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ORIGINAL ARTICLE

The impact of uterine artery embolization to reduce postpartum hysterectomy

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Abstract Uterine artery embolization (UAE) has been part of treatment options for postpartum hemorrhage (PPH) at Oslo University Hospital since 2007. We wanted to investigate if introduction of UAE influenced the incidence of postpartum hysterectomy and in addition to evaluate clinical success and fertility after UAE. This retrospective study includes patients treated for severe PPH undergoing UAE from 2007 to 2010 and patients undergoing hysterectomy in the period *before* (2003–2006) and *after* (2007–2010) the introduction of UAE. Hospital records were reviewed. Patients who were embolized were contacted with a questionnaire to evaluate fertility. We observed a decrease in the incidence of postpartum hysterectomy since introduction of UAE for PPH; however, the reduction was not significant (0.40/1000 versus 0.35/1000, $p = 0.80$). UAE resulted in clinical success in 28 patients (82 %). None were re-embolized. Twenty women were hysterectomized. Five of these patients had preceding embolization, four were hysterectomized due to re-bleeding, and one due to sepsis with suspected uterine necrosis. One patient had a uterine horn removed due to bleeding. Nine women became pregnant after UAE. There were 11 reported pregnancies and 8 live births. PPH re-occurred in 63 % of live births, with median bleeding volume of 700 ml (range 500–1600 ml). Introducing UAE decreased postpartum hysterectomy rate in our department, however not significant. Our success rate of UAE (82 %) is in line with previously published data. UAE may preserve fertility potential. High recurrence rate of PPH after previous UAE was observed.

Keywords Postpartum hemorrhage · Uterine artery embolization · Hysterectomy · Fertility

Background

Postpartum hemorrhage (PPH) is a major cause of maternal mortality worldwide [1]. The most common cause of PPH is uterine atony [2]. Other causes are trauma to the birth canal, uterine rupture, retained placental tissue, and coagulopathy. Treatment options for PPH include manual compression, medical treatment, aortic occlusion, arterial embolization, and surgical interventions [3]. In case of life-threatening bleeding, hysterectomy may be necessary [3]. Uterine artery embolization (UAE) has emerged as an alternative to surgical intervention as it is less invasive with fewer adverse side effects and is uterine sparing [4–6]. UAE is regarded as a safe alternative to control PPH [4, 5, 7] and has been reported to preserve fertility [8–11]. Success rate of hemostasis after UAE has been reported in the range of 79–95 % [4, 5, 7, 9, 12–15].

UAE in treating postpartum hemorrhage was introduced in our department in 2002 [16]. In the following 4 years, UAE for PPH was performed in only four patients. From 2007, it has been included as part of our treatment options in the management of PPH, which also includes active management of third stage labor, medical and surgical treatment options. The objective of this study was primarily to evaluate the impact of UAE on the incidence of hysterectomy due to PPH and, secondly, to evaluate clinical effectiveness, safety, and fertility after UAE for treatment of PPH.

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Methods

The study was retrospective and carried out at Oslo University Hospital (OUH) in Norway. The study was approved by the Regional Committee for Medical and Health Research Ethics, South East Norway, and permission from OUH's Advisory Committee on the Protection of Patient Records was granted for the study protocol. The number of births at OUH in the period of January 2003 to December 2010 was identified through hospital records. All live and stillborn children with birth weight more than 500 g or above 22 weeks gestation were included. We defined PPH as blood loss >500 ml. We included both primary and secondary PPH, i.e., PPH <24 h after delivery and >24 h after delivery but less than 12 weeks after delivery [17]. The number of patients with PPH at OUH from January 2003 to December 2010 was registered by using hospital records linked to diagnosis-related group (DRG) coding system.

All postpartum hysterectomies and embolizations were identified with the DRG coding system. The study included patients who underwent postpartum UAE from January 2007 to December 2010 and patients who underwent postpartum hysterectomy from January 2003 to December 2010. We compared the incidence of postpartum hysterectomy 4 years before and 4 years after the introduction of UAE in 2007. Our definition of hysterectomy included both total and subtotal hysterectomy. Major intervention for postpartum hemorrhage was defined as either hysterectomy or embolization. Patients' hospital medical records were reviewed by one data manager not involved in management or follow-up of the patients. Recorded information was kept in an anonymized register for each patient. Data collected for all patients included patient age, parity, obstetric history, previous illnesses, mode of delivery, birth weight, cause of PPH, and complications. Pregnancies and births in patients who had been treated with UAE were recorded. In addition, technical data from the UAE procedure included information on embolized vessels and embolization material used. Acute successful hemostasis was defined as successful embolization of the uterine arteries and/or the bleeding artery and gynecologic inspection for cessation of bleeding in the interventional radiology suite. Clinical success also included no hysterectomy within 30 days. The amount of blood transfusions required for each patient was registered in collaboration with the Department of Immunohematology at the hospital.

Patients with a preserved uterus after UAE from January 2007 to December 2010 were contacted with a questionnaire in May 2012 to ensure complete data regarding pregnancies, deliveries, and birth weight. The original questionnaire contained 19 questions, and patients were asked about health background, menstrual cycle before and after UAE, pregnancies and births before and after UAE, previous complications during delivery, risk factors for PPH, complications after UAE, and birth weight before and after UAE. Written informed consent was obtained. Follow-up period after the UAE procedure was 18–64 months. Hospital records of these patients were reviewed again in December 2014 to have updated and complete fertility details.

All patients with PPH were initially treated with active management of third stage labor in cases of vaginal delivery. In addition, conservative medical treatment including uterine massage and uterotonic agents like oxytocin, prostaglandin and methergin were used after vaginal delivery and during cesarean sections. Hysterectomy was performed in patients with PPH with life-threatening bleeding or if there was an obvious cause of bleeding that could not be fully treated with UAE, e.g., uterine rupture. The leading gynecologist on-call decided whether a patient should be embolized or undergo surgery due to PPH. In case of re-bleeding, each patients' further treatment was considered individually. UAE was performed by a team of senior interventional radiologists in the interventional radiology suite. In our department, UAE is routinely performed under local anesthesia. However, in cases when the patient was under general anesthesia, UAE was performed before recovery. Unilateral femoral artery puncture was performed, and pelvic arteries were examined through flush aortic injection of contrast medium followed by selective injection into both uterine arteries. Microcatheters were not used for this procedure. In most patients, 4 F Cobra (C1) catheter Glidecath (Terumo, Leuven, Belgium) was utilized. An aortogram was performed to localize any arterial injury and thereby save time. The site of injury could be treated immediately and if necessary be followed by occlusion of the uterine arteries bilaterally. Standard embolization material was absorbable Spongostan (Ferrosan Medical Devices A/S, Søborg, Denmark) in cases when no arterial injury was detected at angiography as it re-establishes blood flow within 4–6 weeks. Microcoils (Cook Medical, Bloomington, Indiana, USA) were used when arterial injury was observed, placing coils as close to the injury as possible. Coils were in some cases combined with Spongostan. Polyvinyl alcohol particles (PVA—contour 355–500 μm, Boston Scientific, Cork, Ireland) was used in one patient with PPH and myomas. Aortic occlusion was used in patients who were regarded unstable before transfer to the interventional radiology suite [18].

SPSS version 21.0 (LEAD Technologies, USA) was used in data analysis. Results are expressed as mean ± SD. To compare continuous data, Student's t test was used. The chi-squared test was used for qualitative data. A p value ≤ 0.05 was considered significant. A two sided p value was utilized.

Findings

From 2003 to 2010, there were 53,488 births at OUH. The number of births increased from 25,242 in the first period of

2003–2006 to 28,246 births in the second period of 2007–2010. The number of patients in total with PPH in 2003–2006 was 2323 and in 2007–2010 was 3536. There were 20 postpartum hysterectomies during 2003–2010, ten between 2003 and 2006 (0.40/1000 deliveries), and ten between 2007 and 2010 (0.35/1000 deliveries) ($p = 0.80$). There were four UAEs due to PPH from 2003 to 2006 (0.16/1000 deliveries). The number of postpartum embolizations from 2007 to 2010 were 34 (1.2/1000 deliveries). In five of 34 patients (15 %), a subsequent hysterectomy was performed, four due to continuous hemorrhage, and one due to suspected uterine necrosis. In addition, one of 34 patients had a uterine horn removed after UAE due to continuous bleeding. There was a statistical significant increase in the incidence of patients treated for PPH with a major intervention, i.e., either hysterectomy or UAE, in the second period ($p = 0.002$). Fourteen patients (0.55/1000 deliveries) were treated for PPH in 2003–2006, i.e., 10 hysterectomies and four UAEs. Thirty-nine patients (1.4/1000 deliveries) were treated for PPH in 2007–2010, i.e., ten hysterectomies including five with prior UAE and 29 with UAE only.

The baseline characteristics of the patients who went through postpartum hysterectomy between 2003 and 2010 and those who had postpartum embolization between 2007 and 2010 are shown in Table 1. The cause of PPH is shown in Table 2. The major cause of PPH was atony among patients who were embolized or went through hysterectomy. Of the two patients who underwent UAE due to uterine rupture, one ended with a hysterectomy and one had one uterine horn removed. Of the 34 patients who underwent UAE, clinical success was achieved in 28 patients (82 %). In 30 out of 34 patients, time interval between delivery, vaginal or cesarean section, and UAE was within 48 h with a median time interval of 3 h (range 0.83–47 h). We are missing accurate data for time of delivery for two patients. Both were treated within 24 h of delivery. Two patients had UAE 12 and 77 days after c-section. The first patient was bleeding from a vaginal branch; the other patient had a pseudoaneurysm in one of the uterine arteries. Twenty-five of 34 patients had both uterine arteries embolized. Four patients had one uterine artery embolized. Five patients had one uterine artery and one additional artery embolized. Two patients underwent aortic occlusion before bilateral UAE. Spongostan as the only embolization agent was used in 25 patients, PVA only was used in one patient, microcoils only in three patients, Spongostan and microcoils in four patients, and a combination of PVA, Spongostan, and microcoils in one patient.

Acute clinical success was not achieved in six patients after embolization. Five went through hysterectomy, four of them within 24 h of embolization. The fifth patient had myomas, and the embolization was carried out with use of a large volume of PVA particles in addition to Spongostan. Hemostasis was achieved, and there was no re-bleeding after UAE. However, she developed sepsis and paralytic ileus 3 weeks after the procedure, and a hysterectomy was performed on day 27 after UAE. Histopathological examination of the removed uterus showed only necrosis in the myomas and not in the myometrium. The sixth patient had one uterine horn removed.

There was a statistical significant increase in the number of patients with PPH when comparing the time periods 2003–2006 (92/1000 deliveries) and 2007–2010 (125/1000

Table 1 Patient characteristics—hysterectomied patients 2003–2010 and embolized patients 2007–2010

Period	Hysterectomied patients 2003–2006 ($n = 10$)	Hysterectomied patients 2007–2010 ($n = 10$)[b]	Embolized patients with success 2007–2010 ($n = 28$)	Embolized patients with no success 2007–2010 ($n = 6$)
Age (years) median	33.5 (range 25–37)	36.5 (range 29–42)	33 (range 24–40)	31 (range 29–42)
Primiparous	0 (0 %)	2 (20 %)	14 (50 %)	2 (33 %)
Multiparous	10 (100 %)	8 (80 %)	14 (50 %)	4 (67 %)
Induced labor	4 (40 %)	1 (10 %)	3 (11 %)	0 (0 %)
Unassisted vaginal deliveries	2 (20 %)	1 (10 %)	9 (32 %)	0 (0 %)
Instrumental vaginal deliveries	1 (10 %)	1 (10 %)	7 (25 %)	0 (0 %)
Cesarean section, elective	3 (30 %)	5 (50 %)[a]	6 (21 %)[c]	1 (17 %)
Cesarean section, acute	4 (40 %)[a]	3 (30 %)	3 (11 %)	3 (50 %)[a]
Previous cesarean section	4 (40 %)	6 (60 %)[a,c]	12 (43 %)[a]	2 (33 %)
Pevious abdominal surgery	2 (20 %)	3 (30 %)	6 (21 %)[a,c]	4 (67 %)

[a] One patient with twins

[b] Five patients with embolization failure belong to this period

[c] One patient had two previous cesarean sections

Table 2 Cause of major postpartum hemorrhage

	Embolization only ($n=29$)	Hysterectomy ($n=20$)[b]	p value
Atony	18 (62 %)	9 (45 %)	0.154
Uterine rupture	0 (0 %)	5 (25 %)	0.004
Placenta accreta[a]	4 (14 %)	1 (5 %)	0.318
Placenta increta[a]	0 (0 %)	1 (5 %)	0.408
Inversio uteri	0 (0 %)	2 (10 %)	0.162
Genital tract lacerations	2 (7 %)	0 (0 %)	0.345
Placenta previa	2 (7 %)	1 (5 %)	0.837
HELLP	1 (3 %)	0 (0 %)	0.592
Retained placental tissue/placenta	2 (7 %)	1 (5 %)	0.837

[a] Histologically verified after delivery

[b] Five patients with UAE ended with hysterectomy and are included in the hysterectomy group, third column

deliveries), $p=0.018$. Transfusion requirement was significantly higher in the group of 20 patients who had hysterectomy compared with the 28 patients who received embolization only. Mean transfused units of erythrocytes was 12.2 (range 4–26, ±SD 5.6) in the hysterectomy group compared to 5.7 (range 0–16, ±SD 3.8) in the embolization only group, $p<0.001$. The group containing 15 patients who had hysterectomy without prior embolization required a mean of 12.1 units of erythrocytes (range 4–20, ±SD 4.7). The group of five patients who went through unsuccessful embolization before hysterectomy required 12.8 units (range 4–26, ±SD 8.3). There was no statistical significance between these two groups, $p=0.81$.

There were no acute complications following embolization. Of the 20 postpartum hysterectomies performed in the 8-year period, only one complication was noted. One patient experienced rupture of the abdominal fascia 10 days after hysterectomy, which needed surgical repair.

Twenty-one of the 29 patients with intact uterus after UAE were contacted with a questionnaire, of which 19 responded (90 %). Eight patients were excluded and not sent questionnaires, four did not speak Norwegian, three had unknown address, and one patient died of unknown cause 2 years after UAE. Nine of 19 patients conceived after embolization. Eleven pregnancies resulted in 8 (73 %) live births at the time of our study. There were two spontaneous abortions, and one patient was 20 weeks pregnant when she answered the questionnaire. There was one premature birth and seven births to full term. Two patients became pregnant twice after the embolization, one of them delivered to full term twice. Ten pregnancies occurred spontaneously, while one after IVF treatment in one women who previously also had an IVF pregnancy. Intrauterine growth retardation was found by ultrasound examinations during one of the pregnancies in one woman. She delivered a live child with a congenital defect in week 32 after premature rupture of membranes in week 25. PPH reoccurred in 63 % of live births with median bleeding volume of 700 ml (range 500–1600 ml). All patients with recurrent PPH were treated with active management of third stage of labor and conservative medical treatment. None of these patients with previous UAE and reoccurring PPH were treated with UAE again.

Discussion

Hysterectomy rate was reduced due to PPH after the introduction of UAE, however not significant. We found that embolization was an effective treatment for PPH in most cases. Only 15 % of the patients needed a subsequent hysterectomy. UAE in our hospital appears to be a safe minimal invasive treatment alternative, although one major complication with suspected uterine necrosis in a patient with myomas occurred. Nine women conceived during a 5-year period after embolization, resulting in 11 pregnancies and 8 live births.

Some authors have speculated that an implementation of therapeutic embolization as a treatment option for PPH could reduce the number of hysterectomies [19]. In our study, the incidence of hysterectomy in the 4 years before and the 4 years after introduction of embolization at our hospital decreased slightly from 0.40/1000 deliveries to 0.32/1000 deliveries. However, the total number of hysterectomies was low and the reduction in incidence not significant.

Although the hysterectomy rate did not increase, there was a significant increase in intervention for PPH with either hysterectomy or embolization in 2007–2010 compared to 2003–2006. According to our hospital records, the number of patients with PPH has increased between 2003 and 2010. In general, the incidence of severe PPH appears to be increasing [20]. Joseph et al. have found that the incidence of postpartum hysterectomy increased from 0.24/1000 deliveries in 1991 to 0.42/1000 deliveries in 2004 [21]. Other studies have reported a similar or higher postpartum hysterectomy rate of 0.39–1.39/1000 deliveries [22, 23].

The increase in patients with PPH can explain the larger number of major interventions over time if we assume that embolization was done instead of hysterectomy. Another explanation could be a lower threshold for embolization in our department due to increased awareness and knowledge of UAE. Our rate of postpartum embolization in relation to hysterectomy (1.2/1000 versus 0.32/1000) is higher than what was found in a study by Zwart and colleagues. They found 0.32/1000 embolizations versus 0.30/1000 hysterectomies [14]. It is unknown how many of these patients had needed a hysterectomy if embolization was not available.

Our success rate of 82 % for UAE as treatment for PPH was similar to a number of other studies [5, 14, 15], while others report higher success rates of 88–95 % [4, 7, 12, 13]. Cesarean section rate among our embolized patients was 54 %, which is higher than that in other studies, 42 % [14] and 31 % [12]. Increased transfusion requirement and cesarean section are found to be risk factors for lack of hemostatic effect after UAE [13, 14, 24, 25]. In accordance with these findings, five out of six patients with unsuccessful embolization delivered through cesarean section. These patients also needed more transfused units of erythrocytes compared to the group with successful embolization. The highest transfused units of erythrocytes was observed in patients who underwent hysterectomy, both in the group with previous embolization and in the group that went through hysterectomy only. It is difficult to draw any conclusion about the reason for this difference since our data is retrospective. An increased number of transfused units might have been needed because of a more severe postpartum hemorrhage in these women or because of the hysterectomy itself.

Pregnancies were registered after UAE. Eleven of our pregnancies resulted in 8 live births (73 %) which is comparable to other studies, range 60–78 % [8, 10, 24, 26, 27]. Seventy-one percent of patients delivered by cesarean section which is a higher rate compared to that in other studies [9, 11, 24], while some authors found a cesarean section frequency higher than 83 % [28, 29]. There have been varying reports regarding recurrence rate of PPH for patients who have delivered after embolization. Some studies report no recurrent PPH [10, 28], while others report a rate of 18 % [26], 32 % [15], and 100 % [8]. In our material, five out of eight (63 %) patients experienced subsequent PPH. However, we included patients with blood loss more than 500 ml and none of them required repeat embolization.

Conclusion

Introducing UAE decreased postpartum hysterectomy rate in our department, however, not significant. Our success rate of UAE (82 %) is in line with previously published data. UAE may preserve fertility potential. High recurrence rate of PPH after previous UAE was observed.

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Authors' contribution MK Aas-Eng was responsible for the project development, data collection, data analysis, and manuscript writing. E Qvigstad, NE Kløw, and K Hald participated in the project development, data analysis, and manuscript writing.

Compliance with ethical standards The study was approved by the Regional Committee for Medical and Health Research Ethics, South East Norway, and permission from OUH's Advisory Committee on the Protection of Patient Records was granted for the study protocol.

Conflict of interest The authors declare that they have no competing interests.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

Informed consent Informed written consent was obtained from patients who had been contacted with a questionnaire regarding fertility outcomes after embolization for postpartum hemorrhage.

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