Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

Assessment of the Best Predictor for Diagnosis of Polycystic Ovarian Disease in Color Doppler Study of Ovarian Artery

Sudeept Dwivedi, Mayank Kumar Ujjaliya, Ashish Kaushik

Post Graduate Student, Department of Radio Diagnosis, Gandhi Medical College, Bhopal, Madhya Pradesh, India

Abstract

Objective: The objective of this study was to study the Doppler hemodynamic changes, compare different parameters in ovarian arteries, and review grayscale ultrasound findings in follicular phase of the cycle in polycystic ovary syndrome (PCOS) patients.

Design: This was a case–control study.

Patients: A total of 100 cases who had a history of oligo/anovulation and confirmed by Rotterdam criteria with 100 age-matched controls who had normal menstrual history were selected. Forty patients with confirmed PCO disease (PCOD) and 50 control patients in various phases of spontaneous menstrual cycles.

Results: Polycystic ovaries showed typical vascular pattern: Increased stromal vascularity, increased peak systolic velocity and end-diastolic velocity, and a trend toward lower resistance index and PI values, with $P < 0.001$. Overall, the most sensitive and specific predictor for the diagnosis of PCOS was PI.

Conclusion: The observed specific ovarian vascular pattern in PCOD patients may provide additional data for conventional endocrinological and ultrasonic diagnostic methods for PCOD.

Key words: Polycystic, Disease, Color doppler

INTRODUCTION

Polycystic ovary syndrome (PCOS) is the most common cause of anovulatory infertility accounting for >70% of cases. PCOS was first described by Stein and Leventhal, in 1935.[1] PCOS is a diverse pathological condition characterized by reproductive disorders and frequently associated with hyperandrogenism, obesity, hyperinsulinemia, and insulin resistance.[2-4] PCOS is the most common female endocrinopathy, and its frequency is about 6–8% in the reproductive period.[2] Even though polycystic ovaries can be found in approximately 33% of the female population, they are not necessarily associated with the typical symptoms and PCOS, which may be manifested at some time during the fertile life span when provoked by, for example, weight gain or insulin resistance.[3,4] In 2003, a joint European Society for Human Reproduction and Embryology and the American Society for Reproductive Medicine (ESHRE/ASRM) consensus meeting produced a refined definition of PCOS, namely the occurrence of two of the following three criteria: (1) oligo and/or anovulation, (2) hyperandrogenism (clinical and/or biochemical), and (3) polycystic ovaries, with the exclusion of other etiologies.[1] The morphology of the PCO was redefined as an ovary with 12 or more follicles measuring 2–9 mm in diameter and/or increased ovarian volume (>10 cm^3).[5]

Ultrasound assessment of ovarian morphology is considered to be necessary in the diagnosis of PCOS and gold standard for defining PCO.[6] The PCO is the morphological ovarian phenotype in women with the PCO syndrome.

Most investigators would concur that blood flow and the

Access this article online

www.ijss-sn.com

Month of Submission : 01-2019
Month of Peer Review : 02-2019
Month of Acceptance : 02-2019
Month of Publishing : 03-2019

Corresponding Author: Dr. Mayank Kumar Ujjaliya, B, 197 Veena Nagar, Sukhaliya, Indore–452 010, Madhya Pradesh, India. Phone: +90-9098394923. E-mail: mayankujjaliya.ujjaliya@gmail.com

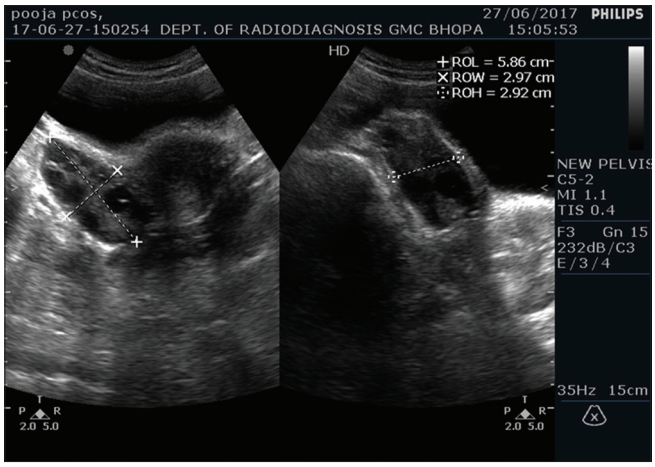

Figure 1: Grayscale ultrasound showing ovarian volume measurement, bulky ovary, and multiple peripherally arranged follicles with echogenic stroma

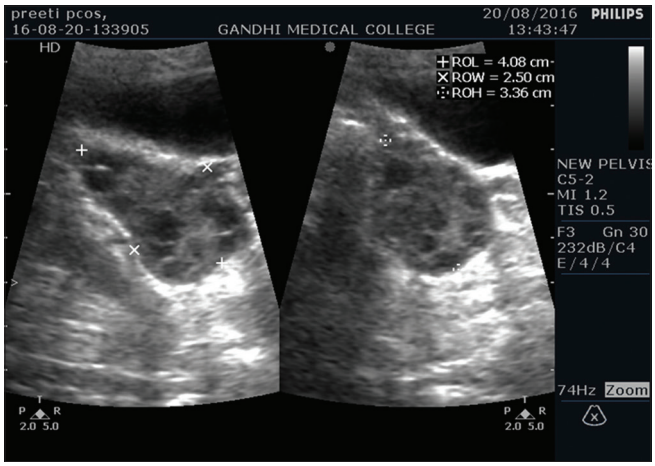

Figure 2: Enlarged view of ovarian volume measurement, with multiple follicles

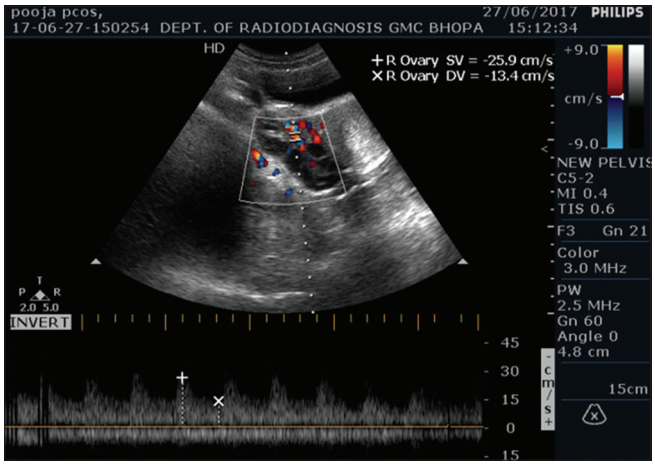

Figure 3: Color Doppler study showing increased ovarian vascularity and increased peak systolic velocity and end-diastolic velocity in a case of polycystic ovary syndrome

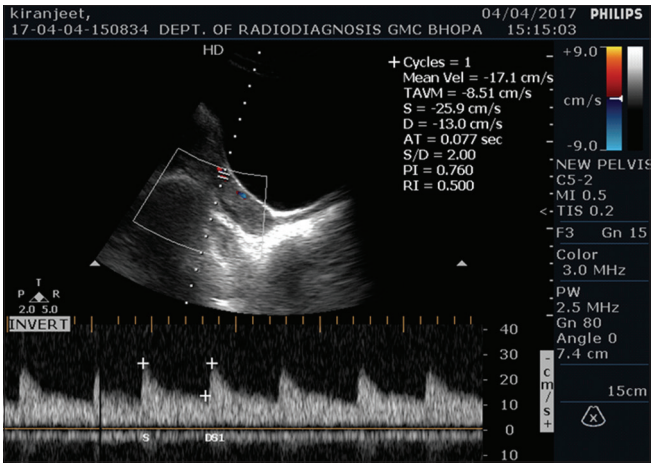

Figure 4: Color Doppler study showing elevated peak systolic velocity and end-diastolic velocity with reduced resistive index and pulsatility index in a case of polycystic ovary syndrome

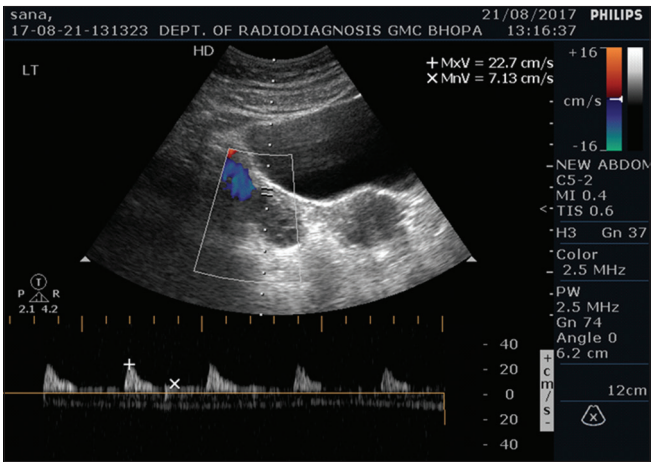

Figure 5: Color Doppler study in a control showing reduced systolic and diastolic and high resistance flow

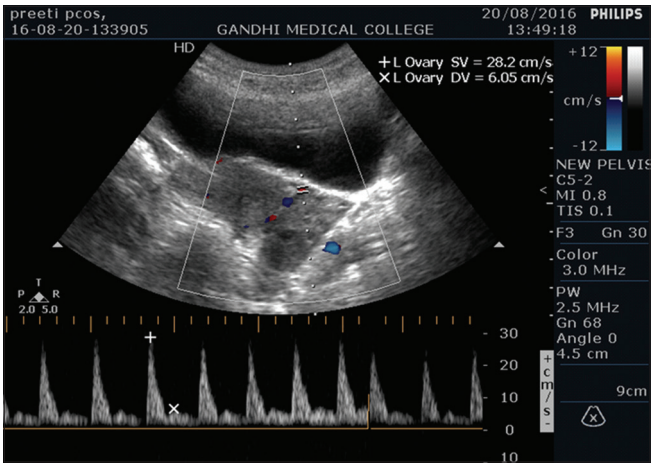

Figure 6: Color Doppler study showing high resistance flow in a control

vascular pattern of an organ are directly related to organ's morphology and function. Therefore, the clinician may consider an ability to identify alteration in an organ's blood flow and vascular pattern a valuable tool in evaluation of organic and functional anomalies.

Ultrasound has given much new morphological and pathophysiological information on blood flow dynamics within the female pelvis.[7,8] It has been publicized that, in patients with polycystic ovarian syndrome, important changes in ovarian vascularization occur at the level of the ovarian arteries. Battaglia *et al.*,[9] Zaidi *et al.*,[10] and Aleem and Predanic[11] successively established that, in patients with PCOS, significant changes occur within the ovarian vessels and confirmed that Doppler analysis of ovarian arteries in PCOS may be useful to improve the diagnosis and to provide further insight about the pathophysiology and evolution of the syndrome. These hypotheses have been recently confirmed either using two- or three-dimensional color Doppler systems analysis.

An understanding of vascular changes in women with PCOS may allow us to gain further insights into the underlying pathophysiology of this condition.

Aim and Objectives

The aim of this study was as follows:

- To study Doppler hemodynamic changes in ovarian arteries in follicular phase of the cycle in PCOS patients.
- To review gray scale ultrasound findings in diagnosis of polycystic ovarian syndrome patients.
- To compare different parameters of Doppler hemodynamics in ovarian artery of PCOS patients among each other and with normal patients.

MATERIALS AND METHODS

Study Design

- This was a prospective case–control study.

Study Area

- This study was conducted at the Department of Radiodiagnosis, Gandhi Medical College and Hamidia Hospital.

Sample Source

- All the patients were referred to our department for ultrasound from the Department of Obstetrics and Gynecology, Sultania Zanana Hospital.

Sample Size

- 100 cases.
- 100 age-matched controls.

Inclusion Criteria

- Cases – All the cases referred to our department had a history of primary or secondary infertility and complaint of oligo/anovulation or clinical signs of hyperandrogenism. Enlistment of all PCOS patients was made according to the ESHRE/ASRM criteria. PCOS was diagnosed when two of the following three features were present: Oligo and/or anovulation, clinical and/or biochemical signs of hyperandrogenism, and polycystic ovaries on ultrasound examination (the presence of 12 or more follicles of 2–9 mm in diameter and/or ovarian volume >10 cm^3).
- Controls – The control group was those having complaints other than menstrual trouble, not having any signs or symptoms of hyperandrogenemia. The health of the control group was determined on the basis of medical past, physical, and pelvic examinations, blood chemistry, and pelvic ultrasound. None of the women in the control group had signs or symptoms according to the ESHRE/ASRM criteria. All participants had not taken any medication for at least 6 months before entering the study that could influence the biochemical profile or metabolic variables. The women in the control group had regular, normal menstruation (days 25–35).

Exclusion Criteria

- The exclusion criteria were the use of hormonal contraception, fertility medications in the 3 months earlier to enrolment, hyperprolactinemia, hypercortisolemia, and thyroid dysfunction.

Instrumentation

- All examinations were performed using ultrasound machines available in our department with a 3.5–5 MHz transducer.

Statistics

- Statistics used were ratio, proportion, and percentages. Test for statistical association applied was Chi-square and odds ratio using Microsoft Excel 2016 and SPSS version 20 wherever applicable. $P < 0.005$ was taken as statistically significant.

Methodology

- Detailed history from all participants was taken including identification data, reproductive history, menstrual history, history of weight gain, history of thyroid disease, history of galactorrhea, and any other noteworthy complains. General physical examination, height (m), weight (kg), and body mass index (kg/m^2) were recorded. Systemic examination of all systems was done.
- Patients were instructed to have full bladder and 6 h fasting as required. Routinely, the patients were examined in the supine position. Ultrasound and Doppler analyses were performed during the follicular phase of the menstrual cycle (between the 3rd and 5th days). All patients were evaluated at the uniform time of day to avoid fluctuations of the ovarian artery blood flow due to the circadian rhythm. A 50-Hz filter was used to get rid of low-frequency signals originating from blood vessel wall movements. Ovarian volume was calculated using the formula for an prolate ellipse (length × width × height × 0.523). Number of follicles of size 2–9 mm in the periphery of ovary was

measured. Any follicle of size >9 was not counted in calculation.

- Ovarian artery was found lateral to the upper pole of the ovary, near the infundibulopelvic ligament or at hilum. At least three satisfactory blood flow velocity waveforms were obtained and employed for statistical analysis of the average from three waveforms. The angle of insonation was always changed to obtain maximum color intensity. When good color signals were obtained, blood flow velocity waveforms were recorded by placing the sample volume across the vessel and using the pulsed Doppler mode. No significant differences between the left and right ovarian arteries were observed, and therefore, the mean value of both was taken. The resistive index (RI) was calculated as the difference between peak systolic velocity (PSV) and end-diastolic velocity (EDV) divided by PSV. The pulsatility index (PI) defined as the difference between peak systolic and end-diastolic flow divided by the mean maximum flow velocity was determined using calculation software.

OBSERVATION AND RESULTS [FIGURES 1-5]

Body mass index (BMI)

Parameter	Cases *n* (%)	Control *n* (%)	Total *n* (%)
Underweight (<18.5)	2 (2)	8 (8)	10 (5)
Normal (18.5–24.9)	38 (38)	80 (70)	118 (59)
Overweight (≥25)	60 (60)	12 (22)	72 (36)
Pre-obese (25–29.9)	45 (45)	10 (20)	55 (27.5)
Obese I (30–34.9)	12 (12)	2 (2)	14 (7)
Obese II (35–39.9)	3 (3)	0	3 (1.5)
Obese III (≥40)	0	0	0
Total	100	100	200
Mean BMI±SD	26.275±4.19	22.84±4.17	
Odds ratio	11		
Significance *P* value	<0.0001		

SD: Standard deviation, BMI: Body mass index

Obesity	Case	Control
+(>25)	60	12
−(<24.9)	40	88

Ovarian Volume

Volume	Cases *n* (%)	Control *n* (%)	Total *n* (%)
0–9 cc	0 (0)	94 (98)	98 (49)
10–19 cc	85 (85)	6 (2)	87 (43.5)
20–29 cc	12 (12)	0	12 (6)
≥30 cc	3 (3)	0	3 (1.5)
Total	100	100	200
Mean±SD	16.25±4.96	5.5±2.4	
Significance *P* value	<0.0001		

SD: Standard deviation

Volume12	Case	Control
≥10	100	6
<10	0	94

Number of Follicles

Number	Cases *n* (%)	Control *n* (%)	Total *n* (%)
0–5	0	97 (97)	97 (48.5)
6–10	0	3 (3)	3 (1.5)
11–15	71 (71)	0	71 (35.5)
16–20	29 (29)	0	29 (14.5)
Total	100	100	200
Mean±SD	14.39±1.95	3±1.5	
Significance *P* value	<0.0001		

SD: Standard deviation

Echogenic Stroma

Echogenic stroma	Cases *n* (%)	Control *n* (%)	Total *n* (%)
+	98 (98)	4 (4)	102 (51)
-	2 (2)	96 (96)	98 (49)
Total	100	100	200
Significance *P* value	<0.0001		

PSV

PSV	Cases *n* (%)	Control *n* (%)	Total *n* (%)
≤10 cm/s	10 (10)	30 (30)	40 (20)
11–20	20 (20)	45 (45)	65 (32.5)
21–30	51 (51)	23 (23)	78 (39)
31–40	14 (14)	2 (2)	16 (8)
41–50	4 (4)	0	4 (2)
≥51	1 (1)	0	1 (0.5)
Total	100	100	200
Mean±SD	24.6±9.9	15.4±7.02	
Odd's ratio	7		
Significance *P* value	<0.0001		

PSV: Peak systolic velocity, SD: Standard deviation

PSV	Cases	Control
>20	70	25
<20	30	75
Sensitivity (%)	70	
Specificity (%)	75	
PPV (%)	73	
NPV (%)	71	

PSV: Peak systolic velocity

PSV	Case	Control
>31	19	2
<30	81	98
Sensitivity (%)	19	
Specificity (%)	98	
PPV	90	
NPV	54	

PSV: Peak systolic velocity

EDV

EDV	Cases *n* (%)	Control *n* (%)	Total *n* (%)
<10 cm/s	45 (45)	97 (97)	142 (71)
11–20	54 (54)	3 (3)	57 (28.5)
21–30	1 (1)	0	1 (0.5)
Total	100	100	200
Mean±SD	11.3±3.9	4.4±2.4	
Odds ratio	39		
Significance *P* value	<0.0001		

EDV: End-diastolic velocity, SD: Standard deviation

EDV	Cases	Controls
>10	55	3
≤10	45	97
Sensitivity (%)	55	
Specificity (%)	97	
PPV (%)	94.8	
NPV (%)	68.3	

EDV: End-diastolic velocity

EDV	Cases	Controls
>8	85	9
<8	15	91
Sensitivity (%)	85	
Specificity (%)	91	
PPV (%)	90	
NPV (%)	85.8	

EDV: End-diastolic velocity

RI

RI value	Cases *n* (%)	Control *n* (%)	Total *n* (%)
≤0.40	12 (12)	0	12 (6)
0.41–0.50	29 (29)	1 (1)	30 (15)
0.51–0.60	41 (41)	8 (8)	49 (24.5)
0.61–0.70	16 (16)	42 (42)	58 (29)
0.71–0.80	2 (2)	38 (38)	40 (20)
≥0.81	0	11 (11)	11 (5.5)
Total	100	100	200
Mean±SD	0.52±0.09	0.71±0.08	
Odds ratio	46		
Significance *P* value	<0.0001		

RI: Resistive index, SD: Standard deviation

RI value	Case	Control
≤0.6	82	11
>0.6	18	91
Sensitivity (%)	82	
Specificity (%)	91	
PPV (%)	90	
NPV (%)	83.5	

RI: Resistive index

PI

PI value	Cases *n* (%)	Control *n* (%)	Total *n* (%)
0.1–1	58	0	58 (29)
1.1–2.0	33	3	36 (18)
2.1–3	9	3	12 (6)
3.1–4	0	17	17 (8.5)
≥4.1	0	77	77 (38.5)
Total	100	100	200
Mean±SD	1.15±0.45	4.2±0.78	
Significance *P* value		<0.0001	

PI: Pulsatility index, SD: Standard deviation

PI value	Case	Control
<2	91	6
>2	9	94
Sensitivity (%)	91	
Specificity (%)	94	
PPV (%)	93	
NPV (%)	91	

PI: Pulsatility index

PI	Case	Control
<1	58	0
>1	42	100
Sensitivity (%)	58	
Specificity (%)	100	
PPV (%)	100	
NPV (%)	70.4	

PI: Pulsatility index

Systolic/Diastolic (S/D) Ratio

S/D ratio	Cases *n* (%)	Control *n* (%)	Total *n* (%)
1.1–2.0	54 (27)	1 (0.5)	55 (27.4)
2.1–3.0	42 (21)	37 (118.5)	79 (39.5)
3.1–4.0	4 (2)	39 (19.5)	43 (21.5)
≥4.1	0	23 (11.5)	23 (11.5)
Total	100	100	200
Mean±SD	2.2±0.4	3.8±1.5	
Odds ratio	39		
Significance *P* value	<0.0001		

S/D ratio: Systolic/diastolic ratio, SD: Standard deviation

S/D	Cases	Control
≤3.0	94	38
≥3.1	6	62
Sensitivity (%)	94	
Specificity (%)	62	
PPV (%)	71	
NPV (%)	91	

(*Contd*...)

Different Doppler Parameters

Doppler indices	Number of findings				Sensitivity a/a+c (%)	Specificity d/d+b (%)	Predictive value	
	TP (a)	FP (b)	TN (d)	FN (c)			Positive (%)	Negative (%)
OA-PSV	70	25	75	30	70	75	73	71
OA-EDV	85	9	91	15	85	91	90	85.8
OA-RI	82	11	91	18	82	91	90	83.5
OA-PI	91	6	94	9	91	94	93	91
OA-S/D	96	38	62	4	94	62	71	91

OA: Ovarian artery, TP: True positive, TN: True negative, FP: False positive, FN: False negative, PSV Peak systolic velocity, EDV: End-diastolic velocity, PI: Pulsatility index, RI: Resistive index

DISCUSSION

Our study is the first to give absolute values of EDV and S/D ratio in the diagnosis of PCOS. The results of this study demonstrate that there is an increased blood flow in patients of PCOS.

PCOS is the most common female endocrinopathy, affecting 6–8% of women in their reproductive years; however, its exact etiology is still unknown. According to recent studies, the prevalence of PCOS is increasing and in some studies found to be between 22 and 24%.[29,30]

In the present study, we used indices of color Doppler ultrasound for the diagnosis of PCO. It is non-invasive assessment of blood flow. Different studies, however, have shown conflict in values of average RI and average PI of ovarian artery in the diagnosis of PCOS.

Age

The mean age of patients in our study was 26.27±5.4 which was comparable to a study done by Belosi *et al.*[22] in which they found the mean age of patients as 26.38 ± 5.76. Since the controls were age matched, there was no significant difference between the ages of cases and controls.

The main burden of the disease was in between 21 and 30 years.

BMI

Reproductive disturbances are more common in obese women apart from the diagnosis of PCOS. Obese women are more likely to have menstrual irregularities and anovulatory infertility than normal weight women. In reproductive age women, the relative risk of anovulatory infertility rises at a BMI of 24 kg/m^2 and continues to rise with increasing BMI.

Furthermore, PCOS is connected with high rates of glucose intolerance resulting from defects in insulin action and β-cell function. Obesity substantially exacerbates these defects, so obese reproductive age women with PCOS are at very high risk of glucose intolerance.[23]

The mean BMI of cases in my study was 26.275±4.19, and for controls, it was 22.84±4.17. This concurs with a study done by Belosi *et al.*,[22] whereby the mean BMI of cases was 25.89 ± 4.38 and 21.80 ± 3.30 for controls. Furthermore, Battaglia *et al.* measured the mean BMI of 24.4 ± 5.6 for cases in his study on PCOS.[24]

Ovarian Volume

Increase in ovarian volume is essential criteria for the diagnosis of PCOS.

According to Balen *et al.*, the criteria fulfilling sufficient specificity and sensitivity to define PCO should have at least one of the followings: Either 12 or more follicles measuring 2–9 mm in diameter or increased ovarian volume (>10 cm^3). In our study, all of our patients had volume >10 as it was one of the inclusion criteria, but only 6 (2%) of controls had volume above that. Maximum bulk of patients was in between 10 and 19 cc.

In this study, mean ovarian volume of cases was 16.25 ± 4.96, and for controls, it was 5.5 ± 2.4 cc. This concurs with a study done by Belosi *et al.*,[22] in which he found ovarian volume to be 16.04 ± 4.18 for cases and 8.28 ± 1.28 for controls. According to Battaglia *et al.*,[24] the average volume in patients of peripheral cystic group of PCOS was 12.5 ± 2.9 cc.

Number of follicles

A number of follicles of varying sizes increase in PCOS. However, different studies have given different values for a minimum number of follicles.

In our study, the mean number of follicles in cases was 14, and in cases, it was 3. Our study is in accordance with Lujan *et al.*[25] who suggested that a significantly higher threshold than 12 is needed to adequately discriminate between polycystic and normal ovaries and S Jonard *et al.*[12] who modified the ultrasound definition of PCO advocated by Adams *et al.*[13] as follows: "Increased ovarian area (>5.5 cm^2) or volume (>11 ml) and/or presence of ≥12 follicles measuring 2–9 mm in diameter (mean of both ovaries)" with a specificity (99%) and sensitivity (75%). According to Tugrul *et al.*, the mean number of follicles was 13.91 ± 4.11 in cases, whereas they were 5.55 ± 2.34 in the control group ($P < 0.05$).[17]

Echogenic Stroma

Apparent subjective increase in stromal echogenicity in PCO is due to a combination of the raised volume of ovarian stroma and the significantly lower mean echogenicity of the entire ovary in these women. It has been suggested that vascular endothelial growth factor (VEGF) has a part in the maintenance of perifollicular blood flow and recent evidence shows a positive correlation between VEGF and ovarian stromal blood flow velocities in women with ultrasound-diagnosed polycystic ovaries and PCOS.[16] This increased vascularity, possibly mediated by VEGF, is, therefore, probably responsible for the formation of increased stroma and the ultimate phenotype associated with PCOS that is stromal echogenicity.

According to Atiomo*et al.*,[26] the most sensitive features were the presence of 10 or more follicles (82% and 69% in the left and right ovary) and a peripheral distribution of follicles (81.8% and 71.9% in the left and right ovary), and

although ovarian enlargement and stromal brightness were not as sensitive as the previous criteria, stromal brightness was most specific. Combining all the criteria predicted a diagnosis of PCOS or control correctly in 86.4% of cases. They finally concluded that established US criteria of polycystic ovaries remain of value in the diagnosis of PCOS. In our study, echogenic stroma was seen in 98 (98%) of cases and 4(4%) of controls ($P < 0.0001$).

PCOS and PSV

Ovarian vessels are engorged and dilated in patients of PCOS and result in increased vascularity and hence increased PSV.[11] In this study, average PSV of cases was 24.6 ± 9.9, and for controls, it was 15.4 ± 7.02. According to Aleem and Predanic,[15] there is an increase in stromal vascularity and reduced RI and PI in cases of PCOS. Zaidi *et al.*[10] found PSV in cases to be 30.7 ± 4.6. The sensitivity of diagnosing PCOS was 70% if PSV was >20 cm/s with a specificity of 75%; specificity can be increased to 98% if PSV >30 cm/s was considered; however, sensitivity drops to 19%.

PCOS and EDV

Since the vascularity of ovary is increased in PCOS, there is increased in EDV out of proportion to PSV which results in decrease in RI, pulsatlity index, and S/D ratio.

None of the earlier studies have given the values of EDV for the diagnosis of disease. In our study, EDV of cases was 11.3 ± 3.9 and of controls was 4.4 ± 2.4. Pellizari (2002) measured EDV of 2.64 ± 1.75 in controls. The sensitivity of diagnosing PCOS was 55% and specificity 97% if the criteria of velocity >10 cm/s were taken. Setting the threshold at EDV>8 cm/s offered the best compromise between sensitivity (85%) and specificity (91%).

PCOS and RI

The impedance in the blood flow of the ovarian artery was significantly lower in women with PCOS, i.e. the ovarian RI was significantly lower in PCOS group (0.52 ± 0.09 in cases and 0.71 ± 0.08 in controls) as previously reported by Kupesić *et al.*[14] (ovarian RI 0.54 ± 0.05 in cases), Mohammed *et al.* 2003 (0.55 ± 0.16),[19] Bostanci *et al.* 2013[20] (ovarian RI 0.56 ± 0.05), Dolz *et al.* 1999 (0.55 ± 0.08),[27] And Aleem and Predanic 1996 (ovarian RI 0.55 ± 0.01 in cases and 0.78 ± 0.06 in controls).[15] Setting the cutoff as 0.6 offers the best sensitivity (82%) and specificity (91%).

PCOS and PI

Increased vascularity has been demonstrated by color Doppler imaging and pulsed Doppler spectral analysis within the ovary.

In this study, the PI of the ovarian stromal artery was significantly lower (1.15 ± 0.45 in case and 4.2 ± 0.78 in control), i.e., blood flow in ovarian stromal artery was higher in patients with PCOS compared with the controls as reported by Adali *et al.* 2009 (Ovarian PI, 1.40 ± 0.63 in cases and 2.90 ± 0.20 in controls), Dhingra 2017[21] (0.96 + 0.19 in cases and 2.6 + 0.26 in controls), and Battaglia *et al.*[9] The low PI values indicate that ovarian vessels are probably dilated and engorged and more abundant in the ovaries of women with PCOS.[28] A sensitivity of PI <2 in diagnosing PCOS was 91% and specificity was 94%. If the cutoff was to be taken as <1, sensitivity was reduced to 58%, but specificity and PPV became 100%.

PCOS and S/D Index

There was a significant decrease in S/D ratio in cases as compared to controls. According to Fetouh,[29] there was a statistically significant decrease in the right and left ovarian S/D ratio in cases in comparison to controls ($P < 0.001$). These results are also in agreement with those of Ozkan *et al.*,[18] who demonstrated the same in polycystic ovarian patients. Setting the cutoff value as <3.0 gave high sensitivity as 96% but poor specificity (62%).

Sensitivity and Specificity of Various Doppler Indices

Thus, the ovarian artery PI and S/D ratio are the most sensitive and PI is the most specific test in diagnosing polycystic ovarian syndrome.

Overall best indicator is PI followed by EDV. Hence, a combination of above two indicators will help in diagnosing hemodynamic alteration in PCOS in early stage and with more precision than grayscale alone.

CONCLUSION AND SUMMARY

Almost 30% of patients with endocrinologic features of polycystic ovaries may have normal-sized ovaries on sonograms. Alternatively, when polycystic ovaries are an incidental radiologic finding, approximately 25% of the patients have no clinical abnormality.

- The highest incidence of polycystic ovarian syndrome was found in 21–25 years of age group followed by 26–30 years with mean (±standard deviation) of patient 26.27 ± 5.4 years.
- Burden of obesity is more in PCOS patients than normal fertile females.
- There was no significant difference in ovarian volume, follicle number, and stromal echogenicity between the ovaries in the same subject, except two patients in whom the disease was unilateral. Therefore, averaged values of both ovaries were used for statistical analysis in control as well as PCOS women, except in two patients with unilateral disease.
- PCOS patients have increased ovarian volume with majority of patients lying in the range of 10–19 cc.

- The number of follicles increases in PCOS patients with maximum patients lying in the range of 11–15 and mean of 14 and 3 in cases and controls, respectively.
- Increased stromal echogenicity was very sensitive and specific criteria for differentiating PCOS and normal patients, however, are observer dependent.
- Vascularity is significantly increased in ovarian artery and stroma with a reduction in resistance to blood flow in PCOS cases as compared to controls.
- Setting the criteria of velocity 20 cm/s for PSV allows maximum sensitivity (70%) and specificity (75%). If criteria wer S patients, with 91 (91%) of patients having PI<2.0 with a sensitivity of 91% and specificity of 94%. If the value of PI is revised to <1.0, then the specificity becomes 100%.
- Setting the cutoff value as <3.0 for S/D velocity (S/D ratio) gave high sensitivity of 96% but poor specificity (62%).
- Thus, the ovarian artery PI and S/D ratio are the most sensitive tests. PI is the most specific test in diagnosing polycystic ovarian syndrome.
- Overall best indicator is PI followed by EDV. Hence, a combination of above two indicators will help in diagnosing hemodynamic alteration in PCOS in early stage and with more precision than grayscale alone.
- From the above data, it is possible to conclude that PCOS itself does not predetermine a single intraovarian blood flow pattern. However, the combined assessment of ovarian morphology by transabdominal/vaginal ultrasound and color Doppler flow analysis of ovarian arteries may provide insight into the pathological state of the disease. Longitudinal studies with careful follow-up are necessary to corroborate and expand the above findings.

Recommendation

Polycystic ovarian syndrome is a major cause of infertility in female population Since there is variability in diagnostic criteria for PCOS, and also various investigators have suggested different criteria for diagnostic consideration, to establish uniformity, randomized, and prospective studies have to be performed with large sample size.

Our observations confirm that patients with PCOS have significant alterations in ovarian vascular flow. There are no standardized values for Doppler indices in available literature. Hence, more studies are needed in this direction so that Doppler findings can be combined with grayscale findings, and together the diagnostic accuracy of ultrasound can be increased. Observations from this study have confirmed that Doppler evaluation of ovarian arteries can be added to the traditional endocrinological and ultrasonographic parameters clinically used in the diagnosis of PCOS.

REFERENCES

1. Stein IF, Leventhal ML. Amenorrhea associated with bilateral polycystic ovaries. Am J Obstet Gynecol 1935;29:181-8.
2. Azziz R, Woods KS, Reyna R, Key TJ, Knochenhauer ES, Yildiz BO, *et al.* The prevalence and features of the polycystic ovary syndrome in an unselected population. J Clin Endocrinol Metab 2004;89:2745-9.
3. Norman RJ, Davies MJ, Lord J, Moran LJ. The role of lifestyle modification in polycystic ovary syndrome. Trends Endocrinol Metab 2002;13:251-7.
4. Homburg R. Polycystic ovary syndrome from gynaecological curiosity to multisystem endocrinopathy. Hum Reprod 1996;11:29-39.
5. Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group. Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome. Fertil Steril 2004;81:19-25.
6. Balen AH, Laven JS, Tan SL, Dewailly D. Ultrasound assessment of the polycystic ovary: International consensus definitions. Hum Reprod Update 2003;9:505-14.
7. Kurjak A, Zalud I, Jurković D, Alfirević Z, Miljan M. Transvaginal Color Doppler for the assessment of pelvic circulation. Acta Obstet Gynecol Scand 1989;68:131-5.
8. Kurjak A, Jurkovic D, Alfirevic Z, Zalud I. Transvaginal Color Doppler imaging. J Clin Ultrasound 1990;18:227-34.
9. Battaglia C, Artini PG, D'Ambrogio G, Genazzani AD, Genazzani AR. The role of Color Doppler imaging in the diagnosis of polycystic ovary syndrome. Am J Obstet Gynecol 1995;172:108-13.
10. Zaidi J, Campbell S, Pittrof R, Kyei-Mensah A, Shaker A, Jacobs HS, *et al.* Ovarian stromal blood flow in women with polycystic ovaries a possible new marker for diagnosis? Hum Reprod 1995;10:1992-6.
11. Aleem FA, Predanic M. Transvaginal Color Doppler determination of the ovarian and uterine blood flow characteristics in polycystic ovary disease. Fertil Steril 1996;65:510-6.
12. Jonard S, Robert Y, Dewailly D. Revisiting the ovarian volume as a diagnostic criterion for polycystic ovaries. Hum Reprod 2005;20:2893-8.
13. Adams J, Franks S, Polson DW, Mason HD, Abdulwahid N, Tucker M, *et al.* Multifollicular ovaries: Clinical and endocrine features and response to pulsatile gonadotropin releasing hormone. Lancet 1985;2:1375-9.
14. Kupesić S, Marton U, Kurjak A. Polycystic ovary syndrome Doppler parameters. Lijec Vjesn 1996;118 Suppl 1:42-4.
15. Battaglia C, Battaglia B, Morotti E, Paradisi R, Zanetti I, Meriggiola MC, Venturoli S. Two and three-dimensional sonographic and color doppler techniques for diagnosis of polycystic ovary syndrome: The stromal/ovarian volume ratio as a new diagnostic criterion. Journal of Ultrasound in Medicine 2012;31:1015-24.
16. Agrawal R, Sladkevicius P, Engmann L, Conway GS, Payne NN, Bekis J, *et al.* Serum vascular endothelial growth factor concentrations and ovarian stromal blood flow are increased in women with polycystic ovaries. Hum Reprod 1998;13:651-5.
17. Tugrul S, Oral O, Güçlü M, Kutlu T, Uslu H, Pekin O, *et al.* Significance of Doppler ultrasonography in the diagnosis of polycystic ovary syndrome. Clin Exp Obstet Gynecol 2006;33:154-8.
18. Ozkan S, Vural B, Calişkan E, Bodur H, Türköz E, Vural F, *et al.* Color doppler sonographic analysis of uterine and ovarian artery blood flow in women with polycystic ovary syndrome. J Clin Ultrasound 2007;35:305-13.
19. Mohamed A, Ebrahim H. Doppler Study of Uterine and Ovarian Vasculature During different Phases of the Menstrual Cycle in Polycystic Ovarian Disease, Faculty of Medicine. Cairo: Cairo University; 2012.
20. Bostanci MS, Sagsoz N, Noyan V, Yucel A, Goren K. Comprasion of ovarian stromal and uterin artery blood flow measured by Color Doppler ultrasonography in polycystic ovary syndrome patients and patients with ultrasonographic evidence of polycystic. J Clin Gynecol Obstet 2013;2:20-6.
21. Dhingra D, Prateek S, Sinha R, Agarwal Y, Doppler flow velocities of uterine and ovarian arteries and hormonalpatterns in patients with polycystic ovary syndrome (PCOS). Int J Healthc Biomed Res 2017;5:48-57.
22. Belosi C, Selvaggi L, Apa R, Guido M, Romualdi D, Fulghesu AM, *et al.* Is the PCOS diagnosis solved by ESHRE/ASRM 2003 consensus or could it include ultrasound examination of the ovarian stroma? Hum Reprod 2006;21:3108-15.
23. Rich-Edwards JW, Spiegelman D, Garland M, Hertzmark E, Hunter DJ,

Colditz GA, *et al.* Physical activity, body mass index, and ovulatory disorder infertility. Epidemiology 2002;13:184-90.
24. Battaglia C, Artini PG, Salvatori M, Giulini S, Petraglia F, Maxia N, *et al.* Ultrasonographic patterns of polycystic ovaries: Color Doppler and hormonal correlations. Ultrasound Obstet Gynecol 1998;11:332-6.
25. Lujan ME, Chizen DR, Peppin AK, Dhir A, Pierson RA. Assessment of ultrasonographic features of polycystic ovaries is associated with modest levels of inter-observer agreement. J Ovarian Res 2009;2:6.
26. Atiomo WU, Pearson S, Shaw S, Prentice A, Dubbins P. Ultrasound criteria in the diagnosis of polycystic ovary syndrome (PCOS). Ultrasound Med Biol 2000;26:977-80.
27. Dolz M, Osborne NG, Blanes J, Raga F, Abad-Velasco L, Villalobos A, *et al.* Polycystic ovarian syndrome: Assessment with color doppler angiography and three-dimensional ultrasonography. J Ultrasound Med 1999;18:303-13.
28. Loverro G, Vicino M, Lorusso F, Vimercati A, Greco P, Selvaggi L, *et al.* Polycystic ovary syndrome: Relationship between insulin sensitivity, sex hormone levels and ovarian stromal blood flow. Gynecol Endocrinol 2001;15:142-9.
29. Fetouh AA, Mohamed RS. Ovarian Doppler study in polycystic ovary syndrome in relation to body weight. Al Azhar Assiut Med J 2015;13:34-42.
30. Joshi B, Mukherjee S, Patil A, Purandare A, Chauhan S, Vaidya R, *et al.* A cross-sectional study of polycystic ovarian syndrome among adolescent and young girls in Mumbai, India. Indian J Endocrinol Metab 2014;18:317-24.
31. Nainar AT, Loganathan M. PCOS: A raising problem; due to recent trends. Int J Reprod Contracept Obstet Gynecol 2017;6:1762-5.

How to cite this article: Dwivedi S, Ujjaliya MK, Kaushik A. Assessment of the Best Predictor for Diagnosis of Polycystic Ovarian Disease in Color Doppler Study of Ovarian Artery. Int J Sci Stud 2019;6(12):154-162.

Source of Support: Nil, **Conflict of Interest:** None declared.