American Journal of Medicine and Medical Sciences 2025, 15(10): 3474-3479
DOI: 10.5923/j.ajmms.20251510.41

Diagnostic Value of Sonographic and Doppler Parameters in Infertile Women with Endometrial Dysfunction

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Abstract **Introduction.** Infertility affects 10–15% of reproductive-age couples, with endometrial dysfunction being a significant contributing factor. Morphological and functional alterations reduce endometrial receptivity and impair implantation outcomes. **Objective.** To evaluate the diagnostic value of sonographic and Doppler parameters in infertile women with endometrial dysfunction. Materials and Methods. A prospective study included 120 women: Group I – 40 infertile women of early reproductive age, Group II – 50 infertile women of late reproductive age, and Control – 30 healthy women. Endometrial thickness, echogenicity, structure, and blood flow indices (RI, PI) were assessed. **Results.** Endometrial thickness was 6.2±0.21 mm and 5.7±0.20 mm in patients vs. 9.1±0.28 mm in controls ($p<0.001$). Hypoplasia was present in 100%, increased echogenicity in 90–92%, stromal fibrosis in 72.5–76%. Elevated RI (≥0.65) was observed in 42.5% and 54%, PI (≥1.4) in 37.5% and 48%. A strong negative correlation was found between endometrial thickness and RI ($r=–0.61$; $p<0.001$). **Conclusion.** Sonographic and Doppler parameters provide reliable diagnostic markers for endometrial dysfunction, supporting prediction of implantation outcomes and personalized infertility treatment strategies.

Keywords Endometrial dysfunction, Infertility, Sonography, Doppler, Receptivity, RI, PI

1. Introduction

Infertility is one of the most pressing issues in modern gynecology and reproductive medicine, and according to various epidemiological data, it is observed in approximately 10–15% of couples of reproductive age [1,2]. Among the main causes of infertility, in addition to ovulatory dysfunctions, tubal-peritoneal factors, and endocrine disorders, particular importance is attributed to endometrial dysfunction [3,4]. The endometrium, through normal cyclic changes and the development of receptivity, represents the key tissue in preparing for pregnancy. When its physiological function is impaired, implantation failure and infertility may occur [5].

Endometrial receptivity, particularly during the post-ovulatory phase, is ensured by secretory transformation and adequate blood circulation. Morphofunctional alterations in these processes can hinder the establishment of pregnancy [6,7]. According to the World Health Organization (WHO) and the FIGO classification, endometrial dysfunction is recognized as an independent cause of infertility, with its prevalence ranging from 30% to 60% across different countries [8].

Clinically, infertility associated with endometrial dysfunction is closely linked to menstrual irregularities, anovulation, echographic hypoplasia, the loss of endometrial receptivity markers, as well as repeated instrumental interventions [9,10]. Furthermore, chronic endometritis and subclinical inflammation aggravate functional alterations in the endometrium [11,12]. As a result, hypoplasia, stromal fibrosis, pathological echogenicity, and disturbances in vascular structures are frequently observed in the endometrium [13,14].

At present, although hormonal and immunomodulatory therapies are employed in the treatment of infertility associated with endometrial dysfunction, their effectiveness remains limited, with some studies reporting success rates not exceeding 20–30% [15,16]. Therefore, a more in-depth evaluation of endometrial morphology and blood circulation, particularly through echographic and Dopplerometric techniques, has become of critical importance [17].

In recent years, ultrasound and Dopplerometric methods have been increasingly applied in the evaluation of endometrial receptivity. Parameters such as endometrial thickness, structural characteristics, echogenicity, and blood flow indices (resistance index – RI, pulsatility index – PI) are recommended as reliable markers of pregnancy preparedness and implantation success [18–20]. It has been established that an endometrial thickness of ≥8 mm is associated with a higher probability of pregnancy, whereas elevated RI and PI values are linked to reduced receptivity [21]. Moreover, in infertile women with endometrial dysfunction, echographic hypoplasia and impaired blood flow have been reported to decrease implantation efficiency by 3–4 times [22].

In this regard, an in-depth investigation of the diagnostic value of echographic and Dopplerometric parameters in

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Received: Sep. 16, 2025; Accepted: Oct. 10, 2025; Published: Oct. 25, 2025
Published online at http://journal.sapub.org/ajmms

infertile women with endometrial dysfunction represents an important step in elucidating the pathogenesis of infertility, developing individualized preventive measures, and advancing innovative therapeutic approaches.

2. Purpose of the Research

The aim of the study was to evaluate echographic and Dopplerometric indicators in infertile women with endometrial dysfunction and to determine their diagnostic significance.

3. Materials and Methods

This study had a prospective clinical design and included a total of 120 women of reproductive age. Based on clinical and instrumental parameters, participants were divided into three groups: Group I – 40 infertile women aged 18–35 years with endometrial dysfunction (early reproductive age); Group II – 50 infertile women aged 36–40 years with endometrial dysfunction (late reproductive age); and the comparison group – 30 healthy women of reproductive age, whose health status was confirmed through clinical and laboratory examinations.

Inclusion criteria were defined as: age between 18 and 40 years, inability to achieve pregnancy for at least 12 months, and presence of endometrial dysfunction confirmed by hormonal and echographic evaluations. Exclusion criteria included severe somatic or oncological diseases, tubal-peritoneal infertility, and congenital anomalies of the reproductive organs.

Echographic examinations were performed in the luteal phase of the menstrual cycle using a transvaginal probe (7.5 MHz frequency). Endometrial thickness (mm), structural features, echogenicity, and the presence of the "triple-line" sign were assessed. Additional parameters such as the condition of the functional-glandular layer, signs of hypoplasia, stromal fibrosis, micropolyposis, and perimetrial changes were recorded.

Dopplerometric assessment was conducted by evaluating blood flow in the spiral arteries and subendometrial circulation. The resistance index (RI) and pulsatility index (PI) were measured, with deviations from normal values considered at RI $\geq$0.65 and PI $\geq$1.4. In patients with reduced endometrial perfusion, the frequency of morphological changes (hypoplasia, fibrosis, pathological echogenicity) was comparatively analyzed.

All laboratory and instrumental studies were performed according to standard protocols. The hormonal profile (FSH, LH, estradiol, prolactin, AMH) was assessed using the immunochemiluminescence method. The study was conducted in accordance with WHO and FIGO clinical recommendations.

Statistical analysis was carried out using Microsoft Excel and SPSS Statistics version 26.0. Mean values (M ±m) were calculated, and differences between groups were evaluated using Student's *t*-test and the χ^2 test. Pearson's method was applied to determine correlation coefficients. Risk factors were assessed using odds ratios (OR) and 95% confidence intervals (CI). A *p*-value of <0.05 was considered statistically significant.

4. Results and Discussion

According to the study findings, all patients with infertility associated with endometrial dysfunction (Group I – 40 women, Group II – 50 women) demonstrated a significant reduction in endometrial thickness during the luteal phase of the cycle. The mean values were 6.2 ± 0.21 mm in Group I and 5.7 ± 0.20 mm in Group II, which were markedly and statistically significantly lower compared with healthy women in the comparison group (9.1 ± 0.28 mm; p<0.001). This observation once again confirms that physiological endometrial thickness plays a decisive role in enhancing implantation and pregnancy potential.

Echosonographic analysis revealed a high prevalence of clinically significant pathological changes in all infertile women with endometrial dysfunction. In particular, functional-glandular layer hypoplasia was detected in 100% of patients in both Group I (40/40) and Group II (50/50). Increased endometrial echogenicity was identified in 36 patients (90%) in Group I and 46 patients (92%) in Group II; in most cases, this alteration was associated with stromal fibrosis, inflammation, and trophic changes. Stromal fibrosis and sclerosis were observed in 29 women (72.5%) in Group I and 38 women (76%) in Group II. Micropolypoid formations and vascular "depressions" were noted in 15 women (37.5%) in Group I and 21 women (42%) in Group II. In addition, perimetrial fibrosis was documented in 12 women (30%) in Group I and 19 women (38%) in Group II.

These findings indicate that distinct pathological changes in the morphological and functional state of the endometrium may reduce the degree of readiness for implantation and thereby contribute to the persistence of infertility.

In the comparison group of healthy women (n = 30), endometrial thickness, structure, and echogenicity fully corresponded to physiological norms; no pathological changes were identified on echosonographic analysis. In 28 women (93.3%), a "triple-line" endometrial pattern was observed, while no cases of micropolyposis, fibrosis, or pathological echogenicity were detected (Table 1).

These findings suggest that, in cases of infertility associated with endometrial dysfunction, echosonographic parameters—including endometrial thickness, structure, and echogenicity—serve as reliable and objective markers for the comprehensive evaluation of reproductive function and the pathogenesis of implantation. Notably, functional-glandular hypoplasia and stromal fibrosis were observed 3.0–4.0 times more frequently, while increased echogenicity and micropolyposis were nearly 5.0–7.0 times more prevalent in infertile women with endometrial dysfunction compared with the control group. Such pathological alterations indicate a marked reduction in endometrial receptivity and reproductive

potential, significantly limiting the likelihood of achieving pregnancy. Frequency of echographic pathological changes in infertile women with endometrial dysfunction compared with healthy women (table 1).

Accordingly, the results of echosonographic assessment are of great importance for the early and effective diagnosis of infertility, as well as for the development of individualized treatment strategies. Endometrial perfusion and its functional state were evaluated using transvaginal Doppler ultrasonography by measuring blood flow parameters in the spiral arteries and the subendometrial zone.

The study results showed that in infertile women of early reproductive age with endometrial dysfunction (Group I, n = 40), the mean resistance index (RI) was 0.62 ± 0.021; among them, 17 patients (42.5%) had RI ≥ 0.65 (p<0.001). In late reproductive-age infertile women (Group II, n = 50), the mean RI was 0.66 ± 0.022 (p<0.001), with 27 patients (54.0%) demonstrating RI ≥ 0.65. By contrast, in the comparison group of healthy women (n = 30), the mean RI was 0.51 ± 0.017, and only 2 women (6.7%) had RI ≥ 0.65.

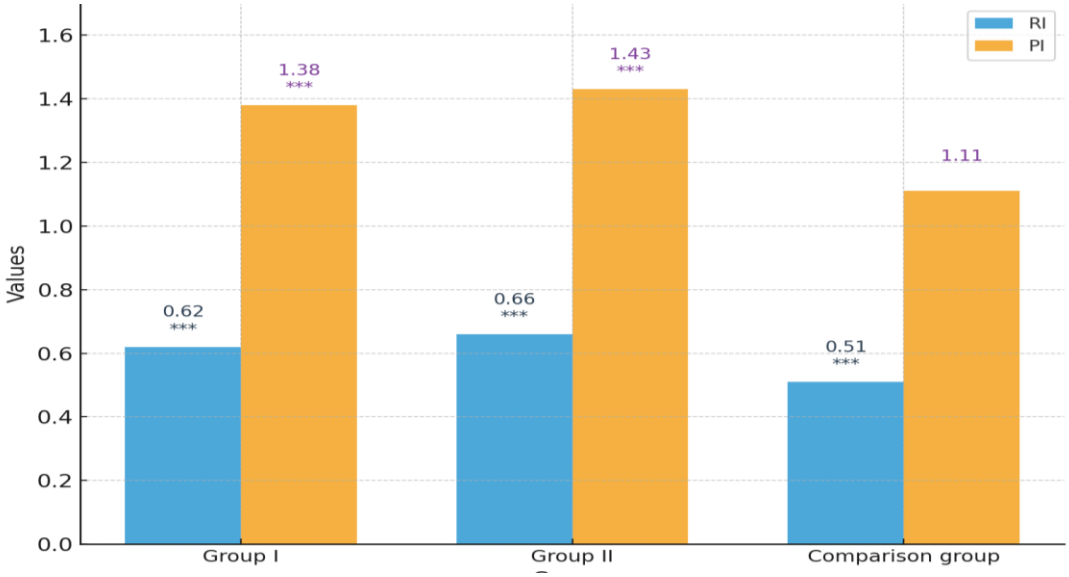
The pulsatility index (PI) was likewise elevated in the patient groups. In Group I, the mean PI was 1.38 ± 0.046 (p<0.001), with 15 women (37.5%) showing PI ≥ 1.4; in Group II, the mean PI was 1.43 ± 0.045 (p<0.001), with 24 women (48.0%) above this threshold. In the comparison group, the mean PI was 1.11 ± 0.038, and only 1 woman (3.3%) had PI ≥ 1.4. For all major differences, p<0.05, indicating statistical significance (Figure 1).

Among patients with reduced endometrial perfusion, echosonographic analysis revealed a higher prevalence of functional-glandular hypoplasia, increased echogenicity, stromal fibrosis, and micropolypoid elements. Specifically, in women with PI ≥ 1.4, functional-glandular hypoplasia and increased echogenicity were observed in 100% of cases, stromal fibrosis in more than 80%, and micropolypoid elements in 50% of cases (p<0.05). Thus, elevated resistance and pulsatility indices of endometrial perfusion were found to be closely associated with reduced endometrial receptivity and pathological alterations in morphological structure and trophic support. Such integrated hemodynamic and morphological assessment holds substantial scientific and practical significance for developing individualized diagnostic and therapeutic strategies.

Correlation analysis demonstrated a strong inverse relationship between endometrial thickness and RI (r = –0.61; p<0.001): as endometrial thickness decreased, perfusion deteriorated, reflected by an increase in RI. Moreover, a moderate negative correlation was observed between increasing age and both endometrial thickness and vascularization (r = –0.54; p<0.01) (Figure 2).

Table 1. Frequency of echographic pathological changes in infertile women with endometrial dysfunction compared with healthy women

Parameter	Group I (n=40)	Group II (n=50)	Comparison group (n=30)	*p*-value
Functional-glandular hypoplasia	40 (100%)	50 (100%)	0 (0%)	<0.001
Increased echogenicity	36 (90%)	46 (92%)	0 (0%)	<0.001
Stromal fibrosis/sclerosis	29 (72.5%)	38 (76%)	0 (0%)	<0.001
Micropolypoid elements	15 (37.5%)	21 (42%)	0 (0%)	<0.001
Perimetrial fibrosis	12 (30%)	19 (38%)	0 (0%)	<0.001
“Triple-line” endometrial pattern	0 (0%)	0 (0%)	28 (93.3%)	–



Note. * – statistically significant difference compared with the comparison group (*** p<0.001).

Figure 1. Dopplerometric parameters in infertile women with endometrial dysfunction

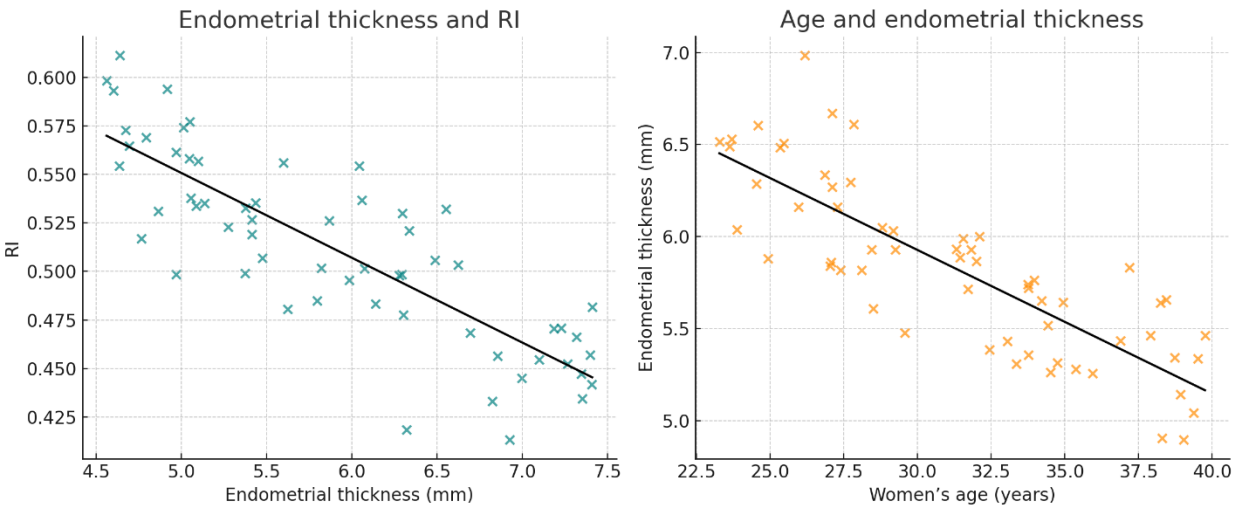


Figure 2. Correlation between endometrial thickness, vascularization, and resistance index (RI) in infertile women with endometrial dysfunction

Overall, the comprehensive analysis of echosonographic and Dopplerometric parameters in infertile women with endometrial dysfunction—including endometrial thickness, structure, echogenicity, the condition of the functional-glandular layer, as well as vascularization and perfusion parameters (resistance index, pulsatility index, etc.)—represents the most reliable and objective markers of implantation readiness in modern reproductive medicine.

The obtained echodopplerographic results indicate that the simultaneous assessment of the morphological and hemodynamic state of the endometrium serves as a key clinical-instrumental criterion for predicting embryo implantation success, as well as for evaluating and determining female fertility potential. In particular, pathological changes such as reduced endometrial thickness, hypoplasia and stromal fibrosis on echostructural evaluation, increased echogenicity, the presence of micropolypoid formations and perimetrial fibrosis, along with impaired blood flow (elevated PI and RI values), reflect a marked compromise in reproductive capacity.

In such women, the degree of endometrial readiness for implantation is significantly reduced, which increases the risk of failure to achieve natural pregnancy or embryo implantation mismatch in ART cycles. Therefore, a comprehensive evaluation of echosonographic and Dopplerometric parameters constitutes an essential component of modern infertility diagnostics, serving not only for diagnostic purposes but also for guiding individualized prevention and treatment strategies, as well as for selecting optimal preparation and correction approaches.

Importantly, echosonographic and Dopplerometric assessments allow for the early and precise evaluation of endometrial receptivity, stratification of women into high- and low-risk groups for implantation, identification of specific pathogenetic associations, and implementation of individualized treatment approaches. In this regard, these methods represent critical scientific and practical tools for effectively overcoming infertility and improving implantation outcomes.

5. Discussion

The present study confirms that infertile women with endometrial dysfunction display a high prevalence of pathological echographic and Dopplerometric findings, including reduced endometrial thickness, increased echogenicity, hypoplasia, stromal fibrosis, and impaired vascularization. These observations are in agreement with earlier reports, where morphological alterations of the endometrium were shown to compromise implantation potential and reproductive outcomes (Wang et al., 2020; Motovilova et al., 2024).

Importantly, our data highlight that elevated resistance index (RI) and pulsatility index (PI) values are strongly associated with poor perfusion and reduced receptivity. This finding supports previous Doppler-based studies, which identified abnormal uterine and subendometrial blood flow as predictors of implantation failure (Volovsky & Seifer, 2024). However, by demonstrating a strong inverse correlation between RI and endometrial thickness ($r = –0.61$; $p<0.001$), as well as an age-dependent decline in endometrial morphology and vascularization ($r = –0.54$; $p<0.01$), our results provide additional evidence of the integrative role of hemodynamic and morphological markers in predicting fertility outcomes.

Recent advances in reproductive biology have introduced molecular and genomic approaches for assessing endometrial receptivity. Transcriptomic profiling (D áz-Gimeno et al., 2011), microRNA-based biomarkers (Burns et al., 2023), and endometrial microbiota characterization (Ni et al., 2019; Fan et al., 2021) offer complementary strategies to identify implantation failure. Nevertheless, these technologies remain costly and not widely available. In contrast, sonographic and Dopplerometric assessments are inexpensive, reproducible, and can be integrated into routine gynecological practice. Our findings thus underscore the clinical utility of these non-invasive tools in settings where advanced molecular diagnostics are not accessible.

The novelty of this study lies in the combined evaluation of echographic and Dopplerometric markers in a prospective

cohort of infertile women stratified by reproductive age. By establishing clear associations between morphological changes, vascular parameters, and fertility potential, our work bridges the gap between traditional ultrasound assessment and emerging molecular approaches. This integrative perspective may aid in developing individualized treatment strategies, including patient stratification before assisted reproductive technology (ART) cycles.

In summary, the present results strengthen the evidence that combined sonographic and Doppler evaluation of the endometrium is a reliable diagnostic approach to predict implantation outcomes. When integrated with modern molecular research, these parameters may serve as a cornerstone for precision medicine in reproductive care.

The novelty of our study lies in the fact that it is the first prospective clinical investigation in the Central Asian region to comprehensively evaluate both echographic and Dopplerometric markers in infertile women with endometrial dysfunction. By integrating morphological assessment with hemodynamic parameters and performing correlation analysis, our work provides unique region-specific insights and strengthens the global evidence base on endometrial receptivity.

6. Conclusions

This study confirms that infertile women with endometrial dysfunction exhibit marked pathological echographic and Dopplerometric changes, including reduced endometrial thickness, hypoplasia, stromal fibrosis, increased echogenicity, and impaired vascularization. Elevated RI and PI values were closely linked to poor perfusion and diminished receptivity, while correlation analysis highlighted the inverse association between endometrial thickness and RI, as well as age-related declines in morphology and blood flow.

Taken together, these findings demonstrate that integrated sonographic and Doppler evaluation provides reliable, non-invasive markers for predicting implantation success and tailoring individualized infertility management. Early and accurate assessment of endometrial status is therefore essential for implementing innovative, personalized strategies to improve fertility outcomes.

REFERENCES

[1] Abubakirov A.N., Adamyan L.V., Andreeva E.N. Female infertility: diagnostic problems and ways of overcoming them. Okhrana materinstva i detstva. 2019; 1(33): 42–47.

[2] Aganezov S.S., Aganezova N.V., Morotskaya A.V., Ponomarenko K.Yu. Endometrial receptivity in women with reproductive function disorders. Zhurnal akusherstva i zhenskikh boleznei. 2017; 66(3): 135–142.

[3] Aganezov S.S., Gogichashvili K.E., Aganezova N.V. Receptivity at different endometrial thicknesses in women of reproductive age (literature review). Ginekologiya. 2022; 24(1): 4–10.

[4] Motovilova T.M., Simakova V.Yu., Kazakova K.V., Kazarinova D.A. Current concepts of endometrial infertility associated with “thin endometrium”. Consilium Medicum. 2024; 26(7): 403–410.

[5] Kirillova E.N., Pavlyukova S.A., Davydov D.A. Endometrial pathology in polycystic ovary syndrome in infertile women. Meditsinskii zhurnal. 2025; (2): 57–61.

[6] Orazov M.R., Toktar L.R., Mikhaleva L.M., Silantyeva E.S., Semenov P.A., Lagutina E.V., Orekhov R.E. Chronic endometritis and endometrial dysfunction: is there a causal relationship? Akusherstvo i ginekologiya: Novosti. Mneniya. Obucheniya. 2020; 8(3): 61–69.

[7] Krasnopolskaya K.V., Mikhaleva L.M., Orazov M.R., Dolgov E.D. Opportunities to overcome implantation failures in uterine-factor infertility. Ginekologiya. 2022; 24(5): 399–406.

[8] Uryupina K.V., Kutsenko I.I., Kravtsova E.I., et al. Endometrial factor of infertility in patients of late reproductive age (review). Kubanskii nauchnyi meditsinskii vestnik. 2020; 27(6): 149–163.

[9] Savelyeva O.E., Krivolesova T.A., Sigareva L.P., et al. Local and systemic immune status in women with infertility associated with chronic endometritis. Pediatr. 2025; 16(2): 56–65.

[10] Shakhabova Kh.R., Palieva N.V., Petrov Yu.A., Chernavskii V.V. Uterine inflammation and reproductive disorders in women. Glavnyi vrach Yuga Rossii. 2022; (2): 17–22.

[11] Pirtea P, de Ziegler D, Ayoubi JM. Endometrial receptivity in adenomyosis and/or endometriosis. *Fertil Steril*. 2023; 119(5): 741–745. doi:10.1016/j.fertnstert.2023.03.004.

[12] Li J, Zhang S, Wang Y. Molecular and biological markers for assessing endometrial receptivity in infertile women: A narrative review. *J Int Med Res*. 2025; 53(1): 030006052312 00723. doi:10.1177/03000605231200723.

[13] Wang L, Lv S, Mao W, Pei M, Yang X. Assessment of endometrial receptivity during implantation window in women with unexplained infertility. *Gynecol Endocrinol.* 2020; 36(10): 917–921. doi:10.1080/09513590.2020.1727433.

[14] Volovsky M, Seifer DB. Current status of ovarian and endometrial biomarkers in predicting ART outcomes. *Reprod Sci*. 2024; 31(8): 1622–1635. doi:10.1007/s43032-024-01234 -5.

[15] Narang S, et al. Factors influencing endometrial receptivity in women with recurrent implantation failure. *BMC Womens Health*. 2024; 24(1): 315. doi:10.1186/s12905-024-03531-z.

[16] Tang X, Zhu Y, et al. Identification of serum small non-coding RNA as biomarkers for non-invasive endometrial receptivity detection. *Hum Reprod*. 2025; 40(1): 1–14. doi:10.1093/humrep/deae246.

[17] D ́az-Gimeno P, Horcajadas JA, Mart ́nez-Conejero JA, et al. A genomic diagnostic tool for human endometrial receptivity based on the transcriptomic signature. *Fertil Steril*. 2011; 95(1): 50–60.e15. doi:10.1016/j.fertnstert.2010.05.071.

[18] Simon C, et al. Recurrent implantation failure: update review and overview of the management. *Reprod Biomed Online*. 2020; 40(2): 133–140. doi:10.1016/j.rbmo.2019.10.032.

[19] Ni H, et al. Endometrial microbiota influences receptivity and pregnancy outcomes. *Am J Obstet Gynecol*. 2019; 221(1): 97.e1–97.e17. doi:10.1016/j.ajog.2019.02.048.

[20] Fan H, et al. Endometrial microbiota and implantation outcome in IVF patients. *Fertil Steril*. 2021; 115(4): 850–859.e2. doi:10.1016/j.fertnstert.2020.10.036.

[21] Burns JS, Yang S, et al. MicroRNAs as biomarkers and therapeutic targets in female infertility. *Hum Reprod Update*. 2023; 29(2): 301–320. doi:10.1093/humupd/dmy046.

[22] Garrido-Gómez T, Domínguez F, Quiñonero A, et al. Disordered expression of glyoxalase 1 and its link to endometrial receptivity failure. *Mol Hum Reprod*. 2013; 19(4): 224–233. doi:10.1093/molehr/gas054.

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