performed after IV injection of Gd-DTPA by 1.5-T unit. The ovarian tumors were examined for several features including size, bilaterality, shape, content (solid–cystic), signal intensity, and enhancement. Secondary signs such as ascites, peritoneal disease, and lymphadenopathy were noted. The imaging features with the surgical and pathologic findings were compared and the MRI features of benign and malignant ovarian tumors were compared and summarized. MRI features of 33 cases of malignant ovarian tumors were cystic-solid or solid masses, with irregular wall, and intense enhancement. MRI features of 15 cases of benign ovarian tumors were cystic masses, with regular wall, and not or slightly enhanced. The differences of bilaterality, shape, content (solid–cystic), signal intensity, and enhancement between benign and malignant ovarian tumors were statistically significant ($p < 0.01$). The data demonstrate MRI features may help differentiate benign ovarian tumors from malignant ovarian tumors.

Key words: Ovary tumor; Magnetic resonance imaging; Diagnosis.

Introduction

Ovarian tumors have the highest mortality rate of all gynecologic malignant tumors [1]. Ovarian tumors present a special diagnostic challenge when imaging findings cannot be categorized into benign or malignant pathology. Ultrasonography (US), is the first-line imaging investigation for suspected adnexal masses, helping in detection and characterization of ovarian tumors. US morphological analysis of adnexal masses is usually accurate for identifying low- or high-risk lesions [2]. An adnexal mass is defined as indeterminate on US when it cannot be confidently placed into either the benign or malignant category, even after thorough interrogation, including Doppler assessment which helps the diagnosis, identifying vascularized components within the mass [3]. A meta-analysis suggested that US and color Doppler imaging alone were insufficient to accurately characterize adnexal tumors, although a combination of the two methods significantly increases the diagnostic accuracy [4]. Computed tomography (CT) is commonly performed in preoperative evaluation of a suspected ovarian malignancy, but it exposes patients to radiation.

Magnetic resonance imaging (MRI) is currently used to evaluate ovarian tumors, which has played an important role in the diagnosis of ovarian tumors, and the high diagnostic accuracy of this method in the differentiation of benign and malignant ovarian tumors has been reported [5-8]. A reliable method with which to differentiate a benign from a malignant ovarian tumors would provide a basis for optimal preoperative planning and may also reduce the number of unnecessary laparotomies patients undergo for benign disease. Preoperative characterization of benign or malignant ovarian tumors is crucial for informing patients about possible surgical strategies. However, only limited information is available as to which MRI features are best to use in distinguishing benign from malignant ovarian tumors [6].

The aim of the present study was to evaluate the accuracy of MRI in the detection and characterization of ovarian tumors and to determine which morphologic features are most predictive of malignancy.

Materials and Methods

The institutional review board approved the study and waived the requirement to obtain written informed consent. The subjects for this study were 48 patients with ovarian tumors treated at the Third People's Hospital of Nantong or the Tumor Hospital of Nantong between September 2009 and July 2011. A retrospective review of MRI data was undertaken. The MRI studies met the following inclusion criteria for the study: (1) MRI was performed

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using a 1.5T magnet, and (2) both conventional MRI and dynamic contrasted-enhancement MRI were performed. In addition, the diagnosis was confirmed by surgery and pathological examination.

MRI was performed on a 1.5-T MR imaging unit. A pelvic phased array coil was used in all patients. The following sequences were obtained: axial T1-weighted and T2-weighted MR imaging from the renal hilum to the symphysis pubis or beyond if necessary to cover the larger ovarian masses (TR/TE, 117/4.76; slice thickness, six mm; gap, one mm; field of view, 40–36 cm; matrix, 288–192; and respiratory compensation); fat-suppressed sagittal and coronal T2-weighted fast imaging from the renal hilum to the symphysis pubis or beyond if necessary to cover the larger ovarian masses (TR/TE, 117/4.76; slice thickness, six mm; gap, one mm; field of view, 40–36 cm; matrix, 288–192; and respiratory compensation).

The dynamic contrast-enhanced pelvic axial images of arterial and venous phase were obtained at 20 and 48 seconds after IV injection of 0.2 mmol/kg of gadopentetate dimeglumine (Gd-DTPA) (TR/TE, 5.14/2.30; slice thickness, five mm; gap, 2.5 mm; field of view, 40–36 cm; matrix, 288–192); the dynamic contrast-enhanced pelvic axial, sagittal and coronal images of delayed scan were obtained at 68 and 88 seconds after IV injection of Gd-DTPA) (TR/TE, 5.14/2.30; slice thickness, five mm; gap, 2.5 mm; field of view, 40–36 cm; matrix, 288–192).

MRI were evaluated by two senior radiologists experienced with MRI. Divergent interpretations resulted in a second evaluation and a new diagnosis made with a consensus of both examiners. The imaging features documented include the number of ovarian masses per patient, lesion shape, lesion size, lesion boundary, content of lesion (solid, solid–cystic, and cystic), contrast medium–uptake behavior, and signal pattern in the individual weighted sequences. Other MRI features included in the study were the presence of ascites, peritoneal disease, and lymphomas.

Diagnosis was based on morphological abnormalities on non-enhanced MRI and enhancement on dynamic-contrast MRI. Lesions were considered benign if one or more of the following criteria were met: exclusively cystic structures without any solid areas, presence of typical characteristics of a dermoid cyst or endometrioma. If one of these criteria was not fulfilled, the lesion was considered malignant. Additional criteria for malignancy included peritoneal disease manifestation and the presence of lymphomas or ascites. In findings without evidence of malignancy, signal patterns in T1-weighted and T2-weighted sequences were used as the basis for diagnosis, such as in serous cysts, endometriomas, or teratomas.

The characters of MRI of benign and malignant ovarian tumors were assessed. Statistical analysis was performed using Statistics Package for Social Science 16.0 (SPSS 16.0). Statistical comparisons were performed using the chi-square test and differences at $p < 0.05$ were considered statistically significant.

Table 1. — *Histopathologic diagnosis of 163 adnexal masses.*

Diagnosis	No.	% of all masses studied
Benign	15	31.25
Mature teratoma	6	12.5
Serous cystadenoma	4	8.33
Mucinous cystadenoma	4	8.33
Fibroma	1	2.08
Malignant	33	68.75
Serous cystadenocarcinoma	15	31.25
Mucinous cystadenocarcinoma	6	12.5
Undifferentiated carcinoma	2	4.17
Yolk sac tumor	1	2.08
Endometrioid carcinoma	1	2.08
Disgerminoma	1	2.08
Metastatic tumors	7	14.58

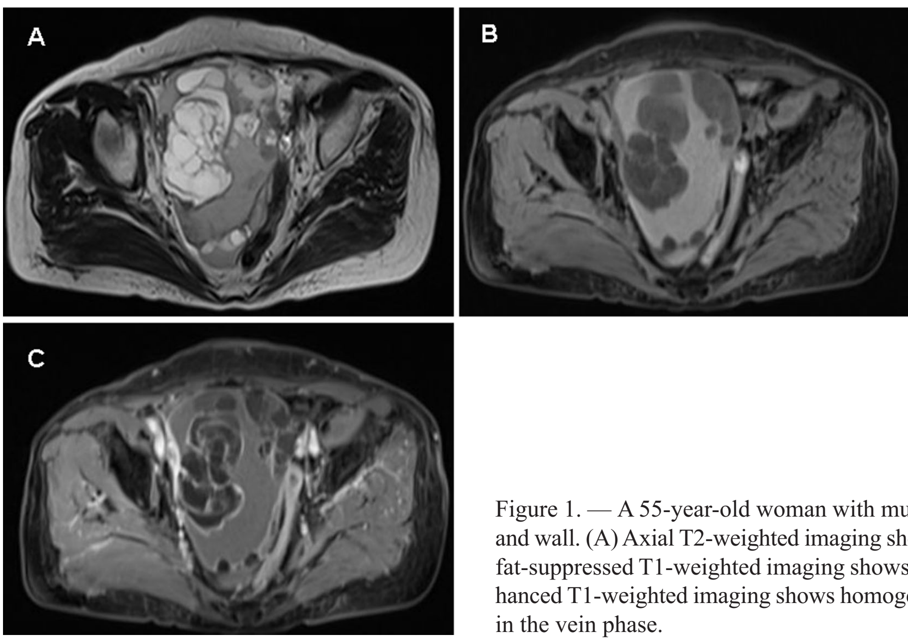

Figure 1. — A 55-year-old woman with mucinous cystadenoma with regular shape and wall. (A) Axial T2-weighted imaging shows high homogeneous signal. (B) Axial fat-suppressed T1-weighted imaging shows low homogeneous signal. (C) Axial enhanced T1-weighted imaging shows homogeneous enhancement on the wall of mass in the vein phase.

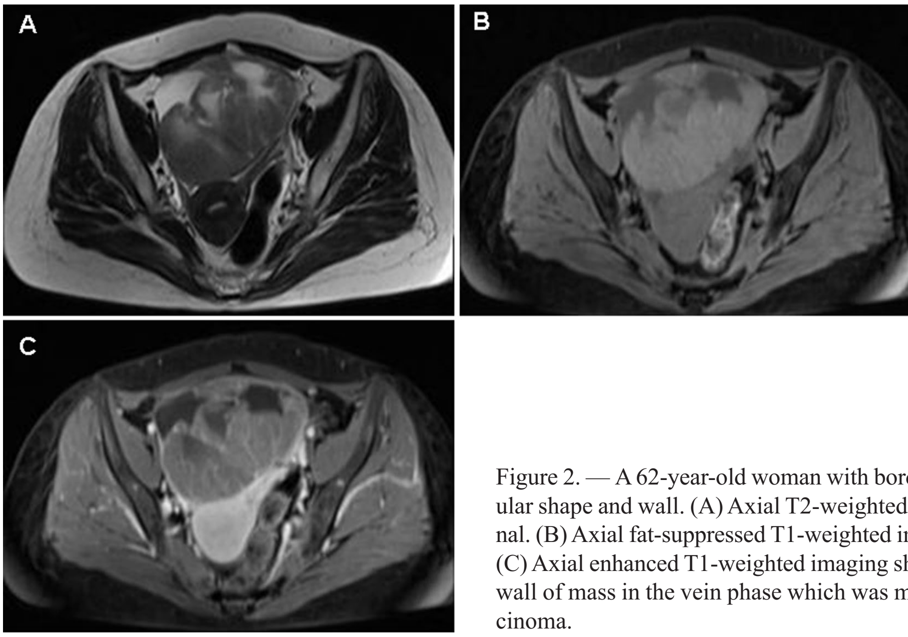

Figure 2. — A 62-year-old woman with borderline mucinous cystadenoma with regular shape and wall. (A) Axial T2-weighted imaging shows high heterogeneous signal. (B) Axial fat-suppressed T1-weighted imaging shows low heterogeneous signal. (C) Axial enhanced T1-weighted imaging shows heterogeneous enhancement on the wall of mass in the vein phase which was misdiagnosed as mucinous cystadenocarcinoma.

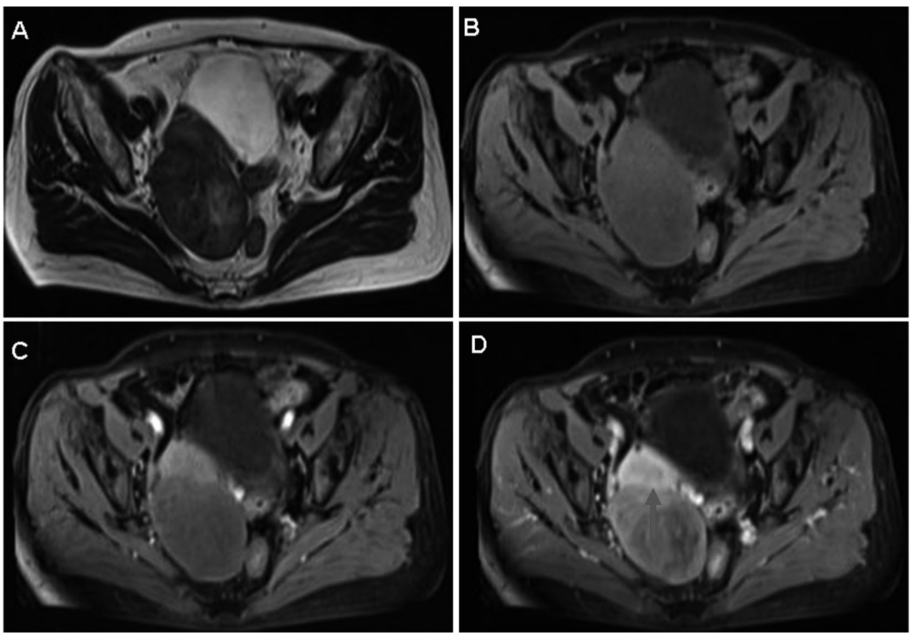

Figure 3. — A 50-year-old woman with fibroma which was misdiagnosed as uterus subserous myoma. (A) Axial T2-weighted imaging shows high heterogeneous signal. (B) Axial fat-suppressed T1-weighted imaging shows low heterogeneous signal. (C) Axial enhanced T1-weighted imaging shows slight enhancement on the wall of mass in the artery phase. (D) Axial enhanced T1-weighted imaging shows high enhancement on the wall of mass in the vein phase. The lesion was adjacent to the posterior wall of uterine and the edge was rough (red arrow), which was misdiagnosed as uterus subserous myoma.

Results

At surgery and pathology, 69 masses were found in the 48 patients; 15 (31.25%) were benign and 33 (68.75%) were malignant. The histopathologic diagnoses of the 69 lesions are shown in Table 1.

Visual evaluation of MRI findings resulted in correct diagnosis of benign in 13 of 15 patients (Figure 1). The cases of misdiagnosis included one borderline mucinous cystadenoma which was diagnosed with mucinous cystadenocarcinoma with tenuous contrast-enhanced septa (Figure 2) and one fibroma which was diagnosed with uterus subserous myoma with solid high signal on T2-weighted imaging (Figure 3). Visual evaluation of MR imaging findings resulted in correct diagnosis of malignant in 33 of 33 patients (Figure 4).

Table 2 summarizes the characteristics of the benign and malignant ovarian tumors. Features that were shown not to be significantly different between benign and malignant masses included maximal diameter and lymphadenopathy. Features that were shown to be significantly different be-

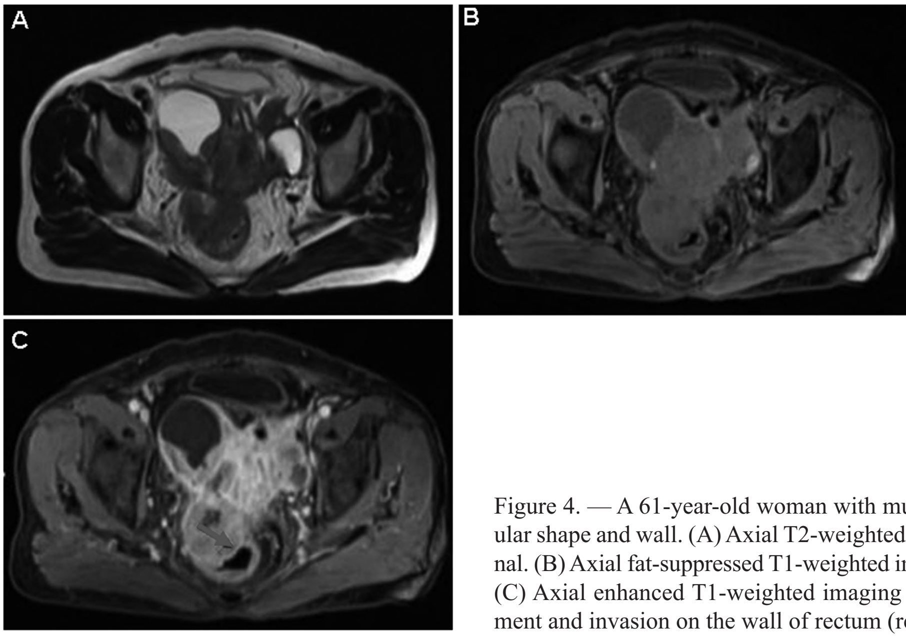

Figure 4. — A 61-year-old woman with mucinous cystadenocarcinoma with irregular shape and wall. (A) Axial T2-weighted imaging shows high heterogeneous signal. (B) Axial fat-suppressed T1-weighted imaging shows low heterogeneous signal. (C) Axial enhanced T1-weighted imaging shows intense heterogeneous enhancement and invasion on the wall of rectum (red arrow) in the vein phase.

Table 2. — *Charateristics of the 48 benign and malignant ovarian tumors detected by MRI.*

Variable	Benign (n=15)	Malignant (n=33)
Maximal diameter	10.26	11.35
Bilaterality	1	20*
Shape		
Regularity	15	13
Irregularity	1	40*
Wall		
Regularity	16	17
Irregularity	0	36*
Content		
Solid only	1	50*
Solid-cystic	1	3
Cystic only	14	0*
Low signal on fat-suppressed T1-weighted imaging		
Homogeneous signal	6	
Heterogeneous signal		37*
High signal on T2-weighted imaging		
Homogeneous signal	6	
Heterogeneous signal		51*
Enhancement	3	53*
Ascites	1	14*
Peritoneal disease	1	14*
Lymphadenopathy	0	1

* *vs.* benign, $p < 0.05$.

tween benign and malignant masses included bilaterality, shape, wall, content, signal intensity, enhancement, ascites, and peritoneal disease.

Discussion

Malignant ovarian tumors are responsible for 4% of all cancers affecting women, are the second most common cause of death from gynecologic cancer, and the fourth most common cause of death from all types of cancer affecting women [9]. Low survival rates among women with malignant processes of the ovary underscore the need for early detection and correct diagnosis of adnexal tumors [10].

Ovarian tumors are the leading indication for surgery. The preoperative characterization of complex solid and cystic adnexal masses is crucial for possible surgical strategies [11-13]. The differentiation of benign from malignant adnexal masses is of great value because the therapeutic approach is different for each entity. Benign ovarian masses can be managed with more conservative approaches, either with close observation or with laparoscopic surgery [14]. On the contrary, when the tumor is malignant, there is a need for urgent laparotomy [15, 16]. It is believed that laparoscopic surgery used for the treatment of benign ovarian could improve quality of life, but no evidence showed that laparoscopy for the management of early stage malignant ovarian tumors may improve the quality of life [15].

US is the first-line imaging modality for adnexal tumors and is a particularly useful preoperative test for the characterization of non-complex masses. An adnexal mass is defined as indeterminate on US when it cannot be confidently placed into either the benign or malignant category, even after thorough interrogation, including Doppler assessment which helps the diagnosis identifying vascularized components within the mass [3]. CT is commonly performed in preoperative evaluation of a suspected ovarian malignancy, but it exposes patients to radiation. CT, the usefulness of which in the workup of adnexal lesions, remains controversial. MRI is used increasingly as an additional cross-sectional imaging method with advantages including high soft tissue contrast, different degrees of signal intensity, and absence of radiation exposure. MRI technique with dynamic contrast-enhanced imaging is a useful tool to distinguish benign and malignant tumors [17, 18]. Contrast enhancement with intravenous gadolinium allows better resolution of the internal architecture and the differentiation of cystic from solid lesions [19, 20]. It may be of great help in identifying malignant lesions before surgery, particularly when US findings are suboptimal or indeterminate [21-24].

The present findings demonstrate that bilaterality, shape, wall, content, signal intensity, enhancement, ascites, and peritoneal disease can be used to distinguish malignant from benign ovarian tumors. The main characteristics of the malignant ovarian tumors on MRI include bilaterality, irregular shape, irregular wall, solid only or solid-cystic, low heterogeneous signal on fat-suppressed T1-weighted imaging, high heterogeneous signal on T2-weighted imaging, intense enhancement, ascites, and peritoneal disease. Detection rate of the present research was 100%. The accuracy rate of diagnosis for malignant ovarian tumors was 100% and for benign ovarian tumors it was 86.7%. This result is consistent with previous reports [25-28]. Among lesions that were incorrectly classified were borderline ovarian tumors and other benign lesions with some solid enhancing elements. One case of misdiagnosis in the present study was one fibroma adhering to uterine wall with solid high signal on T2-weighted imaging, which was diagnosed as uterus subserous myoma. Borderline ovarian tumors are often difficult to characterize because their morphologic features are similar to those of benign ovarian lesions and are therefore frequently misclassified [29]. However the case of misdiagnosis in the present study was one borderline mucinous cystadenoma with tenuous contrast-enhanced septa which was diagnosed as mucinous cystadenocarcinoma.

All in all, morphologic criteria were useful for discriminating malignant from benign ovarian tumors, but none of the morphologic criteria reliably distinguished benign from borderline ovarian tumors. MRI (1.5 T) is a useful preoperative test for the prediction of the benign or malignant nature of a ovarian mass.

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Corresponding Author:
JIAN LU, M.D.
Department of Radiology
Nantong Third People's Hospital
99 Mid-Youth Road
Nantong 226001Jiangsu Province (China)
e-mail: ntuyixin@foxmail.com