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Assessment of uterine receptivity by the endometrial–subendometrial blood flow distribution pattern in women undergoing in vitro fertilization–embryo transfer

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Objective: To investigate the correlation of blood flow detected by color Doppler sonography in the endometrial–subendometrial unit with pregnancy outcome of IVF-ET treatments.

Design: Prospective clinical study.

Setting: University setting.

Patient(s): Six hundred twenty-three patients selected prospectively on the day of ET.

Intervention(s): Transvaginal ultrasound examination was performed before ET.

Main Outcome Measure(s): Association between pregnancy outcome and distribution of endometrial–subendometrial blood flow (primary outcome measure) and between pregnancy rate and endometrial measurements as well as uterine arterial blood flow (secondary outcome measures).

Result(s): The overall pregnancy rate was 28.4% (177/623) per ET. The pregnancy and implantation rates of patients with the presence of both endometrial and subendometrial flow were 47.8% (64/134) and 24.2% (94/388); for patients with subendometrial flow only, 29.7% (102/343) and 15.8% (153/967); and for patients with no detectable endometrial–subendometrial flow, 7.5% (11/146) and 3.5% (13/376), respectively. The presence of both endometrial and subendometrial blood flow is indicative of good endometrial receptivity, whereas the absence of both represents a poor uterine environment. Nondetectable endometrial–subendometrial flow was associated with women who were older, had a thinner endometrium, and had higher uterine arterial resistance compared with those women who had detectable flow.

Conclusion(s): Endometrial–subendometrial blood flow distribution pattern assessed by transvaginal color Doppler before ET is correlated with the implantation and pregnancy rate of IVF treatment. (Fertil Steril® 2002;78:245–51. ©2002 by American Society for Reproductive Medicine.)

Key Words: Color Doppler, endometrial–subendometrial unit, blood flow, endometrial receptivity, in vitro fertilization

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The condition of the uterus during IVF treatment at present mainly is assessed by ultrasonographic examination. Sonographic evaluation of endometrial thickness and texture has been used for endometrium assessment, but it is not possible to predict the likelihood of pregnancy based solely on this method. The introduction of transvaginal Doppler ultrasound makes the measurement of uterine artery blood flow possible, and at one time it was hoped that uterine arterial resistance changes might reflect uterine receptivity (1–3). Although pregnancy outcome tended to be poor in patients with higher mean uterine arterial impedance indices, the predictive value of using a specific resistance index (RI) or pulsatility index (PI) variable in assessing endometrial receptivity seems to be limited (4, 5). One of the explanations is that the major uterine compartment is the myometrium and not the endometrium, and thus most of the blood passing through the uterine arteries never reaches the endometrium. A more logical approach would be to evaluate the vascularization around the endometrium directly in an attempt to assess endometrial receptivity.

Endometrial blood flow studies, either with conventional color Doppler sonography (6, 7) or the newer techniques of power and three-dimensional (3-D) power Doppler sonography (8–10), have become clinically feasible in recent years. Although initial studies showed promising results in predicting the pregnancy outcome of IVF-ET treatments (6, 7), some recent investigations failed to demonstrate significant differences between pregnant and nonpregnant patients (11–13). Different approaches in measuring endometrial blood flow between these studies may have contributed to the inconsistent conclusions.

Blood flow to the endometrium comes from the radial artery, which divides after passing through the myometrial–endometrial junction to form the basal arteries that supply the basal portion of the endometrium, and the spiral arterioles that continue up toward the endometrial surface. At the myometrial–endometrial junction, a specific subendometrial area can be identified as a thin hypoechoic layer between the echogenic endometrium and myometrium on ultrasound examination (14–16). It has been described as the subendometrial halo or the junctional zone of the myometrium. Histological studies have confirmed that the subendometrial halo surrounding the endometrium represents the innermost layer of the myometrium, and compared with the outer myometrium, it consists of a distinct compartment of more tightly packed muscle cells with increased vascularity (15, 16). Many studies have shown that interactions between the junctional zone and the endometrium may play an important role in the implantation process (17, 18).

Considering that the blood supply to the endometrium must go through this area, vascularization within the subendometrial region may be related to endometrial perfusion and, ultimately, endometrial function. In this report, we investigate the correlation of blood flow in the endometrial–subendometrial region detected by color Doppler sonography with pregnancy outcome of an IVF-ET program.

MATERIALS AND METHODS

Patient Characteristics

A total of 623 women were recruited from our IVF-ET program between January, 1996 and June, 2000. The inclusion criterion was that the participant had at least one good-quality embryo, as defined by the morphology criteria, for transfer on the 2nd or 3rd day after oocyte retrieval. The mean age of the women was 33.8 years (range, 22–42 years), and 297 (47.7%) of them had primary infertility. The predominant diagnoses were male-factor infertility (n = 256, 41.1%), endometriosis (n = 188, 30.2%), tubal occlusion (n = 134, 21.5%), endocrinological abnormalities (n = 12, 1.9%), or unexplained infertility (n = 33, 5.3%). Exclusion criteria were distortions of the uterine cavity detected during transvaginal ultrasound examinations. All patients were included in this study only once to avoid selection bias. The study was approved by the institutional review board of Taipei Medical University Hospital, and each woman gave verbal informed consent.

Ovarian Hyperstimulation and IVF Procedures

Women whose partners had severe male factors were treated with intracytoplasmic sperm injection procedures, whereas standard IVF techniques were used for other patients. Briefly, GnRH-agonist suppression either in an ultrashort protocol by s.c. injections of buserelin acetate (Supremon, 0.5 mg/d; Hoechst, Frankfurt am Main, Germany), started on the 2nd day of the menstrual cycle for a fixed 3-day treatment course, or in an ultralong protocol by monthly leuprolide acetate (Leuplin Depot, 3.75 mg; Takeda Chemical Industries, Osaka, Japan) injection on the 2nd day of the menstrual cycle for 2–3 months was used. Ovarian hyperstimulation was then initiated with FSH (Metrodin; Serono, Rome, Italy) and hMG (Pergonal; Serono). Human chorionic gonadotropin (HCG-SERONO; Serono) at 10,000 IU was given i.m. when there were at least two leading follicles with a diameter of >16 mm. Oocytes were retrieved by transvaginal ultrasound-guided follicular aspiration 34–36 hours after hCG injection.

The embryos were evaluated before transfer based on the fragmentation pattern previously outlined by Alikani et al. (19), with fragmentation pattern I exhibiting minimal fragments and pattern V exhibiting extensive fragmentation. Embryos with fragmentation pattern I to fragmentation pattern III were defined as good quality in this study. Micronized vaginal progesterone (Utrogestan; Laboratories Piette International, Brussels, Belgium) was used for luteal support. Serum β-hCG levels were measured 14 days after ET, and, if positive, micronized progesterone was continued for 4 weeks.

Ultrasound Investigation

On the day of ET, transvaginal sonography examination using a 5-MHz transvaginal transducer (C5 IVT) with color Doppler facility (ATL Ultramark 9) was performed between 1:00 P.M. and 3:00 P.M. with the patient in the lithotomy position. All ultrasound scans were performed by L.W.C. When a longitudinal view of the uterus was obtained, the color Doppler mode was activated. The area of interest was the endometrium and the subendometrial regions within 10 mm of the echogenic endometrial borders. The pulse repetition frequency was chosen for a color velocity range of 3 cm/s, and the color gain was adjusted to 80% ± 2% to optimize detection of blood flow in the small vessels. Identical color Doppler settings were used in all patients to standardize the examination.

The layer comprising the subendometrial myometrium could be documented as a sonographically hypoechoic band (the halo) that regularly encircled the endometrium at the level of the uterine cavity. In most cases, the expanded halo was hypoechoic in appearance, but in some cases it was found to be intermediately echogenic or isoechoic in comparison to the myometrium. With real-time measurements, however, it was always possible to determine the boundary between the expanded halo and the outer myometrium.

The endometrial–subendometrial blood flow distribution pattern was determined by demonstrating pulsatile color signals in the subendometrial and endometrial regions. For those with vascularization penetrating the subendometrial area, we adopted the definition from Applebaum (6), summarized as follows: zone 1, vessels penetrating the outer hypoechogenic area surrounding the endometrium but not entering the hyperechogenic outer margin; zone 2, vessels penetrating the hyperechogenic outer margin of the endometrium but not entering the hypoechogenic inner area; and zone 3, vessels entering the hypoechogenic inner area. The blood flow distribution pattern was observed at the beginning and the end of the ultrasound examination. If different patterns were observed, the pattern with deeper vascular penetration into the endometrium was adopted for analysis.

Doppler sonography was then performed on the vessels with the highest color intensity within the innermost endometrial–subendometrial area. The insonation angle was kept at 0° because the course of the small spiral arteries could not be determined. After confirming that waveforms were continuous, an average of three to five cardiac cycles was selected for calculation of RI, PI, maximum peak systolic blood flow velocity (Vmax), and time-averaged peak systolic blood flow velocity (Vmean). The vessel with the lowest PI was considered for further statistical analysis.

Uterine circulation was assessed simultaneously in each examination; bilateral uterine arteries were sampled lateral to the cervix near the internal os. Mean levels of both uterine RI and PI were used for analysis. The temporal average intensity of the spatial peak of ultrasound for B-mode and Doppler examinations was <50 mW/cm, and the total examination time was kept to ≤15 minutes. The intraobserver variation of Doppler flow measurement was 7.8% ± 2.5%.

Diagnosis of Pregnancy

Clinical pregnancy was defined as the presence of gestational sac by ultrasound with appropriately rising β-hCG levels. The diagnosis of extrauterine pregnancy was confirmed by laparoscopy. Miscarriage was defined as pregnancy loss before 20 weeks of gestation.

Statistical Analysis

Continuous data are presented as mean ± SD. Comparisons among the groups for pregnancy outcome variables were made by Fisher's exact test or χ^2 test, adjusted for multiple comparisons using the Bonferroni technique. For comparisons among the groups for prognostic factors, the Mann-Whitney *U* test and Kruskal-Wallis test were used where appropriate. Multiple linear regression techniques were performed to adjust the confounding factors that may affect the pregnancy outcome between patients with presence or absence of subendometrial flow. A *P* value of <.05 was considered statistically significant.

TABLE 1

Clinical details of patients.

Parameter	Nonpregnant (n = 446)	Pregnant (n = 177)	*P* value[a]
Age (y)	34.2 ± 3.8	32.8 ± 3.5	<.0001
Duration of infertility (y)	4.5 ± 2.4	4.2 ± 2.2	NS
Duration of stimulation (d)	10.0 ± 1.7	9.9 ± 2.1	NS
Oocytes retrieved (no.)	7.2 ± 4.3	8.6 ± 4.0	.004
Embryos transferred (no.)	2.6 ± 1.2	3.1 ± 1.1	<.0001
Endometrial thickness (mm)	10.9 ± 2.6	11.2 ± 2.5	NS
Serum E_2 (pg/mL)	798.5 ± 752.0	889.7 ± 789.8	NS
Serum P (ng/mL)	107.0 ± 74.2	114.4 ± 85.3	NS
Uterine arterial RI	0.85 ± 0.10	0.85 ± 0.07	NS
Uterine arterial PI	2.56 ± 0.77	2.37 ± 0.51	NS

Note: Values are mean ± SD. NS = not significant.

[a] By Mann-Whitney *U* test.

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RESULTS

The overall pregnancy rate was 28.4% (177/623) per ET, with 16.9% (30/177) aborted and 7.3% (13/177) being extrauterine pregnancies. There were no significant differences between the pregnant and nonpregnant groups with regard to the duration of infertility, duration of gonadotropin stimulation, endometrial thickness, or serum estradiol or progesterone concentrations on the day of ET (Table 1). The mean age of the women who became pregnant was lower than that of those who did not achieve pregnancy ($P<.0001$ by Mann-Whitney *U* test). The mean number of oocytes aspirated and mean number of embryos transferred were significantly higher in pregnant patients than in nonpregnant patients ($P=.004$ and $P<.0001$, respectively).

Subendometrial blood flow was detected in 477 (76.6%) cases; pregnancy and implantation rates were significantly higher for these than for those with no detectable flow ($P<.0001$, Table 2). After adjustment for the age and the number of embryos transferred, patients with presence of flow were estimated to be 5.9 times as likely to become pregnant as were those with absence of flow (OR = 5.9; 95% CI = 3.2 to 11.9; $P=.0001$).

The degree of vascular penetration into the endometrium in relation to pregnancy outcome is shown in Table 2. Although pregnancy and implantation rates were significantly higher in patients with zone 3 penetration compared with zone 1 or zone 2 penetration, there was no significant difference between the groups with zone 1 and zone 2 penetration. Therefore, we propose a classification based on the blood flow distribution over the endometrial–subendometrial region to simplify the examination.

Group A represents patients with no flow in the region, group B represents patients with subendometrial flow but without endometrial flow, and group C represents patients

TABLE 2

Pregnancy and implantation rates in relation to the presence or absence of subendometrial blood flow and zone of vascular penetration.

Parameter	Pregnancy rate, % (n/N)	Implantation rate, % (n/N)
Flow		
Present	34.8 (166/477)[a]	18.2 (247/1,355)[a]
Absent	7.5 (11/146)	3.5 (13/376)
Zone		
1	28.0 (35/125)[b]	13.4 (46/343)[c]
2	30.7 (67/218)	17.1 (107/624)
3	47.8 (64/134)	24.2 (94/388)

[a] $P<.0001$ by χ^2 test.

[b] Zone 1 vs. zone 2, $P=.28$; zone 1 vs. zone 3, $P=.0011$; zone 2 vs. zone 3, $P=.0013$. All by χ^2 test. The P value that indicates statistical significance after the Bonferroni correction is .0167.

[c] Zone 1 vs. zone 2, $P=.17$; zone 1 vs. zone 3, $P=.0009$; zone 2 vs. zone 3, $P=.03$. All by χ^2 test. The P value that indicates statistical significance after the Bonferroni correction is .0167.

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with the presence of both subendometrial and endometrial flow (Fig. 1). There were significant differences in pregnancy outcome among these three groups of patients (Table 3); group C had the highest pregnancy rate and implantation rate, and group A had the lowest rates (group C, 47.8% and 24.2%; group B, 29.7% and 15.8%; and group A, 7.5% and 3.5%). The miscarriage rate of group A was significantly higher than that of those in group B or group C (54.5% vs. 15.2% or 12.5%; $P=.0068$ and $P<.0001$, respectively).

Patients in group A were significantly older than those in group B or group C ($P=.0029$ and $P=.0022$, respectively, by Mann-Whitney U test; Table 4). The duration of infertility, duration of stimulation, number of oocytes aspirated or embryos transferred, and serum estradiol or progesterone showed no significant differences among the three groups of patients (Table 4). Group C patients had the thickest endometrium (12.0 ± 2.4 mm), and those in group A had the thinnest endometrium (10.1 ± 2.3 mm) on the day of ET ($P<.0001$ by Kruskal-Wallis test). Mean uterine arterial resistance, either RI or PI value, was highest in group A patients (group A: 0.88 ± 0.15 and 2.55 ± 0.68, group B: 0.85 ± 0.07 and 2.41 ± 0.75, and group C: 0.85 ± 0.08 and 2.42 ± 0.74; $P=.004$ and $P=.006$, respectively; Table 4).

Among patients with the presence of subendometrial flow on the day of ET, there were no significant differences ($P>.05$ by Mann-Whitney U test) in the subendometrial blood flow parameters including RI (0.63 ± 0.19 vs. 0.61 ± 0.17), PI (1.27 ± 1.05 vs. 1.51 ± 1.43), Vmax (6.15 ± 2.14 vs. 6.27 ± 2.58 cm/s), and Vmean (3.55 ± 1.53 vs. 3.49 ± 1.76 cm/s) between the conception (n = 166) and nonconception (n = 311) groups.

FIGURE 1

Classification of endometrial–subendometrial blood flow distribution pattern. (**A**), No detectable endometrial or subendometrial flow. (**B**), Presence of subendometrial flow only. (**C**), Presence of endometrial and subendometrial flow.

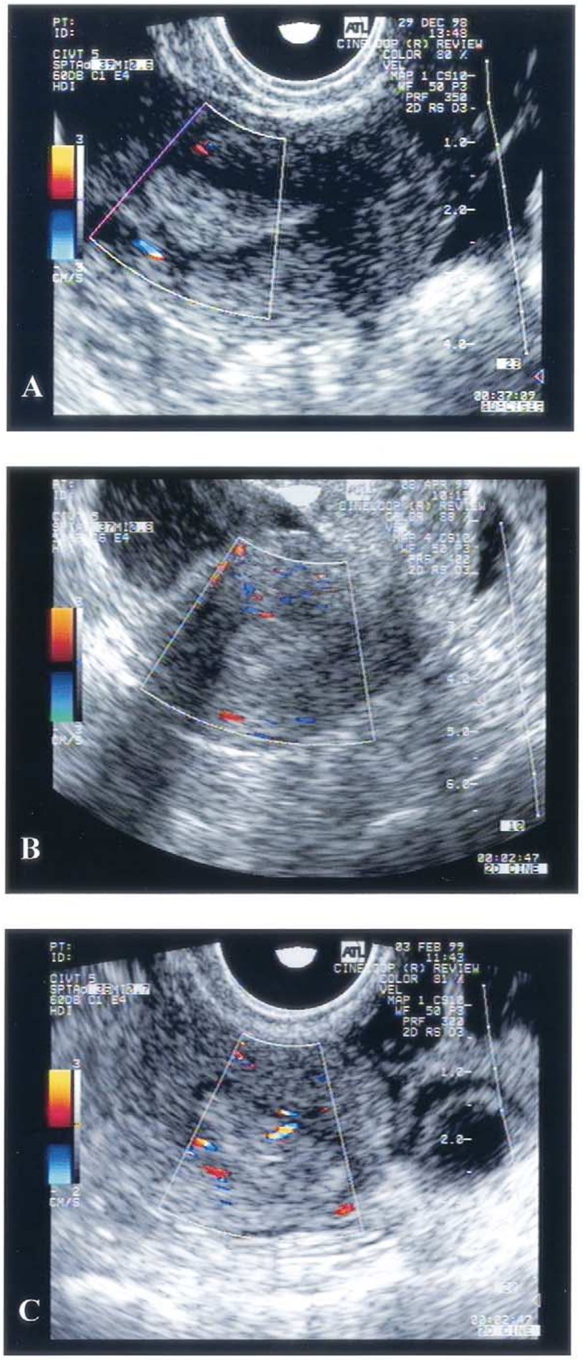

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TABLE 3

Pregnancy outcome in relation to the pattern of endometrial–subendometrial flow distribution.

Outcome	Group A: subendometrial flow (−), endometrial flow (−)	Group B: subendometrial flow (+), endometrial flow (−)	Group C: subendometrial flow (+), endometrial flow (+)
Pregnancy rate,[a] % (n/N)	7.5 (11/146)	29.7 (102/343)	47.8 (64/134)
Implantation rate,[b] % (n/N)	3.5 (13/376)	15.8 (153/967)	24.2 (94/388)
Miscarriage rate,[c] % (n/N)	54.5 (6/11)	15.7 (16/102)	12.5 (8/64)

[a,b] Group A vs. B, $P<.0001$; group A vs. C, $P<.0001$; group B vs. C, $P=.0002$. All by χ^2 test. The P value that indicates statistical significance after the Bonferroni correction is .0167.

[c] Group A vs. B, $P=.0068$; group A vs. C, $P=.004$; group B vs. C, $P=.65$. All by Fisher's exact test. The P value that indicates statistical significance after the Bonferroni correction is .0167.

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DISCUSSION

The condition of the uterus is critical to the process of embryo implantation, and among uterine conditions, endometrium development is the most important. Endometrial vasculature has been shown to play a prominent role in the early endometrial response to the implanting blastocyst, and vascular changes may contribute to uterine receptivity (20). Recent developments in ultrasonography have presented new opportunities for assessing endometrial perfusion with a noninvasive method.

Zaidi et al. (7) assessed the presence or absence of subendometrial or intraendometrial color flow, intraendometrial vascular penetration, and subendometrial blood flow velocimetry on the day of hCG administration and related the results to pregnancy rates. They found no significant difference in subendometrial peak systolic velocity or subendometrial PI between conception and nonconception cycles. The absence of both subendometrial and intraendometrial vascularization, however, was shown to be associated with failure of implantation. In an attempt to use endometrial vascular resistance measured by Doppler spectral analysis to predict the success rate of in vitro fertilization, Yuval et al. (11) failed to find significant differences between pregnant and nonpregnant patients.

A novel approach called intraendometrial power Doppler area (EDPA), defined as vascular signals seen within the endometrial borders as measured by power Doppler sonography, was reported by Yang et al. (8). Patients with a higher EDPA had a better chance of achieving successful implantation than did those with a lower EDPA. The predictive role of EDPA was limited because approximately one in four patients achieved an intrauterine pregnancy despite an unfa-

TABLE 4

Clinical details in relation to the pattern of endometrial–subendometrial flow distribution.

Parameter	Group A: subendometrial flow (−), endometrial flow (−)	Group B: subendometrial flow (+), endometrial flow (−)	Group C: subendometrial flow (+), endometrial flow (+)	P value[a]
Age (y)	34.7 ± 3.7	33.6 ± 3.7	33.3 ± 3.9	.003
Duration of infertility (y)	4.4 ± 2.5	4.4 ± 2.7	4.4 ± 2.3	NS
Duration of stimulation (d)	9.9 ± 2.0	10.0 ± 1.9	10.2 ± 1.7	NS
Oocytes retrieved (no.)	7.2 ± 4.1	7.8 ± 4.4	7.6 ± 3.9	NS
Embryos transferred (no.)	2.6 ± 1.1	2.8 ± 1.2	2.9 ± 1.3	NS
Endometrial thickness (mm)	10.1 ± 2.3	10.8 ± 2.6	12.0 ± 2.4	<.0001
Serum E_2 (pg/mL)	703.7 ± 582.6	878.0 ± 860.0	811.5 ± 645.4	NS
Serum P (ng/mL)	105.8 ± 62.4	110.8 ± 80.1	114.5 ± 83.1	NS
Uterine arterial RI	0.88 ± 0.15	0.85 ± 0.07	0.85 ± 0.08	.004
Uterine arterial PI	2.55 ± 0.68	2.41 ± 0.75	2.42 ± 0.74	.006

Note: Values are mean ± SD. NS = not significant.

[a] By Kruskal-Wallis test.

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vorable EDPA. Contart et al. (12) found that the isolated evaluation of endometrial vascularization with power Doppler is insufficient to predict pregnancy in an intracytoplasmic sperm injection program. They considered the endometrial flow to be positive only when the color Doppler signal reached at least the basal layer of the endometrium, which can be observed only in a certain proportion of the patients, according to our experiences.

Schild et al. (9) investigated the role of 3-D power Doppler sonography of the subendometrial area on the 1st day of ovarian stimulation in predicting the outcome of an IVF program and demonstrated that neither endometrial measurements nor uterine blood flow were correlated with the pregnancy rate. Recently, Kupesic et al. (10) demonstrated that quantitative analysis of blood flow could be obtained by implementing the color histogram mode and calculations by the built-in computer for 3-D power Doppler examinations. A significantly higher flow index on the day of ET was found in pregnant patients by using these new and complicated techniques. Patients who became pregnant were characterized by a significantly lower RI, obtained from subendometrial vessels by transvaginal color Doppler ultrasonography.

On the other hand, the concept of evaluating uterine receptivity by a uterine score including the endometrial blood flow was first introduced by Applebaum (6). With the absence of subendometrial blood flow, even in the presence of other favorable parameters, no conception was achieved. By using a similar approach, Salle et al. (21) calculated a uterine score in the secretory phase of the menstrual cycle preceding IVF. Vascularization was considered to be positive if more than three vessels penetrating the outer hypoechogenic area surrounding the endometrium could be seen. None of the individual ultrasonographic or Doppler parameters tested was of sufficient accuracy to predict uterine receptivity, whereas the uterine score seemed to be a useful predictor of implantation. Kupesic et al. (10) compared the 2-D and 3-D ultrasonographic scoring systems by combining parameters including endometrial thickness, volume, echogenicity, and subendometrial blood flow and found the two systems had similar efficiencies in predicting pregnancy outcome of IVF-ET procedures.

Although most investigators agree that a high degree of endometrial perfusion shown by color or power Doppler examination indicates a more receptive endometrium, there is no consensus in how to assess changes in endometrial perfusion during IVF-ET cycles. When examining the data in the literature, we noticed that those combining the endometrial and subendometrial flow parameters showed significant differences between pregnant and nonpregnant patients (7, 8, 10). In contrast, there was no significant difference if attention was only focused on intraendometrial or subendometrial blood flow (11–13). These results imply that the endometrial–subendometrial area must be considered as a whole in evaluating endometrial perfusion.

A recent study by immunocytochemistry revealed that the subendometrial myometrium, also called the junctional zone myometrium or archimyometrium, exhibits a cyclic pattern of estrogen and progesterone receptor expression that parallels that of the endometrium (22). Thus, the endometrium and subendometrial myometrium may form a functional unit with various cyclic reproductive functions. In fact, the responsiveness of the junctional zone has been shown to be associated with implantation success during IVF-ET treatment (18). The junctional zone became significantly thicker at ET in the pregnant group; in contrast, changes in the junctional zone were less pronounced in patients who did not conceive (18).

Many investigators have also noted the correlation of junctional zone contractions with pregnancy outcome in both natural (23) and assisted reproduction cycles (24, 25). Less-active junctional zone contractility is associated with higher pregnancy rates. It would help to explain changes of vascularization over the endometrial–subendometrial region if we knew the correlation of junctional zone development or contractility with blood flow distribution in this area. However, the observation of junctional zone contraction may require a computer-assisted image analysis system, which is not practical for on-site examination as in this study.

Our data are consistent with previous studies that have shown that the absence of subendometrial blood flow is associated with poor pregnancy outcome; however, this condition is not indicative of a nonreceptive endometrium as suggested in one study (7). Although women with no detectable endometrial–subendometrial flow on the day of ET tend to be older, it is noteworthy that more than half (6 of 11, 54.5%) of pregnancies in such women aborted spontaneously. Although these data suggest that development of the endometrial vessel system may play a role in maintaining pregnancy in the early stages, the case number is too small to draw any conclusion.

In contrast to the report from Kupesic et al. (10), which showed that the resistance to endometrial blood flow is more indicative than the presence or absence of subendometrial blood flow alone, we found that Doppler indices of subendometrial blood flow velocity do not correlate with pregnancy rates. Exactly where the subendometrial vessels are measured, that is, inside or outside the hyperechogenic endometrial margin, may affect the result. For that reason, Doppler indices of subendometrial vessels may not be suitable for assessing endometrial receptivity.

The thickness of the endometrium significantly differed with the pattern of endometrial–subendometrial flow distribution. Intraendometrial vascular penetration was associated with a thicker endometrium, suggesting a correlation of blood perfusion with endometrial development. Patients with no detectable endometrial–subendometrial flow demonstrated a higher uterine arterial resistance than those with the presence of flow. This finding is consistent with the notion that changes in uterine arterial resistance may reflect peripheral endometrial blood flow, yet it may not be sensitive enough to indicate endometrial receptivity. A trend of increasing pregnancy rates with deeper intraendometrial vascular penetration was noted in a previous study (7), but pregnancy rates were not significantly different in that report. We found that patients with the presence of endometrial flow had significantly higher pregnancy rates than did those without endometrial flow. Endometrial assessment was done on the day of ET in this study instead of the day of hCG injection as in the previous study. According to our observations, endometrial–subendometrial flow distributions can be different before and after hCG administration (26). Therefore, it may be necessary to examine the patient until the day of ET for a better evaluation of endometrial receptivity.

Recent advancements in in vitro culture systems and cryopreservation techniques for preimplanted embryos have allowed greater flexibility in the timing and number of ET. A more effective approach to assessing the uterine condition is necessary for making clinical decisions concerning ET. Because the color Doppler mode has become a standard component in most current ultrasound machines, we suggest that it should be added to the routine examination of the endometrium during IVF-ET treatments. However, the appearance of blood flow within the endometrial–subendometrial area is influenced by the quality of the equipment, the settings of ultrasound, the position of the uterus, and the experience of the operators.

In conclusion, transvaginal color Doppler examination of the endometrial–subendometrial blood flow distribution provides a simple and effective method to evaluate endometrial receptivity. The presence of both endometrial and subendometrial blood flow is indicative of good endometrial receptivity, whereas the absence of both represents a poor uterine environment. This approach may be helpful in deciding the number and timing of ET in IVF treatments.

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