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Uterine artery embolization in the management of postpartum hemorrhage

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Abstract

Background Postpartum hemorrhage (PPH) is one of the leading preventable causes of maternal morbidity and mortality causing one-fourth of all maternal deaths. We aimed to study the role of uterine artery embolization (UAE) in controlling PPH and its impact on the need for hysterectomy.

Methods We studied patients who were diagnosed with primary PPH between February 2012 and March 2020 at Al Ain Hospital, United Arab Emirates. We studied the characteristics and outcomes of those undergoing interventional radiology via UAE. Logistic regression analysis was done to define the factors that predict the need for emergency UAE.

Results Out of 79 patients who had elective ($n=53$) or emergency ($n=26$) embolization, the placenta previa accreta (69.8% vs. 23.1%) and placenta previa (24.4% vs. 3.8%) were the common indications for elective versus emergency UAE ($p<0.001$). The indication for UAE was the most significant factor for predicting an emergency procedure ($p=0.002$) with placenta previa being significantly different from other indications ($p<0.001$). Bleeding stopped in 78/79 patients (success rate of 98.7%) following UAE. Those who failed stopping of the bleeding were similar between the elective and emergency IR, (1/53 (1.9%) compared with 0/26 (0%), $p=0.99$ Fisher's Exact test). Overall, eight patients (10%) had hysterectomy, one of them was needed as the final solution to stop bleeding. There were no maternal deaths.

Conclusions Interventional radiological UAE is very efficient in controlling postpartum hemorrhage. It should be recommended as the first line of treatment for significant bleeding when expertise and facilities are available. It increases survival, reduces hysterectomy rate, without a difference if done as an emergency or elective procedure.

Keywords Postpartum hemorrhage, Uterine artery embolization, Maternal mortality

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Introduction

Postpartum hemorrhage (PPH) is one of the global preventable leading causes of maternal morbidity and mortality [1, 2]. According to the World Health Organization (WHO), nearly one-fourth of all maternal deaths are attributed to PPH [3]. Blood loss greater than 500 ml and 1000 ml is considered pathologic for vaginal and cesarean deliveries respectively. If it occurs within 24 h of parturition, it is called primary PPH [2]. The common causes of PPH include intra-pelvic arterial injury, lacerations of the birth canal, coagulopathy, perineal lacerations, and uterine atony [4, 5]. The conventional management for PPH is hysterectomy, however, it leads to infertility [6, 7]. It should be done only if other treatment options fail to stop the bleeding. One option is uterine artery embolization (UAE), which is reported to have a success rate up to 98% in stopping the bleeding [8–10]. Both treatment options block the uterine blood flow and are efficient in stopping bleeding and have comparable effects on uterine blood flow and uterus function. Uterine artery ligation (UAL) is a surgical procedure that has its own risks. Nevertheless, UAE needs shorter time than UAL. One retrospective study of a small sample size ($n = 16$) showed that pelvic artery embolization was successful in stopping PPH in all patients [11]. Another study in women who underwent C-sections showed that prophylactic UAE in women having placenta previa significantly reduced blood loss when compared with controls [12]. We aimed to study the role of uterine artery embolization (UAE) in controlling PPH and its impact on the need for hysterectomy.

Methods

Ethical considerations

Human research ethics approval was obtained (with approval# MF2058-2021-803 dated 23rd January 2023) for this study. The study is reported in compliance with the STROBE checklist [13].

Study design

This is a retrospective descriptive cohort study.

Inclusion exclusion criteria

All pregnant women presenting with primary PPH and who were managed with uterine artery embolization (UAE) during the period of February 2012 till March 2020 at Al Ain Hospital, Al-Ain City, United Arab Emirates were included in the study. These patients had 1) persistent bleeding despite using other less invasive methods like uterotonic medications and mechanical interventions (intrauterine balloon tamponade. 2) The hemodynamic status was stabilized after initial resuscitation to allow time for UAE with an aim to preserve the uterus.

UAE was not used in patients with (1) severe hemorrhagic shock judged clinically to require immediate surgical intervention with concern to delay of management if UAE was instead performed, (2) severe allergy to contrast media, (3) pre-existing kidney failure, (4) coagulopathy unresponsive to correction, (5) extra-uterine bleeding including vaginal bleeding and cervical tears, 5) severe pelvic infection, and (6) uterine rupture. There were 80 patients studied in this cohort, one of them had missing important outcome data and was not included in the comparative statistical analysis between emergency and elective UAE.

Embolization technique

We used the Seldinger technique to access the common femoral artery either with fluoroscopy or ultrasound guidance followed by retrograde approach to reach the uterine artery of the opposite side [12] (Fig. 1). Unilateral access was used in emergency cases while bilateral access was used in elective cases. When the location of a laceration was unknown, a nonselective aortogram was used to screen the injury. A Roberts Uterine Catheter (RUC) (Cook Inc.) located in the abdominal aorta can select the contralateral or ipsilateral hypogastric artery. Selective catheterization of the uterine artery using the 5-French RUC or Cobra (using the Waltman loop) was preferred. If this could not be achieved, a microcatheter was inserted coaxially through the 5 F Catheter. When focal injury was found, the road map approach was used to selectively cannulate the terminal branches of the uterine or hypogastric artery. Active bleeding foci were defined as: (1) extravasation of the contrast media; (2) pseudoaneurysms; or (3) abrupt cut off an artery.

When bleeding was non focal, absorbable gelatin sponge (Gelfoam; Pfizer Inc., New York, NY) was utilized (Fig. 2). It was divided into very tiny cubes, or pledgets that are administered hydrostatically via the catheter. The Gelfoam cubes were mixed to create the slurry. We diluted the mixture 1:1 with iodinated contrast and regular saline to get the "cake frosting," consistency. Bilateral internal iliac artery arteriograms were used to locate any further bleeding sites. If the patients are suspected to have another source of bleeding (like the ovarian arteries or round ligament arteries), then aortography was performed to locate the source of bleeding.

When bleeding was severe, or the patient was hemodynamically unstable, rapid bilateral nonselective embolization of the anterior divisions of the internal iliac or hypogastric arteries was performed. Speculum examination was always performed on-site for assessment of bleeding cessation following the procedure.

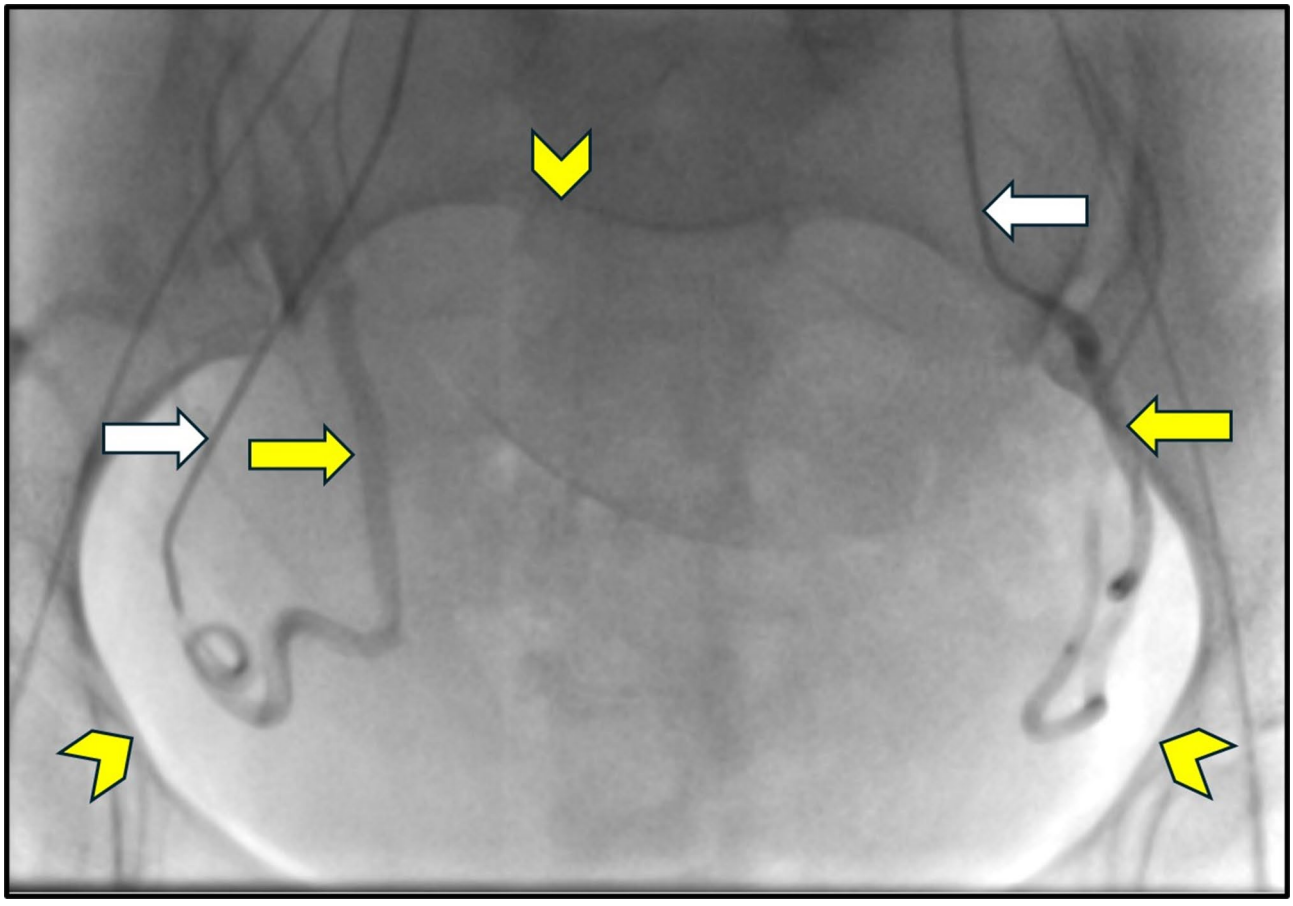

Fig. 1 Bilateral uterine arteries catheterization in Angio-suite before going to operation room for Caesarean section showing the catheters (white arrow), uterine arteries (yellow arrow) and the head of the fetus (yellow arrow heads)

Studied variables

These included demography of the patients (age, BMI, gestational diabetes, number of previous pregnancies and C-sections), predisposing factors for bleeding including the position of the placenta, placenta accreta, previous history of PPH and bleeding tendency, the mode of delivery whether C-section or vaginal delivery, and the urgency of the C-section, the need for general anesthesia and the management of the placenta, the blood product transfusions, stoppage of bleeding and the need for a hysterectomy.

Statistical methods

Categorical data were presented as number (valid percentage) excluding missing data. Continuous and ordinal data were presented as median (25-75% interquartile (IQR) range). Fisher's Exact test was used to compare the categorical data of two independent groups while Mann Whitney U test was used to compare ordinal or continuous data of two independent groups [14]. The patients were divided into two groups, those who had emergency interventional embolization and those who had elective interventional embolization. Variables who had a loose *p* value of less than 0.1 were entered into a direct logistic regression model [15] to define the factors predicting emergency interventions. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS version 28; Chicago, IL, USA). A *p* value of less than 0.05 was accepted as statistically significant.

Results

Table 1 shows the demography and risk factors of the patients. The patients had a median age of 33, a median pregnancy of 4 times, and a median of 4 C-sections. 75% had a low-lying placenta while 62.5% had placenta accreta. The most common comorbidity was gestational diabetes (15%). 2.6% had a known bleeding disorder while 5% had a history of previous PPH. Table 2 shows the mode of delivery. 95% had delivery through C-section of which 41% were emergency while 59% were elective. Placenta was successfully delivered in 57.5% of the cases.

Table 3 shows the laboratory results before the C-section, estimated blood loss, and given blood products. The median (IQR) of blood hemoglobin, platelet count, PT time and APTT time before going into the operating theatre were within normal ranges. The patients bled

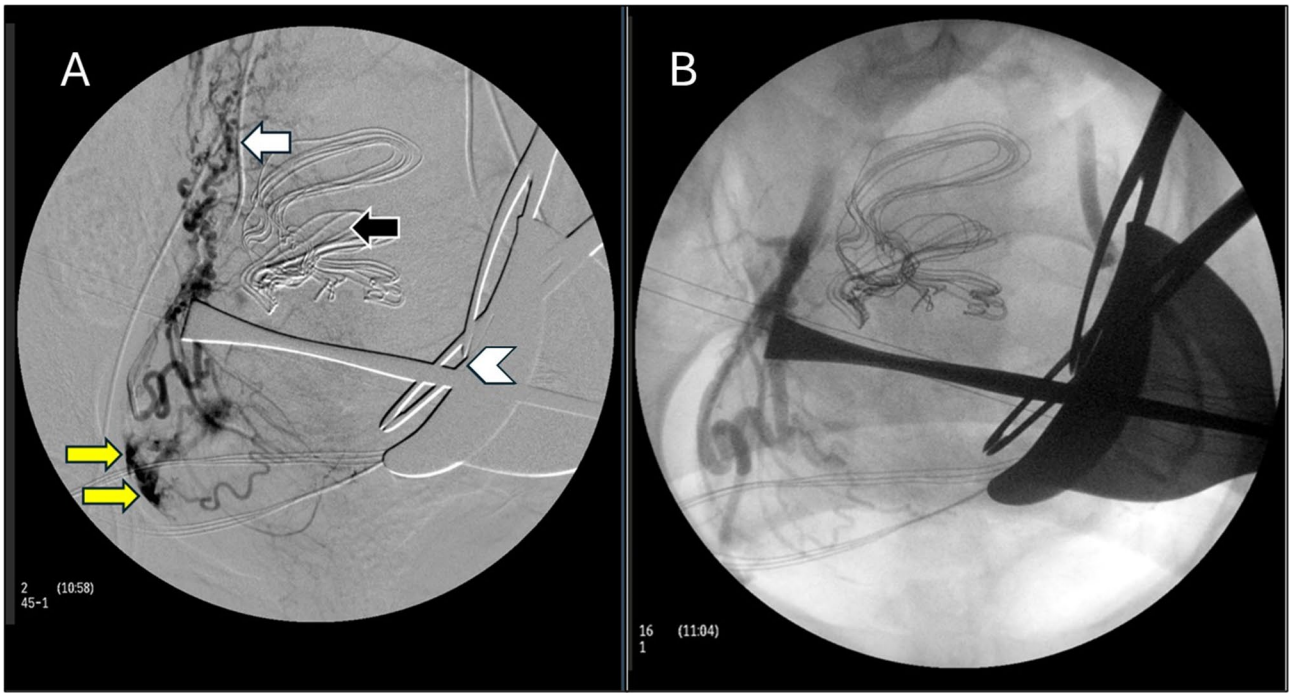

Fig. 2 Angiogram on the C-ARM X-ray machine after a Caesarean section (**A**) showing a catheter (white arrow), bleeding from the right uterine artery (yellow arrows), abdominal pack (black arrow), and surgical tools (white arrowhead) in the field. Angiogram on the C-ARM X-ray machine in the operating room after embolization (**B**) showing stagnant flow in both internal iliac arteries after Gelfoam embolization. The Catheters were removed while the surgical tools are still in the field

Table 1 Demographic characteristics of the women with postpartum hemorrhage managed by uterine artery embolization ($n=80$)

Characteristic	Median	Interquartile range
Age (years)	33	30–37
Body mass index	30.2	27.3–32.3
Gravida	4	3–5
Para	2	2–4
Number of previous Cesarian sections	2	1–3
Low lying placenta	60	75
Placenta accreta	50	62.5
Gestational diabetes	15	19
Pre-eclampsia in current pregnancy	4	5
Uterine fibroids	4	5.3
Previous PPH	4	5.3
Known bleeding disorder	2	2.6
Polyhydramnios	2	2.6
Pre-existing hypertension/diabetes	1	1.3

Percentages are calculated excluding missing data

Table 2 Delivery characteristics of the women with postpartum hemorrhage managed by uterine artery embolization (total = 80)

Characteristic	Number	%
Vaginal delivery	4	5
Emergency C-section	31	40.8
Elective C-section	45	59.2
Placenta delivered	46	57.5
Placenta left in situ	34	42.5
Exploration under GA	7	9

Percentages are calculated excluding missing values, GA = general anesthesia

Table 3 Laboratory results and transfused blood products of the patients

Characteristic	Median	Interquartile range
Laboratory results		
Hemoglobin (g/dl)	10.7	9.53–11.6
Platelets count (1000)/ml	201	153–242
PT (Seconds)	11.6	10.9–12.8
APTT (Seconds)	28.1	25.5–32.4
Plasma fibrinogen level (g/L)	3.4	3–4
Estimated blood loss (ml)	2000	1250–2500
Transfused blood products		
Packed RBCs	4	2–6
Fresh Frozen Plasma	4	4-6.5
Cryoprecipitate	10	6–10

an estimated median of 2 L of blood. Packed RBCs were transfused to 64 patients (80%), Fresh Frozen Plasm to 34 patients (42.5%), while Cryoprecipitate was given to 7 patients (8.8%), fibrinogen to 4 patients (5%) and Factor 7 to three patients (3.8%). Rh D negative blood was needed in two patients (2.6%). Patients who received blood products received a median of 4 units of Packed RBCs, 4 units of FFP, and 10 units of cryoprecipitate.

Table 4 Univariate comparison of categorical data between patients who had emergency embolization ($n=26$) and those who had elective embolization ($n=53$)

Variable	Emergency Interventional Radiology, $n=26$	Elective Interventional Radiology, $n=53$	p value
Indication			< 0.001
Placenta previa accreta	6 (23.1%)	37 (69.8%)	
Placenta previa	1 (3.8%)	13 (24.5%)	
PPH	16 (61.5%)	3 (5.7%)	
Others	3 (11.5%)	0 (0%)	
Gestational diabetes	6 (23.1%)	9 (17.3%)	0.56
Pre-eclampsia	3 (11.5%)	1 (1.9%)	0.1
Bleeding disorder	1 (3.8%)	1 (2%)	0.99
Low lying placenta	15 (57.7%)	44 (83%)	0.026
Placenta accreta	12 (46.2%)	37 (69.8%)	0.05
Uterine fibroid	2 (8.3%)	2 (3.9%)	0.59
Previous PPH	1 (4%)	2 (4%)	0.99
Previous CS	18 (69.2%)	43 (81.1%)	0.25
Bakri Ballon	7 (26.9%)	10 (18.9%)	0.56
Hemostatic sutures	19 (73.1%)	41 (78.8%)	0.58

Data are presented as number (valid percentage), p = Fisher's Exact test, PPH = postpartum hemorrhage, CS = Caesarian section

Table 5 Univariate comparison of continuous and ordinal data between patients who had emergency embolization ($n=26$) and those who had elective embolization ($n=53$)

Variable	Emergency Interventional Radiology, $n=26$	Elective Interventional Radiology, $n=53$	P Value
Age	32 (28.5–37)	33 (30–37)	0.36
BMI	30.45 (27.33–33.6)	29.48 (27.32–32.03)	0.27
Gravida	4 (3–5)	4 (3–6)	0.62
Para	2 (1–3)	3 (2–4)	0.19
Caesarian sections	1 (0–3)	2 (1-2.5)	0.55
Blood hemoglobin	10.4 (8.8–11.3)	11 (9.85–11.7)	0.18
Platelets	219,500 (166250–249750)	184,000 (152250–233750)	0.32
Prothrombin time	11.6 (10.95–12.25)	11.55 (10.9-12.95)	0.71
Activated prothrombin time	27.45 (25.53–35.23)	28.3 (25.1–31.8)	0.98

Data are presented as median (25-75% interquartile range), p = Mann Whitney U test

Table 6 Direct logistic regression showing the factors predicting emergency interventional radiology

	Coefficient	SE	Wald	p value	OR	LL 95% CI	UL 95% CI
Indication of IR*			15.26	0.002			
1) Placenta previa accreta	-1.29	1.2	1.16	0.28	0.28	0.03	2.89
2) Placenta previa	4.17	1.13	13.58	< 0.001	64.48	7.03	591.01
3) Postpartum hemorrhage	23.37	23,062	0	0.99	14,168,014,608	0	-
Low lying placenta	1.81	1.26	2.07	0.15	6.11	0.52	71.94
Placenta Accreta	-1.18	0.83	2.031	0.15	0.31	0.06	1.56
Constant	-2.56	1.13	5.11	0.024	0.08		

SE = Standard error, OR = odds ratio, CI = Confidence interval, UL upper limit, LL lower limit

*Compared with Others

Tables 4 and 5 show the comparison of variables between emergency embolization group ($n=26$) and elective embolization group ($n=53$). Those who had elective intervention had significantly lower location of the placenta ($p=0.026$, Fisher's Exact test), and more placenta accreta ($p=0.05$, Fisher's Exact test). The indications of the procedure were significantly different between the emergency and elective embolization ($p<0.001$, Fisher's Exact test). Placenta previa and accreta were more in the elective interventional embolization.

Table 6 shows the direct logistic regression model. It was statistically significant ($P<0.001$) having Nagelkerke R Square of 0.6 indicating that the model was acceptable explaining 60% of the variation of the data. The model correctly predicted the outcome in 87.3% of the cases. Indication of interventional radiology was the only

significant factor predicting the type of the procedure whether elective or emergency ($p = 0.002$).

Bleeding stopped following IR in 78/79 patients (success rate of 98.7%). Bleeding could not be stopped by unilateral IR in six patients having emergency IR. Further intervention required was bilateral uterine artery embolisation in three patinets, bilateral uterine artery and internal iliac artery embolization in two patients, and hysterectomy in one patient when bilateral uterine artery and internal iliac artery embolization failed. Those who failed stopping of the bleeding were similar between the elective and emergency IR, (1/53 (1.9%) in the elective IR compared with 0/26 (0%) in the emergency IR, $p = 0.99$ Fisher's Exact test). Postprocedural complications occurred in three patients (4%). Two patients developed acute ischemia of the lower limb. One due to an embolus which was treated with an embolectomy. The arterial circulation was restored, and the limb was saved. The second patient had absent pulses in both feet which were cold due to arterial spasm. The foot pulses were later reestablished without an intervention in the ICU with no signs of ischemia. The third patient had left leg weakness/numbness due to a nerve injury which gradually improved after physiotherapy. The patient was able to walk supported by a walker. Overall, eight patients (10%) had hysterectomy, one of them to stop bleeding. None of the patients died.

Discussion

Our results have shown that UAE is very efficient for controlling PPH. There were no deaths, over 98% control of bleeding, and around 10% hysterectomy rate. Placenta previa was a significant predictive factor for elective IR. Two-thirds of placenta previa accreta and a quarter of placenta previa were the common indications for elective IR. These results are comparable to the published literature [10, 16–20].

PPH is one of the most serious obstetric complications associated with severe maternal morbidity and death. Placental abnormalities, linked to the rising number of cesarean sections, rates of placenta previa and placenta accreta are increasing [21]. This hinders proper uterine contraction leading to continuing blood loss. As placental detachment occurs spontaneously and draws blood from nearby collaterals, the patient is more likely to have excessive bleeding if placental tissue remains. Intervention radiology has a role in this situation [21–23]. A retrospective study on 16 PPH patients showed that UAE stopped bleeding in all patients [11]. Another study in women who underwent C-sections and had placenta previa showed that prophylactic UAE significantly reduced bleeding when compared with controls [12]. In a further study, the success rate of UAE for controlling PPH was 87.2% and the risk factor for failure of UAE was narrow uterine arteries [24]. The literature shows that UAE does not affect menstruation or subsequent pregnancies [25], but it may increase the risk of placenta previa [26]. Both UAE and UAL block the uterine blood flow and are equally efficient in stopping bleeding. Nevertheless, UAL is an open surgical procedure that has its own complications [27] compared with UAE which is less invasive and takes less time.

Several strategies can be considered for severe PPH [28–30]. UAE can be used in the operating room when there is massive bleeding resulting from a placental anomaly. Prophylactic catheter implantation with or without UAE following delivery should be considered in high-risk cases. Preventive balloon catheter occlusion of the aorta during delivery may preserve hemodynamic stability during UAE, however, there is a possibility of vascular complications. Furthermore, its efficacy may be reduced due to extensive collateral circulation of the uterus [27]. Prophylactic embolization is debatable because it leads to radiation exposure and possible vascular complications. On the other hand, UAE when used promptly when needed after delivery can effectively treat PPH, controlling the hemorrhage and improving the likelihood of uterine preservation. An interventional radiologist should be involved as soon as abnormal bleeding is observed following the first-line PPH treatment, such as removal of traumatic factors including uterine rupture or genital tract laceration, blood transfusions, uterotonic drug administration, and uterine compression. The timing of the UAE is pivotal. The main cause of complications in PPH is delay of treatment. When a patient is transported from a community setting to a hospital where UAE is available, it should be considered as the first-line hemostatic measure. This is because surgical ligation of the uterine arteries or internal iliac arteries usually fails due to collateral circulation. One benefit of performing early UAE is that it can reduce blood loss and make surgery easier with a clear surgical field. This proactive approach is necessary for prompt treatment of PPH with embolization.

Limitations of this study

We acknowledge that our study has certain limitations. *First*, our sample size was relatively small although our study represents an eight-year experience of a busy community-based hospital having excellent interventional radiological expertise and facility. *Second*, the retrospective nature of the study limits available variables which may miss important data. *Third*, UAE is a high technical procedure that requires proper facility, expert operator, and well-trained multidisciplinary team. This may not be available in many hospitals. *Finally*, the single center nature of the study limits its generalizability to other centers. Based on our results we think that the availability of

UAE 24 h a day in certain centers that work as referral centers should be encouraged and planned for.

Conclusions

Interventional radiological uterine artery embolization is a very successful method for controlling postpartum hemorrhage. It should be recommended as the first line of treatment for significant bleeding. It increases survival, reduces hysterectomy rate, without a difference if done as emergency or elective procedure.

Abbreviations

C-section	Cesarean section
PPH	Postpartum hemorrhage
UAE	Uterine Artery Embolization
UAL	Uterine Artery Ligation
WHO	World Health Organization

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Author contributions

Howaida Khair and Shamsa Al Awar had the idea, obtained the ethical approval, coded the data, and drafted the manuscript. Jamal Koteesh participated in the idea, performed the interventional radiology, and helped draft the manuscript, Hassan Elbiss, Sara Maki and Dana Abdalla participated in the idea, performed the data collection, and helped draft the manuscript. Fikri Abu-Zidan participated in the idea, helped to code the data, did the statistical analysis, and wrote the results section. Fikri Abu-Zidan and Shamsa Al Awar co-supervised the project. All authors critically read, edited the manuscript, and approved the last version of the paper.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by Tawam Human Research Ethics Committee (with approval# MF2058-2021-803 dated 23rd January 2023) for this observational study at Al-Ain Hospital, United Arab Emirates.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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