INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

COMPARISON OF OVARIAN STROMAL BLOOD FLOW BETWEEN FERTILE WOMEN WITH NORMAL OVARIES AND INFERTILE WOMEN WITHPOLYCYSTIC OVARIAN SYNDROME: A CROSS-SECTIONAL ANALYTICAL STUDY

Original Research

Maooz Ahmad[1]*, Aamir Ali Khan[2], Safura[3], Sohail Ahmad Khan[4], Muhammad Arshad[5], Laiba Gul[6], Anmol Arif[7].
[1]Senior Lecturer, Allied Health Sciences Radiology, The University of Haripur, Pakistan.
[2]Director/Assistant Professor, Institute of Health Sciences, Khyber Medical University, Peshawar, Pakistan.
[3]Lecturer, Kalam Bibi International Women Institute, Bannu, Pakistan.
[4]Program Coordinator/HoD Radiology, Northwest Institute of Health Science, Peshawar, Pakistan.
[5]Assistant Professor, Allied Health Sciences Radiology Program, The University of Haripur, Pakistan.
[6]Ministry of National Guard Health Affairs, Kingdom of Saudi Arabia.
[7]Lecturer, Allied Health Science Department, Rashid Latif Khan University, Lahore, Pakistan.
Corresponding Author: Maooz Ahmad, Senior Lecturer, Allied Health Sciences Radiology, The University of Haripur, Pakistan, maooz.ahmad@uoh.edu.pk
Acknowledgement: We sincerely acknowledge the participants and the Radiology Department of Northwest General Hospital & Research Center for their support and cooperation in this study.

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Polycystic ovary syndrome (PCOS) is the commonest endocrine disorder in women of reproductive age as this syn- drome may affect 5–10% of premenopausal women (Franks, 1995). Women with this syndrome may present with one, all or any combination of menstrual irregularities, chronic anovulation, infertility, obesity and hyperandrogenism.

Objective: To compare the Doppler indices of ovarian stromal blood flow between fertile women ovaries and infertile women with polycystic ovarian syndrome.

Methodology: A cross sectional analytical study was conducted in 9 months at Radiology Department, Northwest General Hospital & Research Center Hayatabad Peshawar. 60 patients were selected with Convenient sampling technique, fertile married females with age 18-40 and infertile married females with age 18-45 who diagnosed with PCOs included in this study. Patients with any uterine anomaly, any acquired and congenital uterine abnormality, infertility caused by other than PCOS, females taking any medication for fertility were excluded.

Results: The mean of resistive index of right ovarian stromal artery in infertile women was 0.5871 and in fertile it was 0.6069. Their S/D were 0.16880 and 0.14375 respectively. The mean of Pulsatility index of right ovarian stromal artery in infertile was 1.7774 and in fertile it was 2.4483. Their S/D 0.98275 and 1.48435 respectively. The mean of Pulsatility index of left ovarian stromal artery in infertile was 2.3194 and in fertile it was 1.8310. Their S/D 1.84380 and 1.08697 respectively. The mean of peak systolic velocity of left ovarian stromal artery in infertile women was 62.4677 and in fertile it was 65.9207. Their S/D were 13.88571 and 15.41637 respectively. The mean of end diastolic velocity of left ovarian stromal artery in infertile was 15.6032 and in fertile it was 15.0034. Their S/D 2.52514and 3.50443 respectively. The mean of age was 26.6000 and S/D 4.50311. The mean of BMI was 21.1450 and S/D 2.47115.

Conclusion: Fertile females and PCOS women had similar ovarian Doppler flow indices. Normal weight PCOS women had significantly higher ovarian stromal Doppler flow indices than their overweight counterparts.

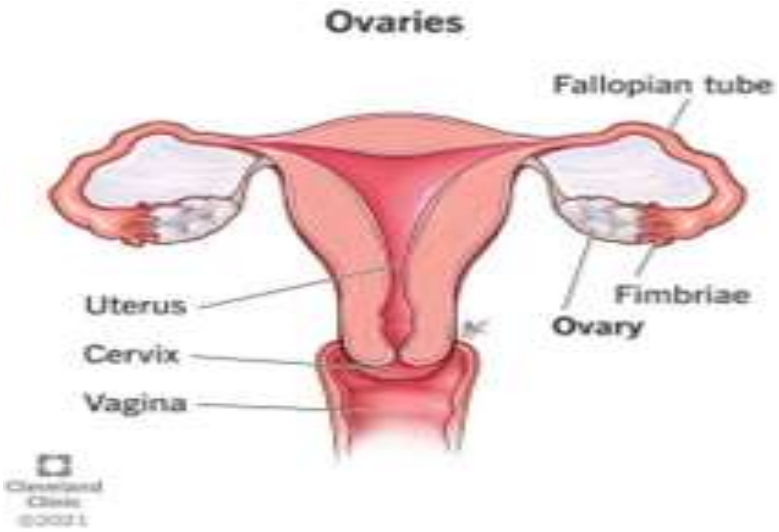
Key words: Polycystic Ovarian Syndrome, Ultrasound, Infertility.

INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH
AND REHABILITATION

INTRODUCTION

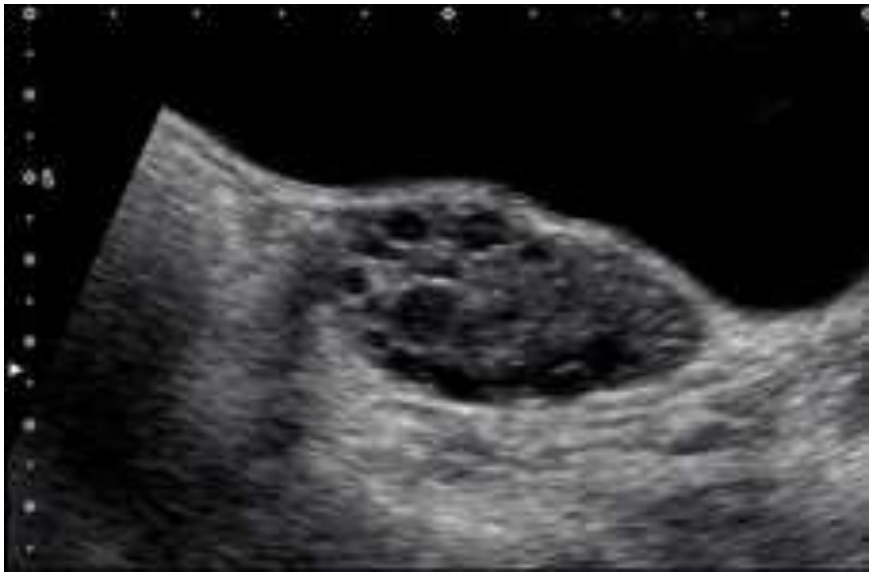
Infertility is clinically defined as the failure to achieve pregnancy after one year of regular, unprotected intercourse and remains a significant global reproductive health concern affecting millions of couples worldwide (1). Beyond its biological implications, infertility carries profound psychological, social, and emotional consequences, often resulting in diminished self-esteem, marital strain, anxiety, and depression among affected individuals and their families (2,3). The etiological spectrum of infertility is multifactorial, with male factors accounting for approximately 20–30% of cases, anovulation contributing to 10–30%, tubal pathology 15%, cervical factors 5%, endometriosis 5–25%, and unexplained causes comprising 15–30% of cases (4). These distributions may vary across geographical regions due to genetic, environmental, and socio-cultural influences (4). Successful conception in a spontaneous cycle depends on a complex interplay of hormonal balance, ovulatory function, tubal patency, endometrial receptivity, and sperm quality—many of which are beyond voluntary control yet directly influence implantation and pregnancy outcomes (5). Among female-related causes, ovarian dysfunction plays a central role. The ovaries, paired reproductive organs situated bilaterally to the uterus within the broad ligament, are responsible for oocyte production and the synthesis of essential sex steroids that regulate menstrual cyclicity and fertility (6). Disruption in ovarian structure or endocrine function can therefore profoundly impair reproductive potential and overall health.



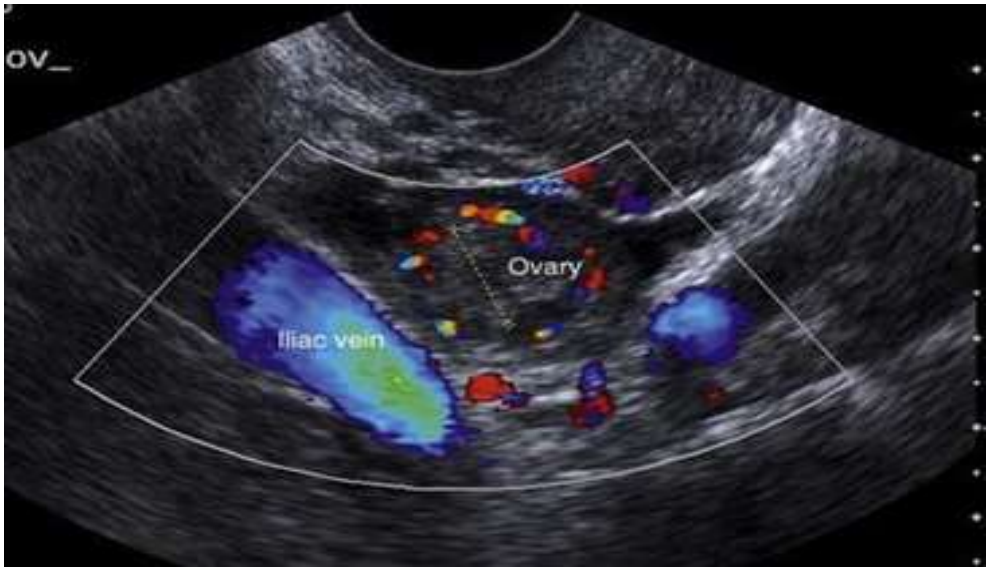
Polycystic ovary syndrome (PCOS) represents one of the most prevalent endocrine disorders affecting women of reproductive age and is a leading contributor to anovulatory infertility (7). It is characterized by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology, although its clinical presentation is heterogeneous (7,8). Prevalence estimates vary depending on diagnostic criteria, ranging from 5.5% to 19.9% under the Rotterdam criteria, and may reach as high as 15.7–37% in certain populations, including Pakistan (9,10). First described by Stein and Leventhal in 1935, PCOS has since undergone multiple refinements in diagnostic definition, with the National Institutes of Health (NIH) criteria emphasizing chronic oligo-anovulation and hyperandrogenism after exclusion of other endocrine disorders such as congenital adrenal hyperplasia, hyperprolactinemia, and androgen-secreting tumors (11,12). Despite decades of research, the precise etiology of PCOS remains incompletely understood; proposed mechanisms include genetic susceptibility, insulin resistance, neuroendocrine dysregulation, and altered sympathetic activity (13,14). Clinically, women with PCOS may present with hirsutism, acne, alopecia, obesity, irregular or absent menses, pelvic discomfort, and infertility, frequently accompanied by psychological distress (15). Although polycystic ovarian morphology is a defining feature, its presence alone is insufficient for diagnosis, as similar sonographic findings may be observed in healthy women (16).

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Beyond reproductive dysfunction, PCOS is increasingly recognized as a systemic metabolic disorder. Insulin resistance and obesity, common in affected women, independently elevate the risks of miscarriage, reduced live birth rates, and obstetric complications (17). Women with PCOS face higher incidences of gestational diabetes mellitus, preeclampsia, preterm delivery, and neonatal intensive care unit admissions, with some studies reporting a threefold increase in adverse pregnancy outcomes (12,18). Long-term health risks include endometrial hyperplasia and carcinoma due to prolonged unopposed estrogen exposure, as well as heightened cardiovascular morbidity linked to dyslipidemia, hypertension, and metabolic syndrome (19,20). Ultrasonography plays a pivotal role in diagnosis, with follicle number per ovary and ovarian volume forming key components of the Rotterdam criteria; however, variability in interpretation and overlap with normal physiology limit its specificity (21,22).



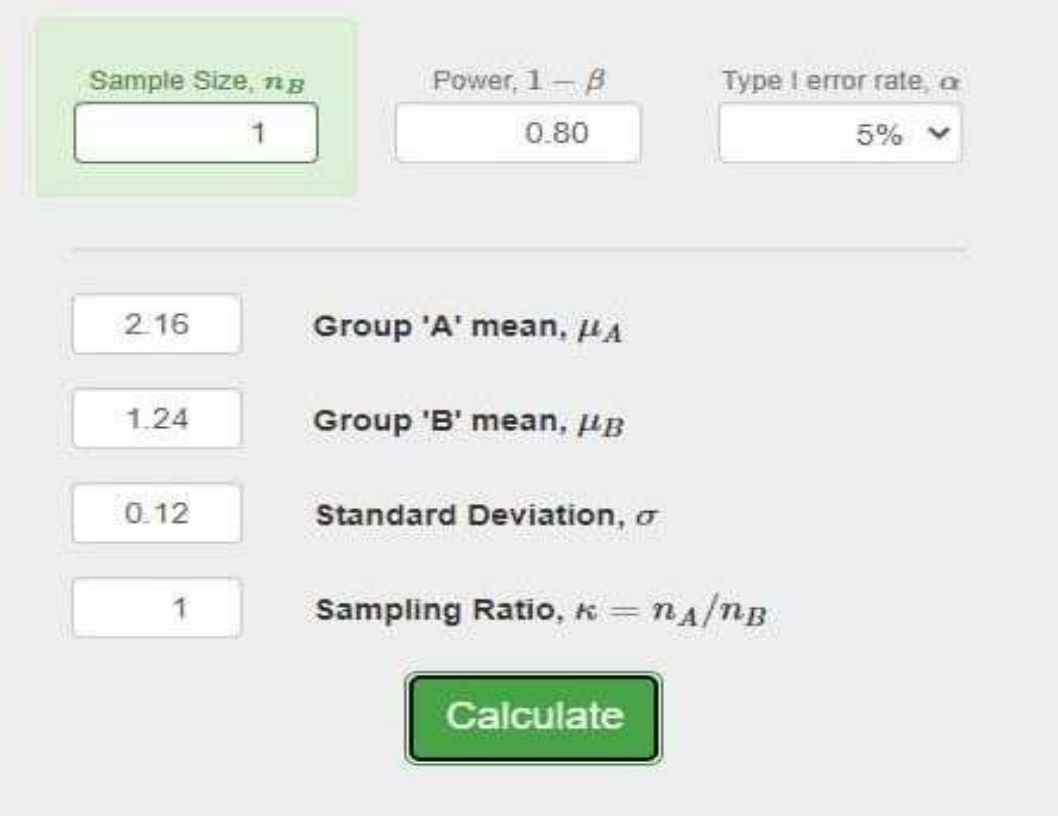
Emerging evidence suggests that alterations in ovarian stromal vascularization and Doppler blood flow patterns may provide additional insight into the pathophysiology of PCOS, although these parameters are not yet incorporated into standard diagnostic guidelines (23). Given the limited regional data and the need to distinguish between true PCOS and isolated polycystic ovarian morphology, further investigation is warranted. Therefore, the objective of the present study is to evaluate the relationship between ovarian stromal blood flow indices and ovarian volume in women with diagnosed PCOS compared to those exhibiting polycystic ovarian morphology alone, in order to enhance diagnostic precision and inform therapeutic decision-making.



INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

METHODS

This cross-sectional analytical study was conducted in the Department of Radiology, Northwest General Hospital & Research Center, Hayatabad, Peshawar, over a period of nine months following approval of the research synopsis by the institutional ethical review committee. The study was designed to evaluate and compare ovarian stromal blood flow parameters and ovarian volume among women diagnosed with polycystic ovary syndrome (PCOS) and women with normal ovaries. Written informed consent was obtained from all participants prior to enrollment, and confidentiality of patient information was strictly maintained in accordance with institutional ethical standards. The sample size was initially calculated using the formula for comparison of two independent means, taking the average pulsatility index (PI) values reported in females with normal ovaries and those with PCOS in a previous study (Manzoor, I., Bacha, R., & Gilani, S. A. 2019). Although the statistical calculation yielded a minimal sample size of one participant per group, this was methodologically insufficient to ensure reliability and external validity. Therefore, in accordance with minimum sample size recommendations for analytical studies, 30 participants were included in each group, resulting in a total sample size of 60 women.



A non-probability convenience sampling technique was employed to recruit participants who met the predefined eligibility criteria during the study period. The study population was divided into two groups. The fertile (control) group included married women aged 18–40 years, of any parity, with no known gynecological disorders and with sonographically normal ovaries. The infertile (PCOS) group comprised married women aged 18–45 years, with a history of primary infertility (no prior parity), and previously diagnosed with polycystic ovaries based on established ultrasound criteria. Women with known uterine anomalies, congenital or acquired uterine abnormalities, infertility attributable to causes other than PCOS (such as tubal factor, male factor, or endometriosis), and those receiving fertility medications or hormonal therapy were excluded to minimize confounding variables. All participants underwent detailed clinical history taking, including menstrual history and obstetric profile, followed by transvaginal ultrasonographic examination.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Ultrasound assessments were performed using a Toshiba Xario 200 ultrasound machine equipped with a transvaginal probe. Scans were conducted during the early follicular phase of the menstrual cycle (days 2–5) to ensure standardization of ovarian morphology and Doppler parameters. Ovarian volume was calculated using the prolate ellipsoid formula (length × width × height × 0.523). Gray-scale ultrasound was used to assess follicle number per ovary and stromal echogenicity, while color Doppler imaging was utilized to evaluate ovarian stromal blood flow indices, including pulsatility index (PI) and resistive index (RI). To reduce intra-observer variability, all scans were performed by a single experienced radiologist under standardized imaging conditions. The collected data were recorded on a structured proforma and subsequently analyzed using appropriate statistical software. Quantitative variables were expressed as mean ± standard deviation, and comparisons between groups were performed using independent sample t-tests, with a p-value of ≤0.05 considered statistically significant.

RESULT

Table 1: Group statistics

	Fertility	N	Mean	Std. Deviation	Std. Error mean
Infertile		31	.5871	.16880	.03032
Ovarian stroma right - ri		29	.6069	.14375	.02669
Fertile		31	1.7774	.98275	.17651
Infertile		29	2.4483	1.48435	.27564
Ovarian stroma right - pi		31	60.3194	15.33431	2.75412
Fertile		29	63.2655	15.63333	2.90304
Infertile		31	15.1581	2.84497	.51097
Ovarian stroma right - psv		29	14.6069	2.79182	.51843
Fertile					
Infertile					
Ovarian stroma right - edv					
Fertile					

Table 1 shows that mean of resistive index of right ovarian stromal artery in infertile women was 0.5871 and in fertile it was 0.6069. Their s/d were 0.16880 and 0.14375 respectively. The mean of pulsatility index of right ovarian stromal artery in infertile was 1.7774 and in fertile it was 2.4483. Their s/d 0.98275 and 1.48435 respectively. The mean of peak systolic velocity of right ovarian stromal artery in infertile women was 60.3194 and in fertile it was 63.2655.

Their s/d were 15.33431and 15.63333 respectively. The mean of end diastolic velocity of right ovarian stromal artery in infertile was 15.1581and in fertile it was 14.6069. Their s/d .
2.84497 and 2.79182 respectively.

Table 2: Independent samples test

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

		Levene's test for equality of Variances		T-test for equality of means						
		F	Sig.	T	Df	Sig. (2-Tailed)	Mean difference	Std. Error difference Ce	95% confidence interval of the difference	
									Lower	Upper
Equal variances		.470	.496	-.488	58	.628	-.01980	.04061	-.10110	.06150
Ovarian stroma	assumed									
Right - ri	equal			-.490	57.51	.626	-.01980	.04040	-.10067	.06107
variances										
Not assumed					1					
Equal variances		12.759	.001	-	58	.042	-.67086	.32300	-1.31742	-.02430
Ovarian stroma	assumed			2.077						
Right - pi	equal			-	48.12	.046	-.67086	.32731	-1.32891	-.01280
variances										
Not assumed				2.050	0					
	Equal variances	.053	.819	-.737	58	.464	-2.94616	3.99898	-	5.05867
Ovarian stroma	Assumed								10.95099	
Right - psv	Equal variances			-.736	57.56	.465	-2.94616	4.00160	-	5.06521
	Not assumed				3				10.95753	
	Equal variances	.001	.979	.757	58	.452	.55117	.72838	-.90684	2.00918

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

		Levene's test for equality of Variances		T-test for equality of means						
		F	Sig.	T	Df	Sig. (2-Tailed)	Mean difference	Std. Error difference Ce	95% confidence interval of the difference	
									Lower	Upper
Ovarian stroma	**Assumed**									
Right - edv	**Equal variances**			**.757**	**57.86**	**.452**	**.55117**	**.72791**	**-.90598**	**2.00832**
	Not assumed				**1**					

Table 3: Group statistics

	Fertility	N	Mean	Std. Deviation	Std. Error mean
Infertile		31	.5548	.08500	.01527
Ovarian stroma left - ri		29	.5483	.17448	.03240
Fertile		31	2.3194	1.84380	.33116
Infertile		29	1.8310	1.08697	.20185
Ovarian stroma left - pi		31	62.4677	13.88571	2.49395
Fertile		29	65.9207	15.41637	2.86275
Infertile		31	15.6032	2.52514	.45353
Ovarian stroma left - psv		29	15.0034	3.50443	.65076
Fertile					
Infertile					
Ovarian stroma left - edv					
Fertile					

Table 3 shows that mean of resistive index of left ovarian stromal artery in infertile women was 0.5548 and in fertile it was 0.5483. Their s/d were 0.08500 and 0.17448 respectively. The mean of pulsatility index of left ovarian stromal artery in infertile was 2.3194 and in fertile it was 1.8310. Their s/d 1.84380 and 1.08697 respectively. The mean of peak systolic velocity of left ovarian stromal artery in infertile women was 62.4677 and in fertile it was 65.9207.Their s/d were 13.88571 and 15.41637 respectively. The mean of end diastolic velocity of left ovarian stromal artery in infertile was 15.6032 and in fertile it was 15.0034. Their s/d 2.52514and 3.50443 respectively.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Table 4: Independent samples test

	Levene's test for equality of Variances		**T-test for equality of means**						
	F	Sig.	T	Df	Sig. (2-Tailed)	Mean difference	Std. Error difference	95% confidence interval of the difference	
								Lower	Upper
Equal variances	11.723	.001	.187	58	.852	.00656	.03508	-.06365	.07677
Ovarian stroma assumed									
Left - ri equal variances			.183	39.9	.856	.00656	.03582	-.06583	.07895
Not assumed				75					
Equal variances	17.605	.000	1.23	58	.220	.48832	.39424	-.30084	1.27748
Ovarian stroma assumed			9						
Left - pi equal variances			1.25	49.1	.214	.48832	.38782	-.29097	1.26761
Not assumed			9	61					
Equal variances Assumed Ovarian stroma	.770	.384	-.913	58	.365	-3.45295	3.78333	-11.0261 1	4.12021
Left - psv Equal variances Not assumed			-.909	56.3 40	.367	-3.45295	3.79672	-11.0576 8	4.15179
Equal variances	7.672	.008	.764	58	.448	.59978	.78474	-.97104	2.17060
Ovarian stroma assumed									
Left - edv equal variances			.756	50.6	.453	.59978	.79320	-.99291	2.19247
Not assumed				**52**					

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Table 5: Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age	**60**	**18.00**	**38.00**	**26.6000**	**4.50311**

The mean of age was 26.6000 and s/d 4.50311.

Table 6: Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Bmi	**60**	**18.00**	**28.00**	**21.1450**	**2.47115**

The mean of bmi was 21.1450 and s/d 2.47115.

DISCUSSION

The present study evaluated ovarian morphology and stromal blood flow parameters in women with polycystic ovary syndrome (PCOS) compared with fertile controls, emphasizing the complementary role of transvaginal ultrasonography and Doppler assessment in improving diagnostic precision. The findings demonstrated that integrating grayscale ultrasound characteristics with Doppler indices provided a more comprehensive understanding of ovarian physiology, thereby supporting more accurate patient selection and potentially optimizing therapeutic strategies. PCOS is widely recognized as a heterogeneous endocrine disorder characterized by reproductive dysfunction, hyperandrogenism, obesity, hyperinsulinemia, and insulin resistance (24). Ultrasonographic assessment of ovarian morphology constitutes a fundamental component of the Rotterdam diagnostic criteria, while Doppler ultrasound facilitates evaluation of vascular resistance within ovarian stromal and uterine vessels (25). In the present study, 60 women fulfilling the inclusion criteria were analyzed, including infertile women with PCOS and fertile controls. The mean age of participants was 26.6 years, and the overall mean body mass index (BMI) was 21.14 kg/m². Notably, BMI was significantly higher in the infertile PCOS group compared with the fertile group ($p \leq 0.01$), aligning with previous evidence suggesting a strong association between obesity and ovulatory dysfunction (26). Elevated BMI in PCOS has been consistently linked to metabolic derangements and adverse reproductive outcomes, reinforcing the metabolic dimension of this disorder beyond its gynecological manifestations.

With respect to ovarian morphology, no statistically significant inter-ovarian difference was observed between the right and left ovaries, permitting analysis of mean ovarian parameters. According to established Rotterdam criteria, an ovarian volume exceeding 10 cc is considered suggestive of polycystic ovarian morphology. In this study, the mean ovarian volume in the PCOS group was 16 cc, compared to 12.4 cc in women with polycystic ovarian appearance without full clinical syndrome and 8.1 cc in normal fertile controls. These findings confirmed that ovarian enlargement was more pronounced in women meeting full PCOS criteria, while those with isolated polycystic morphology demonstrated intermediate values. Comparable observations were reported by Decanter et al., who highlighted significantly increased ovarian volumes in women exhibiting polycystic features (27). The present findings supported the concept that ovarian volume may reflect stromal hypertrophy and follicular excess characteristic of PCOS. However, the overlap between polycystic ovarian appearance and normal ovaries underscored the limited specificity of morphology alone, emphasizing the importance of integrating biochemical and clinical criteria. This integrated diagnostic approach reduced misclassification and strengthened clinical relevance.

Doppler assessment of ovarian stromal blood flow revealed statistically significant differences in vascular indices among the studied groups. Although no significant side-to-side variation in resistive index (RI) was detected, the mean stromal RI values differed significantly between groups, indicating altered vascular dynamics in PCOS. These findings were consistent with those reported by Elmashad, who demonstrated significant alterations in ovarian stromal blood flow in women with PCOS (28). Increased stromal vascularity has been attributed to enhanced angiogenesis and increased stromal activity associated with hyperandrogenism. However, previous literature has presented conflicting evidence. Järvelä et al. did not demonstrate increased stromal vascularization in polycystic ovaries, potentially due to methodological variations, including assessment during mid-cycle and inclusion of dominant follicles, which may have reduced stromal flow measurements (29). Similarly, earlier studies by Battaglia and Dolz did not identify significant

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

differences in intraovarian Doppler indices between fertile and infertile women with PCOS (27). Such discrepancies likely reflected differences in ultrasound technique, timing of examination within the menstrual cycle, sample size, and diagnostic definitions. The standardization of scanning during the early follicular phase in the present study may have minimized physiological variation, thereby enhancing internal consistency (28).

This study possessed several strengths, including the use of standardized transvaginal ultrasonography, Doppler evaluation performed by a single experienced operator to reduce inter-observer variability, and the inclusion of a comparison group, which enhanced analytical validity. The focus on a local population addressed an existing regional research gap and contributed context-specific data. Nevertheless, certain limitations were acknowledged. The use of convenience sampling may have introduced selection bias and limited generalizability. The relatively modest sample size, although adequate for preliminary comparison, restricted broader extrapolation. Additionally, biochemical parameters such as serum androgen levels and insulin resistance indices were not quantitatively correlated with Doppler findings, which could have strengthened pathophysiological interpretation. Despite these constraints, the study provided meaningful insight into the relationship between ovarian morphology and vascular indices in PCOS. Collectively, the findings supported the growing perspective that Doppler evaluation of ovarian stromal blood flow may serve as an adjunctive diagnostic tool alongside established morphological and clinical criteria, potentially refining disease characterization and guiding individualized management strategies (29).

CONCLUSION

Fertile females and PCOS women had similar ovarian Doppler flow indices. Normal weight PCOS women had significantly higher ovarian stromal Doppler flow indices than their overweight counterparts.

AUTHOR CONTRIBUTIONS

Author	Contribution
Maooz Ahmad*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Aamir Ali Khan	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Safura	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Sohail Ahmad Khan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Arshad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Laiba Gul	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Anmol Arif	Contributed to study concept and Data collection Has given Final Approval of the version to be published

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

REFERENCES

1. Zehravi M, Maqbool M, Ara I. Polycystic ovary syndrome and infertility: an update. International journal of adolescent medicine and health. 2022 Apr 18;34(2):1-9.

2. Kicińska AM, Maksym RB, Zabielska-Kaczorowska MA, Stachowska A, Babińska A. Immunological and metabolic causes of infertility in polycystic ovary syndrome. Biomedicines. 2023 May 28;11(6):1567.

3. Ding H, Zhang J, Zhang F, Zhang S, Chen X, Liang W, Xie Q. Resistance to the insulin and elevated level of androgen: a major cause of polycystic ovary syndrome. Frontiers in endocrinology. 2021 Oct 20;12:741764.

4. Zeng X, Xie YJ, Liu YT, Long SL, Mo ZC. Polycystic ovarian syndrome: correlation between hyperandrogenism, insulin resistance and obesity. Clinica chimica acta. 2020 Mar 1;502:214-21.

5. Xu Y, Qiao J. Association of insulin resistance and elevated androgen levels with polycystic ovarian syndrome (PCOS): a review of literature. Journal of healthcare engineering. 2022;2022(1):9240569.

6. Subhash VV. Correlation of ovarian volume with fasting plasma insulin levels, and insulin resistance using homeostasis model assessment 2 computational model in women with polycystic ovaries (Master's thesis, Rajiv Gandhi University of Health Sciences (India)).

7. Younesi L, Lima ZS, Sene AA, Jebelli ZH, Amjad G. Comparison of uterine and ovarian stromal blood flow in patients with polycystic ovarian syndrome. Endocrine Connections. 2019 Jan 1;8(1):50-6.

8. Dai M, Hong L, Yin T, Liu S. Disturbed follicular microenvironment in polycystic ovary syndrome: relationship to oocyte quality and infertility. Endocrinology. 2024 Apr;165(4):bqae023.

9. Haddad-Filho H, Tosatti JA, Vale FM, Gomes KB, Reis FM. Updates in diagnosing polycystic ovary syndrome-related infertility. Expert Review of Molecular Diagnostics. 2023 Feb 1;23(2):123-32.

10. Jiang NX, Li XL. The disorders of endometrial receptivity in PCOS and its mechanisms. Reproductive Sciences. 2022 Sep;29(9):2465-76.

11. Purwar A, Nagpure S. Insulin resistance in polycystic ovarian syndrome. Cureus. 2022 Oct 16;14(10).

12. Wen X, Wang L, Lv S. Follicular development and endometrial receptivity of different androgen phenotypes in women with polycystic ovary syndrome. Frontiers in Endocrinology. 2024 Dec 12;15:1400880.

13. Guo F, Huang Y, Fernando T, Shi Y. Altered molecular pathways and biomarkers of endometrial receptivity in infertile women with polycystic ovary syndrome. Reproductive Sciences. 2022 Dec;29(12):3335-45.

14. Zhao H, Zhang J, Cheng X, Nie X, He B. Insulin resistance in polycystic ovary syndrome across various tissues: an updated review of pathogenesis, evaluation, and treatment. Journal of ovarian research. 2023 Jan 11;16(1):9.

15. Sarwar A, Bacha R, Gilani SY, Gilani SA, Khan AA. Sonographic correlation of polycystic ovarian syndrome (PCOS) with uterine artery resistive index (RI). EAS J Radiol Imaging Technol. 2019;1(5):94-100.

16. Abd EL-Sattar M, Osama EK, Alaa EL, Esmaeel H. Effect of metformin treatment on ovarian stromal blood flow in women with polycystic ovary syndrome. Menoufia Medical Journal. 2019 Oct 1;32(4):1371-.

17. Maqbool M, Dar MA, Gani I, Geer MI. Insulin resistance and polycystic ovary syndrome: a review. J drug deliv ther. 2019 Jan 2;9(1-s):433-6.

18. Mansour A, Hashemi Taheri AP, Moradi B, Mohajeri-Tehrani MR, Qorbani M, Ghorbani Pashakolaee S, Sanginabadi M, Sajjadi-Jazi SM. Ovarian volume, not follicle count, is independently associated with androgens in patients with polycystic ovary syndrome. BMC Endocrine Disorders. 2022 Dec 1;22(1):298.

19. Velez LM, Seldin M, Motta AB. Inflammation and reproductive function in women with polycystic ovary syndrome. Biology of reproduction. 2021 Jun;104(6):1205-17.

20. Sahu A, Tripathy P, Mohanty J, Nagy A. Doppler analysis of ovarian stromal blood flow changes after treatment with metformin versus ethinyl estradiol-cyproterone acetate in women with polycystic ovarian syndrome: A randomized controlled trial. Journal of gynecology obstetrics and human reproduction. 2019 May 1;48(5):335-9.

21. Seow KM, Chang YW, Chen KH, Juan CC, Huang CY, Lin LT, Tsui KH, Chen YJ, Lee WL, Wang PH. Molecular mechanisms of laparoscopic ovarian drilling and its therapeutic effects in polycystic ovary syndrome. International journal of molecular sciences. 2020 Oct 31;21(21):8147.

22. Yusuf AN, Amri MF, Ugusman A, Hamid AA, Wahab NA, Mokhtar MH. Hyperandrogenism and its possible effects on endometrial receptivity: a review. International Journal of Molecular Sciences. 2023 Jul 27;24(15):12026.

23. Le NS, Le MT, Nguyen ND, Tran NQ, Nguyen QH, Cao TN. A cross-sectional study on potential ovarian volume and related factors in women with polycystic ovary syndrome from infertile couples. International Journal of Women's Health. 2021 Aug 29:793-801.

24. Lei R, Chen S, Li W. Advances in the study of the correlation between insulin resistance and infertility. Frontiers in endocrinology. 2024 Jan 26;15:1288326.

25. Chen X, Wan Y, Xie L. Insulin resistance in polycystic ovary syndrome: pathophysiological mechanisms of menstrual dysfunction and evidence-based treatment strategies. Biology of Reproduction. 2025 Dec;113(6):1340-54.

26. Stener-Victorin E, Teede H, Norman RJ, Legro R, Goodarzi MO, Dokras A, Laven J, Hoeger K, Piltonen TT. Polycystic ovary syndrome. Nature Reviews Disease Primers. 2024 Apr 18;10(1):27.

27. Hamed ST, Shedid AA, Hassan W. Doppler Study of Uterine and Ovarian Arteries in Relation to Clinical and Laboratory Findings in Cases of Polycystic Ovarian Syndrome. Evidence Based Women's Health Journal. 2024 Aug 1;14(3):286-95.

28. Hernández-Jiménez JL, Barrera D, Espinoza-Simón E, González J, Ortíz-Hernández R, Escobar L, Echeverría O, Torres-Ramírez N. Polycystic ovarian syndrome: signs and feedback effects of hyperandrogenism and insulin resistance. Gynecological Endocrinology. 2022 Jan 2;38(1):2-9.

29. Naidu S, Ramdin S, Naicker T, Moodley J, Naidoo G, Govender N. Polycystic Ovarian Syndrome: Current Insights. InHow to use 3D Printing Innovations and Digital Storage to Democratize Anatomy Education 2024 Nov 6 (pp. 191-228). Cham: Springer Nature Switzerland.

