Original Article

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The Treatment of Post-Partum Bleeding with Transcatheter Arterial Embolization

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Background: Our aim was to assess the safety and efficacy of transcatheter embolization in the treatment of post-partum bleedings.
Methods: In a single institution, the outcome of 15 patients who underwent transarterial embolization (TAE) for post-partum hemorrhages (PPH) were retrospectively reviewed. Eleven patients presented with hemodynamic instability requiring blood transfusion (73%) and four patients were hemodynamically stable (27%). Arterial embolization was performed with gelatin sponge, particles, and coils.
Results: Mean follow-up time was 21.2 months (range 12–48 months). Technical success rate was 100%. The overall clinical success rate was 100%. No major complications that required intensive care treatment were registered during or after the procedures. No patient required emergency surgery and subsequent hysterectomy. During follow-up, four patients became pregnant after transcatheter arterial embolization and delivered full-term, healthy infants.
Conclusions: TAE is a safe method that allows for the avoidance of surgery and hysterectomy for uncontrollable PPH; a future normal pregnancy after embolization may be hypothesized.

Keywords: *Post-Partum Bleeding; PPH; Post-Partum Hemorrhages; Embolization; Interventional Radiology*

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INTRODUCTION

Life-threatening uterine hemorrhage unresponsive to conservative medical treatment is still one of the leading causes of maternal morbidity and mortality worldwide [1,2]. Among these, post-partum hemorrhage (PPH) is the emergency most commonly encountered in the perinatal clinical practice [2]. PPH has many causes, including uterine atony, lower genital tract lacerations, coagulopathy, and placental anomalies. Uterine vascular abnormalities, including pseudoaneurysms, acquired arteriovenous malformations, arteriovenous fistulas, and rupture of vessels may be caused by uterine curettage or surgical trauma [3]. Correction of coagulopathy and identification of the cause of bleeding are mainstays of treatment [1–3].

In the past, in case of failure of conservative local measures, patients traditionally underwent bilateral hypogastric artery or uterine artery ligation or surgical hysterectomy. Transcatheter embolizations are minimally invasive procedures that may prevent surgery, thus decreasing morbidity and mortality and safeguarding the patient's future fertility potential [4].

In the United Kingdom, the Royal College of Obstetricians and Gynecologists, together with the Royal College of Radiologists and the British Society of Interventional Radiology, has recommended that interventional radiology has to be taken into account in the following circumstances [5]: (a) atonic uterus; (b) surgical complications or uterine tears at the time of caesarean section; (c) bleeding while the patient is in the recovery unit or in the

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Table 1 Patients and procedure characteristics.

Pt	Age	Partum	Haemodynamic Status	CT	Bleeding	Embolic Aagent	FU (m)	Successive Pregnancy
1	22	tv (p)	Stable	No	Uterine a.	Spongostan + PVA	48	Yes
2	30	Cesarean	Stable	Yes	IMA (2°)	Spongostan + coil	12	No
3	21	tv (p)	Unstable	No	Uterine a.	Spongostan + PVA	40	No
4	39	tv	Unstable	No	Uterine a.	Spongostan	32	Yes
5	28	tv (p)	Unstable	No	Uterine a.	Spongostan	32	Yes
6	33	Cesarean	Unstable	No	Pudenda a.	Spongostan + coil	20	No
7	36	Cesarean (p)	Unstable	No	Uterine a.	Spongostan (uni)	28	Yes
8	30	tv	Unstable	Yes	Uterine a. (2°)	Spongostan (uni)	12	No
9	32	Cesarean	Stable	Yes	Uterine a.	Spongostan + coil	12	No
10	27	Cesarean	Unstable	No	Uterine a.	Spongostan	12	No
11	38	Cesarean	Unstable	No	Uterine a.	Spongostan(uni)	14	No
12	40	Cesarean	Unstable	No	Uterine a.	Spongostan	12	No
13	30	tv	Stable	No	Uterine a.	Spongostan + coil	15	No
14	39	Cesarean	Unstable	No	Uterine a.	Spongostan	12	No
15	26	Cesarean	Unstable	No	Uterine a.	Spongostan	18	No

Pt: patient; CT: computed tomography; FU: follow up; m: months; tv: trans vaginal; p: primiparous; a:artery; IMA: inferior mesenteric artery; PVA: polivinyl alcohol; 2°: secondary PPH; uni: unilateral.

postnatal ward, following a natural delivery or a caesarean section; and (d) bleeding after hysterectomy [6]. In general, transarterial embolization (TAE) may be performed to treat uncontrolled bleeding associated with various obstetric conditions [4].

The aim of our study was to review our experience and to analyze, in a long-term follow up, the outcome of our cohort of patients treated with transcatheter embolization after PPHs.

METHODS

In our institution, during the past 3 years, 15 cases of post-partum arterial bleedings were diagnosed, which consisted of a pseudoaneurysm of a branch of the internal pudendal artery (n = 1), a blush of a branch of the inferior mesenteric artery (IMA; n = 1), and blushes from branches of the uterine artery (n = 13; Table 1). All patients were within the reproductive age group (21–40 years old) and were referred from the gynecologists to our Service of Interventional. Radiology for intractable vaginal bleeding (n = 11) and pelvic hematoma (n = 4). Hemorrhage was attributed to surgical maneuvers (n = 9) or to placental abnormalities (placenta previa (n = 6)) in accordance with gynecological report. Four patients were primiparous. TAE represented the first-choice treatment in the series described.

Five patients had natural delivery and ten patients underwent cesarean section. Primary or early PPH is defined as blood loss >500 ml (natural childbirth) and >1000 ml (cesarean section) within the first 24 h after delivery; secondary or delayed PPH occurs more than 24 h after delivery [1,7]. In all cases, the initial treatment consists of the administration of uterotonic drugs, such as oxytocin or prostaglandin E2 analogs, but if they fail, other management options should be considered. Laboratory data included platelet count, prothrombin time-international normalized ratio, fibrinogen, fibrin degradation products, and anti-thrombin-III , as well as hematocrit and hemoglobin levels. Supportive therapies for blood loss and treatment for coagulopathy were performed when necessary prior to, during, and after embolization.

Indications for diagnostic angiography and endovascular treatment included: signs and symptoms suggestive of vascular injury (such as hemodynamic instability necessitating blood transfusion, uncontrolled intraoperative blood loss, non-resolving vaginal or pelvic hematoma in a hemodynamically stable patient), and suspicious laboratory findings (low hematocrit or hemoglobin levels).

All patients underwent transabdominal and endovaginal grayscale and color Doppler ultrasound; in three cases computed tomography (CT) was performed and it revealed an arterial blush (Figure 1*a,b*). TAE was performed in 12 patients for primary PPH occurring within the first 24 h after delivery and in the remaining 3 patients for secondary PPH that occurred >24 h but <6 weeks from delivery.

Extravasation occurred in all patients. The uterine arteries, or the peripheral branches of the uterine arteries, were embolized unilaterally in 3 patients and bilaterally in 12 patients (Figure 2*a–d*). Regarding the embolization agents, absorbable gelatin sponges were used in all patients (n = 15), absorbable gelatin sponges and polyvinyl alcohol (PVA) particles 700–900 μm (Contour Emboli, Boston Scientific Corporation, Natick, MA) were used in two patients, absorbable gelatin sponges and microcoils in four patients (Figure 3*a–d*) and gelatin sponges alone in the remaining patients.

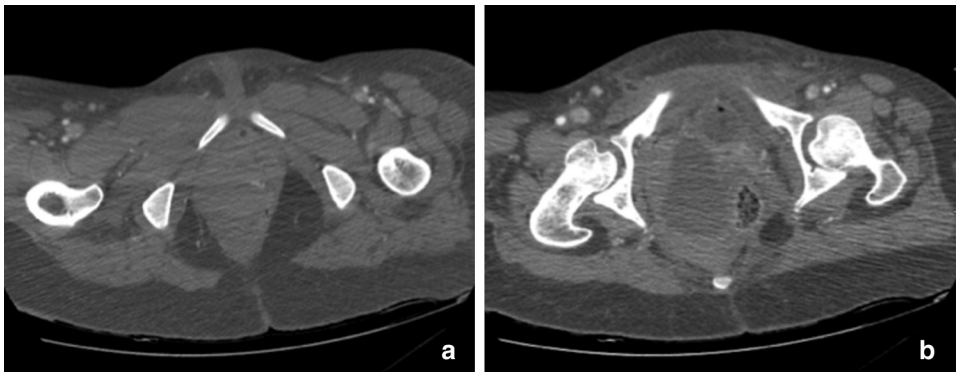

Figure 1 CT scan of a pelvic haematoma. Contrast-enhanced CT shows (**a**) the bleeding site and (**b**) pelvic hematoma.

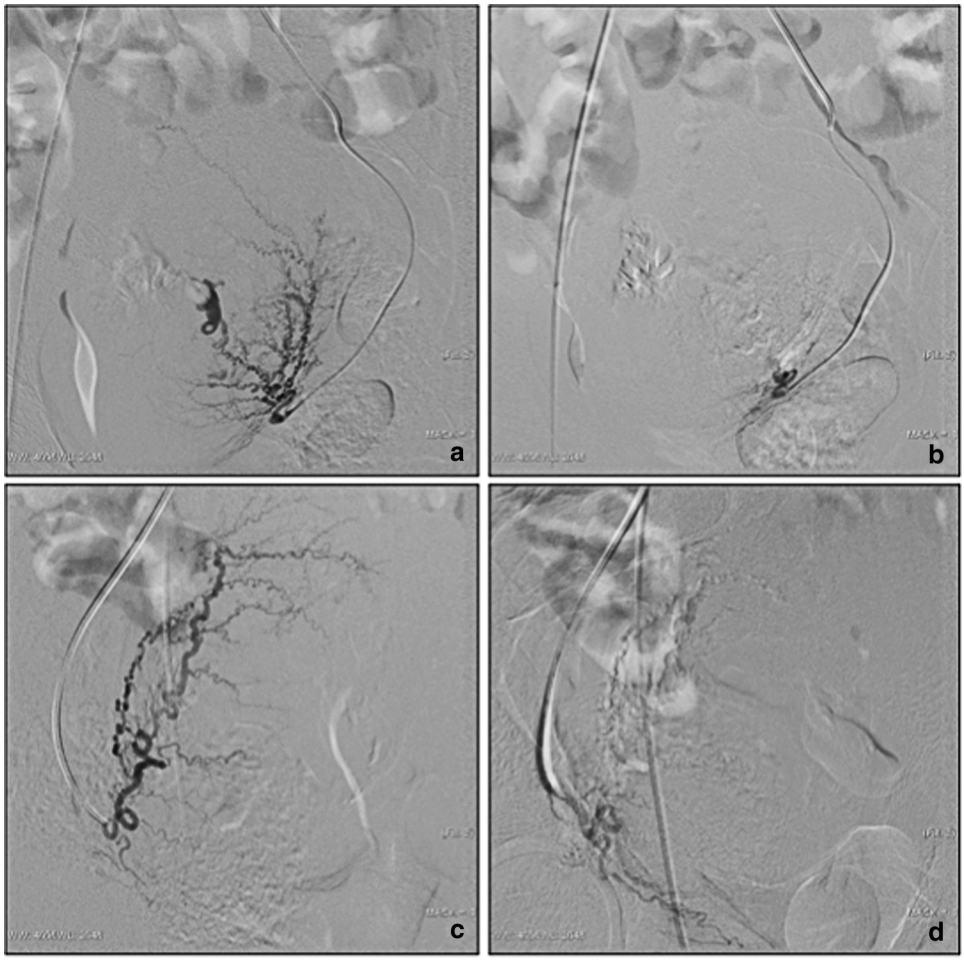

Figure 2 Selective angiograms of uterine arteries. (**a**) Contrast medium blush from branches of left uterine artery is revealed by selective angiogram. (**b**) Angiogram performed after embolization with gelatin sponge revealed complete embolization. (**c**) Angiogram of right uterine artery did not show bleeding. (**d**) Final angiogram performed after gelatin sponge embolization revealed devascularization of the treated area.

The efficacy of TAE was evaluated according to the halting of blood loss, considering both clinical and laboratory parameters. Complete hemostasis was defined based on hemodynamic parameters, hemoglobin level, and vaginal blood loss per hour.

Procedure

All endovascular procedures were performed by an interventional radiologist. Selection of embolic agents was based on the doctor's personal experience and

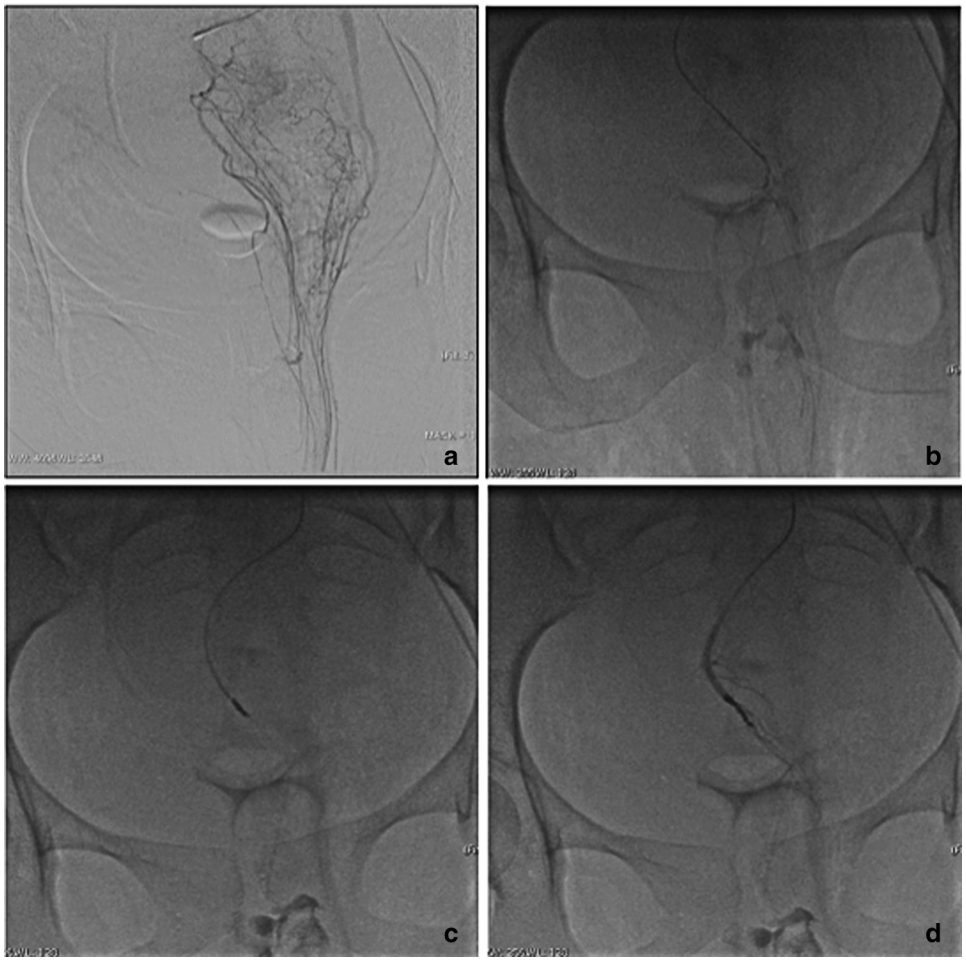

Figure 3 Selective angiogram of the inferior mesenteric artery. (a) Initial angiogram revealed bleeding from branches of inferior mesenteric artery. (b) Selective catheterization of one of the superior rectal branches permitted (c) super-selective embolization performed with coils. (d) Final angiogram revealed complete embolization.

preference, considering also site and type of vascular injury. In all cases, an anesthesiologist assisted with the procedure.

The procedure was performed in the angiography suite (GE-Innova 2100-IQ, GE Healthcare, USA) under local anesthesia and continuous cardiovascular and respiratory monitoring. Before treatment, each patient received an intravenous dose of 5% mannitol, 3 ml/kg/min of dopamine plus 600 mg of intravenous N-acetylcysteine as a protection against the ischemia-related production of free radicals and contrast medium-induced renal damage. Short-term antibiotic prophylaxis with a first-generation cephalosporin (cefazolin 2 gr) was initiated at the beginning of each endovascular procedure.

In all patients, from a common femoral approach, a bilateral selective internal iliac angiography and inferior mesenteric artery angiogram was initially performed, using a 5-F rim or a vertebral and/or a Simons 1 catheter (Cordis, Miami Lakes, FL, USA), followed by selective bleeding vessel digital subtraction angiography. Superselective embolization was carried out with a 2.7-F coaxial microcatheter (Progreat, Terumo, Tokyo, Japan). A femoral sheath was left in place for 24–48 h until hemodynamic and laboratory data confirmed patient stability.

Follow-up

All patients were closely monitored (symptoms and laboratory data) every 6 h in the first 48 h and for 1 week after the endovascular procedure. A CT scan and/or color Doppler ultrasound was performed to rule out new and/or residual bleeding, pseudoaneurysms, or fistulas in cases of incomplete hemodynamic stabilization (n = 2); in both cases a new bleeding site was not detected. The embolization procedure must be repeated if the indication persists. The interval between completion of the intervention and first imaging follow-up was in the range of 3 days to 2 months. A minimum 12-month follow-up was available for all of our patients who underwent embolization.

Outcomes

Technical success, clinical success, and complications were evaluated. Technical success was defined as the stopping of bleeding with the restoration of peripheral flow. Early clinical success was defined as cessation of symptoms and stabilization of laboratory data within 24 h and again within 1 week after endovascular procedure (i.e. absence of recurrent hemoglobin level drops <1.5 g/dl, circulatory stabilization). Late success was defined as absence of reperfusion of bleeding during follow-up, and the proportion of injuries that did not require a new endovascular treatment or subsequent surgical intervention; moreover, during follow-up, new pregnancies were registered and evaluated as late clinical success. All complications were recorded and classified according to the Society of Interventional Radiology classification [8].

Ethical Approval and Informed Consent

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

RESULTS

Hysterectomy was avoided in all cases. All patients underwent a Doppler ultrasound immediately after embolization, before discharge, and then usually at 3-month intervals for 1 year and yearly for up to 3 years. No recurrence was detected at follow-up US. Two patients underwent a new CT scan for incomplete hemodynamic stabilization, but a new bleeding site was not identified.

Technical success rate was 100% as shown by the complete exclusion of bleeding on angiography performed at the end of the procedure. After the procedure, in all patients, return to hemodynamic parameters was obtained with increased blood pressure and normalization of peripheral pulses. No patient required conversion to open surgery and none required a second treatment, whether surgical or endovascular.

Clinical success, early and late, attributed to endovascular therapy alone was documented in every patient (100%). During follow up (12–48 months), no recurrence of bleeding or sequelae related to non-target embolization was registered; moreover, four patients became pregnant again, and all of them delivered full-term, healthy infants with no abnormal delay in conception.

No major complications requiring intensive care were encountered during or after the procedure; mild post embolization syndrome was registered in four patients.

DISCUSSION

In this study, the efficacy of TAE for PPH was evaluated by analyzing the blood loss and the time interval from the end of TAE to complete hemostasis. PPH refractory to conventional procedures was well controlled by endovascular procedure alone, with a success rate of 100%.

In a literature review, the only predictive factor for the efficacy of endovascular procedure resulted in the presence or absence of coagulopathy [9]. In our series, none of the patients presented coagulopathy. In all cases, in accordance with the gynecological report, extravasation of contrast media was attributed to a surgical maneuver. The embolic agent of choice is gelatin sponge, which provides temporary occlusion with recanalization of the arterial bed in 3–6 weeks, in accordance with literature data [6]. In this particular series, absorbable gelatin sponges were used in all cases. Gelatin sponge relies on the clotting cascade and is functionally impaired in the setting of disseminated intravascular coagulation. Based on the operator's preference, coils were utilized to embolize bleeding from branches of the pudendal artery and the IMA; PVA particles were used selectively to help hemostasis when absorbable gelatin sponges were considered insufficient. Microspheres leave the capillary bed intact, and there is limited potential for recanalization. To avoid uterine necrosis, 500–900 μm particles are preferred; necrosis has been described with both absorbable and non-absorbable embolics.

The use of a permanent embolic agent for the embolization of the distal branch of the uterine artery preserved uterine perfusion and future fertility in one of our cases. Permanent agents such as particles have also been used successfully to control PPH, both alone and in combination with gelatin sponge [10].

Small embolic particles (150–250 μm) should be avoided because they can potentially increase the risk of ischemic complications [11]. Other agents, such as n-butyl-2-cyanoacrylate (NBCA) or coils, may be of particular value in genital tract tears and arteriovenous fistulae. Moreover, NBCA may be useful in cases where total vessel occlusion is necessary, such as recurrent PPH after TAE [12].

According to the localization of puerperal hematoma, it can be classified as vulvar, vulvo-vaginal, and retroperitoneal [13]. Localization of the hematoma depends on the blood vessel. One of our patients presented with bleeding from a branch of the inferior mesenteric artery; on the basis of the surgical history, this complication has been linked to an injury during the cesarean section.

In our cohort, six cases of PPH have been attributed to placenta previa, which is strongly associated with maternal hemorrhage, even though most literature focuses on morbidity in the setting of placenta accreta [14]. The fact that no cases of PPH related to placenta accreta were registered may depend on the fact that in those cases, which are considered high risk, more effective precautions are taken during pregnancy and before delivery.

TAE should be considered before surgical alternatives because arterial ligation makes subsequent TAE difficult [15] but not impossible [16,17]; moreover, embolization does not preclude later surgery.

Complications after arterial embolization are rare [6]. Postembolization syndrome should be expected and includes transient abdominal pain, fever, nausea, and mild leukocytosis.

Ischemic complications are rare but may occur if small embolic particles are used or if there is an interruption of collateral supply by previous surgical ligation of the internal iliac artery [18]. Buttock ischemia, small bowel necrosis, and uterine, vaginal, cervical, and bladder necrosis have all been reported [6,18].

Only limited data are available on the long-term follow-up of women and their future fertility after TAE [6,18,19]. In our small series, in a mean follow-up of 21.2 months, four women have become pregnant after embolization, and delivered full-term, healthy infants.

Limitations of this study are mainly its retrospective nature and the small number of patients yielding an absence of statistical power. However, the results confirm that TAE is a safe alternative method to treat uncontrollable PPH and should guarantee a normal pregnancy after embolization.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

AMI, EMF wrote the paper and collected data. AP collected data. MS and GC reviewed the paper. All authors approved the paper.

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