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Parallel transverse uterine incisions, a novel approach for managing heavy hemorrhage and preserving the uterus

A retrospective cohort study for patients with anterior placenta previa and accreta

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Abstract

Placenta previa and accreta with prior cesarean section is an extremely serious condition that is associated with maternal morbidity and mortality from obstetric hemorrhage. The aim of our study was to evaluate the efficacy and advantages of a novel surgical technique, parallel transverse uterine incisions (PTUI), during conservative cesarean delivery in patients with placenta previa and accreta.

This was a retrospective cohort study including 124 pregnant women, who had at least 1 prior cesarean section and were diagnosed with anterior placenta previa and accreta between January 2014 and October 2017. Using the hospital's information system, patients were retrospectively classified into undergoing either the PTUI surgery (Group A) or the ordinary cesarean section (Group B). Surgical outcomes and maternal complications during hospitalization were collected. The results from 2 groups were compared and analyzed statistically. Multivariable regression analyses were further used to assess the effect of PTUI on severe maternal outcomes.

Patients who underwent PTUI were not statistically different from patients who underwent the ordinary cesarean section in terms of maternal and infants' characteristics. However, PTUI was associated with remarkably reduced intraoperative blood loss ($P = .005$), related vaginal blood loss after surgery ($P = .026$), and transfusion requirement of packed red cells ($P = .000$), compared to the ordinary cesarean section. Moreover, cesarean hysterectomy (3.3% vs 21.9%; $P = .002$) and intensive care unit admission (1.7% vs 29.7%; $P = .000$) were significantly fewer among patients who underwent PTUI. Multivariable regression analyses further showed that the risk of intraoperative hemorrhage ($\beta = -2343.299$, $P = .000$) and cesarean hysterectomy (odds ratio = 0.027, $P = .018$) were both significantly decreased by PTUI.

PTUI is a novel approach that may significantly reduce maternal complications, while preserving the uterus for patients with anterior placenta previa and accreta.

Abbreviation: PTUI = parallel transverse uterine incisions.

Keywords: cesarean delivery, cesarean hysterectomy, conservative surgery, parallel transverse uterine incisions, placenta accreta, placenta previa

1. Introduction

Placenta previa is accompanied by a higher risk of placenta accreta among women who had prior cesarean deliveries.[1–3] The incidence of placenta previa and accreta shows a notably growing tendency for decades, mostly secondary to a remarkable increase in the cesarean section rate in both developed and developing countries.[4–6] Mainland China has the highest prevalence of placenta previa in the world, measuring an average of 12.2 per 1000 pregnancies.[5] Specifically, the increase in cesarean delivery rates, as well as the implementation of the 2-child policy in China, account for a gradual increase in prevalence of placenta previa and accreta.[4,6] This condition is life-threatening, because it is a major cause of fatal bleeding and maternal mortality in obstetrical practice. Management could be varied, mainly according to maternal preferences and surgeons' experience, skill, and resources.[2]

Because bleeding is sometimes catastrophic, choosing the appropriate uterine incision during cesarean surgery in these patients is stressful for obstetricians.[7] If the placenta broadly covers the anterior uterine wall, it would be especially difficult to avoid transecting the placenta. Performing a single low transverse uterine incision (ordinary cesarean section), which means an

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incision directly into the placenta, usually needs rapid delivery due to sudden and profuse maternal blood loss as well as removal of the placenta without direct visualization. Traditional approaches to managing overwhelming hemorrhage are likely to fail.[8,9] Generally, the recommended management of this situation is a planned cesarean hysterectomy with the placenta left in situ.[10] However, this approach may be unacceptable to women desiring uterine preservation or considered inappropriate by the surgical team.[3,11–13] Attempts to establish an effective operative approach for both controlling massive hemorrhage and preserving the uterus in patients with placenta previa and accreta are progressing.[14]

According to our previous experience, a novel, uterine-sparing operative technique, parallel transverse uterine incisions (PTUI), during cesarean delivery for patients with anterior placenta previa and accreta was proposed. This new procedure consists of 2 incisions: the first transverse incision is made near the uterine fundus and above the upper border of placenta for fetal delivery with less bleeding; the second transverse uterine incision is made at the lower uterine segment, which allows delayed removal of the placenta after pelvic devascularization and under direct observation. We previously preliminarily reported this new double incisions technique in 15 cases.[15] After its publication in 2016, we had a clinical impression that this technique is quite useful to reduce bleeding and avoid hysterectomy, and thus we presently attempted to determine if this technique is useful to practice with a much large number, with comparison with the single uterine incision (ordinary cesarean section). To evaluate the advantages and efficacy of this technique further, we conducted a retrospective cohort study, using data from 124 patients with anterior placenta previa, accreta, and history of cesarean delivery.

2. Methods

2.1. Study design and setting

The present study was retrospectively conducted in the Department of Obstetrics and Gynecology, West China Second University Hospital, Sichuan University, People's Republic of China, which is a tertiary referral medical center for pregnant and lying-in women in southwest China, with approximately 10,000 deliveries each year. All human studies have been approved by the Medical Ethics Committee of West China Second University Hospital of Sichuan University, and all of them have therefore been performed in accordance with the ethical standards laid down in the 1975 Declaration of Helsinki and its later amendments. Approval and informed consent from the patients have been obtained.

Using the hospital's information system, 183 patients with cesarean delivery history were diagnosed with placenta previa and accreta between January 2014 and October 2017. Eventually, data from 124 patients who met the inclusion criteria of conservative surgery were reviewed and analyzed (Fig. 1). All included women had at least 1 prior cesarean section, and they were diagnosed with anterior placenta previa (the placenta completely covered the internal ostium and mainly covered the anterior uterine wall) and accreta (abnormally invasive placenta in the myometrium) by both the surgeon's assessment at the time of surgery, and the histopathological evidence of the placenta. On the other hand, those with posterior placenta previa and accreta, or with invasion of placenta accreta into the deep pelvic organs, such as bladder, or with wide invasive placentation involving the uterine fundus, or with insufficiently controlled comorbidities, or with multiple pregnancies, or who underwent emergency cesarean section or delivered before a 28-week gestation, were all excluded.

In the clinic, all women prenatally suspected with placenta previa and accreta by both color Doppler ultrasonography and magnetic resonance imaging were fully informed of the surgical indications, surgical procedures, potential benefits and risks of the PTUI technique (double uterine incisions) and the ordinary cesarean section method (single uterine incision) by their doctors. After close consultation with patients, they underwent either the PTUI surgery or the ordinary cesarean section. All of them were aware of the likelihood of hysterectomy based on the intraoperative findings. Signed informed consents were all obtained from the patients before surgery. All the operative procedures were performed by the same medical team experienced in obstetrical surgery.

Thus, the included 124 pregnant women were retrospectively assigned into 2 groups, the PTUI group (Group A, n = 60) and the ordinary cesarean section group (Group B, n = 64). All outcomes were anonymized for recording and analysis, including maternal demographics, obstetrical history, surgery findings, intraoperative and postoperative maternal complications, and care. Neonatal information was also recorded and discussed.

2.2. Preoperative preparation

The 2 groups had the same preoperative preparation. All patients in this study underwent a planned cesarean section after 33^{+0} weeks of pregnancy, depending on maternal or fetal concerns. A single course of prenatal corticosteroid therapy should be considered routine for all preterm deliveries. Multidisciplinary perinatal management was provided for these patients, including experienced ultrasonography technicians, obstetricians, neonatologists, gynecological surgeons, and anesthesiologists. Before surgery, the blood bank was forewarned to prepare for sufficient blood products. Before the scheduled cesarean section, all 124 patients underwent prophylactic bilateral internal iliac artery balloon catheterization with interventional radiology. After catheterization, the patient was immediately transferred to the operating room for surgery.

2.3. Operative procedures

Every patient under general anesthesia was placed in the supine position. Regardless of previous surgery scar, a vertical abdominal incision began at the upper margin of the symphysis pubis and extended longitudinally around the umbilicus, with further extension if necessary. After laparotomy, the surgeons should observe the lower uterine segment carefully and palpate the uterus gently to confirm fetal presentation and placenta position. However, if the invasion of placenta accreta was clinically assessed serious in depth (with deep pelvic invasion) or wide in surface area (covering the uterine fundus) at the time of surgery, cesarean section hysterectomy with the placenta left in situ was preferable to attempting to separate it from the uterine wall.

Group A patients underwent the PTUI technique (double uterine incisions). The first ultrasound-guided transverse incision was made near the uterine fundus and above the upper border of the placenta to avoid cutting through the placenta (Fig. 2A). Bleeding from the first incision was usually minimal and easily controlled. The neonate was grasped and then delivered smoothly

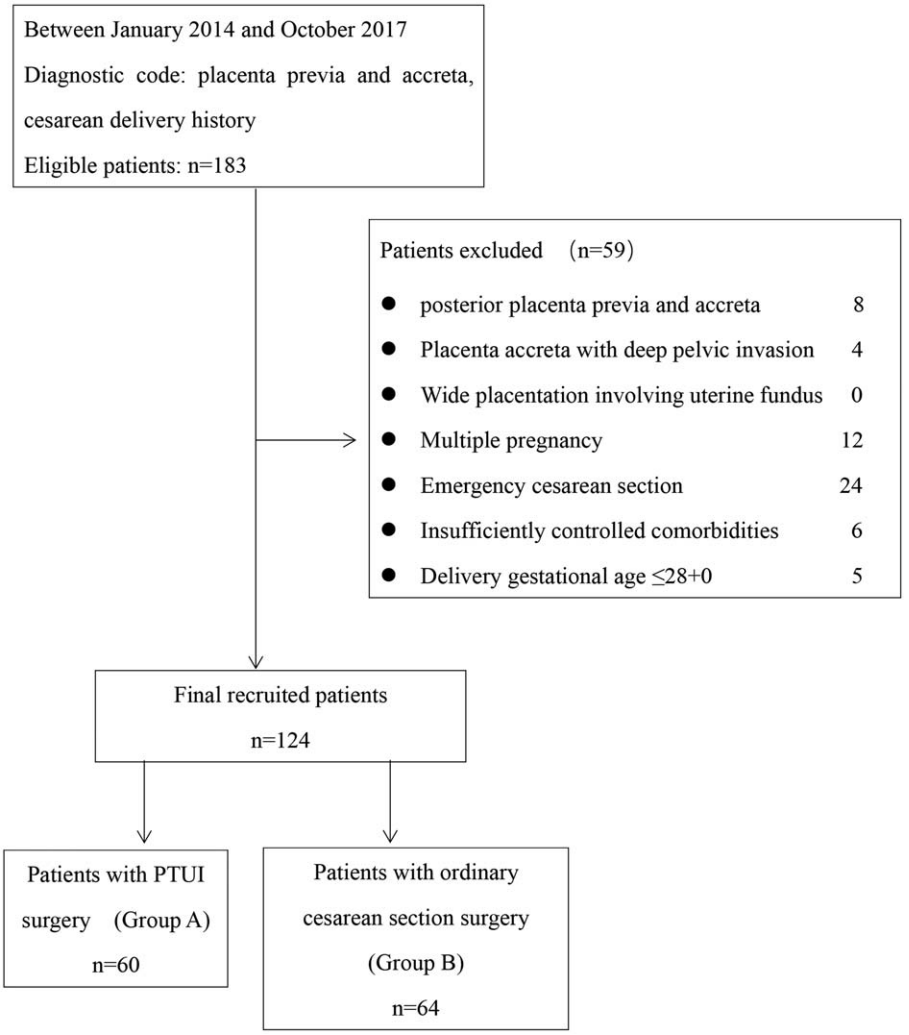

Figure 1. Participant flow chart.

through the first incision. After extraction of the fetus, the umbilical cord was clamped without trial separation of the placenta. The first uterine incision was closed with double layers and continuous, full-thickness sutures immediately (Fig. 2A).

The uterus was exteriorized and then preserved by wrapping it in a layer of warm, moistened gauze, which enabled a comprehensive evaluation of the lower uterine segment and placenta invasion and the feasibility of uterine preservation. Next, the vesical-uterine fold was incised, and the urinary bladder was carefully dissected from the uterus (Fig. 2A). After exposing the lower uterine segment completely, bilateral small openings were performed in an avascular area of the broad ligament at the level of the internal cervix os. A narrow rubber tube was first passed through both openings and tightly ligated the lower uterine segment to restrict uterine blood flow (Fig. 2B).[7,16] Another narrow rubber tube tightly ligated the uterine body to restrict uterine blood flow from the bilateral ovarian proper ligaments (Fig. 2C). This procedure was defined as double binding of the uterus attached to the PTUI technique. Prepositioned occlusion balloons of the bilateral internal iliac artery were then filled with normal saline to obstruct the associated uterine blood supply. Just before placenta removal, 10 U oxytocin was routinely administered by a 500 mL intravenous drip, and another 10 U oxytocin was intramuscularly injected into the uterus. After that, a second transverse uterine incision was made in the lower segment of the uterus, and removal or resection of the invasive placenta to varying degrees was carefully attempted under direct visualization (Fig. 2D). Depending on the extent of the attack, we then performed a wedge resection of the myometrium invaded by the placenta around the second incision (Fig. 2E) and followed by a histopathological examination of the resected tissue. Because the second lower transverse uterine incision facilitated a direct and clear identification of the bleeding point, precise performance of hemostatic sutures was allowed in the lower uterine segment or even in the cervix. Once hemostasis was initially achieved, the bilateral balloons were deflated, and the rubber tubes were successively loosened to confirm it. If catastrophic bleeding presented, uterine blood flow was restricted and interrupted again. Uterotonic agents and surgical approaches such as uterine compression suture, pelvic artery ligation, or intrauterine balloon tamponade were applied when necessary. The second uterine incision was then closed by double layers and continuous sutures (Fig. 2F). If uterus-preserving attempts failed, early recourse to hysterectomy was recommended.

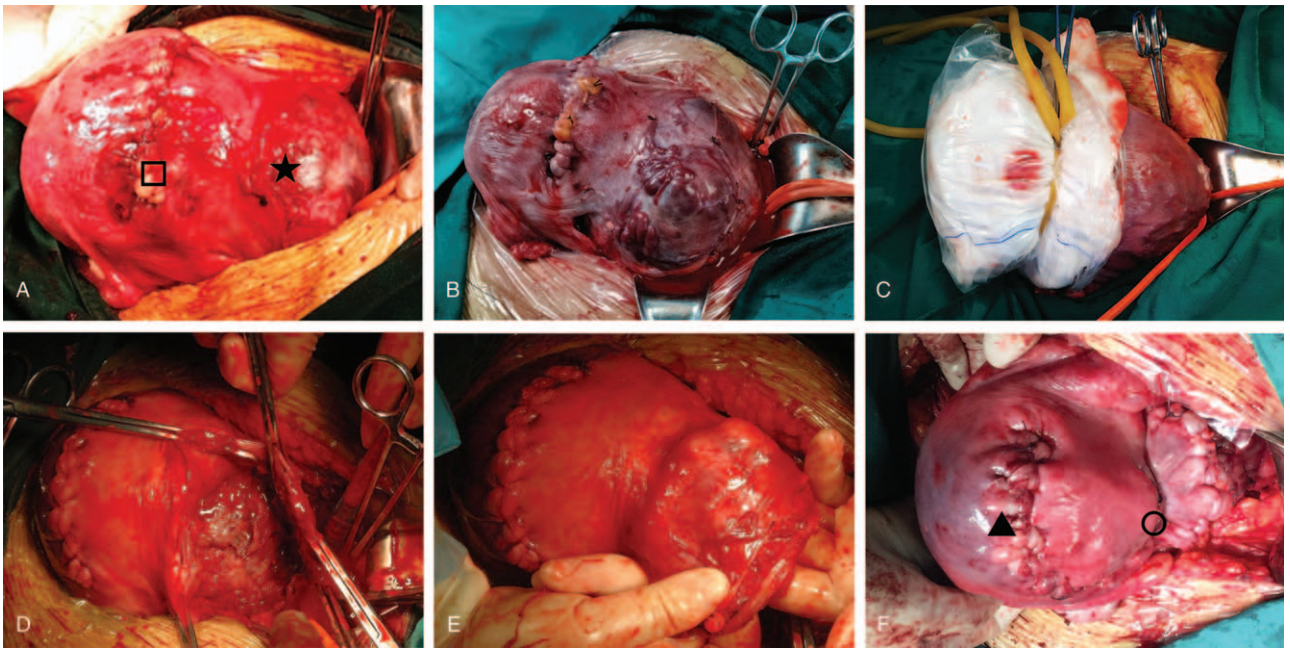

Figure 2. Operative procedures of PTUI were shown. (A) The first uterine incision and delivery of the baby. Square: the first transverse uterus incision was made near the uterine fundus. The incision should be made above the upper border of the placenta without cutting through the placenta. Suture the uterine incision and the placenta was retained in the uterus. Star: dissection of the urinary bladder from the uterine and exposure of the lower segment of uterus. (B) Modified Rubin's tourniquet technique. A narrow rubber tube was first passed through both openings and tightly ligated the lower segment of uterus to restrict uterine blood flow. (C) The double binding of uterus. Another narrow rubber tube tightly ligated the uterine body to restrict blood flow from the bilateral ovarian proper ligaments. (D) The second uterine incision and delivery of the placenta. The second transverse uterine incision was made at the lower uterine segment, which allows delayed removal of the placenta after pelvic devascularization and under direct observation. (E) Hemostasis of the uterus. Methods include full-thickness sutures, wedge resection, hemostatic suture, ligation of the ascending branch of uterine artery, or uterine balloon tamponade were applied when necessary. (F) Closure of the second uterine incision. PTUI were shown at the end of surgery. Triangle: the first transverse uterus incision. Circle: the second transverse uterus incision. PTUI = parallel transverse uterine incisions.

Group B patients were treated by the ordinary cesarean section method (single uterine incision). As mentioned above, bilateral internal iliac artery balloons were also placed preoperatively in Group B patients. However, a single transverse uterine incision, usually located at the upper uterine segment or above the upper border of the placenta, was performed to avoid the placenta. If the placenta was transected during the uterine incision, immediate clamping of the umbilical cord after fetal delivery was accomplished to avoid excessive fetal blood loss. After exposing the lower uterine segment, a single narrow rubber tube tightly ligated the lower uterine segment to restrict uterine blood flow (modified Rubin tourniquet technique).[16] Then an attempt at placenta removal or resection was made through the single uterine incision. Pharmacological measures and surgical hemostatic techniques were used during surgery to control hemorrhage. However, hysterectomy was considered if conservative medical and surgical interventions proved ineffective.

Intraoperative blood loss was estimated by combining the weight of compresses and blood volume collected by suction, as well as other assessment methods, involving hematocrit and hemoglobin.

2.4. Postoperative management

All patients received postoperative monitoring and extensive nursing care for at least 24 to 48 hours. The decision of intensive care unit admission was made by anesthesiologists if necessary. Monitoring measurements mainly included hemodynamic surveillance, ventilator support, and vaginal bleeding estimation. Uterotonic drugs and prophylactic antibiotics were usually continued for the first 24 hours after surgery.

2.5. Statistical analysis

Statistical analysis was performed using SPSS 22.0. Categorical variables were presented as frequencies or percentages. Continuous variables were presented using mean ± standard deviation, median, or range. The correlations between groups and categorical variables were examined using the χ^2 test or Fisher exact test. For continuous variables, Kolmogorov–Smirnov tests of normality were used to evaluate the distributions. Data were analyzed using Student t test or Mann–Whitney U test. Multivariable regression analyses were constructed to assess the effect of PTUI on maternal outcomes involving intraoperative hemorrhage and cesarean hysterectomy. Variables included in the multivariable model were selected based on the known experience from other studies. The multivariable linear regression model was used for the continuous dependent variable, intraoperative hemorrhage, and logistic regression analysis was used for the cesarean hysterectomy binary outcome. Statistical significance was considered $P < .05$.

3. Results

From January 2014 to October 2017, data from 124 women with anterior placenta previa and accreta was reviewed and analyzed in this study. Sixty cases underwent the PTUI technique (Group A), and the remaining 64 cases underwent the ordinary cesarean

Table 1

Maternal and infants' characteristics.

	Group A* (n = 60)	Group B* (n = 64)	P
Maternal characteristics			
Maternal age, yr	32.07 ± 4.49	33.14 ± 5.16	.220
Parity	4.35 ± 1.66	4.32 ± 1.27	.739
BMI	21.86 ± 2.86	21.40 ± 2.84	.394
Number of uterine curettages	2.12 ± 1.60	1.95 ± 1.21	.853
Number of previous cesarean deliveries	1.13 ± 0.34	1.13 ± 0.38	.710
1	52/60 (86.7%)	57/64 (89.1%)	/
2	8/60 (13.3%)	6/64 (9.4%)	/
3	0/60 (0%)	1/64 (1.5%)	/
Gestational age at delivery, wk.	36.56 ± 1.22	35.77 ± 2.85	.462
Time interval between last cesarean delivery and current delivery, yr	4 (5–15)	6 (4–17)	.087
Any prenatal vaginal bleeding	15/60 (25.0%)	25/64 (39.1%)	.094
Hemoglobin before delivery, g/L	113.10 ± 13.74	109.83 ± 14.40	.091
Platelet before delivery, 10^9/L	173.93 ± 49.27	170.52 ± 55.01	.717
Infants' characteristics			
Birth weight, g	2742.25 ± 405.55	2571.86 ± 554.11	.055
5-min Apgar score	8.70 ± 2.28	8.77 ± 2.16	.683
Admission to NICU	16/60 (26.7%)	22/64 (34.4%)	.352

BMI = body mass index, NICU = newborn intensive care unit.

* Values are given as number (percentage) or mean ± SD, unless stated otherwise.

section (Group B). Demographic and clinical characteristics of patients from the 2 groups (Table 1) presented no statistical differences in terms of maternal age, parity, body mass index, number of uterine curettages, number of previous cesarean deliveries, gestational age at delivery, time interval between last cesarean delivery and current delivery, any prenatal vaginal bleeding, or hemoglobin and platelet counts before delivery. All patients in both groups presented with identifiable risk factors for placenta previa or placenta accreta, such as at least 1 previous cesarean section, and 15 cases (12.1%) in total had undergone 2 or more previous cesarean deliveries.

Neonatal outcomes at birth did not differ statistically between the groups (Table 1), including birth weight, 5-minutes Apgar score, and newborn intensive care unit admission.

Table 2 shows the comparison of intra/postoperative data between Group A and Group B. Significant statistical differences were observed in terms of blood loss during surgery or after surgery (within 24 hours), units of packed red blood cells used, operation time, uterine cavity tamponade, uterine artery ligation, cesarean hysterectomy, and intensive care unit admission. Specifically, the estimated intraoperative blood loss was remarkably lower since the introduction of the PTUI technique (median 2150 mL vs 2800 mL; $P = .005$), as well as the related vaginal blood loss in the first 24 hours after surgery (median 50 mL vs 90 mL; $P = .026$). A dramatically decreased transfusion requirement of packed red cells was observed in Group A compared to that in Group B (median 0 U vs 6 U; $P = .000$). The total operation time was around 50 minutes longer in Group A (161.47 ± 39.09 minutes vs 113.52 ± 63.10 minutes; $P = .000$), due to the increased surgical procedures. As for hemostatic methods, a significantly smaller number of patients required uterine cavity tamponade (8.3% vs 21.9%; $P = .029$) and/or uterine artery ligation (55% vs 81.3%; $P = .001$) in the PTUI group than in the ordinary method group. However, what really made sense was that the percentages of cesarean hysterectomy (3.3% vs 21.9%; $P = .002$) and intensive care unit admission

Table 2

Surgical outcome and maternal morbidity during hospitalization.

	Group A* (n = 60)	Group B* (n = 64)	P
Intraoperative hemorrhage, mL	2150 (800–6500)†	2800 (800–15000)†	.005
Transfusion of packed red blood cell, U	0 (0–15)†	6 (0–31.5)†	.000
Transfusion of plasma, mL	0 (0–1850)†	600 (0–2250)†	.086
Hemorrhage after operation (24 h), mL	50 (0–810)†	90 (0–1908)†	.026
Time for operation, min	161.47 ± 39.09	113.52 ± 63.10	.000
Hospitalization after operation, d	5.57 ± 1.44	5.86 ± 2.69	.695
Uterine cavity tamponade	5/60 (8.3%)	14/64 (21.9%)	.029
Surgical uterine arterial ligation	33/60 (55%)	52/64 (81.3%)	.001
Cesarean hysterectomy	2/60 (3.3%)	14/64 (21.9%)	.002
Postpartum fever (>38.5 °C)	6/60 (10.0%)	8/64 (12.5%)	.660
Admission to intensive care unit	1/60 (1.7%)	19/64 (29.7%)	.000
Maternal death	0	0	/

* Values are given as number (percentage) or mean ± SD, unless stated otherwise.

† Median (range).

Table 3

Multivariable linear regression model for intraoperative hemorrhage.

Independent variable	β	*P*	95% CI
Maternal age	47.35	.058	−1.674 to 96.375
Parity	66.771	.363	−78.111 to 211.653
BMI	−51.222	.163	−123.517 to 21.073
Number of previous cesarean deliveries	−281.71	.368	−899.309 to 335.889
Time interval between last cesarean delivery and current delivery	−64.730	.039*	−126.051 to −3.410
Any prenatal vaginal bleeding	15.023	.951	−464.304 to 494.349
Time for operation	27.293	.000*	22.531 to 32.056
PTUI technique	−2343.299	.000*	−2865.860 to −1820.737
Uterine cavity tamponade	25.311	.911	−424.684 to 475.307
Surgical uterine arterial ligation	−481.883	.052	−968.609 to 4.843
Hemoglobin before delivery	3.791	.624	−11.506 to 19.089
Platelet before delivery	2.015	.331	−2.077 to 6.108

β = regression coefficient, BMI = body mass index, CI = confidence interval, PTUI = parallel transverse uterine incisions.
* $P < .05$

(1.7% vs 29.7%; $P = .000$) were significantly minimized after the application of PTUI.

No statistical differences were noted between the 2 groups, shown in Table 2, such as transfusion requirement of plasma, hospitalization after surgery, and associated postoperative complications such as postpartum fever. In 124 cases, placenta accreta was both confirmed by the surgeon's assessment of the abnormal invasive placenta at the time of surgery, and by the histopathological evidence of the myometrial invasion of the chorionic villi, which meant that the comparability of the 2 groups in histological results of placenta could be ensured. There were no maternal deaths, and all patients had a smooth postoperative recovery. No other complications, such as pyometra, synechiae, or uterine necrosis, were observed in either group during a 6-month follow-up visit after the operation. All of the patients were discharged from the hospital in good condition, and no readmission or reoperation was ever reported. In addition, clinical follow-up is continuing, aiming to assess the impacts of the PTUI technique on the resumption of normal menstruation and subsequent pregnancy in the future.

To assess the effect of PTUI further on maternal outcomes involving intraoperative hemorrhage and cesarean hysterectomy, we constructed a multivariable linear regression model for the continuous dependent variable, intraoperative hemorrhage, including all the associated features (Table 3). The following 3 features were significant ($P < .05$):

(1) PTUI technique ($\beta = -2343.299$, $P = .000$),
(2) time for operation ($\beta = 27.293$, $P = .000$), and
(3) time interval between last cesarean delivery and current delivery ($\beta = -64.730$, $P = .039$).

Logistic regression analysis was used to determine which parameters were significantly associated with the risk of cesarean hysterectomy (Table 4). PTUI technique (odds ratio [OR] = .027, $P = .018$) and surgical uterine arterial ligation (OR = .051, $P = .005$) were found to offer significant improvement in preserving the uterus for patients with placenta previa and accreta.

4. Discussion

4.1. Main findings

In this investigation, we proposed a novel, uterine-sparing procedure during cesarean delivery for patients with anterior placenta previa and accreta, defined as the PTUI technique. We demonstrated that the PTUI technique was quite useful for these patients with respect to the reduction of maternal blood loss during the operation. The PTUI technique was associated with remarkably reduced intraoperative blood loss, related vaginal blood loss in the first 24 hours after surgery, and transfusion requirement of packed red cells, compared to the ordinary cesarean section. Moreover, cesarean hysterectomy and intensive care unit admission were significantly fewer among patients who underwent PTUI. Multivariable regression analyses further

Table 4

Binary logistic regression model for cesarean hysterectomy.

Independent variable	β	*P*	OR	95% CI
Maternal age	0.146	.227	1.157	0.913–1.466
Parity	0.370	.292	1.448	0.727–2.881
BMI	−0.133	.599	0.875	0.533–1.438
Number of previous cesarean deliveries	−18.315	.998	0.000	0.000
Time interval between last cesarean delivery and current delivery	−0.123	.319	0.885	0.695–1.126
Any prenatal vaginal bleeding	0.298	.747	1.347	0.220–8.256
PTUI technique	−3.599	.018*	0.027	0.001–0.546
Uterine cavity tamponade	−2.498	.064	0.082	0.006–1.151
Surgical uterine arterial ligation	−2.984	.005*	0.051	0.006–0.402
Hemoglobin before delivery	0.036	.318	1.037	0.966–1.114
Platelet before delivery	−0.003	.761	0.997	0.976–1.018

β = regression coefficient, BMI = body mass index, CI = confidence interval, OR = odds ratio, PTUI = parallel transverse uterine incisions.
* $P < .05$

showed that the risks of intraoperative hemorrhage and cesarean hysterectomy were both significantly decreased by PTUI.

4.2. Strengths and limitations

The PTUI strategy is based on the following 3 advantages:

(1) safe fetal delivery with less bleeding in a very short time, through a uterine fundal incision at the upper border of the placenta, instead of a vesical–uterine dissection and fetal–placental circulation damage[7,12];
(2) effective reduction of blood loss during the extraction of the pathologically invasive placenta. After fetal delivery, the surgeons would be given sufficient time to evaluate the placental invasion and would more calmly concentrate on the placenta delivery and hemostasis. Moreover, application of prophylactic internal iliac artery balloon catheterization can interrupt only most of the pelvic arteries, whereas the double binding of the uterus we proposed in this study may come up to the expected uterine devascularization, because it can further restrict the arterial and venous blood flow from both the lower uterine segment and the bilateral ovarian proper ligaments. Above all, this new technique involves a second transverse incision in the lower uterine segment, thus the bleeding point in the lower uterine segment or even in the cervix could be directly visualized through the second transverse incision. This visualization has the prominent advantages of allowing precise placement of sutures to achieve efficient hemostasis, uterine reconstruction, and bladder reinforcement;
(3) easily change the conservative surgical procedure to hysterectomy if necessary. An infra-umbilical midline skin incision was recommended for these patients in consideration of better exposure and more feasible approaches for surgery. Besides, both a promised fetal delivery and having sufficient time to evaluate the possibility of placenta delivery during surgery are essential prerequisites for any following surgical procedures.

The PTUI technique definitely has several limitations. The choice of conservative surgical technique will depend on the position of the placenta, the depth of invasion, and the parametrial extension of the placenta accreta. A possible limitation might occur if the placenta widely covered the entire anterior uterine wall and fundus, so that the upper border of the placenta would reach or exceed the uterine fundus; as a result, the first incision might not be feasible because of the unavoidable placenta. Another important limitation of this technique regarding placental localization should be highlighted that if the placenta invades the lateral border of uterus or uterine artery, it would be a great challenge to remove the invasive placenta, restore uterine structure and stop catastrophic bleeding. However, in cases of posterior placenta previa with accreta, choosing the appropriate uterine incision without transecting the placenta is not difficult, so the PTUI technique would not be appropriate for this situation. Furthermore, cases of serious placenta accreta, when the villous tissue broadly perforates through the entire uterine wall and invades the surrounding pelvic organs, such as the bladder, should not be considered and recruited in this PTUI study in view of its high risks.

On the other hand, this was a retrospective cohort study with susceptibility to selected bias. Randomized controlled trials with large cohorts are necessary before this procedure can be introduced into routine clinical practice, regarding its benefits and safety, but it is also clinically challenging because of its rarity and ethical concerns.

4.3. Interpretation

To our knowledge, some studies have reported conservative management of placenta previa with accreta. The rate of cesarean hysterectomy reported varied from 4.3% to 72.7%,[7,11,17–19] which is significantly higher than that noted in our PTUI group (3.3%). The following 3 methods have been described more in the reported literature[14]:

(1) manual removal of the placenta;
(2) leaving the placenta in situ or in the expectant approach;
(3) alternative conservative surgical procedures.

These methods could be used alone or in combination with additional procedures such as prophylactic internal iliac artery balloon catheterization or surgical procedures for hemostasis.[14] Generally, each method has its weaknesses and strengths. Complications may be severe and life-threatening, such as massive hemorrhage, especially when trying manual removal of invasive placenta. However, leaving the placenta in situ for resorption or in the expectant approach is indeed a risky strategy because of the long-term complications of infection and hemorrhage.[11] The risk of delayed secondary hysterectomy could rise to 58% after leaving the placenta in situ.[20] Thus, this method has never been performed in our cases. As for surgical technique, it primarily includes 1-step conservative surgery[19] and the triple-P procedure,[18] variations such as transverse uterine fundal incision[7] and the stepwise approach.[11] Compared to the PTUI procedure, only a single transverse uterine incision should be made in these approaches, which is usually located at the upper uterine segment such as the fundus or above the upper border of the placenta, whereas the entire or partial myometrial wall overlying the placenta bed, together with the adherent placenta, should be resected in 1 piece. As for double uterine incision, a 5-step local resection technique included 8 cases by Karaman et al[21] is similar to the PTUI. However, the main differences are as follows: the number of included cases; the way of incision at the uterine fundus during fetal delivery; the step of pelvic devascularization; the step of local resection of the uterine segment involving placenta invasion. Compared to these alternatives, our study first included 124 cases, with a larger sample size than previous studies. Then, the vertical fundal incision may not show the advantage over the transverse incision regarding the fetal delivery and a possible increased risk of uterine rupture in a subsequent pregnancy. Second, prophylactic hypogastric artery ligation wound not completely interrupt uterine blood circulation, it may be difficult to achieve pelvic devascularization. Besides, it is more difficult to perform this procedure in cases with placenta left in situ, as the uterus is too large filled in the pelvic cavity to expose the operative field well. Third, a large uterine defect results from placental invasion described in other techniques may be hard to repair. In particular if the placenta invades broadly, myometrial excision may not be feasible because of abundant vascularity. Another important issue to be taken into consideration is whether there is adequate lower segment uterine tissue to restore the anatomical structure after resection. In addition, because of the obscured visualization of the lower uterine segment and the cervix, a single transverse uterine incision made at the upper uterine segment might not be

favorable for the delivery of an invasive placenta and the attempts at hemostatic sutures. Moreover, these procedures might be less reproducible for conservative treatment, mainly because efficient surgical hemostasis and uterine reconstruction are operator-dependent.[14] Accordingly, we believe the PTUI procedure is indicated for such cases.

Long-term complications are a constant source of concern in the conservative management of placenta previa and accreta. The main issue regarding the PTUI technique is the potentially increased risk of uterine rupture, and the safety of a subsequent pregnancy following this strategy has not yet been established. Follow-up studies are currently underway in our patient cohort. Careful observations are mandatory in any future pregnancies.

5. Conclusions

Placenta previa and accreta with prior cesarean section is an extremely serious condition that is associated with maternal morbidity and mortality from obstetric hemorrhage. Modern medicine appears to emphasize conservative management rather than radical surgical aspects for women who desire an intact uterus. Although further studies are needed to confirm it, the PTUI technique is indeed a potential approach that could significantly reduce complications such as maternal blood loss, blood transfusion requirements, and intensive care unit transfer with promised preservation of the uterus. What's more, technical advances in vascular control and placenta extraction might further benefit innovations in this strategy.

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