Cardiovasc Intervent Radiol (2019) 42:829–834
https://doi.org/10.1007/s00270-019-02170-4

Prophylactic Occlusion Balloon Placement in the Abdominal Aorta Combined with Uterine or Ovarian Artery Embolization for the Prevention of Cesarean Hysterectomy Due to Placenta Accreta: A Retrospective Study

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Received: 30 October 2018 / Accepted: 23 January 2019 / Published online: 30 January 2019

Abstract
Objective To evaluate the outcomes of uterine-conserving surgery with the occlusion balloon technique followed by uterine or ovarian artery embolization (OAE) in women with placenta accreta.
Methods A total of 31 consecutive patients, who were diagnosed with placenta accreta through grayscale ultrasonography or magnetic resonance imaging prenatally, were retrospectively analyzed in our hospital between October 2015 and September 2017. All of the women underwent a Cesarean section combined with prophylactic placement of a balloon catheter in the abdominal aorta followed by uterine artery embolization (UAE) or OAE when necessary.
Results Technical success was achieved in 31 cases (100%), including successful catheterization and inflation of balloons. The uterus was conserved in 30 (96.77%) patients. The estimated blood loss, packed RBC transfused, and the operation time were 1906.45 ± 1117.64 ml, 4(0–6) U, and 88.68 ± 28.35 min, respectively. Out of all of the patients, we found nine cases of bleeding after the release of the balloon. Among these patients, six cases originated from the ovarian arteries and three cases originated from uterine arteries. Further embolization was performed through catheterization. The mean fetal radiation exposure was 4.33 ± 0.79 mGy.
Conclusions Prophylactic abdominal aorta balloon occlusion followed by UAE or OAE can effectively control postpartum hemorrhaging with reduced blood loss, transfusion requirements, and hysterectomy rates in patients with placenta accreta.

Keywords Balloon catheter · Inferior abdominal aorta · Placenta accreta · Uterine artery embolization · Ovarian artery embolization

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Introduction

Placenta accreta represents a main cause of obstetric hemorrhage, which occurs when all or part of the placenta invades and penetrates the uterine wall as a result of deficiency of the decidua basalis or invasion of chorionic villi directly into the myometrium or even the adjacent organs. According to the depth of implantation, placenta accreta is classified into three subtypes: "accreta" represents superficial invasion of the placental villi into the myometrium; "increta" represents deep invasion into the myometrium; and "percreta" represents deep invasion throughout uterus serosa or even the adjacent tissues [1]. An abnormally

invasive placenta may lead to severe morbidity, such as major obstetric hemorrhage, disseminated intravascular coagulopathy (DIC), or even maternal and neonatal mortality [2]. Thus, the diagnosis of placenta accreta before delivery is of great value as it allows for multidisciplinary cooperation to reduce morbidity and mortality. The diagnosis is based on grayscale ultrasonography and is occasionally supplemented with magnetic resonance imaging (MRI) [3]. Cesarean hysterectomy remains the mainstream management approach to reduce the incidence of maternal death [4]. Unfortunately, this method makes women lose their fertility forever. To avoid a hysterectomy, conservative management, such as intrauterine tamponade and B-Lynch suture, is effective to a certain degree, which might decrease both maternal morbidity and the need for a Cesarean hysterectomy. However, several complications, such as delayed massive hemorrhage, delayed hysterectomy, infection, sepsis, and DIC, should not be ignored [5].

Recently, the use of endovascular interventional procedures has been described in the management of obstetric hemorrhage of placenta accreta, such as temporary occlusion of the abdominal aorta and bilateral occlusion of the common iliac arteries and internal iliac arteries during Cesarean section [6–8]. As a result of the use of these interventional procedures, the rate of hysterectomies has been reduced. Some authors advocate that temporary balloon occlusion combined with uterine artery embolization (UAE) is an effective technique for addressing severe hemorrhage intraoperation [9]. However, the technique does not always produce good results. Wang MQ reports that transcatheter uterine artery embolization is not sufficient for controlling postpartum hemorrhaging due to incomplete embolization of the blood supply from other sources, especially the abundant natural collateral circulations to the uterus from the ovarian artery blood supply [10]. Kim [11] confirms that the proportion of postpartum hemorrhages from ovarian arteries is as high as 11.8%.

Hence, in this study, we present our efforts for uterus preservation with the aid of temporary balloon occlusion of the abdominal aorta followed by UAE or ovarian artery embolization (OAE) in patients with suspected placenta accreta. The primary end point of this study is estimated blood loss intraoperation, packed RBC transfused, the rate of transcatheter uterine or ovarian arterial embolization, and uterus conservation.

Materials and Methods

Between October 2015 and September 2017, the clinical data of 31 patients who had temporary abdominal aorta balloons performed prior to Cesarean section were retrospectively analyzed in our institution. All of them met the following inclusion criteria: (a) Prenatal diagnosis of placenta accreta by Doppler ultrasonography or MRI, confirmed by intraoperative or postoperative pathologic examination; (b) the placenta was located in the anterior wall of the uterus, overlying the Cesarean scar; (c) pregnancy length > 28 weeks; (d) desire to preserve fertility. Before surgery, informed consent was obtained. As this procedure is a potential effective treatment option to prevent hemorrhage in patients with placenta accreta, approval from the local ethics committee was not required.

All procedures were performed in the hybrid operation room equipped with a C-arm for digital subtraction angiography (DSA) under general anesthesia. Seldinger puncture was achieved at the right common femoral artery by local/regional anesthesia. Then, a 5-F pigtail catheter (Cook, Bloomington, IN, USA) was introduced through an 8-F arterial sheath (Bard Peripheral Vascular Inc., USA), through which 8 ml iodixanol (Visipaque-320, Nycomed, Oslo, Norway) was injected by hand to locate the aortic bifurcation (Fig. 1A). The commonly used balloon catheters were 8 F, 40 × 16 mm and 40 × 18 mm balloon catheters (Bard Peripheral Vascular, Tempe, AZ, USA) based on the diameter acquired by the abdominal aorta on US or MRI. Before Cesarean section, the balloon catheter was inserted via the guide wire above the bifurcation of the abdominal aorta (Fig. 1B).

Immediately after the fetus was delivered and the umbilical cord was ligated, the balloon catheter was inflated with an injection of 0.9% sodium chloride solution (10–15 mL). Simultaneously, uterotonics, such as oxytocin (20 U) and carboprost tromethamine (250 μg), were injected into the myometrium. Effective occlusion was achieved when the pulse oximeter decreased to 0 as assessed by distal foot–toe monitor. With the aid of successful balloon occlusion of the abdominal aorta, the obstetricians were able to separate the placenta from the uterine wall in a bloodless vision. Other hemostasis methods, such as the placental separation suture and the B-Lynch suture, were often used. In some situations, the placenta and part of the uterine wall were removed to achieve hemostasis. Furthermore, if the bladder posterior wall was injured by placenta percreta, the urologists were often asked for help. The single blocking time was 10 min with a 1-min interval. During this interval, the uterus cervix was blocked with an elastic tourniquet. This procedure could be performed repeatedly through a 10-min inflation, 1-min deflation, 10-min inflation, and 1-min deflation cycle until bleeding could not be controlled whether the balloon was filled or not. Interventional radiologists did not hesitate to perform angiography of bilateral uterine arteries. If a tortuous uterine artery was noted obvious vessel staining, UAE with gelatin sponge particles (Alicon Pharm SCT and TEC, Hangzhou, China; 710–1000 μm) was performed

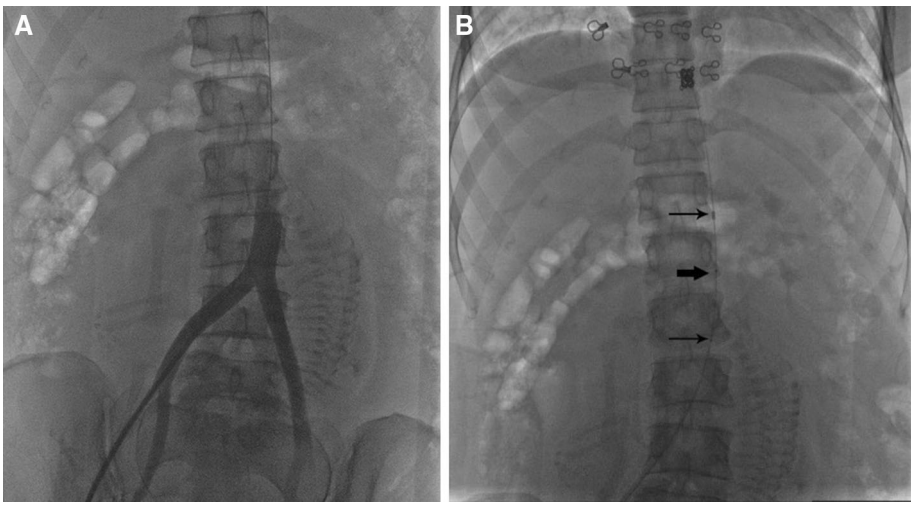

Fig. 1 **A** Iodixanol was injected by hand through the 8-F arterial sheath, and the location of aortic bifurcation is clearly presented (at the lower margin of the third lumbar vertebra); **B** the balloon catheter was then inserted via the guide wire, insuring that the lower marker of the balloon is above the abdominal bifurcation. The black arrows indicated the markers on both ends of the balloon, and the bold black arrow indicates the central marker of the balloon

immediately. Unless satisfactory hemostasis was achieved, the angiography of ovarian arteries was demanded through a 5-F pigtail catheter at the level of T12–L1. If the result was positive, OAE with gelatin sponge particles was performed subsequently. If all of the methods of hemostasis above were inadequate, a subtotal hysterectomy was undertaken. The sheath was removed, and manual compression was applied to the puncture sites for at least 15 min.

The primary outcomes of this study were estimated intraoperation blood loss, packed RBC transfused, the rate of transcatheter uterine or ovarian arterial embolization, conservation of the uterus, and fetal radiation exposure.

Statistical Analysis

Statistical analysis was performed using SPSS 19.0 (SPSS Inc., Chicago, IL, USA). Continuous data were described by the mean ± SD or median (range). Categorical variables were expressed as percentages. The Chi-squared test for proportions and Kruskal–Wallis test were used when there were more than two variables tested. $P < 0.05$ was considered statistically significant.

Results

The demographic and obstetric characteristics are listed in Table 1. All women in this study had at least one prior Cesarean section. Balloon catheters were successfully placed (100%) preoperatively.

The uterus was conserved in 30 cases (96.77%). A hysterectomy was required in one (3.23%) patient as the result of persistent uterine atony, although uterine and ovarian artery embolization had been performed. No maternal mortality or fetal morbidity related to the surgery

Table 1 Patient characteristics and outcomes

Characteristic	Value (n = 31)
Age (years)	32.97 ± 3.73
Pregnancy length (week)	35.90 ± 1.24
Weight gain during pregnancy (kg)	12.94 ± 3.07
BMI (kg/m^2)	27.03 ± 1.32
Gravidity	4.23 ± 1.02
Prior Cesarean section	1.61 ± 0.62
Parity	1.29 ± 0.94
Diabetes in pregnancy	3
Hypertension	2
Estimated blood loss (mL)	1906.45 ± 1117.64
Packed RBC transfused (U)	4(0–6)
Fresh frozen plasma (mL)	0 (0–600)
Any transfusion	16 (51.61%)
Placental types	
Accreta	8
Increta	14
Percreta	9
The number of patients need TAE	9 (29.03%)
UAE only	3 (9.68%)
UAE + OAE	6 (19.35%)
Operating time (min)	88.68 ± 28.35
Uterus preservation	30 (96.77%)
Urine output (mL)	1030 ± 459.44
Fetal radiation exposure (mGy)	4.33 ± 0.79
Apagar score less than 7 at 1 min	0
Mean birth weight(g)	2587.42 ± 259
Bladder injury	2
Thrombosis	2

TAE transcatheter arterial embolization

occurred. Placenta accerta was confirmed by intraoperative or postoperative histology, and 8, 14, 9 cases of accreta, increta, and percreta, respectively, were noted. The estimated blood loss and packed RBC transfused were 1906.45 ± 1117.64 mL and 4(0–6) U, respectively. Among all these cases, there were nine cases (29.03%) of bleeding after the release of the balloon. Of these cases, six cases (19.35%) originated from the ovarian arteries, resulting in OAE, and three cases (9.68%) were derived from uterine arteries, and UAE was subsequently performed. The mean operating time and urine output were 88.68 ± 28.35 min and 1030 ± 459.44 mL, respectively. The fetal radiation exposure was 4.33 ± 0.79 mGy. Two women had thrombosis in the right femoral artery and recovered after thrombolysis and anticoagulation therapy before discharge.

According to the placenta subgroup analysis, the estimated blood loss among the three groups exhibited a significant difference ($P < 0.001$). The estimated blood loss in the subgroup of placenta accreta was the least (699.53 ± 147.97 mL) compared with that in placenta increta group (1903.59 ± 593.37 mL) and placenta percreta group (3295.36 ± 858.47 mL), resulting in statistically significant differences in hemoglobin reduction (4.81 ± 1.66 g/L vs. 10.22 ± 1.98 g/L vs. 13.74 ± 2.41 g/L, $P < 0.001$) among groups. The ratio of patients of transfusion requirements was 0/8 in the accreta group, 8/14 for the increta group, and 8/9 for the percreta groups. Thus, the requirement of blood transfusion was related to the degree of placenta accreta, and a statistically significant difference ($P < 0.001$) was noted. With regard to balloon inflation time, we observed a statistically significant difference correlating with the degree of placenta invasion (Table 2; Fig. 2).

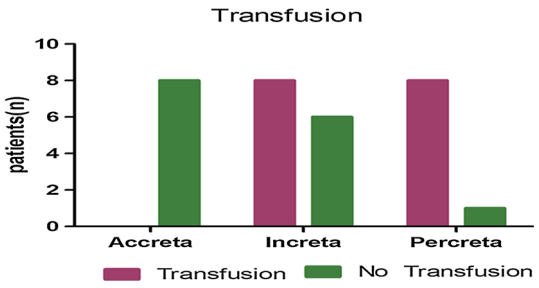

Fig. 2 Blood transfusion requirement correlating with the degree of placenta invasion

Discussion

In the present study, prophylactic abdominal aortic balloon occlusion played an important role in reducing the amount of bleeding and transfusions requiring during Cesarean section. The uterus was conserved in 30 cases (96.77%), and only one woman required subtotal hysterectomy. There were nine cases (29.03%) of bleeding after the release of the balloon, of which six cases (19.35%) originated from the ovarian arteries, ultimately resulting in OAE.

US and MRI are commonly used prenatally to diagnose placenta accreta. This methodology allows multidisciplinary teams to organize a suitable plan individually before surgery [3]. Prophylactic balloon occlusion before surgery has been recommended instead of Cesarean hysterectomy in patients with placenta accreta [4]. Two opinions about the role of balloon occlusion in placenta accreta exist. Some authors have confirmed that balloon occlusion is effective in reducing blood loss and transfusion requirements [12–14]. On the other hand, other authors did not find differences in terms of estimated blood loss, transfusion demand, and postoperative hospital stay duration and hysterectomy ratio [8].

The position of the balloon catheter placement remains controversial. Some scholars proved better results of common iliac artery balloon occlusion than internal iliac artery occlusion in preventing blood loss during Cesarean hysterectomy [7, 15]. Other scholars hold opinions that balloon occlusion in abdominal aorta is more effective in PPH control and uterus conservation, as this procedure is able to block pelvic blood supply and natural collateral circulations from the sacral, rectal, external iliac, and inferior mesenteric arteries [16–19].

Table 2 Comparisons among the three different grades of placenta accreta

	Accreta	Increta	Percreta	*P*
EBL (mL)	699.53 ± 147.97	1903.59 ± 593.37	3295.36 ± 858.47	0.000
Number of patients requiring transfusion	0	8	8	0.000
Hemoglobin reduction (g/L)	4.81 ± 1.66	10.22 ± 1.98	13.74 ± 2.41	0.000
Balloon inflation time	19.25 ± 6.23	24.43 ± 7.91	36.56 ± 8.60	0.001
UAE + OAE	0	2	4	0.062

EBL estimated blood loss, *UAE* uterine arterial embolization, *OAE* ovarian arterial embolization

Abdominal aortic balloon occlusion is superior compared with internal iliac and common iliac artery balloon occlusion in reduction of blood loss and blood transfusion [19]. In the present study, the mean estimated blood loss was 1906 mL, which demonstrated obvious advantages over that reported by Picel et al. [20] (2540 mL). Recently, Li et al. [13] reported good safety outcomes for balloon occlusion in abdominal aorta compared with common iliac arteries and internal iliac arteries. In addition, this procedure is far easier and quicker to lodge in the aorta than in smaller arteries owing to the shorter theoretical distance, which is coincident with reduced operation time. Moreover, the process does not require bilateral puncture or superselective catheterization, and less radiation exposure is consequently noted. In this study, the fetal radiation dose was 4.33 ± 0.79 mGy, which is far less than 29.4 ± 25.0 mGy for bilateral common iliac arteries occlusion [7] and 52.7 ± 64.7 mGy for bilateral internal iliac arteries [20].

Shahin Y and his colleagues performed a meta-analysis based on 385 studies including 1811 patients, revealing that balloon occlusion in abdominal aorta has more advantages in uterine preservation compared with other smaller arteries [14]. However, abdominal aortic occlusion alone is not adequate to control PPH and preserve the uterus. Scholars have reported a uterine preservation rate of 78.9–91.1% using abdominal aortic occlusion alone [17, 21]. In the present study, the rate of uterine conservation was 96.77%, and this encouraging result is attributed to the combined use of UAE or OAE. Pelvic artery embolization has been proven to be absolutely necessary and is recommended as the first-line therapy for refractory PPH [22]. Wang MQ concludes from his study of approximately eight patients with PPH that ovarian artery angiography and embolization should be performed in cases of UAE failure. She confirms that an additional blood supply arising from ovarian arteries and OAE can avoid hysterectomy [10]. In the present study, we found that nine patients (29.03%) with PPH required arterial embolization. Of these patients, continued hemorrhage in 6 (19.35%) patients was due to additional blood supply originating from the ovarian arteries.

Complications of iliac artery occlusion have also been reported, such as popliteal arterial thrombosis and rupture of multiple pseudoaneurysms arising from the left common iliac artery to the external iliac artery [23, 24]. In the present study, no severe complications associated with the use of balloon catheters were observed. Only two cases of thrombosis in the right femoral artery were noted. Reducing the number of punctures and shortening the operation time may help prevent complications to some extent.

It should be noted that there are limitations in our study. First, it is a small study with a limited number of patients. Second, it is a retrospective study. Third, some patients had a lack of pathological diagnosis after surgery. Consequently, there is a very real need for prospective, randomized, controlled trails with a larger number of participants to support the wider generalizability of the proposed method.

In conclusion, uterine preservation can be achieved with the aid of temporary balloon occlusion of the abdominal aorta followed by UAE or OAE in patients with a suspected placenta accreta. The combined treatments effectively control postpartum hemorrhaging with reduced blood loss, transfusion requirements, and hysterectomy rate. This protocol is safe and effective and should be considered as one of the first-line treatments for patients with placenta accreta who wish to preserve their uterus.

Acknowledgements We would like to acknowledge the whole Interventional Radiology and Obstetric teams of The First Affiliated Hospital of Zhengzhou University for their contribution in the management of these patients.

Author Contributions Juanfang Liu, collected data and wrote manuscript; Dechao Jiao contributed to design; Yanli Wang and Wenjun Zhang contributed to data analysis; Xinwei Han contributed to design and conducted the study.

Compliance with Ethical Standards

Conflict of interest Authors declare to have no conflict of interest.

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