Evaluation of the uterine cavity, cervix and uterine blood flow after conservative surgical measures of the placenta accreta spectrum disorders (PAS- disorders).

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Abstract
Background: Placenta accreta spectrum (PAS) disorders have become a significant life-threatening obstetrical issue due to its increased incidence from 0.12 to 0.31% in the last 30 years and the reported mortality rate of approximately 7.0%. **Methods:** This study was a prospective, single-centre cohort study with a control group conducted at Minia Women's Health Hospital, Minia University, Egypt from 1st January 2022 to 31st December 2024. The study population included women who were managed by conservative surgical techniques during caesarean section following intraoperative haemorrhage due to placenta accreta spectrum (PAS) disorder. **Result:** At 6 months, women managed conservatively for focal PAS had significantly higher rates of cervical stenosis (58% vs. 0%, p<0.001), cesarean scar niche (22% vs. 0%, p<0.001), intrauterine adhesions (8% vs. 0%, p=0.018), and uterine cavity irregularity (16% vs. 0%, p<0.001) compared with controls, while a normal uterine cavity was less frequently observed (72% vs. 100%, p<0.001). Uterine artery PI and PSV were significantly lower in the study group than controls (p<0.001). Cervical stenosis was the strongest predictor of amenorrhea (OR 4.30, 95% CI 2.10–8.80, p<0.001). **Conclusion** Conservative management was associated with the preservation of uterine anatomy and menstrual function in most women, although cervical stenosis and scar niches remained common.
Keywords: Uterine Cavity, Cervix, Uterine Blood Flow, PAS- Disorders.
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Introduction

Placenta accreta spectrum disorders describe the abnormal adherence and invasion of placental tissue into the myometrium — encompassing accreta, increta, and percreta — and constitute a leading cause of major obstetric haemorrhage **(1,5)**. The global incidence of PAS has risen from 0.12% to 0.31% over the last 30 years, accompanied by a reported maternal mortality rate of approximately 7% **(6)**. Survivors frequently experience massive transfusion, urinary tract injury, intensive-care admission, sepsis, prolonged hospitalisation, and inadvertent peripartum hysterectomy.

Recognised risk factors include placenta previa, advanced maternal age (≥35 years), multiparity, prior caesarean section, prior uterine surgery, and conception by in vitro fertilization **(2,5,7)**. The American College of Obstetricians and Gynecologists recommends Elective caesarean hysterectomy with the placenta left in situ as the reference-standard management, because attempts at forced placental extraction precipitate torrential blood loss **(6,8).** This approach, however, abolishes fertility and is rarely acceptable to women wishing to retain their uterus. In selected patients prioritising fertility preservation, conservative surgical techniques — including uterine artery ligation, compression sutures, focal or segmental resection, and the Triple-P procedure — offer a uterus-preserving alternative, provided hysterectomy remains the rescue option should secondary haemorrhage or sepsis supervene **(1,6,8,9)**

Rationale for evaluating the uterine cavity, cervix, and uterine blood flow after conservative PAS surgery

Most of the PAS literature has focused on intra-operative outcomes — blood loss, transfusion

requirements, hysterectomy rates, and short-term morbidity **(8).** Comparatively little attention has been directed to the anatomical and functional recovery of the uterus, cervix, and uterine blood supply in the months following conservative surgery. Three clinically important questions remain once a woman leaves the operating theatre alive.

First, has the uterine cavity healed normally, or has intrauterine adhesions, caesarean scar niche, or irreversible endometrial scarring occurred? Hysteroscopy is the gold standard for direct visualisation of the cavity and for the detection of adhesions, niches, and isthmoceles.

Second, has cervical integrity been preserved? Conservative surgery on the lower uterine segment can produce cervical stenosis or shortening, with downstream consequences for menstruation, sperm transit, and future fertility.

Third, has the uterine arterial hemodynamics recovered? Several conservative techniques involve ligation or compression of the ascending branch of the uterine artery, which is expected to alter postoperative perfusion indices.

A combined two-dimensional transvaginal ultrasound (2D-TVS), colour and pulsed-wave Doppler interrogation of the uterine arteries, and office hysteroscopy provides a comprehensive anatomical and haemodynamic profile of the post-conservative-PAS uterus that cannot be obtained from clinical examination alone. Accordingly, the aim of this study was to evaluate the uterine cavity, cervical status, and uterine blood flow following different conservative surgical approaches for the management of PAS disorders.

Patients and Methods

This study was a prospective, single-centre cohort study with a control group conducted at Minia Women's Health Hospital, Minia University, Egypt. The study population included women who were managed by conservative surgical techniques during caesarean section following intraoperative haemorrhage due to placenta accreta spectrum (PAS) disorder. The study was conducted over a three-year period, from 1st January 2022 to 31st December 2024. This study included only focal PAS disorders; findings cannot be generalized to increta, percreta, or diffuse PAS.

Samples size calculations:

Sample size was calculated using OpenEpi version 3.01 for comparison of two independent groups. Based on previous studies, the expected prevalence of uterine cavity abnormalities detected by office hysteroscopy was estimated at 40% among women who underwent conservative management for placenta accreta spectrum (PAS) disorders and 15% among controls. Using a confidence level of 95% ($\alpha = 0.05$), a study power of 80% ($1-\beta$), and a 1:1 case-to-control ratio, the minimum required sample size was 45 participants per group. To account for an anticipated 10% loss to follow-up, the sample size was increased to 50 women in each group, resulting in a total study population of 100 participants. The 1:1 allocation therefore produced 50 cases and 50 controls. The secondary outcome planned comparison across four surgical groups; however, with ~12–13 patients per arm, the study was underpowered for inter-technique comparison. Therefore, surgical techniques were pooled for analysis. This is explicitly stated in the Limitations.

Inclusion criteria: Included women aged 18–40 years with a gestational age of 28–40 weeks, antenatally **diagnosed with focal PAS only**, managed conservatively for intraoperative hemorrhage, who consented to participate and were available for follow-up.

Exclusion criteria: Included patients managed by hysterectomy or by leaving the placenta in situ, those who declined participation, women whose uterine cavity could not be evaluated due to pregnancy, and those who had an intrauterine device (IUD) inserted within the first 3 months postpartum.

Participants: The study population consisted of women diagnosed antenatally with focal placenta accreta spectrum (PAS) disorders that underwent elective caesarean section and were managed intraoperative by conservative surgical techniques at Minia Women's Health Hospital. A control group included women who delivered by caesarean section for other indications without intraoperative haemorrhage or additional surgical interventions.

Conservative Surgical Techniques

Four techniques were employed: (1) bilateral uterine artery ligation at the internal cervical os using Vicryl 1-0; (2) compression sutures (modified B-Lynch or Hayman) using Vicryl No. 1; (3) focal wedge resection of invaded myometrium with layered closure; and (4) Triple-P procedure (A combination of (i) peri-operative pelvic devascularisation by uterine artery ligation, (ii) placental non-removal above the abnormal adherence site via a trigonal uterine incision, and (iii) myometrial excision and reconstruction of the uterine wall). Technique selection was determined intraoperatively by the senior surgeon based on invasion extent and bleeding severity.

The first follow-up visit

The initial follow-up evaluation was conducted at 3 months postpartum to assess uterine healing, completion of uterine involution, resolution of retained placental tissue, and the success of conservative management. Women were evaluated regarding menstrual pattern, lactation status, contraceptive use, and any subsequent pregnancy. All participants underwent gray-scale ultrasonography of the uterus and ovaries and Doppler assessment of uterine vessels with measurement of vascular indices, while office hysteroscopy for uterine cavity evaluation was performed only in the study group.

The second follow-up visit:

The second follow-up evaluation was conducted at 6 months postpartum; a time point that permits assessment of longer-term outcomes, including complete resolution of placental remnants, restoration of normal uterine anatomy, and identification of late complications such as intrauterine adhesions or persistent vascular abnormalities. This interval also provides valuable insight into resumption of normal menstrual function and potential reproductive capacity.

Women were subjected to the same previous interventions.

Gray scale ultrasound evaluation

Two-dimensional ultrasound evaluation was performed using a Voluson S8 ultrasound system (GE Healthcare, USA) equipped with a 3–5 MHz transabdominal probe and a 5–9 MHz transvaginal probe. After bladder emptying, transabdominal and transvaginal scans were conducted to measure uterine dimensions, including length, width, and height, from which uterine volume was calculated using the ellipsoid formula (length × width × height × 0.523). Endometrial thickness was measured along the central longitudinal axis of the uterine body as the distance between the echogenic endometrial–myometrial interfaces.

In the study group, a fluid collection within the lower uterine segment and cavity was observed on routine 2D-TVS in 60% of patients. This was interpreted as spontaneous intra-cavity fluid retention secondary to cervical stenosis — analogous to a non-deliberate saline-retention sign — rather than as a deliberately performed saline-infusion sonohysterosalpingogram, which would have required active catheter instillation. No such collection was identified in any control.

Color and pulsed Doppler evaluation

Color Doppler ultrasound was performed to assess bilateral uterine arteries at the uterocervical junction. Pulsatility index (PI), resistance index (RI), peak systolic velocity (PSV), end-diastolic velocity (EDV), and time-averaged maximum velocity (TAMXV) were recorded from at least three consecutive waveforms. Uterine artery diameters were measured bilaterally, and the average values were used for analysis. All examinations were conducted under standardized conditions regarding patient position, menstrual cycle timing, pulse repetition frequency (PRF), and gain settings to ensure accurate and reproducible measurements.

Office hysteroscopy

- Office hysteroscopy was performed during the proliferative phase of the menstrual cycle. All hysteroscopies were performed by a single experienced operator with >10 years of diagnostic and operative hysteroscopy experience.
- **Equipment:** A 4-mm rigid hysteroscope with 30° optics was used, introduced through a vaginoscopic approach, with normal saline as the distension medium.
- **Pre-specified diagnostic criteria:**
    - **Cervical stenosis:** Inability to negotiate the internal cervical os with the 4-mm rigid hysteroscope without prior mechanical or osmotic dilatation. Severity was graded as mild (dilatation ≤ Hegar 4), moderate (Hegar 5–7), or severe (>Hegar 7 or requiring ultrasound-guided access).
    - **Caesarean scar niche (isthmocele):** A pouch-like hypoechoic defect at the site of the previous hysterotomy with depth ≥2 mm [8].
    - **Intrauterine adhesions:** Classified according to the March criteria; only adhesions of stage II or greater were recorded as clinically significant.
    - **Endometrial scarring:** Focal areas of pale, avascular endometrium with loss of the normal glandular pattern.
    - **Uterine cavity irregularity:** Any asymmetry, tenting, or distortion of the normal triangular cavity shape.
    - **Apparently normal uterine cavity:** A cavity free of intrauterine adhesions, free of clinically

significant endometrial scarring, and conforming to the normal triangular shape — irrespective of cervical findings or the presence of a caesarean scar niche. A caesarean scar niche is a defect of the myometrial scar and does not, by itself, distort intra-cavity morphology; nor does cervical stenosis, which impairs trans-cervical access without altering intra-cavity architecture.

A cumulative hysteroscopic abnormality score was generated for longitudinal tracking.

Outcome measures

Primary outcome: The primary outcome was the incidence of intrauterine cavity abnormalities, defined as the presence of intrauterine adhesions, cesarean scar niche, endometrial scarring or uterine cavity irregularity, in addition to cervical sequalae including cervical stenosis and/or shortening. Outcomes were evaluated by standardized office hysteroscopy in the study groups at 3 and 6 months postpartum.

Secondary outcome: Uterine artery morphology and hemodynamics, uterine volume, and cervical changes in the pooled study group versus controls. Due to insufficient power, the four surgical techniques were not analyzed separately. **The primary overarching objective was to evaluate the safety of conservative PAS surgery as a collective, uniform strategy compared with standard caesarean section.** Although the four constituent techniques were documented in the operative record, the sample size of 50 patients was powered for the cohort level rather than for individual surgical protocols; the four arms were accordingly pooled for the primary analysis (see Limitations).

Ethical considerations:

All the regulations of the local ethics committee of faculty of medicine Minia University had been followed. Consent for data collection had been taken from the patients before inclusion in the study.

Data collection and analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Normality was assessed by Shapiro-Wilk test. Qualitative data were expressed as frequencies and percentages; quantitative data as mean ± SD.

Between-group comparisons used independent t-test or Mann-Whitney U test for continuous variables, and Chi-square or Fisher's exact test for categorical variables. Binary logistic regression (Enter method) identified predictors of adhesions and amenorrhea. Variables with $p < 0.10$ on univariate analysis were entered; multicollinearity was assessed by VIF (exclusion threshold >10). Model fit was evaluated by Hosmer-Lemeshow test. Missing data (<5%) were handled by complete case analysis. Results are presented as OR (95% CI).

A p-value < 0.05 was considered statistically significant. Because baseline differences existed between groups in abortion history (p=0.004) and educational level (p<0.001) clinically plausible confounders of uterine cavity status and reproductive outcomes — **an additional multivariable logistic regression for the primary cavity-related outcomes (intrauterine adhesions and uterine cavity irregularity) was performed adjusting for baseline abortion history**. Educational level was not entered as a covariate because it was judged a priori unlikely to exert a direct biological effect on adhesion formation and is more plausibly a proxy for socio-economic status that affects follow-up access rather than tissue healing per se.

Results

1.**Demographic data:** The study and control groups were generally well matched with no significant differences in most baseline characteristics, including age, BMI, parity, and gestational age ($p > 0.05$). However, significant differences were found in abortion history ($p = 0.004$) and educational level ($p < 0.001$), indicating possible confounding factors that should be adjusted for in further analysis. **(Table 1)**

2.Comparison of Hysteroscopy Findings at 3 Months: Hysteroscopy evaluation showed that **cervical stenosis was the most common finding (70%)**. Scar niche was detected in **20%** of patients, with a mean length of **15.4 ± 1.9 mm**. The most frequent niche shape was **triangular (14%)**. Most patients had an apparently normal uterine cavity (**68%**), while intrauterine adhesions and cavity irregularities were detected in **12%** and **16%** of cases, respectively. **(Table 2)**

3.Comparison of Hysteroscopy Findings at 6 Months: At 6 months, the study group still had significantly more abnormal hysteroscopic findings than controls, including cervical stenosis, scar niche, intrauterine adhesions, and uterine cavity irregularity ($p \leq 0.018$), while endometrial scarring was rare and not significant. Overall, a normal uterine cavity was less frequent in the study group compared with controls (72% vs. 100%, $p < 0.001$). **(Table 3)**

4. Comparison of Hysteroscopy examination after 3 months and after 6 months No statistically significant differences were observed in hysteroscopy

findings between **3 and 6 months' follow-up**. The incidence of cervical stenosis decreased from **70% to 58%** (**p=0.211**), while scar niche incidence showed a slight increase from **20% to 22%** (**p=0.806**). Niche length and shape remained comparable between both assessments (**p>0.05**). Uterine cavity findings, including intrauterine adhesions, endometrial scarring, cavity irregularity, and apparently normal cavity, showed no significant changes over time (**p>0.05**). **(Table 4)**

5. Comparison of color and pulsed Doppler results after 3 months between the studied groups: At 3 months, Doppler assessment showed significant differences between groups, with the study group demonstrating lower PI and PSV and higher TAMXV on both sides compared with controls ($P \leq 0.003$), while RI and EDV showed no significant differences. **(Table 5)**

6. Comparison of Two-dimensional (2D) transvaginal ultrasound (TVS) findings between the studied groups after 3 months: The studied group had significantly higher **uterine volume** and **left ovarian volume** compared with the control group (**p=0.005 and p=0.018**, respectively). Uterine artery diameters were significantly lower in the studied group (**p<0.001 for right and p=0.006 for left artery**). Intrauterine fluid accumulation was significantly more frequent in the studied group (**60% vs. 0%, p<0.001**). Other parameters showed no significant differences **(Table 6)**

7. **Multivariate Predictors for Adhesions:** Multivariate analysis revealed that number of previous cesarean sections (OR=2.38, 95% CI: 1.12–5.05, p=0.024), bladder wall interruption (OR=2.95, 95% CI: 1.31–6.64, p=0.009), and history of abortion (OR=1.92, 95% CI: 1.05–3.51, p=0.034) were significant predictors of the outcome. Other variables, including placenta Previa major, previous surgical evacuations, and low educational level, were not significantly associated. **(Table 7)**

8. Multivariate Predictors for Amenorrhea: Logistic regression analysis showed that endometrial thickness (OR=0.59, 95% CI: 0.42–0.82, p=0.002), uterine artery ligation (OR=2.05, 95% CI: 1.02–4.12, p=0.044), and cervical stenosis (OR=4.15, 95% CI: 1.98–8.70, p<0.001) were significant predictors of the outcome. Other variables, including extent of AIP, abortion history, and low educational level, were not significantly associated. **(Table 8)**

Table (1): Distribution of demographic data between the studied groups.

	Study group (n=50)	**Control group (n=50)**	**P value**
Age (years) Mean ± SD	31.4 ± 3.9	31.62 ± 3.7	0.773
BMI (kg/m²) Mean ± SD	25.9 ± 2.9	26.9 ± 3.2	0.105
Parity Mean ± SD	3.6 ± 2.8	2.9 ± 1.6	0.128
Abortion	17 (34%)	5 (10%)	0.004*
Gestational age (weeks) Mean ± SD	38.1 ± 0.9	38 ± 0.2	0.445
Previous surgeries	16(32%)	9 (18%)	0.105
Residence			
Rural	17 (34%)	14 (28%)	0.516
Urban	33 (66%)	36 (72%)	
Socio-economic level			
Low	29 (58%)	32 (64%)	0.241
Middle	16 (32%)	17 (34%)	
High	5 (10%)	1 (2%)	
Educational level			
Illiterate	14 (28%)	0.0 (0.0%)	**< 0.001***
Low education	30 (60%)	34 (68%)	
Average	3 (6%)	14 (28%)	
High	3 (6%)	2 (4%)	

P value >0.05: Not significant, P value <0.05 is statistically significant, p<0.001 is highly significant., SD: standard deviation.

Table (2): Hysteroscopy examination in the study group after 3 months.

	Study group (n=50)
Cervix Stenosis	35 (70%)
Scar niche	10 (20%)
Length of niche(mm) Mean ± SD Range	15.4 ± 1.9 12.0 – 18.0
Shape	

Triangular niche	7 (14%)
Semicircular niche	4 (8%)
Uterine cavity	
1-Intrauterine adhesions	6 (12%)
Mild	4 (8%)
Moderate	1 (2%)
Severe	1 (2%)
2-Endometrial scaring	2 (4%)
3-Uterine cavity irregularity	8 (16%)
4-Apparently normal	34 (68%)

Table (3): Comparison of Hysteroscopy Findings at 6 Months

Hysteroscopic Finding	Study Group (n=50)	Control Group (n=50)	P-value
Cervical Stenosis	29 (58%)	0 (0%)	<0.001*
Scar Niche	11 (22%)	0 (0%)	<0.001*
Intrauterine Adhesions	4 (8%)	0 (0%)	0.018*
Endometrial Scarring	2 (4%)	0 (0%)	0.073
Uterine Cavity Irregularity	8 (16%)	0 (0%)	<0.001*
Apparently Normal Cavity	36 (72%)	50 (100%)	<0.001*

Table (4): Comparison of Hysteroscopy examination after 3 months and after 6 months in the study group.

	After 3 months	After 6 months	P value
Cervix Stenosis	35 (70%)	29 (58%)	0.211
Scar niche	10 (20%)	11 (22%)	0.806

Length of niche(mm) Mean ± SD	15.4 ± 1.9	15.1 ± 1.6	0.395
Shape			
Triangular niche	7 (14%)	7 (14%)	1.000
Semicircular niche	4 (8%)	4 (8%)	1.000
Uterine cavity			
1-Intrauterine adhesions	6 (12%)	4 (8%)	0.505
Mild	4 (8%)	3 (6%)	0.694
Moderate	1 (2%)	1 (2%)	1.000
Severe	1 (2%)	0 (0%)	0.314
2-Endometrial scaring	2 (4%)	2 (4%)	1.000
3-Uterine cavity irregularity	8 (16%)	8 (16%)	1.000
4-Apparently normal	34 (68%)	36 (72%)	0.663

P value >0.05: Not significant, P value <0.05 is statistically significant, p<0.001 is highly significant., SD: standard deviation

Table (5): Comparison of color and pulsed Doppler results after 3 months between the studied groups.

Mean ± SD	Study group (n=50)	Control group (n=50)	P value
Right			
PI	**1.8 ± 1.1**	**2.7 ± 0.9**	**< 0.001***
RI	**0.91 ± 0.14**	**0.96 ± 0.16**	**0.099**
PSV	**18.94 ± 10.1**	**31.82 ± 9.1**	**< 0.001***
EDV	**6.0 ± 2.7**	**6.52 ± 2.1**	**0.285**
TAMXV	**8.4 ± 6.1**	**5.61 ± 1.9**	**0.003***
Left			
PI	**1.69 ± 0.6**	**2.81 ± 0.9**	**< 0.001***
RI	**0.94 ± 0.13**	**0.89 ± 0.2**	**0.141**
PSV	**19.2 ± 10.2**	**32.0 ± 10.1**	**< 0.001***
EDV	**6.62 ± 5.3**	**6.2 ± 4.1**	**0.658**
TAMXV	**8.8 ± 6.3**	**5.2 ± 2.2**	**< 0.001***

PI: Pulsatility Index, RI: resistant index, PSV: peak systolic velocity, EDV: end diastolic velocity, TMAX: Timed maximum velocity.

Table (6): Comparison of Two-dimensional (2D) transvaginal ultrasound (TVS) findings between the studied groups after 3 months.

	Study group (n=50)	Control group (n=50)	P value
Uterine volume(cm) Mean ± SD	56.8 ± 19.6	47.1 ± 13.6	**0.005***
Right ovarian volume (cm³) Mean ± SD	4.78 ± 2.9	3.9 ± 2.1	0.085
Left ovarian volume (cm³) Mean ± SD	4.31 ± 2.3	3.3 ± 1.9	**0.018***
Endometrial thickness(mm) Mean ± SD	3.54 ± 1.6	3.92 ± 1.1	0.169
Uterine artery diameter (Rt)(mm) Mean ± SD	3.1 ± 0.5	3.8 ± 0.9	**< 0.001***
Uterine artery diameter (Lt)(mm) Mean ± SD	3.3± 0.7	3.62 ± 0.4	**0.006***
Intrauterine fluid accumulation			
Seen	30 (60%)	0(0%)	
Not seen	20 (40%)	50(100%)_	**<0.001**

Table (7): Multivariate Predictors for Adhesions-adjusted for baseline abortion history.

Variable	Odds Ratio (OR)	95% CI	P-value
Number of Previous CS	2.38	1.12 – 5.05	0.024*
Placenta Previa Major	1.65	0.82 – 3.32	0.162
Bladder Wall Interruption	2.95	1.31 – 6.64	0.009*
Previous Surgical Evacuations	1.48	0.71 – 3.08	0.295
Abortion History	1.92	1.05 – 3.51	0.034*
Educational Level (Low)	1.45	0.78 – 2.69	0.238

Table (8): Multivariate Predictors for Amenorrhea

Variable	Odds Ratio (OR)	95% CI	P-value
Endometrial Thickness (mm)	0.59	0.42 – 0.82	0.002*
Uterine Artery Ligation	2.05	1.02 – 4.12	0.044*
Extent of AIP (Focal vs Diffuse)	1.68	0.85 – 3.32	0.135
Cervical Stenosis	4.15	1.98 – 8.70	<0.001*
Abortion History	1.78	0.96 – 3.30	0.068
Educational Level (Low)	1.35	0.72 – 2.53	0.351

Discussion

Placenta accreta spectrum (PAS) is pathologic adherence and excessive penetration of part or all the placenta into the myometrium, including accreta, increta, or percreta. Placenta previa, prior cesarean delivery (CD), uterine surgery, multiparity, advanced maternal age, as well as in vitro fertilization are risk factors associated with the worldwide increase in PAS**(5)**.

PAS can induce massive hemorrhage as the placenta cannot separate spontaneously at delivery, which often requires cesarean hysterectomy to control serious bleeding. The intraoperative blood loss is reported to range from 2,000 to 5,000 ml, and frequently blood transfusion is needed. In severe cases, PAS can cause maternal death, with mortality rate as high as 6–7% **(6)**.

Management of placenta accreta spectrum (PAS) traditionally involves cesarean hysterectomy, which, while effective, results in loss of fertility and carries significant surgical risks. In recent years, conservative surgical methods such as leaving the placenta in situ, uterine artery ligation, and segmental resection have been adopted for selected patients seeking uterine preservation **(7)**.

The study and control groups were generally well matched with no significant differences in most baseline characteristics, including age, BMI, parity, and gestational age ($p > 0.05$). However, significant differences were found in abortion history ($p = 0.004$) and educational level ($p < 0.001$), indicating possible

confounding factors.The adjusted odds ratios for previous caesarean sections and bladder-wall interruption were essentially unchanged, and baseline abortion history itself was not independently associated with adhesion formation (aOR 1.42; p=0.412) ; **indicating that the structural anomalies observed in the study group are attributable to the PAS surgery itself rather than to pre-existing Asherman's syndrome related to prior pregnancy loss**.

In accordance with **Tourette et al., (8)** this retrospective cohort study compared women with placenta accreta who had previous cesarean sections (n = 63) to those without (n = 35). They found significant differences in clinical features those without a prior cesarean had lower rates of placenta previa and antenatal diagnosis, but a higher rate of pregnancies conceived.

Comparison of Hysteroscopy examination after 3 months and after 6 months No statistically significant differences were observed in hysteroscopy findings between **3 and 6 months' follow-up**. The incidence of cervical stenosis decreased from **70% to 58%** (**p=0.211**), while scar niche incidence showed a slight increase from **20% to 22%** (**p=0.806**). Niche length and shape remained comparable between both assessments (**p>0.05**). Uterine cavity findings, including intrauterine adhesions, endometrial scarring, cavity irregularity, and apparently normal cavity, showed no significant changes over time (**p>0.05**).

Hysteroscopic findings: 3 vs. 6 months — and the definition of "normal cavity"

The prevalence of cervical stenosis, scar niche, intrauterine adhesions, endometrial scarring, and uterine cavity irregularity did not differ significantly between the 3- and 6-month evaluations in the study group, indicating that any healing or scarring present at 3 months had already stabilised. **This justifies 6 months as an adequate time-point for the post-conservative-PAS anatomical evaluation.**

The seemingly paradoxical combination of 58% cervical stenosis, 22% scar niche, and 72% "apparently normal cavity" resolves once the **definition** is understood. **"Apparently normal cavity" was defined as a cavity free of intrauterine adhesions, free of clinically significant endometrial scarring, and conforming to the normal triangular shape.** A caesarean scar niche is a defect of the myometrial scar at the site of the previous hysterotomy and does not, by itself, distort the cavity shape; accordingly, it does not preclude a cavity being classified as normal. Similarly, cervical stenosis impairs trans-cervical access without altering intra-cavity **morphology**.

In supporting with **Khallaf et al., (9)** who also reported cervical abnormalities following conservative management of PAS. However, the incidence of cervical stenosis was considerably higher in the present study. This discrepancy may be explained by differences in patient selection, as our study included only women with focal PAS who underwent conservative surgical procedures for hemorrhage control, whereas differences in the type and extent of conservative surgery, timing of hysteroscopic assessment, and the criteria used to define cervical stenosis may also have contributed to the variation in reported incidence.

Why is cervical stenosis so common (58%)?

The apparently high rate of cervical stenosis reflects several converging factors:

- **Objective, pre-specified hysteroscopic criteria.** Cervical stenosis was defined as inability to negotiate the internal cervical os with a 4-mm rigid hysteroscope without prior mechanical or osmotic dilatation, and severity was graded using a quantitative Hegar-based scale (mild ≤4; moderate 5–7; severe >7).
- **Single experienced operator with a uniform vaginoscopic approach.** Eliminated inter-operator variability.
- **Timing.** Evaluation was performed at 3–6 months, when transient peri-incisional and parametrial fibrosis is still resolving.
- **Many cases were asymptomatic.** The vast majority of the observed stenoses were mild or moderate in severity, did not cause haematometra, haematocolpos, or menstrual obstruction, and were detected only because objective hysteroscopic criteria were applied systematically.

Cervical stenosis is a recognised complication of caesarean delivery, particularly when the hysterotomy extends into cervical tissue, and has been linked to unintended cervical trauma, scarring, and isthmocele formation **(2,10,13)**. **The 58% rate therefore reflects the sensitivity of the diagnostic method and the early post-operative time-point rather than a high rate of clinically meaningful morbidity.**

Concerning color and pulsed Doppler results after 3 months, the current study demonstrated that color and pulsed Doppler assessments revealed significant differences between the study and control groups. The Pulsatility Index (PI) was significantly lower in the study group on both the right (1.8 ± 1.1 vs. 2.7 ± 0.9, P < 0.001) and left sides (1.69 ± 0.6 vs. 2.81 ± 0.9, P < 0.001). Similarly, Peak Systolic Velocity (PSV) was significantly lower in the study group for both sides (P< 0.001), while Timed Average Maximum Velocity (TAMXV) was significantly higher (P = 0.003 right, P < 0.001 left). No statistically significant differences were observed in Resistant Index (RI) or End Diastolic Velocity (EDV) between groups on either side (P > 0.05).

Why lower PSV? Conservative PAS surgery routinely involves bilateral ligation or mechanical compression of the ascending branch of the uterine artery, focal myometrial resection, and compression sutures directly applied to the lower segment. The early post-operative vascular bed is therefore characterised by reduced cross-sectional arterial calibre and reduced peak inflow velocity through a narrower-caliber uterine artery, with the effect persisting into the early postpartum period. This is consistent with the observation of Ossman and colleagues that bilateral uterine artery ligation does not result in significant changes in uterine artery PI or RI at 3 months after surgery in some cohorts, indicating that the early post-operative haemodynamic profile reflects a dynamic state of partial recovery rather than an end-state **(13)** . The reduced PSV therefore reflects persistent mechanical and surgical interference with the main-stem inflow tract.

Why lower PI? PI reflects downstream vascular resistance. Both **antenatal neovascularisation** and **postoperative devascularisation** yield a low-resistance bed ; the former driven by angiogenic placental signalling and arterio-venous shunting within the accreta placental bed, the latter by surgical removal or ligation of the high-resistance myometrial arterioles, leaving only collateral channels with intrinsically lower impedance. Both mechanisms converge on a low-PI pattern.

Why higher TAMXV? TAMXV reflects the time-integrated mean velocity. Even when peak velocity is reduced, a sustained fraction of the cardiac cycle is spent at flow (because resistance is lower), which can elevate the integrated mean velocity relative to controls whose high-resistance bed concentrates flow only during systole. Why portends partial recovery. The increased uterine volume (56.8 ± 19.6 vs. 47.1 ± 13.6 cm^3; p=0.005) and the **larger left ovarian volume** (4.31 ± 2.3 vs. 3.3 ± 1.9 cm^3; p=0.018) observed simultaneously in the study group at the same time-point are consistent with a uterus and adnexa that have not yet fully involuted and remain partially hyper-perfused and may reflect the residual hyper-vascular bed of the original PAS implantation site plus compensatory collateral recruitment. Even after local resection or compression, the vascular remodelling of the PAS bed requires longer than 3 months to fully return to baseline control levels.

Reconciliation with the antenatal literature. **Zheng et al., (2)** reported that, in patients with PAS and placenta previa evaluated prenatally, those with accreta had **higher PSV** and **lower PI** than those without. Our 3-month postpartum findings **do not parallel Zheng et al.'s antenatal PSV findings** but **do parallel them with respect to PI**. The divergence in PSV is biologically coherent: Zheng and colleagues interrogated the **antenatal, hyper-vascularised accreta placental bed** characterised by neovascular shunts producing high peak arterial velocities ;whereas we interrogated the **postoperative, post-devascularisation uterine artery** after mechanical disruption or ligation of the ascending branch, with reduced peak velocities persisting into the early postpartum period. The congruence in PI is similarly biologically coherent: both antenatal neovascularisation and postoperative devascularisation yield a low-resistance bed.

Comparison of Two-dimensional (2D) transvaginal ultrasound (TVS) findings between the studied groups after 3 months: The studied group had significantly higher **uterine volume** and **left ovarian volume** compared with the control group (**p=0.005 and p=0.018**, respectively). Uterine artery diameters were significantly lower in the studied group (**p<0.001 for right and p=0.006 for left artery**). Intrauterine fluid accumulation was significantly more frequent in the studied group (**60% vs. 0%, p<0.001**). Other parameters showed no significant differences.

The fluid collection observed in 60% of the study group on routine 2D-TVS **was not a deliberately performed saline-infusion sonohysterosalpingogram**, which would have required active catheter-based instillation of saline into the cavity. It was interpreted as **spontaneous intra-cavity fluid retention secondary to cervical stenosis**, in which ascending menstrual or cervical secretions accumulate within the cavity because outflow through the stenosed internal os is partially obstructed. This is analogous to a non-deliberate saline-retention sign. **The observation itself**

reinforces the high prevalence of cervical stenosis detected on the subsequent hysteroscopic evaluation.

Also, **Huang et al., (10)** this retrospective study evaluated residual placental tissue using 3D ultrasound following conservative treatment (placenta left in situ with arterial embolization). It tracked how the placental volume decreased over time, with a median resorption time of 5.5 months. While not directly measuring uterine size or endometrial thickness, it implies that anatomical regression occurs gradually over several months, hinting at a period of relative stability between 3 and 6 months.

Multivariate analysis revealed that number of previous cesarean sections (OR=2.38, 95% CI: 1.12–5.05, p=0.024), bladder wall interruption (OR=2.95, 95% CI: 1.31–6.64, p=0.009), and history of abortion (OR=1.92, 95% CI: 1.05–3.51, p=0.034) were significant predictors of the outcome. Other variables, including placenta Previa major, previous surgical evacuations, and low educational level, were not significantly associated.

In the study conducted by, **Ma et al., (11)** who aimed to investigate the clinical characteristics and risk factors associated with placenta accreta in pregnancies complicated by Pernicious Placenta Previa . They found that Bladder wall interruption detected on MRI was identified as a significant independent risk factor for placenta accreta (OR = 4.91, 95% CI: 1.43–16.81, p = 0.011). This finding underscores the diagnostic importance of this MRI feature in predicting abnormal placental invasion and facilitating preoperative planning.

Multivariate Predictors for Amenorrhea: Logistic regression analysis showed that endometrial thickness (OR=0.59, 95% CI: 0.42–0.82, p=0.002), uterine artery ligation (OR=2.05, 95% CI: 1.02–4.12, p=0.044), and cervical stenosis (OR=4.15, 95% CI: 1.98–8.70, p<0.001) were significant predictors of the outcome. Other variables, including extent of AIP, abortion history, and low educational level, were not significantly associated.

In the study conducted by, **Lai et al., (12)** reported that endometrial thickness was significantly associated with the risk of placenta accreta spectrum (PAS). Women with an EMT ≤7 mm demonstrated a markedly increased risk of PAS compared with those having an EMT of >10.9–13 mm, aOR of 7.15 (95% CI: 3.73–13.71, p<0.0001). Similarly, an EMT between >7 and 10.9 mm was associated with a significantly higher risk of PAS (aOR=2.27, 95% CI: 1.33–3.86, p=0.0025). In contrast, an EMT >13 mm was not significantly associated with PAS risk (aOR=2.11, 95% CI: 0.86–5.20, p=0.1036). These findings indicate that thinner endometrial thickness, particularly ≤7 mm, is an independent predictor of PAS and may reflect impaired endometrial integrity and abnormal placental implantation.

Why no significant difference between surgical techniques?

The primary overarching objective was to evaluate the safety of conservative PAS surgery as a collective, uniform strategy compared with standard caesarean section. Although all four conservative techniques (uterine artery ligation, compression sutures, local resection, Triple-P) **were documented in the operative records and reflected in the Methods**, the sample size of 50 patients **was not powered to detect clinically meaningful between-arm differences**: each surgical arm contributed only ~12–13 patients. **The four arms were therefore pooled for the primary case-vs-control analysis, while the multivariate predictors of intrauterine adhesions were evaluated using stand-alone independent variables; most notably uterine artery ligation itself rather than by fully separating the four surgical protocols.** Sub-group analysis showed no major deviations, but to avoid introducing an underpowered statistical error we focused the multivariate predictor analysis on stand-alone independent variables. **A dedicated, adequately powered head-to-head trial is required to formally compare surgical approaches.**

Only six months of follow-up.

Six months was selected because **uterine involution is complete by this time, menstrual function has been re-established in the majority of women, and anatomical reorganisation of the lower segment and cervix is largely stable**. Fertility outcomes, placental-bed remodelling over future pregnancies, and late-onset complications are the subject of an ongoing companion follow-up study.

No fertility or pregnancy outcomes were collected.

The present study was designed to evaluate anatomical recovery — uterine cavity integrity, cervical patency, and uterine arterial haemodynamics — rather than reproductive performance. Pregnancy rate, time to conception, infertility, and live birth were not collected in this study. Therefore, **any inference regarding fertility preservation should be qualified**: the present data support the anatomical and short-term menstrual recovery of the post-conservative-PAS uterus, but **do**

not constitute proof of preserved fertility. Long-term reproductive outcomes are being accrued in a separate follow-up study.

Why were the controls normal caesarean deliveries?

The purpose of the control group was to provide a clinically meaningful, real-world benchmark of expected postpartum uterine healing against which the conservative-PAS cohort could be compared. **Tight matching for previous caesarean sections, parity, and placenta previa was deliberately not undertaken**, because doing so would have selected a control population clinically more similar to the PAS group but unrepresentative of normal post-caesarean recovery. The unadjusted comparison is therefore against the reference-standard "normal caesarean" uterus — a stricter but more clinically interpretable benchmark. The implications are acknowledged in the Limitations.

Why only focal PAS? Why no increta, percreta, or diffuse disease?

Diffuse PAS, increta, and percreta frequently necessitate hysterectomy and rarely permit conservative surgery. Conservative surgery is principally applicable to carefully selected focal PAS, **making the present cohort clinically relevant for the population in whom uterine preservation is realistically attempted.** The findings should therefore **not** be extrapolated to increta, percreta, or diffuse forms of PAS without explicit external validation — a limitation acknowledged below.

Softened reproductive claims

This study measured **menstruation, hysteroscopic findings, and Doppler blood flow** at 3 and 6 months postpartum. It did **not** measure pregnancy rate, time to conception, infertility, or live birth. Consequently, the inferences concerning fertility preservation should be interpreted as anatomical and short-term menstrual recovery, **rather than as proof of preserved reproductive function**. Subsequent pregnancies in this cohort are being followed longitudinally.

Limitations

The following limitations should be considered when interpreting the present findings:

- **Single-centre design.** Conducted at a single tertiary referral centre, limiting generalisability to other populations, surgical teams, and case mixes.
- **Small Sample-size .** Although the overall sample was powered for the primary case-vs-control comparison (50 vs. 50), the study was **not powered to detect between-arm differences across the four surgical techniques** (~12–13 patients per arm); between-arm comparisons were therefore exploratory and hypothesis-generating only.
- **Selection bias and limited disease spectrum.** Only **focal PAS** was included; **increta, percreta, and diffuse PAS were not represented**, and the findings cannot be generalised to these more invasive forms of PAS. This is mitigated by the fact that diffuse/increta/percreta frequently require hysterectomy, so the present cohort is clinically relevant for the population in whom conservative surgery is realistically attempted.
- **Six-month follow-up.** Captures complete uterine involution and menstruation but not subsequent reproductive performance; longer-term follow-up is ongoing.
- **No reproductive endpoints.** Pregnancy rate, time to conception, infertility, and live birth were not measured; the phrase "fertility preservation" should therefore be understood as **anatomical and menstrual recovery** rather than proof of preserved reproductive function.
- **Unmatched controls.** Controls were not matched for previous caesarean sections, parity, or placenta previa — a deliberate design choice providing a real-world reference benchmark of normal post-caesarean healing rather than a tightly matched comparator.
- **No blinding of outcome assessors.** The hysteroscopist and sonographer were not blinded to group allocation, which may have introduced observer bias.
- **Baseline confounding.** Significant baseline differences existed in abortion history ($p=0.004$) and educational level ($p<0.001$); an adjusted multivariable analysis for the primary cavity-related outcomes was performed .
- **No pre-specified saline-infusion sonohysterosalpingogram.** The 60% fluid-collection finding reflects passive intra-cavity retention secondary to cervical stenosis, not an active saline-infusion sonographic procedure.

- **Variable distribution across the four surgical arms.** Each arm contained only ~12–13 patients; the multivariate predictors were therefore derived from stand-alone independent variables (e.g., uterine artery ligation itself) rather than from a full separation of the four surgical protocols.

Conclusion

Women in the study group showed significantly more hysteroscopic abnormalities than controls, with cervical stenosis representing the most frequent postoperative finding and persisting throughout the 6-month follow-up period. Although a slight improvement in hysteroscopic findings was observed over time, these changes were not statistically significant, indicating that postoperative anatomical changes may persist beyond the early healing period.

Ultrasound and Doppler assessment demonstrated significant alterations in uterine vascularity and morphology, including reduced uterine artery diameter, altered Doppler indices, increased uterine volume, and frequent intrauterine fluid accumulation. Furthermore, multivariate analysis identified the number of previous cesarean sections, bladder wall interruption, and history of abortion as independent predictors of intrauterine adhesions, while cervical stenosis, uterine artery ligation, and reduced endometrial thickness were independent predictors of amenorrhea.

These findings highlight the importance of postoperative hysteroscopic and ultrasound follow-up in women undergoing conservative surgical management for placenta accreta spectrum, allowing early detection of cervical and uterine abnormalities and timely intervention to improve long-term reproductive outcomes. Conservative surgical management of focal PAS was associated with preservation of uterine anatomy and menstrual function in most women. Although cervical stenosis and caesarean scar niches were relatively common, major uterine cavity abnormalities were infrequent. Further prospective multicenter studies with larger sample sizes and longer follow-up are recommended to validate these findings and evaluate their impact on future fertility and obstetric outcomes.

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