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Research article

MRI features and score for differentiating borderline from malignant epithelial ovarian tumors☆

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ABSTRACT

Purpose: To identify the MRI features of borderline epithelial ovarian tumors (BEOTs) and to differentiate BEOTs from malignant epithelial ovarian tumors (MEOTs).

Materials and methods: The clinical and MRI data of 89 patients with a BEOT and 109 patients with a MEOT proven by surgery and histopathology were retrospectively reviewed. MRI features, including bilaterality, size, shape, margin, cystic-solid interface, configuration, papillae or nodules, signal intensity, enhancement, presence of an ipsilateral ovary, peritoneal implants and ascites were analyzed and compared. Based on the odds ratio (OR) values, the significant risk features for BEOTs were scored as 3 ($OR \approx \infty$), 2 ($5 \leq OR < \infty$) or 1 ($OR < 5$).

Results: There were 89 BEOT patients with 113 tumors [mean size of (13 ± 6.7) cm], with bilateral ovary involvement in 24 cases. There were 109 MEOT patients with 142 tumors [(9.3 ± 4.2) cm] with bilateral ovary involvement in 33 cases. There were eight significant risk factors for BEOTs, including round or oval shape ($OR = 2.714$), well-defined margins ($OR = 3.318$), clear cystic-solid interfaces ($OR = 5.593$), purely cystic ($OR = 15.206$), predominantly cystic with papillae or nodules ($OR = 2.579$), exophytic papillae or nodules ($OR = 5.351$), branching papilla ($OR \approx \infty$) and the presence of an ipsilateral ovary ($OR \approx \infty$). Based on the scoring of the eight risk factors, a cut-off score of 3.5 yielded a differential sensitivity, specificity, and accuracy of 82%, 85% and 84%, respectively.

Conclusion: In contrast to MEOTs, BEOTs frequently had the following features on MRI: round or oval, with well-defined margins and clear cystic-solid interfaces, purely cystic or predominantly cystic with papillae or nodules, branching or exophytic papillae, with the presence of an ipsilateral ovary. MRI can reveal the distinct morphological features of BEOTs and MEOTs and facilitate their discrimination.

1. Introduction

Borderline epithelial ovarian tumors (BEOTs) are common epithelial tumors of the ovary, accounting for 15%–20% [1] of all ovarian tumors. The characteristics of BEOTs include low malignant potential, mitotic activity and nuclear atypia, and no stromal invasion [1]. In contrast to malignant epithelial ovarian tumors (MEOTs), BEOTs commonly occur in younger women and have a good prognosis. The reported 5-year survival rate is 92%, in contrast to 35% for MEOTs [2,3]. Younger BEOT patients who desire to preserve fertility or maintain ovarian function can undergo conservative surgery, whereas MEOT patients require thorough surgical staging, followed by adjuvant chemotherapy. Thus, the accurate preoperative differentiation between BEOT and MEOT is important for determining the proper surgical strategy for each patient, avoiding unnecessary excision of the ovary and uterus, and improving the patient's postoperative quality of life.

In contrast to ultrasonography and computed tomography, MRI is a valuable tool for identifying the morphological characteristics of BEOTs [4–7]. However, previous studies with small sample sizes have indicated limitations in the ability of MRI to distinguish BEOTs from MEOTs [8–10]. Few comprehensive large cohort studies have concentrated on investigating the differential MRI features of BEOTs and MEOTs. In this study, we analyzed the clinical and MRI data of 89 patients with a BEOT and 109 patients with a MEOT to determine the

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Table 1
The histology of borderline and malignant epithelial ovarian tumors.

Histology	BEOTs (n = 113)	MEOTs (n = 142)
Serous	67	96
Mucinous	43	9
Endometrioid	2	13
Clear cell	0	23
Mixed	1	1

ability of conventional MRI to differentiate BEOTs from MEOTs and to improve the accuracy of preoperative diagnosis.

2. Materials and methods

2.1. Patient population

The institutional review board of our hospitals approved this retrospective study, and informed consent was waived. From 2010 to 2016, the clinical and MRI data of 89 patients with BEOT and 109 patients with MEOT proven by surgery and histopathology were retrospectively reviewed. The mean age was 38 ± 14.6 years (range, 16–82 years) in patients with BEOT and 56 ± 8.4 years (range, 36–75 years) in patients with MEOT. There was a significant difference in age between the two groups ($P < 0.001$). All patients underwent surgery within 2 weeks after the MR scan and were staged according to the International Federation of Gynecology and Obstetrics (FIGO) staging system.

2.2. MRI protocol

MRI was performed using a 1.5-T MRI system (Symphony, Avanto, Siemens, Erlangen, Germany) and a pelvic phased-array coil. Patients were supine and allowed free breathing during acquisition. The sequences were obtained as follows: axial T1-weighted imaging (T1WI) including spin-echo with and without fat saturation (FS) ([time of repetition (TR)/time of echo (TE), 196 ms/2.9 ms and 340 ms/10 ms, respectively), T2-weighted imaging (T2WI) including turbo spin-echo with and without FS (TR/TE, 8000 ms/83 ms and 4000 ms/98 ms, respectively); and sagittal T2WI turbo spin-echo (TR/TE, 4000 ms/98 ms). Contrast-enhanced T1WI with FS (TR/TE, 196 ms/2.9 ms) was performed in the axial, sagittal and coronal planes at 40–60 s (early

Table 2
The comparison of MRI features between BEOTs and MEOTs./span >

MRI feature	BEOTs	MEOTs	*P* value
Bilaterality	24/89 (27%)	33/109 (30%)	0.609
Maximum diameter (cm)[a]	1.5 ~ 36 (13 ± 6.7)	2.4 ~ 21.8 (9.3 ± 4.2)	0.846
Shape			< 0.001
Round or oval	69/113 (61%)	52/142 (37%)	
Lobulated or irregular	44/113 (39%)	90/142 (63%)	
Margin			< 0.001
Well-defined	94/113 (83%)	85/142 (60%)	
Ill-defined	19/113 (17%)	57/142 (40%)	
Cystic-solid interface			< 0.001
Clear	54/73 (74%)	31/92 (34%)	
Unclear	19/73 (26%)	61/92 (66%)	
Configuration			
Purely cystic[b]	11/113 (10%)	1/142 (0%)	0.001
Predominantly cystic with papilla or nodule	45/113 (40%)	29/142 (21%)	0.001
Cystic-solid	28/113 (25%)	63/142 (44%)	0.001
Solid	29/113 (25%)	49/142 (35%)	0.128
Papilla growth pattern			
Endophytic	65/102 (64%)	46/92 (50%)	0.054
Exophytic	28/102 (27%)	6/92 (7%)	< 0.001
Mixed	9/102 (9%)	40/92 (43%)	< 0.001
Branching papilla[b]	41/113 (36%)	0/142 (0%)	< 0.001
SI of solid on FS T1WI[c]			0.084
Moderate to low	80/94 (85%)	130/141 (92%)	
High	14/94 (15%)	11/141 (8%)	
SI of solid on T2WI[c]			0.021
Moderate to low	79/94 (84%)	100/141 (71%)	
High	15/94 (16%)	41/141 (29%)	
SI of cystic on FS T1WI			< 0.001
Moderate to low	37/84 (44%)	66/93 (71%)	
High	47/84 (56%)	27/93 (29%)	
SI of cystic on T2WI			0.053
Low	13/84 (15%)	6/93 (6%)	
Moderate to high	71/84 (85%)	87/93 (94%)	
Enhanced ratio[a,d]			
Early phase	0.76 ~ 2.4 (1.43 ± 0.41)	0.79 ~ 2.76 (1.46 ± 0.44)	0.579
Middle phase	0.75 ~ 2.51 (1.61 ± 0.39)	0.80 ~ 2.92 (1.71 ± 0.37)	0.011
Late phase	0.79 ~ 3.01 (1.76 ± 0.51)	0.82 ~ 2.67 (1.72 ± 0.37)	0.328
Ipsilateral ovary[b]	34/113 (30%)	0/142 (0%)	< 0.001
Peritoneal implant	9/89 (10%)	48/109 (44%)	< 0.001
Ascites			
Massive	6/89 (7%)	24/109 (22%)	0.003
Moderate	5/89 (6%)	10/109 (9%)	0.347
Physiological	27/89 (30%)	23/109 (21%)	0.137

[a] The two independent-sample Student *t*-test.
[b] The Fisher's exact test. The others used Pearson χ^2 test.
[c] Eight BEOT show flannel-like papillae seen only on the contrast-enhanced imaging, and the signal of solid component can not be evaluated and excluded.
[d] The enhanced ratio of tumor/iliopsoas is obtained in 89 BEOTs and 109 MEOTs.