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CORRELATION OF OVARIAN AND UTERINE BLOOD FLOW PARAMETERS ON TRANSVAGINAL ULTRASOUND IN POLYCYSTIC OVARY SYNDROME (PCOS)

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Abstract

Background: *Polycystic ovarian syndrome is a common endocrine condition affecting women of reproductive age and is frequently associated with menstrual irregularities, obesity, infertility, and metabolic conditions. Doppler ultrasonography is a valuable non-invasive technique for assessing uterine and ovarian blood-flow changes in patients with PCOS.*

Objective: *To evaluate the correlation of uterine and ovarian blood-flow parameters on transvaginal Doppler ultrasonography in women diagnosed with PCOS.*

Methods: *This retrospective cross-sectional study included 163 women diagnosed with PCOS. Transvaginal Doppler ultrasound reports were reviewed for the resistive index (RI) and pulsatility index (PI) of the right and left uterine and ovarian arteries. Demographic information and menstrual pattern were obtained from medical records. Data were analyzed in SPSS version 20, and Pearson correlation was used to assess the relationship between uterine and ovarian Doppler indices.*

Results: *The mean age was 32.43 +/- 5.75 years and the mean weight was 78.36 +/- 10.25 kg. Menstrual cycles were irregular in 153 participants (93.9%). Mean right and left uterine artery RI were 0.8247 +/- 0.1337 and 0.8234 +/- 0.1234, while mean right and left uterine artery PI were 3.0226 +/- 1.1738 and 3.0697 +/- 1.1504. Mean right and left ovarian artery RI were 0.3972 +/- 0.2765 and 0.3815 +/- 0.1585, and mean right and left ovarian artery PI were 0.5329 +/- 0.3285 and 0.5393 +/- 0.3530. Significant negative correlations were found for right RI (r=-0.409), right PI (r=-0.735), left RI (r=-0.605), and left PI (r=-0.766); all $p<0.001$.*

Conclusion: *Uterine and ovarian Doppler indices were significantly and inversely correlated in women with PCOS. Transvaginal Doppler ultrasonography is a safe, non-invasive tool for evaluating uterine and ovarian blood-flow changes associated with PCOS.*

INTRODUCTION

Polycystic ovary syndrome (PCOS) is a common endocrine and metabolic disorder affecting women of reproductive age. It is characterized by hyperandrogenism, abnormal ovulation, menstrual irregularity, and polycystic ovarian morphology. PCOS is now considered a chronic condition with reproductive, cardiovascular, metabolic, and psychological implications rather than only a gynecologic disorder [1,2]. Risk factors reported in association with PCOS include obesity, a family history of diabetes or infertility, depression, and physical inactivity [3]. Obesity can aggravate clinical manifestations and insulin resistance. Women with PCOS may also experience anxiety, depression, reduced quality of life, anovulatory infertility, metabolic dysfunction, cardiovascular risk, and pregnancy-related complications [4,7].The clinical presentation of PCOS is broad and may include difficulty losing weight, irregular menstrual cycles, infertility, hirsutism, insulin resistance, depression, acne, ovarian cysts, and type 2 diabetes. Polycystic ovarian morphology is characterized by ovarian enlargement, increased ovarian volume, and an excess of small follicles. The manifestations of PCOS may also vary across the reproductive years because ovarian function and metabolic regulation can change over time [5,7].Reported prevalence varies according to the population and diagnostic criteria, with estimates ranging from 5-10% to 15-20%, while another report described a prevalence of approximately 22% [7,8]. Diagnostic assessment includes ovulatory dysfunction, hyperandrogenism, and polycystic ovarian morphology after excluding other causes. Pelvic ultrasonography is important for demonstrating ovarian morphology, including increased ovarian volume and an excess of small follicles [5].Transvaginal ultrasound provides high-resolution images of the female pelvic organs and is widely used because it is safe, minimally invasive, and does not use ionizing radiation. Endovaginal probes improve visualization of the ovaries, and color and pulsed Doppler permit localization of vessels and assessment of blood-flow waveforms. Transvaginal Doppler ultrasound has therefore improved assessment of blood flow in the uterus, ovaries, and follicles [6,9].Ultrasound assessment of reproductive blood flow may include grayscale imaging, color Doppler, and spectral Doppler waveforms. These techniques provide information about the location of vessels and the velocity and resistance of blood flow. Studies discussed in the literature reported that blood-flow patterns are related to ovarian morphology and function, with PCOS patients showing increased intraovarian stromal vascularity and altered pelvic hemodynamics [9,11-13]. Ovarian vascularity can be evaluated by measuring Doppler indices in ovarian or stromal arteries. In one technique summarized in the literature, RI and PI were measured using two-dimensional Doppler, three consecutive waveforms were obtained from both ovaries, and mean values were calculated [10]. Previous studies reported increased intraovarian stromal vascularity and altered ovarian vascular resistance in women with PCOS [11-13].The resistive index and pulsatility index describe resistance to blood flow. Previous studies suggest that PCOS may be associated with reduced ovarian arterial resistance and increased ovarian stromal vascularity, while uterine arterial resistance may be increased. These changes may be related to ovarian function, endometrial perfusion, menstrual irregularity, and infertility [6,11-13].Assessment of vascular parameters adds a functional component to the structural evaluation of polycystic ovaries. In infertility-related cases, reduced uterine perfusion may affect endometrial receptivity and implantation, whereas increased ovarian stromal blood flow may reflect altered ovarian function. Evaluating these patterns together may therefore help clinicians understand the reproductive and hemodynamic features associated with PCOS [6,9].Evaluating uterine and ovarian blood flow together may help describe the hemodynamic changes associated with PCOS. Transvaginal Doppler ultrasound is readily available, non-invasive, and capable of assessing both structural and vascular features. The aim of this study was to evaluate uterine and ovarian artery RI and PI and determine their correlation in patients with PCOS using transvaginal ultrasonography.

MATERIALS AND METHODS

Study design and setting,

This was a retrospective cross-sectional study conducted in the Department of Radiology, Northwest General Hospital and Research Center, Peshawar.

Sample size and sampling

The sample size was 163, calculated from a population size of 285 using a 95% confidence interval and 5% error. Convenience sampling was used.

Eligibility criteria

Women aged 18-45 years who were non-pregnant, underwent transvaginal ultrasound examination, and had not taken hormonal therapy or ovulation-inducing drugs for at least three months were included. Pregnant or lactating women, women with diabetes mellitus, and women with a history of pelvic surgery were excluded.

Data collection

After approval from the Institutional Review Board and Ethical Committee of Northwest General Hospital and Research Center, permission was obtained from the Head of the Radiology Department. Medical records of eligible women diagnosed with PCOS were reviewed. Transvaginal Doppler ultrasound reports were used to record RI and PI of the right and left uterine arteries and the right and left ovarian arteries. Age, weight, menstrual pattern, and confirmation of PCOS were recorded in a structured proforma. Personal identifiers were kept anonymous, and the data were used only for research purposes.

Data analysis

Data were analyzed using SPSS version 20. Categorical variables were presented as frequencies and percentages. Mean, median, mode, standard deviation, minimum, and maximum were used to summarize continuous variables. Pearson correlation was used to determine the association between corresponding uterine and ovarian Doppler indices, and p values were reported.

RESULTS

Participant characteristics

The study included 163 women with confirmed PCOS. The mean age was 32.43 +/- 5.75 years, with a median of 32 years and a range of 19-45 years. Mean body weight was 78.36 +/- 10.25 kg, with a median of 80 kg and a range of 45-100 kg. Menstrual cycles were irregular in 153 women (93.9%) and regular in 10 women (6.1%) (Table 1).

Table 1. Participant characteristics (n=163)

Characteristic	Mean +/- SD or n (%)	Median	Mode	Range
Age, years	32.43 +/- 5.75	32.00	35	19-45
Weight, kg	78.36 +/- 10.25	80.00	80	45-100
Irregular menstrual cycle	153 (93.9)	-	-	-
Regular menstrual cycle	10 (6.1)	-	-	-
Confirmed PCOS	163 (100.0)	-	-	-

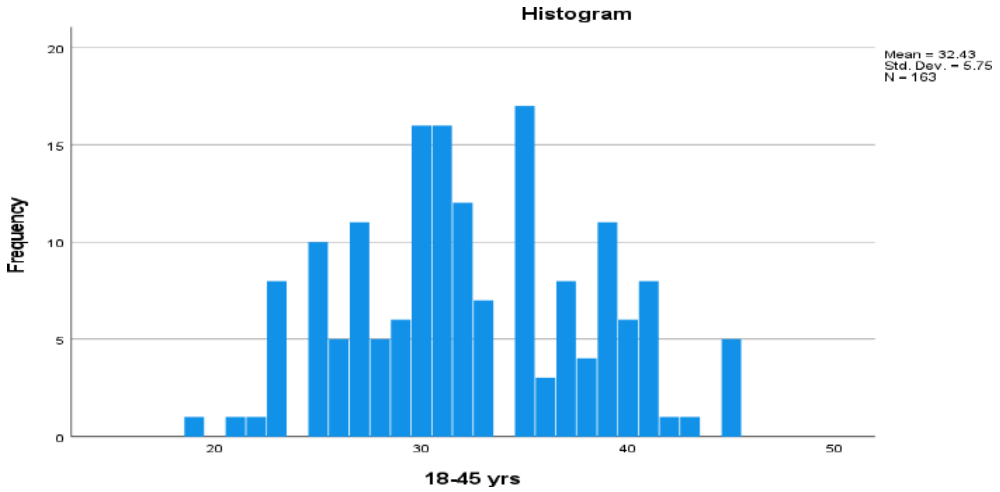


Figure 1. Histogram showing the age distribution of participants.

Uterine and ovarian Doppler indices

The mean right uterine artery RI and PI were 0.8247 +/- 0.1337 and 3.0226 +/- 1.1738, respectively. The mean left uterine artery RI and PI were 0.8234 +/- 0.1234 and 3.0697 +/- 1.1504. Mean right ovarian artery RI and PI were 0.3972 +/- 0.2765 and 0.5329 +/- 0.3285, while mean left ovarian artery RI and PI were 0.3815 +/- 0.1585 and 0.5393 +/- 0.3530 (Table 2). Uterine artery indices were higher than the corresponding ovarian artery indices.

Table 2. Bilateral uterine and ovarian arterial Doppler indices

Vessel and index	Mean	SD	Median
Right uterine artery RI	0.8247	0.1337	0.8500
Right uterine artery PI	3.0226	1.1738	3.2000
Left uterine artery RI	0.8234	0.1234	0.8500
Left uterine artery PI	3.0697	1.1504	3.3000
Right ovarian artery RI	0.3972	0.2765	0.3200
Right ovarian artery PI	0.5329	0.3285	0.4100
Left ovarian artery RI	0.3815	0.1585	0.3300
Left ovarian artery PI	0.5393	0.3530	0.4300

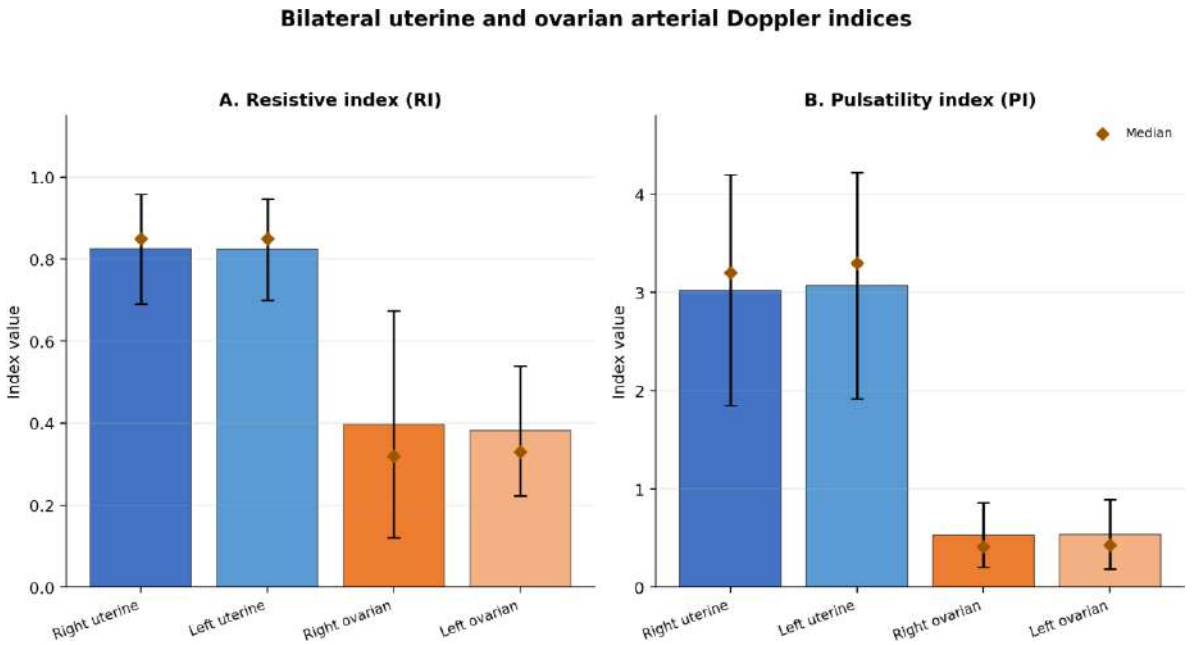


Figure 2. Bilateral uterine and ovarian arterial Doppler indices.

Bars show mean values, error bars show standard deviations, and diamonds show medians. Uterine artery RI and PI were higher than the corresponding ovarian artery values, while right- and left-sided values were similar.

Correlation of uterine and ovarian indices

All four corresponding uterine-ovarian correlations were negative and statistically significant. Right uterine RI and right ovarian RI showed a moderate negative correlation ($r=-0.409$, $p<0.001$). Right uterine PI and right ovarian PI showed a strong negative correlation ($r=-0.735$, $p<0.001$). Left uterine RI and left ovarian RI were strongly negatively correlated ($r=-0.605$, $p<0.001$), while left uterine PI and left ovarian PI showed the highest negative correlation ($r=-0.766$, $p<0.001$) (Table 3).

Table 3. Within-side correlations between uterine and ovarian Doppler indices

Comparison	r	p value	Interpretation
Right uterine RI vs right ovarian RI	-0.409	<0.001	Moderate negative
Right uterine PI vs right ovarian PI	-0.735	<0.001	Strong negative
Left uterine RI vs left ovarian RI	-0.605	<0.001	Strong negative
Left uterine PI vs left ovarian PI	-0.766	<0.001	Very high negative

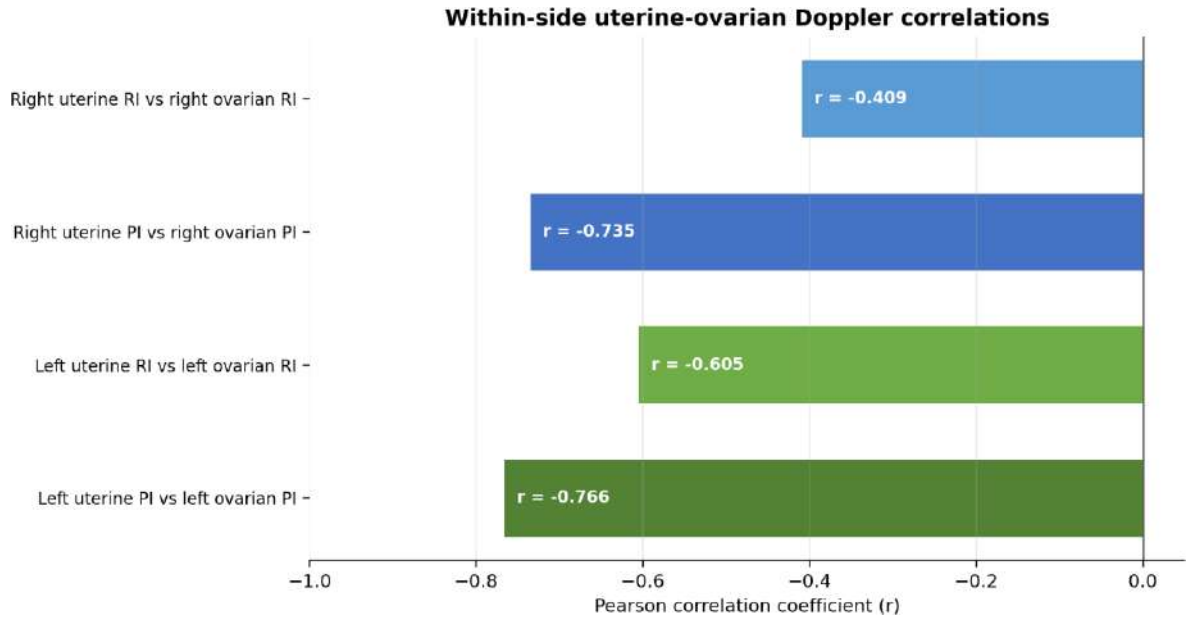


Figure 3. Within-side correlations between uterine and ovarian Doppler indices.

Bars display the Pearson correlation coefficients. All four correlations were negative and statistically significant ($p<0.001$). The highest negative correlation was between left uterine PI and left ovarian PI ($r=-0.766$).

DISCUSSION

This study evaluated uterine and ovarian artery Doppler indices in 163 women with PCOS. The findings demonstrated higher uterine arterial resistance indices, lower ovarian arterial resistance indices, and statistically significant negative correlations between the corresponding uterine and ovarian measurements. The mean age was 32.43 +/- 5.75 years, and most participants were within the reproductive-age range. This agrees with Khan et al., who reported PCOS among women in reproductive age groups [14]. The mean body weight was 78.36 +/- 10.25 kg. Increased body weight has been related to insulin resistance, hormonal imbalance, and metabolic dysfunction in PCOS [3].Most participants were aged 31-36 years, while body weight was commonly within the 76-90 kg range. This concentration of cases within the reproductive-age period is consistent with the usual age distribution of PCOS. The weight pattern also supports the relationship described in previous studies between increased body mass, insulin resistance, hormonal imbalance, and the clinical expression of PCOS [3,14].Menstrual irregularity was present in 153 participants (93.9%), while 10 participants (6.1%) had regular cycles. Menstrual dysfunction is an important clinical feature of PCOS related to anovulation and hormonal imbalance [13].Uterine artery Doppler evaluation showed mean RI and PI values of 0.8247 +/- 0.1337 and 3.0226 +/- 1.1738 on the right, and 0.8234 +/- 0.1234 and 3.0697 +/- 1.1504 on the left. Previous studies have also reported increased uterine arterial resistance in women with PCOS [15-17].The close similarity of the right- and left-sided uterine values indicates that increased uterine vascular resistance was present bilaterally in this sample. Previous studies relate this pattern to endocrine and vascular changes associated with PCOS, including endothelial dysfunction and altered pelvic vasculature. Increased uterine resistance may also have implications for endometrial receptivity and fertility outcomes [15-17].Ovarian artery Doppler indices were lower than uterine artery indices. Mean right ovarian RI and PI were 0.3972 +/- 0.2765 and 0.5329 +/- 0.3285, while

mean left ovarian RI and PI were 0.3815 +/- 0.1585 and 0.5393 +/- 0.3530. Lower ovarian vascular resistance has been related to increased stromal vascularity, and three-dimensional power Doppler and microvascular imaging studies have described increased ovarian stromal vascularity in PCOS [18-20].The bilateral reduction in ovarian resistance is consistent with increased stromal ovarian blood flow. Song et al. described increased ovarian stromal blood flow using three-dimensional Doppler ultrasonography, while Senyuva et al. demonstrated increased stromal vascularity using superb microvascular imaging. These observations support the interpretation that lower ovarian RI and PI values reflect enhanced ovarian vascularity in PCOS [18,19].Correlation analysis demonstrated inverse relationships on both sides. The RI correlation was moderate on the right and strong on the left, while PI correlations were strong on both sides. The left uterine PI-left ovarian PI correlation was the highest in magnitude. These results indicate that higher uterine vascular resistance was associated with lower ovarian vascular resistance in this PCOS sample.The inverse pattern was observed for all four paired measurements, with coefficients ranging from -0.409 to -0.766 and $p<0.001$ for every comparison. The stronger PI correlations, particularly on the left side, demonstrate a consistent relationship between increased uterine pulsatility and decreased ovarian pulsatility. These findings describe coordinated but opposite changes in uterine and ovarian vascular resistance within the study population.Younesi et al. described higher uterine arterial resistance together with lower ovarian stromal capillary resistance in patients with PCOS, suggesting altered uterine perfusion and enhanced ovarian stromal vascularity. Dwivedi et al. similarly reported increased uterine resistance and increased ovarian stromal blood flow with reduced ovarian vascular resistance. These previous observations are consistent with the utero-ovarian Doppler pattern identified in the present study [21,22].Taken together, the demographic findings, menstrual pattern, bilateral Doppler measurements, and inverse correlations support the presence of altered pelvic hemodynamics in women with PCOS. These vascular changes may be linked with endocrine dysfunction, irregular menstruation, anovulation, infertility, and other reproductive concerns described in previous studies. Transvaginal Doppler ultrasonography therefore provides a safe, non-invasive method for examining both uterine and ovarian blood-flow changes and for improving understanding of the pathophysiology of PCOS [6,21,22].

LIMITATIONS

The study used two-dimensional Doppler imaging rather than three-dimensional Doppler imaging, which may have reduced the precision and depth of vascular assessment. It was conducted at a single center, which may limit external validity. The relatively small sample size may also affect the strength and generalizability of the findings.

RECOMMENDATIONS

Further studies should assess the relationship between Doppler indices, including RI, PI, and peak systolic velocity, and hormonal and metabolic variables. Doppler acquisition should be standardized with respect to examination timing and vascular assessment. Multicenter studies are recommended to validate the results among different populations and PCOS types. Doppler ultrasound may also be evaluated for risk stratification and for monitoring interventions related to ovulation and fertility.

CONCLUSION

Women with PCOS demonstrated differences between uterine and ovarian artery Doppler indices. Uterine artery RI and PI were higher than ovarian artery RI and PI, and significant negative correlations were present between the corresponding right- and left-sided indices. Higher uterine vascular resistance was associated with lower ovarian vascular resistance and vice versa. Transvaginal Doppler ultrasonography is a safe, non-invasive technique that can assist in evaluating uterine and ovarian blood-flow changes associated with PCOS.

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