

EVALUATION OF ADNEXAL MASSES ON ULTRASOUND AND COLOR DOPPLER AND ITS HISTOPATHOLOGY CORRELATION

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ABSTRACT

Background: Accurate preoperative differentiation between benign and malignant adnexal masses is crucial for optimal patient management. Doppler ultrasound offers valuable insights into tumor vascularity, aiding in this differentiation.

Aim: To evaluate the diagnostic utility of Doppler indices—resistance index (RI) and pulsatility index (PI)—in assessing adnexal masses, using histopathology as the gold standard.

Methods: This study included 100 patients with clinically suspected adnexal masses who underwent transvaginal and transabdominal Doppler ultrasound. Vascular patterns, RI, and PI were recorded and compared with postoperative histopathological diagnoses.

Results: Malignant masses showed significantly lower RI and PI values compared to benign ones. An RI < 0.4 and PI < 1.0 were strongly predictive of malignancy. Doppler findings demonstrated high sensitivity and specificity in predicting histopathological outcomes.

Conclusion: Doppler ultrasound is a valuable, non-invasive tool in the preoperative evaluation of adnexal masses. Low RI and PI are significant indicators of malignancy and correlate well with histopathological results, enhancing diagnostic confidence and clinical decision-making.

Keywords: Adnexal Masses, Ultrasound and Color Doppler, Histopathological Correlation

INTRODUCTION

Adnexal masses are a common clinical problem encountered in women of all age groups, particularly during the reproductive years [1]. These masses may arise from the ovaries, fallopian tubes, or surrounding connective tissues, and they can be functional, benign, or malignant in nature [2]. The early and accurate diagnosis of these lesions is crucial for initiating appropriate management, avoiding unnecessary surgery, and improving clinical outcomes, especially in cases of ovarian malignancy [3].

Ultrasonography (USG) is the first-line imaging modality used in the evaluation of adnexal masses due to its affordability, availability, and non-invasiveness [4]. While conventional grey-scale ultrasound provides valuable information regarding the size, shape, internal consistency, and presence of septations or solid components in a mass, it often lacks specificity in differentiating benign from malignant lesions [5].

Color Doppler imaging, when added to grey-scale ultrasound, improves diagnostic accuracy by evaluating vascular patterns and blood flow within the lesion [6]. Malignant tumors tend to show increased vascularity, low resistance index (RI), and low pulsatility index (PI), indicative of neoangiogenesis [7]. Hence, the integration of morphological criteria with Doppler flow parameters enhances the sensitivity and specificity of preoperative diagnosis [8].

Despite the utility of imaging, histopathological examination remains the gold standard for the final diagnosis of adnexal masses [9]. Therefore, correlating radiological findings with histopathological outcomes not only validates the accuracy of ultrasound and color Doppler but also helps in refining diagnostic protocols.

This study aims to evaluate the role of ultrasound and color Doppler in characterizing adnexal masses and to correlate these findings with histopathological results to determine their diagnostic value.

METHOD AND MATERIAL

Study setting: This study was conducted in the Department of Radio Diagnosis tertiary care centre at Dr. Panjabrao alias Bhausaheb Deshmukh Memorial Medical College, Amravati.

Study design: This was an evaluation of a diagnostic test study.

Study population: All female patients of reproductive age (15–49 years) were admitted to the study setting during the study period and met the study's selection criteria.

Study period: The total duration of the study was 18 months.

Sample size: This study utilized a sample size of 64 patients.

Sampling technique: The sampling technique used for the study was the Convenience sampling method.

Ethical considerations in the study: Ethical clearance was taken from the institutional ethical committee. The ethical Clearance letter is annexed.

Eligibility criteria:

a. Inclusion criteria:

- All women diagnosed to have a significant adnexal mass (size > 5 cm)
- With a reproductive age group of 15 to 49 years.
- The patients were ready to give consent.
-

b. Exclusion criteria:

- Unilocular anechoic small cyst (less than 5 centimeters), which resolves on follow-up ultrasound examination, Tubal gestation, Masses that were found to arise from the uterus.
- Women who do not consent to take part in the study.
- Severe Medical and Surgical Complications, including heart, liver, kidney, brain, and blood disorders.

METHODOLOGY

All patients were evaluated through a structured assessment that included the collection of detailed menstrual history, obstetric history, and any past history of adnexal mass removal, along with specific complaints related to their current condition. A comprehensive general examination was performed, which involved measuring height and weight, recording vital signs, and conducting evaluations of the cardiovascular and respiratory systems. An abdominal examination was carried out, followed by a vaginal examination to palpate for any masses or tenderness and to assess the adnexal regions more thoroughly. Subsequently, all patients underwent color Doppler ultrasonography, utilizing a Doppler system equipped with a color velocity imaging system for the codification of blood flow.

After characterizing the masses based on their morphological features, the color velocity imaging gate was activated to identify the presence and characteristics of blood flow within the masses. Masses that were completely avascular, showing no detectable blood flow, were classified as benign, while those with a color Doppler score of ≥ 4 were considered suggestive of malignancy, indicating significant vascularity or abnormal flow patterns typically associated with malignant lesions. For patients who underwent surgical intervention at our institute, definitive Histopathological diagnoses were obtained, serving as the gold standard for validating the imaging findings. The diagnostic performance of color Doppler ultrasonography was quantitatively assessed by calculating its sensitivity, specificity, positive predictive value, and negative predictive value, thereby providing a comprehensive evaluation of its efficacy in differentiating between benign and malignant ovarian masses. This thorough assessment process ensured accurate diagnosis and effective management of ovarian lesions.

Statistical analysis

Data was entered into Microsoft Excel version 17 and analyzed utilizing Statistical Package for Social Sciences (SPSS). Descriptive format & diagrammatic presentation were done using bar diagrams or pie charts as required. For descriptive analysis, we used mean, standard deviation, ratio, and proportion with percentage. The quantitative data, if required, was analyzed using an independent student's t-test, and $p < 0.05$ was considered a level of statistical significance.

RESULTS AND OBSERVATIONS;

Table 1: Distribution of cases in study population.

Tumors	No. of cases	Percentage
Benign	47	73%
Malignant	17	27%
Total	64	100%

The above table showed that 47 were benign (73%) and 17 were malignant (27%).

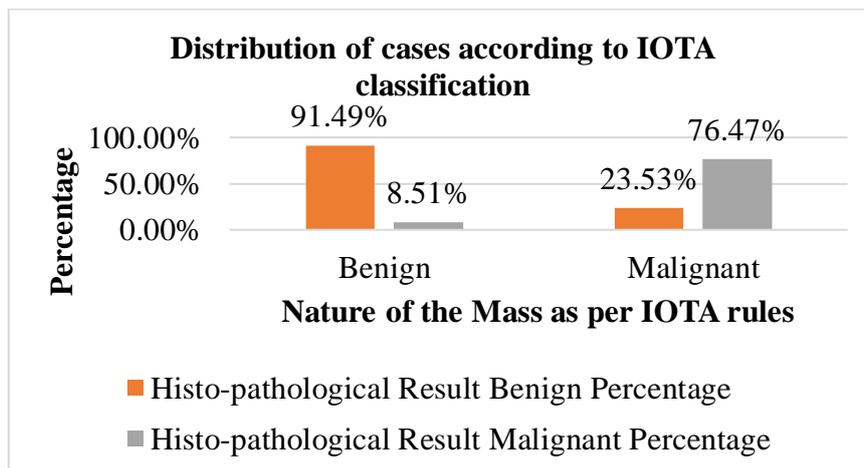


Figure 1: Distribution of cases according to IOTA classification

Table 2: Age group distribution of the cases of the groups.

Tumors	Age group			Total
	≤25	26-36	37-49	
Benign	12(26%)	20(43%)	15(32%)	47
Malignant	5(29%)	3(18%)	9(53%)	17

The above table showed that the highest number (43%) in the 26-36 age group. For malignant tumors, 14 cases were recorded, with the majority (53%) in the 37-49 age group.

Table-3: Adnexal masses

Adnexal Masses	Causes	No of cases	Percentage	
Benign (n=47)	Gynaecological Causes (n=28)	Ovarian cyst	18	64.29%
		Broad ligament fibroid	10	35.71%
	Non-Gynaecological Causes (n=19)	Appendicular Mass	4	21.05%
		Mesenteric Cyst	7	36.84%
		Ectopic. pregnancy	8	42.11%
Malignant Masses (17)	Gynaecological Causes (n=12)	Ovarian Malignancy	5	41.67%
		Tubo-ovarian Malignancy	7	58.33%
	Non-Gynaecological Causes (n=5)	Gastrointestinal Malignancy,	3	60.00%
		Retroperitoneal Tumor	2	40.00%

Among the 47 benign adnexal masses, 28 were of gynecological origin, with ovarian cysts being the most common (64.29%), followed by broad ligament fibroids (35.71%). Non-gynecological benign masses (19 cases) included mesenteric cysts (36.84%), appendicular masses (21.05%), and ectopic pregnancies (42.11%). Among the 17 malignant adnexal masses, 12 were gynecological, with tubo-ovarian malignancies (58.33%) being more common than ovarian malignancies (41.67%). Non-gynecological malignant masses (5 cases) included gastrointestinal malignancies (60%).

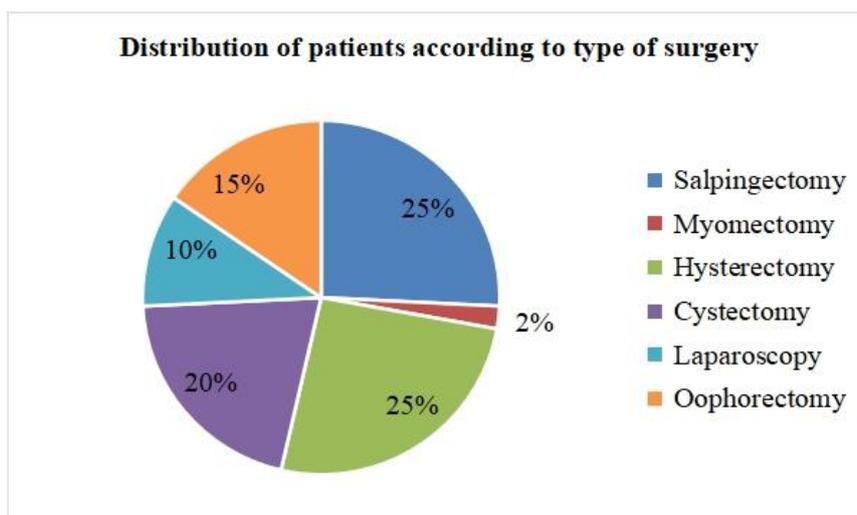


Figure 2: Distribution of patients according to type of surgery

Table 4: Distribution of patients according to histopathological diagnosis

Histological diagnosis	Benign (n=47)		Malignant (n=17)		
	No of cases	Percentage	No of cases	No of cases	Percentage
Serous cystadenoma	7	20.00%	Mucinous carcinoma	3	23.08%
Simple cysts	6	17.14%	Serous cystadenocarcinoma	3	23.08%
Hemorrhagic cysts	5	14.29%	Poorly differentiated adenocarcinoma	1	7.69%
Dermoid	3	8.57%	a germ cell tumor	2	15.38%
Endometrioma	3	8.57%	Teratoma	2	15.38%
corpus luteal cyst	2	5.71%	Clear cell carcinoma	1	7.69%
Others	9	25.71%	malignant Brenner tumor	2	7.69%

Among the 47 benign cases, the most common histopathological findings were serous cystadenoma (20.00%), simple cysts (17.14%), and hemorrhagic cysts (14.29%). Other benign lesions included dermoid cysts (8.57%), endometriomas (8.57%), corpus luteal cysts (5.71%), and various other benign pathologies (25.71%).

Among the 17 malignant cases, mucinous carcinoma (23.08%) and serous cystadenocarcinoma (23.08%) were the most frequent diagnoses, followed by poorly differentiated adenocarcinoma (7.69%), germ cell tumors (15.38%), teratomas (15.38%), clear cell carcinoma (7.69%), and malignant Brenner tumors (7.69%).

Table-5: Distribution according to morphology characteristics.

Morphology characteristics	Benign	Malignant	Total	p-value
Cystic	30	5	35	0.047
Solid-cystic	15	11	26	
Solid	2	1	3	
Papillary projections				
Absent	27	4	31	0.017
Present	20	13	33	

Cystic morphology was more common in benign tumors (30 cases) compared to malignant ones (5 cases), with a significant difference ($p=0.047$). Papillary projections were absent in most benign tumors (27 cases), while they were present in more malignant tumors (13 cases), with a significant difference ($p=0.017$). Solid-cystic and solid types were less frequent overall.

Table 6: Distribution according to Vascularity.

Vascularity	Benign	Malignant	Total	P-value
Present	26(55%)	16(94%)	42	0.004
Absent	21(45%)	1(6%)	22	

Vascularity was present in 26 benign tumors (55%) and 16 malignant tumors (94%), with a significant difference ($p=0.004$). Vascularity was absent in 21 benign tumors (45%) and only 1 malignant tumor (6%).

Table 7: RI values in the two tumour groups.

RI	Benign	Malignant
Mean with standard deviation	0.61 ± 0.20	0.42 ± 0.14
Minimum	0.38	0.2
Maximum	0.8	0.7

Benign tumors had a mean RI of 0.61 ± 0.20, while malignant tumors had a lower mean RI of 0.42 ± 0.14. The RI ranged from 0.38 to 0.8 for benign tumors and from 0.2 to 0.7 for malignant tumors.

Table 8: PI values in the two tumour groups.

PI	Benign	Malignant
Mean with standard deviation	0.96 ± 0.30	0.82 ± 0.19
Minimum	0.9	0.548
Maximum	1.6	0.86

Benign tumors had a mean PI of 0.96 ± 0.30, while malignant tumors had a mean PI of 0.82 ± 0.19. The PI ranged from 0.9 to 1.6 for benign tumors and from 0.548 to 0.86 for malignant tumors.

Table 9: Sensitivity, specificity, positive predictive value, and negative predictive value of CA-125, transvaginal ultrasound (papillary projections (PP) and morphological index (MI)), and color Doppler ultrasonography (vascularity (V), RI, and PI).

Modality		Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	False Positive (%)	False Negative (%)
CA-125		47.12	91.88	73	82	55.64	9.15
TVS	PP	94.26	53.99	46.98	96	45.92	6.87
	MI	100	48.91	46.12	100	51.75	0
CDS	V	100	45.78	45.42	100	55.18	0
	RI	46.89	94.97	86.76	70.22	5.36	53.69
	PI	87.91	68.75	68.89	88.78	32.15	13.89

The diagnostic modalities showed varying performance: CA-125 had high specificity (91.88%) but low sensitivity (47.12%). TVS (PP) and CDS (V) both had 100% sensitivity but lower specificity. CDS (RI) had high specificity (94.97%) but low sensitivity (46.89%), while CDS (PI) showed good sensitivity (87.91%) and moderate specificity (68.75%).

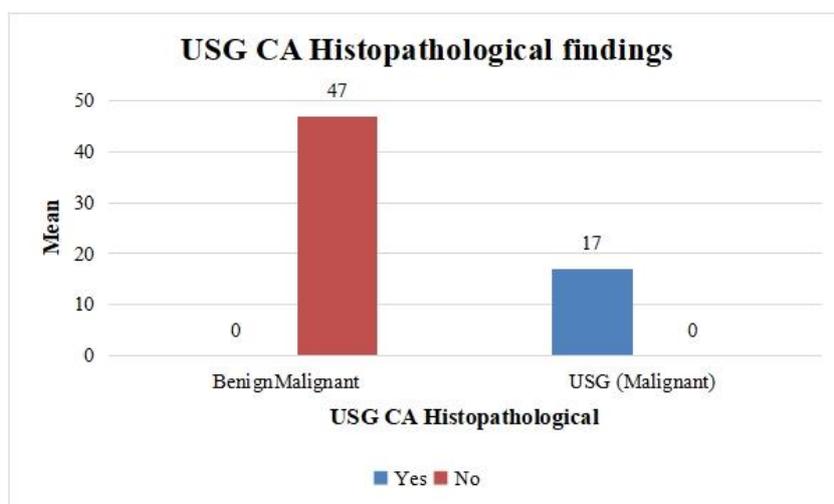


Figure 3: USG CA Histopathological findings

DISCUSSION

The accurate preoperative characterization of adnexal masses is essential to distinguish between benign and malignant lesions and guide clinical management. Ultrasonography, particularly transvaginal ultrasound (TVUS), continues to serve as the cornerstone of initial evaluation due to its high-resolution imaging, non-invasiveness, and widespread availability [1]. It provides valuable information on lesion morphology, internal architecture, and other features that help classify adnexal masses [2].

However, gray-scale sonography alone has limitations, especially in differentiating complex benign lesions from early-stage malignancies [3]. To overcome this, the integration of color and spectral Doppler studies allows for the evaluation of tumor vascularity, which is a critical marker of malignancy due to increased neovascularization in cancerous tissues [4,5].

In the present study, Doppler findings such as low Resistance Index (RI) and low Pulsatility Index (PI) were strongly associated with malignant lesions. This observation is supported by several other studies that have found low RI (<0.4) and PI (<1.0) as indicative of malignant tumors due to their abnormal vasculature and low impedance flow [6,7,8].

Benign masses in our cohort, such as serous cystadenomas, mature cystic teratomas, and hemorrhagic cysts, typically displayed high RI values and minimal to moderate vascularity on Doppler examination. These findings are consistent with the literature, which demonstrates that benign tumors often have peripheral vascularity and higher impedance flow [9,10].

Conversely, malignant masses like serous cystadenocarcinomas and metastatic tumors showed irregular margins, solid components, central vascularity, and low RI/PI values. These features are in line with those reported by Alcázar and colleagues, who emphasized the utility of subjective Doppler assessment in combination with morphological scoring for accurate diagnosis [11,12].

Color Doppler imaging also helps reduce false positives by differentiating avascular benign lesions (e.g., endometriomas) from hypervascular malignant tumors [13]. A study by Guerriero et al. demonstrated that Doppler flow analysis significantly enhances the positive predictive value (PPV) of ultrasound in ovarian cancer detection [14].

Despite its advantages, Doppler evaluation is operator-dependent and influenced by machine settings and technical expertise. Hence, histopathological correlation remains the gold standard for confirmation of the imaging diagnosis [15,16].

Emerging techniques such as contrast-enhanced ultrasound, three-dimensional (3D) Doppler, and elastography are being explored to further enhance diagnostic accuracy. Recent studies suggest that combining these modalities with Doppler may provide superior sensitivity and specificity in ovarian tumor characterization [17,18].

Furthermore, the incorporation of standardized scoring systems, such as the International Ovarian Tumor Analysis (IOTA) simple rules, ADNEX model, and Risk of Malignancy Index (RMI), along with imaging features, significantly improves the clinician's ability to triage adnexal masses appropriately [19,20].

CONCLUSION

Doppler ultrasound significantly enhances the preoperative evaluation of adnexal masses by providing non-invasive insights into tumor vascularity. Low RI and PI values are strongly associated with malignancy, showing a good correlation with histopathological findings. Thus, Doppler indices serve as reliable adjuncts to gray-scale ultrasound, improving diagnostic accuracy and aiding in timely clinical management.

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