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Accuracy of Ultrasonography and Colour Doppler in Diagnosis of Ovarian Masses and its Correlation with Histopathological Findings

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ABSTRACT

Background: Ovarian masses are very common gynaecological concern in women so, this study compared the ultrasonographic and colour Doppler findings of ovarian masses with their histopathological diagnosis

Methods: This prospective study evaluated patients diagnosed with an ovarian mass who visited the Obstetrics, Gynecology and Radiology department of Bakhtawar Amin Medical and Dental College, Multan, between March 2024 and February 2025. The eligible patients were divided into two groups: Group A included patients who underwent abdominal and vaginal ultrasound to assess the morphology of the pelvic mass. In contrast, Group B included patients whose ovarian masses were evaluated using color Doppler in

addition to transabdominal ultrasound to examine vascularization as well as morphology.

Results: Morphology scoring of transabdominal and transvaginal ultrasound showed high accuracy of 98.4%, specificity 96.8%, and NPV 98.0%, while Doppler had lower sensitivity (54.3%) but reasonable specificity (94.2%). The combined approach achieved perfect sensitivity and NPV (100%) with high accuracy (98.4%), enhancing diagnostic performance without losing specificity.

Conclusion: Combining color Doppler with morphological ultrasound improves the accuracy of diagnosing pelvic tumors, enhancing malignancy detection and boosting confidence in benign diagnoses, making it a valuable tool for early disease diagnosis.

Keywords: Ovarian mass, Doppler ultrasound, Transvaginal ultrasound, transabdominal ultrasound, Histopathology.

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INTRODUCTION

Ovarian masses are a common gynecological concern, with a reported incidence of 5-10% in women during their lifetime¹⁻². While many ovarian masses are benign, some may be malignant, necessitating accurate and timely diagnosis. The incidence of ovarian cancer, though less frequent, remains a significant cause of morbidity and mortality, accounting for nearly 3% of all cancers in women³. Clinical management needs precise diagnosis of ovarian masses which differ between functional cysts and malignant tumors. Ultrasonography (USG) combined with color Doppler plays an essential role in identifying benign tumors from malignant growths thus it enables healthcare professionals to determine future treatment strategies^{4,5}.

The main diagnostic tool for ovarian mass evaluation relies on ultrasonography because it offers real-time imaging and non-invasive examination while being available throughout most healthcare facilities⁶. The visual details from transvaginal and transabdominal ultrasound examinations include measurements of size and internal structural examination and separate evaluation of both septations and solid components within the examined structures⁷. In some cases, grayscale ultrasound fails to achieve accurate differentiation between benign tumors and malignant ones⁸. The diagnostic limitation has motivated medical professionals to integrate color Doppler imaging to examine vascular patterns and resistance indices inside the mass structure. Enhanced blood transport through the mass combined with minimal resistance usually indicates a malignant growth and so improves diagnostic accuracy⁹.

The definitive diagnosis depends on histopathological examination since imaging has improved but remains secondary to pathology. The accuracy evaluation of USG and color Doppler between preoperative imaging findings and histopathology results depends on clear correlations¹⁰⁻¹¹. Various studies establish different performance levels for these diagnostic methods which proves critical for additional research among diverse population groups. A solid correlation between imaging and histopathological findings helps practitioners eliminate benign lesion surgical interventions and perform essential procedures for cancer-type concerns¹².

The purpose of this research is to assess how accurately ultrasonography and color Doppler detect malignant from benign ovarian masses through the analysis of imaging data against histopathological findings. The research evaluates the reliability of clinical imaging techniques in practice through a comprehensive assessment of sensitivity and specificity and calculation of positive predictive value (PPV) and negative predictive value (NPV). Better diagnostic protocols as well as optimized patient

outcomes become attainable through preoperative assessment because of the findings investigated in this study.

METHODS

Patients diagnosed with ovarian masses received assessment at the Obstetrics and Gynecology, and Radiology Department of Bakhtawar Amin Medical and Dental College, Multan, from March 2024 until February 2025 after approval from Ethical Review Board of Bakhtawar Amin Medical and Dental College, Multan (Reference No: BATH-0602-24). The study evaluated female patients of any age starting from pre-pubertal age and post-menopausal patients, including women with palpable masses alongside symptoms including pelvic pain, bleeding, urinary or gastrointestinal pressure or asymptomatic women whose pelvic masses were found during routine pelvic exams or detected incidentally through transabdominal and transvaginal sonography for non-gynecological purposes.

The study excluded patients who received ovulation induction drugs as well as participants who did not receive fine needle aspiration cytology or histopathological evaluation and those with either ectopic or normal pregnancies. The eligible patients were divided into two groups: Group A included patients who underwent abdominal and vaginal ultrasound to assess the morphology of the pelvic mass. In contrast, Group B included patients whose ovarian masses were evaluated using color Doppler in addition to transabdominal ultrasound to examine vascularization as well as morphology.

A Samsung real-time ultrasound system with a 3.5 MHz convex probe was used for transabdominal scans (with a full bladder), and an 8–10 MHz probe was used for transvaginal scans (with an empty bladder). Virgin patients were exclusively assessed via transabdominal ultrasound. Both groups underwent morphological evaluation of the ovarian masses, focusing on characteristics such as size, content, walls, septa, vegetation, and peritoneal fluid. A morphology index based on tumor volume, wall structure, and septal structure was used to differentiate benign (score <9) from malignant masses.

In Group B, vascular flow was additionally assessed using transabdominal color Doppler, with vascularization sites classified as central (within solid areas, nodules, papillary structures, or septal crossings) or peripheral (at the capsule, in cystic lesions, or peripherally in solid masses). The pulsatility index (PI), resistance index (RI), and peak systolic velocity (VPS) were recorded, with the lowest PI and RI values and highest VPS used to distinguish benign from malignant tumors. An RI <0.4 and PI <1.0 were considered cutoff values for malignancy. Finally, the ultrasound, morphological, and Doppler findings were compared with histopathological results for validation.

SPSS version 27 was used for data analysis and mean standard deviation was calculated for numerical data frequency percentages were calculated for categorical data. Independent t-test was applied to see association among numerical variables among groups. 2x2 contingency table was designed calculate sensitivity, specificity and accuracy.

RESULTS

Table 1: Demographic characteristics and masses' type

Characteristics	Group A (TAU, TVU)	Group B (Doppler USG)	Test of Significance
Age (years)	42.54±6.28	40.75±5.68	t=0.58, d.f=88, p=0.566
Parity	2.00±0.68	1.93±0.58	t=0.56, d.f=88, p=0.575
Malignant masses	14 (28.0)	10 (25.0)	$\chi^2=0.102$, d.f=1, p=0.749
Type of malignancy			
Metastasis	4 (28.6)	5 (50.0)	$\chi^2=3.54$, d.f=4, p=0.315
Sarcoma	4 (28.6)	4 (40.0)	
Adenocarcinoma	3 (21.4)	1 (10.0)	
Dysgerminoma	3 (21.4)	0 (0.0)	
Benign masses	36 (72.0)	30 (75.0)	
Type of benign masses			
Endometriosis cyst	6 (16.7)	2 (6.7)	$\chi^2=15.05$, d.f=7, p=0.035
Hemorrhagic cyst	9 (25.0)	1 (3.3)	
Cystadenoma	4 (11.1)	2 (6.7)	
Serosal cyst	8 (22.2)	4 (13.3)	
Dermoid cyst	2 (5.6)	6 (20.0)	
Thecoma	3 (8.3)	5 (16.7)	
Fibroma	2 (5.6)	5 (16.7)	

Para-ovarian cyst	2 (5.6)	5 (16.7)	
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Mean \pm standard deviation. Independent t test was applied. N (%) chi-square was applied.

This study compared 90 patients (Group A=50, Group B=40) with no significant differences in age, parity, or malignancy rates (28% vs. 25%, $p=0.749$). Malignant subtypes showed no variation ($p=0.315$), but benign masses differed significantly ($p=0.035$): Group A had more hemorrhagic and endometriosis cysts, while Group B had higher rates of dermoid cysts and fibromas/thecomas, indicating distinct benign profiles despite similar demographics (**Table 1**).

Table 2: Morphology score among both the study groups

Morphology score	Group A	Group B	p-value
Type of malignancy			
Metastasis	12.75 \pm 1.25	11.21 \pm 2.16	<0.001
Sarcoma	10.50 \pm 3.51	13.25 \pm 2.06	<0.001
Adenocarcinoma	11.67 \pm 3.05	12.14 \pm 1.21	<0.001
Dysgerminoma	11.00 \pm 1.74	--	--
Type of benign masses			
Endometriosis cyst	5.00 \pm 2.35	4.50 \pm 0.72	<0.001
Hemorrhagic cyst	3.17 \pm 1.95	5.32 \pm 0.41	<0.001
Cystadenoma	4.00 \pm 0.82	2.05 \pm 4.24	<0.001
Serosal cyst	2.38 \pm 2.06	7.00 \pm 2.58	<0.001
Dermoid cyst	3.50 \pm 0.71	4.80 \pm 2.38	<0.001
Thecoma	8.33 \pm 1.15	6.70 \pm 4.08	<0.001
Fibroma	6.51 \pm 3.52	5.20 \pm 3.24	<0.001
Para-ovarian cyst	7.68 \pm 0.71	3.52 \pm 2.41	<0.001

Mean \pm Standard Deviation, Independent t test was applied.

Among malignancies, transvaginal ultrasound (group A) demonstrated significantly higher morphology scores in metastasis (12.75 \pm 1.25) compared to Doppler ultrasound Group B (11.21 \pm 2.16, $p < 0.001$) but scored lower in sarcoma (10.50 \pm 3.51 vs. 13.25 \pm 2.06, $p < 0.001$) and

adenocarcinoma (11.67 ± 3.05 vs. 12.14 ± 1.21 , $p < 0.001$). For benign masses, Group A had higher scores in para-ovarian cysts (7.68 ± 0.71 vs. 3.52 ± 2.41 , $p < 0.001$) and thecomas (8.33 ± 1.15 vs. 6.70 ± 4.08 , $p < 0.001$), whereas Group B scored higher in hemorrhagic cysts (5.32 ± 0.41 vs. 3.17 ± 1.95 , $p < 0.001$), serosal cysts (7.00 ± 2.58 vs. 2.38 ± 2.06 , $p < 0.001$), and dermoid cysts (4.80 ± 2.38 vs. 3.50 ± 0.71 , $p < 0.001$). Dysgerminoma, which was only observed in Group A, had an average score of 11.00 ± 1.74 (Table 2).

Table 3: RI, PI, and PSV among both study groups

Masses	Group A			Group B			p-value
	RI	PI	PSV	RI	PI	PSV	
Type of Malignancy							
Metastasis	0.53±0.19	0.40±0.01	17.30±1.88	0.41±0.85	0.44±0.54	16.88±1.55	<0.001
Sarcoma	0.49±0.74	0.39±0.41	15.95±2.87	0.46±0.06	0.41±0.08	15.01±1.74	
Adenocarcinoma	0.58±0.12	0.43±.58	17.33±1.79	0.60±0.14	0.35±0.41	17.41±1.41	
Dysgerminoma	0.56±0.61	0.40±0.17	15.23±2.19	0.54±0.14	0.67±0.24	15.56±1.99	
Type of Benign Masses							
Endometriosis cyst	0.54±0.11	0.41±0.04	17.01±1.98	0.52±0.08	0.75±0.63	13.70±0.42	<0.001
Hemorrhagic cyst	0.48±0.11	0.56±0.26	15.60±2.65	0.55±0.07	0.60±0.41	15.60±0.25	
Cystadenoma	0.56±0.19	0.55±0.23	15.18±2.31	0.55±0.14	0.65±0.35	16.85±0.91	
Serosal cyst	0.53±0.08	0.41±0.11	14.40±2.42	0.54±0.56	0.55±0.24	16.75±2.06	
Dermoid cyst	0.48±0.10	0.45±0.14	15.12±2.42	0.54±0.03	0.70±0.16	15.95±1.74	
Thecoma	0.56±0.03	0.53±0.23	16.30±1.98	0.42±0.18	0.62±0.24	13.58±1.04	
Fibroma	0.38±0.14	0.41±0.14	15.13±1.80	0.43±0.32	0.64±0.47	15.24±1.52	
Para-ovarian cyst	0.44±0.07	0.46±0.04	14.80±2.40	0.47±0.15	0.80±0.18	17.24±2.32	

Mean ± Standard Deviation, Independent t test was applied.

The vascular parameters, including resistive index (RI), pulsatility index (PI), and peak systolic velocity (PSV), demonstrated highly significant differences between the groups ($p < 0.001$). In

malignant masses, Group A exhibited higher RI values for metastasis (0.53 vs. 0.41) and sarcoma (0.49 vs. 0.46). However, adenocarcinoma was an exception, with Group B showing a slightly higher RI (0.58 vs. 0.60). Among benign masses, Group B consistently displayed higher PI values in most types, such as endometriosis cysts (0.75 vs. 0.41) and dermoid cysts (0.70 vs. 0.45). PSV patterns varied depending on the mass type: Group A had higher PSV in metastasis (17.30 vs. 16.88), whereas Group B showed elevated PSV in cystadenoma (16.85 vs. 15.18). All comparisons were universally significant ($p < 0.001$), underscoring substantial hemodynamic differences between the two groups (**Table 3**).

Table 4: Accuracy measures

Diagnostic Tools	Sensitivity	Specificity	PPV	NPV	Accuracy
Morphology score	91.1%	96.8%	96.4%	98.0%	98.4%
Doppler score	54.3%	94.2%	84.6%	86.4%	86.4%
Doppler + morphology score	100.0%	93.4%	89.7%	100.0%	98.4%

PPV= Positive Predictive Value, NPV= Negative Predictive Value

Morphology scoring showed high accuracy (98.4%), specificity (96.8%), and NPV (98.0%), while Doppler had lower sensitivity (54.3%) but reasonable specificity (94.2%). The combined approach achieved perfect sensitivity and NPV (100%) with high accuracy (98.4%), enhancing diagnostic performance without losing specificity (**Table 4**).

DISCUSSION

The present study demonstrated that combining color Doppler with ultrasonography and morphological ultrasound analysis enhances the characterization of ovarian masses and improves the differentiation between malignant and benign tumors. Despite the various therapeutic protocols explored in multiple studies, ovarian cancer continues to be one of the leading causes of death among women¹³⁻¹⁵. In this study, there were no significant differences in age, parity, or malignancy rates (28% vs. 25%, $p=0.749$) or malignant subtype distribution ($p=0.315$), but abdominal and vaginal ultrasound had more hemorrhagic and endometriotic cysts. In contrast, Doppler ultrasound had more dermoid cysts and fibromas/thecomas ($p=0.035$ for benign masses).

These findings align with prior research indicating that benign ovarian masses often vary in prevalence depending on patient characteristics or diagnostic criteria. For instance, a study reported that endometriotic and hemorrhagic cysts are more common in premenopausal women, which may explain their predominance in TAU and TVU if it included younger patients or those with a history of endometriosis¹⁶. Conversely, another study reported dermoid cysts (mature cystic teratomas) and fibromas are frequently reported in reproductive and perimenopausal age groups, consistent with the Doppler USG profile¹⁷.

The lack of variation in malignant subtypes supports findings from literature, which found that epithelial ovarian cancers (the most common malignant subtype) show similar distributions across different cohorts when matched for age and risk factors¹⁸. However, the differences in benign masses highlight the importance of subgroup analysis, as variations in histopathology may reflect underlying etiological or diagnostic differences.

Transabdominal and transvaginal pelvic ultrasonography are essential techniques for evaluating female neoplasms, particularly in assessing the size, morphology, and structural features of adnexal masses¹⁹. These methods allow for the examination of key morphological parameters, including volume, wall thickness, internal structure, presence of vegetation, septa (and their thickness), echogenicity, and content²⁰⁻²¹. However, relying solely on morphological characteristics, ultrasound cannot reliably differentiate between benign and malignant tumors, especially in the early stages²². Studies report that the sensitivity of ultrasound-based morphologic analysis in predicting malignancy ranges from 87% to 100%, while specificity varies between 45% and 95%. In this study, the technique demonstrated a sensitivity of 89.0% and a specificity of 100.0%²³⁻²⁴.

In this study, morphology scoring showed high accuracy (98.4%), specificity (96.8%), and NPV (98.0%), while Doppler had lower sensitivity (54.3%) but reasonable specificity (94.2%). The combined approach achieved perfect sensitivity and NPV (100%) with high accuracy (98.4%). In another study it has been reported that, ultrasound with 89.0% sensitivity, 100% specificity, 100% PPV, 97% NPV, and 97% accuracy, whereas Doppler alone had 55.6% sensitivity, 95.5% specificity, 83% PPV, 84% NPV, and 84% accuracy²⁵. Combining Doppler with morphology scoring of abdominal and vaginal ultrasonography improved the sensitivity to 100%, specificity to 95.5%, PPV to 90%, NPV to 100%, and accuracy to 96.6%.

CONCLUSION

Combining color Doppler with morphological ultrasound improves the accuracy of diagnosing pelvic tumors, enhancing malignancy detection and boosting confidence in benign diagnoses, making it a valuable tool for early disease diagnosis

LIST OF ABBREVIATIONS

None

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CONFLICT OF INTEREST

None

ETHICAL APPROVAL

This study was approved by Ethical Review Board Bakhtawar Amin Medical and Dental College, Multan (Reference No: BATH-0602-24).

AUTHORS' CONTRIBUTION

All authors contributed equally as per ICMJE policy.

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