Original Article

Uterine Artery Doppler findings in patients with suspicion of adnexal masses

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Abstract

Objective: To evaluate uterine artery Doppler parameters and assess their diagnostic accuracy in differentiating benign from malignant adnexal masses.

Study design: It was a descriptive study.

Place and duration of study: This study included 385 women aged 18–65 years with suspected adnexal masses who underwent transabdominal Doppler ultrasound between August and December 2024 at Sammar Diagnostic Lab, Lahore.

Material and Methods: This descriptive study included 385 women aged 18–65 years with suspected adnexal masses who underwent transabdominal Doppler ultrasound between August and December 2024 at Sammar Diagnostic Lab, Lahore. Doppler parameters from bilateral uterine arteries were measured and correlated with adnexal mass characteristics. Data were analyzed using SPSS 25.0 with Pearson correlation and t-tests; $p < 0.05$ was considered statistically significant.

Results: Among 385 patients evaluated, mixed-type adnexal masses were most common (24.2%), followed by malignant (20.5%) and solid or benign lesions (19.7% each). Pearson correlation analysis showed a significant negative correlation between malignancy and both Right Uterine Artery Resistance Index ($r = –0.503$) and Pulsatility Index ($r = –0.476$). The Left Uterine Artery RI also showed a moderate negative correlation ($r = –0.423$), while Peak Systolic Velocity was moderately positively correlated with malignancy ($r = 0.371$; $p < 0.001$). One-sample t-tests confirmed that the mean values of Doppler parameters were statistically significant ($p < 0.001$), supporting their diagnostic relevance.

Conclusion: Uterine artery Doppler parameters, particularly low RI and PI and elevated PSV, are significantly associated with malignant adnexal masses. These indices serve as valuable non-invasive markers for early malignancy detection and can complement grayscale ultrasound in improving diagnostic accuracy. Further multicenter studies are recommended to validate these findings and standardize Doppler criteria.

Keywords: Adnexal Masses, Doppler Ultrasound, Resistance Index, Pulsatility Index, Peak Systolic Velocity, Ovarian Cancer

1. Introduction

Nearly 20% of women will develop a pelvic mass during their lifetime, making adnexal masses—a broad term referring to ovarian, tubal, or surrounding connective tissue abnormalities—one of the most frequently encountered conditions in gynecological practice. The most feared diagnosis among adnexal masses is ovarian cancer, one of the deadliest gynecologic malignancies, primarily due to delayed detection. This is attributed to the lack of specific early symptoms and ineffective screening methods. According to GLOBOCAN 2020, approximately 314,000 women were diagnosed with ovarian cancer, resulting in 207,000 deaths. Globally, ovarian cancer ranks ninth in both incidence and mortality among women. (1)

Ovarian masses are generally classified as benign or malignant based on their histopathological nature. essential, yet morphological evaluation alone can be misleading due to overlapping sonographic features between benign and malignant lesions. (2) Ultrasound (US) is

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the first-line imaging modality for assessing adnexal lesions due to its non-invasiveness, affordability, and accessibility. Transabdominal ultrasound is typically used in younger or non-sexually active patients, while transvaginal ultrasound is preferred for sexually active individuals. While tumor markers such as CA-125, alpha-fetoprotein (AFP), beta-human chorionic gonadotropin (β-hCG), and lactate dehydrogenase (LDH) may aid diagnosis, their limited sensitivity—elevated in only about 50% of malignancies—reduces their reliability. [3]

To enhance diagnostic accuracy, Color Doppler ultrasonography is often combined with gray-scale imaging. It assesses tumor vascularity by analyzing key Doppler indices:

Resistance Index (RI): A dimensionless ratio indicating vascular resistance, calculated as (Systolic Velocity – Diastolic Velocity) / Systolic Velocity. Low RI values (<0.4) may suggest malignancy due to neovascularization.

Pulsatility Index (PI): Reflects the variability of blood flow velocity during the cardiac cycle, calculated as (Systolic – Diastolic Velocity) / Mean Velocity. Lower PI values are associated with malignant lesions.

Peak Systolic Velocity (PSV): Represents the maximum blood flow velocity during systole, with elevated values often indicating increased vascularity in malignant tumors. [4,5]

Studies have shown that malignant tumors tend to have irregular borders, larger solid components, and increased blood flow, which can be identified using Doppler sonography. [6,7] However, standardized Doppler cut-offs for classifying adnexal masses are still lacking, and many previous studies have used unvalidated criteria . [6]

Additionally, while some studies report uterine artery RI values ranging from 0.37–1.16 and PI values from 0.41–0.82, their correlation with adnexal pathology has not been systematically explored. [8] Similarly, PSV values are variably reported, and their diagnostic thresholds remain poorly defined in clinical settings. [9,10] This study aims to assess the diagnostic value of uterine artery Doppler parameters—RI, PI, and PSV—in differentiating benign from malignant adnexal masses. These indices may serve as non-invasive biomarkers, enhancing early detection and guiding appropriate clinicalmanagement. Previous studies have not fully evaluated the combined diagnostic accuracy of uterine artery RI, PI, and PSV in suspected adnexal masses, especially in local clinical settings. There is a need for a standardized, evidence-based approach using these Doppler indices in routine practice.

2. Materials & Methods

A Descriptive study was conducted in Sammar Diagnostic Lab, Baghbanpura, Lahore to obtain for uterine artery doppler findings in patients with suspicion of different adnexal masses.

Participant Selection

Females were included if they were between 18 and 65 years of age and presented with clinically suspected adnexal masses. Patients were eligible if they exhibited relevant gynecological symptoms, such as pelvic pain, infertility, or irregular menstrual cycles. Exclusion criteria included ongoing treatment for adnexal pathology, presence of non-adnexal pelvic abnormalities, history of previous pelvic or abdominal surgery, and any systemic illness that could confound Doppler evaluation.

Sample Size

The estimated sample size for the study was calculated using the Fisher formula to ensure adequate statistical power. A confidence level (Z) of 1.96 was used, corresponding to a 95% confidence interval. Since no prior prevalence data was available, the proportion (p) was set at 0.5 to maximize sample size. A margin of error (d) of 0.05 was selected to ensure precision.

Using the formula

$n = Z^2 \times p \times (1 - p) / d^2$

$n = (1.96)^2 \times 0.5 \times (1 - 0.5) / (0.05)^2$

$n = 3.8416 \times 0.25 / 0.0025 = 384.16$

Thus, the calculated sample size was 385 participants, which was deemed sufficient to achieve statistical reliability for the objectives of the study.

Ethical Considerations

Ethical approval was obtained from the institutional review board, and written informed consent was obtained from all participants. To maintain confidentiality, participant data was anonymized and stored securely in password-protected digital files.

Data Collection Procedure:

- Eligible patients were recruited based on the study's inclusion and exclusion criteria.
- Prior to enrollment, written informed consent was obtained from each participant. Patient confidentiality was strictly maintained in accordance with ethical research standards throughout the study period.
- Demographic and clinical data were collected by using a well structured questionnaire/performa, including Age, Menopausal status and relevant medical history, such as infertility, pelvic pain, or menstrual irregularities
- Following data collection, all participants underwent a pelvic ultrasound examination, which included grayscale imaging and Doppler assessment.

Scanning Technique

All participants underwent a transabdominal ultrasound with a full bladder to enhance pelvic visualization. Using a 3.5–5 MHz convex transducer, adnexal masses were assessed for size, morphology, and echogenicity. Uterine artery Doppler evaluation was performed bilaterally at the level of the internal cervical os, where color and spectral Doppler were used to obtain flow signals. Doppler indices—including Resistance Index (RI), Pulsatility Index (PI), Peak Systolic Velocity (PSV), and End Diastolic Velocity (EDV)—were measured over three cardiac cycles, and the average values were documented. Images and Doppler waveforms were saved for analysis, with emphasis on detecting abnormal vascular patterns suggestive of malignancy.

Data analysis:

Data were analyzed using IBM SPSS Statistics version 25. Descriptive statistics summarized demographics and Doppler findings, with means and standard deviations for continuous variables and frequencies for categorical ones. Pearson correlation assessed relationships between Doppler parameters and adnexal masses, while group differences were analyzed using t-tests and one-way ANOVA. A p-value < 0.05 was considered statistically significant.

The study was executed to check kidneys in hypertensive patients co-morbid with diabetes mellitus presenting for ultrasonography. The Study

design used is Descriptive cross sectional. Study was conducted in Sonex diagnostic centre, Rawalpindi. Duration of study is 08 months i.e., July 2024 to February 2024. 75 patients were included. All patients meeting the inclusion criteria were included in the study after taking a written consent during data collection. Detailed history was taken regarding the presenting complaints. Ultrasound was performed with 3.5-5MHz curvilinear transducer and findings as well as the impression were noted down. Appropriate analysis skills using IBM SPSS 25 method was applied. After the data analysis the frequency is computed using bar and pie charts and graphs.

3. Results

A total of 385 women with suspected adnexal masses were evaluated using transabdominal Doppler ultrasound. The mean age of participants was 41.4 ± 13.4 years, with an age range of 18 to 64 years.

Types of Adnexal Masses and Clinical Parameters

Table 1 summarizes the distribution of adnexal mass types, endometrial thickness, and uterine orientation. Mixed-type masses were the most common (24.2%), followed by malignant (20.5%), solid (19.7%), and benign (19.7%) lesions. Cystic masses were least frequent (15.8%). Endometrial thickness was nearly evenly distributed, with 50.1% of participants having values >7–11 mm. Retroverted uterus was the most frequent uterine position (26.8%).

Table 1: Frequency Distribution of Adnexal Mass Types, Endometrial Thickness, and Uterine Orientation

Parameter	Category	Frequency	Percentage (%)
Adnexal Mass	Benign	76	19.74
	Malignant	79	20.52
	Cystic	61	15.84
	Solid	76	19.74
	Mixed	93	24.16
Endometrial Thickness	<7-11mm	192	49.87
	>7-11mm	193	50.13
Uterus Appearance	Retroverted	103	26.75
	Anteflexed	96	24.94
	Retroflexed	94	24.42
	Anteverted	92	23.90

Doppler Parameter Distribution

Table 2 presents the distribution of Doppler indices. RI and PI values showed near-equal distribution across their respective categories. Approximately 53.5% had lower Right Uterine Artery RI values (<1.16) and 50.1% had PSV >60 cm/s. This distribution reflects vascular variability across the sample.

Table 2: Frequency Distribution of Uterine Artery Doppler Parameters

Parameter	Category	Frequency	Percentage (%)
Right Uterine Artery RI Value	<0.37-1.16	206	53.51
	>0.37-1.16	179	46.49
Left Uterine Artery RI Value	>0.41-0.82	200	51.95
	<0.41-0.82	185	48.05
Right Uterine Artery PI Value	<0.53-1.58	193	50.13
	>0.53-1.58	192	49.87
Left Uterine Artery PI Value	>0.58-1.83	206	53.51
	<0.58-1.83	179	46.49
PSV	<60cm/s	192	49.87
	>60cm/s	193	50.13

Correlation Between Doppler Indices and Adnexal Masses

Pearson correlation revealed significant associations between Doppler parameters and adnexal mass types (Table III). Right Uterine Artery RI (r = -0.503) and PI (r = -0.476) had moderate negative correlations with malignancy. PSV showed a moderate positive correlation (r = 0.371), suggesting increased vascularity in malignant lesions.

Table 3: Correlation Matrix Between Uterine Artery Doppler Parameters and Adnexal Masses

Variables	Adnexal Mass	Right Uterine Artery RI	Left Uterine Artery RI	Right Uterine Artery PI	Left Uterine Artery PI	PSV
Adnexal Mass	1					
Right Uterine Artery RI	-0.503	1				
Left Uterine Artery RI	-0.423	-0.398	1			
Right Uterine Artery PI	-0.476	0.452	0.472	1		
Left Uterine Artery PI	0.342	0.316	-0.285	-0.254	1	
PSV	0.371	0.290	0.360	0.290	-0.210	1

T-Test Analysis

A one-sample t-test was performed to evaluate whether the mean values of Doppler parameters and adnexal mass scores significantly differ from a hypothetical test value of zero. This statistical approach helps determine the relevance of these parameters in the context of adnexal mass evaluation by identifying whether their observed means are statistically

Table 4: One-Sample T-Test Results

One-Sample Test						
	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Right Uterine Artery RI Value	57.555	384	.000	1.46494	1.4149	1.5150
Left Uterine Artery RI Value	59.596	384	.000	1.51948	1.4694	1.5696
Right Uterine Artery PI Value	58.737	384	.000	1.49870	1.4485	1.5489
Left Uterine Artery PI Value	60.187	384	.000	1.53247	1.4824	1.5825
Adnexal Mass	41.150	384	.000	3.08052	2.9333	3.2277

Table 4 presents the results of the one-sample t-test conducted to determine whether the observed mean values of Doppler parameters and adnexal mass scores significantly differ from a hypothetical baseline value (zero). The results reveal that all variables under study are statistically significant, as indicated by very high t-values and p-values less than 0.001, confirming the non-random nature of the observed measurements.

- The Right Uterine Artery RI demonstrated a t-statistic of 57.555, with a mean difference of 1.46494 and a 95% confidence interval (CI) ranging from 1.4149 to 1.5150.
- The Left Uterine Artery RI had a slightly higher mean difference (1.51948) and an even stronger t-value of 59.596.
- The Pulsatility Index (PI) values for both arteries followed similar patterns, with high t-values of 58.737 (right) and 60.187

(left), and narrow CIs, indicating reliable and consistent measurements.

- The adnexal mass score had a mean of 3.08052 and a t-value of 41.150, with a relatively wider confidence interval (2.9333–3.2277), reflecting the heterogeneous nature of the adnexal lesions in the study population.

These highly significant results suggest that uterine artery Doppler indices (RI, PI, and PSV) are robust and meaningful variables in the context of adnexal mass evaluation. The strong statistical significance and tight confidence intervals further support their diagnostic utility. Collectively, these findings reinforce the hypothesis that Doppler parameters can serve as valuable, non-invasive indicators for differentiating between types of adnexal masses based on their vascular characteristics.

4. Discussion

The findings of this study provide strong evidence for the diagnostic utility of Doppler indices in the evaluation of adnexal mass. Resistance index (RI), pulsatility index (PI), and peak systolic velocity (PSV) showed statistically significant relations with adnexal masses consistent with previously known features of vascularity in benign and malignant disease. Also, the moderate negative correlations between RI values and adnexal masses confirm the results of previous studies that showed that abnormally increased vascularity leads to malignancy owing to abnormal angiogenesis which is a hallmark of malignancy. [(12)] Right Uterine Artery RI- r= -0.503, indicating that lower RI values are consistent with malignancy corroborate. [(13)]

The negative correlation of the Left Uterine Artery RI value was (-0.423) with adnexal masses. This conclusion is consistent with the findings of Zanetta et al. (1994) stated that RI values of malignant tissues are generally lower than normal tissues owing to immature, chaotic, and dysplastic vascular architecture. Such behavior mimics the physiological adaptations in malignancies, where the vascular resistance decreases to fulfill the increased demand for blood flow and poorly formed vessels. [(14)]

Pulsatility Index (PI) values mirrored this pattern, with the Right Uterine Artery PI also showing the same moderate negative correlation (-0.476) with adnexal masses. This observation corroborates previous studies highlighting the diagnostic significance of lower pulsatility within malignant tissues where the disorganized vascular architecture within malignancies causes an alteration of normal pulsatility patterns. [(15)]

The weak positive correlation (0.342) between the Left Uterine Artery PI is in contrast to the above anatomical variability or side differences in uterine blood flow, as a possibility documented by. [(16)] We conclude that the presence and quality of the Doppler signal from one and/or the other uterine artery can provide important diagnostic information for the diagnosis of adnexal masses.

The moderate positive correlation between PSV and adnexal masses (0.371) is in accordance with the results by [(17)] and increased systolic velocities in malignant lesions due to increased vascular activity. Particularly, malignant tissues impose increased metabolic demands, and hypervascularization is often observed in tumors leading to higher PSV. [(18)] The correlation strengthens PSV as an adjunct parameter to the standard diagnosis, especially for discriminating between benign and malignant adnexal masses.

The one-sample t-test results for Doppler indices truly reinforced their statistical significance in distinguishing between the two groups of adnexal masses. The t-values were high with narrow confidence intervals for all parameters, indicating

that these were different from baseline values. The mean difference (mean ±sd) for the RI value of the Right Uterine Artery was 1.4649 showing high precision and reproducibility for this parameter. [23] Other parameters also showed similar trends and confirmed their prognostic value.

In particular, descriptive statistics reflected this study population made the same observations in their study which also confirms that the characteristics of adnexal masses and their vascularity are heterogeneous; the balanced distribution of Doppler indices is a testament to this. The frequency distribution showed that heterogeneous masses were the most frequent (24.16%), followed by malignant masses (20.52%) (Table 4.3). The finding of a large proportion of complex and malignant adnexal masses in our clinical population is consistent with previous studies. [18]

When reviewing the literature, multiple studies have established threshold values for Resistance Index (RI) and Pulsatility Index (PI) to differentiate between benign and malignant adnexal masses. The operational definitions used in this study—RI values less than 0.6 and PI values less than 1.0 being indicative of malignancy—are consistent with findings by Kurjak et al. (1992), Alcázar et al. (1995), and Kouam et al. (1997), among others. [19,20,21] These thresholds have been widely accepted as reliable indicators of malignant ovarian pathology. Doppler ultrasonography, when combined with clinical examination and gray-scale imaging, significantly enhances diagnostic accuracy in evaluating adnexal masses. [22]

The findings of the present study reinforce the validity of Doppler parameters (RI, PI, and PSV) as non-invasive, cost-effective, and widely available diagnostic tools. They contribute further evidence supporting their inclusion in standard gynecologic imaging protocols. This study builds upon previous work by validating the utility of these vascular parameters and encourages their incorporation into future multi-parametric diagnostic models for adnexal lesions.

These data should be further investigated in future research that integrates Doppler indices with advanced imaging modalities such as MRI or 3D ultrasonography. Additionally, larger multi-center studies would help validate these results and refine diagnostic criteria for better stratification of adnexal masses. [24]

Conclusion:

This study confirms the diagnostic value of Doppler ultrasound parameters-Resistance Index (RI), Pulsatility Index (PI), and Peak Systolic Velocity (PSV)—in differentiating benign from malignant adnexal masses. Lower RI and PI, along with higher PSV, were significantly associated with malignancy, reflecting underlying tumor vascularity. These findings support the integration of Doppler indices into routine sonographic evaluation to enhance the accuracy of adnexal mass diagnosis.

Limitations:

- The relatively small sample (385 patients) may limit the generalizability of the results to the broader population.
- Thus study is conducted at a single center, the study's external validity is limited. Multi-center studies could provide more diverse and representative data.
- The study did not compare Doppler findings with advanced imaging techniques such as MRI or 3D ultrasound, which could have strengthened diagnostic validation.

Recommendations

- Conduct multi-center studies with larger, more diverse populations to enhance generalizability.
- Integrate Doppler parameters into standardized multi-parametric diagnostic protocols.
- Compare Doppler findings with other imaging modalities (e.g., MRI, 3D ultrasonography) to further refine the diagnostic algorithm for adnexal masses.

Disclosure /Conflict of interest:

Authors declare no conflict of interest.

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