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Original Research Article

Diagnostic Accuracy of Resistive Index of Doppler Ultrasound in Diagnosing Malignant Ovarian Tumors, Taking Histopathology as Gold Standard

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Abstract: *Ovarian cancer remains a leading cause of gynecologic malignancy-related mortality worldwide due to delayed diagnosis and nonspecific clinical presentation. Differentiating benign from malignant ovarian tumors preoperatively is essential for optimal patient management and surgical planning. Doppler ultrasound, particularly the assessment of resistive index (RI), has emerged as a valuable, non-invasive diagnostic tool for evaluating adnexal masses.* ***Objective:*** *To determine the diagnostic accuracy of the resistive index of Doppler ultrasound in diagnosing malignant ovarian tumour, taking histopathology as the Gold standard.* ***Methodology:*** *This cross-sectional study was conducted at Sheikh Zayed Hospital's radiology department from September 2024 to February 2025. It involved patients presenting with adnexal masses on ultrasound, following ethical approval and informed consent. A sample size of 110 was determined based on a 95% confidence level, with a focus on malignant ovarian tumors. Inclusion criteria included patients aged 20 to 60 years, with a disease duration exceeding three months and specific ultrasound characteristics. Patients with simple cysts, metabolic disorders, and prior anti-tumor treatments were excluded. Each subject underwent Doppler sonography, and the resistive index (RI) was measured to differentiate between benign and malignant tumors. Surgical samples were analyzed histopathologically to confirm diagnoses. Data were recorded using a proforma and analyzed with SPSS 25.0, focusing on diagnostic accuracy, sensitivity, and specificity of the Doppler ultrasound findings compared to histopathology results. Stratification was applied based on age, disease duration, and other variables.* ***Result:*** *In our study, the mean age of patients was 39.08 years, with a disease duration of 20.27 months and average lesion sizes of 10.48 mm. Among participants, 70.8% had benign tumors and 29.2% malignant, with significant differences noted in marital status. Doppler color ultrasound identified 75.5% of lesions as benign and 24.5% malignant, yielding a sensitivity of 80% and specificity of 91.76%. Notably, benign tumors averaged 8.18 mm, while malignant ones were larger at 17.55 mm (p-value 0.00).* ***Conclusion:*** *Doppler ultrasound, particularly resistive index, effectively differentiates benign from malignant ovarian tumors, with a sensitivity of 80% and specificity of 91.76%. Younger women tend to have benign lesions, while older, postmenopausal women are at higher risk for malignancy, making this tool vital for early screening.*

Keywords: Doppler, ovarian tumors, benign, malignant, resistive index, sensitivity, specificity, diagnostic accuracy

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Introduction

Reproductive organs are one of the most common sites for female tumors, second only to breast cancer. Ovarian masses are a frequent cause of gynecological consultation and are usually detected during imaging or surgery for evaluation of pelvic or abdominal pain syndromes. With more than 2 million new cases reported annually, ovarian malignancy represents the fourth most common cause of cancer-related deaths globally (1,2). Ovarian cancer has the highest mortality rate among gynecologic cancers. Because most ovarian cancer is diagnosed in the advanced stage of the disease, the five-year survival rate is very poor. Preoperative characterization of ovarian masses poses a special diagnostic challenge, as it significantly impacts the patient's prognosis, survival rate, and treatment strategies (3**)**. Serum CA-125 levels and pelvic examination have failed to discriminate between benign and malignant ovarian lesions, owing to their low sensitivity and high false-positive rate. Different modalities were available for the prompt identification and categorization of ovarian malignancies (4).

Tissue Biopsy is so far the Gold standard for the Diagnosis of ovarian cancer (5). The biopsy for ovarian cancer is done in several different ways. It can be done through a surgical biopsy, a laparoscopic biopsy, a core needle biopsy, or a fine needle biopsy. Although biopsy is the most accurate procedure to confirm and differentiate a benign or malignant ovarian cancer, it is associated with some risks like bleeding, blood clots, damage to nearby abdominal organs, infections, and incisional hernia. (6,7) In addition to the risks associated with the procedure, it also costs a fortune. Ovarian tumor is only the second to brain tumor in terms of the cost needed for treatment. The biopsy only costs $1000 to $5000 on average in America, making a big difference in the lives of patients (8). Moreover, an invasive procedure imposes negative effects on the mental health of the patients as well, mounting stress, anxiety, fear, and even depression (9). Ultrasonography is one of the first-line methods in the investigation of female pelvic pathologies (10). Conventional two-dimensional (2D) ultrasound has been widely used for the evaluation of adnexal malignancy in the gynecologic field. This 2D ultrasound evaluation includes a morphological assessment, color/power and pulsed Doppler sonographic assessment, scoring system, and contrast agent assessment of adnexal masses (11).

Doppler flow measures and assesses tumor vascularity, increasing the confidence with which a correct Diagnosis can be made. Color and pulsed Doppler sonography depict the vascularity of pelvic organs and can be used to assess angiogenesis in tumor masses, providing insight into the tumor.[12] Thus, patients may have a less invasive surgical procedure, such as laparoscopy, or be referred to a gynecological oncologist. In a study, the specificity of Doppler ultrasound resistive index in diagnosing malignant ovarian tumors was found to be 90.3% and the sensitivity was 79.2%. Positive and negative predicative values were 92.9% and 73.1%, respectively (13). In another study, the sensitivity, specificity, and diagnostic accuracy of RI Doppler were 98.33%, 91.25%, and 95.5% respectively (14).

In a study, the prevalence of malignant ovarian tumors was found to be 52.5%, the sensitivity of 9 1 .3%, and the specificity of 90.59% (15).

Although, Doppler ultrasound allows detection of tumor flow, but its role has not been found consistent in Diagnosis of malignant ovarian tumor and the available data on the diagnostic accuracy of resistive index of doppler ultrasound in diagnosing malignant ovarian tumor is variable, so we have planned this study to determine the diagnostic accuracy of resistive index of doppler ultrasound in diagnosing malignant ovarian tumor, taking histopathology as Gold standard.

My study will help both the patients and doctors by providing an accurate characterization of the ovarian lesions using a non-invasive method, which would help in opting for targeted treatment plans in order to reduce the morbidity and mortality of these patients.

Methodology

This cross-sectional study was carried out in the radiology department of Sheikh Zayed Hospital, Rahim Yar Khan, on patients who presented with an adnexal mass on ultrasound, from September 2024 to February 2025. Data collection started after taking ethical approval from the Institutional Review Board of the institute and informed written consent from study subjects. A sample size of 110 was calculated using the WHO calculator, with a 95% confidence level, an expected prevalence of malignant ovarian tumour of 52.5%, and a desired precision of 8% for sensitivity of 91.3% and specificity of 90.59%.[16] By the inclusion criteria, patients aged between 20 and 60 years, and with a duration of disease of more than 3 months and presence of an adnexal mass on ultrasonography (of any size having papillary projections/solid component/septations >3.0 mm/ color score 1-3, of O-RADS US 3/4). Patients with simple cysts (physiological) who will not undergo any surgery for their masses, patients with metabolic disorders (diabetes mellitus), patients with cardiovascular or respiratory disorders, immunocompromised patients, and patients who have a history of anti-tumour treatment (surgery, chemotherapy, or radiotherapy) were not included. Informed consent was taken from each patient. Then, age, duration of disease, size of lesion, marital status (unmarried/married), and menopausal status (pre-menopausal/postmenopausal) were noted. After this, Doppler sonography with a 7 MHz probe was done in the patients using the standard technique in the presence of female staff. After morphological evaluation, color flow Doppler was activated. It was stated as having flow when the flow was central, and it was considered to have no flow when no signal could be detected or if the blood flow was peripheral. Once a central vessel was identified by the color Doppler US, the spectral Doppler parameters, such as the resistive index (RI), were automatically calculated. Each ultrasound finding was interpreted by one consultant radiologist (at least 5 years of experience) and assessed for the presence of a benign (resistive index >20.5) or malignant (resistive index <0.5) ovarian tumour. Then these females underwent surgery performed by a gynecologist with 4 years of residency experience. Samples were obtained and sent to the Pathology department for histopathological assessment of the type of lesion. Reports were assessed, and patients were confirmed as having benign or malignant ovarian tumours. Doppler findings were compared with the histopathology report. All this data was recorded on a specially designed proforma. The collected data were analysed through the computer software SPSS 25.0. The Shapiro-Wilk test was used to check the normality of data, which came out to be statistically significant (p-value 0.00). Age, duration of disease, and size of lesion were presented as mean and SD or median (IQR). Frequency and percentage were calculated for marital status (unmarried/married), menopausal status (pre-menopausal/postmenopausal), benign and malignant ovarian tumors on Doppler and histopathology. A 2x2 contingency table was used to calculate sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the resistive index of Doppler ultrasound in diagnosing malignant ovarian tumour, taking histopathology as the Gold standard. Stratification was done for age, duration of disease, size of lesion, marital status (unmarried/married), and menopausal status (premenopausal/postmenopausal). Post-stratification sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the resistive index of Doppler ultrasound were calculated.

Results

The patients included in the study had a mean age of 39.08 ± 10.92 years. The mean duration of their disease was 20.27±6.5 months, and the mean size of the lesion was 10.48±5.85 millimetres. Among the participants, 89 (80.9%) were married, and 21 (19.1%) were unmarried. 70.8% of the married patients had benign tumors, whereas 29.2% of married women had malignant tumors according to Doppler colour ultrasound. On the other hand, 95.2% of unmarried women had benign tumors, whereas 4.8% of unmarried women had malignant tumors according to Doppler colour ultrasound. (P-value 0.01) (Table 1)

41 (37.3%) females in the study had already entered menopause, whereas 69 (62.7%) were still having their menstrual cycles. 79.7% of females in their premenopause phase had benign tumours, whereas 20.3% had malignant tumors. On the other hand, 68.3% of females in the postmenopause phase in this study had benign tumors, and 31.7% had malignant tumors according to Doppler colour ultrasound. (P-value 0.17). These female patients were tested through two modalities. One is the radiological technique, where we used the doppler colour ultrasound to assess if the lesion is benign (75.5%) or malignant (24.5%) depending on the resistive index (RI). The other technique used was histopathology to determine if the lesion is benign (77.3%) or malignant (22.7%). The outcomes are summarized in Table 2. The true positive cases, i.e., malignant on both Doppler and histopathology, were 20 (18.2%), and the true negative cases, i.e., benign on both Doppler and histopathology, were 78 (70.9%).

On the other hand, there were seven false positive cases (6.4%), where the histopathology was benign. However, the Doppler was malignant, and five false negative cases (4.5%), where the histopathology was malignant but the Doppler was benign. The chi-square test for the 2x2 contingency table is statistically significant (p-value 0.00). This is further illustrated in Table 3. Given the above data, the Doppler colour ultrasound has a sensitivity of 80% and specificity of 91.76%. It has a positive predictive value of 74.04% and a negative predictive value of 93.98%. The diagnostic accuracy of Doppler color ultrasound for diagnosing benign/malignant ovarian tumors in our study is 89.09%. Moreover, the ROC chart also shows a statistically significant (p-value 0.00) value, showing that the Doppler ultrasound is highly sensitive and specific for diagnosing benign/malignant ovarian tumors. Studying the data further, it is notable that most of the younger patients (42.7%) between the age ranges of 20 to 40 years had benign tumors. Similarly, malignant tumors were dominantly seen in older patients (17.3%) in the age range 40-60 years.

Younger age patients (20-40 years) also had malignant tumors (7.3%), but this was significantly lower than in the older age groups. (p-value 0.045) Post-stratification analysis of the data shows that the benign ovarian tumors become symptomatically apparent around 19.5 months, which is not very different from the malignant tumors, which become noticeable in around 22.5 months. The data on the duration of disease to reach a benign or malignant tumor Diagnosis is not statistically significant when applying the independent sample t-test (p-value 0.489). (Table 4)

However, the size of lesions of benign and malignant tumors does show statistical significance. An independent sample t-test states a p-value of

0.00. The size of benign lesions is 8.18±3.3 mm, whereas the size of lesions in malignant tumors is 17.55±6.2 mm. (Table 5)

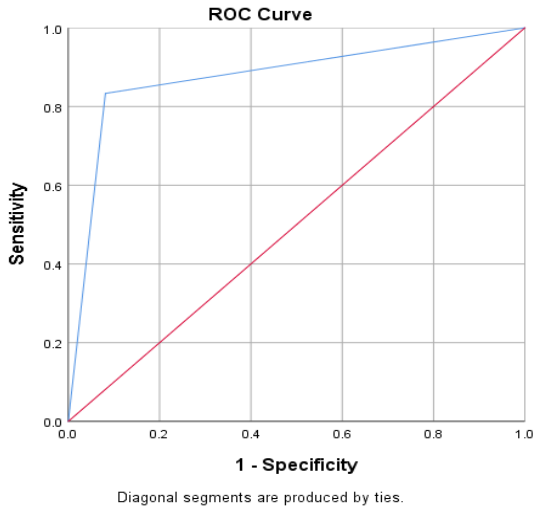

Figure 1 ROC curve for Doppler colour Ultrasound.

Table 1 Means of Age, duration of disease, and sizes of lesions

	Mean	Standard Deviation
Age of Patients	39.0818	10.91093
Duration of Disease	20.27	6.511
Size of lesion	10.4818	5.85095

Table 2 frequency of patients diagnosed with benign or malignant lesions on Doppler USG and histopathology

	Doppler USG	Histopathology
Benign	83 (75.5%)	85 (77.3%)
Malignant	27 (24.5%)	25 (22.7%)
total	110 (100%)	110 (100%)

Table 3, 2x2 contingency table for histopathology and Doppler ultrasound

		Histopathology		Total	p-value
		malignant	benign		
Doppler Ultrasound	malignant	20(18.2%) (true positive)	7 (6.4%) (false positive)	27(24.5%)	0.00
	benign	5(4.5%) (false negative)	78(70.9%) (true negative)	83 (75.5%)	
Total		25 (22.7%)	85(77.3%)	100 (100%)	

Table 4 Diagnostic parameters of Doppler colour ultrasound

Diagnostic parameters of Doppler colour ultrasound	
Sensitivity	80%
Specificity	91.76%
Positive predictive value	74.04%
Negative predictive value	93.98%
Diagnostic Accuracy	89.09%

Table 5:

	Findings of Doppler Ultrasound		p-value
	Benign	Malignant	
Duration of disease in months	19.54±6.2	22.5±6.9	0.039
Size of lesion in mm	8.18±3.3	17.55±6.2	0.00

Discussion

In our study, the patients had a mean age of 39.08 years and a disease duration of 20.27 months, with lesion sizes averaging 10.48 millimetres. Of the participants, 89 (80.9%) were married, with 70.8% having benign tumors, while 29.2% had malignant tumors as per Doppler color ultrasound. In contrast, 95.2% of unmarried women had benign tumors and 4.8% malignant (p-value 0.01). The study included 41 (37.3%) postmenopausal and 69 (62.7%) premenopausal females. Among premenopausal women, 79.7% had benign tumors compared to 20.3% with malignant tumors; in postmenopausal women, 68.3% had benign tumors and 31.7% malignant tumors (p-value 0.17). Doppler color ultrasound identified 75.5% of lesions as benign and 24.5% as malignant, while histopathology showed benign results in 77.3% and malignant in 22.7%. True positive cases totalled 20 (18.2%), while true negatives were 78 (70.9%), with false positives at 7 (6.4%) and false negatives at 5 (4.5%). The chi-square test yielded significant results (p-value 0.00), with Doppler ultrasound demonstrating a sensitivity of 80%, specificity of 91.76%, positive predictive value of 74.04%, negative predictive value of 93.98% and diagnostic accuracy of 89.09%. The study found that 42.7% of younger patients (20-40 years) had benign tumors, while 17.3% of older patients (40-60 years) had malignant tumors (p-value 0.045). Both benign and malignant tumors became symptomatic around 19.54 months and 22.5 months, respectively, although this was not statistically significant (p-value 0.489). However, lesion sizes significantly differed: benign tumors averaged 8.18±3.3 mm and malignant tumors 17.55±6.2 mm (p-value 0.00).

Sheikh A, et al. conducted a study in 2020 involving 153 patients, using Duplex ultrasonography to assess ovarian masses and record various parameters such as flow score, Resistive Index (RI), and Pulsatility Index (PI). The histopathology results distinguished between benign and malignant cases. Doppler ultrasound demonstrated a diagnostic accuracy of 95.4%, with a sensitivity of 86.2%, specificity of 97.58%, positive predictive value of 89.28%, and negative predictive value of 96.8%. The findings indicate that while Doppler ultrasound is a reliable method for diagnosing malignant ovarian neoplasms, histopathology remains the Gold standard for definitive Diagnosis. The results of this study, including sensitivity and specificity, were more favorable compared to those of our study, particularly about the positive and negative predictive values (17).

Hameer A, et al. conducted a study in 2024 focusing on women aged 20-45 with ovarian lesions larger than 8 cm identified through ultrasound. After undergoing laparotomy, the diagnostic accuracy of ultrasound was assessed against histopathological findings as the Gold standard. The mean age of participants was 36.01 years, which in our study was 39.08 years, with a mean symptom duration of 27.75 months (in our study, it was 20.27 months). In terms of parity, 11.50% had one child, while 88.50% had multiple children. The ultrasound's diagnostic accuracy for malignancy was notable, with a sensitivity of 82.68%, a specificity of 73.68%, a positive predictive value (PPV) of 93.67%, a negative predictive value (NPV) of 47.46%, and an overall accuracy of 81.11%. The diagnostic parameters evaluated in our study demonstrated comparable sensitivity; however, we observed that both the positive and negative predictive values were notably improved in our findings (18).

In 2019, a study was conducted in the ultrasonography department of Central Cangzhou Hospital in China by Zhou L, et al., which found that the diagnostic parameters of Doppler color USG are a highly effective non-invasive method for diagnosing ovarian tumors, depending on the resistive indices. According to the study, its sensitivity was 96.49%, specificity was 90.01%, and accuracy was 93.75%. In our study, the sensitivity of Doppler ultrasound was found to be greater than its specificity. However, it is noteworthy that the diagnostic accuracy was lower in comparison to the specificity (19).

In 2020, Saleem A, et al. conducted a study at Rawalpindi Medical University on the diagnostic accuracy of color Doppler for ovarian masses. The histopathology reports of these masses were compared with the results of color Doppler USG. The sensitivity, specificity, and diagnostic accuracy were found to be 86.2%, 97.58% and 95.4%, respectively. The test's positive predictive value was 89.28%, whereas the negative predictive value was 96.8% (20).

In 2020, Liaqat F, et al. did a study involving 213 women diagnosed with ovarian masses through ultrasound. After comprehensive examinations, those suspected of having ovarian masses underwent transvaginal ultrasound and serum CA-125 testing, which allowed for scoring and classification of the conditions as malignant or benign. Histopathological analysis of surgical specimens confirmed the diagnoses. The results indicated that 29.2% of the cases were malignant. Using a cut-off value of RMI > 200, the sensitivity was 90.2%, the specificity was 54.9%, the positive predictive value was 58.7%, the negative predictive value was 97.3%, and the overall accuracy was 85.9% (21).

In the analysis of 156 ovarian lesions, 53 were classified as malignant and 103 as benign, in a study done by Khalaf LMR, et al, in Egypt, in 2020. Notably, malignant ovarian lesions were more commonly found in older patients compared to benign lesions, with statistical significance ($p < 0.001$). The majority of malignant lesions exhibited a non-hyperechoic solid component (92.5%). This characteristic demonstrated a high sensitivity of 92.5%, a specificity of 97%, an accuracy of 94.8%, a positive predictive value of 94%, a negative predictive value of 96%, and an area under the curve (AUC) of 0.94 in differentiating between benign and malignant ovarian lesions. Our study demonstrates a high level of accuracy in using Doppler scans for the non-invasive Diagnosis of malignant ovarian tumours. However, it is noteworthy that the statistics from studies conducted in Egypt indicate even more favorable outcomes (11).

A recent cross-sectional study was conducted at Bangabandhu Sheikh Mujib Medical University and the National Institute of Cancer Research & Hospital in Dhaka in December 2024, involving 65 patients with ovarian tumors. They underwent color Doppler ultrasonography and CT scans, followed by laparotomy and frozen section biopsy for histopathology confirmation. The sensitivity rates were 96.9% for color Doppler USG and 87.5% for CT scans, while the specificity rates were 60.6% and 57.6%, respectively. Accuracy rates were 78.5% for color Doppler USG and 72.3% for CT scans, with positive predictive values of 70.5% and 66.7%, and negative predictive values of 95.2% and 82.6%. This study incorporated both computed tomography (CT) scans and Doppler ultrasound; however, our research demonstrated superior diagnostic parameters (22).

Invasive procedures always bring a significant amount of fear and discomfort for both patients and surgeons worldwide. It is one of the causes of anxiety for patients undergoing surgery, whether it be a laparotomy or toenail extraction. It does affect the mental state of both patients and doctors (23). Therefore, a non-invasive procedure for diagnostic purposes is always a relief and less stressful. It not only provides a sense of safety but also ensures a lesser economic burden on the patient in an age where ovarian tumor incidence is increasing with each passing year in developing countries and is the eighth most prevalent cause of malignancy in women (24). Measures need to be taken to improve its early and easy Diagnosis. The high sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of color Doppler ultrasound in diagnosing ovarian tumors should be encouraged and more reliably used as a diagnostic tool in the field of medicine.

Conclusion

This study demonstrates that Doppler ultrasound, specifically the measurement of resistive index, shows good diagnostic accuracy in differentiating between benign and malignant ovarian tumors when compared to histopathology, the Gold standard. With a sensitivity of 80%, specificity of 91.76%, and an overall diagnostic accuracy of 89.09%, Doppler ultrasound proves to be a reliable, non-invasive tool, particularly valuable in resource-limited settings like Pakistan. The findings also reveal that younger, premenopausal, and unmarried women are more likely to present with benign lesions, while increasing age and

postmenopausal status are associated with a higher incidence of malignancy, though not all associations reached statistical significance. Importantly, lesion size emerged as a strong differentiator, with malignant tumors being significantly larger than benign ones. These results underscore the clinical utility of Doppler ultrasound in early screening and triaging of ovarian tumors, potentially reducing the diagnostic burden in underserved healthcare environments. Further large-scale, multicenter studies are recommended to validate and refine the use of the resistive index in diverse populations.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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