Uterine Artery Embolization in Postabortion Hemorrhage

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OBJECTIVE: To summarize the efficacy of postabortion uterine artery embolization in cases of refractory hemorrhage.

METHODS: Forty-two women were identified who had postabortion uterine artery embolization at San Francisco General Hospital between January 2000 and August 2007. Seven underwent embolization for hemorrhage caused by abnormal placentation.

RESULTS: Embolization was successful in 90% (38 of 42) of cases. All failures (n=4) were in patients who had confirmed abnormal placentation. However, three of seven women (43%) with probable accreta diagnosed by ultrasonography were treated successfully with uterine artery embolization. Two patients experienced complications of uterine artery embolization. These complications—one contrast reaction and one femoral artery embolus—were treated without further sequelae.

CONCLUSION: Uterine artery embolization is an alternative to hysterectomy in patients with postabortion hemorrhage refractory to conservative measures, especially when hemorrhage is caused by uterine atony or cervical laceration.

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LEVEL OF EVIDENCE: III

Induced abortion, the most common surgical procedure among reproductive-aged women, has low morbidity and mortality.[1] The most common serious

complication of abortion—hemorrhage, as defined by an estimated blood loss of greater than 500 mL or bleeding requiring a transfusion—occurs in approximately 0.82 per 100,000 abortions, with risk increasing with gestation.[2] Usually hemorrhage is initially managed with conservative measures such as uterotonics, laceration repair, bimanual uterine massage, and tamponade with an intrauterine pack or Foley bulb. When these methods fail, hemorrhage leads to hysterectomy in approximately 1.1–1.4 per 10,000 abortions.[3,4]

Uterine artery embolization has been in use for decades to treat postpartum hemorrhage and pelvic trauma with the goal of avoiding hysterectomy and preserving fertility.[5–8] Uterine artery embolization has less commonly been used for postabortion hemorrhage. Three published case series[9–11] and three case reports[12–14] describe a total of 21 patients who underwent embolization after abortion. Uterine artery embolization was a successful therapy in the vast majority (91%) of the published cases.[9–14] However, in each of these six studies, the number was low, and none included more than four women from the same institution. The most common causes of postabortion hemorrhage in these papers were uterine atony and perforation. Only three of these cases are patients with postabortion hemorrhage caused by probable placenta accreta, and all three were successfully treated with embolization.[10]

The limited availability of uterine artery embolization would make it unlikely that a low-risk patient having an abortion in an outpatient center would have the option of embolization. However, women who are at higher risk of hemorrhage, such as those with prior cesarean deliveries or abnormal placentation, may be referred for an in-hospital abortion and, therefore, have access to embolization. In this study we review a series of patients who underwent uterine artery embolization for treatment of refractory hemorrhage after an abortion.

MATERIALS AND METHODS

The Women's Options Center is a hospital-based outpatient clinic at San Francisco General Hospital providing 2,200 abortions per year. Forty-three percent are in the first trimester, 22% are between $14^{0/7}$ and $19^{6/7}$ weeks, and 35% are between $20^{0/7}$ and $23^{1/7}$ weeks. The clinic receives referrals of patients in the second trimester because, other than the University of California, San Francisco, and San Francisco General Hospital, no outpatient abortion clinic in Northern California accepts state insurance for abortions after 18 weeks, and many other clinics do not care for high-risk patients in the second trimester. Our clinic, therefore, has a disproportionate representation of women with prior cesarean deliveries, suspected placenta accreta, and diseases such as obesity, hypertension, and diabetes.

At the Women's Options Center, if a patient has one or more previous cesarean deliveries, the location of the placenta is determined by clinic or formal ultrasonography before placing cervical laminaria. If she is viewed as high risk for abnormal placentation, the Department of Radiology is contacted before surgery to ensure availability of an Interventional Radiology suite in the case of a refractory hemorrhage. All terminations after 14 weeks of gestational duration are done under ultrasound guidance. At the time of a hemorrhage, the usual diagnostic and treatment algorithm begins with inspection of the cervix for lacerations and examination of the uterus for evidence of atony. If the uterus is atonic, uterotonics are administered, usually beginning with methylergonovine. If the hemorrhage does not appear to be caused by atony or cervical laceration, we attempt to identify the source of bleeding by inserting a cannula to the fundus and slowly withdrawing it to the os, observing at what location within the uterus bleeding increases.[15] In the event that uterotonics do not control the bleeding and no other source is found, an intrauterine Foley bulb is inflated with 40–60 mL of fluid to tamponade the lower uterine segment. The balloon is left in place as the patient's bleeding is monitored. If the balloon stops the patient's bleeding, she is then observed for at least several hours, depending on clinical concern, and after removal of the balloon she is discharged, if stable. If bleeding continues despite all measures, the attending physician determines if the patient is transferred to Interventional Radiology for embolization.

We reviewed all cases of uterine artery embolization from January 2000 to August 2007 after abortion. These cases were identified by searching the Women's Option Center complication log and patient database using the terms "post-abortion hemorrhage" and "uterine artery embolization." The cases were then cross-referenced with the San Francisco General Hospital Department of Radiology case log for "uterine artery embolization" and "post-abortion hemorrhage." Using these methods we identified 42 women who underwent uterine artery embolization for postabortion hemorrhage.

Data were abstracted by a trained clinician from the original hospital charts, operation notes, anesthesia notes, discharge summaries, nursing notes, and laboratory records. Microsoft Excel (Microsoft Corporation, Redmond, WA) and SPSS 15 (SPSS Institute Inc., Chicago, IL) were used to organize and describe the cases. Abstracted information included demographic, medical, and procedural data, as well as risk factors for abnormal placentation. Gestational age was determined by ultrasonographic evaluation of biparietal diameter for all patients.[16] The study was approved by the Institutional Review Board of the University of California, San Francisco.

Detailed information about complications and treatments was abstracted. The cause of postabortion bleeding for each patient was identified as one of the following: uterine atony, cervical laceration, abnormal placentation (ie, placenta accreta, increta, or percreta), disseminated intravascular coagulation (DIC), uterine perforation, or "unknown" if records were not available. If a patient had a cervical laceration that was easily repaired and became hemostatic, the laceration was not listed as the primary cause. When patients were diagnosed with bleeding from the lower uterine segment without diagnosis of atony or cervical laceration, we considered the diagnosis to be lower uterine segment bleeding. "Formal" ultrasound scans were performed by registered ultrasonographers using both grayscale and color Doppler ultrasonography, and perinatal or radiological faculty interpreted all studies. "Clinic" ultrasonograms were done by nurse practitioners, registered nursing personal with ultrasound training, or obstetrics and gynecology residents using grayscale ultrasonography and interpreted by obstetrics and gynecology faculty.

RESULTS

Forty-two women received uterine artery embolization for treatment of postabortion hemorrhage from January 2000 to August 2007, including one woman who had prophylactic embolization (Tables 1 and 2). Of these women, 22 (52%) had hemorrhage from atony, seven (17%) from abnormal placentation, five (12%) from cervical laceration, three (7%) from perfo-

Table 1. Descriptive Characteristics of Patients Without Evidence of Abnormal Placentation Who Underwent Postabortion Uterine Artery Embolization*

Case No.	Age	Parity[†]	Gestation (wk)[‡]	Cause or Contributors to Hemorrhage[§]	Total Blood Loss (mL)	Transfusion	Abortion to Embolization (h)[‖]	Duration of UAE (h)	Further Treatment and Complications
1[¶]	33	4 (4)	$22^{1/7}$	Atony	1,000	None	1.3	1.2	
2	24	3 (3)	$18^{6/7}$	Atony	1,800	4 units RBC	5.2	1.2	
3	29	8	$19^{5/7}$	Atony	800	None	2.0	1.2	
4	27	2	$22^{5/7}$	Atony	1,200	2 units RBC	6.1	0.6	
5	30	3 (3)	$23^{1/7}$	Atony	1,000	2 units RBC	3.6	0.8	
6	19	0	$22^{3/7}$	Atony	1,600	4 units RBC, 5 units FFP, 2 units cryoprecipitate	9.9	Not available	
7	25	3 (3)	$17^{5/7}$	Atony	1,000	2 units RBC	9.0	0.9	
8	25	0	$23^{0/7}$	Atony	800	None	3.3	1.6	
9	28	0	$23^{0/7}$	Atony	1,250	1 unit RBC	1.5	2.5	
10	24	1 (1)	$19^{6/7}$	Atony	1,000	4 units RBC, 3 units FFP	6.0	1.7	
11	18	0	$21^{6/7}$	Atony	1,000	4 units RBC, 2 units FFP	4.1	2.2	
12	33	3	$21^{6/7}$	Atony	500	None	4.0	0.8	
13	31	0	$23^{0/7}$	Atony	2,500	5 units RBC, 3 units FFP	2.9	5.3	
14	24	2	$22^{6/7}$	Atony	600	None	5.8	2.0	
15	41	5 (1)	$23^{1/7}$	Atony	1,000	2 units RBC, 2 units FFP	6.1	2.1	
16	26	1	$23^{6/7\#}$	Atony	1,200	4 units RBC, 4 units FFP	3.2	1.8	
17	26	2	$20^{1/7}$	Atony	500	4 units RBC, 4 units FFP, 20 units cryoprecipitate	3.4	Not available	
18	25	2	$19^{6/7}$	Atony	700	None	Not available	0.75	
19	37	2 (2)	$22^{1/7}$	Atony; cervical laceration	2,000	2 units RBC, 6 units FFP	3.3	2.3	
20	16	0	$21^{4/7}$	Atony; cervical laceration	2,400	4 units RBC, 3 units FFP, 1 six-pack platelets	4.1	3.5	
21	21	2	$20^{0/7}$	Atony; cervical laceration	900	None	4.0	2.3	Endometritis
22[¶]	26	4	$23^{1/7}$	Atony; cervical laceration	4,000	8 units RBC, 4 units FFP, 2 units cryoprecipitate	3.8	3.3	
23	23	1	$22^{2/7}$	Cervical laceration	1,000	1 unit RBC	2.6	1.7	
24	34	0	$22^{0/7}$	Cervical laceration	3,000	6 units RBC, 2 units FFP	3.0	2.8	
25	40	2	$22^{4/7}$	Cervical laceration	1,500	4 units RBC	0.2	4.5	
26	28	2	$22^{2/7}$	Cervical laceration	2,000	4 units RBC	2.0	2.8	
27	22	2 (2)	$19^{5/7}$	Cervical laceration	2,500	6 units RBC, 2 units FFP	0.8	4.5	
28[¶]	22	1	$22^{6/7}$	Perforation; atony	4,000	14 units RBC, 12 units FFP, 1 six-pack platelets, 1 unit cryoprecipitate	1.5	Not available	Embolization→continued bleeding→diagnosis of pelvic hematoma→laparotomy and salpingo-oophorectomy→ pulmonary edema and pneumonia

(continued)

Table 1. Descriptive Characteristics of Patients Without Evidence of Abnormal Placentation Who Underwent Postabortion Uterine Artery Embolization* (continued)

Case No.	Age	Parity[†]	Gestation (wk)[‡]	Cause or Contributors to Hemorrhage[§]	Total Blood Loss (mL)	Transfusion	Abortion to Embolization (h)[‖]	Duration of UAE (h)	Further Treatment and Complications
29[¶]	20	1	12[5/7]	Perforation	900	10 units RBC	48.0	Not available	Laparotomy: stable broad ligament hematoma→ embolization→pulmonary embolism
30	30	3 (3)	10[3/7]	Probable perforation	1,100	None	4.7	1.9	Endometritis
31	27	4	19[0/7]	DIC-abruption	2,800	4 units RBC, 8 units FFP, 1 six-pack platelets, 4 units cryoprecipitate	0.1	1.8	
32	28	1	14[6/7]	DIC-demise	800	2 units FFP	6.9	1.2	Reaction to contrast
33	26	2 (2)	20[1/7]	Lower uterine segment bleeding**	650	None	25.6	0.5	
34	30	1	22[3/7]	Lower uterine segment bleeding**	500	None	3.1	0.6	
35	16	0	20[0/7]	Unknown; DIC[††]	2,000	3 units RBC, 6 units FFP	Not available	1.2	Acute respiratory distress syndrome

UAE, uterine artery embolization; RBC, packed red blood cells; FFP, fresh frozen plasma; DIC, disseminated intravascular coagulation.
* All patients with the exception of four (1, 22, 28, 29) underwent bilateral uterine artery embolization with Gelfoam (see footnote below).
[†] Data in parentheses indicate number of cesarean deliveries.
[‡] Gestational age as determined by the Hadlock criteria for biparietal diameter on preoperative ultrasonography.
[§] First item listed indicates primary contributor to hemorrhage; second item indicates secondary contributor.
[‖] Time reported from completion of abortion to arrival of patient in the Interventional Radiology suite.
[¶] Patient 1 underwent embolization of bilateral internal iliac arteries; patient 22 received coil embolization in left uterine artery and Gelfoam in the right uterine artery; patient 28 underwent embolization of bilateral internal iliac arteries embolized with Gelfoam and coils placed in the right uterine artery; and patient 29 underwent embolization of the left uterine artery only.
[#] Dilation and evacuation for fetal anomalies.
** Lower uterine segment bleeding indicates bleeding localized to the lower uterine segment with no other source identified.
[††] Patient 35 was transferred from an outside clinic after her dilation and evacuation.

Table 2. Descriptive Characteristics of Patients With Evidence of Abnormal Placentation Who Underwent Postabortion Uterine Artery Embolization*

Case No.	Age	Parity[†]	Gestation (w)[‡]	Cause of Hemorrhage[§]	Confirmation of Diagnosis	Total Blood Loss (mL)	Transfusion[‖]	Abortion to Embolization (h)	Duration of UAE (h)	Treatment	Complications
36	34	3 (2)	18⁶ᐟ⁷	Accreta	Formal ultrasound	400	None	2.0	3.2	None	
37	24	3 (2)	22⁵ᐟ⁷	Accreta	Formal ultrasound	1,500	5 units RBC	3.6	1.9	None	
38	35	1 (1)	21⁰ᐟ⁷	Increta	MRI	3,000	8 units RBC, 4 units FFP	0.7	0.8	Methotrexate	
39	27	3 (3)	18⁴ᐟ⁷	Accreta	Natural history	900	5 units RBC	0.3	1.5	Hysterectomy	Femoral embolus
40	29	2 (2)	22³ᐟ⁷	Increta	Pathology	3,000	9 units RBC, 5 units FFP, 1 six-pack platelets, 2 units cryoprecipitate	0.5	1.8	Hysterectomy	
41	34	2 (2)	21⁰ᐟ⁷	Percreta	Pathology	3,200	5 units RBC	0.5	2.9	Hysterectomy	
42	20	2 (2)	22¹ᐟ⁷	Increta	Pathology	3,000	5 units RBC, 2 units FFP	Prophylactic UAE	1.1	Hysterectomy	

UAE, uterine artery embolization; RBC, packed red blood cells; MRI, magnetic resonance imaging; FFP, fresh frozen plasma.
* All patients received bilateral uterine artery embolization; all cases in this table are described in the manuscript.
[†] Parenthesis indicate number of cesarean deliveries.
[‡] Gestational age as determined by the Hadlock criteria for biparietal diameter on preoperative ultrasonography.
[§] Accreta, percreta, and increta refer to pathology of the placenta.
[‖] Time reported from completion of abortion to arrival of patient in the Interventional Radiology suite.

ration, two (5%) from lower uterine segment bleeding, and two (5%) from DIC. The mean estimated blood loss was 1,580 mL, and the median estimated blood loss was 1,150 mL and ranged from 400 mL to 4,000 mL. One patient underwent embolization after only 400 mL of blood loss because of high suspicion for abnormal placentation. Uterine artery embolization was successful in avoiding hysterectomy in 38 of 42 patients (90%). One patient received a prophylactic uterine artery embolization before her abortion and subsequently required a hysterectomy. All four embolization failures were in women who had histopathological confirmation of accreta, increta, or percreta. However, three of seven women (43%) with probable accreta diagnosed by formal ultrasonography were treated successfully with embolization. The median time from completion of abortion to transfer to the Interventional Radiology suite was 3 hours, 18 minutes (mean 5 hours, 6 minutes, 95% confidence interval 2 hours, 36 minutes to 7 hours, 36 minutes). Seven women (17%) were transferred emergently to the Interventional Radiology suite in less than 1 hour. In one patient with known DIC who had presented to Labor and Delivery with bleeding, the patient was transferred immediately after her abortion to Interventional Radiology in 6 minutes. The remaining 35 women (83%) were transferred after a period of stable observation, the longest of which was 25 hours (excluding patient 29 who is described below). All but two women had bilateral embolization with Gelfoam (Pfizer Inc., New York, NY). One woman had coil embolization in the left uterine artery and Gelfoam in the right uterine artery, and one woman received only a left uterine artery embolization due to localized extravasation from the left uterine artery, which became immediately hemostatic upon embolization. In 40 of 42 cases, Gelfoam was used alone as the embolic material. Two cases used a combination of Gelfoam and embolization coils to ensure hemostasis. Procedure length ranged from 35 to 315 minutes. The mean duration of the procedure was 2 hours (95% confidence interval 1 hour, 40 minutes to 2 hours, 20 minutes).

During chart review 10 cases warranted special attention, including six cases of accreta with postoperative uterine artery embolization, the one preoperative prophylactic embolization, two cases of uterine perforation and broad ligament hematomas, and one case of probable perforation.

Abnormal Placentation Successfully Treated With Embolization

Patient 36 is a 34-year-old woman with two prior cesarean deliveries who presented for termination of an 18-week pregnancy. Formal ultrasonography showed evidence of placenta accreta. Because of an immediate brisk postoperative hemorrhage, the patient underwent uncomplicated uterine artery embolization (total estimated blood loss 400 mL) and had a normal postoperative course. Patient 37 is a 24-year-old woman with two prior cesarean deliveries. She presented for termination of a 22-week pregnancy, and formal ultrasonography suggested placenta accreta. She had moderate bleeding during uterine evacuation, which was controlled initially with placement of a Foley bulb. The patient was observed for 3 hours, at which time bleeding increased and she was transferred to the Interventional Radiology suite for embolization followed by an uncomplicated postoperative course (total estimated blood loss 1,500 mL). Patient 38 is a 35-year-old woman with one prior cesarean delivery who presented for termination of a pregnancy at 21 weeks. Formal ultrasonography confirmed placenta previa and showed no evidence of accreta. She had heavy bleeding during her procedure and was transferred to Interventional Radiology for embolization (total estimated blood loss 3,000 mL). Because of the high probability of placenta accreta, a methotrexate/leucovorin rescue protocol was initiated after the uterine artery embolization. This protocol entails alternating doses of methotrexate (1 mg/kg, intramuscularly on days 1, 3, 5, etc.) with doses of leucovorin (0.1 mg/kg intramuscularly on days 2, 4, 6, etc.) until four doses of methotrexate have been administered. Our patient received two doses of methotrexate (75 mg each dose) on postoperative days 1 and 3. On day 4, she was found to have elevated liver enzymes and a drop in β-hCG from 10,093 to 4,085, and methotrexate was discontinued. After discharge she was stable, and her β-hCG levels returned to normal.

Abnormal Placentation Unsuccessfully Treated With Embolization

Patient 39 is a 27-year-old woman with three prior cesarean deliveries who presented for termination of an 18-week twin gestation. Clinic ultrasonography detected a placenta previa with concern for accreta. During uterine evacuation a partial-thickness defect in the anterior lower uterine segment was noted on intraoperative ultrasonogram. Conservative measures including methylergonovine did not control her hemorrhage (total estimated blood loss 1,000 mL), and she received one dose of phenylephrine to control a brief episode of hypotension before she was transferred to the Interventional Radiology suite. After her embolization she developed a femoral artery embolus requiring embolectomy by vascular surgery. She spent 2

days in intensive care and was discharged on her sixth postoperative day and with full lower extremity function. She ultimately had a hysterectomy at another hospital for persistent bleeding. Patient 40 is a 29-year-old woman with two prior cesarean deliveries who presented for termination of a 22-week pregnancy for multiple anatomic abnormalities. Formal ultrasonography suggested placenta previa and possible accreta. The uterine evacuation was complicated by hemorrhage initially treated with uterine artery embolization. Heavy vaginal bleeding continued on her first postoperative day, and on hospital day 2 the patient underwent total abdominal hysterectomy, which confirmed placenta increta (total estimated blood loss 3,000 mL).

Patient 41 is a 34-year-old woman with two prior cesarean deliveries who presented for termination of a 21-week pregnancy. Clinic ultrasonography demonstrated a high anterior placenta. Because of refractory hemorrhage (total estimated blood loss 3,200 mL) she underwent uncomplicated uterine artery embolization. Subsequently, she had decreasing hematocrit measurements over the next 3 days, and magnetic resonance imaging (MRI) revealed evidence of placenta percreta. The patient did not desire future fertility and underwent a supracervical hysterectomy that confirmed placenta percreta by pathology. Patient 42 is a 20-year-old woman with two prior cesarean deliveries who desired termination of a 22-week pregnancy. A clinic ultrasonography showed placenta previa and likely increta, which was confirmed by subsequent formal ultrasonography. At the time, clinic protocol for suspected accreta was to perform prophylactic bilateral uterine artery embolization, which was uncomplicated. The evacuation proceeded without complication until removal of placenta, when she began to hemorrhage (total estimated blood loss 3,000 mL), and intraoperative ultrasonography showed almost no myometrium between the placenta and the bladder. A total abdominal hysterectomy with left salpingo-oophorectomy was ultimately necessary for hemostasis, and increta was confirmed on pathology.

Uterine Perforation

Patient 28 is a 22-year-old woman who presented for termination of a 22-week pregnancy. Clinic ultrasonography was unremarkable. Blood loss after evacuation was average, but while in recovery she bled briskly and did not respond to conservative treatment (total estimated blood loss 4,000 mL). The patient was intubated and transferred to Interventional Radiology where DIC was treated with 4 units of packed red

blood cells and 2 units of fresh frozen plasma. Embolization was uncomplicated and initially thought to be successful, but postoperatively her hematocrit continued to decrease. Computed tomography scan revealed a right pelvic hematoma and right hydronephrosis. Exploratory laparotomy lead to a right salpingo-oophorectomy, evacuation of the hematoma, repair of the right uterine laceration, and placement of a stent in the right ureter. Her hospital course was further complicated by prolonged intubation for pulmonary edema and subsequent pneumonia. After an 11-day hospitalization with 7 days in intensive care, she was discharged in stable condition and did not require a hysterectomy.

Patient 29 is a 20-year-old woman who requested a termination at 12 weeks of gestation. Formal ultrasonography revealed either a bicornuate or septate uterus. Her evacuation was complicated by bleeding (100 mL) that stabilized with uterotonics and massage. She was discharged and returned 2 hours later with pain and increased vaginal bleeding. Her uterus was reaspirated and she became hypotensive, so she was admitted for observation. Computed tomography scan on the first postoperative day suggested a left broad ligament hematoma. An exploratory laparotomy on the second postoperative day revealed 600 mL of hemoperitoneum and a large but stable left broad ligament hematoma. Surgeons elected left uterine artery embolization rather than evacuate the hematoma, which was successful in controlling bleeding (total estimated blood loss 900 mL, including hemoperitoneum). After the exploratory laparotomy, the patient was having low oxygen saturation, and by spiral computed tomography was diagnosed with a right lower lobe pulmonary embolism and started on a heparin protocol. She was discharged on postoperative day 13.

Patient 30 is a 30-year-old woman with three prior cesarean deliveries who requested a termination at 10 weeks of gestation. Her procedure was complicated by increased pain, nausea, and vomiting in the recovery room. She was reaspirated with ultrasonographic guidance, and 500 mL of bright red blood was evacuated. A partial-thickness false passage was identified in the anterior uterus. After the aspiration, a Foley bulb was placed in the uterine cavity and inflated because of continued bleeding. The collection bag filled with 300 mL of blood in 30 minutes, prompting uterine artery embolization which controlled her bleeding. On postoperative ultrasonography, there was no evidence of hemoperitoneum, but a fluid collection, suggestive of a hematoma, was noted in the anterior myometrium consistent with a partial

perforation. The patient was observed overnight and discharged on postoperative day 2. She returned on postoperative day 6 with endometritis and was treated successfully with antibiotics.

Complications of Uterine Artery Embolization

There were two complications of uterine artery embolization in our series of 42 women. The first case involved patient 32, a 28-year-old woman who required uterine evacuation for intrauterine fetal demise at 20 weeks. She developed refractory hemorrhage (total estimated blood loss 800 mL) requiring embolization. Her procedure was complicated by an anaphylactic reaction to the contrast, which was treated with subcutaneous epinephrine and intravenous diphenhydramine. The embolization was otherwise successful and postoperative care was unremarkable. The second case involves patient 39, whose course was described previously. The patient's embolization was complicated by embolus of the right femoral artery, requiring embolectomy. She had received methylergonovine and phenylephrine for management of atony and hypotension after her abortion.

DISCUSSION

Our series suggests that uterine artery embolization can safely control postabortion hemorrhage and avoid hysterectomy. In our 42 cases, the median time from completion of abortion to transfer to the Interventional Radiology suite was 3 hours, 18 minutes. This suggests that there is time to assemble the Interventional Radiology team, prepare the operating room, and transfer the patient if necessary, either urgently or after a period of observation.

As uterine fibroid embolization has become more common, the availability of interventional radiologists skilled in deep pelvic arterial embolization procedures has increased. The primary difference between embolization for uterine fibroids and for postabortion or postpartum hemorrhage is the agent used. In embolization for uterine fibroids, the most commonly used agents are polyvinyl alcohol particles and trisacryl microspheres, which are considered to be permanent. In women who desire future fertility and who undergo embolization for postpartum or postabortion hemorrhage, the most commonly used agent is Gelfoam, which is absorbed over 30–45 days and is considered temporary.[17] There is, however, a subset of postabortion and postpartum hemorrhage patients in whom the bleeding may not respond to Gelfoam alone, and more extensive and permanent embolization with metallic microcoils may be required. Thus, most interventional radiologists trained in uterine fibroid embolization would be able to provide embolization in urgent settings such as pelvic trauma and postpartum and postabortion hemorrhage.

The increasing rate of primary and repeat cesarean deliveries in the United States has increased the incidence of abnormal placentation.[18] Uterine artery embolization can be considered a possible treatment for hemorrhage when accreta is suspected. In the setting of postpartum hemorrhage, abnormal placentation accounts for more than 50% of embolization failures.[19] The success of the procedure in our patients with accreta (n=7) was 43%. Of the three successful cases, one woman received further treatment with methotrexate, and two were in women with accreta suspected on ultrasonography without MRI or pathologic confirmation, thus, making it possible that this estimate of success is overly optimistic.

Ultrasonography is considered the primary tool in screening women at risk of placenta accreta. However, results vary widely in its ability to correctly identify abnormal placentation or its absence,[20] with a sensitivity ranging from as low as 33% to as high as 86%.[18,21,22] It has also been suggested that MRI be used in cases where ultrasonography is inconclusive[18,22] or as an aide in surgical planning,[23] but methodological concerns about studies, and expense and availability of MRI limits its widespread use. Our clinic protocol at the beginning of this case series was to do prophylactic embolization when there was high suspicion of accreta, as has been described in a previous case series.[24] We changed this protocol after considering the poor predictive ability of ultrasonography for accreta, particularly the high false-positive rates of 54.5%,[18,20,25] as well as our experience with the patient who required hysterectomy after preoperative embolization. Further, embolization in the emergent setting may be more successful than prophylactic procedures because active bleeding can be seen under fluoroscopy, allowing embolization in the region of the hemorrhage.[26,27]

When counseling patients with suspected accreta about the efficacy of uterine artery embolization, they should be informed about the risk of requiring subsequent medical or surgical treatment. Women desiring fertility are likely to choose embolization first. Although the effect of embolization on fertility is undetermined, there have been a few studies of women who have had pregnancies after embolization to treat uterine fibroids,[28] and two of the patients in our embolization series presented subsequently for abortions, which were uncomplicated. Women with probable accreta who do not desire future fertility may opt for hysterectomy instead of embolization in the set-

ting of refractory hemorrhage, and they may choose to try embolization with a 43% chance of avoiding surgery. If embolization fails to treat the hemorrhage completely, it may decrease intraoperative blood loss during the subsequent hysterectomy.

In conclusion, using uterine artery embolization to treat refractory postabortion hemorrhage avoids hysterectomy, especially when hemorrhage is caused by uterine atony or cervical laceration. By avoiding hysterectomy in most cases, embolization of the uterine arteries not only maintains potential fertility but also decreases further operative morbidity after abortion complicated by hemorrhage.

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