ORIGINAL RESEARCH ARTICLE

Diagnostic performance of combined ultrasound parameters, B-hCG, and estradiol in early caesarean scar pregnancy and their association with intraoperative bleeding during curettage

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Abstract

Cesarean scar pregnancy (CSP), a serious complication following cesarean section, may increase the risk of massive intraoperative bleeding and hysterectomy due to the implantation of the gestational sac at the uterine scar site. This study employed a prospective cohort analysis to investigate the diagnostic value of ultrasound parameters combined with estrogen levels for CSP in early pregnancy and its correlation with intraoperative bleeding volume during curettage. A total of 98 patients with CSP and 92 healthy controls, admitted from April 2024 to August 2025, were included in this study. All subjects were matched for gestational age (6–8 weeks) to eliminate confounding effects on ultrasound and hormonal measurements. Transvaginal ultrasound parameters [the thickness of the muscular layer at the scar site (T) and the average diameter of the gestational sac/mass (D)], along with serum estradiol (E2) and β-human chorionic gonadotropin (β-hCG) levels, were synchronously collected. The results showed that T, D, E2 and β-hCG in the CSP group were all lower than those in the control group ($P<0.05$), and the blood flow grades were mainly II–III, accounting for 74.49% of cases. There was no correlation between E2 and β-hCG in the CSP group, while in the control group, the level of E2 was positively correlated with the level of β-hCG. The area under the curve (AUC) of the combined index of T + D + E2 + β-hCG for diagnosing CSP was 0.892, with a sensitivity of 88.78% and a specificity of 77.17%, which was superior to the single index ($P<0.05$). In addition, we also found that E2 and T were negatively correlated with intraoperative blood loss ($P<0.05$). These results indicate that estrogen combined with ultrasound parameters can effectively diagnose the occurrence of CSP, providing reference opinions for clinical practice. *(Afr J Reprod Health 2026; 30 [17]: 62-70).*

Keywords: Cesarean scar pregnancy, Ultrasound parameters, Estradiol, β-hCG, Intraoperative bleeding volume

Résumé

La grossesse sur cicatrice de césarienne (GCC), une complication grave survenant après une césarienne, peut accroître le risque d'hémorragie peropératoire massive et d'hystérectomie en raison de l'implantation du sac gestationnel au niveau de la cicatrice utérine. Cette étude a utilisé une analyse de cohorte prospective pour évaluer la valeur diagnostique de paramètres échographiques combinés aux taux d'œstrogènes dans le cadre d'une GCC en début de grossesse, ainsi que leur corrélation avec le volume des saignements peropératoires lors du curetage. Au total, 98 patientes atteintes de GCC et 92 témoins sains, admis entre avril 2024 et août 2025, ont été inclus dans cette étude. Toutes les participantes ont été appariées selon l'âge gestationnel (6 à 8 semaines) afin d'éliminer les facteurs de confusion susceptibles d'affecter les mesures échographiques et hormonales. Les paramètres d'échographie transvaginale [épaisseur de la couche musculaire au niveau de la cicatrice (T) et diamètre moyen du sac gestationnel ou de la masse (D)], ainsi que les taux sériques d'estradiol (E2) et de gonadotrophine chorionique humaine bêta (β-hCG), ont été recueillis simultanément. Les résultats ont montré que les valeurs de T, D, E2 et β-hCG dans le groupe GCC étaient toutes inférieures à celles du groupe témoin ($P < 0,05$) ; les grades de flux sanguin étaient principalement de type II ou III, représentant 74,49 % des cas. Aucune corrélation n'a été observée entre E2 et β-hCG dans le groupe GCC, alors que dans le groupe témoin, le taux d'E2 était positivement corrélé au taux de β-hCG. L'aire sous la courbe (ASC) de l'indice combiné (T + D + E2 + β-hCG) pour le diagnostic de la GCC était de 0,892, avec une sensibilité de 88,78 % et une spécificité de 77,17 %, des performances supérieures à celles des indices pris isolément ($P < 0,05$). Par ailleurs, nous avons constaté que les taux d'E2 et l'épaisseur T étaient négativement corrélés aux pertes sanguines peropératoires ($P < 0,05$). Ces résultats indiquent que la combinaison des taux d'œstrogènes et des paramètres échographiques permet de diagnostiquer efficacement la GCC, offrant ainsi des éléments de référence pour la pratique clinique. *(Afr J Reprod Health 2026; 30 [17]: 62-70).*

Mots-clés: Grossesse sur cicatrice de césarienne, paramètres échographiques, estradiol, β-hCG, volume de saignement peropératoire

Introduction

Cesarean scar pregnancy (CSP), a distinct type of ectopic pregnancy, refers to the implantation of a fertilized egg within the uterine scar from a prior cesarean section. Its incidence has been steadily increasing annually alongside rising cesarean section rates.[1] Early-pregnancy CSP is often misdiagnosed as an intrauterine pregnancy or an ordinary ectopic pregnancy due to the concealed location of the gestational sac. If not promptly identified, the thin myometrium and rich blood supply at the scar site during curettage may lead to uncontrollable massive hemorrhage, necessitating hysterectomy in severe cases, thereby posing a significant threat to the patient's reproductive function and life safety.[2,3] Therefore, precise differentiation of CSP and prediction of intraoperative bleeding risk in early pregnancy are crucial for improving patient outcomes.

Transvaginal ultrasound (TVS) is currently the main diagnostic tool for CSP. However, the diagnostic effect of a single ultrasound indicator is limited and is easily affected by various factors such as the operator's experience and the stage of gestational sac development[4]. In this regard, there are also studies attempting to assist in diagnosis through estrogen. For instance, β-human chorionic gonadotropin (β-hCG) is closely related to pregnancy, but its diagnostic effect on CSP still needs to be improved.[5] Estradiol (E2) is a new hot topic of estrogen research in recent years. Studies have found that CSP may cause E2 metabolic disorders due to abnormal local microenvironment.[6,7] However, the exact clinical role of E2 in CSP remains to be further verified.

We have found that the existing research mainly focuses on the application of single ultrasound parameters or serum biomarkers, lacking exploration of the combined analysis of multi-dimensional indicators.[8,9] Based on this, we hypothesize that the combination of ultrasound parameters (T, D) and serum biomarkers (E2, β-hCG) can improve the diagnostic accuracy of CSP, and that E2 levels are independently associated with intraoperative blood loss. This research is expected to improve the limitations of the single marker method, providing more accurate reference opinions for the early diagnosis of CSP and the assessment of bleeding risk, particularly in low- and middle-income regions where advanced imaging modalities are limited. This cost-effective model can be easily integrated into routine clinical practice without additional infrastructure investment, thereby offering more reliable protection for patients' health.

Methods

Study design and sample size calculation

This is a prospective diagnostic cohort study, with the "area under the receiver operating characteristic (ROC) curve (AUC) for identifying CSP using combined indicators" as the primary endpoint. Referencing previous studies, the AUC for identifying CSP using a single ultrasound parameter is approximately 0.75.[10] Assuming an increase in the AUC to 0.90 using combined indicators, and setting $\alpha = 0.05$ (two-tailed) and $\beta = 0.20$ (test power of 80%), the required sample size per group was calculated to be approximately 80 cases using PASS 15.0 software. Considering a 10% loss to follow-up rate, at least 90 subjects should be included in each group.

Study subjects

A total of 98 patients with CSP admitted to our hospital from April 2024 to August 2025 (the CSP group) and 92 healthy individuals undergoing physical examinations during the same period (the control group) were included as the study subjects. Inclusion criteria: (1) Presenting with vaginal bleeding, abdominal pain, or ultrasound findings suggestive of “suspected intrauterine/scar pregnancy” during early pregnancy (6–8 weeks of gestation, confirmed by transvaginal ultrasound); (2) For the CSP group: Having a definitive history of ≥1 cesarean delivery, with gestational sac implantation confirmed at the uterine scar site by transvaginal ultrasound; For the control group: Having normal intrauterine early pregnancy (6–8 weeks, matched 1:1 for gestational age with the CSP group), confirmed by ultrasound to show intrauterine gestational sac with visible yolk sac and/or fetal heartbeat; those with a history of cesarean section were strictly screened to exclude scar pregnancy; (3) Signing informed consent and being able to complete ultrasound, blood sampling, and follow-up. Exclusion criteria: (1) Multiple pregnancy, trophoblastic disease (e.g., hydatidiform mole), or concurrent uterine fibroids/adenomyosis (impeding ultrasound measurements); (2) Use of estrogen-containing medications or ovulation induction therapy within the past 3 months; (3) Impaired liver or renal function (affecting hormone level measurement) or coagulation disorders; (4) Loss to follow-up or failure to complete all required examinations (ultrasound, blood sampling, curettage). The mean age of the CSP group was (32.27±6.22) years, and the mean age of the control group was (30.93±6.07) years.

Intervention

All patients in the CSP group underwent ultrasound-guided curettage. Intraoperative bleeding volume was recorded: using the weighing method, the total weight of gauze/cotton pads used during the procedure (wet weight) minus dry weight was recorded and converted to milliliters (mL) based on the blood density of 1.05 g/mL.

Ultrasound examination

The GE Voluson E10 ultrasound system was employed, utilizing a transvaginal probe with a center frequency of 4.5 MHz. All examinations were performed by the same senior physician, with 12 years of experience in obstetric and gynecologic ultrasound. To ensure measurement reliability, each parameter was measured independently by the same physician twice with a 24-hour interval, and the intra-class correlation coefficient (ICC) was calculated. The ICC values for T and D were 0.92 and 0.94, respectively, indicating excellent intra-observer reproducibility.. The following parameters were measured and recorded: the thickness of the muscular layer at the scar site (T, in mm) and the average diameter of the gestational sac/mass (D, in mm). Each parameter was measured three times in different planes, and the average value was used for analysis. T was measured in the midsagittal plane as the thinnest myometrial layer between the gestational sac and the bladder wall. D was calculated as the average of the maximum anteroposterior diameter and its perpendicular transverse diameter of the gestational sac/mass. The measurement methods were consistent with previously published standards. Blood flow was graded using the Adler grade:[11] Grade 0: No detectable blood flow; Grade I: Minimal punctate blood flow; Grade II: Moderate linear (strip-like) blood flow; Grade III: Abundant dendritic (branching) blood flow.

Serological test

Three mL of venous blood was collected from each subject on an empty stomach, between 8:00 and 10:00 AM at the same gestational age (6–8 weeks) as the ultrasound examination. The time interval between blood sampling and ultrasound examination was <24 hours, and the interval between specimen collection and curettage was 1–3 days for all CSP patients. The blood was centrifuged at 3000 rpm for 10 minutes at 4°C to separate the serum, and stored at -80°C for testing. E2 and β-hCG levels were measured using a fully automated electrochemiluminescence analyzer (Roche Cobas 8000).

Outcome measures

The diagnostic efficacy of ultrasound parameters (T and D), E2, and β-hCG as single indicators and combined indicators for distinguishing CSP from non-CSP was evaluated. The relationship between the combined indicator (ultrasound parameters + E2) and bleeding volume during curettage was analyzed. Intraoperative major bleeding was defined as blood loss ≥500 mL according to clinical consensus.

Statistical analysis

Statistical analysis was performed using SPSS 28.0 software. Measurement data were expressed as ($\bar{\chi}$±s), with comparisons between groups conducted using the independent-samples t-test (for normally distributed data) or the Mann-Whitney U test (for non-normally distributed data). Enumeration data were presented as rates (%) and analyzed with the χ^2 test. Diagnostic efficacy was evaluated via the receiver operating characteristic

(ROC) curve analysis, and a predictive model for combined indicators was constructed by Logistic regression. Correlations were assessed using Pearson's correlation coefficient. $P<0.05$ was considered statistically significant.

Ethical approval

This study was approved by the Ethics Committee of The Fourth Hospital of Shijiazhuang (Approval No. 20220086, date: february 2, 2024) and was conducted in accordance with the Declaration of Helsinki. All subjects provided written informed consent prior to enrollment.

Results

Differences in ultrasound parameters

Compared with the control group, T and D in the CSP group were decreased ($P<0.05$). In terms of blood flow grades, the CSP group predominantly demonstrated grades II–III, whereas all cases in the control group were classified as grade I or 0 (Table 1).

Differences in serological markers

The estrogen test results showed that both β-hCG and E2 levels in the CSP group were lower than those in the control group ($P<0.05$). Correlation analysis indicated no significant relationship between β-hCG and E2 levels in the CSP group ($P>0.05$), whereas a positive correlation was observed between the two in the control group ($P<0.05$) (Figure 1).

Diagnostic efficacy of ultrasound parameters combined with estrogen for CSP

The ROC curve analysis revealed that individual Measurements of T and D, β-hCG, and E2 each demonstrated certain diagnostic efficacy for CSP, with AUC values ranging from 0.711 to 0.838, indicating room for improved accuracy. Binary logistic regression with the Enter method was used to construct the combined diagnostic model, with CSP status as the dependent variable and T, D, β-hCG, and E2 as independent variables.

The probability of CSP (P) was calculated using the formula, where through Logistic regression analysis, a combined diagnostic formula incorporating ultrasound parameters and estrogen levels was developed based on the regression coefficients (β) of each indicator: $\text{Logit}(P)=15.249+(-0.893)\times T+(-0.056)\times D+(-0.001)\times \beta\text{-hCG}+(-0.003)\times E2$, where P represents the probability of CSP occurrence. This formula achieved a diagnostic sensitivity of 88.78%, a specificity of 77.17%, and an AUC increasing to 0.892 for CSP over single markers ($P<0.05$) (Figure 2 and Table 2).

Correlation analysis with intraoperative bleeding volume during curettage

Statistical analysis revealed a mean bleeding volume of (334.98 ± 73.15) mL in CSP patients. Correlation analysis revealed no significant correlation of β-hCG and D with patient bleeding volume ($P>0.05$). However, E2 and T showed negative correlations with bleeding volume ($P<0.05$), indicating that lower E2 levels and T values were associated with higher bleeding volume.

The simple linear regression equations were as follows: Blood loss (mL) = 682.34 - 172.56×T (mm) ($R^2=0.528$, $P<0.001$); Blood loss (mL) = 526.78 - 0.57×E2 (pg/mL) ($R^2=0.469$, $P<0.001$) (Figure 3

Table 1: Comparison of results of ultrasound examination

Groups	n	Ultrasonic parameters		Classification of blood flow			
		T	D	0	I	II	III
Control group	92	2.5±0.6	44.7±10.5	55 (59.8)	28 (30.4)	8 (8.7)	1 (1.1)
CSP group	98	2.0±0.5	36.4±9.6	10 (10.2)	15 (15.3)	45 (45.9)	28 (28.6)
t or χ^2		5.734	5.681	85.952			
P		<0.001	<0.001	<0.001			

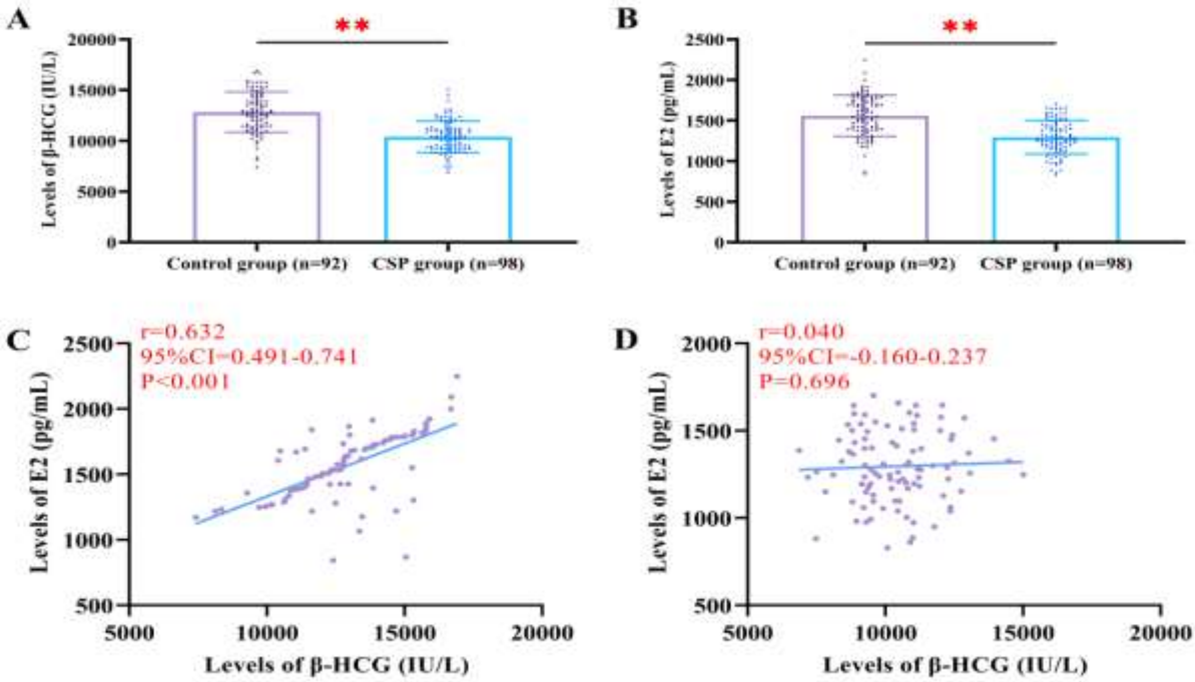

Figure 1: Comparison of test results for estrogen. (A) Comparison of β-hCG levels. (B) comparison of E2 levels. (C) Correlation analysis of β-hCG and E2 in the control group. (D) Correlation analysis of β-hCG and E2 in CSP group. **P < 0.01.

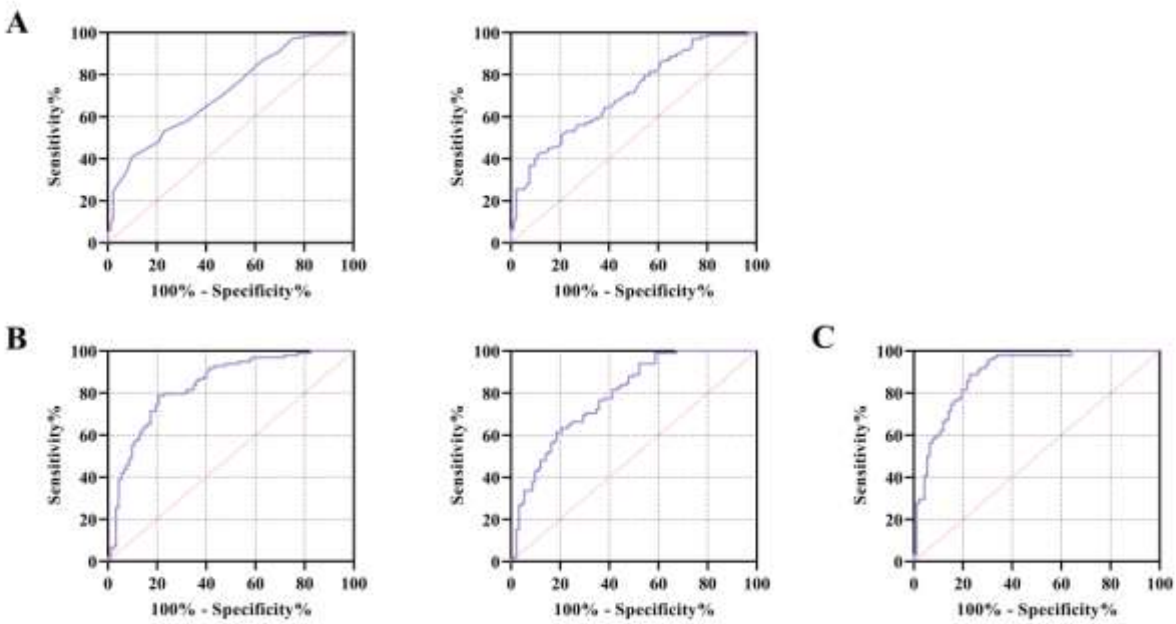

Figure 2: ROC curves of ultrasound parameters and estrogen levels for the diagnosis of CSP. (A) Diagnostic curve of ultrasound parameter T and D. (B) Diagnostic curve of estrogen β-hCG and E2. (C) Diagnostic curve of ultrasound parameters combined with estrogen.

Table 2: Diagnostic efficacy of ultrasound parameters and estrogen for CSP

Diagnostic efficacy							
Projects	B	S.E,	Wals	P	Exp (B)	95%CI	
T	-0.893	0.438	4.156	0.041	0.409	0.173	0.966
D	-0.056	0.023	5.732	0.017	0.945	0.903	0.990
β-hCG	-0.001	0.000	22.939	0.000	0.999	0.999	1.000
E2	-0.003	0.001	7.696	0.006	0.997	0.995	0.999
Constant	15.249	2.172	49.3	<0.001	-	-	-
Logistic regression analysis							
	AUC	95%CI	Sensitivity	Specificity	P	-	-
T	0.714	0.642-0.786	40.82	90.22	<0.001	-	-
D	0.711	0.639-0.783	41.84	89.13	<0.001	-	-
β-hCG	0.838	0.781-0.895	78.57	79.35	<0.001	-	-
E2	0.790	0.727-0.854	61.22	81.52	<0.001	-	-
T+D+ β -hCG+E2	0.892	0.845-0.938	88.78	77.17	<0.001	-	-

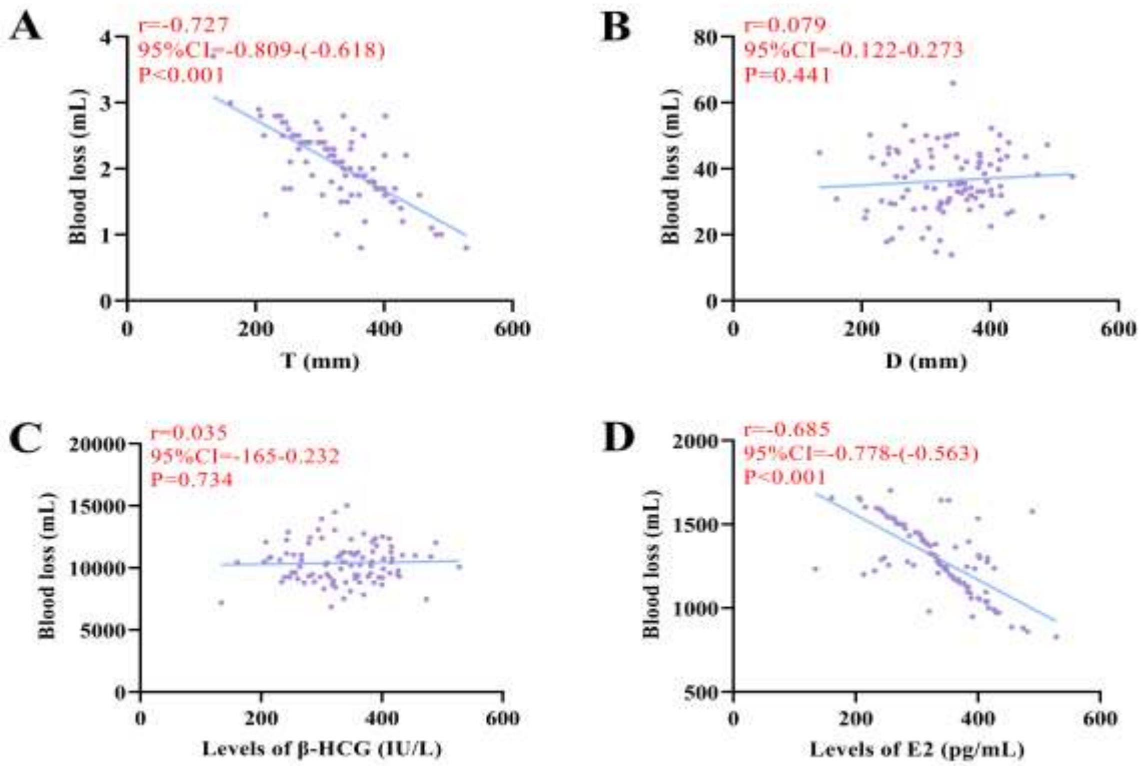

Figure 3: Relationship between ultrasound parameters, estrogen, and intraoperative blood loss in the CSP group. (A-D) respectively demonstrated the correlations and correlation coefficients of T, D, β-hCG, E2 and intraoperative blood loss.

Discussion

The results of this study show that the combined diagnosis of CSP by ultrasound parameters (T, D) and estrogen (E2, β-hCG) has a sensitivity of 88.78% and a specificity of 77.17%. Its AUC=0.892, which is higher than that of the single indicator.

Previous studies have indicated that AUC values for ultrasound parameters alone (e.g., T and

D) generally range from 0.75 to 0.82,[12] and serum estrogen has limited diagnostic value (AUC ≈ 0.65).[13] By constructing a multidimensional model integrating anatomical structure (ultrasound parameters) and hormonal metabolism data, this study overcomes the limitations of single indicators. For example, the significant reduction in T and D values in the CSP group reflects the anatomical characteristics of muscle layer defects at the scar site, while the decrease in E2 levels may be associated with impaired estrogen synthesis due to abnormal local trophoblast invasion.[14] The combination of these two enables identification of CSP from both morphological and functional perspectives, reducing the risk of misdiagnosis. It is worth noting that in the CSP group, there was no correlation between E2 and β-hCG; in the control group, however, the two were positively correlated. This finding suggests that the hormonal secretion pattern of CSP may differ from that of normal intrauterine pregnancy. In normal pregnancies, β-hCG stimulates the ovarian corpus luteum to continuously secrete E2, showing a synergistic upward trend.[15] In contrast, for CSP, such a balance may be disrupted due to abnormal implantation sites and limited trophoblastic invasion capacity, leading to insufficient E2 levels. This mechanism may be associated with the poor embryonic development and increased bleeding risk in CSP patients.

In addition, E2 is negatively correlated with intraoperative blood loss, just like T. We analyze that there might be the following three reasons for this: (1) E2 maintains vascular endothelial integrity and inhibits inflammatory factor release.[16] Therefore, a decrease in E2 may lead to an increase in the release of inflammatory factors. (2) The research results of Shah NJ et al. indicate that E2 regulates uterine contractions by regulating the activity of calcium channels in uterine smooth muscle.[17] Therefore, after the E2 level drops, the uterine contractility also weakens, which may increase the difficulty of hemostasis. (3) Low E2 status may activate the fibrinolytic system, increasing the tendency for intraoperative bleeding.[18]

Previous studies have predominantly focused on the diagnostic value of single indicators. For instance, Wang et al. found that CSP patients with a scar myometrial thickness <3 mm had a threefold increased risk of intraoperative bleeding.[19] This study achieved more precise risk stratification by combining ultrasound parameters with estrogen levels. Additionally, Zhang et al. reported that serum E2 levels were associated with the prognosis of CSP, but did not establish a direct association with bleeding volume.[20] In the present study, the clinical value of E2 was validated through a large-sample cohort, filling this gap in this field. Based on these findings, it is recommended to promote the assessment model combining ultrasound parameters with estrogen levels in the diagnosis and management of CSP. For high-risk CSP populations, early scheduling of ultrasound-guided curettage is advised to safeguard maternal health. Additionally, during curettage procedures, real-time monitoring of E2 levels can be performed to reduce the risk of massive hemorrhage.

In this study, the ultrasound anatomical parameters (muscular thickness at the scar T, gestational sac diameter D) were combined with serum estrogen (E2, β-hCG) to establish a model for early diagnosis and prediction of bleeding risk of cesarean scar pregnancy (CSP). These findings reveal the unique hormone secretion pattern of CSP and provide a new perspective for the study of pathological mechanism. In the future, we suggest that the combined detection of "ultrasound +T+D+E2+β-hCG" should be included in the routine screening process of early CSP, and the high-risk patients with low E2 level and thin muscle layer should be treated with uterine artery embolization in advance to reduce the risk of massive bleeding. This policy is also helpful to promote primary medical institutions to carry out risk assessment of low-cost CSP, reduce serious consequences such as hysterectomy caused by misdiagnosis, and optimize the safety guarantee system for mother and child. However, this study still has persistent limitations that cannot be ignored.For example, the sample size is relatively small. In subsequent studies, the number of cases studied should be increased and subgroups of different menstrual cycle stages should be included. The models of testing instruments in different institutions vary, which may lead to differences in estrogen test results. Subsequently, standardized test kits can be attempted and included for comprehensive assessment involving other hormones (such as progesterone). Finally, this study only determined the correlation between E2 levels and the amount of bleeding, but did not delve into the underlying molecular mechanisms. Subsequent animal experiments or in vitro models are still needed to further explore the exact mechanism of the impact of estrogen on CSP.

Conclusion

The combination of ultrasound parameters T and D with serum markers β-hCG and E2 enhances the diagnostic efficacy for CSP in early pregnancy. The clinical translation and application of this model may help to optimize individualized diagnosis and treatment strategies for CSP. Further validation of the model's external validity requires multicenter prospective studies, thereby ensuring the health of patients.

Contribution of authors

Yanan Yang and Chenjia Liu conceived and designed the project, and wrote the paper. Man Gao and Qian Zhang generated the data. Xiaotong Nie and Lixiao Mi analyzed the data. Yanan Yang and Chenjia Liu modified the manuscript. All authors gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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Conflicts of interest

The authors report no conflict of interest.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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References

1. Hanacek J, Herman H, Krepelka P, Haslik L, Brandejsova A and Krofta L. Cesarean scar pregnancy. Ceska Gynekol 2022; 87(3):193-197.
2. Silva B, Viana Pinto P and Costa MA. Cesarean Scar Pregnancy: A systematic review on expectant management. Eur J Obstet Gynecol Reprod Biol 2023; 288:36-43.
3. Chang WH, Chou FW and Wang PH. Cesarean scar pregnancy. Taiwan J Obstet Gynecol 2022; 61(6):923-924.
4. Zhu W, Zhang X, Liu C, Liu Y and Xu W. Uterine Artery Embolization on Serum beta-HCG Levels, Fertility Function and Clinical Efficacy in Patients With Cesarean Uterine Scar Pregnancy. Front Surg 2022; 9:838879.
5. Zeng K, Lei X and Xia T. Temporary uterine artery blocking and uterine artery embolization in treating cesarean scar pregnancy. Wideochir Inne Tech Maloinwazyjne 2024; 19(3):377-383.
6. Koenigbauer JT, Schalinski E, Jarchau U, Gauger U, Brandt K, Klaucke S, Scharf JP, Rath W and Hellmeyer L. Cervical ripening after cesarean section: a prospective dual center study comparing a mechanical osmotic dilator vs. prostaglandin E2. J Perinat Med 2021; 49(7):797-805.
7. Wei W, Huang L, Tang F, Wang Y, Wang J and Song G. Clinical study of two reversible arterial blockade methods in the treatment of scar pregnancy under combined hysterolaparoscopy. Am J Transl Res 2024; 16(11):6770-6778.
8. Shi J, Ge YR, Ni J and Dong X. The Role of Transvaginal Two-Dimensional Ultrasound Combined With Color Doppler in the Evaluation of Ovarian Function and Fertility After Uterine Artery Embolization. J Ultrasound Med 2022; 41(6):1575-1583.
9. Hosseini RS, Ebrahimi PS and Shokrani A. Diagnostic value of enhanced-contrast ultrasound for cesarean scar pregnancy: A systematic review. Eur J Obstet Gynecol Reprod Biol 2024; 293:119-124.
10. Timor-Tritsch IE, Monteagudo A and Goldstein SR. Early first-trimester transvaginal ultrasound screening for cesarean scar pregnancy in patients with previous cesarean delivery: analysis of the evidence. Am J Obstet Gynecol 2024; 231(6):618-625.
11. Wang K, Yang X, Yang S, Du X, Shi R, Bai W and Wang Y. A diagnostic test of two-dimensional ultrasonic feature extraction based on artificial intelligence combined with blood flow Adler classification and contrast-enhanced ultrasound for predicting HER-2-positive breast cancer. Transl Cancer Res 2025; 14(1):640-650.

12. Wang M, Zheng Q, He M, Jiang H, Zheng J, Xie H and Lin M. A scoring system predicts the adverse outcomes for cesarean scar pregnancy treated with transvaginal hysterotomy. Quant Imaging Med Surg 2025; 15(6):5086-5100.
13. Huang J, Phillips C and Moshiri M. Scarred for life: a review of cesarean section scar pregnancy and potential pitfalls in diagnosis. Abdom Radiol (NY) 2023; 48(8):2672-2683.
14. Deng W, Sun R, Du J, Wu X, Ma L, Wang M and Lv Q. Prediction of miscarriage in first trimester by serum estradiol, progesterone and beta-human chorionic gonadotropin within 9 weeks of gestation. BMC Pregnancy Childbirth 2022; 22(1):112.
15. Wu M, Xiao X, Wang C, Zhao M, Xiong F, Jin X and Zheng X. Combined analysis of estradiol and beta-hCG to predict the early pregnancy outcome of FET: a retrospective study. J Ovarian Res 2024; 17(1):128.
16. Zheng RJ, Chen QL, Ma HM, Liu HD, Chen JP, Liang GS, Chen J, Zhang YY, Li S, Guo B, Wang ML and Du M. [Human chorionic gonadotropin-secreting gonadoblastomas in a girl of 45, X Turner syndrome: a case report and literature review]. Zhonghua Er Ke Za Zhi 2022; 60(11):1202-1206.
17. Shah NJ, Pereira N, Romanski PA, Wright C, Kligman I and Rosenwaks Z. Tubal Ectopic Pregnancy with Undetectable Initial Serum beta-Human Chorionic Gonadotropin Level. J Minim Invasive Gynecol 2021; 28(1):142-145.
18. Liu H, Li Z, Xie L, Jing G, Liang W, He J and Dang Y. The Relationship Between Heavy Metals and Missed Abortion: Using Mediation of Serum Hormones. Biol Trace Elem Res 2024; 202(8):3401-3412.19. Wang Y, Hao X, Chen Y, Wang L, Zhou Y, Xue M, Dong Y and Sun L. Treatment of uterine scar cystoid diverticulum by hysteroscopy combined with laparoscopy. Fertil Steril 2023; 120(4):922-924.20. Zhang L, Wang M, Zhang Q, Zhao W, Yang B, Shang H, Shang X, Ma Y, Wang B and Feng L. Estrogen therapy before hysteroscopic adhesiolysis improves the fertility outcome in patients with intrauterine adhesions. Arch Gynecol Obstet 2019; 300(4):933-939.