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FULL PAPER

Inferior mesenteric artery embolization for persistent postpartum hemorrhage after sufficient bilateral iliac arteries embolization: safety and efficacy in eight patients

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Objective: To assess the safety and efficacy of transcatheter arterial embolization (TAE) of the inferior mesenteric artery (IMA) for the management of post-partum hemorrhage (PPH).

Methods: A retrospective analysis was performed regarding eight patients (mean age, 34.4 y; age range, 31–40 y) who underwent TAE of the IMA for PPH between March 2001 and September 2018. Obstetric records, including maternal characteristics, clinical manifestations, complications, and clinical outcomes, as well as TAE details were obtained.

Results: All eight patients had primary PPH and the vaginal delivery mode. CT scans of two patients showed active bleeding from the lower uterus or hematoma and with the origin of contrast extravasation abutting the adjacent rectum. In seven patients, an aortogram or IMA arteriogram following persistent vaginal bleeding after sufficient embolization of the bleeding focus from the bilateral iliac

arteries, found the bleeding focus of the IMA, while in one patient, the IMA bleeding focus was found at the second session 4 h after the first session. TAE of the IMA was technically successful in all eight patients and cessation of bleeding without repeated TAE or additional hemostatic surgery was achieved in all patients after TAE of the IMA. There were neither procedure-related complications nor bowel ischemia during follow-up.

Conclusion: TAE of the IMA for PPH was safe and effective with successful hemostasis. Bleeding from the IMA should be suspected when there is persistent vaginal bleeding after sufficient embolization of bleeders from the bilateral iliac arteries.

Advances in knowledge: Bleeding from the IMA should be suspected when there is persistent vaginal bleeding after sufficient embolization of bleeders from the bilateral iliac arteries.

INTRODUCTION

Selective embolization for postpartum hemorrhage (PPH) has been reported since 1979 and is known to be an effective alternative to hysterectomy.^{1,2} When embolization of uterine arteries and other branches of the internal iliac arteries fails to achieve hemostasis, other potential bleeders should be considered. Among them, the inferior mesenteric artery (IMA) is known to be a very uncommon bleeding source of PPH, and most of the bleeders are related to PPH due to genital tract injury.^{3–6}

To our knowledge, reports are very limited regarding transcatheter arterial embolization (TAE) of the IMA for the treatment of PPH.^{3–6} In this document we report the clinical efficacy and safety of TAE of the IMA for PPH based on information regarding eight patients at a single, tertiary medical center.

METHODS AND MATERIALS

Clinical data and definitions

This retrospective review of all of the clinical and imaging data was approved by our institutional review board, and written informed consent for each patient was waived due to the

retrospective nature of this study. From March 2001 to September 2018, 783 patients underwent TAE in Asan Medical Center for management of primary or secondary PPH. Among these patients, TAE procedures in which the embolization of IMA was included, were identified in eight patients. Four of these patients were included in the context of TAE for PPH caused by genital tract injury,⁵ however, as detailed information was not provided, there were, therefore, also included in this report.

A review of the obstetric records was performed by two interventional radiologists in consensus in order to gather data regarding maternal characteristics, clinical manifestations, complications related to TAE, and clinical outcomes. All angiographic and other images were also reviewed in consensus by the same two interventional radiologists.

Hemodynamic instability was defined as a systolic blood pressure <90 mmHg and heart rate >120 beats/min even with adequate medical management or when continuous vasopressor administration was required.⁷ DIC was noted if the score was ≥ 5 after the laboratory data were analyzed according to the criteria of the DIC scoring system of the International Society on Thrombosis and Hemostasis.⁸

TAE procedures and angiographic findings

Digital subtraction angiography and TAE were performed by five, clinically experienced, interventional radiologists. A 5 F vascular sheath was inserted into the right, common femoral artery under palpation or ultrasound guidance. When the bleeding focus was recognized on the CT scan, initial angiography was performed in the relevant arteries. In most cases when CT scanning was not performed, both internal iliac angiograms were performed to identify the uterine artery or other potential bleeders. A 5 F diagnostic catheter (Cobra Glidacath or Radifocus; Terumo, Tokyo, Japan) was introduced over a 0.035-inch guidewire in order to catheterize both internal iliac arteries using a Waltman loop. After that, super-selective angiography of the bleeding artery was performed using a 1.9–2.2 F microcatheter (Renegade; Boston Scientific, Cork, Ireland or Progreat; Terumo, Tokyo, Japan).

In general, the embolization of the bilateral uterine arteries was performed regardless of the presence of active bleeding foci. Active bleeding foci were considered when there was extravasation of contrast media, a pseudoaneurysm or abrupt artery cut-off seen on angiography. Super-selective TAE was performed when there an active bleeding focus was noted on the angiography. Embolic materials were gelatin sponge particle (GSP) slurry made by cutting gelatin sponge sheets (Spongostan; Johnson & Johnson, Gauteng, South Africa) with a scalpel and scissors, microcoils (Hilal or Tornado; Cook), and NBCA (n-butyl cyanoacrylate, Histoacryl; Braun, Sempach, Switzerland). Microcoils and NBCA were used for active bleeding foci at the discretion of the attending interventional radiologist. The NBCA was mixed with ethiodized oil (Lipiodol; Andre Guerbet, Aulnay-Sous-Bois, France) at a ratio of 1:2 to 1:6.

The embolization end point was when no further active bleeding foci were shown with complete stasis of contrast medium on

angiography. After the embolization of target arteries, completion angiography at the proximal portion of the target artery and a vaginal examination were performed to make certain there was adequate control of the bleeding. If persistent vaginal bleeding was noted on speculum inspection, pelvic aortography was performed using a 5 F pigtail catheter (Cook, Bloomington, IN, USA) with the tip of the catheter 5 cm above the aortic bifurcation in order to find and subsequently embolize other bleeders responsible for the persistent bleeding.

Technical and clinical end point

A TAE session with embolization of the IMA was referenced for both technical and clinical success. Technical success was defined as the cessation of bleeding seen on post-TAE angiography and cessation of vaginal bleeding seen on speculum inspection performed immediately after TAE. Clinical success was defined as the cessation of bleeding after TAE and without the need for repeated TAE or additional hemostatic surgery during the patient's hospital stay.

RESULTS

Characteristics of patients and TAE

The clinical characteristics of the eight patients (mean age 34.4 years, age range 31–40 years) undergoing TAE of the IMA for PPH are summarized in Table 1. All patients had primary PPH and vaginal delivery mode. Estimated blood loss was an average of 1.25 L (range 1–1.5 L), and all patients had genital tract injury in the vagina and cervix. The average interval between the delivery and angiography was 3.8 h (range 2.5–7 h). Vital signs were unstable with intubation in two patients (Patients # 1, and 2), while stable in six patients. An average of seven packs of red blood cell transfusion was necessary (range, 2–16 packs). DIC was noted in one patient (# 2). There was no patient with rectal bleeding.

CT scans were obtained in two patients and demonstrated contrast extravasation from the lower uterus abutting the rectum (# 3) or contrast extravasation within the hematoma which displaced the uterus and rectum to the right side (# 5, Figure 1). In both of these patients, the origin of the contrast extravasation was found to abut the adjacent rectum.

On angiography, prominent uterine arteries were noted in all of these patients and contrast extravasation from the cervicovaginal or internal pudendal arteries was seen in four patients (# 1, 2, 5, and 8). In seven patients, an aortogram or inferior mesenteric arteriogram was obtained during the same session because there was continuous vaginal bleeding seen on speculum examination after embolization of the bleeding focus, as seen on bilateral iliac arteriograms. Contrast extravasation from the superior rectal artery from IMA was identified during the first session of TAE in these seven patients (Figure 2). While in one patient (# 5), only bilateral iliac arteriograms were obtained during the first session, where the bilateral uterine arteries were embolized with GSP and the right cervicovaginal artery was embolized using NBCA, this resulted in much reduced vaginal bleeding, as seen on speculum examination. Based on the progression of vaginal bleeding and the active bleeding on seen CT scans, a second session of

Table 1. Characteristics of Patients, Postpartum Hemorrhage, and Embolization Details

No./Age/Parity	Delivery mode	EBL / Genital tract injury	Interval (hours) ^a	Vital stability	Transfusion before TAE	DIC	CT findings	Angiographic findings	Embolitic materials	Remark
1/31/P	Vaginal	1.5 L / Rt. vagina & cervix	2.5	Unstable, intubation	RBC 11U, FFP 5U	No	NA	Prominent UAs, CE from Rt. CVA & SRA	UAs, IIAs, Rt. CVA, & SRA - GSP	
2/40/P	Vaginal	1.5 L / Rt. vagina & cervix	7	Unstable, intubation	RBC 16U, FFP 19U, PC 10U	Yes	NA	Prominent UAs, CE from Rt. CVA & SRA	UAs, Rt. CVA, & SRA - GSP	Hematoma evacuation one day later
3/31/P	Vaginal	1 L / Lt. vagina & cervix	3.5	Stable	RBC 10U, FFP 5U	No	CT: CE from lower uterus, CE origin abutting rectum	Prominent UAs, CE from SRA	UAs, IIAs- GSP SRA - NBCA(1:3)**	
4/34/P	Vaginal	1 L / Lt. vagina & cervix	4	Stable	RBC 4U	No	NA	Prominent UAs, CE from SRA	UAs - GSP SRA - GSP, coil	Laceration suture 10 h later
5/34/M	Vaginal	1.5 L / Rt. vagina & cervix	3	Stable	RBC 3U	No	CT: CE within hematoma, CE origin abutting rectum	1. Prominent UAs, CE from Rt. CVA 2. (4 h later) CE from SRA	1)UAs, Rt. IIA - GSP Rt. CVA - NBCA(1:2) 2)SRA - NBCA(1:3)	Two embolization sessions
6/33/P	Vaginal	1 L / Rt. vagina & cervix	5	Stable	RBC 3U	No	NA	Prominent UAs, CE from SRA	UAs - GSP SRA - NBCA(1:6)	
7/40/M	Vaginal	1.5 L / Lt. vagina & cervix	3	Stable	RBC 2U, FFP 2U	No	NA	Prominent UAs, CE from SRA	UAs - GSP SRA - NBCA(1:2)	
8/32/P	Vaginal	1 L / Rt. vagina & cervix	2.5	Stable	RBC 7U, FFP 8U, PC 8U	No	NA	Prominent UAs, CE from both CVAs, left IPA, SRA	UAs - GSP CVA, IPA, SRA - NBCA(1:3)	

CE, contrast extravasation; CVA, cervicovaginal artery; EBL, estimated blood loss; FFP, fresh frozen plasma; GSP, gelatin sponge particles; IIA, internal iliac artery; IPA, internal pudendal artery; LT, left; M, multipara; NA, not available; OA, obturator artery; PC, platelet concentrates; RBC, red blood cell; Rt, right; SRA, superior rectal artery; TAE, transcatheter arterial embolization; UA, uterine artery; P, primipara.

^aInterval indicates time interval between delivery and angiography, ** Ratio of NBCA to ethiodized oil.

Figure 1. A 34-year-old female (Patient # 5) with post-partum hemorrhage with cervicovaginal laceration 3 h after vaginal delivery. (A, B) The left (A) and right (B) left internal iliac arteriograms show prominent uterine arteries (arrows) and contrast extravasation (arrowheads) from the right cervicovaginal artery. Both uterine arteries were embolized with gelatin sponge particles and the right cervicovaginal artery was embolized with NBCA (not shown). (C, D) Axial (C) and coronal (D) CT scans taken three hours after the first session due to persistent vaginal bleeding, show a large, right, paravaginal hematoma with contrast extravasation (arrows) which abuts the rectum (asterisks). (E, F) In the second session 4 h after the first session, the aortogram (E) and inferior mesenteric arteriogram (F) show contrast extravasation (arrows) at the superior rectal artery, which was embolized with NBCA (not shown). NBCA, n-butyl cyanoacrylate.

angiography was performed 4 h later and which revealed active bleeding from the superior rectal artery, after which embolization with NBCA was successfully performed (Figure 1).

Figure 2. A 40-year-old female (Patient # 7) with post-partum hemorrhage with cervicovaginal laceration 3 h after vaginal delivery. (A) Both internal iliac arteriograms (two images combined) show prominent uterine arteries (arrows). Both uterine arteries were embolized with gelatin sponge particles (not shown), however, there was persistent vaginal bleeding seen on speculum inspection. (B) A subsequent, inferior mesenteric arteriogram shows contrast extravasation (arrow) at the superior rectal artery. (C, D) Completion inferior mesenteric arteriograms following superselective NBCA embolization show an NBCA cast (arrowheads in C) without further bleeding. NBCA, n-butyl cyanoacrylate.

As embolic materials, prominent uterine arteries and internal iliac arteries were embolized with GSP. For active bleeding from cervicovaginal or internal pudendal arteries, GSP was used in two patients and NBCA was used in two patients. For active bleeding from the superior rectal artery, GSP was used in two patients, GSP/microcoil in one patient, and NBCA in five patients.

Outcome of TAE

Embolization was technically successful in all eight patients (100%). Clinical success for IMA embolization was achieved in all of the patients. There was no patient with rebleeding following IMA embolization. Procedure-related complications were not observed in any of these patients. There was no bowel ischemia during follow-up.

Hematoma evacuation was performed with a vaginal incision one day following TAE in one patient (# 2) and suturing of the lacerated vagina was performed on the same day as TAE in another patient (# 4). Regular menstruation resumed in all patients with follow-up.

DISCUSSION

PPH from IMA seems quite uncommon as there have been less than 10 cases reported.^{3–6} All of the reported cases as well as the current patients presented with primary PPH (within the first 24 h after delivery) and had vaginal delivery with a substantial degree of genital tract injury reflecting injury of the superior rectal artery manifesting immediately after vaginal delivery as a consequence of concurrent genital tract injury. Vital signs were unstable in two of the eight patients in this study, and DIC was associated in one of them, suggesting that bleeding from the superior rectal artery or associated bleeders can be quite massive.

The most probable mechanism for superior rectal artery bleeding is injury to the rectal artery associated with birth canal expansion and laceration as well as extravasated blood through the torn lower uterine body, cervix or vagina.^{3,5} The CT findings that the origin of the extravasated blood abutted the adjacent rectum in two patients in this study also suggest that the adjacent rectal wall was distended and injured. However, the absence of rectal bleeding in our study patients implies that the injury was not so severe to cause real rectal wall tear. Direct communication between the distal IMA and the uterus as an anatomic variant is another possible mechanism, however, this unusual collateralization has been reported in patients with prior uterine artery ligation or embolization.^{9–11}

Clinical situations to identify IMA as a bleeding focus are quite noteworthy. Considering that the objective of TAE is to stop gross vaginal bleeding, the importance of a speculum examination for determining the clinical success should be emphasized, especially in cases of embolization of bleeders other than uterine arteries. In our study patients, in seven of eight patients, an aortogram or IMA arteriogram was selected based on the

speculum findings which showed persistent vaginal bleeding after sufficient embolization of uterine arteries or other iliac artery branches. In one patient in whom a second TAE session was performed, the absence of a bleeding focus seen on bilateral iliac arteriograms encouraged the operator to perform an aortogram. Therefore, persistent vaginal bleeding after sufficient embolization of the iliac artery bleeding focus may be a clue for considering IMA as the bleeding focus.

As embolic materials, various materials including GSP, a micro-coil, or NBCA, were used in IMA embolization in this study. Although permanent embolic materials, such as NBCA, seem advantageous for achieving devascularization more effectively than using temporary embolic materials such as GSP, as the patient in a previous literature report,³ as well as our study patients in whom temporary embolic materials were used, all showed successful hemostasis without rebleeding. There have been no embolization-related complications, such as bowel ischemia, and therefore suggesting that selective TAE of the superior rectal artery from the IMA is usually safe.^{3,4,6} The volume ratio of NBCA to iodized oil is not fixed and as it varied from 1:2 to 1:6 in this study, and is preferable to be determined depending on the desired penetration distance.

The current study has several limitations. First, this study was of a retrospective design based on clinical and radiological records. Therefore, the true incidence of IMA bleeding might have been underestimated as a result of the selection bias. Second, as there are no clinical guidelines for performing an IMA arteriogram, this decision was made by consensus agreement among the referring obstetricians and interventional radiologists on a case-by-case basis. Third, the choice of embolic materials depended on the preferences of the interventional radiologists.

In conclusion, TAE of the IMA for PPH was safe and effective with successful hemostasis. Bleeding from the IMA should be suspected when there is persistent vaginal bleeding after sufficient embolization of bleeders from bilateral iliac artery branches.

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