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DIAGNOSTIC ACCURACY OF B-MODE AND DOPPLER ULTRASONOGRAPHY IN DIAGNOSING MALIGNANT OVARIAN LESION TAKING HISTOPATHOLOGY AS GOLD STANDARD

Momina Nain[1], Moghira Ghafoor[2], Muhammad Jafir Khan[3], Saba Hassan[4], Naishwa Fareed[5], Saira Bilal[6]

[1,3,5]Postgraduate Residents (FCPS Part-II), Department of Radiology, Punjab Institute of Neurosciences, Lahore, Pakistan
[2,4]Consultant Radiologist, Department of Radiology, Punjab Institute of Neurosciences, Lahore, Pakistan
[6]Professor, Department of Radiology, Punjab Institute of Neurosciences, Lahore, Pakistan
Corresponding author: dr.mominanain@gmail.com

ABSTRACT

Objective: To determine the diagnostic accuracy of B-mode and Doppler ultrasonography in diagnosing malignant ovarian lesion histopathology as gold standard.
Study Design: Cross-sectional study.
Place and Duration of Study: Department of Radiology, Punjab Institute of Neurosciences, General Hospital, Lahore from 16th April 2025 to 15th October 2025.
Methodology: One hundred and thirty-three female patients of aged 15-60 years were enrolled. The diagnostic accuracy of B-mode ultrasonography and Doppler ultrasonography was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy using 2 × 2 contingency tables.
Results: The histopathology confirmed malignant ovarian lesions in 65 (48.9%) patients. B-mode ultrasonography demonstrated sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of 90.77%, 50.00%, 63.44%, 85.00%, and 69.92%, respectively (P<0.001). Doppler ultrasound showed sensitivity of 81.54%, specificity of 94.12%, PPV of 92.98%, NPV of 84.21%, and diagnostic accuracy of 87.97% (P<0.001). Doppler ultrasound exhibited markedly higher specificity and overall diagnostic accuracy compared with B-mode ultrasonography.
Conclusion: Doppler ultrasound demonstrated superior specificity and diagnostic accuracy compared with B-mode ultrasonography in differentiating malignant ovarian lesions. While B-mode ultrasonography showed higher sensitivity and remained useful as an initial screening tool, the addition of Doppler vascular assessment significantly improved diagnostic performance. Combined use of both modalities may enhance early and accurate preoperative diagnosis of ovarian malignancies.

KEYWORDS: Malignant ovarian lesion, B-mode USG, Doppler ultrasonography, Histopathology

INTRODUCTION

Ovarian cancer (OC) is the seventh most common malignancy in women, the eighth greatest cause of cancer-related deaths globally, and the fifth leading cause concerning women in the USA.[1,2] About 70% of ovarian cancers are detected at an advanced stage.[3] Around 240,000 cases of ovarian cancer are diagnosed annually in the world.4 Despite progress, OC remains the most lethal form of female gynaecologic cancer.[5] With an average age of 63 at diagnosis and over 70% of patients presenting with advanced disease, the five-year survival rate is less than 50%.[6-9]

The diagnosis of ovarian malignancy carries significant physical and psychological consequences for patients because of its associated morbidity and mortality. In addition to its impact on patient health, ovarian cancer also imposes a considerable financial burden on both families and healthcare systems.[10]

The standard of care in ovarian cancer is surgical treatment. The qualification for the procedure is an extremely important process. Correct classification should be based on the results of imaging tests.[11] Ovarian lesions hold particular clinical importance because of their malignant potential and the difficulty in accurately distinguishing benign from malignant masses before surgery and histopathological confirmation.[12]

The incidence and frequency of ovarian cancer vary considerably across different countries and ethnic groups, reflecting the influence of genetic, environmental, socioeconomic, and reproductive factors.[13] Accurate preoperative assessment plays a vital role in the evaluation and management of ovarian lesions. Ultrasonography is considered the first-line imaging modality for women with suspected ovarian masses because of its wide availability, cost-effectiveness, non-invasive nature, and high sensitivity in detecting ovarian abnormalities.[12] Goyal and Agarwal[14] have demonstrated that ultrasonography serves as the primary imaging technique for ovarian evaluation, with reported diagnostic accuracy reaching up to 94% in identifying malignant lesions.

Furthermore, Doppler ultrasonography has shown promising diagnostic performance, with a sensitivity of 85%, specificity of 90%, positive predictive value of 85%, and negative predictive value of 90%, demonstrating statistically significant results ($p = 0.001$).

Technological advancements in ultrasonography, particularly the introduction of Doppler imaging, have added a valuable dimension to the accurate diagnosis of ovarian lesions. Ultrasound combined with Doppler evaluation has emerged as a useful modality for the early detection of ovarian malignancies.[15] In addition, pulsed Doppler spectral analysis has improved the characterization of ovarian masses through quantitative assessment of blood flow within tumor vessels. Evaluation of vascular parameters assists in differentiating benign from malignant lesions and enhances the sensitivity and specificity of ovarian mass characterization.[16]

A study conducted in India reported that masses, with statistically significant findings ($p = 0.007$). The same study also reported a Doppler ultrasonography sensitivity of 85% ($p = 0.001$).[14] Another study conducted in Lahore demonstrated that Doppler imaging had a sensitivity of 91.3% for diagnosing ovarian malignancy.[1] Furthermore, transvaginal sonography (TVS) combined with Doppler ultrasound showed high diagnostic performance in differentiating benign from malignant ovarian tumours, with reported sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of 94.34%, 91.49%, 92.59%, 93.48%, and 93.0%, respectively.[12]

The rationale for assessing the diagnostic accuracy of B-mode and Doppler ultrasonography in the detection of malignant ovarian lesions, with histopathology serving as the gold standard, is particularly important in the context of Pakistan, where locally generated evidence in this area remains limited. Ovarian cancer frequently presents with non-specific clinical features, making early and accurate diagnosis crucial for timely intervention and improved survival outcomes. B-mode and Doppler ultrasonography are widely available, cost-effective, and non-invasive imaging modalities that provide essential information regarding morphological characteristics and vascular patterns of ovarian masses. These features are valuable in distinguishing benign from malignant lesions. By comparing imaging findings with histopathological results, which remain the definitive diagnostic standard, this study aimed to determine the sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of both modalities. Establishing the diagnostic reliability and clinical utility of ultrasonography in this setting may support earlier detection, facilitate appropriate clinical decision-making, and contribute to improved patient outcomes. Moreover, it may help strengthen the role of affordable imaging techniques in resource-limited healthcare systems such as Pakistan.

PATIENTS AND METHODS

This cross-sectional study was conducted at Department of Radiology, Punjab Institute of Neurosciences, General Hospital, Lahore from 16th April 2025 to 15th October 2025, after obtaining approval from the Ethical Review Committee. A total of 133 patients were enrolled in the study. Female patients aged 15-60 years presenting with menstrual irregularities, including heavy or irregular bleeding, were included. In addition, women with symptoms such as fatigue, back pain, lower abdominal or pelvic pain, abdominal distension, and altered bowel habits, particularly constipation, were also considered eligible. Patients with ectopic pregnancy, diabetes mellitus, respiratory disorders, or chronic liver disease confirmed on relevant investigations were excluded. Those deemed unfit for anaesthesia or unwilling to undergo surgical intervention were also excluded from the study. Written informed consent was obtained from all participants prior to enrollment, and demographic as well as clinical information was recorded. Patients presenting with ovarian masses on transabdominal ultrasonography were included. The lesions demonstrated suspicious sonographic features, including multiloculation, papillary projections, internal solid components, thick septations greater than 3 mm, free peritoneal fluid, and evidence of metastasis. Patients with adnexal masses persisting for more than three months and showing malignant features on Doppler ultrasonography, such as increased vascularity and elevated Doppler indices including peak systolic velocity, resistive index, and pulsatility index, were also enrolled.

All patients underwent evaluation using both B-mode ultrasonography and Doppler ultrasonography. A detailed clinical history and physical examination were performed prior to imaging. Histopathological examination following surgical intervention was taken as the gold standard for definitive diagnosis. The imaging findings were compared with histopathological results to determine sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of both modalities. This approach minimized selection bias and ensured a reliable and valid comparison between the two diagnostic techniques. Data were entered and analyzed using the SPSS-22.0. Quantitative variables such as age and duration of disease were expressed as mean ± standard deviation, while qualitative variables, including family history of ovarian cancer and presence of malignancy, were presented as frequencies and percentages. Data were stratified according to age, duration of disease, and family history of ovarian cancer to assess their effect on study outcomes. The diagnostic performance of B-mode and Doppler ultrasonography was assessed using 2×2 contingency tables to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy. Post-stratification analysis was performed using the Chi-square test, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

The mean age of the patients was 39.90±12.02 years. The mean duration of the disease was 13.20±7.28 months. It is an indication that many of the patients remained ill for a long time before being medically attended or diagnosed. With regard to family history of cancer, 42 (31.6%) patients reported positive family history while 91 (68.4%) patients had no such history (Table 1).

There are 133 patients out of which 93 had malignant lesions based on the results of B-mode ultrasound. Among them, 59 are true positives, and 34 are false positives. On the other hand, 40 lesions are negative in their diagnosis by means of B-mode ultrasonography. Among the mentioned patients, 34 lesions have proved themselves as true negatives and 6 as false negatives. Sensitivity of B-mode ultrasonography reaches 90.77%. This result proves that the diagnostic method is very efficient in detecting malignant lesions. Specificity, in its turn, equals 50%. PPV and NPV are 63.44% and 85%, respectively while accuracy reached 69.92% (Table 2).

Table 3 reflects the diagnostic accuracy of Doppler ultrasound in detecting malignant ovarian neoplasms with histopathology as the gold standard. Of the 133 patients examined, Doppler ultrasound classified 57 patients as having a malignant lesion, with 53 patients being true positive based on histopathology results and four patients being false positive. Further, there were 76 patients classified by Doppler ultrasound as being negative with 64 patients being true negatives and 12 patients, false negatives. The sensitivity of Doppler ultrasound in diagnosing malignant ovarian neoplasm is 81.54%, which denotes its accuracy in identifying ovarian malignancy. The specificity of Doppler ultrasound is 94.12%, which reflects its high efficiency in discriminating between benign and malignant tumours. The PPV was 92.98% and NPV 84.21% while the diagnostic accuracy of Doppler ultrasound was 87.97%.

Table 4 depicts the stratified analysis of the diagnostic accuracy of B-mode ultrasonography based on age, disease duration, and family history of cancer. The B-mode ultrasonography proved to have a consistently high sensitivity of 90.32% and 91.18% in patients belonging to ages 20–40 years and 41–60 years, respectively, while relatively lower specificity of 50% in both categories, along with a statistical significance (P<0.001). Amongst patients who had a disease duration of >12 months, the sensitivity, specificity, and accuracy were 92.11%, 54.05%, and 73.33%, respectively, in comparison to disease duration ≤12 months. Likewise, patients having a positive family history of cancer presented with a higher sensitivity and negative predictive value than their counterparts.

Stratified diagnostic accuracy of Doppler ultrasound by age, disease duration, and family history is presented in table 5. For both age categories (20-40 years and 41-60 years), Doppler ultrasound showed highly specific results (94.12%), along with high sensitivity (80.65% and 82.35%, respectively) and diagnostic accuracy (87.69% and 88.24%), demonstrating statistically significant correlation (P<0.001). With regard to the duration of disease, those with ≤12 months had significantly high sensitivity and accuracy of 85.19% and 89.66%, respectively, whereas those with >12 months had high specificity (94.59%) with moderate accuracy of 86.67% (P≤0.004-P<0.001). For stratified analysis based on family history, highly diagnostic accuracy for Doppler ultrasound was found in both groups. Those with positive family history had equally sensitive and specific results of 83.33%, whereas those without family history had highly specific (97.73%) and accurate results of 89.01%.

Table 1: Demographic and clinical characteristics of the study participants (n=133)

Variable	No.	%
Family History of cancer		
Yes	42	31.6
No	91	68.4
Age	39.90±12.02	
Duration of disease (months)	13.20±7.28	

Table 2: Diagnostic accuracy of B-mode ultrasound in diagnosing malignant ovarian lesion taking histopathology as gold standard

Malignant ovarian lesion on B-mode USG	Malignant ovarian lesion on Doppler ultrasound		Total	P value
	Positive	Negative		
Positive	59 (TP)	34 (FP)	93	P<0.001
Negative	6 (FN)	34 (TN)	40	
Total	**65**	**68**	**133**	
Sensitivity	90.77%			
Specificity	50.00%			
PPV	63.44%			
NPV	85.00%			
Diagnostic Accuracy	69.92%			

Table 3: Diagnostic accuracy of Doppler ultrasound in diagnosing malignant ovarian lesion taking histopathology as gold standard

Malignant ovarian lesion on B-mode USG	Malignant ovarian lesion on Doppler ultrasound		Total	P value
	Positive	Negative		
Positive	53 (TP)	4 (FP)	57	P<0.001

Negative	12 (FN)	64 (TN)	76	
Total	**65**	**68**	**133**	
Sensitivity	81.54%			
Specificity	94.12%			
PPV	92.98%			
NPV	84.21%			
Diagnostic Accuracy	87.97%			

Table 4: Stratification for age, duration of disease and family history of ovarian cancer with regard to diagnostic accuracy of B-mode ultrasound in diagnosing malignant ovarian lesion taking histopathology as gold standard

Sensitivity	Specificity	PPV	NPV	Accuracy	P value
Age (20-40 year)					
90.32%	50.00%	62.22%	85.00%	69.23%	P<0.001
Age (41-60 year)					
91.18%	50.00%	64.58%	85.00%	70.59%	p<0.001
Duration of disease (≤ 12 months)					
88.89%	45.16%	58.54%	82.35%	65.52%	p=0.004
Duration of disease (> 12 months)					
92.11%	54.05%	67.31%	86.96%	73.33%	p<0.001
Family history of cancer (Yes)					
94.44%	54.17%	60.71%	92.86%	71.43%	p=0.001
Family history of cancer (No)					
89.36%	47.73%	64.62%	80.77%	69.23%	P<0.001

Table 5: Stratification for age, duration of disease and family history of ovarian cancer with regard to diagnostic accuracy of Doppler ultrasound in diagnosing malignant ovarian lesion taking histopathology as gold standard

Sensitivity	Specificity	PPV	NPV	Accuracy	P value
Age (20-40 years)					
80.65%	9412%	92.59%	81.21%	87.69%	P<0.001
Age (41-60 years)					
82.35%	94.12%	93.33%	84.21%	88.24%	p<0.001
Duration of disease (≤ 12 months)					
85.19%	93.55%	92.00%	87.88%	89.66%	p=0.004
Duration of disease (> 12 months)					
78.95%	94.59%	93.75%	81.40%	86.67%	p<0.001
Family history of cancer (Yes)					
83.33%	87.50%	83.33%	87.50%	85.71%	p=0.001
Family history of cancer (No)					
80.85%	97.73%	97.44%	82.69%	89.01%	P<0.001

DISCUSSION

In the present study, B-mode ultrasonography was found to have a very high sensitivity of 90.77% for identifying malignant ovarian masses, although its specificity was low at 50.00%. Moreover, the positive predictive value, negative predictive value, and diagnostic accuracy of B-mode ultrasonography were 63.44%, 85.00%, and 69.92%, respectively. On the other hand, sensitivity was slightly lower in Doppler ultrasound at 81.54%, but its specificity was much higher at 94.12%, and diagnostic accuracy was also relatively high at 87.97%.

The results obtained from the current study are in accordance with the results obtained in the study of Goyal et al.[14] In this study, the sensitivity, specificity, PPV, NPV, and diagnostic accuracy of B-mode ultrasound were found to be 90.77%, 50.00%, 63.44%, 85.00%, and 69.92%, respectively. Similarly, sensitivity, specificity, PPV, and NPV of B-mode USG in the detection of ovarian malignancy were 94.44%, 48.15%, 54.84%, and 92.86%, respectively, whereas its overall diagnostic accuracy was approximately 67%. The sensitivity and specificity of the two studies are nearly equal, thus concluding that B-mode ultrasound is highly effective in diagnosing malignant ovarian tumours but has less specificity because of overlapping sonographic findings in benign lesions. The marginally higher values of PPV and diagnostic accuracy in the current research could be justified by the variations in sample sizes, prevalence rate of the disease, and features of the lesions within the studied population. In the context of the evaluation of Doppler ultrasound, the current study found sensitivity to be 81.54%, specificity 94.12%, PPV 92.98%, NPV 84.21%, and diagnostic accuracy to be 87.97%. All the findings in the current study are consistent with those of Goyal et al[14], who identified sensitivity, specificity, PPV, and NPV of 85%, 90%, 85%, and 90%, respectively. Goyal et al[14] also achieved 88% of diagnostic

accuracy, which was statistically significant (p = 0.0001). Similar to the current findings, both studies found higher specificity and diagnostic accuracy for Doppler ultrasound than for B-mode ultrasonography. Therefore, the higher specificity and PPV in the current study are indicative of the higher ability of Doppler ultrasound to detect blood flow in the tumors.

In this study, sensitivity was seen to be relatively high with regard to B-mode ultrasonography; this is similar to other previous reports on ultrasound morphology, which have been seen to be very reliable in detecting any suspicious adnexal mass. As noted by a multicenter study on the International Ovarian Tumour Analysis (IOTA) phase 3 study, sensitivity using ultrasound model for diagnosing ovarian cancer was found to be between 90%-96%.[17] Similar results were reported by Rashmi et al[18] in their sensitivity results of IOTA simple rules and ADNEX models in predicting malignant ovarian tumours.

On the other hand, there were also some limitations for specificity in B-mode ultrasonography within the current study because its value was quite low (50%). The cause could be the similar appearance of benign and malignant lesions. There are many complex benign tumours that are difficult to distinguish from malignancy since both lesions have similar morphologic appearances based on gray-scale ultrasound images. Benign ovarian lesions such as hemorrhagic cysts, endometriomas, and tubo-ovarian abscesses have the potential to create false-positive results.[19]

The current study shows that Doppler ultrasound was found to be significantly more specific (94.12%) and diagnostic accurate (87.97%) than B-mode ultrasonography. This is in line with well-known uses of Doppler ultrasound for determining the degree of neovascularization within tumours. Malignant ovarian tumours present with greater central vascularity and low-resistance blood flow because of angiogenesis that differentiates them from benign masses. Lu et al[20] examined the use of Doppler enhanced ultrasonography also found better specificity and diagnostic outcomes.

In our current investigation, the positive predictive value of Doppler ultrasonography is exceedingly high (92.98%) implying that the lesions classified as malignant using Doppler imaging are indeed malignant, as confirmed by the final histopathological diagnosis. Similar results have been achieved by other studies on the efficacy of ultrasound-based scoring schemes. According to Xie et al[21] integration of morphological findings and Doppler features using the criteria provided by O-RADS and IOTA can enhance the diagnostic accuracy of ovarian malignancy.

The high negative predictive value (84.21%) seen with Doppler ultrasound in this study suggests excellent reliability in the exclusion of malignancy. The clinical significance of this is that the effective exclusion of malignant conditions can decrease unnecessary surgery due to benign tumours of the ovary. Prior research has pointed out the benefits of standardized ultrasound techniques, especially the use of Doppler vascularization.[18,22]

Doppler ultrasound had an overall superior accuracy of 87.97% compared to B-mode ultrasound accuracy of only 69.92%. This is a common finding in recent medical literature on ultrasounds. Excellent diagnostic performance of the ultrasound modality has been noted by the multicentric IOTA study, with high specificity when more advanced imaging criteria were employed.[17]

These findings suggest that our Doppler-based ultrasonographic results are towards the high side of those reported in the literature, while the sensitivity of our B mode results alone is slightly superior to many recent reports. In either case, these trends highlight the importance of including vascular assessment by means of Doppler studies in ultrasonography when evaluating ovarian tumours, especially when the diagnosis is used for referral and surgery.

CONCLUSION

Both B-mode ultrasonography and Doppler ultrasonography have proved to be excellent diagnostic methods in the detection of ovarian masses. B-mode ultrasonography exhibited high sensitivity levels and was very useful for the initial detection of malignant ovarian tumours. Doppler ultrasonography, on the other hand, showed much higher specificity, positive predictive values, and accuracy rates, making it a better choice for differential diagnosis between benign and malignant ovarian masses.

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