CLINICAL RESEARCH

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Cesarean Scar Pregnancy and Subsequent Obstetric Outcomes: Focus on Postpartum Hemorrhage and Predictive Factors

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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: Cesarean scar pregnancy (CSP), a rare form of ectopic pregnancy, is associated with substantial maternal morbidity and uncertain implications for subsequent pregnancies. This study evaluated the association between prior CSP and adverse obstetric outcomes in subsequent pregnancies; it also explored independent predictors of postpartum hemorrhage (PPH).

Material/Methods: This retrospective single-center study included 15 439 women with prior cesarean section who delivered at a tertiary hospital (January 2015 to December 2023): 83 patients with CSP (Type I: n=24, ultrasound-guided uterine aspiration; Type II/III: n=59, uterine artery embolization [UAE]+aspiration) and 15 356 patients without CSP (non-CSP). Outcomes included PPH and secondary obstetric and neonatal complications. Multivariate logistic regression analysis was performed to address potential confounders.

Results: CSP was associated with higher rates of PPH (21.7% vs 1.7%; adjusted relative risk [aRR] 2.62, *P*=0.024), placenta previa (aRR 6.50, *P*<0.001), placenta accreta spectrum (PAS; aRR 8.31, *P*<0.001), preterm delivery before 33 weeks (aRR 12.05, *P*<0.001), and low birth weight (aRR 4.19, *P*<0.001). Type II/III CSP (adjusted odds ratio [aOR] 17.90, *P*<0.001), placenta previa (aOR 5.12, *P*=0.046), and PAS (aOR 12.48, *P*<0.001) were independent predictors of PPH. UAE did not significantly affect PPH risk (*P*=0.628).

Conclusions: CSP increases the risk of adverse obstetric outcomes. Type II/III CSP, placenta previa, and PAS are predictors of PPH. Prenatal assessments of CSP recurrence and placental disorders are critical for maternal-fetal safety.

Keywords: Obstetric Labor Complications • Retrospective Studies • Uterine Scars

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Introduction

Cesarean scar pregnancy (CSP) constitutes a rare but increasingly recognized form of ectopic pregnancy, characterized by implantation of the gestational sac within a cesarean section scar [1]. The estimated prevalence of CSP is 1 in 1500 to 1 in 2000 women with a prior cesarean section [2]. The incidence of CSP has increased globally due to rising cesarean section rates, with the greatest elevation in Eastern Asia (44.9%) [3,4]. CSP is associated with severe maternal complications, including life-threatening postpartum hemorrhage (PPH), uterine rupture, and hysterectomy – these are attributed to abnormal placentation and scar-related structural compromise [5].

Early diagnosis of CSP is essential for optimal management, and transvaginal ultrasound is considered the gold standard [6]. Diagnostic criteria include an empty uterine cavity and endocervical canal, embedding of the gestational sac or placenta within the hysterotomy scar, a triangular (≤8 weeks) or rounded/oval (>8 weeks) gestational sac filling the scar niche, a thin (1-3 mm) or absent myometrial layer between the sac and the bladder, prominent vascularization in the scar area, and the presence of embryonic or fetal structures with or without cardiac activity [7]. Rotas et al [8] emphasized that accurate sonographic identification of these features is needed to distinguish CSP from other ectopic or intrauterine pregnancies.

Management strategies are tailored to the CSP subtype, classified according to gestational sac location and invasion depth [9]. Type I CSP (endogenous) involves protrusion of the sac into the uterine cavity; ultrasound-guided uterine aspiration is the preferred treatment due to its minimally invasive nature and preservation of uterine function [10]. Type II CSP (endogenous with deep myometrial invasion) and Type III CSP (exogenous with extrapelvic extension) require more aggressive intervention; first-line therapy comprises uterine artery embolization (UAE) combined with aspiration [11]. UAE achieves preoperative hemostasis by occluding the uterine arteries, thus reducing the risk of catastrophic bleeding during surgical evacuation [12].

Despite advances in diagnosis and management, the long-term implications of CSP for subsequent pregnancy outcomes remain incompletely characterized. Although post-treatment conception rates range from 70.6% to 76.2% [13], women with a history of CSP exhibit increased risks of recurrent CSP (15.3-17.6%) [14] and adverse obstetric events. A history of cesarean delivery is associated with adverse assisted reproductive technology (ART) outcomes, and prior CSP has been linked to persistently elevated risks of preterm birth and placental disorders [15,16]. However, the independent association between prior CSP – including its subtypes and treatment modalities – and PPH in subsequent pregnancies remains poorly defined.

Therefore, this retrospective single-center study investigated patients with prior CSP who underwent ultrasound-guided uterine aspiration or UAE combined with aspiration. We aimed to evaluate subsequent pregnancy outcomes, assess PPH risk, and identify independent predictors of PPH.

Material and Methods

The study protocol was approved by the Institutional Review Board of the International Peace Maternity & Child Health Hospital, School of Medicine, Shanghai Jiao Tong University (approval no. GKLW-A-2025-056-01). Informed consent was waived due to the retrospective nature of the study; all data were extracted from de-identified electronic medical records. A certified English version of the ethical approval document is available upon request.

Study Design and Population

This retrospective study enrolled patients with a history of CSP who delivered at our tertiary care hospital from January 2015 to December 2023. Obstetric outcomes of their subsequent pregnancies were obtained from electronic medical records. Detailed and reproducible procedures were utilized to ensure study reproducibility, including standardized data collection protocols (electronic medical record search parameters, CSP ultrasound diagnosis and subtyping with Cohen's kappa=0.89), objective outcome definitions (PPH measurement protocols and diagnostic thresholds for adverse outcomes), and clearly specified statistical methods.

The study included 2 cohorts: women with CSP (CSP group) and women with a history of cesarean section but no prior CSP (non-CSP group). Inclusion criteria were singleton pregnancy, age 18 years and older, and at least 1 prior cesarean section. Exclusion criteria were multiple gestation, fetal chromosomal abnormalities, and preexisting medical conditions such as malignant neoplasms or coagulation disorders.

Data Collection

Data were extracted from electronic medical records by 2 independent researchers, with discrepancies resolved by consensus. Collected variables included demographic information, obstetric history, clinical characteristics of CSP, and pregnancy outcomes.

The primary outcome was PPH, defined as blood loss of at least 1000 mL within 24 hours after cesarean delivery. Secondary outcomes included severe PPH, placenta previa, placenta accreta spectrum (PAS), preterm delivery, low birth weight, small for gestational age, emergency cesarean section, uterine

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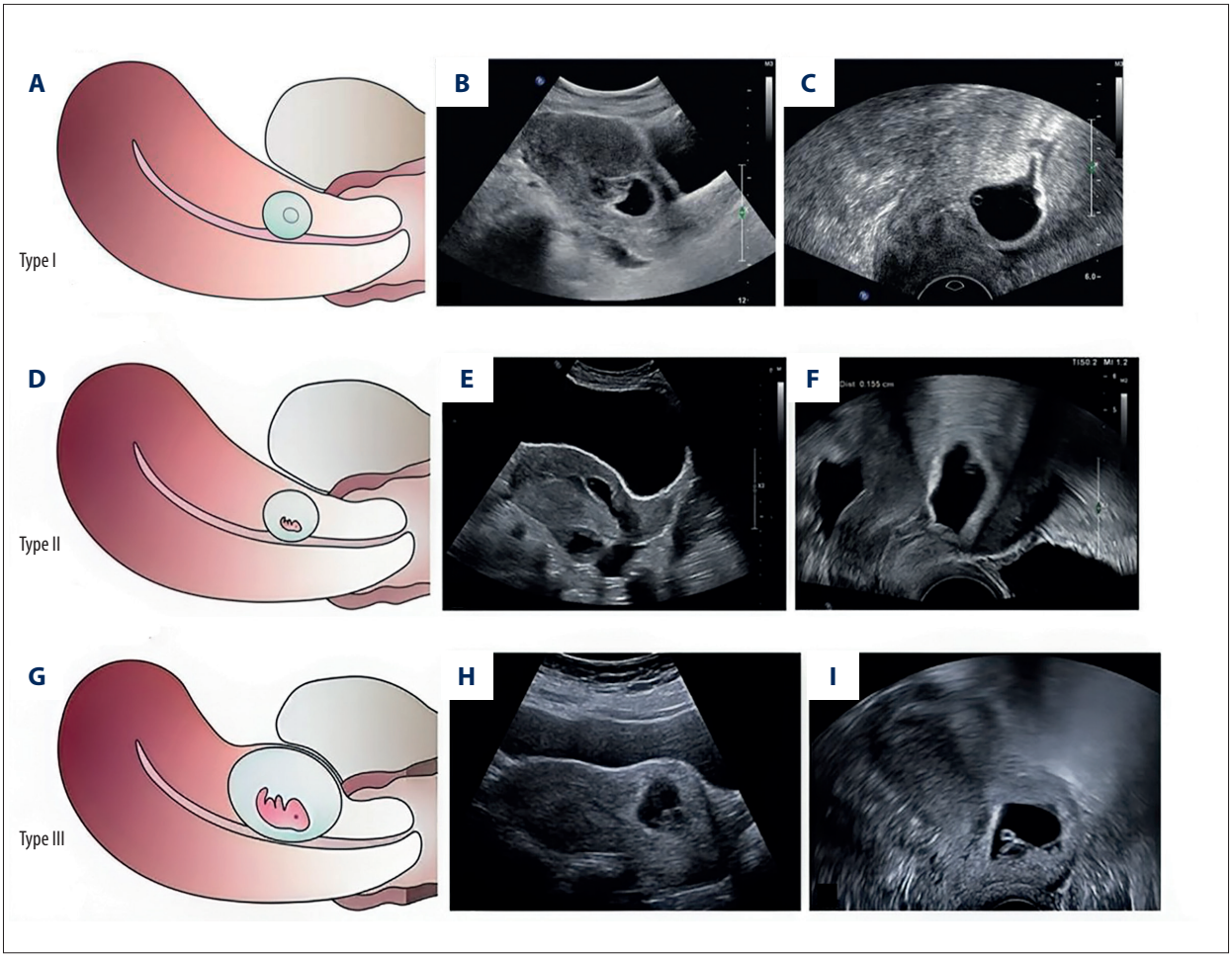

Figure 1. (**A-I**) Representative transvaginal ultrasound images of cesarean scar pregnancy (CSP) subtypes. Type I CSP: Gestational sac protruding into the uterine cavity, with a thick myometrial layer between the sac and the bladder. Type II CSP: Gestational sac embedded in the myometrium without crossing the serosal contour. Type III CSP: Gestational sac partially extending beyond the outer contour of the uterus, indicating extrapelvic extension.

rupture, hysterectomy, Apgar scores, and neonatal intensive care unit admission.

Diagnostic Criteria

CSP was diagnosed based on ultrasound findings of a gestational sac implanted within the cesarean scar. Ultrasonographic criteria for CSP diagnosis were as follows [7]: (1) empty uterine cavity and endocervical canal; (2) placenta or gestational sac, or both, embedded in the hysterotomy scar; (3) triangular gestational sac (≤8 weeks of gestation) or rounded/oval gestational sac (>8 weeks of gestation) filling the scar niche; (4) thin (1-3 mm) or absent myometrial layer between the gestational sac and the bladder; (5) prominent or rich vascular pattern in the cesarean scar area; and (6) presence of an embryonic or fetal pole, yolk sac, or both, with or without fetal cardiac activity.

CSP was classified according to the CSP classification system [9]. Based on location, CSP was categorized into 3 types (shown in **Figure 1**): Type I (endogenous, most of the gestational sac protrudes into the uterine cavity); Type II (endogenous, most of the gestational sac is embedded in the myometrium without crossing the serosal contour); and Type III (exogenous, the gestational sac partially extends beyond the outer contour of the cervix or uterus). PPH was defined as blood loss of at least 1000 mL within the first 24 hours after cesarean delivery [16]. Blood loss was assessed by weighing surgical materials, including sponges and drapes soaked with blood and amniotic fluid. Placenta previa was defined as the placenta covering the internal cervical os. PAS was diagnosed based on ultrasound or magnetic resonance imaging findings indicating abnormal placentation, including placenta accreta, placenta increta, and placenta percreta. Preterm delivery was defined as delivery before 37 weeks of gestation, with additional analysis for delivery before 33 weeks. Low birth weight was defined as

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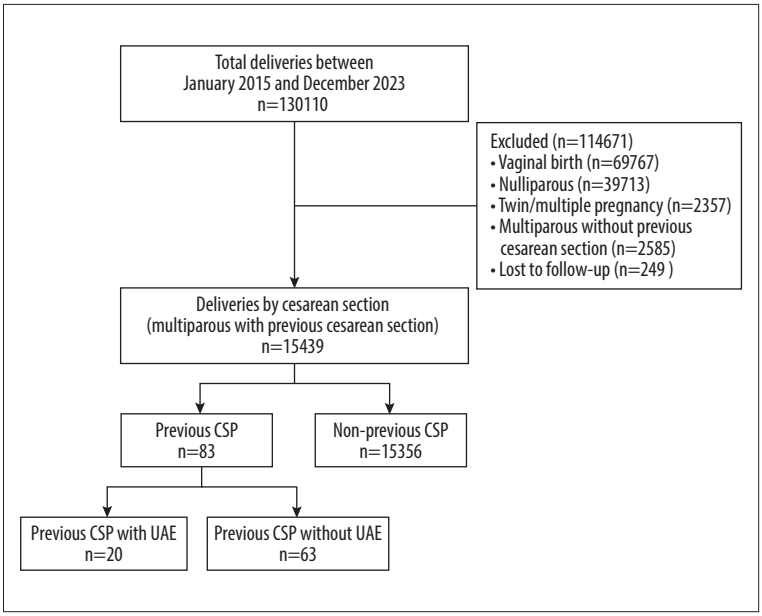

Figure 2. Flowchart of patient enrollment. In total, 130 110 patients delivered during the study period; 15 439 met the inclusion criteria (singleton pregnancy, age ≥18 years, and a history of cesarean section) and were divided into the CSP group (n=83) and the non-CSP group (n=15 356). Excluded patients (n=114 671) comprised those with multiple pregnancies, fetal chromosomal abnormalities, or preexisting medical conditions (malignant neoplasms or coagulation disorders).

Table 1. Clinical characteristics of patients with and without prior cesarean scar pregnancy.

Characteristic	Prior CSP (n=83)	Non-CSP (n=15356)	*P*
Maternal age (years)	34.36±3.267	34.25±3.743	0.796
BMI ≥28 kg/m^2	1 (1.2%)	674 (4.4%)	0.252
Gravidity (times)	4.0 [2.0, 6.0]	3.0 [2.0, 5.0]	0.132
Parity (times)	2.0 [2.0, 3.0]	2.0 [2.0, 4.0]	0.415
Abortion (times)	2.0 [1.0, 4.0]	1.0 [1.0, 3.0]	0.083
Prior cesarean section (times)	1.0 [1.0, 2.0]	1.0 [1.0, 3.0]	0.058
ART	2 (2.4%)	138 (0.9%)	0.386
Prepregnancy hypertension	1 (1.2%)	202 (1.3%)	1.000
Prepregnancy diabetes	1 (1.2%)	190 (1.3%)	1.000
Prepregnancy thyroid diseases	7 (8.4%)	1558 (10.1%)	0.61

Data are presented as mean±standard deviation, median (interquartile range), or n (%). ART – assisted reproductive technology; BMI – body mass index; CSP – cesarean scar pregnancy. *P*<0.05 was considered statistically significant.

weight below 2500 g. Small for gestational age was defined as birth weight below the 10th percentile for gestational age.

Treatment Protocols

Ultrasound-guided uterine aspiration: A minimally invasive transvaginal sonographically guided procedure. Under real-time visualization, the gestational sac is precisely localized, followed by gentle suction curettage for targeted removal of trophoblastic tissue.

Uterine artery embolization (UAE): A radiologically guided endovascular intervention. Embolic agents (eg, polyvinyl alcohol particles) are transfemorally injected into the bilateral uterine arteries to occlude blood supply to the cesarean scar pregnancy site. As an adjuvant therapy to ultrasound-guided uterine aspiration, UAE is primarily indicated for cases of high-risk CSP (eg, deep myometrial invasion, hypervascularity) to reduce the risk of life-threatening intraoperative hemorrhage.

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Table 2. Pregnancy outcomes of patients with and without prior cesarean scar pregnancy.

Pregnancy outcomes	Prior CSP (n=83)	No-CSP (n=15356)	*P*
Maternal outcomes			
Gestational age (weeks)	37.08±2.21	38.21±1.08	<0.001
Placenta previa	23 (27.71%)	670 (4.36%)	<0.001
PAS	26 (31.33%)	566 (3.69%)	<0.001
Prenatal hemorrhage	8 (9.64%)	43 (0.26%)	<0.001
Postpartum hemorrhage (≥1000 mL)	20 (24.09%)	267 (1.74%)	<0.001
Severe postpartum hemorrhage (≥2000 mL)	4 (4.82%)	19 (0.12%)	<0.001
Emergency cesarean section	12 (14.46%)	1003 (6.53%)	0.004
Uterine rupture or threatened uterine rupture	3 (3.61%)	29 (0.19%)	<0.001
Hysterectomy	2 (2.41%)	3 (0.02%)	<0.001
Infant outcomes			
Preterm delivery (<37 weeks)	23 (27.71%)	968 (6.30%)	<0.001
Preterm delivery (<33 weeks)	7 (8.43%)	101 (0.66%)	<0.001
Birth weight (g)	3061.87±643.165	3334.56±432.235	<0.001
Low birth weight	13 (15.66%)	451 (2.94%)	<0.001
SGA	3 (3.61%)	93 (0.61%)	0.005
LGA	2 (2.41%)	759 (4.94%)	0.419
Apgar score (<4 at 1 minute)	1 (1.20%)	21 (0.14%)	0.265
Apgar score (<7 at 5 minutes)	1 (1.20%)	10 (0.07%)	0.069
NICU admission	10 (12.05%)	482 (3.14%)	<0.001

Data are presented as mean±standard deviation, median (interquartile range), or n (%). CSP – cesarean scar pregnancy; LGA – large for gestational age; NICU – neonatal intensive care unit; PAS – placenta accreta spectrum; SGA – small for gestational age. *P*<0.05 was considered statistically significant.

Statistical Analysis

Descriptive statistics were used to summarize the clinical characteristics of the study population. Continuous variables were expressed as mean±standard deviation or median (interquartile range), and categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the chi-square test for categorical variables and Student's t-test or the Mann-Whitney U test for continuous variables, as appropriate. Multivariate logistic regression analysis was conducted to adjust for potential confounders, including maternal age, body mass index (BMI), gravidity, parity, prior cesarean section, and ART use. Adjusted relative risks (aRRs) were estimated using regression models to control for confounding variables. Odds ratios (ORs) and adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were calculated to explore associations between CSP and adverse outcomes. All statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA), and 2-sided P-values <0.05 were considered statistically significant.

Results

Baseline Characteristics

Of 130 110 deliveries during the study period, 15 439 met the inclusion criteria, including 83 (0.64%) in the CSP group (shown in **Figure 2**). Baseline characteristics were comparable between groups (**Table 1**), without significant differences in maternal age, BMI of at least 28 kg/m^2, gravidity, parity, number of prior cesarean sections, ART use, or prepregnancy comorbidities (ie, hypertension, diabetes, or thyroid diseases) (all *P*>0.05).

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Table 3. Crude and adjusted relative risks of adverse pregnancy outcomes for women with and without prior cesarean scar pregnancy.

Pregnancy outcomes	Prior CSP (n=83)	No-CSP (n=15356)	Crude RR 95% CI	Adjusted RR 95% CI	*P*
Placenta previa	23 (27.71%)	670 (4.36%)	6.35 (4.45-9.06)	6.50 (4.46-9.46)	<0.001
PAS	26 (31.3%)	566 (3.7%)	8.45 (6.12-11.81)	8.31 (5.89-11.74)	<0.001
Postpartum hemorrhage (≥1000 mL)	18 (21.7%)	267 (1.7%)	12.47 (8.15-19.09)	2.62 (1.14-6.05)	0.024
Preterm delivery (<37 weeks)	23 (27.7%)	968 (6.3%)	4.40 (3.09-6.26)	1.90 (0.93-3.89)	0.080
Preterm delivery (<33 weeks)	7 (8.4%)	101 (0.7%)	12.82 (6.15-26.74)	12.05 (5.30-27.41)	<0.001
Low birth weight	13 (15.7%)	451 (2.9%)	5.33 (3.21-8.85)	4.19 (2.42-7.25)	<0.001

Data in "Prior CSP" and "No-CSP" columns are presented as n (%). Confounding factors: maternal advanced age (≥35 vs <35 years), smoker (yes vs no), BMI (≥28 vs <28 kg/m^2), number of abortions (≥3 vs <3), number of prior cesarean sections (≥2 vs <2), ART (yes vs no). ART – assisted reproductive technology; BMI – body mass index; CSP – cesarean scar pregnancy; PAS – placenta accreta spectrum; RR – relative risk. *P*<0.05 was considered statistically significant.

Adverse Obstetric and Neonatal Outcomes

The incidence of PPH (≥1000 mL) was significantly higher in the CSP group than in the non-CSP group (24.1% vs 1.7%, *P*<0.001). The CSP group also showed higher incidences of severe PPH (≥2000 mL), placenta previa, PAS, emergency cesarean section, uterine rupture, and hysterectomy (all *P*<0.05). Regarding neonatal outcomes, the CSP group had significantly higher incidences of preterm birth, small for gestational age, low birth weight, and neonatal intensive care unit admission (*P*<0.05). However, there were no significant differences in Apgar scores (<4 at 1 minute and <7 at 5 minutes) between the groups (*P*>0.05) (**Table 2**).

Subtype Analysis and Predictors of PPH in the CSP Group

Univariate analysis was performed to compare clinical characteristics (CSP subtypes, UAE use, placenta previa, PAS, and potential confounders) between patients with CSP who had or did not have PPH. Variables with *P*<0.10 in univariate analysis were entered into multivariate logistic regression. The model was adjusted for maternal age, BMI, prior cesarean section, and ART use. Collinearity was excluded (variance inflation factor <5), and stepwise selection was applied (entry *P*<0.05; removal *P*>0.10).

aRRs of adverse pregnancy outcomes are presented in **Table 3**. The CSP group had significantly higher rates of postpartum hemorrhage (≥1000 mL) (aRR 2.62, 95% CI 1.14-6.05, *P*=0.024), placenta previa (aRR 6.50, 95% CI 4.46-9.46, *P*<0.001), and PAS (aRR 8.31, 95% CI 5.89-11.74, *P*<0.001). The CSP group also had significantly higher rates of preterm delivery (<33 weeks) (aRR 12.05, 95% CI 5.30-27.41, *P*<0.001) and low birth weight (aRR 4.19, 95% CI 2.42-7.25, *P*<0.001).

Clinical characteristics of patients with CSP who had or did not have PPH are shown in **Table 4**. There was a significant difference in blood loss between the groups (1568.25±1208.72 mL vs 246.84±92.83 mL, *P*<0.001). Among patients with CSP, the incidences of placenta previa and PAS were significantly higher in the PPH group than in the non-PPH group (*P*<0.001).

As described above, patients with CSP were stratified into 3 categories. For statistical analysis, Types II and III were combined into a single group. Regarding prior CSP characteristics, the PPH group had higher rates of UAE use and Type II/III CSP compared with the non-PPH group (*P*<0.05).

Table 5 presents the aORs for PPH in patients with CSP. Multivariate logistic regression identified Type II/III CSP (aOR 17.90, 95% CI 3.62-28.61, *P*<0.001), placenta previa (aOR 5.12, 95% CI 1.03-25.51, *P*=0.046), and PAS (aOR 12.48, 95% CI 2.77-26.33, *P*<0.001) as independent predictors of PPH. UAE treatment did not significantly affect PPH risk (aOR 0.67, 95% CI 0.13-3.43, *P*=0.628).

Discussion

Summary of Findings

This study confirms that prior CSP is associated with increased risks of adverse obstetric outcomes in subsequent pregnancies, including PPH, placenta previa, PAS, preterm delivery, and low birth weight. Type II/III CSP, placenta previa, and PAS emerged as independent predictors of PPH; UAE treatment for CSP did not affect PPH risk in subsequent pregnancies. These findings underscore the importance of subtype-specific risk stratification and targeted prenatal monitoring for women with a history of CSP.

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Table 4. Clinical characteristics of patients with prior cesarean scar pregnancy who had or did not have postpartum hemorrhage.

	PPH Group (n=20)	Non-PPH Group (n=63)	*P*
Characteristic			
Maternal age (years)	34.90±3.13	34.19±3.32	0.401
BMI ≥28 kg/m^2	0	1.00 (1.60)	1.000
Gravidity (times)	4.25±1.21	4.59±1.64	0.411
Parity (times)	2.05±0.39	2.11±0.36	0.523
Abortion (times)	2.20±1.11	2.48±1.54	0.461
Previous cesarean section (times)	1.15±0.37	1.13±0.38	0.813
ART	1.00 (5.00)	0	0.542
Placenta previa	10.00 (50.00)	11.00 (17.50)	0.004
PAS	15.00 (75.00)	11.00 (17.50)	<0.001
Gestational age (weeks)	36.88±2.60	37.04±2.22	0.813
Birth weight (g)	3217.01±669.32	3012.62±632.13	0.218
Volume of PPH (mL)	1568.25±1208.72	246.84±92.83	<0.001
Prepregnancy hypertension	0	1.00 (1.60)	1.000
Prepregnancy diabetes	1.00 (5.00)	1.00 (1.60)	0.976
Prepregnancy thyroid diseases	2.00 (10.00)	5.00 (7.90)	1.000
Prenatal hemorrhage	3.00 (15.00)	4.00 (6.30)	0.453
Emergency cesarean section	2.00 (10.00)	10.00 (15.90)	0.775
Prior CSP characteristics			
Interval after prior CSP (years)	2.58±1.82	3.05±2.52	0.451
Length of amenorrhea (weeks)	7.91±1.53	7.18±1.29	0.058
Gestational sac diameter (mm)	25.18±12.32	20.29±9.21	0.145
Myometrial thickness (mm)	3.13±1.52	3.43±1.78	0.383
UAE	12.00 (60.00)	11.00 (17.50)	<0.001
Type of CSP			<0.05
I	2.00 (10.00)	22.00 (34.92)	
II+III	18.00 (90.00)	41.00 (65.08)	

Data are presented as mean±standard deviation, median (interquartile range), or n (%). ART – assisted reproductive technology; BMI – body mass index; CSP – cesarean scar pregnancy; PAS – placenta accreta spectrum; PPH – postpartum hemorrhage; UAE – uterine artery embolization. *P*<0.05 was considered statistically significant.

Comparison With Prior Studies

In this study, Type I CSP was treated with ultrasound-guided uterine aspiration, whereas Types II and III CSP were managed by UAE combined with uterine aspiration. Our findings are consistent with recent studies demonstrating that CSP significantly increases the risk of adverse obstetric outcomes. A systematic review showed that women with prior CSP had a 70% subsequent pregnancy rate, with 82% achieving intrauterine pregnancy and 67% experiencing uncomplicated term live births [11]. However, these women remained at risk for recurrent CSP (15-21%), miscarriage (13.9-22.2%), preterm

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Table 5. Adjusted odds ratios for postpartum hemorrhage in women with cesarean scar pregnancy.

	Adjusted OR	95% CI	*P*
Type II/III CSP (Yes=1 vs No=0)	17.90	3.62-28.61	<0.001
Placenta previa (Yes=1 vs No=0)	5.12	1.03-25.51	0.046
PAS (Yes=1 vs No=0)	12.48	2.77-26.33	<0.001
UAE (Yes=1 vs No=0)	0.67	0.13-3.43	0.628

CI – confidence interval; CSP – cesarean scar pregnancy; OR – odds ratio; PAS – placenta accreta spectrum; UAE – uterine artery embolization. *P*<0.05 was considered statistically significant.

birth (10%), and PAS disorders (4-12%) [17]. Lei et al [13] investigated factors linked to reproductive outcomes in 100 patients with CSP who underwent ultrasound-guided uterine aspiration or laparoscopic scar repair. They reported that 43% achieved live birth, 19% experienced abortion, 38% developed secondary infertility, and 15% had recurrent CSP. No significant differences in reproductive outcomes were observed between treatment groups. Another study [18] evaluated the impact of CSP treatment on fertility and pregnancy outcomes in 499 women, of whom 51 attempted subsequent pregnancy. UAE combined with uterine aspiration achieved a 68.8% success rate, whereas ultrasound-guided lauromacrogol injection combined with uterine aspiration achieved an 88.9% success rate. The CSP recurrence rate was 6.6%. Both treatment methods appeared safe for future pregnancies. However, the impacts of various CSP treatment modalities on subsequent pregnancy outcomes remain unclear. Accordingly, early ultrasound evaluation and close monitoring are recommended for women with a history of CSP who plan future pregnancies.

The present study demonstrated a significant association between prior CSP and subsequent PPH, particularly in patients who exhibit PAS disorders. Jauniaux et al [19] highlighted that scar implantation is an important risk factor for PAS onset. Surgical scar defects, characterized by incomplete endometrial re-epithelialization and vascular remodeling, may promote invasive placentation. Calì et al [20] reported that among 40 women with CSP managed expectantly, 76.9% reached the third trimester, and 39.2% experienced severe bleeding. The incidence of PAS at delivery was 74.8%, and 69.7% of cases involved placenta percreta. In patients with prior CSP, the depth and pattern of placental invasion have substantial effects on PPH risk, particularly when PAS is present. Rising cesarean delivery rates are associated with long-term complications, including uterine scar defects linked to gynecologic symptoms and pregnancy-related complications such as CSP and uterine rupture. However, the optimal uterine closure technique remains uncertain. One study [21] followed 2292 women for 3 years after their first cesarean delivery to compare single-layer and double-layer uterine closure techniques. No significant differences were identified in live birth rates, pregnancy rates, or obstetric complications. CSP incidences were 3/353 (0.8%) in the single-layer group and 0/339 (0.0%) in the double-layer group (RR 0.99, 95% CI 0.98-1.00). Both techniques appeared similarly effective. High rates of gynecologic symptoms, including spotting (30-32%) and dysmenorrhea (47-49%), were reported. Given current data limitations, effective strategies for preventing CSP remain unclear.

Ban et al [22] proposed a CSP classification system based on anterior myometrial thickness and gestational sac diameter to predict intraoperative hemorrhage risk. This system categorizes CSP into 5 types with corresponding surgical strategies. In 564 cases, the success rate of first-line treatment was 97.5%; no hysterectomies were required. Most patients had negative β-human chorionic gonadotropin levels within 3 weeks and resumed menstruation within 8 weeks. Fu et al [23] developed a new classification and risk-scoring system for CSP, which regards gestational sac location and diameter as major risk factors for intraoperative bleeding. They proposed a scoring system, where scores of 0 to 3 indicate low risk and 5 to 7 indicate high risk. This classification approach divided CSP into 3 types based on ultrasound findings. The new system may help guide treatment selection by recommending dilation and curettage or hysteroscopy for low-risk cases and operative resection for high-risk cases. However, further validation is required.

Limitations

Despite the strengths of our study, several limitations should be acknowledged. First, the analysis was based on retrospective data, which may be subject to selection bias and residual confounding. Second, the sample size was relatively small, which may limit the generalizability of the findings. Future studies should validate these results in larger, multicenter cohorts.

Conclusions

A history of CSP significantly increases the risk of adverse obstetric outcomes in subsequent pregnancies; PPH represents

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a major concern. Type II/III CSP, placenta previa, and PAS are independent predictors of PPH. Prenatal screening for CSP recurrence and placental disorders is essential to optimize maternal-fetal safety.

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We disclose that Doubao AI was used during the initial drafting phase to refine grammar, organize descriptive text (excluding the Results and Discussion sections), and standardize scientific terminology. The AI model did not participate in study design, data collection, statistical analysis, result interpretation, or formulation of the conclusions. All content, particularly the data and clinical interpretations, was independently verified by the authors.

Institution Where Work Was Done

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Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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