

# Intraoperative infrarenal aortic balloon occlusion in pregnancies with placenta accreta, increta, and percreta

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## Summary

**Objective:** The objective of this study was to evaluate the efficacy of intraoperative aortic balloon occlusion (IABO) during cesarean section for placenta accreta, increta or percreta. **Materials and Methods:** This was a retrospective case-control study of patients with surgically or pathologically confirmed placenta accreta, increta or percreta who were examined from 2013 to 2017. One hundred and two patients (60%) had aortic balloon catheters placed before cesarean section (balloon group), and the other patients did not undergo balloon placement (control group). Clinical records from 170 subjects were reviewed. **Results:** Forty-nine patients were diagnosed as having placenta accreta (28.8%), 98 patients had placenta increta (57.6%), and 23 patients had placenta percreta (13.6%). Considering all subjects, the patients in the balloon group had a significantly reduced median estimated blood loss ( $p < 0.01$ ), rate of transfusion ( $p = 0.02$ ), amount of packed red blood cells (PRBCs) ( $p = 0.02$ ), and decrease in hemoglobin levels ( $p = 0.03$ ). Nine (8.8%) patients had catheterization-related complications, including eight cases of arterial or venous thrombosis. When the data were analyzed separately according to the different forms of abnormal invasive placenta, no difference in these surgical outcomes was observed between the two groups for women with placenta accreta or placenta percreta; however, for women with placenta increta who underwent IABO, the authors observed significant reductions in the estimated blood loss ( $p < 0.01$ ), the amount of transfused PRBCs ( $p = 0.01$ ), the extent to which hemoglobin levels decreased after surgery ( $p = 0.01$ ), and the incidence of cesarean hysterectomy ( $p = 0.04$ ). **Conclusions:** Although IABO was efficacious in both reducing intraoperative hemorrhage and blood transfusion, and in preventing hysterectomy during cesarean section for placenta increta, it should only be used on the basis of an accurate antenatal diagnosis, as it has a high risk of thrombosis and a high cost; immediate cesarean hysterectomy still seems to be the optimal management for placenta percreta.

**Key words:** Aorta occlusion; Abnormal invasive placenta; Balloon catheter; Caesarean section; Placenta accreta.

## Introduction

Abnormal invasive placenta (AIP), also known as morbidly adherent placenta, is classified into three forms based on the depth of placental invasion. Placenta accreta is the least invasive form, in which the placental villi penetrate through the thinned decidua basalis and adhere directly to the myometrium. Placenta increta is characterized by the invasion of the placenta into the myometrium. Invasion through the myometrium reaching or penetrating the serosa is termed placenta percreta [1, 2].

AIP is a challenging obstetric problem that causes severe maternal morbidity. In previous studies, the approach most often recommended for managing AIP is a cesarean hysterectomy with no attempt to detach the placenta [2-4]. However, hysterectomy results in irreversible fertility loss, and recent studies have demonstrated an interest in attempting to preserve the uterus by manual removal of the placenta with resection of the invaded area or conservative management while leaving the placenta in situ [5-7].

The prophylactic placement of endovascular balloon catheters for controlling intraoperative hemorrhage in

women with AIP has been a topic of debate for nearly two decades. In the authors' previous study, intraoperative aortic balloon occlusion (IABO) was demonstrated to effectively reduce intraoperative hemorrhage during cesarean sections of patients with AIP, as many other studies have also reported [8-11]. Whether this technique can prevent hysterectomy requires further study.

In this study, the clinical data for a group of AIP patients who underwent manual placenta removal during cesarean section were retrospectively analyzed. The authors aimed to evaluate the clinical efficacy of IABO, especially in terms of reducing the incidence of hysterectomy in patients with different forms of AIP.

## Materials and Methods

This retrospective case-control study was conducted from 2013 to 2017 and was approved by the ethics committee of the present Hospital. Pregnant women who were preoperatively diagnosed with AIP based on prenatal ultrasound/MRI findings or clinical risk factors were included in this study, and clinical risk factors for AIP were defined as the presence of placenta previa complicated by a history of at least one prior cesarean section. Women

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confirmed to not have AIP after surgery were excluded. The antenatal diagnosis of AIP was confirmed by [1] a pathological examination of either placental bed biopsies or hysterectomy specimens after surgery or [2] the surgeon's inability to develop a clear cleavage plane between the placenta and the uterus, together with massive bleeding from the implantation site during surgery [8].

All pregnant women were given comprehensive information on the severity of their clinical condition, treatment options, and related risks. Then, the patients were asked to provide written informed consent for the reception of prophylactic aortic catheterization or other options. The planned date of delivery was decided on a case-by-case basis based on factors such as gestational age, contractile activity, prenatal vaginal bleeding, and complications.

Infrarenal aortic balloon catheterization procedures were performed by two experienced interventional radiologists in an interventional operating room. After local anesthesia, a 12-F sheath was inserted into the right femoral artery using the Seldinger technique. Then, a 10-F occlusion balloon catheter was inserted between the iliac bifurcation and the renal arteries. Correct placement and effective vascular occlusion were angiographically confirmed during balloon inflation using a contrast agent. The balloon was then deflated, and the volume of contrast agent required to inflate each balloon (5–8 ml) was recorded in the patient notes. The sheath/balloon catheter system was then fixed to the skin. The patients were then taken to the operating room for a cesarean section, and all babies were delivered by the same team of senior obstetricians who had more than 20 years of experience in cesarean delivery.

Intraoperatively, the balloons were inflated according to the obstetrician's request immediately after delivery and umbilical cord clamping or before uterine incision. The duration of occlusion was recorded for all patients. Typically, a 40-minute continuous aortic occlusion required balloon deflation for approximately ten minutes, and the longest single continuous occlusion could not last for more than 60 minutes. The balloons were routinely deflated before closing the peritoneal cavity to confirm hemostasis. In cases of continuous but non-life-threatening bleeding, the patient may be transferred to the interventional operating room for uterine arterial embolization (UAE). The catheters were removed by the radiologist immediately upon completion of the surgical procedure. Color Doppler ultrasound was performed in the lower limb to determine whether a thrombus was present.

During cesarean section, manual extraction of the placenta was attempted in all patients, and control of bleeding at the implantation site was attempted by administering uterotonic agents, hemostatic sutures, uterine artery (UA) ligation and uterine packing. In some cases with placenta increta or percreta, placental-uterine wall excision was performed if feasible, and the impaired bladder was repaired by a urological surgeon. If the invasive placenta tissue could not be removed in its entirety and hemorrhage remained under control, then methotrexate was injected into the implantation site; in some cases, lower uterine curettage was also performed after surgery. The indications for hysterectomy were uncontrolled bleeding during surgery despite the aforementioned surgical and medical interventions and an estimated blood loss (EBL) of more than 2,000 ml or continuous vaginal bleeding with unstable vital signs after surgery despite UAE or UA ligation having been performed or the uterus were impossible to reconstruct.

Demographic data and clinical data were collected from each patient. The EBL was quantified based on the volume of suction containers, the weight of the surgical pads, and a visual estimation of vaginal blood loss. Surgery-related and catheterization-related complications were also reported. The main surgical outcomes measured included EBL, the rate of cesarean hysterectomy, the

Table 1. — Baseline characteristics and the incidence of different types of AIP for all patients treated with or without aortic balloon catheters.

	Balloon group (n=102)	Control group (n=68)	<i>p</i> value
Maternal age (years)	32.3±5.3	31.6±5.2	0.43
Gestational age at delivery (weeks)	36.5±2.9	35.5±4.4	0.48
Gravidity (n)	4.2±1.9	4.0±2.2	0.51
Parity (n)	1.1±0.6	0.8±0.7	<0.01
Patients with prior cesarean section	79 (77.5%)	38 (55.9%)	<0.01
Postoperative diagnosis			0.88
Placenta accreta	29 (28.4%)	20 (29.4%)	
Placenta increta	58 (56.9%)	40 (58.8%)	
Placenta percreta	15 (14.7%)	8 (11.8%)	
Emergency operation	22 (21.6%)	29 (42.6%)	<0.01

Values are shown as the mean ± SD, or as a number with the respective percentage in brackets.

amount of packed red blood cells (PRBCs) transfused, and decreases in hemoglobin after surgery; the outcomes were further analyzed according to the forms of AIP.

Continuous variables are presented as means ± standard deviations or as medians (with interquartile ranges), and were analyzed using Student's *t*-test and by the Mann-Whitney U-test if the data were not normally distributed. Categorical variables are presented in the form of a rate and were analyzed using the  $\chi^2$  test or Fisher exact test. All analyses were performed using SPSS 19.0. The results were considered statistically significant at  $p < 0.05$ .

## Results

During the study period, 170 patients with surgically or pathologically confirmed AIP were eligible for this study; among these, 49 patients were diagnosed with placenta accreta (28.8%), 98 with placenta increta (57.6%), and 23 with placenta percreta (13.6%). One hundred and two patients (60%) had aortic balloon catheters placed before cesarean section (balloon group), and all balloons were inflated intraoperatively. Sixty-eight (40%) patients underwent cesarean section directly without prophylactic intervention (control group).

No differences were found between the two groups regarding maternal age, gestational age at delivery, gravidity, parity, and the distribution of different forms of AIP (Table 1). A significant difference was found in the percentage of patients with prior cesarean section in the balloon group compared with the control group ( $p < 0.01$ ). Significantly more patients underwent an emergency operation in the control group than in the balloon group ( $p < 0.01$ ).

Considering all women with AIP, significant differences were observed in EBL and the amount of transfused PRBCs. In addition, patients in the control group had a significantly higher incidence of blood transfusion ( $p = 0.02$ ) and a greater decrease in hemoglobin value after surgery ( $p = 0.03$ ) than did those in the balloon group. No signifi-

Table 2. — *Surgical outcomes, postoperative data, and complications for all patients treated with or without aortic balloon catheters.*

	Balloon group (n=102)	Control group (n=68)	<i>p</i> value
EBL (ml)	600 (400-1000)	1000 (650-2000)	<0.01
Transfusion	56 (54.9%)	50 (73.5%)	0.02
Transfused PRBCs (ml)	300 (0-700)	400 (0-1400)	0.02
Decrease in HGB after surgery (g/l)	7.5±15.2	12.4±14.2	0.03
Duration of operation (minutes)	76.5 (60-100)	80 (61.5-125)	0.38
Hysterectomy	17 (16.7%)	17 (25%)	0.24
Admission to ICU	17 (16.7%)	15 (22.1%)	0.43
Postoperative maternal LOS (days)	6±2.8	6.1±3.2	0.90
Surgery-related complications	8 (7.8%)	4 (5.9%)	0.77
Catheterization-related complications	9 (8.8%)	0	N/A

Values are shown as the mean ± SD, or as a number with the respective percentage in brackets, or as a median with the interquartile range in brackets. EBL: estimated blood loss; PRBCs: packed red blood cells; HGB: hemoglobin; ICU: intensive care unit; LOS: length of stay; N/A: not applicable.

Table 3. — *Neonatal outcomes for all patients treated with or without aortic balloon catheters.*

	Balloon group (n=102)	Control group (n=65)	<i>p</i> value
Admission to NICU	9 (8.8%)	12 (18.5%)	0.10
Apgar scores at 5 min	10 (9-10)	10 (10-10)	0.23

Values are shown as the number with the respective percentage in brackets, or as a median with the interquartile range in brackets. NICU: neonatal intensive care unit.

cant differences were found in the operation duration, the percentage of cesarean hysterectomy, the rate of admission to the ICU, the mean postoperative maternal length of stay or the rate of surgery-related complications (Table 2).

In the balloon group, the median time of occlusion was 25 (range: 5-59) minutes, and the median fetal radiation dose was 3.2 (range: 0.2-71) mGy. Nine patients (8.8%) had catheterization-related complications, including one case of hematoma in the front wall of the right common femoral artery, one case of venous thrombosis of the right lower limbs, and seven cases of artery thrombosis of the right lower limbs. Five patients had thromboembolism, and the others were treated conservatively using low-molecular-weight heparin at 2,000 to 6,000 units per day.

No maternal mortality occurred in either group. Seven patients requested a termination of pregnancy by cesarean section during the second trimester, and one patient had intrauterine fetus death at 36 weeks. These eight stillbirths were excluded from the analysis of neonatal outcomes. Including five sets of twins, 102 neonates were included in the balloon group, and 65 neonates were included in the

control group. The number of neonatal ICU admissions and the mean recorded neonatal Apgar score at five minutes did not differ between the groups (Table 3).

Interestingly, different surgical results were obtained when women with different forms of AIP were assessed separately. No differences in the amount of EBL, the amount of transfused RPBCs, the decrease in hemoglobin levels after surgery, and the incidence of cesarean hysterectomy were observed between the balloon and the control groups in women with placenta accreta or placenta percreta, but significant differences were found between the two groups for women with placenta increta (Table 4).

## Discussion

In recent years, prophylactic endovascular balloon catheterization (PEBC) has been used more frequently in cases that are complicated by AIP. Previous studies have evaluated the efficacy of PEBC in patients undergoing planned cesarean section and hysterectomy, and most concluded that PEBC can reduce intraoperative hemorrhage and the amount of transfused blood [1, 12-15]. Increasing expectations regarding quality of life have shifted the management approach for AIP, and more attempts are now made to conserve the uterus using PEBC with or without UAE. In these studies, the reported incidences of cesarean hysterectomy were 0-81.8% [9, 16-22].

These earlier studies mostly reported the occlusion of the bilateral internal iliac artery (IIA), anterior division IIA (hypogastric), or UA. Recently, increasing numbers of obstetricians have introduced IABO during cesarean section in patients with AIP. This technique may provide a higher degree of pelvic devascularization by simultaneously occluding the collateral circulation and reducing the exposure of the patients and fetuses to radiation because unilateral catheter insertion is sufficient, and the lodging location may be easily identified.

According to the results of these studies on IABO during cesarean section in patients with AIP, this technique can effectively reduce the EBL, the amount of transfused blood, and the incidence of cesarean hysterectomy [8, 9, 11]. Wu *et al.* reported that in all 88 patients with placenta percreta, the uterus was successfully conserved using IABO; only two of the patients required further UAE [11].

In the present authors' prior studies, IABO was found to reduce EBL, as also reported by other studies [10, 23]. Due to the limited number of cases studied, the efficacy of this technique in terms of uterus preservation is uncertain. In this study, the authors accumulated more cases of AIP and excluded patients in whom AIP was found intraoperatively, which yielded a more consistent baseline. The efficacy of IABO in terms of reducing EBL and the amount of blood transfusion was reconfirmed in this study, but this technique did not seem to affect uterus preservation in the primary analysis. Interestingly, different results were obtained

Table 4. — *Surgical outcomes for women with different forms of AIP treated with or without aortic balloon catheters.*

	Accreta (n=49)			Increta (n=98)			Percreta (n=23)		
	Balloon group (n=29)	Control group (n=20)	<i>p</i> value	Balloon group (n=58)	Control group (n=40)	<i>p</i> value	Balloon group (n=15)	Control group (n=8)	<i>p</i> value
EBL (ml)	500 (400-600)	650 (400-1000)	0.16	600 (400-1000)	1000 (800-2000)	< 0.01	3,000 (2,250-3,500)	3,500 (2,500-4,750)	0.36
Transfused PRBCs (ml)	0 (0-300)	300 (0-500)	0.09	300 (0-600)	400 (300-1400)	0.01	3,000 (2,250-3,500)	2,150 (1,400-3,250)	0.26
Decrease in HGB after surgery (g/l)	4 (1-9)	9 (0.5-20.5)	0.22	5 (-3-15)	12.5 (4.5-23.5)	0.01	14 (6-29)	18 (7.5-22)	0.72
Hysterectomy	0	0	N/A	5 (8.6%)	10 (25%)	0.04	12 (80%)	7 (87.5%)	1.0

Values are shown as a number with the respective percentage in brackets, or as a median with the interquartile range in brackets. EBL: estimated blood loss; PRBCs: packed red blood cells; HGB: hemoglobin; N/A: not applicable.

when the data were analyzed separately according to AIP type. The main value of using IABO seemed to only be achieved in cases that were complicated by placenta increta; in such cases, this technique can effectively control intraoperative hemorrhage and prevent cesarean hysterectomy. However, in cases that were complicated by placenta accreta or placenta percreta, the technique appears not to reduce EBL or conserve the uterus.

In the patients complicated by placenta accreta, the placentas were relatively simple to remove manually owing to the superficially invasive implantation, and the bleeding from the implantation site was not severe unless other reasons for bleeding were present, such as uterine inertia. Therefore, IABO was not as necessary for this group of patients. In patients with placenta percreta, although IABO can reduce bleeding in theory, hysterectomy was often still required because severe bleeding occurred when the present authors attempted to remove as much of the deep invasive placenta as possible over a large area; in other cases, it was impossible to reconstruct the uterus because large areas of the placental-uterine-wall were excised. Involvement of the cervix was another unavoidable reason for cesarean hysterectomy.

Another noticeable result of the study was that eight patients had arterial or venous thrombosis of the lower limbs, unlike the authors' previous study in which they observed no cases of thrombosis [10, 23]. The catheterization procedure and the size of the catheters used did not change during the study period, and the authors shortened the duration of catheter retention after the initial cases of thrombosis. Teixidor Vinas *et al.* reported one case of right iliac artery thrombosis among 27 patients who underwent IIA balloon occlusion [20], and Wu *et al.* [11] reported two cases of venous thrombosis of the lower limbs in 230 patients who underwent IABO. Possible reasons for the present higher rate of thrombosis include the relatively larger diameter of the sheath and balloon catheter used, the authors' conservative attitude in relation to the prophylactic use of anticoagulation treatment, and the experience of the interventional radiologist.

Since IABO does not seem to be effective in all forms of

AIP, improving the accuracy of antenatal diagnosis becomes more important. At present, antenatal imaging techniques that can help to raise the suspicion of AIP include ultrasound and MRI. The reported sensitivity of color Doppler for diagnosing AIP is 92% and the specificity is 67%, and the corresponding values for MRI are 84% and 78%, resulting in no significant difference [24]. Few studies have aimed to use these techniques to distinguish between different forms of AIP antenatally, but MRI was found to be better at detecting the depth of infiltration in cases of AIP [25]. In any case, an accurate antenatal diagnosis can provide obstetricians with adequate counseling and planning the delivery, thus avoiding unnecessary catheterization and improving peripartum outcomes.

A limitation of the present study was the lack of randomization, and all patients were divided into groups according to whether they chose prophylactic aortic catheterization or refused the procedure voluntarily before delivery. However, randomization would undoubtedly have been exceedingly difficult to achieve for these critical patients. Another unavoidable limitation was the lack of pathological confirmation of the diagnosis of AIP in all patients because the uterus was preserved in some patients.

In summary, the present study shows that intraoperative infrarenal aortic balloon occlusion was efficacious in both reducing intraoperative hemorrhage and blood transfusion, and in preventing hysterectomy during cesarean section for placenta increta; however, no difference was observed in patients with placenta accreta or placenta percreta. Immediate cesarean hysterectomy still seems to be the optimal management for placenta percreta. However, due to the high risk of thrombosis and the high cost of this technique, it should only be used on the basis of an accurate antenatal diagnosis.

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