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Research Article

Correlation of transvaginal ultrasound-derived ovarian volume and follicle count with hormonal and metabolic profiles

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ABSTRACT

Background: Polycystic ovarian morphology is an important diagnostic feature of polycystic ovary syndrome (PCOS) and can be accurately assessed using transvaginal ultrasonography (TVS). Ovarian volume and antral follicle count (AFC) are widely used ultrasonographic markers; however, their relationship with hormonal and metabolic abnormalities remains incompletely understood, particularly in the Indian population. **Objectives:** To evaluate the correlation of transvaginal ultrasound-derived ovarian volume and antral follicle count with hormonal and metabolic profiles in women of reproductive age. **Materials and Methods:** This hospital-based cross-sectional observational study was conducted in the Department of Obstetrics and Gynaecology, Rani Durgawati Medical College, Banda. A total of 100 women aged 18–40 years undergoing transvaginal ultrasonography were included. Ovarian volume and AFC were measured using TVS. Hormonal parameters including luteinizing hormone (LH), follicle-stimulating hormone (FSH), testosterone, and anti-Müllerian hormone (AMH) were assessed. Metabolic evaluation included fasting blood glucose, fasting insulin, lipid profile, and Homeostatic Model Assessment of Insulin Resistance (HOMA-IR). Correlation analyses were performed using Pearson's or Spearman's correlation coefficients. A p-value <0.05 was considered statistically significant. **Results:** The mean ovarian volume was 11.6 ± 3.4 cm³, and the mean AFC was 24.7 ± 7.2. Ovarian volume demonstrated significant positive correlations with LH ($r=0.42$, $p<0.001$), testosterone ($r=0.48$, $p<0.001$), AMH ($r=0.56$, $p<0.001$), fasting insulin ($r=0.39$, $p<0.001$), and HOMA-IR ($r=0.44$, $p<0.001$). Similarly, AFC showed significant positive correlations with LH ($r=0.45$, $p<0.001$), testosterone ($r=0.52$, $p<0.001$), AMH ($r=0.63$, $p<0.001$), fasting insulin ($r=0.36$, $p<0.001$), and HOMA-IR ($r=0.41$, $p<0.001$). No significant correlation was observed between ovarian morphology parameters and FSH levels. **Conclusion:** Transvaginal ultrasound-derived ovarian volume and antral follicle count are significantly associated with hormonal and metabolic abnormalities in women with polycystic ovarian morphology. These ultrasonographic parameters may serve as useful non-invasive markers for assessing endocrine dysfunction and metabolic risk, thereby

aiding in the comprehensive evaluation and management of affected women.

Keywords: Polycystic ovary syndrome, Transvaginal ultrasonography, Ovarian volume, Antral follicle count, Hormonal profile, Metabolic profile, Insulin resistance.

INTRODUCTION

Polycystic ovary syndrome (PCOS) is one of the most prevalent endocrine disorders affecting women of reproductive age and is characterized by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology (PCOM). It affects approximately 8–13% of women worldwide and is associated with significant reproductive, metabolic, and psychological morbidity.[1,2] In India, the prevalence of PCOS has been reported to vary from 6% to 22%, reflecting differences in diagnostic criteria, ethnicity, and lifestyle factors.[3]

Ultrasonographic assessment of ovarian morphology constitutes an important component of the diagnostic evaluation of PCOS. According to the Rotterdam criteria, the presence of polycystic ovarian morphology is defined by increased follicle number and/or enlarged ovarian volume.[4] Transvaginal ultrasonography (TVS) provides superior visualization of ovarian structures and is considered the preferred imaging modality for assessing ovarian volume and antral follicle count (AFC).[5]

Ovarian volume and follicle count are not merely diagnostic parameters but may also reflect the underlying endocrine and metabolic disturbances associated with PCOS. Increased ovarian volume has been linked to stromal hypertrophy and excessive androgen production, whereas elevated follicle count is indicative of disrupted folliculogenesis and follicular arrest. [6] Previous studies have demonstrated significant associations between ovarian morphology and hormonal abnormalities, including elevated luteinizing hormone (LH), increased serum testosterone, and higher anti-Müllerian hormone (AMH) concentrations. [7-8]

Beyond reproductive dysfunction, PCOS is increasingly recognized as a metabolic disorder characterized by insulin resistance, obesity, dyslipidemia, impaired glucose tolerance, and an increased risk of type 2 diabetes mellitus and cardiovascular disease. [9-10] Emerging evidence suggests that women with greater ovarian volume and higher AFC may exhibit more pronounced metabolic abnormalities, indicating that sonographic ovarian parameters could serve as markers of disease severity.[11]

However, the correlation between ultrasound-derived ovarian morphology and hormonal or metabolic profiles remains inconsistent across different populations. Ethnic variations, environmental influences, and differences in body composition may contribute to these discrepancies. Indian women with PCOS often develop metabolic complications at a younger age and lower body mass index compared to Western populations, emphasizing the need for population-specific data.[12] Therefore, the present study was undertaken to evaluate the correlation of transvaginal ultrasound-derived ovarian volume and follicle count with hormonal and metabolic profiles. Understanding these relationships may improve the diagnostic utility of ultrasonography and facilitate early identification of women at increased risk of endocrine and metabolic complications.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional observational study was conducted in the Department of Obstetrics and Gynaecology, Rani Durgawati Medical College, Banda, UP, India, over a period of one year after obtaining approval from the Institutional Ethics Committee.

Study Population

The study included women of reproductive age (18–40 years) attending the outpatient and infertility clinics of the Department of Obstetrics and Gynaecology who underwent transvaginal ultrasonographic evaluation for suspected polycystic ovarian morphology and related menstrual, infertility, or hyperandrogenic complaints.

Sample Size

A total of 100 participants fulfilling the inclusion and exclusion criteria were enrolled consecutively during the study period.

Inclusion Criteria

- Women aged 18–40 years.
- Women willing to provide written informed consent.
- Women undergoing transvaginal ultrasonography for evaluation of menstrual irregularities, infertility, hirsutism, acne, or suspected polycystic ovary syndrome.
- Women in whom hormonal and metabolic investigations were available.

Exclusion Criteria

- Pregnant women.
- Women with ovarian cysts, ovarian tumors, or previous ovarian surgery.
- Women receiving hormonal therapy, insulin sensitizers, corticosteroids, or fertility medications within the preceding three months.
- Women diagnosed with thyroid disorders, hyperprolactinemia, congenital adrenal hyperplasia, Cushing's syndrome, or androgen-secreting tumors.
- Women unwilling to participate in the study.

Clinical Assessment

A detailed history regarding age, menstrual pattern, infertility, obstetric history, and symptoms of hyperandrogenism was recorded. General physical examination included measurement of height, weight, body mass index (BMI), waist circumference, and blood pressure.

Transvaginal Ultrasonography

Transvaginal ultrasonography was performed using a high-frequency transvaginal probe (5–9 MHz) during the early follicular phase of the menstrual cycle (days 2–7) whenever feasible.

The following ovarian parameters were assessed:

Ovarian Volume

Ovarian dimensions were measured in three perpendicular planes. Ovarian volume was calculated using the prolate ellipsoid formula:

Ovarian Volume (cm^3) = Length × Width × Thickness × 0.523

The mean ovarian volume of both ovaries was used for analysis.

Antral Follicle Count (AFC)

The total number of follicles measuring 2–9 mm in diameter in each ovary was counted. The sum of follicle counts from both ovaries was recorded as the total AFC.

Hormonal Profile Assessment

Venous blood samples were collected during the early follicular phase after overnight fasting. The following hormonal parameters were measured:

- Follicle-stimulating hormone (FSH)
- Luteinizing hormone (LH)
- LH/FSH ratio
- Total testosterone
- Anti-Müllerian hormone (AMH)
- Serum prolactin
- Thyroid-stimulating hormone (TSH)

All assays were performed in the central biochemistry laboratory using standardized immunoassay techniques.

Metabolic Profile Assessment

Following an overnight fast of 8–12 hours, blood samples were collected for assessment of:

- Fasting blood glucose (FBG)
- Fasting serum insulin
- Glycated hemoglobin (HbA1c)
- Total cholesterol
- Triglycerides
- High-density lipoprotein cholesterol (HDL-C)
- Low-density lipoprotein cholesterol (LDL-C)

Insulin resistance was estimated using the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR):

HOMA-IR = Fasting Insulin (µIU/mL) × Fasting Glucose (mg/dL) / 405

Outcome Measures

Primary Outcome:

- Correlation of ovarian volume with hormonal and metabolic parameters.
- Secondary Outcome:
- Correlation of antral follicle count with hormonal and metabolic parameters.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 25.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Pearson's correlation coefficient or Spearman's rank correlation coefficient was used to assess the relationship between ovarian volume, follicle count, hormonal parameters, and metabolic variables depending on data distribution. Independent t-test and Chi-square test were applied where appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics of Study Participants

A total of 100 women aged 18–40 years were included in the study. The mean age of the participants was 26.8 ± 4.5 years. The mean body mass index (BMI) was 27.3 ± 4.2 kg/m². Menstrual irregularities were present in 68% of participants, infertility in 42%, hirsutism in 38%, and acne in 31%.

Table 1. Baseline Characteristics of Study Participants (n=100)

Parameter	Mean ± SD / n (%)
Age (years)	26.8 ± 4.5
BMI (kg/m²)	27.3 ± 4.2
Menstrual irregularity	68 (68%)

Infertility	42 (42%)
Hirsutism	38 (38%)
Acne	31 (31%)

The mean ovarian volume was 11.6 ± 3.4 cm³, while the mean antral follicle count (AFC) was 24.7 ± 7.2 follicles.

Table 2. Ultrasonographic Findings

Parameter	Mean ± SD
Ovarian Volume (cm³)	11.6 ± 3.4
Antral Follicle Count	24.7 ± 7.2

The mean LH level was 10.8 ± 4.2 IU/L, FSH was 5.9 ± 1.8 IU/L, and the mean LH/FSH ratio was 1.89 ± 0.74. Mean serum testosterone and AMH levels were 0.81 ± 0.29 ng/mL and 6.5 ± 2.8 ng/mL, respectively.

Table 3. Hormonal Profile of Participants

Parameter	Mean ± SD
LH (IU/L)	10.8 ± 4.2
FSH (IU/L)	5.9 ± 1.8
LH/FSH Ratio	1.89 ± 0.74
Testosterone (ng/mL)	0.81 ± 0.29
AMH (ng/mL)	6.5 ± 2.8

The mean fasting blood glucose was 96.4 ± 12.8 mg/dL and mean HOMA-IR was 3.1 ± 1.2. Dyslipidemia was observed in a substantial proportion of participants.

Table 4. Metabolic Profile of Participants

Parameter	Mean ± SD
Fasting Blood Glucose (mg/dL)	96.4 ± 12.8
Fasting Insulin (µIU/mL)	13.2 ± 5.4
HOMA-IR	3.1 ± 1.2
Total Cholesterol (mg/dL)	184.5 ± 32.6
Triglycerides (mg/dL)	156.4 ± 46.8
HDL-C (mg/dL)	42.6 ± 8.4
LDL-C (mg/dL)	108.3 ± 24.2

Ovarian volume showed a significant positive correlation with serum LH ($r = 0.42$, $p < 0.001$), testosterone ($r = 0.48$, $p < 0.001$), and AMH levels ($r = 0.56$, $p < 0.001$). No significant correlation was observed with FSH levels ($p > 0.05$).

Table 5. Correlation Between Ovarian Volume and Hormonal Parameters

Parameter	Correlation Coefficient (r)	p-value
LH	0.42	<0.001
FSH	-0.08	0.421

Testosterone	0.48	<0.001
AMH	0.56	<0.001

Ovarian volume demonstrated significant positive correlations with fasting insulin ($r = 0.39$, $p < 0.001$), HOMA-IR ($r = 0.44$, $p < 0.001$), and triglyceride levels ($r = 0.31$, $p = 0.002$).

Table 6. Correlation Between Ovarian Volume and Metabolic Parameters

Parameter	Correlation Coefficient (r)	p-value
Fasting Glucose	0.19	0.061
Fasting Insulin	0.39	<0.001
HOMA-IR	0.44	<0.001
Triglycerides	0.31	0.002

AFC showed significant positive correlations with LH ($r = 0.45$, $p < 0.001$), testosterone ($r = 0.52$, $p < 0.001$), and AMH ($r = 0.63$, $p < 0.001$).

Table 7. Correlation Between AFC and Hormonal Parameters

Parameter	Correlation Coefficient (r)	p-value
LH	0.45	<0.001
FSH	-0.05	0.612
Testosterone	0.52	<0.001
AMH	0.63	<0.001

AFC demonstrated significant positive correlations with fasting insulin ($r = 0.36$, $p < 0.001$) and HOMA-IR ($r = 0.41$, $p < 0.001$).

Table 8. Correlation Between AFC and Metabolic Parameters

Parameter	Correlation Coefficient (r)	p-value
Fasting Glucose	0.17	0.087
Fasting Insulin	0.36	<0.001
HOMA-IR	0.41	<0.001

DISCUSSION

The present study evaluated the correlation of transvaginal ultrasound-derived ovarian volume and antral follicle count (AFC) with hormonal and metabolic profiles in women of reproductive age. The findings demonstrated significant positive correlations between ovarian morphology parameters and endocrine as well as metabolic disturbances, suggesting that

ultrasonographic markers may serve as useful indicators of disease severity.

In the present study, the mean ovarian volume and AFC were elevated among women exhibiting hormonal and metabolic abnormalities. Ovarian enlargement and increased follicle number are characteristic features of polycystic ovarian morphology and reflect disrupted folliculogenesis and stromal hypertrophy. Similar observations have been reported by Jonard and Dewailly, who demonstrated that excessive follicle accumulation and ovarian stromal expansion are central features of polycystic ovaries.[6]

A significant positive correlation was observed between ovarian volume and serum LH levels. This finding is consistent with the studies of Adams et al.[11] and Dewailly et al.[5], who reported that enlarged ovarian volume is associated with increased gonadotropin secretion and ovarian dysfunction. Elevated LH promotes androgen production by ovarian theca cells, contributing to stromal hypertrophy and ovarian enlargement.

The present study also demonstrated a positive correlation between ovarian volume and serum testosterone levels. Similar findings have been reported by Carmina and Lobo,[13] who observed that women with greater ovarian volume exhibit higher androgen concentrations. Hyperandrogenism is a hallmark of PCOS and contributes to follicular arrest, anovulation, and the development of polycystic ovarian morphology.

Among the hormonal parameters evaluated, anti-Müllerian hormone (AMH) exhibited the strongest correlation with both ovarian volume and AFC. This observation is in agreement with the findings of Pigny et al.,[7] who reported that AMH levels are closely related to the number of small antral follicles. Since AMH is secreted by granulosa cells of preantral and small antral follicles, elevated follicle counts are naturally associated with increased serum AMH concentrations. Therefore, AFC and AMH may represent complementary markers of ovarian follicular activity.

The study further revealed significant positive correlations between ovarian morphology and markers of insulin resistance, particularly fasting insulin levels and HOMA-IR. These findings support the concept that ovarian morphology is linked not only to reproductive dysfunction but also to metabolic abnormalities. Dunaif[6] highlighted the central role of insulin resistance in the pathogenesis of PCOS, demonstrating that hyperinsulinemia enhances ovarian androgen production and exacerbates follicular dysfunction. Similar associations between ovarian volume, AFC, and insulin resistance have been reported by Moran et al.[10] and Lim et al.[14]

A positive relationship between ovarian morphology and triglyceride levels was also observed in the present study. Dyslipidemia is a common metabolic feature of PCOS and contributes to increased cardiovascular risk. Elevated triglyceride levels in women with larger ovarian volume may reflect underlying insulin resistance and metabolic dysfunction. Previous studies have likewise demonstrated significant associations between polycystic ovarian morphology and adverse lipid profiles.[10,14]

The stronger correlations observed between AFC and hormonal parameters compared with ovarian volume suggest that follicle count may be a more sensitive indicator of ovarian dysfunction. Similar conclusions were drawn by Sahmay et al.,[15] who reported that AFC and AMH provide better assessment of disease severity than ovarian volume alone. With advances in ultrasound technology, AFC has become an increasingly reliable marker of ovarian morphology and follicular reserve.

The findings of the present study have important clinical implications. Transvaginal ultrasonography is

inexpensive, non-invasive, and widely available in routine gynecological practice. Identification of increased ovarian volume and follicle count may help clinicians recognize women at greater risk of endocrine and metabolic abnormalities, facilitating early intervention and individualized management strategies. Furthermore, incorporation of ultrasonographic markers into routine evaluation may improve risk stratification and long-term monitoring.

The study has certain limitations. The cross-sectional design precludes establishment of a causal relationship between ovarian morphology and metabolic abnormalities. The study was conducted at a single tertiary care center, which may limit generalizability of the findings. Additionally, larger multicentric studies involving diverse populations are required to validate these observations.

Despite these limitations, the study provides valuable evidence regarding the association of transvaginal ultrasound-derived ovarian parameters with hormonal and metabolic profiles. The significant correlations observed reinforce the role of ovarian morphology as an important marker of endocrine and metabolic dysfunction in women with polycystic ovarian morphology.

CONCLUSION

The present study demonstrated significant positive correlations between transvaginal ultrasound-derived ovarian volume, antral follicle count, and hormonal as well as metabolic parameters in women with polycystic ovarian morphology. Increased ovarian volume and follicle count were associated with elevated serum LH, testosterone, AMH levels, and markers of insulin resistance, indicating a close relationship between ovarian morphology and underlying endocrine-metabolic dysfunction. These findings highlight the potential utility of transvaginal ultrasonography as a non-invasive and readily available tool not only for the diagnosis of polycystic ovarian morphology but also for identifying women at increased risk of hormonal and metabolic abnormalities. Ovarian volume and follicle count may serve as valuable adjunctive markers for assessing disease severity and guiding clinical management. Further large-scale prospective studies are warranted to establish the predictive value of these ultrasonographic parameters in determining long-term reproductive and metabolic outcomes.

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