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Original Article

Magnetic Resonance Imaging of Sonographically Indeterminate Adnexal Masses: A Reliable Diagnostic Tool to Detect Benign and Malignant Lesion

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Abstract

Introduction: Adnexal masses are a quite common clinical problem. Around 5-10% women undergo surgery for suspicious adnexal masses, but only 25% or less are malignant.

Aims and Objectives: To study the sensitivity and specificity of magnetic resonance imaging (MRI) in differentiating sonographically indeterminate adnexal masses into benign and malignant, in considering biopsy as the reference standard.

Materials and Methods: Our study is observational, analytical study with cross-sectional, data collection done from February 2015 to September 2016. 58 patients with sonographically indeterminate adnexal mass were selected as the study population. On the basis of ultrasound, we studied the distinguishing features of benignity and malignancy, origin and tissue characterization in MRI and the final diagnosis was confirmed with histopathology.

Results: On MRI out of 58 masses, we diagnosed 30 masses as benign and 28 masses as malignant, however, on histopathological examination it was 27 and 31, respectively. The overall sensitivity and specificity of MRI to differentiate benign and malignant adnexal mass was 91.1% and 100%, respectively. The positive predictive value, negative predictive value, and accuracy were 100%, 90%, and 94.4%, respectively.

Conclusion: In our study, MRI proved to be highly sensitive and specific in differentiating malignant from benign adnexal masses which were indeterminate on ultrasonography examination. Thus can be used to categorize indeterminate masses into benign or malignant and help the surgeon to plan surgery in the required persons, whereas those with benign masses can undergo conservative management.

Key words: Adnexal masses, Magnetic resonance imaging, Ultrasonographically indeterminate masses

INTRODUCTION

Adnexal masses are a quite common clinical problem. Around 5-10% women undergo surgery for suspicious adnexal masses, but only 25% or less are malignant.[1] Sometimes 50-60% of benign cases are operated unnecessarily on the basis of suspicious ultrasonographic findings.[2] To avoid this, magnetic resonance imaging (MRI) seems the logical choice. Moreover, it is extremely important for a surgeon to plan the type and extent of surgery in women of childbearing age.

Sonography is always the initial choice because of its easy availability and cost-effectiveness. Computed tomography scan has a limited role in the diagnosis of adnexal masses.

MRI has been effectively used not only in diagnosing the indeterminate masses with greater accuracy but also in

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characterizing the tissue content into benign or malignant and hence of great value for a clinician.

MATERIALS AND METHODS

Our study is observational (diagnostic analytical), prospective study with cross sectional data collection in a period of February 2015 - September 2016 done at Department of radio diagnosis Pt. JNM Medical College, Raipur (Chhattisgarh).

After obtaining approval from the ethics committee, we enrolled women having sonographically indeterminate pelvic mass. They were sent for pelvic MRI. The inclusion criteria of the study were, women of any age group having indeterminate adnexal masses. We identified a total of 72 indeterminate masses. We excluded 14 mass on the basis of exclusion criteria which were unwillingness to take part in study, claustrophobia and deranged renal function. Masses were considered sonographically indeterminate when the origin of mass was uncertain due to its large size, suboptimal image quality due to large body habitus, excessive bowel gas, shadowing from fibroids, poor pelvic detail, or lack of tissue specificity (purely solid mass, purely cystic mass, and complex cystic mass). "Lack of tissue specificity" for solid, cystic, or complex cystic masses implies that the finding is not specific for any one diagnosis and can be seen in a wide spectrum of lesions, including both benign and malignant entities. Finally, 58 sonographically indeterminate adnexal masses composed the final study population. The mean interval between sonography and MRI was 18 days (Range, 5-90 days). The final diagnosis for each of the 58 masses was established by histopathology.

The selection of study population as sonographically indeterminate adnexal mass was done by the two experienced radiologist using Toshiba Aplio MX ultrasound machine having a high-frequency small part probe and low-frequency curvilinear probe and transvaginal scan probe.

All 58 MRI studies were performed on MAGNETOM Skyra, Siemens, Germany and accessories including pelvic phased-array coil 3T field strength. 70 cm open bore design, 173 cm system length, approximately 35 m^2 room size. RF Tim (204×48) (204×64) (204×128), Gradient strength - XQ gradients (45mT/m @ 200T/m/s). Zero helium boil-off technology.

The following sequences were performed: T2 weighted images (T2WI) in the axial, coronal and sagittal plane, a slice thickness of 3 mm, a field of view (FOV) of 200 mm and repetition time/time to echo (TR/TE) - 3500/86, voxel size 0.5×0.5×3 mm. Fat-Suppressed (FS) T2WI MR protocol was: TR, 1600 ms; TE, 95 ms; and thickness, 5.0 mm. Voxel size 0.6×0.6×3 mm, FOV of 204. Short T1 inversion recovery (STIR) images in the axial plane, a slice thickness of 3 mm, a FOV of 180 mm and TR/TE - 5150/38, voxel size 0.6×0.6×3 mm. T1WI in the axial plane, a slice thickness of 3 mm a FOV of 200 mm and TR/TE - 550/12, voxel size 0.6×0.6×3 mm. Post contrast Gadolinium T1 Axial, sagittal and coronal images a slice thickness of 3 mm a FOV of 200 mm and TR/TE - 600/12, voxel size 0.8×0.8×3 mm. Susceptibility weighted imaging sequence taken at in axial plane, a slice thickness of 2.5 mm a FOV of 220 mm and TR/TE - 27/20, voxel size 0.4×0.4×2.5 mm.

The examiners were blinded to the sonography findings. We assessed each adnexal masses in following points: (1) Origin of mass (ovarian, uterine, or extra ovarian), (2) size, shape, and margin of lesion, (3) number of masses, and (4) lesion and tissue content (solid, purely cystic, complex or cystic, and solid). The signal characteristics of the mass on T1, T2-WI, STIR, gradient recalled echo (GRE) were documented for determining tissue content and tissue characterization, accordingly presence of fat, hemorrhage, and fibrous or leiomyomatous tissue was recorded. If there is a fatty component in mass lesion, it gives a bright signal on T1-WI and lost signal intensity on fat-suppressed T2-weighted sequences. Hemorrhage was easily identified on GRE sequences appeared as blooming and also by high signal intensity on both non-fat-suppressed and fat-suppressed T1-WI. Fibrous and leiomyomatous tissue was defined as being hypointense to skeletal muscle on T2-WI. A thick enhancing wall, internal enhancement, septations, papillary projection, necrosis, lobulation, and mural nodules within the mass were used to help characterize a mass as benign or malignant. The presence of an abnormal amount of pelvic fluid, lymph node enlargement, and peritoneal metastases was also recorded. Final impressions of benign or malignant mass were given on the basis of above-described findings.

Statistical Evaluation

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of a correct MRI diagnosis of a mass (malignant or benign), as determined by the final diagnosis, were calculated using two by two contingency tables. Chi-square/Fisher exact test has been used to find the significance of study parameters on a categorical scale between two or more groups.

RESULTS

On histopathological examination, we detected 27 indeterminate mass as benign and 31 as malignant.

Specific diagnoses are listed in (Table 1). The mean diameter of all 58 masses was 9.3 cm (range, 2.5-27 cm).

On MRI 30 masses were diagnosed benign and 28 masses were diagnosed as malignant, however, the true diagnosis of benign and malignant was 27 and 31, respectively. All the diagnosis were confirmed by histopathology however immunohistochemistry were required for specific diagnosis in (n = 16) malignant cases and (n = 3) in benign cases. The MRI diagnosis of three masses that wrongly diagnosed as benign was cystadenoma, inflammatory ovarian mass, and Brenner's tumor. Thus, on the basis of MRI we were unable to identify three malignant mass correctly (Table 2). The sensitivity of MRI for correctly identifying a malignant lesion was 91.4%, and the specificity for correctly making a benign diagnosis was 100%. The PPV, NPV, and accuracy of the test is 100%, 90%, and 94.8%, respectively. Various parameters were chosen to describe to differentiate the benign from the malignant mass. A significant association was found between malignancy and poorly defined lesions (P = 0.013), heterogeneous and intense enhancement (P < 0.0001), increased (>3 mm) septal thickness (P < 0.0001), lobulated lesion (P = 0.02), necrosis (P = 0.004), papillary projections (P = 0.017), metastasis (0.029), and ascites (0.006) show high association with malignant lesion.

In sonography, the origin of 27 mass was not identified but was correctly identified on MRI as 2 uterine masses, 43 ovarian masses (right and left), and 3 extra ovarian-extra uterine lesions. The origin of 10 adnexal mass could not be identified on MRI also (Table 3). These masses were very large with a mean diameter of 13.9 cm range (11.1-27 cm).

Out of 58 adnexal mass 21 masses were solid cystic or complex cystic, 17 masses were pure solid, and 20 masses were cystic. Solid masses and solid cystic masses mainly contribute to the malignant lesion (38.7 and 51.6%, respectively) of total malignant lesions. Cystic masses with thick septa (3.38 mm) became serous cystadenocarcinoma (Figure 1). Some solid benign masses were fibroid, fibrothecoma and torsion of ovary. Solid lobulated mass with characteristic fibrovascular septa in a young woman is suggestive of dysgerminoma (Figure 2). Fat, hemorrhage and T2 hypointensity of the lesion shows strong association (P = 0.049) with benignity. These lesions were mainly hemorrhagic cyst, dermoid cyst having fat (Figure 3), fibroids and fibrothecoma showed T2 hypointensity.

Table 1: Final diagnoses of 58 sonographically indeterminate adnexal masses

Type of tumor	Frequency (%)	Subtype	Number
Epithelial tumor	18/31	Serous cystadenoma	9
		Serous cystadenocarcinoma	2
		Mucinous cystadenoma	1
		Mucinous cystadenocarcinoma	3
		Endometrioid carcinoma	2
		Transitional cell carcinoma	1
Germ cell tumor	8/13.7	Mature teratoma	4
		Immature teratoma	2
		Dysgerminoma	2
Sex cord tumor	1/1.7	Fibrothecoma	1
Extras ovarian	5/8.6	Sarcoma	1
		Fibroid	3
		Broad ligament carcinoma	1
Malignant unclassified*	16/27	Malignant unclassified	16
Benign unclassified#	3/5	Benign unclassified	3
Misc	7/12	simple cyst	2
		Hemorrhagic cyst	4
		Torsion ovary	1
Total	58/100		58

*,#Immunohistochemistry required for further classification of the malignant and benign mass respectively

Table 2: Diagnostic significance of MRI for malignant lesions

Diagnosis on MRI	Diagnosis on pathological examination		Total
	Benign	Malignant	
Benign			
Count	27	3	30
% within diagnosis on MRI	90.0	10.0	100.0
% within diagnosis on pathological examination	100.0	9.7	51.7
Malignant			
Count	0	28	28
% within diagnosis on MRI	0.0	100.0	100.0
% within diagnosis on pathological examination	0.0	90.3	48.3
Total			
Count	27	31	58
% within diagnosis on MRI	46.6	53.4	100.0
% within diagnosis on pathological examination	100.0	100.0	100.0

MRI: Magnetic resonance imaging

DISCUSSION

In our study, most common age group of presentation with adnexal mass was ≤30 years and also had the highest frequency of malignancy accounting 41% of total malignant tumors. The age ranges from 13 to 80 years. Comparison of age distribution between benign and malignant lesions was performed using Fischer's exact test. Our study shows no any correlation between increasing age and incidence of malignancy. This finding goes against the previous studies done by

Table 3: Origin of lesion

Origin of lesion	Histopathological diagnosis		Total
	Benign	Malignant	
Broad ligament			
Count	0	1	1
% within histopathological diagnosis	0.0	3.2	1.7
Left ovary			
Count	9	8	17
% within histopathological diagnosis	33.3	25.8	29.3
Not determined			
Count	4	6	10
% within histopathological diagnosis	14.8	19.4	17.2
Pelvic floor			
Count	0	1	1
% within histopathological diagnosis	0.0	3.2	1.7
Right ovary			
Count	11	14	25
% within histopathological diagnosis	40.7	45.2	43.1
Uterus			
Count	3	1	4
% within histopathological diagnosis	11.1	3.2	6.9
Total			
Count	27	31	58
% within histopathological diagnosis	100.0	100.0	100.0

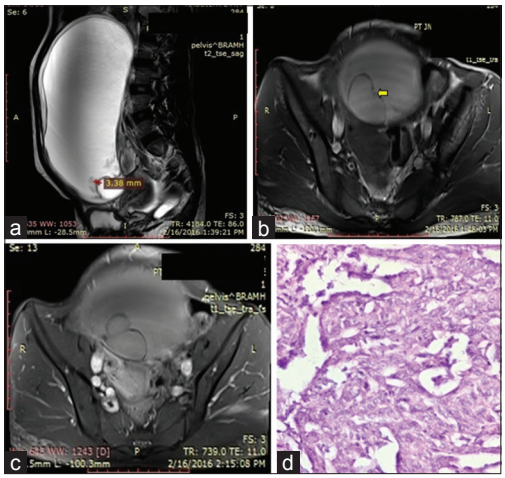

Figure 1: (a) 24-years-old woman presented with lower abdominal pain, menstrual irregularity. T2WI sagittal image shows large abdominopelvic cystic lesion with thick septations and subtle papillary projection, (b) T1WI and, (c) T1C+FS axial images show no contrast enhancement of septa, (d) histopathology ×10 low power slide show epithelial pluristratification and mild atypical suggestive of serous cystadenocarcinoma.

Jeong *et al.* and Jung *et al.* in which they observed that prevalence increases with age and peak in 6th-7th decade.[3,4] This outcome could be due to small sample size of our study. We found that epithelial tumors (30%) were the most common ovarian neoplasm. Single most common epithelial tumor was serous cystadenoma ($n = 9$). Germ cell tumor accounts 13% in our study and was 2nd most common type tumor. The most common germ cell tumor was teratoma. These findings are similar to study done by Jeong *et al.* in which they observed that epithelial tumor is the most common tumor and serous cystadenocarcinoma is the most common type.[3] Jung *et al.* also concluded in their study that epithelial tumor is the most common ovarian neoplasm.[4]

In our study, we divided adnexal masses into two standard groups of diameter ≤4 cm and >4 cm. No correlation was seen ($P = 0.233$) with size and incidence of malignancy of adnexal mass. This finding does not match with the similar studies[5] which showed smaller adnexal mass is less likely to be carcinoma ovary and large incidentally detected mass with mean size 6.5 cm is mostly malignant similarly Ahmad *et al.* and Valentini *et al.* concluded that size >4 cm is associated with malignancy.[6,7] The probable cause of the discrepancy between our study and previous studies may be the unequal distribution of study population in ≤4 cm group ($n = 4$) and >4 cm group ($n = 54$). However, our study shows that ≤4 cm group is having only four masses in which three were benign.

The shape/margin was divided into two groups as well defined and poorly defined on the basis of delineation of margin. Significantly higher frequency of poorly defined lesions in malignant and well-defined lesions in benign lesions was noted ($P = 0.013$). We had total 18 poorly defined mass in our study out of which 14 showed malignancy.[7] Comparison of morphology of lesion as detected on MRI between benign and malignant lesion was performed. Significantly higher frequency of solid and solid cystic consistency in malignant lesions and that of cystic consistency in benign lesion was noted ($P < 0.0001$). We found the frequency of malignancy was highest in the solid cystic tumor (51.6%) followed by solid tumors (38.7%). This finding is consistent with the previous study of McDonald *et al.* in which they found that high risk of ovarian malignancy as those with an adnexal mass having complex or solid morphology.[8,9]

Septal thickness is an important criteria to differentiate between benign and malignant lesions in complex cystic lesions. 3 mm was taken as cutoff to divide into two groups as thin and thick septa. In our study, 17 tumors were showing thick septa out of which 15 were malignant, i.e., 88.2% of tumors with thick septa were malignant. Similarly, 16 tumors were showing thin septations; out of which 15 were benign, i.e., 93.7% tumors with thin septa were benign. Significantly higher frequency of increased septal thickness (>3 mm) in the malignant lesion and decreases septal thickness (<3 mm) in benign lesion was observed ($P < 0.0001$). This result is very similar to the previous studies done by Hricak *et al.* in which significant association ($P < 0.001$) seen between malignancy and septal thickness of more than 3 mm.[10]

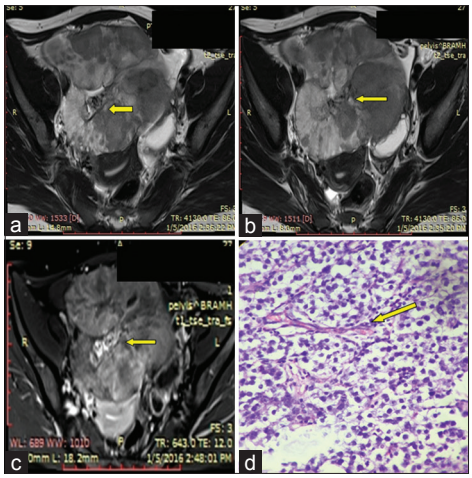

Figure 2: 13-year-old lady presented with lump abdomen and pain, (a) axial T2WI showing heterogeneous multilobulated solid mass with fibrovascular septa (arrows) appearing hypointense, (b) and (c) T1 and T1+C axial image showing heterogeneous enhancement of mass with intense enhancement of fibrovascular septa and nonenhancing necrotic areas, (d) histopathological examination shows nest of malignant cell separated by fibrous septa proves it to be dysgerminoma

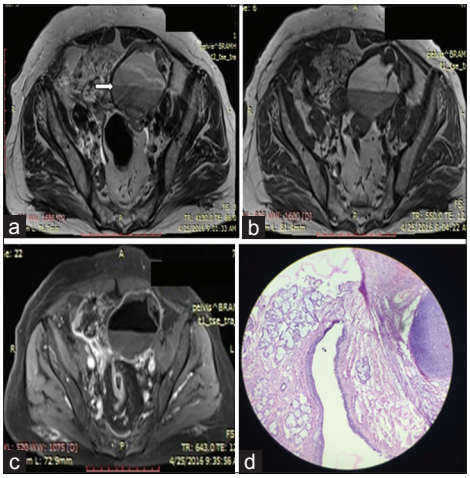

Figure 3: (a) Axial T2WI showing well-defined lesion with fat-fluid level (arrow) and soft tissue component, (b) T1, and (c) T1C+FS axial image also show fat-fluid level with mild enhancement of soft tissue component and suppressed fat signal on T1C+FS images. (d) Low power ×10 Human pose estimation image shows all three germ layers (cartilage, GI tissue, and epidermis) confirms mature teratoma

Various findings on MRI characterization between benign and malignant lesion were performed using Chi-square/ Fischer's exact test. Significantly higher frequency of lobulated lesion (P = 0.02), necrosis (0.004), papillary projections (0.017), metastasis (0.029), and ascites (0.006) was noted in malignant lesion. These associations are very similar to the previous study like Valentini *et al.* in 2012 proved significant correlation between malignancy and solid part of the mass with heterogeneous enhancement pattern, cystic mass with vegetation and internal structures, thickness of wall or septa >3 mm, lobulated mass, tiny amorphous calcifications, necrosis, papillary projections, tumor vessels with heterogeneous enhancement pattern, ascites, metastasis, and lymphadenopathy.[7] Yamashita *et al.* developed a model of a computer-assisted diagnosis and identified system was developed with the logistic regression analysis. 87% of the lesions accurately as benign or malignant.[11] Hricak *et al.* demonstrated the conspicuity ratings were significantly higher on the gadolinium-enhanced images ($P < 0.01$) for classification of a predominantly solid or cystic lesion, determination of wall and septal thicknesses, detection of vegetations in a cystic lesion and identification of necrosis in a solid lesion.[10] Significantly higher frequency of heterogeneous and intense enhancement in the malignant lesion and that of mild enhancement in benign lesion was noted ($P < 0.0001$). We found 83.3% intensely enhancing tumors and 71% heterogeneously enhancing tumors were malignant. This is in agreement with other studies.[7,12]

In our study, 45% of malignant lesions were from right ovary, 30% were from left. Whereas we were unable to determine the origin in 20% of malignant cases as entire lesions were very large in size and bilateral ovaries were not separately visualized. No significant difference in frequency distribution was found ($P = 0.614$).

There was strong evidence of a relationship between MRI and pathological examination for diagnosis of the malignant lesion ($P < 0.0001$). The sensitivity of MRI for diagnosis of the malignant lesion was found to be 91.1%, specificity was found to be 100%. PPV was found to be 100.00% and NPV was 90.00%. Accuracy was found to be 94.82%. These findings are very similar to the previous well-known studies.[13,14]

CONCLUSION

In our study, MRI proved to be highly sensitive and accurate in differentiating benign and malignant lesions of adnexal masses which were indeterminate on ultrasonography examination. Thus, MRI can be considered as second most confirmatory tool followed by tissue diagnosis in women with indeterminate masses.

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