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Postpartum Hemorrhages: Prevention

Francesco Giurazza, MD, PhD, EBIR,* Salvatore Alessio Angileri, MD,† Fabio Corvino, MD, EBIR,* Giuseppe Granata, MD,‡ Pasquale Grillo, MD,‡ Anna Paola Savoldi, MD,‡ Giuseppe Albano, MD,§ Laura Bracchi, MD,‖ Gianpaolo Carrafiello, MD,† and Raffaella Niola, MD, MBA*

The strict correlation between abnormal invasive placentation and postpartum hemorrhage suggests that a widespread antenatal diagnosis of placental anomalies would improve the management of these challenging patients; acting preventive solutions at the moment of delivery reduces blood loss and avoid hysterectomies.
The role of endovascular procedures in this field has been encouraged by multiple studies reporting prophylactic uterine arteries embolization and iliac/aortic balloon catheters positioning.
This paper aims to review the main imaging diagnostic findings of placental implant anomalies and summarize the principal preventive endovascular strategies proposed in literature.
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Introduction

Reducing maternal death is a priority of all the public health systems[1] and postpartum hemorrhage (PPH) is the main cause of maternal death worldwide,[2,3] accounting for approximately 25% of all the maternal deaths.[4]

PPH and severe PPH occur in 6% and 1.86% of all deliveries, respectively[4,5]; however, PPH is often underestimated due to the difficulties in assessing the blood loss. Intensive care unit (ICU) admission is frequently required, reported in up to 50% of cases.[6]

Conservative management of PPH includes resuscitation, blood transfusion, administration of uterotonic drugs such as oxytocin and prostaglandin, uterine compression, and intrauterine balloon tamponade.

When conservative management fails, embolization or surgical management are applied. Surgical management includes vessel ligation (bilateral ligation of the uterine or internal iliac arteries), uterine compression suture and finally hysterectomy.[5]

As underlined by an Italian study[6] published in 2019, the risk factors associated with severe PPH are previous cesarean section, multiple pregnancy and maternal age >35 years; the most common causes of peripartum hysterectomy are uterine atony (45.1%) and abnormally invasive placentation (AIP; 40.2%).[6]

Another recent paper from Sweden has described an increasing trend in the postpartum rate of massive transfusions (>10 RBCU), women with AIP having the highest increased risk.[7]

Apart from a more a complex clinical management, all of these aspects determine also a relevant increase in the costs for the public health system[8] compared to uncomplicated deliveries.

Considering the strict correlation between AIP and PPH and the rising trend in women affected by AIP, a widespread antenatal diagnosis would certainly improve their management by acting preventive solutions at the moment of delivery with the aim of avoiding hysterectomy and reduce the rate of massive transfusions.

Concerning endovascular preventive management, multiple studies have described different approaches with encouraging experiences. However, a unique standardized strategy still has to be recognized and large cohort trials are lacking; this may be due to the different instrumental facilities and hospital settings that clinicians face in their daily medical practice.

*Vascular and Interventional Radiology Department, Cardarelli Hospital, Naples, Italy.
†Unit of Radiology, IRCCS Cà Granda, Ospedale Maggiore Policlinico, Milan, Italy.
‡Postgraduate School in Radiodiagnostic, Facoltà di Medicina e Chirurgia, Università degli Studi di Milano, Milan, Italy.
§Gynecological and Obstetric Department, Vico Equense, Italy.
‖Diagnostic and Therapeutic Imaging Department, Cerba Healthcare Italia, Milan, Italy.
Address reprint requests to: Francesco Giurazza, MD, PhD, EBIR, Vascular and Interventional Radiology Department, Cardarelli Hospital, Via A. Cardarelli 9, 80131 Naples, Italy E-mail: francescogiurazza@hotmail.it

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A strict multidisciplinary cooperation between interventional radiologists and gynecologists, neonatologists and anesthesiologists is mandatory to organize the best local protocol of shared management that finally has to be functional for the gynecologist surgeon at the moment of delivery.

This paper aims to review the main imaging diagnostic findings of AIP and reports the principal preventive endovascular strategies reported in literature for PPH.

Definitions

The standard definition of PPH is a blood loss >500 mL within 24 hours after vaginal delivery or >1000 mL after cesarean delivery.[9]

PPH is considered primary if occurring during the first 24 hours after delivery and secondary if occurring after 24 hours and up to 12 weeks from delivery.[10]

Severe PPH is a life-threatening hemorrhage associated with one or more of the following conditions: red blood cell units (RBCU) transfusion; transcatheter arterial embolization; conservative uterine surgery; hysterectomy; ICU admissions; peripartum hemoglobin reduction of 4 g/dL or more (considered equivalent to the loss of 1000 mL or more of blood); maternal death.[9]

AIP is a defect of the decidua basalis allowing the invasion of chorionic villi into the myometrium. It is classified on the basis of the depth of myometrial invasion: placenta is increta when villi partially invade the myometrium, accreta when villi are attached to the myometrium not invading the muscle; percreta when villi penetrate through the entire myometrial thickness or beyond the serosa.[11]

Diagnosis of AIP

From an anatomical point of view, the deficiency of the decidua basalis at the site of the scar is the causative factor of AIP.

Prior cesarean section and placenta previa are the 2 most important risk factors for AIP. Other risk factors are: advanced maternal age, uterine anomalies, previous uterine surgery, dilation, and curettage and myomectomy.[12]

The diagnostic gold standard is represented by histologic evaluation; however not all patients undergo to hysterectomy and this causes large underdiagnosis. The clinical criteria are objective finding in manually removing the placenta, the need for surgical removal of the placenta, uncontrolled bleeding after placental separation in a well-contracted uterus. However pathologic and clinical findings allow diagnosis only at the moment of delivery during the cesarean section. So prenatal imaging, through ultrasound (US) and magnetic resonance (MR), coupled with anamnestic data plays a pivotal role in proper diagnosis.

When prenatal diagnosis of AIP is obtained, cesarean section can be planned at 36 weeks of gestation to reduce the risk of PPH during spontaneous labor; this would lead to an optimized management performed by a dedicated team where skilled interventional radiologists, anesthesiologists, and neonatologists support the gynecologists.

US diagnosis

US is recommended as the primary imaging modality for the evaluation of suspected placenta accreta. The overall sensitivity and specificity of US for the diagnosis of placenta accreta have been reported to be 77%-93% and 71%-96%, respectively.[13,14] The use of transvaginal Doppler US has been shown to be particularly useful in suspected lower uterine segment disease.[15]

The normal sonographic aspect of the placenta is a focal hyperechoic mass, lobulated into the gestational sac. The myometrium is thin and hypoechoic with well defined margins, clearly surrounding this mass; the subplacental clear space is a markedly hypoechoic thin line between the myometrium and the placenta. In the first trimester the placenta is relatively homogeneous; during pregnancy evolution, vascular lakes and calcifications develop inside, determining a disomogeneous aspect, appreciable especially during the third trimester. The vascular lakes present a regular round shape with laminar flow.

Normal placental blood flow patterns consist of a large amount of retroplacental myometrial blood flow.[16]

On the other hand, in case of AIP, US is able to depict some typical findings that allow to orientate the prenatal diagnosis: lacunae, reduced myometrial thickness, and placenta previa are the most common. Lacunae are vascular structures into the placenta creating a “Swiss cheese” placental appearance.[16] These irregular vascular channels (Fig. 1) develop from the placenta to the myometrium and present turbulent flow (Fig. 2), findings allowing distinction from the normal vascular lakes. They are the most predictive US signs for placenta accreta allowing identification in 78%-93% of cases after 15 weeks of gestation.[17,18] Reduced myometrial

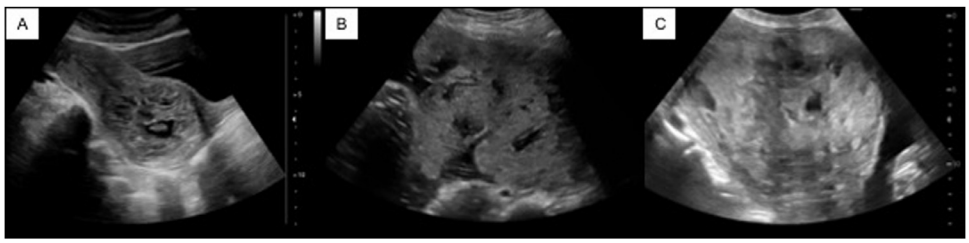

Figure 1 US B-mode: in A, B, and C multiple anechoic placental lacunae are evident into the placenta with irregular shape. Irregular septa are also appreciable in B.

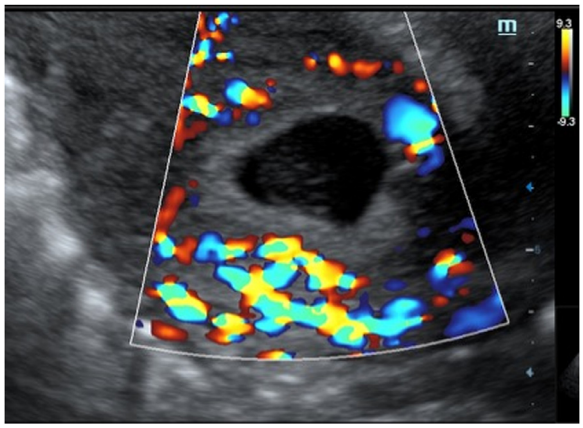

Figure 2 US color: turbulent flow is appreciable into the lacunae.

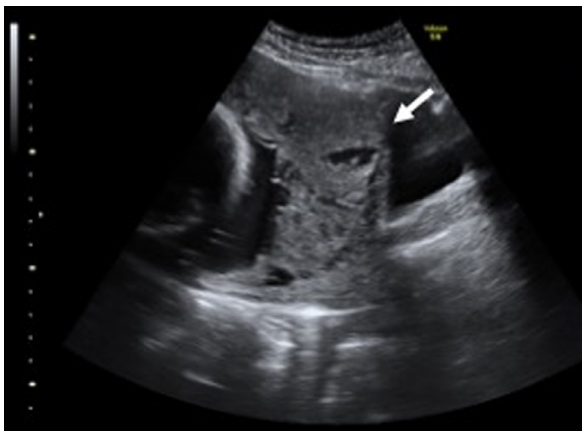

Figure 3 US B-mode: absent myometrial thickness with placental infiltration of the top of the bladder (white arrow) is appreciable and referable to a condition of placenta percreta; this patient performed a MR confirming the diagnosis.

thickness or loss of myometrium visualization is typical in case of AIP, therefore the contour of the whole myometrium should be carefully evaluated,[19] even if it requires skilled operators, especially in the postero-inferior margin of the uterus (Fig. 3). Placenta previa refers to the anomalous site of placental attachment on the myometrium, near or over the cervical opening. It significantly increases the risk of concomitant AIP.[20,21] So in case of placenta previa, eventual AIP should be investigated.

The loss of retroplacental clear space is another finding described in association with AIP, but it can be encountered even in normal placenta.[16]

MR diagnosis

In recent years, MR has been introduced for AIP evaluation. It is indicated in case of unclear US, especially when there is suspicion of AIP in the postero-inferior margin of the uterus. By definition, it is a panoramic imaging that allows a more comprehensive evaluation of the uterus related to the surrounding structures. The overall sensitivity and specificity of MR imaging have been given as 80%-88% and 65%-100%, respectively.[13,14] The sequences commonly adopted are fast T2-weighted. Some authors[22] have suggested that, given the significant morbidity and mortality, the use of intravenous gadolinium contrast material is indicated in these cases; however, its use is still debated due to its unknown half-life in the fetus.

Bladder should be filled. Imaging acquisition is usually performed in the third trimester.

The normal placenta is an isointense mass, with thin hypointense placental septa extending in parallel and regularly to the myometrium. The myometrium is hypo-isointense and thin, surrounded by 2 markedly hypointense layers (external and internal); inside the myometrium and especially just below the placenta, round-shaped flow voids corresponds to the normal vascularization.

The most useful findings of AIP are uterine bulging, heterogeneous signal intensity within the placenta and dark intraplacental bands.[23]

When uterine bulging is present, a focal outward contour bulge can be seen, or there can be disruption of the normal pear shape of the uterus.[16]

Heterogeneous signal intensity in the placenta with increased vascularity is also associated with placental invasion, corresponding to the lacunae visualized at US.

The intraplacental bands, compared to the normal placental septa, are thick-nodular ipointensities on T2-weighted sequences with random distribution.

Focal interruptions of the myometrium can be seen at the sites of placental invasion[16] (Figs. 4 and 5). Finally, in case of placenta percreta, extrauterine placental infiltration in the surrounding structures can be detected, especially involving the bladder.

Preventive treatment

First of all, it is mandatory to underline that in the preventive endovascular scenario the radiological technique must be standardized by applying several measures to achieve an appropriate balance between image quality and radiation dose to the fetus. In accordance with the SIR and CIRSE guidelines for the use of radiation during pregnancy,[24] these measures include: low-dose rate pulsed fluoroscopy with the lowest pulse rate allowed by the equipment, no angiography exposure, use of the "last image hold" to record the study and plan the procedure, no enlargement of the field of view, use of a half-dose filter, postero-anterior beam projection, x-ray tube at maximal distance from the patient, tube current as low as possible by keeping the tube potential as high as possible. Finally, the interventional radiologist should keep the beam-on time to an absolute minimum.

Nowadays endovascular interventional modalities for hemorrhage control during caesarean section for AIP are increasingly used.

Multiple studies[25] have compared endovascular intervention with no endovascular intervention as control, concluding that prophylactic endovascular procedures are effective for hemorrhage control during or after deliveries complicated by AIP by significantly reducing blood loss volume.

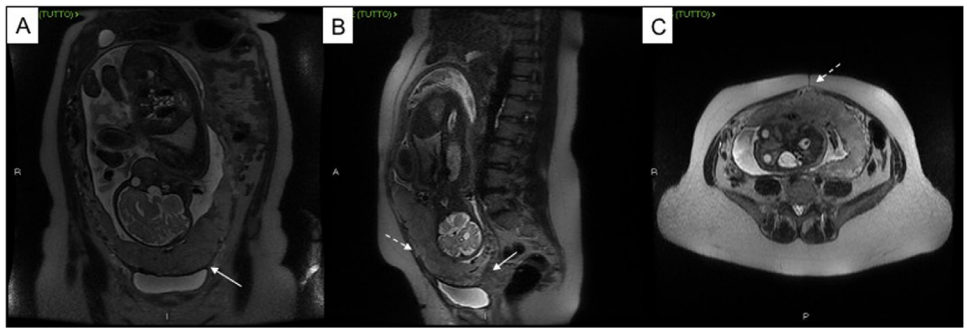

Figure 4 A 33-years-old female, three previous cesarean sections. Despite a scar pregnancy diagnosis, she wanted to carry on the pregnancy. MR planned at 32nd week and cesarean delivery planned at 36th week. T2-weighted MR sequences in coronal (A), sagittal (B) and axial planes (C) showing scar pregnancy with infiltration of the myometrium (placenta increta) associated with a placenta previa major.

Uterine bulging and heterogeneous signal intensity of the placenta are appreciable.

In A and B, white arrows show the placenta previa major occluding the cervical segment, while in B and C dotted white arrows show infiltration of the myometrium in correspondence of the previous scar.

Figure 5 Patient with cesarean scar pregnancy with suspected accrete MRI sequences: T2 axial (a), T2 FS sagittal (b), GE axial (c).

The primary outcome is to reduce the blood loss, while the secondary outcomes are to reduce hospital stay, minimize ICU admissions and prevent hysterectomy. Until now, there is no consensus regarding the best protocol and large cohort trials are lacking.

Actually, compared to patients with uncomplicated placentation, the rationale of all the preventive approaches in patients affected by AIP is based on the elevated risk of severe PPH with consequent massive blood transfusions and hysterectomies, running between 20% and 70%[26] of the cases.

Here are summarized the different endovascular strategies.

Preventive embolization after cesarean delivery

Some authors have proposed to perform UAE (uterine artery embolization) immediately after cesarean delivery to prevent a possible PPH. Usually a monolateral or a bilateral femoral access was obtained before surgery. The cesarean sections were performed in some studies directly in the angio suite to reduce the delay between foetus extraction and embolization; in other cases, interventionalists worked with a mobile C-arm in the operating room or the patients were transferred.

Yuan et al[27] published a retrospective analysis on 54 patients with placenta accreta: in 28, a monolateral 5Fr femoral access was positioned and after cesarean delivery in the angio suite, preventive UAE was performed with gelatin sponge pledgets; compared to the control group of 26 patients, no differences in hysterectomy incidence or duration of ICU stay or postoperative hospitalization were appreciated; however, the incidence of disseminated intravascular coagulation (DIC), mean estimated blood loss and blood transfusion (P= 0.011) were significantly lower in the UAE group.

Li et al[28] described more encouraging results on 12 patients (4 previa, 7 accreta, 1 percreta): 10 patients retained their uterus, the mean operative blood loss was 1391 mL, the average fetal X-ray dose was 17.66 mGy and the average fluoroscopy time was 1 minute 42 seconds.

Diop et al[29] positioned bilateral femoral 4 French accesses in a group of 6 patients with placenta accreta that after delivery (in operating room) underwent to preventive Spongel or particles UAE (in angio suite); comparing their data with a control group of 11 patients with accretism, they found a statistical significant difference in blood loss, favorable for the preventive group.

Bouvier et al[30] reported their experience on 14 patients (10 accreta and 4 percreta) performing preventive hypogastric arteries embolization after cesarean delivery; in this study the authors described the feasibility of acting the cesarean delivery into the angio-suite in order to immediately proceed with embolization after newborn extraction. They positioned a 4 French introducer just before delivery and then embolized the vessels contributing to utero-placental perfusion with gelatin sponge or particles: 50% of the patients had PPH while in the other 50% blood loss was insignificant.

Preventive embolization before cesarean delivery

An Italian group have proposed UAE before delivery,[8,12,31] scheduled between the 35th week and the 36th week of gestation. They worked in an operating room with a mobile C-arm. The whole embolization procedure was performed just before the cesarean delivery through a monolateral femoral access (Fig. 6). The embolizing agents adopted were Spongel particles or calibrated microparticles 500-700 μ. On overall 119 patients affected by placenta previa (55) and/or accretism (64) published in 2 studies, they reported blood transfusion in 36%-47.8% with a mean of 0.7-1.2 blood units per patients. Hysterectomy rate ranged between 26% and 43.5%. Two patients were transferred to the ICU. The mean uterine dose, considered as the dose to the foetus, was in mean between 15.61 and 26.75 mGy. Concerning the newborns conditions, no pH anomalies were measured from the umbilical cord blood, except in 2 cases where a slight respiratory acidosis (pH values 7.12 and 7.29) normalized in 2 hours; the Apgar score at 5 minutes was always $\geq$8; the analysis of the neuro-developmental milestones showed normal cognitive development in all children followed-up at 6 months.

A cost analysis[8] comparing a group of patients where UAE was performed postpartum in emergency settlement with a group of patients where the abovementioned preventive protocol was applied, showed a significant lower expense mainly related to a reduction in the length of the hospital stay and the number of ICU admissions.

Iliac artery balloon occlusion

Thirty-four publications[32-65] describing the placement of an iliac artery balloon for postpartum hemorrhage prevention in patients with AIP were identified.

These articles are summarized in Tables 1 and 2. Group A (Table 1) includes 30 studies where balloon catheters have been positioned in internal iliac arteries (PBOIIA)[32-61] (Figs. 7 and 8). Group B (Table 2) includes 4 studies where balloon catheters have been positioned in the common iliac arteries (PBOCIA).[62-65] Some of these were comparative studies evaluating one or more placement techniques. For each group three points were analyzed: incidence of hysterectomy, estimated blood loss, and number of RBCU transfusions.

The data described by the authors are highly variable depending on the heterogeneity of the published articles. This represents a significant limitation as described by a recent metanalysis.[25]

In Group A, a total of 759 women with a prenatal diagnosis of AIP at risk of PPH were identified. To evaluate the first objective, 8 articles were excluded describing hysterectomy as an elective procedure.[33,37,42,43,47,54,55,59]

The average number of hysterectomies performed among the studies was from 0% to 83.3%. The most representative study was carried out by Wang et al[56] who analyzed 48 patients who underwent balloon placement in the internal iliac artery finding that in no case hysterectomy had been necessary to control PPH.

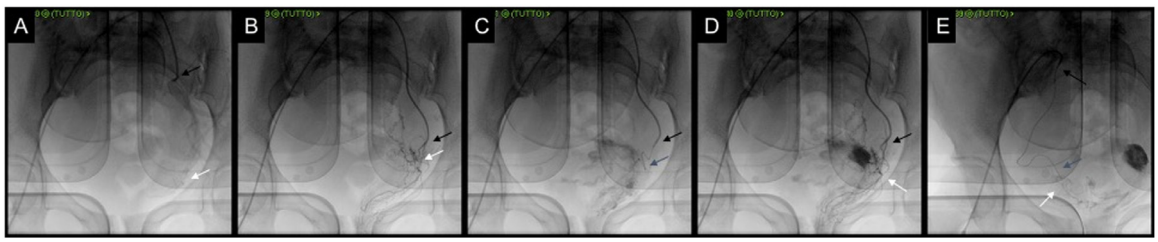

Figure 6 Same patient of Fig. 4; immediately before the cesarean delivery, UAE was performed in the operating room with a C-arm. The foetus and the operating table are visibl in all figures. Superselective UAE was performed with injection of 500-700 micron particles. The delay between UAE accomplishment and newborn extraction was 4 minutes and 16 seconds. The patients required two blood units transfusion and underwent to hysterectomy, already planned before the delivery because of her anamnesis (see legend Fig. 4). The APGAR score at 5 minutes was >8 and pH from humbilical cord blood was normal. The fluoroscopy quality is not elevated to reduce radiation dose; similarly, contrast agent is diluted to reduce iodine submission. In (A) black arrow shows the tip of a 5Fr Cobra catheter into the anterior trunk of the left hypogastric artery and the white arrow indicates hypertrophic left uterine artery. In (B) black arrow shows the tip of a 5Fr Cobra catheter into the vertical segment of the left uterine artery and white arrow indicates hypertrophic left uterine artery. In (C) black arrow shows the tip of a 5Fr Cobra catheter into the vertical segment of the left uterine artery and grey arrow indicates a 2.7Fr microcatheter into the horizontal segment of the uterine artery. In (D) black arrow shows the tip of a 5Fr Cobra catheter into the vertical segment of the left uterine artery and white arrow indicates contrast stain in the uterine artery after embolization. In (E) black arrow shows the tip of a 5Fr Cobra catheter into the origin of the right hypogastric artery, and grey arrow indicates a 2.7Fr microcatheter into the horizontal segment of the right uterine artery; white arrow indicates contrast stain in the uterine artery after embolization.

Table 1 Group A. Internal iliac artery balloon occlusion; NR: not reported; EBL: Estimated Blood Loss; RBC: Red Blood Cells.

Authors (year of publication)	N° of patients underwent prophylactic balloon	Hysterectomy	Embolization	Complications	EBL (L)	RBC transfusion units
Bodner L. J. et al. (2006)	6	5	6	NR	2,8	6,5
Carnevale F. C. et al. (2011)	21	21	NR	2	1,6	1,24
Nicholson P. J. et al. (2018)	22	2	NR	0	1,4	2
Gulino F. A. et al. (2018)	16	2	NR	1	1,1	2
Angileri S. A. et al. (2017)	37	0	0	9	2	3,9
Shrivastava V. et al. (2007)	19	19	0	3	2,7	10
Tan C. H. et al. (2007)	11	5	5	3	2	3,4
Ojala K. et al. (2005)	7	3	5	0	4,5	5,4
Sivan E. et al. (2010)	30	2	23	5	2	4
Teixidor Viñas M et al. (2014)	27	3	8	2	1	NR
Cali G. et al. (2014)	30	30	NR	6	0,8	0,4
Picel A. C. et al. (2018)	90	90	NR	21	2,3	3,5
Mei Y et al. (2018)	20	0	7	3	0,8	0,3
Zhou X. et al. (2019)	58	4	0	8	1,2	1,4
Clausen C. et al. (2013)	15	6	NR	5	4	5,8
Kidney D. D. et al. (2001)	5	5	0	4	2,2	2
Feng S. et al. (2017)	30	13	16	1	1	0
Tan Y. L. et al. (2016)	13	9	2	0	1	2,2
Fan Y. et al. (2017)	74	2	6	2	1,2	2,3
D'Souza D. L. et al. (2015)	10	3	10	5	1,2	0,5
Broekman E. A. et al. (2015)	42	NR	NR	0	0,8	0,2
Darwish H. S. et al. (2014)	32	4	NR	21	1,9	2,9
Greenberg J. I. et al. (2007)	1	1	0	2	2	9
Dubois J. et al. (1997)	2	2	2	0	1,7	0
Wang Y-L et al. (2017)	48	NR	14	0	0,6	1,98
Salim R. et al. (2015)	13	6	7	2	1,6	5,2
Krutman M. et al. (2013)	15	8	NR	2	NR	2
Yi K. W. et al. (2010)	1	1	0	0	0,8	0
Cho Y. J. et al. (2017)	18	3	8	0	1,9	6,4
Li K. et al. (2018)	37	9	NR	1	2,9	3,9

Minas et al[64] reported 3 cases of hysterectomy: in 2 due to persistence of bleeding despite balloon inflations and embolization, and in 1 due to balloon rupture. About estimated blood loss, an inter-study range between (0.6-4.5 mL) and an average of 1.6 L was calculated.

Fan et al[50] showed that patients who underwent balloon placement in the internal iliac arteries had a lower blood loss compared to the group in which the procedure was not performed (1.2 L vs 1.7 L; *P* value 0.01). The average number of RBCU was 2.9 (range 0-10). Balloon catheters placement in the internal iliac arteries allows a decrease in the number of blood transfusion compared to control cases without balloon placement.

In the majority of cases, complications were not related to the interventional procedures but to peripartum or surgical complications.

In Group B, a total of 84 patients with a prenatal diagnosis of AIP and PPH was found. Studies reporting elective

Table 2 Group B. Common iliac artery balloon occlusion; NR: not reported; EBL: Estimated Blood Loss; RBC: Red Blood Cells.

Authors (year of publication)	N° of patients underwent prophylactic balloon	Hysterectomy	Embolization	Complications	EBL (L)	RBC transfusion units
Al-Hadethi S. et al. (2016)	25	16	1	2	2,4	NR
Chou M. M. et al. (2015)	13	11	1	3	1,9	NR
Minas V. et al. (2015)	3	3	NR	0	3,2	4,6
Shih J. C. et al. (2005)	1	1	0	1	0,8	1,06

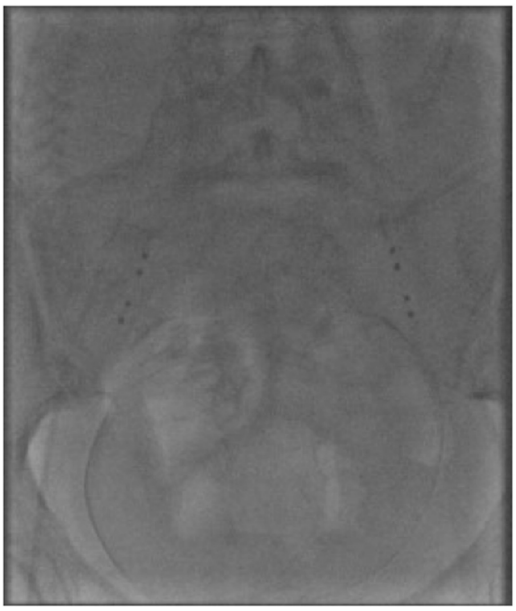

Figure 7 Fluoroscopy with bilateral balloon catheters positioning in internal iliac arteries.

hysterectomy procedure or in which hysterectomy was not specified were excluded. The average number of hysterectomies was between 7.1% and 84.6%.

Li et al[61] analyzed 42 patients with a diagnosis of AIP who underwent to balloon catheter placement in the common iliac artery, and found that only in 3 cases hysterectomy had been necessary as bleeding was not otherwise controllable; moreover, the comparison between balloon placement in the IIA, CIA, and IAA showed a statistically significant decrease in blood loss in subgroups where the balloon was positioned in the CIA and IAA compared to IIA (P value < 0.001).

The weighted average of blood loss was similar to group A, 1.6 L (range: 0.8-3.2 L). The average number of RBCU transfused was 0.88 (range: 0.6-4.6).

A study by Chou et al[63] related to 13 women showed a statistically significant decrease in blood loss after balloon placement in the CIA compared with historical controls of similar demographic groups previously published. Furthermore, it identified 2 complications associated with the procedure: thrombosis of the popliteal artery and of the external iliac artery, both treated with anticoagulant therapy.

Aortic balloon occlusion

Sixteen articles describing balloon placement in the infrarenal aorta were considered, totally 681 patients with a redelivery diagnosis of AIP (Table 3).[66-81]

The incidence of hysterectomies ranged from 0% to 22%. About blood loss, an inter-study range between 0.6 and 4.5 L was found. Xie et al[69] published a study comparing 2 groups, respectively with and without balloon placement in the aorta. The results showed that the average estimated blood loss and decrease in hemoglobin after surgery was significantly lower in the group undergoing to balloon positioning compared to the control group. The number of RBCU transfused was 2.1 units (range 0-5.8). Also in this study, complications were often mild and treated conservatively.

In conclusion, based on the data obtained, aortic balloon placement for PPH control may be considered a valid alternative compared to conventional treatment (ie, surgery alone).[81]

Balloons techniques comparison

The comparison of the 3 vascular districts most often involved in balloon placement (IAA, IIA, and CIA) was best reported in the study by Li et al,[61] which states that balloon placement is able to decrease intraoperative blood loss and improves several perioperative outcomes in patients with AIP. Moreover, balloon placement in the CIA and IAA seems to more effective than in the IIA.

A study by Shahin et al[25] argues that patients undergoing balloon placement in the aorta have a lower risk of hysterectomy than patients undergoing to other endovascular interventions, because of the lower blood loss during delivery, the absence of significant complications associated to endovascular interventions and the lower radiation exposure of the mother and fetus.

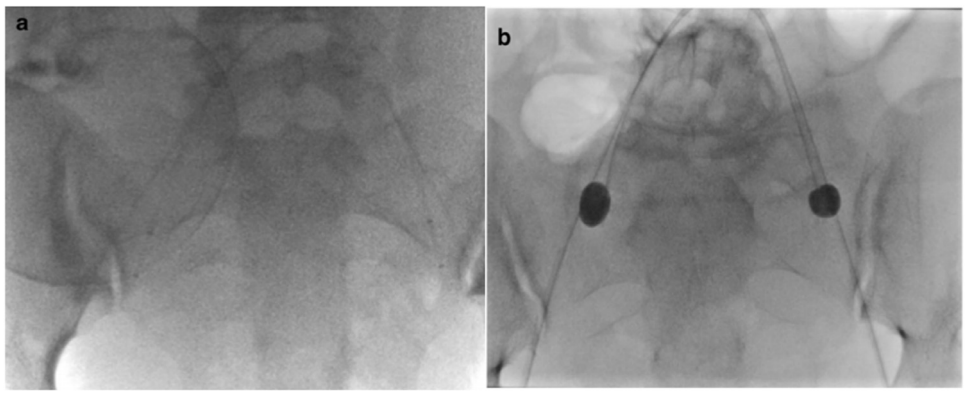

Figure 8 Fluoroscopy before (a) and after (b) delivery with inflations of occlusion balloons in bilateral internal iliac arteries.

Table 3 Aortic balloon occlusion; NR: not reported; EBL: Estimated Blood Loss; RBC: Red Blood Cells.

Authors (year of publication)	N° of patients underwent prophylactic balloon	Hysterectomy	Embolization	Complications	EBL (L)	RBC transfusion units
Cui S. et al. (2017)	38	2	12	1	1,5	3,6
Liu J. et al. (2019)	31	1	9	2	1,9	4
Wei X. et al. (2016)	45	4	NR	2	0,8	1,7
Xie L. et al. (2017)	30	5	NR	1	0,9	1,3
Wu Q. et al. (2016)	230	0	2	2	0,9	1,4
Li N. et al. (2018)	24	2	NR	1	1,6	5,8
Peng Z. H. et al. (2019)	9	2	2	0	1,8	3,8
Zeng C. et al. (2017)	48	2	0	5	1,4	5,4
Qiu Z. et al. (2017)	23	5	NR	1	1,7	2,3
Duan X.H. et al. (2015)	42	1	42	0	0,6	1,04
Chen M. et al. (2016)	20	0	1	0	1,1	0,5
Wang Y-L et al. (2017)	57	2	16	0	0,4	1,4
Panici P. B. et al. (2012)	15	2	NR	0	0,9	0
Masamoto H. et al. (2009)	1	1	0	0	3,2	3,9
Sun W. et al. (2019)	19	0	0	1	1,2	2,6
Blumenthal E. et al. (2018)	16	15	0	7	2	2

On the other side, PBOAAI requires a larger introducer, in order to support the balloon against the aortic wall preventing its migration, and also a vascular closure device or surgical removal.

Summary

Antenatal diagnosis of AIP by US and MR would improve the management of patients at high risk of PPH, by acting preventive solutions at the moment of delivery with the aim of reducing blood loss and avoiding hysterectomy.

Multiple transarterial approaches have been proposed, from preventive UAE to iliac/aortic temporary occlusion with balloon catheters; however, a univoque standardized strategy still has to be recognized due to the different instrumental facilities and local hospital settings.[82]

Certainly, endovascular control of hemorrhage in deliveries complicated by AIP is nowadays essential in this potentially life-threatening condition, therefore a strong support provided by the interventional radiologists to the gynecologists at moment of delivery should be always applied in this scenario; on the other hand, the gynecologists should actively involve the interventionalists in the management of patients with AIP.

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