Effect of prophylactic interventional therapy of internal iliac artery balloon occlusion in pregnancies complicated by placenta previa and accreta: a retrospective cohort study

Daijuan Chen

Department of Obstetrics and Gynecology, West China Second University Hospital of Sichuan University and the Key Laboratory of Birth Defects and Related Diseases of Women and Children, Sichuan Univ

Jinfeng Xu

Department of Obstetrics and Gynecology, West China Second University Hospital of Sichuan University and the Key Laboratory of Birth Defects and Related Diseases of Women and Children, Sichuan Univ

Yuan tian

Department of Obstetrics and Gynecology, West China Second University Hospital of Sichuan University and the Key Laboratory of Birth Defects and Related Diseases of Women and Children, Sichuan Univ

Pengfei Ye

Department of Radiology, West China Second University Hospital, Sichuan University, Chengdu, 610041, Sichuan,

Fumin Zhao

Department of Radiology, West China Second University Hospital, Sichuan University, Chengdu, 610041, Sichuan,

Xinghui Liu

Department of Obstetrics and Gynecology, West China Second University Hospital of Sichuan University and the Key Laboratory of Birth Defects and Related Diseases of Women and Children, Sichuan Univ

Xiaodong Wang

Department of Obstetrics and Gynecology, West China Second University Hospital of Sichuan University and the Key Laboratory of Birth Defects and Related Diseases of Women and Children, Sichuan Univ

Bing Peng (✉ bingpeng2020@163.com)

Department of Obstetrics and Gynecology, West China Second University Hospital of Sichuan University and the Key Laboratory of Birth Defects and Related Diseases of Women and Children, Sichuan Univ

Research Article

Keywords: interventional therapy, internal iliac arteries, placenta previa, placenta accreta, hemorrhage

Posted Date: February 16th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-199296/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background: Placenta previa and accreta are serious obstetric conditions that are associated with a high risk of intraoperative massive hemorrhage, the prophylactic intravascular balloon occlusion technique is increasingly used in managing uncontrolled hemorrhage in cesarean section (CS). We aim to examine the clinical effectiveness of prophylactic interventional therapy of the internal iliac artery balloon occlusion (PBOIIA) during CS in improving maternal outcomes for patients with placenta previa and accreta.

Methods: A total of 420 women with placenta previa and accreta who underwent CS from January 2014 to December 2018 were included retrospectively. Patients were divided into balloon group in which patients had PBOIIA (n=248) and the control group in which patients did not have PBOIIA (n=172). Meanwhile, we performed a subgroup analysis in whether taking PTUI surgery. Information on conditions of patients and newborns, perioperative blood indicators, surgical outcomes were collected.

Results: Median estimated blood loss (mEBL) was 2200mL in the balloon group and 2150mL in the control group respectively, there was no significant difference between two-groups comparison ($P=0.05$). The rate of patients with hysterectomy (36.3% versus 35.5%) and amount of PRBCs transfused [(0-31.5) versus 3 (0-39)] were not different between two groups ($P=0.05$). However, the total hospitalization costs (7044.4 ± 1708.0 versus 5793.6 ± 2263.8) and surgery costs (3074.2 ± 404.9 versus 1829.7 ± 485.8) in balloon group were significantly higher than those in control group ($P<0.05$). Subgroup analysis showed PTUI surgery had no significant differences in EBL ($P=0.05$), but it could significantly decrease hysterectomy rates ($P=0.05$).

Conclusions: PBOIIA has no significant effect on reducing intraoperative EBL and hysterectomy rate in patients with placenta previa and accreta, but it significantly increases the financial cost for patients. PBOIIA should not be routinely recommended to patients with placenta previa and accreta.

Background

Placenta previa and accreta associated with previous cesarean section are related to severe adverse maternal–fetal pregnancy outcomes and are even accountable for a high risk of maternal death [1]. These placental conditions can cause disseminated intravascular coagulation, shock, and a high rate of hysterectomy [2]. Placenta previa and placenta accreta are the major causes of postpartum hemorrhage, and is currently a leading cause of maternal death worldwide [3]. Massive hemorrhage during cesarean section (CS), which is hard to predict and control, is the main threaten to the life of patients with placenta previa and accreta. Cesarean hysterectomy is an important treatment for placenta previa and accreta, but it should be performed with caution [4]. Recently, a lot of conservative management has been conducted to reduce intraoperative hemorrhage and the hysterectomy rate, and to ensure maternal and newborn safety during CS. The prophylactic intravascular balloon occlusion technique is increasingly used in managing uncontrolled hemorrhage in CS. This technique includes prophylactic intravascular balloon occlusion of the internal iliac arteries (PBOIIA) and abdominal aorta arteries (PBOAA) [5].

Owing to the low risk of vascular complications [6], PBOIIA has been used in our hospital for patients with placenta previa and accreta since 2014. The effectiveness of PBOIIA remains controversial because of the inconsistent results of different research. Deng, Wang et al reported that PBOIIA was an effective method of hemostasis in CS. However, Huang, Salim, Liu et al showed that PBOIIA had no benefit in reducing estimated blood loss (EBL) and improving maternal outcomes for patients with placenta previa and accreta. There is still a lack of large-sample studies on the effectiveness of internal iliac artery balloons. Therefore, we performed a large-sample, retrospective cohort study and aimed to evaluate the effectiveness and practicality of PBOIIA in improving maternal outcomes for patients with placenta previa and accreta.

Methods

Study population

The retrospective, observational study was approved by the Ethics Review Committee of West China Second University Hospital of Sichuan University, and because of the nature of the retrospective, observational setting for our study, and the data are anonymous, an informed consent was waived for all included patients by the Ethics Review Committee of West China Second

University Hospital. All study methods of the retrospective study were conducted following the relevant regulations of a protocol approved by the Institutional Review Board from the West China Second University Hospital of Sichuan University. This study was conducted from January 2014 to December 2017. Placenta previa occurred when the placenta was wholly or partially implanted in the lower uterine segment. Placenta accreta was defined as the situation where the placental trophoblast invaded into the myometrium, according to the depth of villous tissue invasiveness. Placenta accreta has been subdivided by modern pathologists into “creta” or “adherenta”. An adherent placenta is where the villi adhere superficially to the myometrium without interposing the decidua. Placenta increta is where the villi penetrate deeply into the uterine myometrium down to the serosa. Placenta percreta is where the villous tissue perforates through the entire uterine wall and may invade the surrounding pelvic organs, such as the bladder [7,8]. All included patients had at least one prior CS and were diagnosed with placenta previa or placenta accreta when the placenta covered a previous cesarean scar by color Doppler ultrasonography and pelvic magnetic resonance imaging (MRI) examinations before delivery. The diagnosis was confirmed by intraoperative findings or histopathological examination after surgery. Patients with an adherent placenta were excluded in this study because balloon occlusion was not routinely used for these patients in our clinical work. Therefore, we only included patients with placenta increta or percreta. Patients with serious medical and surgical diseases, incomplete data, multiple pregnancies, or those who delivered before 28 weeks of gestation were excluded.

According to the above-mentioned inclusion and exclusion criteria, of 713 patients with placenta previa and accreta associated with previous CS who delivered in our hospital, 420 were included in this study (**Figure 1**). The 420 patients were divided into two groups according to whether they had PBOIIA (n=248, 59.0%) (balloon group) and whether they did not have PBOIIA (n=172, 41.0%) (control group). In 2017, doctors in our hospital investigated a novel approach called parallel transverse uterine incision (PTUI) surgery. PTUI had a significant effect on reducing intraoperative blood loss and the hysterectomy rate for patients with placenta previa and accreta [9,10]. Among our included patients, we found that some patients underwent PTUI surgery simultaneously. To avoid the effect of PTUI surgery on the results, we conducted a subgroup analysis on the two groups of patients according to whether they had PTUI surgery during CS. Among the 420 patients, 86 had PTUI surgery and 334 did not have PTUI surgery. In the PTUI group, the 86 women were subdivided into the balloon group that had PBOIIA (group A1; n=58) and the control group that did not have PBOIIA (group B1; n=28). In the non-PTUI group, the 334 women were subdivided into the balloon group (group A2; n=190) and the control group (group B2; n=144).

Comprehensive management of patients with placenta previa and accreta required the cooperation of a multidisciplinary medical team. All patients underwent scheduled CS at 35–36+6 weeks of gestation [11]. Fluid transfusion, blood transfusion, strong uterine contraction drugs, and conservative surgical treatments were provided to patients during CS. If the conservative treatments were not effective, hysterectomy was performed to save the patient's life. Since the effectiveness of PBOIIA in patients with placenta previa and accreta remains controversial and it is not definitively reliable, and there are complications associated with PBOIIA. The decision of preoperative prophylactic placement of balloon occlusion was made on a case by case basis through preoperative multi-department discussion before surgery. This decision was jointly made by the surgeon and radiologist after evaluating the condition of patients in our hospital. All patients who accepted PBOIIA provided written informed consent, and balloon occlusion of the right and left internal iliac arteries was inflated in all cases.

Placement of the occlusion balloon

In the balloon group, all included pregnant women were fully informed of the benefits and complications of PBOIIA by their doctors before CS. For the surgical procedure, after routine disinfection and laying of towels, bilateral femoral arteries were punctured by the Seldinger technique and a 5-French vascular sheath was inserted. A 5-French Cobra and 0.035-inch guidewire were used to guide the balloon catheter into the bilateral internal iliac artery through the vascular sheath, with the balloon catheter tip slightly above the opening of the bilateral uterine artery (low-profile PTA balloon dilatation catheter PTA5-35-80-8-6.0; Cook Medical Inc., Bloomington, IN, USA). An indwelling catheter was fixed in both lower limbs and the patients were brought into the operating room. During the operation, approximately 2 mL of eunepiac, which is a diluent contrast agent, was injected to temporarily inflate the internal iliac artery balloon after the fetus was delivered and the umbilical cord was cut. This diluent contrast agent can block blood flow of bilateral internal iliac arteries and reduce the amount of uterine bleeding [12] (**Figure 2**).

Clinical characteristics and outcomes

The clinical characteristics of the included patients were collected by reviewing the medical records. The clinical indicators were retrospectively collected by two obstetricians, and if any discrepancy existed, it was resolved by a third obstetrician. All reviewers were blinded to the data of patients. The clinical indicators included maternal and neonatal characteristics, perioperative blood indicators, and surgical outcomes during hospitalization. Maternal and neonatal characteristics included maternal age, gravidity, parity, number of previous CSs and abortions, gestational age at delivery, body mass index (BMI), birth weight of the newborn, 1-min Apgar score, neonatal intensive care unit (ICU) admission, neonatal asphyxia, and neonatal death. Perioperative blood indicators included hemoglobin (HGB), hematocrit, platelets, prothrombin time, activated partial thromboplastin time, and fibrinogen. Surgical outcomes included intraoperative EBL, cesarean hysterectomy, packed red blood cell (PRBC) transfusion (in China, one unit of PRBC is approximately equal to 200 mL of whole blood), fresh frozen plasma transfusion, platelet transfusion, the volume of autologous blood transfusion, blood loss within 24 hours postoperatively, maternal ICU admission rate, postoperative pyrexia ($\geq 38.5^{\circ}\text{C}$), anemia (HGB <100 g/L), total hospitalization costs, and surgery costs.

Statistical analysis

Categorical variables are presented as number/proportion (%) and were analyzed by the chi-square test. The Kolmogorov–Smirnov test was performed to determine normality of continuous variables. Data are shown as mean $\pm$ standard for normally distributed variables. If variables were normally distributed, the independent t-test was used for analysis. The Mann–Whitney U test was used for the analysis of non-normally distributed data and data are shown as the median (range). All statistical analyses and data processing were conducted by SPSS18.0 statistical software (IBM, Armonk, NY, USA). P values and 95% confidence intervals are shown for assessment of clinical indicators of patients with placenta previa and accreta. $P < 0.05$ indicates that the difference was significant.

Results

Comparison of baseline characteristics between the balloon and control groups

The mean maternal age in the balloon group and control group was 32.48 ± 5.09 and 32.70 ± 4.72 years, respectively, the mean values of previous CSs were 1 (1-3) and 1 (1-3) in the balloon group and control group, and the mean gestational age at delivery in the balloon and control group were $36+3(28+3-40+4)$ weeks and $36+2(28+1-39+3)$ weeks respectively. There were no significant differences in maternal basic characteristics, such as maternal age, gravidity, parity, number of previous CSs and abortions, gestational age at delivery, and body mass index, between the balloon and control groups, which indicated that the two groups were comparable. With regards to neonatal characteristics, the newborn weight of the balloon group was significantly higher and the rate of neonatal ICU admission was lower than those in the control group (both $P < 0.05$). There were no differences in the neonatal asphyxia rate, neonatal death rate, and 1-min Apgar score between the balloon and control groups (**Table 1**).

Comparison of perioperative blood indicators between the balloon and control groups

There were no significant differences in preoperative blood indicators and postoperative blood indicators, including HGB, hematocrit, platelets, prothrombin time, activated partial thromboplastin time, and fibrinogen, between the balloon and control groups ($P \geq 0.05$) (**Table 2**).

Comparison of surgical outcomes between the balloon and control groups

Median blood loss and the cesarean hysterectomy rate were not significantly different between the balloon and control groups, the median blood loss was 2200 mL (range, 500–12000) in the balloon group and 2150 mL (range, 500–15000) in the control group, and in balloon group, 36.3% patients with cesarean hysterectomy versus 35.5% in control group, which were no significant difference ($P \geq 0.05$). The amount of PRBC transfusion and the rate of maternal ICU admission was significantly lower in the balloon group than in the control group ($P < 0.05$). The total hospitalization and surgery costs in the balloon group were significantly higher than those in the control group (7044.4 ± 1708.0 versus 5793.6 ± 2263.8 USD and 3074.2 ± 404.9 versus 1829.7 ± 485.8 , both $P < 0.05$). However, there were no significant differences in fresh frozen plasma transfusion, volume of autologous blood transfusion, blood loss within 24 h postoperatively, postoperative pyrexia ($\geq 38.5^{\circ}\text{C}$), and anemia (HGB <100 g/L) between the balloon and control groups ($P \geq 0.05$) (**Table 3**).

Comparison of intraoperative conditions in the PTUI subgroup

We performed subgroup analysis on whether PTUI surgery was performed in the balloon and control groups. There was no significant difference in EBL [2200 (900-5500)] vs 2200 (500-12000), $P>0.05$] in patients of balloon group between Group A1 (PTUI surgery) and Group A2 (non-PTUI surgery), and there was also no significant differences in EBL [2200 (1000-6000) vs 2100 (500-15000) ml, $P>0.05$] in patients of control group between Group B1 (PTUI surgery) and Group B2 (non-PTUI surgery). The hysterectomy rates of PTUI surgery group (Group A1 and Group B1) were significantly lower than those of non-PTUI surgery group (Group A2 and Group B2) [(5.17% vs 45.79%), (7.14% vs 40.97%); $P<0.05$] (**Tables 4 and 5**).

Discussion

Placenta previa and accreta after previous CS are extremely serious obstetric conditions associated with a high risk of intraoperative massive hemorrhage. These conditions dramatically increase the risk of blood transfusion and hysterectomy during CS [13,14]. Placenta previa and placenta accreta are the two major risk factors for postpartum hemorrhage [15]. The incidence of placenta previa after CS is 1.22% [16]. However, prior CS appears to be the major risk factor for placenta accreta. Previous studies reported that the incidence of placenta accreta was 3.3%, 11%, 40%, 61%, 67%, and 67% after first, second, third, fourth, fifth, and sixth or more cesarean deliveries, respectively [11,17]. Owing to the high morbidity associated with placenta previa and accreta, accurate preoperative diagnosis and a multidisciplinary medical team for management of these conditions play a vital role [4,18]. Prenatal ultrasound and MRI techniques have been used to diagnose and guide clinical management, and favorable outcomes have been achieved [19,20]. With the wide use of ultrasound and MRI in the medical field, abnormal placenta accreta can be diagnosed in advance, and a plan can be provided for reducing intraoperative blood loss. Surgical hemostasis and uterine contractile agents are used to manage intraoperative hemorrhage and preserve the uterus during CS. If all methods of hemostasis fail to control the bleeding, hysterectomy is the ultimate solution for patients with placenta previa and accrete [21].

In recent years, an increasing amount of hemostasis methods have been applied in CS, such as the prophylactic intravascular balloon occlusion technique. As early as 1997, PBOIIA was first reported as a hemostatic method in CS for patients with placenta percreta [22]. With the increasing use of internal iliac artery balloon occlusion in CS for treating placenta previa and accreta, the role of PBOIIA in managing uncontrolled hemorrhage has become important for obstetricians and anesthesiologists. However, the efficacy of PBOIIA reported in the literature is controversial. Some scholars reported that PBOIIA was an effective hemostasis method in CS. Deng et al conducted a prospective observational study, which included 163 patients with placenta previa and accreta [21]. These authors found that PBOIIA was an effective strategy for controlling severe hemorrhage, and it reduced the amount of intraoperative blood loss for patients with placenta previa–accreta (1236.0 vs 1694.0 mL). Picel et al reported that, in 151 patients with invasive placenta undergoing cesarean hysterectomy, there was a significant difference in blood loss (2000 vs 2500 mL) and PRBC transfusions (2 vs 5 U) in the balloon group compared with the control group [23]. These findings indicated that PBOIIA could reduce intraoperative blood loss and transfusion requirements. Wang et al studied 83 patients with pernicious placenta previa coexisting with placenta accreta and found that PBOIIA was an effective method for managing postpartum hemorrhage [24]. However, some researchers failed to show that PBOIIA improves maternal outcomes. Previous randomized, controlled trials included 13 patients who were diagnosed with placenta accreta in the intervention group and 14 cases in the control group [25,26]. There were no significant differences in calculated blood loss (4950 vs 4709 mL) and PRBC units transfused (5.2 vs 4.1 U) between the intervention and control groups. These findings suggested that PBOIIA had no benefit in patients with placenta accreta. Liu et al compared 83 patients with placenta previa and accreta who underwent cesarean hysterectomy in the balloon group and 31 patients in the control group [27]. They found that PBOIIA had no significant effects on reducing EBL (3000 vs 3700 mL) and improving maternal outcomes.

A great deal of studies have investigated the effect of PBOIIA, but the sample sizes were small and the power of the studies was limited. We conducted a large-sample study to evaluate the effectiveness and practicality of PBOIIA for patients with placenta previa and accreta. In our study, we included 420 patients with placenta previa or accreta, and divided them into the balloon (248 cases) and control groups (172 cases). The results of this study are consistent with the previous negative finding that PBOIIA had no significant effects on improving maternal outcomes. Among the included patients, some underwent PTUI surgery simultaneously. A previous study showed that PTUI had a significant effect on reducing intraoperative blood loss and the hysterectomy rate [10]. Therefore, we conducted subgroup analysis to examine the effectiveness of PBOIIA when eliminating the

effect of PTUI surgery during CS. We found that there were no significant differences in intraoperative EBL, but the rate of hysterectomy was significantly decreased when PTUI surgery was taken. Additionally, no significant differences in postoperative blood indicators were found between the two groups. This finding indicated that PBOIIA may have no beneficial effect on recovery of the blood indicators in patients after CS. However, the total hospitalization cost and surgery costs in the balloon group were significantly higher than those in the control group, which greatly increased the financial burden of patients. Therefore, we should take a cautious attitude towards PBOIIA according to the individual situation of the patients. Abdominal aorta artery balloon occlusion is more effective than internal iliac artery occlusion in hemostasis in patients with placenta previa and accreta, but it is associated with a higher risk of vascular-related complications [28]. The indications of abdominal aorta artery balloon occlusion should be strictly controlled in clinical practice. Further studies are required to compare the advantages and disadvantages of the two types of intervention surgery in patients with placenta previa and accreta [5,29].

Balloon occlusion-related complications are rarely reported, with a rate of approximately 6%–15.8%, and these include ischemia, thrombosis, pain, fever, anemia, hematoma, and infection [30,31]. In our study, there were no significant differences in the rates of postoperative fever ($\geq 38.5^{\circ}\text{C}$) and anemia ($\text{HGB} < 100 \text{ g/L}$). There were also no balloon occlusion-related complications in patients after major surgery in our study, such as ischemia and thrombosis.

Strengths and limitations

The main advantage of our study is that the number of included patients was larger than that in previous studies, and therefore, the results are more reliable. We also performed subgroup analysis to evaluate the effectiveness of PBOIIA after eliminating the effect of PTUI surgery on hemorrhage. This provided a more reliable analysis of the results. The main limitation of our study is that it was a retrospective, single-center study. Additionally, our study was observational, and the included subjects could not be randomly allocated. Therefore, selection bias may have been present. However, we calculated the basic characteristics of the two groups, and the two groups of patients were comparable.

Conclusion

Our study shows that PBOIIA has no benefit in improving maternal outcomes for patients with placenta previa and accreta, including reducing intraoperative blood loss and hysterectomy rates. Additionally, PBOIIA significantly increased the financial burden of patients. When the effect of PTUI surgery on hemorrhage is eliminated, there is still no significant difference in intraoperative EBL and the hysterectomy rate. Therefore, PBOIIA should not be routinely recommended to patients with placenta previa and accreta.

Abbreviations

PBOIIA: prophylactic balloon occlusion of the internal iliac arteries, CS: cesarean section, PTUI: parallel transverse uterine incision, EBL: estimated blood loss

Declarations

Acknowledgements

We would like to express our special gratitude to our co-workers who contribute to the article in the Department of Obstetrics and Gynecology, West China Second University Hospital, Sichuan University.

Authors' contributions

Bing Peng and Daijuan Chen conceived the study, and participated in its design; Daijuan Chen drafted the manuscript; Bing Peng, Xiaodong Wang and Xinghui Liu revised the manuscript; Bing Peng and Xinghui Liu provided the financial support; Jinfeng Xu, Yuan tian and Daijuan Chen completed the collection of clinical data; Pengfei Ye and Fumin Zhao completed the collection and analysis of imaging data. We thank all the patients who willingly consented to the study.

Funding

This study was jointly funded by grants from the Applied Basic Research Program of the Science & Technology Department of Sichuan Province, China (2018JY0575) and the National Key Research and Development Program of Reproductive Health & Major Birth Defects Control and Prevention of China (2016YFC1000406).

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and informed consent

The retrospective, observational study was approved by the Ethics Review Committee of West China Second University Hospital of Sichuan University, and because of the nature of the retrospective, observational setting for our study, and the data are anonymous, an informed consent was waived for all included patients by the Ethics Review Committee of West China Second University Hospital. All study methods of the retrospective study were conducted in accordance with relevant regulations of a protocol approved by the Institutional Review Board from the West China Second University Hospital of Sichuan University.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

References

1. Silver RM. Abnormal Placentation: Placenta Previa, Vasa Previa, and Placenta Accreta. *Obstet Gynecol.* 2015; 126(3): 654-68.
2. Grobman WA, Gersnoviez R, Landon MB, Spong CY, Leveno KJ, Rouse DJ, et al. Pregnancy outcomes for women with placenta previa in relation to the number of prior cesarean deliveries. *Obstet Gynecol.* 2007; 110(6): 1249-55.
3. Khan KS, Wojdyla D, Say L, Gülmezoglu AM, Van Look PF. WHO analysis of causes of maternal death: a systematic review. *Lancet.* 2006; 367(9516):1066-74.
4. Allen L, Jauniaux E, Hobson S, Papillon-Smith J, Belfort MA. FIGO consensus guidelines on placenta accreta spectrum disorders: Nonconservative surgical management. *Int J Gynaecol Obstet.* 2018; 140(3): 281-90.
5. Shahin Y, Pang CL. Endovascular interventional modalities for haemorrhage control in abnormal placental implantation deliveries: a systematic review and meta-analysis. *Eur Radiol.* 2018; 28(7): 2713-26.
6. Greenberg JI, Suliman A, Iranpour P, Angle N. Prophylactic balloon occlusion of the internal iliac arteries to treat abnormal placentation: a cautionary case. *Am J Obstet Gynecol.* 2007; 197(5): 470.e1-4.
7. Garmi G, Goldman S, Shalev E, Salim R. The Effects of Decidual Injury on the Invasion Potential of Trophoblastic Cells. *Obstet Gynecol.* 2011; 117(1):55-9.
8. Jauniaux E, Alfirevic Z, Bhide AG, Belfort MA, Burton GJ, Collins SL, et al. Placenta Praevia and Placenta Accreta: Diagnosis and Management. Green-top Guideline No. 27a. *BJOG.* 2019; 126(1): 1-48.
9. Peng X, Chen D, Xu J, Liu X, You Y, Peng B. 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. *Medicine.* 2019; 98(44): e17742.
10. You Y, Fu J, Chen H, Luo L, Liu X, Peng B. Parallel transverse uterine incisions to control postpartum hemorrhage and preserve fertility during cesarean delivery for placenta previa and accreta. *Int J Gynaecol Obstet.* 2016; 134(2):221-2.
11. Q Yang, SW Wen, L Oppenheimer, et al (2007) Association of caesarean delivery for first birth with placenta praevia and placental abruption in second pregnancy. *BJOG: An International Journal of Obstetrics & Gynaecology* 114: 609-613.
12. Nicholson PJ, O'Connor O, Buckley J, Spence LD, Greene RA, Tuite DJ. Prophylactic Placement of Internal Iliac Balloons in Patients with Abnormal Placental Implantation: Maternal and Foetal Outcomes. *Cardiovasc Intervent Radiol.* 2018; 41(10):1488-93.

13. Rosenberg T, Pariente G, Sergienko R, Wiznitzer A, Sheiner E. Critical analysis of risk factors and outcome of placenta previa. *Arch Gynecol Obstet*. 2011; 284(1): 47-51.
14. Zlatnik MG, Cheng YW, Norton ME, Thiet MP, Caughey AB. Placenta previa and the risk of preterm delivery. *J Matern Fetal Neonatal Med*. 2007; 20(10): 719-23.
15. Committee on Practice Bulletins-Obstetrics. Practice Bulletin No. 183: Postpartum Hemorrhage. *Obstet Gynecol*. 2017; 130(4): e168-86.
16. Luo X L, Zhang W Y. Obstetrical Disease Spectrum in China: An Epidemiological Study of 111,767 Cases in 2011. *Chin Med J (Engl)*. 2015; 128(9):1137-46.
17. Silver RM, Landon MB, Rouse DJ, Leveno KJ, Spong CY, Thom EA, et al Maternal morbidity associated with multiple repeat cesarean deliveries. *Obstet Gynecol*. 2006; 107(6):1226-32.
18. Fitzpatrick KE, Sellers S, Spark P, Kurinczuk JJ, Brocklehurst P, Knight M. The management and outcomes of placenta accreta, increta, and percreta in the UK: a population-based descriptive study. *BJOG*. 2014; 121(1): 62-70.
19. Comstock CH, Bronsteen RA. The antenatal diagnosis of placenta accreta. *BJOG*. 2014;121:171-81.
20. Lim PS, Greenberg M, Edelson MI, Bell KA, Edmonds PR, Mackey AM. Utility of Ultrasound and MRI in Prenatal Diagnosis of Placenta Accreta: A Pilot Study. *AJR Am J Roentgenol*. 2011; 197(6):1506-13.
21. Fan Y, Gong X, Wang N, Mu K, Feng L, Qiao F, et al. A prospective observational study evaluating the efficacy of prophylactic internal iliac artery balloon catheterization in the management of placenta previa–accreta: A STROBE compliant article. *Medicine*. 2017; 96(45): e8276.
22. Dubois J, Garel L, Grignon A, Lemay M, Leduc L. Placenta percreta: Balloon occlusion and embolization of the internal iliac arteries to reduce intraoperative blood losses. *Am J Obstet Gynecol*. 1997; 176(3):723-26.
23. Picel AC, Wolford B, Cochran RL, Ramos GA, Roberts AC. Prophylactic Internal Iliac Artery Occlusion Balloon Placement to Reduce Operative Blood Loss in Patients with Invasive Placenta. *J Vasc Interv Radiol*. 2018; 29(2):219-24.
24. Zhou X, Sun X, Wang M, Huang L, Xiong W. The effectiveness of prophylactic internal iliac artery balloon occlusion in the treatment of patients with pernicious placenta previa coexisting with placenta accreta. *J Matern Fetal Neonatal Med*. 2021; 34(1):93-8.
25. Feng S, Liao Z, Huang, H. Effect of prophylactic placement of internal iliac artery balloon catheters on outcomes of women with placenta accreta: an impact study. *Anaesthesia*. 2017; 72(7):853-58.
26. Salim R, Chulski A, Romano S, Garmi G, Rudin M, Shalev E. Precesarean Prophylactic Balloon Catheters for Suspected Placenta Accreta: A Randomized Controlled Trial. *Obstet Gynecol*. 2015; 126(5): 1022-28.
27. Chen M, Lv B, He G, Liu X. Internal iliac artery balloon occlusion during cesarean hysterectomy in women with placenta previa accreta. *Int J Gynaecol Obstet*. 2019; 145(1):110-5.
28. Shahin Y, Pang CL. Endovascular interventional modalities for haemorrhage control in abnormal placental implantation deliveries: a systematic review and meta-analysis[J]. *Eur Radiol*. 2018; 28(7): 2713–26.
29. Wang YL, Duan XH, Han XW, Wang L, Zhao XL, Chen ZM, et al. Comparison of temporary abdominal aortic occlusion with internal iliac artery occlusion for patients with placenta accreta - a non-randomised prospective study. 2017; 46(1):53-7.
30. Bishop S, Butler k, Monaghan S, Chan k, Murphy G, Edozien L. Multiple complications following the use of prophylactic internal iliac artery balloon catheterisation in a patient with placenta percreta. *Int J Obstet Anesth*. 201; 20(1):70-3.
31. Thon S, McIntic A, Wagner Y (2011) Prophylactic endovascular placement of internal iliac occlusion balloon catheters in parturients with placenta accreta: a retrospective case series. *Int J Obstet Anesth*. 2011; 20(1): 64-70.

Tables

Table 1. The comparison of maternal and neonatal characteristics between balloon and control groups

Indicators	Balloon group (n=248)		Control group (n=172)		P
	Mean ± SD	Median (Range)	Mean ± SD	Median (Range)	
Maternal characteristics					
Maternal age (years)	32.5±5.1	31 (21-59)	32.7±4.7	32 (21-45)	0.654
BMI (kg/m ²)	21.7±2.7	21.4 [16.0-29.8]	21.2±2.5	21.0 [16.4-27.6]	0.081
Gravidity (n)	4.4±1.6	4 (2-13)	4.3±1.6	4 (2-10)	0.539
Parity (n)	1.3±0.6	1 [1-5]	1.2±0.4	1 [1-3]	0.123
Number of previous CSs (n)	1.2±0.4	1 [1-3]	1.1±0.4	1 [1-3]	0.332
Number of previous abortions (n)	2.0±1.4	2 (0-7)	2.1±1.6	2 (0-8)	0.531
Gestational age at delivery (weeks)	36.5±1.4	36 ⁺³ (28 ⁺³ -40 ⁺⁴)	35.6±1.9	36 ⁺² (28 ⁺¹ -39 ⁺³)	0.137
Neonatal characteristics					
Birthweight of the newborn (g)	2778.3±410.6	2760 (1080-3870)	2592.7±477.4	2620 (1270-3880)	0.000
1 min Apgar score (min)	9.1±1.6	10 [0-10]	9.0±1.8	10 (0-10)	0.696
neonatal ICU admission (n%)	50/248 (20.16%)		55/172 (31.98%)		0.006
neonatal asphyxia (n%)	34/248 (13.71%)		26/172 (15.12%)		0.685
neonatal death (n%)	2/248 (0.81%)		4/172 (2.33%)		0.197
	Note-Data are presented as mean±SD, as median (Range) or as number (%) BMI=body mass index; CS=cesarean section; ICU=intensive care unit.				

Table 2. The comparison of perioperative blood indicators between balloon group and control groups

Blood Indicators		Balloon Group (n=248)		Control Group (n=172)		<i>P</i>
		Mean ± SD	Median (Range)	Mean ± SD	Median (Range)	
HGB	Preoperative	110.2±13.8	110 [68-150]	109.2±14.4	109 [73-141]	0.468
	Postoperative	95.1±13.4	95.5 [61.0-130.0]	95.4±15.8	94 [58-140]	0.818
HCT	Preoperative	33.4±3.6	33.3 [21.9-42.6]	33.1±3.8	33.1 [23.7-40.6]	0.419
	Postoperative	28.5±3.9	28.7 [17.0-38.3]	28.5±4.6	28.5 [17.3-41.1]	0.870
PLT	Preoperative	167.5±50.5	157 (58-344)	172.0±50.1	168 (57-365)	0.280
	Postoperative	141.3±53.3	135 [39-339]	139.4±50.3	134.5 [26.0-300.0]	0.982
PT	Preoperative	11.9±0.8	11.9 [10.2-14.6]	12.0±0.7	12.0 [10.2-13.7]	0.279
	Postoperative	12.4±0.8	12.4 [10.8-14.5]	12.4±0.7	12.3 [10.8-14.4]	0.644
APTT	Preoperative	28.6±3.8	28.4 [12.4-45.7]	27.6±3.5	28.2 [19.9-40.2]	0.452
	Postoperative	32.3±4.7	32.3 [20.1-45.3]	31.8±5.0	31.4 [22.0-45.2]	0.296
FIG	Preoperative	389.9±74.9	384.5 (167-666)	392.0±83.5	385 (79-795)	0.938
	Postoperative	344.4±106.5	326 [161-701]	352.3±103.6	341 [154-641]	0.269

Note—Data are presented as mean ± SD, or as median (Range)

HGB: hemoglobin; HCT: hematocrit; PLT: platelet; PT: prothrombin time,

APTT: activated partial thromboplastin time; FIG: fibrinogen.

Table 3. Comparison of surgical outcomes of 420 patients with placenta previa and accreta

Indicators	Balloon Group (n=248)		Control Group (n=172)		<i>P</i>
	Mean ± SD	Median (Range)	Mean ± SD	Median (Range)	
EBL (ml)	2594.2±1598.5	2200[500-12000]	2841.5±2281.8	2150[500-15000]	0.897
PRBCs transfusion (U)	3.21±4.36	3[0-31.5]	4.8±6.3	3[0-39]	0.042
FFP transfusion (U)	343.4±456.8	0[0-2250]	429.7±561.0	0[0-2800]	0.171
PLT transfusion (U)	0.02±0.13	0[0-1]	0.05±0.22	0[0-1]	0.035
Autologous blood transfusion (ml)	391.3±501.5	220[0-2700]	347.0±475.1	217[0-2144]	0.527
Operative fluids transfusion (ml)	4392.8±1847.1	4000(1000-15600)	4506.8±2644.8	3700(1700-17700)	0.137
Blood loss within postoperative 24h (ml)	82.6±202.6	35(0-2210)	65.8±163.0	40(0-1908)	0.555
Postoperative length of stay (d)	5.7±2.2	5(2-17)	5.7±2.3	5[2-16]	0.497
Maternal ICU admission of days (d)	2.0±0.8	2[1-5]	2.1±0.9	2[1-6]	0.310
Total hospitalization costs (USD)	7044.4±1708.0	6708.3(2866.6-13682.5)	5793.6±2263.8	5172.7(2502.0-14049.2)	0.000
Surgery costs (USD)	3074.2±404.9	3069.1(1283.0-4421.7)	1829.7±485.8	1703.6(1033.9-3664.1)	0.000
Maternal ICU admission rate (n%)	42/248[16.94%]		47/172 (27.33%)		0.010
Postoperative pyrexia (≥38.5°C) n%	24/248 (9.68%)		10/172 (5.81%)		0.153
Postoperative anemia (HGB<100g/L), n%	158/248 (63.71%)		103/172 (59.88%)		0.427
Cesarean hysterectomy (n%)	90/248 (36.3%)		61/172 (35.5%)		0.862

Note-Data are presented as mean ± SD, as median (Range) or as number (%)

EBL: estimated blood loss; PRBCs: packed red blood cells; FFP: fresh frozen plasma; PLT: platelet; ICU: intensive care unit.

Table 4. Comparison of EBL and cesarean hysterectomy rate in Group A1 and A2 of balloon group

Indicators	Group A1 (PTUI surgery)			Group A2 (non-PTUI surgery)			<i>P</i>	
	n	Mean± Standard	median (Range)	n	Mean± Standard	Median (Range)		
EBL (ml)	58	2585.17±1223.73	2200[900-5500]	190	2596.91±1699.36	2200[500-12000]	0.456	z=-0.745
Cesarean hysterectomy (n%)		3/58 [5.17%]			87/190 (45.79%)			0.000 x ² =31.707

Note-Data are presented as mean ± SD, as median (Range) or as number (%)

PTUI: parallel transverse uterine incision; EBL: estimated blood loss.

Table 5. Comparison of EBL and cesarean hysterectomy rate in Group B1 and B2 of control group

Indicators	Group B1 (PTUI surgery)			Group B2 (non-PTUI surgery)			<i>P</i>	
	n	Mean± Standard	Median (Range)	n	Mean± Standard	Median (Range)		
EBL (ml)	28	2536.07±1285.10	2200□1000-6000□	144	2900.9±2427.542	2100□500-15000□	0.771	z=-0.291
Cesarean hysterectomy (n%)	2/28 (7.14%)			59/144 (40.97%)			0.001	x ² =11.72

Note-Data are presented as mean ± SD, as median (Range) or as number (%)

PTUI: parallel transverse uterine incision; EBL: estimated blood loss.

Figures

Figure 1

Flowchart of selection of the patients for the study.

Figure 2

Angiographic image of occlusion balloons placed within the internal iliac arteries. (A) balloon placed within the right internal iliac artery (allow); (B) balloon placed within the left internal iliac artery (allow); (C) A panoramic view of prophylactic balloon occlusion of internal iliac arteries: The position between the two arrows is the balloon (allows); (D) posture of patient with PBOIIA.