Doppler and 3D Power Doppler Assessment of the Endometrium and its Correlation to Abortion Rates

Sonal Panchal¹, Chaitanya Nagori², Manish Thaker³

ABSTRACT

Introduction: Endometrial vascularity has been documented as an important factor for the assessment of endometrial receptivity. This study was done to evaluate whether the vascularity of the endometrium is also predictive of prognosis of pregnancy.

Materials and methods: In total, 850 patients undergoing *in vitro* fertilization (IVF) and frozen embryo transfer were recruited for the study. Endometrial preparation was done by artificial cycle protocol in all by estradiol valerate. Evaluation of the endometrium for its thickness and its vascularity as seen on B-mode ultrasound, power Doppler (PD), and pulsed-wave Doppler. Endometrial volume (EV) was calculated by three-dimensional (3D) ultrasound and virtual organ computer-aided analysis (VOCAL) and after acquiring volume of the endometrium with PD. A quantitative assessment of the global vascularity of the endometrium was done by 3D PD to calculate vascularity index (VI), flow index (FI), and vascularity flow index (VFI) for the endometrium. Post-embryo transfer, β -hCG was checked for confirmation of pregnancy in all the patients on day 14 after the embryo transfer, and in all positive cases, ultrasound was done after 10 days of positive β -hCG. All patients with pregnancy were followed up by ultrasound for the entire first trimester and abortions were documented.

Results: Patients with endometrial vascularity in zones 3 and 4, RI < 0.6, had a high conception rate and low miscarriage rate with EV of <1.5 mL, not a single pregnancy was noted. If the endometrial FI before the trigger for ovulation is between 37 and 41 and endometrial VFI was between 25 and 27, not only there are significantly higher chances of leading to conception, but these values also carry a high chance of ongoing pregnancy.

Keywords: 3D power Doppler, Endometrial vascularity, Endometrial volume, Miscarriage rate.

Donald School Journal of Ultrasound in Obstetrics and Gynecology (2020): 10.5005/jp-journals-10009-1638

INTRODUCTION

An increasing trend toward fertility treatment has been observed since more than a decade. In spite of major advances in the *in vitro* fertilization (IVF) technology, the main limiting factor in the improvement of results is implantation. Embryo and the endometrium are the two important factors for implantation. Lot of technical advances for the study of embryo have been implemented. Evaluation of the endometrium is still a limiting factor. Endometrial vascularity has been documented as an important factor for the assessment of endometrial receptivity. Several studies have endorsed the importance of endometrial vascularity in implantation.^{1,2} This study was done to evaluate the role of endometrial vascularity in early pregnancy losses.

MATERIALS AND METHODS

In total, 850 patients undergoing IVF and frozen embryo transfer were recruited for the study. Endometrial preparation was done by estradiol valerate. It was given 2 mg once a day for the first 3 days, followed by 2 mg, twice a day for another 3 days, and then 2 mg estradiol valerate three times a day till the endometrial maturity is achieved. In cases where after 5–6 days of 6 mg of estradiol valerate a day, B-mode and color Doppler parameters of endometrial maturity was not achieved, the dose was increased to 8 mg estradiol valerate a day. Minimum of 12 days and maximum of 28 days of estradiol were given to any patient. All the patients were also given Aspirin 75 mg daily. Transvaginal scan was done for all the patients using a Voluson E10 Ultrasound (GE Medical Systems Kretztechnik GmbH, Zipf, Austria), with 5- to 9-MHz transvaginal volume probe and virtual organ computer-aided analysis (VOCAL) software (GE Medical Systems Kretztechnik GmbH).

^{1,2}Dr Nagori's Institute for Infertility and IVF, Jodhpur, Ahmedabad, Gujarat, India

³Statistics Department, MG Science Institute, Ahmedabad, Gujarat, India

Corresponding Author: Sonal Panchal, Dr Nagori's Institute for Infertility and IVF, Jodhpur, Ahmedabad, Gujarat, India

How to cite this article: Panchal S, Nagori C, Thaker M. Doppler and 3D Power Doppler Assessment of the Endometrium and its Correlation to Abortion Rates. *Donald School J Ultrasound Obstet Gynecol* 2020;14(2):150–156.

Source of support: Nil

Conflict of interest: None

The expected endometrial thickness was minimum 6 mm. The endometrial thickness was measured from anterior outer margin to posterior outer margin of peripheral hyperechoic lines of endometrium, perpendicular to the central endometrial line, at the thickest part of the endometrium (Fig. 1). This is usually about 1–2 cm caudal to the fundal end of the endometrium.

Then, high-definition (HD) power Doppler (PD) is switched on. The pulse repetition frequency for HD flow is set at 0.3 and wall motion filter is set at low setting. The flow box is placed on the midsagittal plane of the endometrium, large enough to include the entire endometrium (Fig. 2). The extent of flow of the endometrium is documented according to the Applebaum's vascularity zones.³

Pulsed-wave Doppler is used to assess the flow in these vessels (spiral vessels, supplying the endometrium). At least three different samples of blood flows are selected for assessment and the lowest RI is selected for decision-making. Endometrial vascularity reaching zones 3 and 4 according to Applebaum's vascularity zones

(intraendometrial flow)³ (Fig. 3) and covering at least 5 mm² area⁴ with resistance index (RI) < 0.6 was considered to be optimal for endometrial receptivity. Moreover, color Doppler is also used for assessment of the uterine artery. Uterine artery is located in the sagittal plane by scrolling the probe laterally from the midsagittal plane of the uterus. A serpiginous anechoic tubular shadow entering the uterus from lateral wall is the uterine artery (Fig. 4). Uterine artery PI of 3.2 was taken as a highest cutoff.⁵

Endometrial volume (EV) was calculated by 3D ultrasound and VOCAL and after acquiring volume of the endometrium with PD (Fig. 5). The step of rotation selected for VOCAL was 9°. A quantitative assessment of the global vascularity of the endometrium was done by 3D PD to calculate vascularity index (VI), flow index (FI), and vascularity flow index (VFI) for the endometrium (Fig. 6). After embryo transfer, micronized progesterone 8% vaginal cream was given twice a day with aqueous progesterone 25 mg daily. Estradiol valerate is continued in the same dose that was given before the transfer for endometrial preparation. Aspirin 75 mg is given daily till 14 days post transfer.

Post embryo transfer, β -hCG was checked for confirmation of pregnancy in all the patients on day 14 after the transfer, and in

all positive cases, ultrasound was done after 10 days of positive β -hCG. After the positive β -hCG, the micronized progesterone 8% vaginal cream was given twice a day, and estradiol valerate is continued in the same dose that was given before the transfer for endometrial preparation. Aspirin 75 mg is given daily. All patients with pregnancy were followed by ultrasound for the entire first trimester with ultrasound done every 2 weeks. Abortion was documented when embryonic pole did not develop till the gestational sac size of 25 mm⁶ or the gestational sac size did not increase for 1 week. (normal growth rate of the gestational sac is 1 mm a day.)

Inclusion Criteria

Patients undergoing IVF treatment with frozen transfer.

Exclusion Criteria

Patients with endometrial polyp, subendometrial fibroid, endometritis, or adenomyosis. Patients having coagulopathies, diabetes mellitus, and thyroid irregularities.

Fig. 1: B-mode image of the midsagittal plane of the uterus with zoom showing measurement of endometrial thickness

Fig. 2: Power Doppler image of the uterus in midsagittal plane showing the PD box by arrow

Figs 3A to D: (A) Midsagittal plane of the uterus with PD showing blood vessels only up to zone 1 (till endometrio-myometrial junction); (B) Midsagittal plane of the uterus with PD HD flow showing blood vessels till zone 2 (till outer hyperechoic line of the endometrium); (C) Midsagittal plane of the uterus with PD showing blood vessels till zone 3 (till the intervening area between the lines in the endometrium); (D) Midsagittal plane of the uterus with PD HD flow showing blood vessels till zone 4 (touching the central line)

Fig. 4: Color Doppler and spectral image uterus showing the uterine artery flow

Fig. 5: Virtual organ computer-aided analysis calculated 3D volume of the uterus acquired with PD

Fig. 6: Virtual organ computer-aided analysis calculated 3D volume of the uterus acquired with PD and 3D PD vascular indices VI, FI, and VFI calculated with volume histogram

Table 1: Endometrial vascularity in zone 1 to zone 4 relating to positive beta hCG, appearance of gestational sac and miscarriages in numbers

Vascularity	Zone 1	Zone 2	Zone 3	Zone 4
Patients	78	151	418	203
+β-hCG	15	46	226	139
Gest. sac	10	40	221	135
miscarriage	4	11	14	8

Table 2: Endometrial vascularity in zone 1 to zone 4 relating to positive beta hCG, appearance of gestational sac and miscarriages in percentage

Vascularity zone	Zone 1 (%)	Zone 2 (%)	Zone 3 (%)	Zone 4 (%)
β-hCG/ET	19	30.4	54	68.4
GS/ET	12	26.4	52.8	66
Abortion/ET	5.12	7.2	3.34	3.9
Abortion/β-hCG	26.66	23.9	6.2	5.75
Abortion/GS	40	27.5	6.33	5.9

STATISTICAL ANALYSIS

Using extended Excel for statistical analysis, measurement data EV, endometrial vascularity index (VI), flow index (FI), and vascularity flow index (VFI) were tested by "t" test for their efficacy to predict abortion primarily though the values were also tested to evaluate their efficacy for prediction and possibility of biochemical pregnancy and ultrasound evidence of pregnancy. The independent samples t test was applied to compare data. A p value < 0.05 was considered statistically significant.

RESULTS

Patients with endometrial vascularity in zones 3 and 4 had a high conception rate and low abortion rate (Tables 1 and 2).

To test the significance difference in EV for hCG positive and hCG negative cases, t test was performed under the null hypothesis.

H_0 : EV for hCG positive = EV for hCG negative.

vs

H_1 : EV is significantly different for hCG positive and hCG negative.

A similar hypothesis was made for other parameters endometrial VI, endometrial FI, and endometrial VFI.

The test showed that the EV was not significantly different for the two groups (hCG positive and hCG negative for the treated cycles), though at and below EV of < 1.5 mL, not a single pregnancy was noted. But there was a significant difference in the endometrial VI, endometrial FI, and endometrial VFI values between the two groups, i.e., mean endometrial VI for hCG positive cases was significantly greater than that for hCG negative cases and same was observed for endometrial FI and endometrial VFI, with t test positive. From the t test table, it is shown that endometrial VI, FI, and VFI are significant for hCG positive cases at 0.000, 0.000, and 0.000, respectively. The VI values for positive hCG were 30.967–34.948, compared with 20.315–23.747 for hCG negative cases. The FI values for positive hCG cases were 35.385–39.099, compared with 20.412–24.558 for hCG negative cases. The VFI values for positive hCG cases were 24.412–27.219, compared with 18.573–21.474 for hCG negative cases.

Now considering only those cases where hCG is positive and to observe significant difference in EV for the presence of gestational sac seen and gestational (G) sac not seen, the null hypothesis made here is

H_0 : There is no significant difference in EV for gestation sac seen and gestation sac not seen cases.

vs

H_1 : There is a significant difference in EV for gestation sac seen and gestation sac not seen cases.

A similar hypothesis is made for other three parameters, endometrial VI, endometrial FI, and endometrial VFI:

H_0 : EV for gestational sac seen = EV for gestational sac not seen.

H_0 : Endometrial VI for gestational sac (G sac) seen = endometrial VI for gestational sac not seen.

H_0 : Endometrial FI for gestational sac (G sac) seen = endometrial FI for gestational sac not seen.

H_0 : Endometrial VFI for gestational sac (G sac) seen = endometrial VFI for gestational sac not seen.

t test was performed for EV, endometrial VI, endometrial FI, and endometrial VFI for gestational sac (G sac) seen and gestational sac not seen cases.

The test showed significant t test for EV, endometrial FI, and endometrial VFI for the two groups (gestational sac seen and gestational sac not seen on ultrasound). Endometrial VI was not found to be significant in this case (Tables 3 to 8).

From the t test table, it is shown that EV, FI, and VFI are significant for appearance of the sac at t values of 0.002, 0.000, and 0.006, respectively. The VI values for G sac seen were 31.591–34.306, compared with 27.575–38.592 for G sac not seen cases. The values are absolutely overlapping and therefore endometrial VI is not a parameter of importance for differentiation of the cases in which in spite of positive β -hCG, gestational sac is less likely to appear.

The FI values for G sac seen were 36.508–40.305, compared with 20.635–29.891 for G sac not seen cases. The VFI values for G sac seen cases were 25.244–27.190, compared with 18.588–24.780 for hCG negative cases.

Now considering all those cases for which hCG is positive and G sac is seen.

To test the significant difference in EV for abortion and no abortion

H_0 : There is no significant difference in EV for abortion and no abortion cases.

vs

H_1 : There is a significant difference in EV for abortion and no abortion.

A similar null hypothesis is constructed for other three parameters:

H_0 : EV for abortion = EV for no abortion.

H_0 : Endometrial VI for abortion = endometrial VI for no abortion.

H_0 : Endometrial FI for abortion = endometrial FI for no abortion.

H_0 : Endometrial VFI for abortion = endometrial VFI for no abortion.

For all those cases in which the hCG was positive and the gestational sac was also documented.

t test was performed for EV, endometrial VI, endometrial FI, and endometrial VFI for abortion and no abortion.

The test showed significant t test for endometrial FI and endometrial VFI for the two groups (abortion and no abortion). Endometrial volume and endometrial VI were not found to be significant in this case.

The FI values for abortion were 22.930–36.955, compared with 37.318–41.159 for no abortion cases. The VFI values for abortion were 18.604–25.509 compared with 25.621–27.631 for no abortion cases. Endometrial FI and endometrial VFI were significant in predicting

Table 3: t test for hCG positive vs hCG negative

<i>hCG</i>		<i>n</i>	<i>Mean</i>	<i>Standard deviation</i>	<i>Standard error mean</i>	<i>3-s Confidence interval</i>	
Endo VI	hCG test negative	416	22.031	11.6688	0.5721	20.3149	23.7475
	hCG test positive	429	32.958	13.7405	0.6634	30.9678	34.9482
Endo FI	hCG test negative	416	22.49	14.094	0.691	20.4124	24.5586
	hCG test positive	429	37.24	12.823	0.619	35.3851	39.0997
Endo VFI	hCG test negative	415	20.024	9.8483	0.4834	18.5737	21.4744
	hCG test positive	429	25.816	9.6906	0.4679	24.4122	27.2194

Table 4: Independent sample test: t test for equality of means

<i>Independent sample test</i>								
<i>t-test for equality of means</i>								
		<i>t</i>	<i>df</i>	<i>Significant (two-tailed)</i>	<i>Mean difference</i>	<i>Standard error difference</i>	<i>95% Confidence interval of the difference</i>	
							<i>Lower</i>	<i>Upper</i>
EV	Equal variances assumed	0.653	843	0.514	0.0686	0.1051	−0.1377	0.2749
Endo VI	Equal variances assumed	−12.442	843	0.000	−10.9268	0.8782	−12.6505	−9.2031
Endo FI	Equal variances assumed	−15.928	843	0.000	−14.757	0.926	−16.575	−12.938
Endo VFI	Equal variances assumed	−8.611	842	0.000	−5.7918	0.6726	−7.1119	−4.4716

Table 5: t-test for G sac positive vs G sac negative given hCG positive

Group statistics									
	hCG		n	Mean	Standard deviation	Standard error mean	Confidence interval		
hCG test positive	EV	Sac test negative	38	3.568	1.3208	0.2143	3.139913	3.99692	2-sigma
		Sac test positive	391	4.400	1.5998	0.0809	4.237938	4.56155	
	Endo VI	Sac test negative	38	33.053	16.8811	2.7385	27.57569	38.5295	2-sigma
		Sac test positive	391	32.949	13.4224	0.6788	31.59124	34.3064	
	Endo FI	Sac test negative	38	25.26	9.509	1.543	20.63561	29.8907	3-sigma
		Sac test positive	391	38.41	12.511	0.633	36.50846	40.3048	
	Endo VFI	Sac test negative	38	21.684	9.5411	1.5478	18.58866	24.7797	2-sigma
		Sac test positive	391	26.217	9.6227	0.4866	25.24411	27.1906	

Table 6: Independent sample test, t test for equality of means for G sac positive vs G sac negative given hCG positive

Independent sample test ^a											
Levene's test for equality of variances				t-test for equality of means							
hCG			F	Significance	t	df	Significance (2-tailed)	Mean difference	Std. error difference	95% Confidence interval of the difference	
hCG test positive	EV	Equal variances assumed	1.766	0.185	-3.101	427	0.002	-0.8313	0.2681	-1.3582	-0.3044
	Endo VI	Equal variances assumed	2.959	0.086	0.044	427	0.965	0.1038	2.3375	-4.4907	4.6983
	Endo FI	Equal variances assumed	3.325	0.069	-6.299	427	0.000	-13.143	2.087	-17.245	-9.042
	Endo VFI	Equal variances assumed	0.140	0.708	-2.774	427	0.006	-4.5332	1.6339	-7.7447	-1.3217

^aNot significant**Table 7:** hCG positive G sac positive and abortion vs no abortion for endometrial FI and endometrial VFI

Group statistics ^a								
	Abortion	n	Mean	Standard deviation	Standard error mean	Confidence interval		
Endo FI	No abortion	356	39.24	12.079	0.640	37.3183	41.1593	3-sigma
	Abortion	35	29.94	13.829	2.337	22.9304	36.9553	
Endo VFI	No abortion	356	26.626	9.4796	0.5024	25.6216	27.6312	2-sigma
	Abortion	35	22.057	10.2123	1.7262	18.6048	25.5095	

^aNot significant**Table 8:** Independent sample test, t test for equality of means for hCG positive G sac positive and abortion vs no abortion

Independent sample test ^a								
t-test for equality of means								
		t	df	Significance (2-tailed)	Mean difference	Standard error difference	95% Confidence interval of the difference	
EV	Equal variances assumed	1.452	389	0.147	0.4108	0.2830	-0.1456	0.9672
Endo VI	Equal variances assumed	-0.894	389	0.372	-2.1273	2.3783	-6.8033	2.5487
Endo FI	Equal variances assumed	4.287	389	0.000	9.296	2.169	5.032	13.559
Endo VFI	Equal variances assumed	2.702	389	0.007	4.5693	1.6910	1.2446	7.8939

^aNot significant

the possibility of abortion with *t* test significant with significance of 0.000 and 0.007, respectively.

DISCUSSION

In this study, we have evaluated the role of 3D and 3D PD indices of the endometrium, before starting progesterone for the preparation in patients undergoing IVF FET cycles in predicting the possibility of conception and also the risk of early miscarriage. In all the patients, the endometrial preparation was done by estradiol valerate and aspirin 75 mg daily. Endometrium was considered to be mature when it was 7–13 mm in thickness and showed a triple-layer pattern or appeared homogeneously isoechoic to the myometrium.⁷ Further evaluation of the endometrium was also done by Doppler, and it was confirmed that the blood vessels reach at least zone 3.³ Progesterone was started after this, and blastocyst transfer was done on the fifth day of starting progesterone. These patients were not only followed up for the conception, but were followed up to 12 weeks for miscarriage.

This study is one of the largest studies done so far, for evaluation of the role 3D and 3D PD for endometrial receptivity, but it also studies if particular values of these parameters have an effect on the ongoing pregnancy. There are a few studies that have used midluteal EV and global vascular indices for prediction of prognosis of pregnancy, but this study is one of the very rare ones that uses preovulatory EV and 3D vascular parameters for the prediction of prognosis of pregnancy.

It is well established in studies,⁸ that midluteal EV and global vascular parameters like VI, FI, and VFI can reflect the pregnancy prognosis and the risk of abortion. This is explainable because in early to early-midluteal phase, the embryo gets implanted in the endometrium, and the endometrial vascularity at that time is very crucial for adequate placentation by conversion of high-resistance spiral vessels into low resistance placental vessels. This is the combined effect of vascular endothelial growth factor (VEGF), placental growth factor (PGF), hCG, and progesterone. Instead of midluteal endometrial parameters, in this study pre-progesterone parameters are taken into consideration.

The concept is that the effect of progesterone and may be even the other factors helping post-implantation changes on the endometrium is dependent on the estrogen priming of the endometrium. It has been already documented that the patients who do not have had adequate estrogen priming of the endometrium developed luteal phase defect and therefore failed to conceive. Estrogen priming can be best assessed by studying the endometrial vascularity by Doppler. Subendometrial vascularity is not taken into consideration, because there is no definite universally accepted thickness of the subendometrial area.⁹ Moreover, the implantation is dependent on the endometrial vascularity more than on the subendometrial vascularity. It is therefore not possible to compare our results with the other studies. But this information can definitely be of more practical use. If the bad pregnancy prognosis and the risk of abortion even if is suspected in the midluteal phase, in larger percentage of cases the time to act for prevention of abortion is passed. Instead if in the pre-progesterone phase, the endometrial vascularity is not adequate, either estrogen priming can be continued for or two more or drugs like aspirin (75 mg), sildenafil, nitrous oxide donor patches, etc., can be given, wait for proper estrogen priming before starting progesterone for the best result. It is also shown that endometrial and subendometrial hypoxia caused by inadequate

blood flow induces low receptivity, which decreases embryo implantation and increases spontaneous abortion.¹⁰

A study by Ng et al., is fairly comparable with our study, and the results are also comparable. According to this study, higher vascularity was observed in endometrium and subendometrium on the day of oocyte retrieval, in patients who got pregnant with live birth following stimulated IVF and frozen embryo transfer (FET) treatment than in those who suffer a miscarriage.¹¹

Patients in the live birth group had significantly higher endometrial VI and VFI and subendometrial VI, FI, and VFI, when compared with those in the miscarriage group on the day of oocyte retrieval. In a multiple logistic regression analysis, only endometrial VI was significantly associated with the chance of live birth with an odds ratio (OR) of 1.384 [95% confidence interval (CI) 1.025–1.869, $p = 0.034$]. In the prediction of live birth, in FET cycles, the area under the receiver operating characteristic (ROC) curve for endometrial VI was 0.64 and the odds ratio (OR) was 3.2 (95% CI: 1.5–6.8) with a cutoff of >0.306 .¹¹

A study by Merce et al. is also comparable with ours, according to which EV and endometrial VI, FI, and VFI on the day of trigger were all significantly higher in the pregnant group than in the nonpregnant group in patients undergoing IVF/ICSI and ET with area under ROC curve was statistically significant for EV (0.746), VI (0.724), FI (0.828), and VFI (0.800) when no grade I embryos or only one were transferred. These parameters were statistically significant in predicting a normal pregnancy outcome (no early pregnancy loss).¹²

Another study has also shown that endometrial thickness, EV, endometrial VI, FI, and VFI of the midluteal phase were lower in the recurrent miscarriage group compared with the normal pregnancy group ($p < 0.05$). Though this study is not comparable with our study because this study is done on patients with recurrent pregnancy loss and again the endometrial evaluation is done in the midluteal phase of nontreatment cycle.⁸

In a study on evaluation of the EV before appearance of the gestational sac, it has been shown that 3D ultrasound measurement of EV of less than 2 mL during early IVF pregnancy and prior to the appearance of gestational sac is a powerful predictor of pregnancy loss.¹³

Other studies like that by Yaman et al., established a cutoff of 2.5 mL volume of endometrium to favor pregnancy, but this study does not investigate the abortion rates with EV or thickness.¹⁴ A study by Raga et al. shows very little chance of pregnancy for EV of <2 mL.¹⁵ Our group demonstrated that the best intraclass correlation indexes to measure the EV and endometrial VIs with the VOCAL program could be obtained working in the coronal or "C" plane with a rotational angle of 9° .¹⁶

Zohav et al.¹³ and Kovachev et al.¹⁷ applied 3D ultrasound to 60 patients after the 15th to 17th day of transplant. They found that the miscarriage rate was higher when EV was <2 mL compared with those >2 mL. Schild et al.¹⁸ considered that for the minimum EV of 1.59 mL and below that volume, the miscarriage rate was very high. Though in their earlier study, they did not find difference in pregnancy rate for lower volumes.¹⁹

A study quite similar to ours has shown that in stimulated IVF cycles, 45 (28.0%) out of 161 pregnant patients subsequently miscarried. Patients in the live birth group had significantly higher endometrial VI and VFI and subendometrial VI, FI, and VFI, when compared with those in the miscarriage group. In a multiple logistic regression analysis, only endometrial VI was significantly

associated with the chance of live birth with an OR of 1.384 (95% CI: 1.025–1.869, $p = 0.034$). For FET cycles, patients in the live birth group had significantly higher endometrial VFI and subendometrial VI and VFI than those in the miscarriage group.¹¹

Detection of the subendometrial VFI by 3D ultrasound may be useful for predicting the pregnancy rate for patients undergoing IVF–embryo transfer.^{14,20}

CONCLUSION

A very interesting fact is that the degree of change in endometrial perfusion from the late follicular phase through to the early luteal phase is a more important determinant of implantation.²¹

In IVF/ICSI cycles, 3D ultrasound power doppler angiography (PDA) is useful for evaluating endometrial receptivity. Endometrial volume and 3D PD indexes are statistically significant in predicting the cycle outcome when one grade I or no grade I embryos are transferred.¹² Considering the values of this study, if the endometrial FI before the trigger for ovulation is between 37 and 41 and endometrial VFI was between 25 and 27, not only there are significantly higher chances of leading to conception, but these values also carry a high chance of ongoing pregnancy. Adding these values for pre-trigger endometrial receptivity evaluation improves the outcome of the infertility treatment for live births.

REFERENCES

- Kupesic S, Kurjak A. Uterine and ovarian perfusion during the periovulatory period assessed by transvaginal colour Doppler. *Fertil Steril* 1993;60(3):439–443. DOI: 10.1016/s0015-0282(16)56157-3.
- Zaidi J, Campbell S, Pittrof R, et al. Endometrial thickness, morphology, vascular penetration and velocimetry in predicting implantation in an in vitro fertilization program. *Ultrasound Obstet Gynecol* 1995;6(3):191–198. DOI: 10.1046/j.1469-0705.1995.06030191.x.
- Applebaum M. The 'steel' or 'teflon' endometrium—ultrasound visualization of endometrial vascularity in IVF patients and outcome. Presented at the third world congress of ultrasound in obstetrics and gynecology. *Ultrasound Obstet Gynecol* 1993;3:10.
- Yang GH, Yang JH, Wu MY, et al. Association of endometrial blood flow as determined by a modified colour Doppler technique with subsequent outcome of in-vitro fertilization. *Hum Reprod* 1999;14(6):1606–1610. DOI: 10.1093/humrep/14.6.1606.
- Zaidi J, Pittrof R, Shaker A, et al. Assessment of uterine artery blood flow on the day of human chorionic gonadotrophin administration by transvaginal colour Doppler ultrasound in an in vitro fertilization program. *Fertil Steril* 1996;65(2):377–381. DOI: 10.1016/s0015-0282(16)58103-5.
- Jeve Y, Rana R, Bhide A, et al. Accuracy of first trimester ultrasound in the diagnosis of early embryonic demise: a systematic review. *Ultrasound Obstet Gynecol* 2011;38(5):489–496. DOI: 10.1002/uog.10108.
- Smith B, Porter R, Ahuja K, et al. Ultrasonic assessment of endometrial changes in stimulated cycles in an in vitro fertilization and embryo transfer program. *J In Vitro Fert Embryo Transf* 1984;1(4):233–238. DOI: 10.1007/BF01131622.
- Tan SY, Hang F, Puvarshi G, et al. Decreased endometrial vascularity and receptivity in unexplained recurrent miscarriage patients during midluteal and early pregnancy phases. *Taiwan J Obstet Gynecol* 2015;54(5):522–526. DOI: 10.1016/j.tjog.2014.10.008.
- Kupesic S, Bekavac I, Bjelos D, et al. Assessment of endometrial receptivity by transvaginal color Doppler and three-dimensional Power Doppler ultrasonography in patients undergoing in vitro fertilization procedures. *J Ultrasound Med* 2001;20(2):125–134. DOI: 10.7863/jum.2001.20.2.125.
- Goldstein SR, Kerenyi T, Scher J, et al. Correlation between karyotype and ultrasound findings in patients with failed early pregnancy. *Ultrasound Obstet Gynecol* 1996;8(5):314–317. DOI: 10.1046/j.1469-0705.1996.08050314.x.
- Ng EHY, Wai Chan CC, Tang OS, et al. Endometrial and subendometrial vascularity is higher in pregnant patients with livebirth following ART than in those who suffer a miscarriage. *Hum Reprod* 2007;22(4):1134–1141. DOI: 10.1093/humrep/del458.
- Merce LT, Barco MJ, Bau S, et al. Are endometrial parameters by three-dimensional ultrasound and Power Doppler angiography related to in vitro fertilization/embryo transfer outcome? *Taiwan J Obstet Gynecol* 2015;52(2):523–526.
- Zohav E, Orvieto R, Anteby EY, et al. Low endometrial volume may predict early pregnancy loss in women undergoing in vitro fertilization. *J Assist Reprod Genet* 2007;24(6):259–261. DOI: 10.1007/s10815-007-9121-1.
- Yaman C, Ebner T, Sommergruber M, et al. Role of three-dimensional ultrasonographic measurement of endometrium volume as a predictor of pregnancy outcome in an IVF-ET program: a preliminary study. *Fertil Steril* 2000;74(4):797–801. DOI: 10.1016/s0015-0282(00)01493-x.
- Raga F, Bonila-Musoles F, Casan EM, et al. Assessment of endometrial volume by three-dimensional ultrasound prior to embryo transfer: clues to endometrial receptivity. *Hum Reprod* 1999;14(11):2851–2854. DOI: 10.1093/humrep/14.11.2851.
- Merce LT, Alcazar JL, Engels V, et al. Endometrial volume and vascularity measurements by transvaginal three-dimensional ultrasonography and Power Doppler angiography in stimulated and tumoral endometria: Intraobserver reproducibility. *Gynecol Oncol* 2006;100(3):544–550. DOI: 10.1016/j.ygyno.2005.09.024.
- Kovachev E, Zh G, Cherneva S, et al. Of endometrial volume and endometrial thickness for assessment of endometrial receptivity in assisted reproductive techniques. *Akush Ginekolo (Sofia)* 2005;44(Suppl. 2):27–33.
- Schild RL, Knobloch C, Dorn C, et al. Endometrial receptivity in an in vitro fertilization program as assessed by spiral artery blood flow, endometrial thickness, endometrial volume, and uterine artery blood flow. *Fertil Steril* 2001;75(2):361–366. DOI: 10.1016/s0015-0282(00)01695-2.
- Schild RL, Indefrei D, Eschweiler S, et al. Three dimensional endometrial volume calculation and pregnancy rate in an in-vitro fertilization program. *Hum Reprod* 1999;14(5):1255–1258. DOI: 10.1093/humrep/14.5.1255.
- Wu HM, Chiang CH, Huang HY, et al. Detection of the subendometrial vascularization flow index by three-dimensional ultrasound may be useful for predicting the pregnancy rate for patients undergoing in vitro fertilization-embryo transfer. *Fertil Steril* 2003;79(3):507–511. DOI: 10.1016/s0015-0282(02)04698-8.
- Raine-Fenning NJ, Campbell BK, Kendall NR, et al. Endometrial and subendometrial perfusion are impaired in women with unexplained subfertility. *Hum Reprod* 2004;19(11):2605–2614. DOI: 10.1093/humrep/deh459.