Assessment of ovarian vascularization in women with PCOS and normal ovarian morphology by three-dimensional power Doppler ultrasonography and correlation with ICSI outcome

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Abstract: **Objective:** Assessment of correlation between ovarian vascularization in women with PCOS and normal ovary and ICSI outcome. **Patients and Methods**: This study included 60 patients recruited from El. Galaa Assisted Reproductive unit and the patients was divided into PCOS group (n=30) and normal group (n=30). All patients first underwent assessment of the right and left ovary using 3D power Doppler ultrasonography, then patients will undergo ICSI treatment regimen. Finally correlation between 3D power Doppler ultrasonography findings and ICSI outcome, then data were set for statistical analysis. **Result:** In comparison between the two groups, there was a statistical significant difference as regarding LH and FSH serum level, ovarian volume, VI, FI, VFI, MG, number of follicles at collection, number of pronuclei embryos and number of embryos transferred. Correlation between 3D power doppler finding and ICSI outcome in the PCOS group in the right ovary revealed strong positive correlation between vascularization index and number of pronuclei embryo. Another weak positive correlation between vascularization flow index and clinical pregnancy rate was found.). In the left ovary a strong positive correlation was found between mean gray value and incidence of OHSS ($r=0.52$, $p<0.05$). There is also significant weak negative correlation between vascularization flow index and total dose of gonadotropin ($r= -0.49$, $p<0.05$). Also, there is a significant weak positive correlation between vascularization flow index and incidence of OHSS. **Conclusion:** Evaluation of the ovarian stromal vascularity by 3D power Doppler will further increase our knowledge of this syndrome.

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1. Introduction:

The polycystic ovary syndrome (PCOS) is one of the most frequent endocrinopathies in women. Its incidence is assessed at 6–8% of the female population in the reproductive age. It is characterized by oligomenorrhea (Oligo), hyperandrogenism (HA), and the presence of polycystic ovaries (PCO) **(Głuszak et al., 2012).**

In 2003, the American Society for Reproductive Medicine/ European Society for Human Reproduction & Embryology consensus workshop on PCOS held in Rotterdam recommended the inclusion of sonographic PCO evidence as an additional diagnostic criterion for PCOS **(Rotterdam ESHRE/ASRM, 2004).** In this workshop, the definition of PCO by ultrasound was based on the presence of > 12 follicles measuring between 2 to 9 mm in diameter per ovary and/or an ovarian volume >10 cm^3. **(Bozdag et al., 2012)**.

Three-dimensional (3D) ultrasound has been introduced in clinical practice. This technique has been shown to be highly reproducible for follicle count and ovarian volume estimation. It also allows a more objective assessment of ovarian vascularization **(Leonhardt et al., 2014)**.

The quantification of power Doppler is used to assess blood flow within the ovary, and quantitative 3D-power Doppler angiography has been used to demonstrate the blood flow around the follicles within the ovary. These tools are new methods with which to analyze effective markers of ovarian function. The power Doppler data within the 3D dataset can be quantified to generate volumetric measures of blood flow within the dataset as a whole, or within specific volumes within the dataset. **(Murai et al., 2010).**

Dramatic changes in the ovarian vasculature are associated with follicle growth and atresia, as well as development and regression of the corpus luteum. Follicular growth is followed by an increase in perifollicular capillary network volume. Findings strongly suggest that the vascular supply plays a critical role in the selection of the dominant follicle that is destined to mature and to ovulate. Furthermore,

findings of an association between perifollicular blood flow and subsequent clinical pregnancy are consistent with the hypothesis that follicular blood flow may be associated with events essential for successful reproduction **(Senaldi et al., 2015)**.

Ovarian blood flow appears to play a crucial role in the development of ovarian follicles when stimulated with gonadotrophins in IVF cycles. More important, follicular blood flow is capable of influencing or mediating oocyte maturation, its potential ability to fertilize and develop and embryo quality **(Balmagambetova et al., 2016)**.

PCOS women undergoing fertility treatment are at increased risk of multiple pregnancies and other adverse outcomes of pregnancy due to ovarian hyperstimulation. Accordingly, after less invasive methods have failed, IVF and ICSI are considered as ideal treatment options aimed at restoring fertility while reducing the chance of twins, triplets and higher-order pregnancies. Since 1978, over one million infants have been born to infertile couples through assisted reproductive technologies (ART). IVF/ICSI is a special type of ART whereby both oocytes and sperm are handled and fertilization occurs outside of the reproductive system. Several steps are taken in an IVF/ICSI treatment cycle. These include ovarian stimulations, oocyte retrieval and fertilization in a liquid medium, embryo selection and embryo transfer into a uterine environment. Therefore, indicators of IVF/ICSI treatment success include process (number and quality of oocytes retrieved, inseminated and fertilized) as well as outcome (pregnancy, miscarriage and live birth rates) measures **(Beydoun et al., 2009).**

A negative correlation between BMI and number of collected oocytes in non-PCOS and PCOS patients was also reported. Furthermore, abnormalities of folliculogenesis and granulose cell function have been observed in patients with PCOS **(Franks et al., 2003)**. The higher percentage of low-quality oocytes in PCOS may promote lower fertilization rates and embryos of poorer quality that have been reported in PCOS patients compared with control women under- going ART. However, others noted comparable general implantation and pregnancy rates in PCOS patients when compared to controls **(Seckin et al., 2016)**.

Patients and Methods

This prospective controlled study enrolled 60 patients from those attending the Assisted Reproductive Center at El Galaa Maternity Teaching Hospital between Jan 2016 till June 2017 with the following inclusion and exclusion criteria.

Based on clinical menstrual history, physical examination, hormonal assay profile and ultrasound findings, the women were divided into two groups:

Study Group (PCOS) Which was consisted of 30 patients of PCOS as diagnosed by ultrasound, with oligo or anovulation and clinical and biochemical features.

Control Group which was consisted of 30 patients with normal ovarian morphology as diagnosed by ultrasound and normal function as diagnosed by hormonal assay.

Inclusion criteria were age from 20 to 37 menstruating female, Primary infertility more than 2 years, First cycle of ICSI, Normal semen analysis, PCOS patients in the study group.

Exclusion criteria were Ovarian failure as diagnosed by hormonal assay, Pathology in uterus or ovary other than PCO, History of medical disorders, History of laparotomy or pelvic surgery, History of ovarian drilling, PCOS patients in the control group.

All patients first will undergo vascular assessment of both ovaries using 3D power Doppler ultrasonography, then patients will undergo ICSI treatment regimen.

Finally correlation between 3D power Doppler ultrasonography findings and ICSI outcome, then data will be set for statistical analysis.

The diagnosis of PCOS was made following Rotterdam criteria; by having two of the following criteria; first, a previous history of anovulatory cycles and/or oligo-ovulation; secondly clinical or biochemical evident of hyperandrogenism and finally; the presence of polycystic ovaries by 2-D transvaginal-ultrasound (The Rotterdam ESHRE/ASRM, 2004). Oligo-ovulation was defined as a menstrual cycle of longer than 35 days. Hyperandrogenism was diagnosed with either clinical or biochemical profiles. Hirsutism was evaluated by modified Ferriman and Gallwey score (mF–G score). PCO was defined as the presence of 12 or more antral follicles in each ovary measuring 2–9 mm in diameter, and/or increased ovarian volume larger than 10 ml (Balen et al., 2003).

All patients were subjected to the following:

Detailed history taking, General and local examinations, Hormonal Profile including Serum FSH, LH, Estradiol, Testosterone, TSH and Prolactin concentrations were determined on day 3-5 of the cycle and Ultrasonographic evaluation.

US evaluation was Done on the same day of hormonal measurements by using a GE Voluson 730 PRO ultrasound system equipped with a transvaginal multi-frequency (5-9 MHz) transducer .

All patients first underwent a 2D B-mode transvaginal ultrasound and Color flow mapping and pulsed Doppler measurements were performed on ovarian stromal blood vessels.

Power Doppler 3D ultrasound was undertaken. The power Doppler characteristics applied were:

normal color quality, color gain 0.8, low wall motion filter of 1 and pulse repetition frequency of 0.6 KHz.

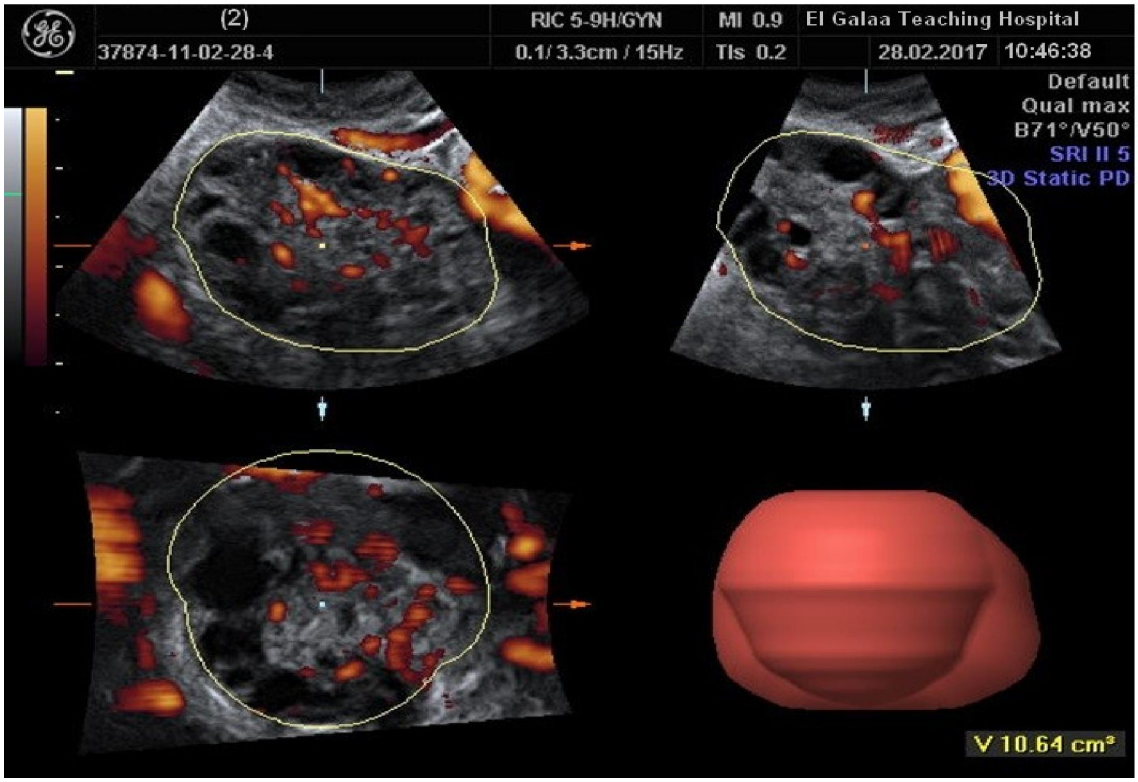

Figure (1): Volume measurement by 3D ultrasound

Figure (2): Histogram and 3D power Doppler indices

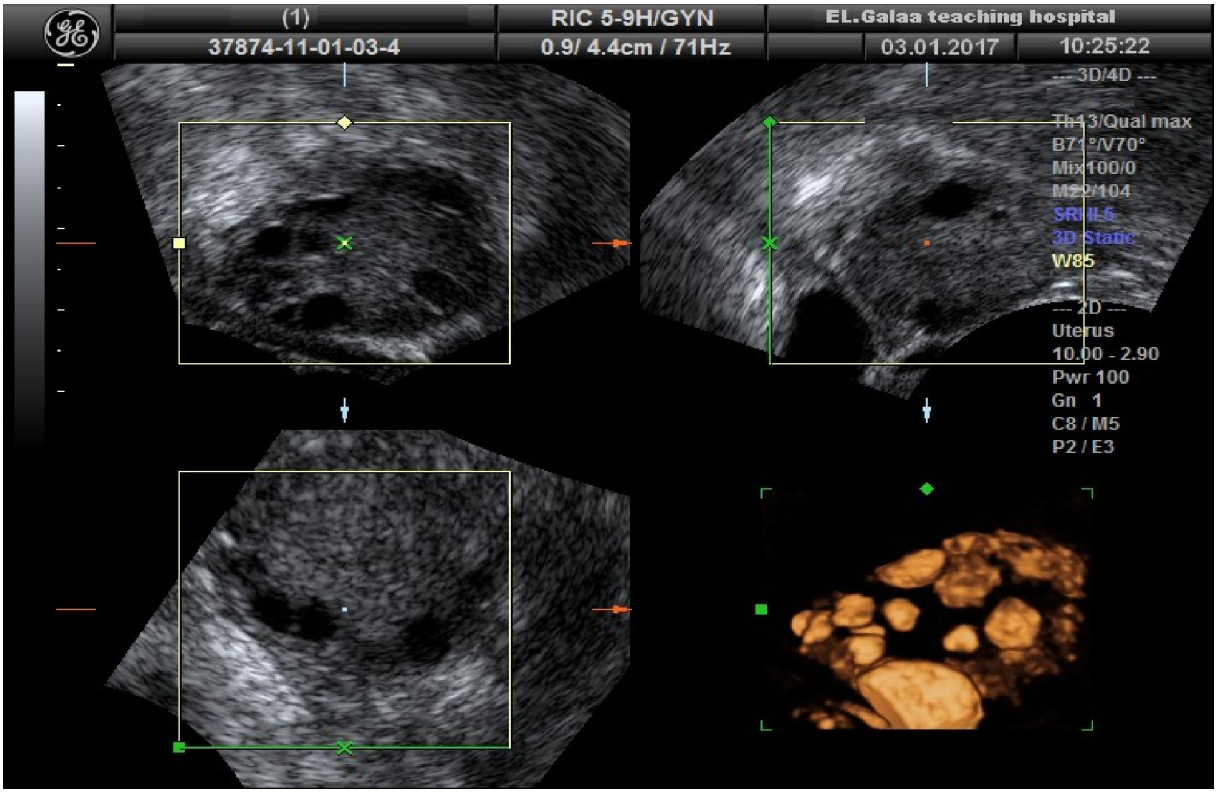

Figure (3): Follicle count by inverted mode

After identifying the ovary the power Doppler gate was activated and adjusted to include the whole ovary. When a satisfactory power Doppler signal was obtained the 3D volume box was opened and adjusted to include the ovary. Then a 3D scan was done with sweep angle set at 90°. Volume acquisition lasted less than 1 min. This produced a multiplanar image showing the whole ovarian surface in three planes (longitudinal, transverse and coronal).

When the volume acquisition was completed, the data file was sent to a personal computer to be analyzed.

The VOCAL imaging program was used to calculate the ovarian volume **(Figure 1),** the 3D power indices and mean gray value. Once the volume was calculated, the ovarian vascularity and echogenicity using the histogram facility was estimated **(Figure 2).** The 3D power Doppler angiography indices calculated were The vascularization index (VI), The flow index (FI), The vascularization flow index (VFI) and The mean gray value (MG) and The number of follicles was counted using the inversion mode **(Figure 3).**

The ICSI treatment regimen using a GnRH agonist long protocol was initiated by pituitary suppression with Decapeptyl 0.1mg once daily subcutaneous starting on day 21 of the previous menstrual cycle.

Once patients were downregulated, Merional (highly purified human menopausal gonadotrophin) was started intramuscular. The dose was determined by the patient's age, BMI, basal serum FSH, LH and E2 levels.

Ultrasound monitoring of follicular response from day 7 of gonadotropins stimulation was then performed. HCG (Choriomon) 5000-10000 IU was then administered intramuscularly when at least three leading follicles were ≥ 16 mm in diameter.

Transvaginal oocyte retrieval was performed after 34-36 hours following hCG administration. ICSI was performed. A maximum of three embryos were transferred to the uterus trans-cervically 3 days later according to the age.

A day 14 post-embryo transfer serum βhCG pregnancy test was then performed. If pregnant, a transvaginal ultrasound 3 weeks later was done to confirm clinical pregnancy.

The following ICSI outcomes were recorded:

- Total dose of HMG for ovarian stimulation.
- Number of follicles at oocyte collection.
- Number of oocytes collected.
- Number of pronuclei embryos.
- Number of embryos transferred on day three.
- Grading of transferred embryos.
- Ovarian hyperstimulation syndrome.
- Clinical pregnancy rate.

- Live birth rate.

Data were statistically described in terms of mean ± standard deviation (± SD), median and range, or frequencies (number of cases) and percentages when appropriate. All statistical calculations were done using computer programs SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

3. Results:

No mature oocytes were collected from three patients so ICSI was not performed and the cycle was cancelled. There were 6 patients showed failure of fertilization so they had no embryos transferred. Contact was lost with 2 patients after proved clinical pregnancy (one patient in the PCOS group and one patient in the control group) so they were not included in live birth rate.

The mean and standard deviation of age for the studied groups PCOS and control was 29.05(4.17) and 29.9(5.56) respectively. In comparison between the two groups, there was a statistical significant difference as regarding LH and FSH serum level, ovarian volume, VI, FI, VFI, MG, number of follicles at collection, number of pronuclei embryos and number of embryos transferred (table 1)

Correlation between 3D power doppler finding and ICSI outcome in the PCOS group in the right ovary revealed strong positive correlation between vascularization index and number of pronuclei embryo ($r=0.52$, $p<0.05$), vascularization flow index and number of pronuclei embryos ($r=0.58$, $p<0.01$). Another weak positive correlation between vascularization flow index and clinical pregnancy rate was found ($r=0.46$, $p<0.05$) (table 2). In the left ovary a strong positive correlation was found between mean gray value and incidence of OHSS ($r=0.52$, $p<0.05$). There is also significant weak negative correlation between vascularization flow index and total dose of gonadotropin ($r= -0.49$, $p<0.05$). Also, there is a significant weak positive correlation between vascularization flow index and incidence of OHSS ($r=0.46$, $p<0.05$) (Table 2).

Lastly, in the control group, as regarding the right ovary, a strong positive correlation is seen between vascularization index and number of follicles at collection ($r=0.66$, $p<0.01$), flow index and number of follicles at collection ($r=0.6$, $p<0.01$), flow index and clinical pregnancy rate ($r=0.59$, $p<0.01$), vascularization flow index and number of follicles at collection ($r=0.77$, $p<0.001$), vascularization flow index and number of oocyte collected ($r=0.73$, $p<0.01$), vascularization index and number of oocytes collected ($r=0.51$, $p<0.05$), flow index and number of oocytes collected ($r=0.56$, $p<0.05$), vascularization flow index with both clinical pregnancy rate ($r=0.55$, $p<0.05$) and live birth rate ($r=0.51$, p0.05). A significant strong negative correlation was found between flow index and total dose of gonadotropins ($r= -0.53$, $p<0.05$). A significant weak positive correlation is found between vascularization index and live birth rate ($r=0.47$, $p<0.05$) and between mean gray value and number of follicles at collection ($r=0.49$, $p<0.05$). A significant weak negative correlation is found between vascularization flow index and total dose of gonadotropins ($r= -0.47$, $p<0.05$). In the left ovary, a significant strong positive correlation between vascularization index and both number of follicles at collection ($r=0.64$, $p<0.01$) and number of oocytes collected ($r=0.51$, $p<0.05$), vascularization flow index with both number of follicles at collection ($r=0.62$, $p<0.01$) and number of oocytes collected ($r=0.59$, $p<0.01$). Correlation between vascularization flow index and clinical pregnancy rate is significant weak positive correlation ($r=0.47$, $p<0.05$). A significant weak negative correlation is found between vascularization flow index and total dose of gonadotropins ($r= -0.45$, $p<0.05$).

Discussion:

In the present study sixty patients was recruited from those attending outpatient clinic and assisted reproduction center at El Galaa Maternity Teaching Hospital. from April 2016 till June 2017. Patients were divided into 2 groups each consisted of 30 patients according to history, examination, hormonal profile and ultrasonographic findings of the ovary.

In the current study the BMI mean in the PCOS group was greater than control groups. These results are in agreement with those of **(Pan et al., 2002)** and **(Demir et al., 2011).** However these results disagreed with those of **(Dolz et al., 1999**) as there was no difference found between the PCOS and the control group as regarding BMI.

In the present study, the mean LH in the PCOS group was higher than the control group. This agrees with the study of **(Agrawal et al., 1998)** who found that basal level of LH was higher in PCOS (mean=9.2) than control (4.5). On the other hand, **Kazer (1995)** found raised serum LH concentrations in 63% of PCOS women.

In the present study, the mean for estradiol serum level was higher in the PCOS group (mean=61.42) than control group (46.09), but with no statistical significant difference between the groups as regarding estradiol and prolactin serum level.

the mean ovarian volume in the PCOS group was higher than the control group (mean ± SD of the PCOS group in the right ovary was 12.09 ± 2.66 cm3 and left ovary was 11.08 ± 2.86 cm3, while mean ± SD of the control group in the right ovary was 5.22 ± 1.03 cm3 and left ovary was 5.37 ± 1.23 cm3). A

statistical significant difference was found between the PCOS and control groups (P=0.000).

The is in agreement with **Wu et al. (2003)** had a published work which included 66 patients undergoing routine gynecologic evaluation and were divided into 2 groups: normal control consisting of 22 patients and 44 patients with PCO.

Similar results were obtained by other investigators as **Pan et al. (2002); Jarvela et al., (2002) and Ng et al., (2005),** who have also demonstrated that the mean ovarian volume was significantly, higher in the women with PCOS compared with the normal ovaries. These results are also in agreement with the present study. **Pache et al., (1992)** found that 20-25% of patients with PCOS had normal ovarian volume.

The current study showed that the mean vascularization index was higher in both ovaries in the PCOS than the control. There was a statistically significant difference between the values of VI between PCOS and control groups (P<0.01).

Also, the mean flow index was higher in both ovaries in the PCOS than the control. There was a statistically significant difference between the values of FI between PCOS and control groups (P<0.01).

Table 1:

			PCOS	Control	P value	Significance
VI	Right ovary	Mean SD Range	5.38 1.57 1.45-8.66	4.02 1.02 2.45-6.17	0.003	HS
	Left ovary	Mean SD Range	5.41 1.84 0.43-10.74	4.18 1.05 2.46-6.68	0.005	HS
FI	Right ovary	Mean SD Range	40.56 4.81 32.75-49.69	31.88 5.88 23.27-44.38	0.000	HS
	Left ovary	Mean SD Range	39.18 5.09 24.68-48.4	33.02 4.86 26.17-41.09	0.002	HS
VFI	Right ovary	Mean SD Range	2.19 0.73 0.6-3.5	1.3 0.49 0.61-2.73	0.000	HS
	Left ovary	Mean SD Range	2.16 0.82 0.1-4.63	1.4 0.48 0.68-2.32	0.001	HS
MG	Right ovary	Mean SD Range	31.42 8.83 12.94-51.93	20.47 4.58 12.49-28.61	0.000	HS
	Left ovary	Mean SD Range	30.72 8.32 13.24-48.91	22.69 4.82 16.43-31.92	0.002	HS
Volume	Right ovary	**Mean** **SD** Range	**12.09** **2.66** 7.03-16.37	**5.22** **1.03** **3.47-7.36**	0.000	HS
	Left ovary	Mean SD Range	11.08 2.86 4.84-16.51	5.37 1.23 3.97-8.24	0.000	HS
FSH (mIU/ml)		Range Mean SD	3-13 6.63 2.55	3.9-13.4 7.92 2.65	0.038	S
LH (mIU/ml)			3.5-16.9 10.04 3.98	2.4-8.6 5.28 1.78	0.000	HS
E2 (pg/ml)		Range Mean SD	20-258 61.42 51.08	19.1-139 46.09 28.94	0.289	NS
Testosterone (ng/ml)		Range Mean SD	0.5-1.4 0.81 0.28	0.2-0.8 0.52 0.14	0.000	HS
Total dose of gonadotropins (in ampoules)		Mean SD Range	38.95 10.69 24-66	44.8 12.77 27-71	0.308	NS
No. of follicles at collection		Mean SD Range	15.55 6.63 3-30	10.65 4.36 4-21	0.003	HS
No. of oocytes collected		Mean SD Range	11 6.03 2-26	9.06 4.49 2-18	0.292	NS
No. of pronuclei embryo		Mean SD Range	4.16 2.58 1-9	4.47 2.9 1-9	0.042	S
No. of embryo transferred		Mean SD Range	3.11 1.28 1-5	2.53 1.12 1-4	0.007	HS

Table 2

		Total dose of gonadotropins	No. of Follicles at col.	No. of Oocytes col.	No. of pronuclei embryo	Ovarian hyperstimulation Syndrome	Clinical Pregnancy rate	Live Birth rate
Rt VI	Correlation Coefficient	-0.335	0.272	0.194	**0.525**	0.260	0.357	0.306
	p value	0.148	0.245	0.411	**0.021**	0.268	0.122	0.203
Rt FI	Correlation Coefficient	-0.313	0.282	0.409	0.356	0.087	0.340	0.306
	p value	0.180	0.229	0.073	0.134	0.716	0.143	0.203
Rt VFI	Correlation Coefficient	-0.390	0.340	0.323	**0.587**	0.260	**0.462**	0.393
	p value	0.089	0.143	0.165	**0.008**	0.268	**0.040**	0.096
Rt MG	Correlation Coefficient	-0.241	-0.028	0.023	0.296	0.231	0.305	0.284
	p value	0.307	0.907	0.924	0.219	0.327	0.191	0.239
Lt VI	Correlation Coefficient	-0.375	0.029	-0.027	0.151	0.405	0.061	0.109
	P value	0.103	0.902	0.909	0.537	0.077	0.798	0.657
Lt FI	Correlation Coefficient	-0.278	-0.168	-0.054	0.071	0.405	-0.044	-0.087
	P value	0.236	0.478	0.820	0.773	0.077	0.855	0.722
Lt VFI	Correlation Coefficient	**-0.491**	-0.024	-0.042	0.113	**0.462**	-0.044	0.087
	p value	**0.028**	0.919	0.859	0.646	**0.040**	0.855	0.722
Lt MG	Correlation Coefficient	-0.275	-0.053	-0.086	-0.010	**0.520**	0.061	0.196
	p value	0.240	0.825	0.720	0.968	**0.019**	0.798	0.420

Table 3

		Total dose of gonadotropins	No. of Follicles at col.	No. of Oocytes col.	No. of pronuclei embryo	Clinical Pregnancy rate	Live Birth rate
Rt VI	Correlation Coefficient	-0.252	**0.668**	**0.515**	0.281	0.391	**0.471**
	p value	0.285	**0.001**	**0.029**	0.311	0.088	**0.036**
Rt FI	Correlation Coefficient	**-0.539**	**0.600**	**0.564**	0.442	**0.591**	0.411
	p value	**0.014**	**0.005**	**0.015**	0.099	**0.006**	0.072
Rt VFI	Correlation Coefficient	**-0.475**	**0.779**	**0.733**	0.385	**0.554**	**0.511**
	p value	**0.034**	**0.000**	**0.001**	0.157	**0.011**	**0.021**
Rt MG	Correlation Coefficient	0.021	**0.491**	0.224	-0.209	0.100	-0.110
	p value	0.929	**0.028**	0.371	0.456	0.675	0.644
Lt VI	Correlation Coefficient	-0.332	**0.642**	**0.519**	0.250	0.409	0.290
	p value	0.152	**0.002**	**0.027**	0.369	0.073	0.214
Lt FI	Correlation Coefficient	-0.406	0.330	0.378	0.336	0.409	0.090
	p value	0.075	0.155	0.122	0.220	0.073	0.706
Lt VFI	Correlation Coefficient	**-0.454**	**0.623**	**0.597**	0.327	**0.473**	0.260
	p value	**0.044**	**0.003**	**0.009**	0.234	**0.035**	0.267
Lt MG	Correlation Coefficient	-0.013	0.406	0.252	-0.104	-0.100	-0.270
	p value	0.957	0.076	0.313	0.711	0.675	0.249

Another significant finding was that the mean vascularization flow index was higher in both ovaries in the PCOS than the control. There was a statistically significant difference between the values of VI between PCOS and control groups (P<0.01).

The results of the present study agrees with **Pan et al. (2002)**, who studied the differences in the ovarian stromal blood flow of women undergoing an ICSI treatment, which was assessed on day 2 or 3 of the menstrual cycle using 3D power doppler ultrasonography to quantify the blood flow and vascularization. Patients were divided into two groups, first with regular, ovulatory menstrual cycles and normal ovaries on ultrasound scan. Second group patients with PCOS. They found that the quantification of Doppler signal in the ovarian stroma appeared to be greater in the PCOS group compared with the normal group. The VI, FI and VFI were significantly higher (p<0.05) in the women with PCOS compared with women with normal ovaries. They concluded that this may help to explain the excessive response often seen during gonadotrophin stimulation, and that a quantification study of the vascular flow, including VI, FI and VFI of the entire ovarian stroma using 3D power doppler is more accurate than the quantification analysis using 2D imaging.

On the other hand, **Pascual et al., (2008)**, used 3D power Doppler angiography (3D-PDA) to study the differences in ovarian echogenicity and vascularization between women with polycystic ovaries and women with normal ovaries. Women were classified into two groups according to the 2003 Rotterdam consensus criteria. The control group comprised women (n = 45) with regular menstrual cycles and proven fertility, whereas the PCO group comprised women (n = 38) with oligo-anovulation, clinical and/or biochemical features of hyperandrogenism, and polycystic ovary morphology at two-dimensional ultrasound. They found no differences in MG, VI, FI and VFI between the groups. They concluded that 3D-PDA indices are not useful for discriminating between normal and polycystic ovaries. These results disagree with the current study.

It is important to say that out of 18 patients with proven clinical pregnancy in PCOS group, only 10 patients delivered living, full term fetus, where, contact was lost with 2 patients after proven clinical pregnancy, 4 aborted at 12 and 17 weeks, 2 suffered a preterm labor at 24 weeks. On the other hand, 10 out of 14 patients delivered living, full term fetus in the control group, where, 2 aborted at 14 weeks and 2 suffered a preterm labor at 28 weeks. This shows that the abortion rate was the higher in the PCOS than the control group but there was no statistical significant difference between the groups (P>0.05).

The results of the current study agree in part with **Heijnen et al. (2006).** They conducted a meta-analysis to compare outcomes of conventional ICSI in women presenting with polycystic ovary syndrome (PCOS) and non-PCOS patients. No difference was observed in chance of embryo transfer per oocyte retrieval between the groups. Significantly more oocytes per retrieval were obtained in PCOS patients compared with controls. The number of oocytes fertilized did not differ significantly between PCOS patients and controls. No significant difference was observed in the clinical pregnancy rates. The incidence of ovarian hyperstimulation syndrome (OHSS) after oocyte retrieval was rarely reported. This meta-analysis demonstrated a lower fertilization rate in PCOS group. Overall, PCOS and control patients achieved similar pregnancy and live birth rates.

Wang et al. (2009) enrolled 189 infertile patients with polycystic ovary syndrome (PCOS), and 142 without PCOS (control) undergoing IVF-ET. The dosage of gonadotrophin, clinical pregnancy rate, spontaneous abortion rate and ovarian hyperstimulation syndrome (OHSS) rate were analyzed and compared between the 2 groups. They found no significant differences in the clinical pregnancy rate between the PCOS group, and control group (51.0% and 46.0%, respectively). Early spontaneous abortion rates were significantly higher in PCOS group than control group (P<0.05). The early spontaneous abortion rates and clinical pregnancy rate showed no significant differences between PCO group and control group (P>0.05). The dosage of Gn was significantly lower and OHSS rate higher in PCOS than in the control group (P<0.05). They concluded that the clinical pregnancy rate of infertile patients with PCOS is similar with control patients undergoing IVF-ET treatment.

Swanton et al. (2010) examined the outcome of ICSI in women who have normal ovaries and PCOS. They found that severe OHSS rates were significantly higher in women with PCOS (15.4%) compared to those with normal ovaries (2.7%). Live birth rates per cycle started are similar among women with PCOS (37%) and normal ovaries (40%).

Mercé et al. (2007) performed a study to evaluate whether three-dimensional ultrasonography (3D-US) and power Doppler angiography (PDA) measurements can predict ovarian response and/or are associated with IVF/ICSI outcome. They recruited 65 women undergoing ICSI cycles. Ovarian volume (OV) and PDA indices: vascularisation index (VI), flow index (FI), and vascularisation flow index (VFI) were evaluated by 3D-US and PDA on the day of pituitary suppression. These measurements were correlated with the number of follicles>10mm on the hCG day and the number of oocytes retrieved. They found that

Ovarian volume, VI, FI and FVI correlate significantly (P<0.01) with the number of follicles and oocytes recovered.

Jayaprakasan et al. (2009) conducted a study to discover if 3D power doppler angiography can be used to predict ovarian hyperstimulation syndrome. They recruited 118 patients undergoing their first cycle of ICSI. Those patients had a three-dimensional (3D) transvaginal ultrasound scan in the early follicular phase of the menstrual cycle preceding ICSI treatment. 18 of them developed moderate or severe OHSS and 100 subjects had normal ovarian response. Ovarian volume and ovarian vascularity (vascularization index, flow index and vascularization flow index) were compared between OHSS and control groups. They showed that the ovarian blood flow indices VI, FI and VFI were similar in the OHSS group and the normal responders. Also, ovarian volume did not differ between the two groups.

Robson et al. (2008) used 3D power Doppler to asses follicle vascularity at the time of oocyte retrieval in ICSI. They found that assessment of follicle vascularity by using 3D power Doppler during oocyte retrieval was found to be reproducible and to add minimally to the workload of the clinician and embryologist. The grade of follicle vascularity did not correlate with the yield of oocytes and fertilization rate. Although the study group was small, there was a statistically significant trend toward higher clinical pregnancy rates when the embryo transfer cohort contained at least one embryo from a highly vascular follicle (50% vs. 15.4%).

In conclusion, the screening technique of three-dimensional ultrasonography can help with 2D ultrasonography for the diagnosis of PCOS. It allows excellent spatial evaluation of PCOS with direct quantitative computations from the data. Evaluation of the ovarian stromal vascularity by 3D power Doppler will further increase our knowledge of this syndrome. Consequently, it is recommended to correlate the stromal blood flow vascularity evaluated by the use of 3D power Doppler with the different modalities of treatment of PCOS and to asses the ovarian vascularity by 3D power Doppler at different timing in relation to ICSI cycle (i.e. at the time of BhCG administration and at the time of oocytes collection). Also, further studies with bigger sample size are recommended.

References:

1. Agrawal R, Conway G, Sladkevicius P, Tan S, Engmann L, Payne N, Bekir J, Campbell S and Jacobs H (1998): Serum vascular endothelial growth factor and Doppler blood flow velocities in in-vitro fertilization: relevance to ovarian hyperstimulation syndrome and polycystic ovaries. Fertil Steril; 70: 651-8.
2. Balen A, Laven J, Tan S and Dewailly D (2003): Ultrasound assessment of the polycystic ovary: international consensus definitions. Hum Reprod Update; 9: 505-14.
3. Balmagambetova A, Abdelazim IA, Bekmukhambetov E, Zhurabekova G, Yehia AH, Abu Faza M (2016): Ovarian parameters and ovarian blood flow of women living in the area of environmental crisis. Eur J Obstet Gynecol Reprod Biol.; 200:68-71.
4. Beydoun H, Stadtmauer L, Beydoun M, Russell H, Zhao Y and Oehninger S (2009): Polycystic Ovary Syndrome, Body Mass Index and Outcomes of Assisted Reproductive Technologies. Reprod Biomed Online; 18: 856-63.
5. Bozdag G, Salman MC, Mumusoglu S, Yapici Z, Gunalp S (2012): Is ovarian volume estimation reliable when compared with true volume? Am J Obstet Gynecol.; 206(1):44.e1-4.
6. Demir B, Pasa S, Demir S, Buyukkaya R, Atay A, Atamer Y and Gul T (2011): Morphologic and functional vascular alterations in patients with polycystic ovary syndrome. Clin Exp Obstet Gynecol; 38: 401-4.
7. Dolz M, Osborne N, Blanes J, Raga F, Abad-Velasco L, Villalobos A, Pellicer A, Bonilla-Musoles F (1999): Polycystic ovarian syndrome: assessment with color Doppler angiography and three-dimensional ultrasonography. J Ultrasound Med; 18: 303-13.
8. Głuszak O, Stopinska-Głuszak U, Glinicki P, Kapuscinska R, Snochowska H, Zgliczynski W and Debski R (2012): Clinical Study Phenotype and Metabolic Disorders in Polycystic Ovary Syndrome. ISRN Endocrinol; 2012: Article ID 569862, 7 pages.
9. Jarvela I, Mason H, Sladkevicius P, Kelly S, Ojha K, Campbell S and Nargund G (2002): Characterization of normal and polycystic ovaries using three-dimensional power Doppler ultrasonography. J Assist Reprod Genet; 19: 582-90.
10. Jayaprakasan K, Jayaprakasan R, Al-Hasie H, Clewes J, Campbell B, Johnson I and Raine-Fenning N (2009): Can quantitative three-dimensional power Doppler angiography be used to predict ovarian hyperstimulation syndrome? Ultrasound Obstet Gynecol; 33: 583-91.
11. Kazer R (1995): Current concepts in polycystic ovary syndrome. Jn: Rock J A, Faro S, Gant N F, Horowitz I R and Murpliy A A (eds.): Advances in Obstetrics and Gynecology (Vol. 20, Mosby-Year Book, Inc., Chicago Illinois), pp. 199-218.
12. Leonhardt H, Gull B, Stener-Victorin E, Hellström M (2014): Ovarian volume and antral

follicle count assessed by MRI and transvaginal ultrasonography: a methodological study. Acta Radiol.; 55(2): 248-56.
13. Mercé L, Barco M, Bau S, Troyano J (2007): Prediction of ovarian response and IVF/ICSI outcome by three-dimensional ultrasonography and power Doppler angiography. Eur J Obstet Gynecol Reprod Biol; 132: 93-100.
14. Murai M, Takatori E, Omi H, Isurugi C, Honda T, Kumagai S, Shoji T, Oyama R, Yoshisaki A and Sugiyama T (2010): Anti-Mullerian hormone and 3D-power Doppler histogram: markers of ovarian function with in vitro fertilization treatment. Reprod Med Biol; 9: 151-61.
15. Ng E, Chan C, Yeung W and Ho P (2005): Comparison of ovarian stromal blood flow between fertile women with normal ovaries and infertile women with polycystic ovary syndrome. Hum Reprod; 20: 1881-6.
16. Pache T, Wladimiroff J, Hop W and Fauser B (1992): How to discriminate between normal and polycystic ovaries: transvaginal US study. Radiol; 183: 421-3.
17. Pan H, Wu M, Cheng Y, Li C and Chang F (2002): Quantification of Doppler signal in polycystic ovarian syndrome using 3D power Doppler ultrasonography. Hum Reprod; 17: 2484.
18. Pascual M, Graupera B, Hereter L, Tresserra F, Rodriguez I and Alcazar J (2008): Assessment of ovarian vascularization in the polycystic ovary by three-dimensional power doppler ultrasonography. Gynecol Endocrinol; 24: 631-6.
19. Robson S, Barry M, Norman R (2008): Power Doppler assessment of follicle vascularity at the time of oocyte retrieval in vitro fertilization cycles. Fertil Steril; 90: 2179-82.
20. Rotterdam ESHRE/ASRM-Sponsored PCOS consensus workshop group (2004): Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome. Fertil Steril; 81: 19-25.
21. Seckin B, Pekcan MK, Bostancı EI, Inal HA, Cicek MN (2016): Comparison of pregnancy rates in PCOS patients undergoing clomiphene citrate and IUI treatment with different leading follicular sizes. Arch Gynecol Obstet.; 293(4):901-6.
22. Senaldi L, Gopi RP, Milla S, Shah B (2015): Is ultrasound useful in the diagnosis of adolescents with polycystic ovary syndrome? J Pediatr Endocrinol Metab.; 28(5-6):605-12.
23. Swanton A, Storey L, Mc Veigh E and Child T (2010): IVF outcome in women with PCOS, PCO and normal ovarian morphology. Eur J Obstet Gynecol Reprod Biol; 149: 68-71.
24. Wang Q, Song J, Chen S, Luo C, Chen X, Li M and Ni Y (2009): Analysis of the clinical outcomes of IVF-ET treatment in infertile patients with polycystic ovary syndrome or polycystic ovaries. Nan Fang Yi Ke Da Xue Xue Bao; 29: 962-5.
25. Wu M, Tsai S, Pan H, Hsiao K, Chang F (2003): Three dimensional power Doppler imaging of ovarian stromal blood flow in women with endometriosis undergoing in vitro fertilization. Ultrasound Obstet Gynecol; 21: 480-5.

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