



Placental uterine artery embolization followed by delayed hysterectomy for placenta percreta: A case series

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ARTICLE INFO

Keywords:

Placenta accreta spectrum
Morbidity adherent placenta
Postpartum hemorrhage
Uterine artery embolization
Multidisciplinary team
Massive transfusion protocol

ABSTRACT

We describe outcomes of patients with suspected placenta percreta treated with placental uterine artery embolization (P-UAE) followed by delayed hysterectomy. This is a prospective case series of subjects from 2005 to 2018 with suspected placenta percreta who underwent P-UAE at the time of cesarean delivery followed by delayed hysterectomy. Both scheduled and unscheduled surgical cases were included. Maternal characteristics, surgical approaches, intra- and postoperative outcomes were abstracted from medical records. In total, twenty-two subjects were included. Median (interquartile range, IQR) delivery gestational age was 34.6 (31.9, 35.7) weeks, occurring as scheduled in 17 (77.3%) subjects and unscheduled in 5 (22.7%). Delayed hysterectomy was performed as scheduled in 17 (77.3%) subjects at a median (IQR) 40.5 (38.0, 44.0) days after delivery, and 5 (22.7%) subjects had a hysterectomy prior to scheduled date, median (IQR) 27.0 (17.0, 35.0) days after delivery. Indications for the 5 unscheduled hysterectomies included bleeding (n = 3) and suspected endometritis (n = 2). Three subjects (13.6%) received a blood transfusion (1, 3, 3 units) during delivery, and 7 (31.8%) were transfused during delayed hysterectomy (median [IQR] 2 [1,3] units). Three (13.6%) subjects had bladder resection at the time of hysterectomy; 1 (4.5%) had an unintentional cystostomy and 1 (4.5%) had a ureteral injury. P-UAE followed by delayed hysterectomy appears to be a safe and feasible, although appropriate patient selection and close surveillance are imperative, as 22.7% of patients underwent unscheduled hysterectomy.

1. Introduction

Placenta accreta spectrum (PAS) includes the extension of trophoblast into or through the uterine myometrium, typically at a dehiscence uterine scar (Einerson et al., 2020). Ongoing research is contemporizing the histopathologic definitions (accreta, increta, and percreta), although percreta differs from the other two subtypes as placentation extends

beyond the myometrium to potentially involve adjacent organs (Stotler et al., 2011). Observational data suggest that antenatal diagnosis and a planned, preterm delivery with a multidisciplinary team are associated with improved outcomes (Shamshirsaz et al., 2017, 2015). Optimal surgical approaches are based on expert opinion, and in the United States, the generally accepted approach is cesarean hysterectomy. Surgery for PAS is associated with perioperative risks due to extensive

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<https://doi.org/10.1016/j.gore.2021.100833>

Received 21 April 2021; Received in revised form 7 July 2021; Accepted 11 July 2021

Available online 16 July 2021

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adhesive disease and engorged pelvic vasculature (Einerson et al., 2020; Marcellin et al., 2018). There is renewed interest in alternative strategies, including conservative management in which hysterectomy is avoided (Fox et al., 2015), and delayed hysterectomy in which hysterectomy is completed after the puerperium. Data on these approaches are limited due to both the low absolute incidence of percreta, non-standardized sonographic, intraoperative, and histologic reporting criteria, and the variability of the interventions studied (Sentilhes et al., 2010). A recent ACOG consensus opinion considers delayed hysterectomy an investigational approach, calling for further research (ACOG, 2018).

In 2005, the gynecologic oncology team at our institution developed a multidisciplinary algorithm to manage PAS, shown in the [Supplementary Fig. #1](#). The current algorithm includes Interventional Radiology (IR) for placental uterine artery embolization (P-UAE) immediately after cesarean delivery, followed by either immediate (preferred) or delayed hysterectomy. The decision for hysterectomy timing depends on intraoperative assessment of surgical risks, with the goal to minimize surgical blood loss and tissue damage by reducing placental “bulging” and extensive bladder resection. If delayed hysterectomy is planned, the completion hysterectomy is completed in 4–6 weeks. In our current algorithm, most subjects are managed with immediate hysterectomy, and delayed hysterectomy is generally reserved for severe cases. Specific anatomic complexity dictated which cases were severe and therefore received a delayed hysterectomy. This has been poorly defined in the literature, but at our institution included extensive bladder involvement or a subjective assessment of the extent of abnormal vasculature in and around hysterectomy planes. This contrasts to cases of accreta or increta, with the placentation contained within the myometrium, and the surgical planes are more discernable.

Because the placenta is left in-situ between cesarean and delayed hysterectomy, it is imperative that patients have a clear discharge plan and instructions for follow up. While there was no radius (miles) defined for living near the hospital, it is imperative that patients understand return precautions and have access to immediate care.

The objective of this study is to describe the clinical outcomes of a cohort of patients who underwent P-UAE followed by a delayed hysterectomy as part of our institutional algorithm.

2. Methods

This is a prospective series of subjects with histologically-confirmed PAS managed at Duke between 2005 and 2018 who underwent delayed hysterectomy with P-UAE for suspected percreta. Subjects were identified using pathologic search terms “accreta”, “increta”, and “percreta”. Subjects were included if P-UAE was performed after cesarean delivery, and the placenta was left in-situ for planned delayed hysterectomy. Subjects were excluded if they did not have P-UAE at the time of cesarean delivery.

Subject demographics and baseline characteristics were abstracted from the electronic medical record. Clinical outcomes included surgical approaches, the postpartum course with the placenta left in situ, and any relevant postoperative complications. The rate and indications for unscheduled cesarean delivery and delayed hysterectomy were noted. The intraoperative assessment of placentation at the time of delivery was compared with final pathologic diagnosis. When calculating median (interquartile range, IQR) packed red blood cells (RBCs) transfused, we only assessed the subjects who received any transfusion. If a particular intraoperative photograph was used as part of the study and manuscript preparation, an additional consent was obtained from the subject.

Descriptive analysis was performed using SAS 9.4 (SAS Institute Inc., Cary, NC). Continuous variables were described as either mean (SD) or median (IQR) and range, determined if the observed distribution appeared to be skewed. Categorical variables were reported as n(%). Duke Institutional Review Board (IRB) approved the study, and subjects were prospectively enrolled as part of the study prior to cesarean

delivery.

3. Results

Twenty-four patients underwent delayed hysterectomy. Of these, 22 underwent P-UAE and therefore met inclusion criteria. Per operative report, all 22 subjects were suspected to have placenta percreta at the time of cesarean delivery. On final pathology, 11 (50.0%) were diagnosed with placenta percreta, 9 (40.9%) had placenta increta, 1 (4.5%) had placenta accreta, and 1 (4.5%) had uterine necrosis, placental depth unable to be categorized.

The median (IQR) gestational age at delivery was 34.6 (31.9, 35.7) weeks, and cesarean delivery occurred as scheduled in 77.3% of cases ([Table 1](#)). Of the five unscheduled cesarean deliveries, three had bleeding warranting emergent cesarean delivery, one had preterm premature rupture of membranes, and one had gross hematuria.

With regards to delayed hysterectomy, 17 (77.3%) had scheduled surgeries at a median (IQR) 40.5 (38.0, 44.0) days after cesarean ([Table 2](#)). There were 5 (22.7%) patients who underwent an unscheduled hysterectomy, at a median (IQR) 27.0 (17.0, 35.0) days after cesarean. The indications for unscheduled hysterectomies were bleeding (n = 3/5, 60.0%), and endometritis (n = 2/5, 40.0%). Of the five patients with unscheduled hysterectomies, two also had unscheduled cesarean deliveries. Most patients (68.1%) lived within sixty miles of the hospital. Three (13.6%) subjects remained inpatient during the interval between cesarean and delayed hysterectomy: two were planned to remain inpatient due to social situations prohibiting safe discharge planning; the other subject, after delivering twins by scheduled cesarean and P-UAE, had vaginal bleeding within hours after arriving to the postpartum floor and subsequently underwent emergent hysterectomy within six hours of delivery.

Table 1
Baseline demographics.

Age (years)	31.5 (5.0)
Range	(23.0, 39.0)
Gravidity median(IQR)	4.0 (3.0, 5.0)
Range	(2.0, 8.0)
Parity median(IQR)	2.0 (1.0, 2.0)
Range	(1.0, 6.0)
BMI (kg/m²)	27.3 (24.1, 35.9)
Range	(20.9, 52.5)
Number of prior cesarean deliveries: n(%)	
1	10 (45.5%)
2	10 (45.5%)
3	2 (9.1%)
Type of conception: n(%)	
Spontaneous	21 (95.5%)
Assisted reproductive technology	1 (4.5%)
Concurrent placental diagnosis: n(%)	
Complete previa	16 (72.7%)
Partial previa	1 (4.5%)
Vasa previa	1 (4.5%)
None	4 (18.2%)
Distance from hospital: n(%)	
<15 miles	4 (19.0%)
10–30 miles	5 (23.8%)
30–60 miles	4 (19.0%)
>60 miles	8 (38.1%)
Missing	1
Type of Insurance: n(%)	
Public	6 (28.6%)
Private	11 (52.4%)
Uninsured	4 (19.0%)
Missing	1

Continuous variables presented as either mean (SD) or median (Interquartile range).

Table 2
Surgical Timing and Indications.

	Cesarean delivery	Delayed hysterectomy
Gestational age at delivery median (IQR)	34.6 (31.9, 35.7)	–
Range	(26.9, 37.3)	–
Scheduled: n(%)	17 (77.3%)	17 (77.3%)
Unscheduled: n(%)	5 (22.7%)	5 (22.7%)
Indications for unscheduled procedure: n(%)		
Bleeding	3 (60.0%)	3 (60.0%)
Non-reassuring fetal status	0 (0.0%)	–
Labor	0 (0.0%)	–
Infection	0 (0.0%)	2 (40.0%)
Other	2 ¹	0 (0.0%)
Days between delivery and hysterectomy		
Scheduled (n = 17)		
Median (IQR)	–	40.0 (38.0, 44.0)
Range	–	(26.0, 68.0)
Unscheduled (n = 5)		
Median (IQR)	–	27.0 (17.0, 35.0)
Range	–	(0.0, 37.0)
Remained inpatient during interval: n(%)	–	3 (13.6%)

Continuous variables presented as either mean (SD) or median (Interquartile range).

¹ Gross hematuria; Preterm, premature rupture of membranes (PPROM).

At the time of cesarean delivery, three (13.6%) of subjects were given 1, 3, and 3 units pRBCs, respectively (Table 3). One subject, in the setting of partial placental abruption at 26 weeks and 6 days, received additional blood products, including 3 units FFP and 3 units cryoprecipitate, during cesarean delivery. Intraoperative decision-making to delay hysterectomy was based on DIC, and further surgery was considered life-threatening. At the time of delayed hysterectomy, 7 (31.8%) subjects were given a median (IQR) of 2 (1, 3) units pRBC, and 3 (13.6%) patients received FFP.

Cesarean delivery procedures lasted a mean (SD) of 165.6 (62.1) minutes, which included the time for IR to complete P-UAE between delivery and abdominal closure. Delayed hysterectomy cases lasting a mean (SD) of 227.9 (76.4) minutes. Four (18.2%) cases were completed by laparoscopy (one conventional, three robotic-assisted); the remainder were completed as open procedures using the previous incision from the cesarean delivery (vertical [n = 16, 72.7%] or pfannenstiell [n = 2, 9.1%]). Preoperative stent placement, used by the primary surgeon on a case-by-case basis, was used in 54.5% (n = 12) of cases. Three patients (13.6%) required partial bladder resection, 1 (4.5%) patient with an unintended cystotomy, and 1 (4.5%) patient with a ureteral injury during hysterectomy. Urology was consulted intraoperatively in four (18.2%) cases to assist with bladder reconstruction (n = 3) including transpositional peritoneal flaps or assistance with ureteral re-implantation when the ureter was ligated (n = 1). Stents and urology consultation are not routinely used as part of the algorithm but are available on standby.

Postoperatively, one patient (4.5%) was discharged with prophylactic antibiotics, and 2 (9.5%) were given methotrexate during the early years of the algorithm (which was later discontinued in 2008). There was at least one IR complication noted, with the patient having a self-limited paresthesia in the femoral nerve distribution, due to iatrogenic nerve injury rather than target embolization. Another patient was diagnosed with a pulmonary embolism. It is unknown whether the embolism was caused by a venous thrombotic event or due to arteriovenous shunting due to the embolization, a theoretical risk of P-UAE. She was treated with low molecular weight heparin. There were no cases of sepsis or maternal deaths.

Table 3
Transfusion, Surgical Approach, and Operative Characteristics and Complications.

	Cesarean delivery	Delayed hysterectomy
Intraoperative Details		
Subjects given products: n(%)		
Packed red blood cells (pRBC)	3 (13.6%)	7 (31.8%)
Number of units among those transfused	3 (1, 3)	2 (1, 3)
pRBC		
Range among those transfused pRBC	(1, 3)	(1, 4)
Fresh frozen plasma	1 (4.5%)	3 (13.6%)
Platelets	0 (0.0%)	0 (0.0%)
Cryoprecipitate	1 (4.5%)	1 (4.5%)
Fibrinogen concentrate	1 (4.5%)	0 (0.0%)
Estimated blood loss (mL)	884.1 (343.8)	850.0 (642.7)
Range	(300.0, 1500.0)	(50.0, 2200.0)
Delivery length (min)	165.6 (62.1)	227.9 (76.4)
Range	(57.0, 291.0)	(108.0, 387.0)
Skin entry: n(%)		
Vertical	20 (90.9%)	16 (72.7%)
Low transverse	2 (9.1%)	2 (9.1%)
Laparoscopic (Straight stick or robotic)	–	4 (18.2%)
Hysterotomy at delivery: n(%)		
Classical	8 (36.4%)	–
Fundal	14 (63.6%)	–
Hysterectomy: n(%)		
Supracervical	–	0 (0.0%)
Total	–	22 (100.0%)
Urologic procedures/injuries: n(%)		
Stents	0 (0.0%)	12 (54.5%)
Cystoscopy	1 (4.5%)	11 (50.0%)
Bladder resection	0 (0.0%)	3 (13.6%)
Unintentional cystotomy	0 (0.0%)	1 (4.5%)
Ureteral injury	0 (0.0%)	1 (4.5%)
Intraoperative consultation: n(%)		
Gynecologic oncology	5 (22.7%) ¹	– ¹
Urology	0 (0.0%)	4 (18.2%)
Immediate postoperative disposition: n(%)		
Intensive care unit	2 (9.1%)	0 (0.0%)
Routine floor	20 (90.9%)	22 (100.0%)
Postoperative blood products given: n(%)		
Packed red blood cells	1 (4.5%)	5 (22.7%)
Number of units among those transfused	2 (–, –)	2 (2, 2)
Range of units among those transfused	2 (–, –)	2 (2, 3)
Postoperative length of stay²	4 (4, 4)	4 (3, 5)
Range	(3.0, 9.0)	(1.0, 8.0)
Postoperative complications: n(%)		
Surgical site complication (non-infectious)	0 (0.0%)	3 (13.6%)
Surgical site infection	3 (13.6%)	1 (4.5%)
Small bowel obstruction	0 (0.0%)	0 (0.0%)
Interventional radiology complications	1 (4.5%)	–
Sepsis	0 (0.0%)	0 (0.0%)
Venous thromboembolism	1 (4.5%)	0 (0.0%)
Hemoglobin drop, preoperative to postoperative nadir	1.8 (1.2)	2.4 (1.6)
Range	(0.0, 4.2)	(-0.9, 4.8)
Subjects given methotrexate for placenta in-situ: n(%)		
Missing	1	–
Subjects given prophylactic antibiotics for placenta in-situ: n(%)		
Missing	1	–

Continuous variables presented as either mean (SD) or median (IQR).

¹ MFEM was primary for cesarean deliveries, Gyn-Onc was primary for all delayed hysterectomy cases.

² Includes 3 subjects remaining inpatient between cesarean and delayed hysterectomy.

4. Discussion

This prospective case series details the clinical outcomes of women with suspected placenta percreta managed with P-UAE and delayed hysterectomy. Our multidisciplinary algorithm incorporates P-UAE in all cases, and defaults subjects to immediate hysterectomy. Delayed hysterectomy is reserved for select cases of placenta percreta, reported here.

Women undergoing planned delayed hysterectomy (with the placenta left in-situ for 4–6 weeks until completion hysterectomy) have similar risks to those undergoing total conservative management (with the placenta left in-situ indefinitely). Data on the rates of delayed hemorrhage and endometritis for women who underwent conservative management are described in [Sentilhes et al. \(2010\)](#). In their retrospective, multicenter study of 167 subjects undergoing conservative management, 36/167 (21.6%) women inevitably required a hysterectomy for infection (18 had a hysterectomy within 24 h of delivery, and an additional 18 had an unscheduled hysterectomy at a median(IQR) 22 (9, 45) days following cesarean). The rate of unscheduled hysterectomy in the aforementioned study (21.6%) is similar to the demonstrated rate in our study (22.7%). Furthermore, both results are similar to the prospective, population-based PACCRETA study ([Sentilhes et al., 2020](#)), in which 19 (22.4%) of the 85 women in the conservative management arm inevitably required a hysterectomy a median (IQR) 44 (20, 62) days after cesarean delivery.

The transfusion outcomes of the 22 subjects in the present study are similar to [Zuckerwise et al. \(2020\)](#), the only other published dataset of delayed hysterectomy, in which 14 subjects were transfused a median (IQR) of 0 (0, 2) pRBCs. An important difference between the present study and Zuckerwise *et al* is that our algorithm systematically incorporates the use of P-UAE at the time of cesarean delivery.

Uterine artery embolization (UAE) is a well-accepted modality in the acute management of refractory postpartum hemorrhage. Targeted embolization has been increasingly employed as an adjunct or alternative for surgical treatment for uterine myoma, vascular malformations, and interstitial ectopic pregnancies. The role of targeted embolization in the adjunctive management of PAS remains under investigation. Similar in technique to a traditional UAE, placental-UAE (P-UAE) uses larger polyvinyl alcohol particles (>900 μm) and deliberate embolization of collateral arterial supply to the puerperal uterus, to further reduce blood flow and contribute to trophoblastic degeneration ([D'Souza et al., 2015](#); [Izbizky et al., 2015](#); [Pan et al., 2017](#)). Data are limited on its use in cesarean hysterectomy: one study of seven patients with pathologic placenta increta, treated with an embolization after cesarean delivery and prior to hysterectomy, demonstrated a significantly lower median EBL, transfusion requirement, and length of ICU stay compared to a control group ([Wang et al., 2019](#)). Further evaluation of P-UAE is needed to assess efficacy in reducing blood loss and transfusion requirements in PAS.

Over the past two decades, the development of regional centers has been associated with improved transfusion and perioperative outcomes for patients with PAS. As the safety profile of cesarean hysterectomy has improved, the risks of delayed hysterectomy likely outweigh the benefit in a majority cases. Given the low absolute incidence of the disease and the heterogeneity of the anatomy studied, a randomized controlled trial is unlikely. Nevertheless, our findings demonstrate that P-UAE, followed by delayed hysterectomy appears to be safe and feasible, although precautions must be undertaken. Prospective patients are counseled that between 20 and 25% of patients may have an unscheduled hysterectomy prior to the planned date. Inability for prompt return to a tertiary care center is an absolute contraindication for outpatient management during the interval between cesarean and delayed hysterectomy.

An interesting finding in this study is the high rate of discordance between intraoperative impression of placentation and the final pathology reports ([Table 4](#)). This discrepancy between intraoperative findings and pathologic findings has also been reported in the literature

Table 4

Clinical versus final pathologic diagnosis.

Intraoperative impression, n(%)	
Placenta percreta	22 (100.0%)
Final pathology, n(%)	
Accreta	1 (4.5%)
Increta	9 (40.9%)
Percreta	11 (50.0%)
Inconclusive/uterine necrosis	1 (4.5%)

for immediate hysterectomy specimens(1) ([Einerson et al., 2020](#)). We hypothesize three reasons in our cohort: overcalling the disease extent in the operating room, variations in sectioning the hysterectomy specimen leading to a false negative in extent of placentation, or due to a regression that is plausible only in delayed hysterectomy specimens. The authors suggest physiologic trophoblastic regression after cesarean delivery (see [Supplementary Fig. #2](#) for intraoperative anatomy at the time of cesarean delivery versus time of delayed hysterectomy [42 days] within the same patient). Physiologic placental regression has been demonstrated in prior radiologic studies in which conservatively-managed patients underwent serial ultrasounds to assess placental resolution ([Roulot et al., 2015](#)). Just as PAS is a spectrum of dehiscence, a spectrum of regression is plausible.

The strengths of the study include the assessment of access to care such as insurance status and distance from the hospital, which are of essence to outpatient management of placenta in-situ. Additionally, data from unscheduled cases (either cesarean or delayed hysterectomy) were included in order to reflect the real-world scenarios of PAS. Study limitations are inherent to the descriptive design. Data collection is dependent on the time periods for which details are entered. For example, intraoperative photos were not routinely taken, and we depended on subjective surgical findings within the operative notes, limited by a recall bias. Although this is the largest published dataset to date of delayed hysterectomy, study sample size is limited by the low absolute incidence of percreta and the option for clinical decision-making to pursue immediate hysterectomy. Subjects are strongly prone to selection bias, as they had to meet certain criteria permitting safe discharge planning.

5. Conclusion

Delayed hysterectomy with targeted embolization appears to be potentially safe and feasible for appropriately-selected patients with placenta percreta. Approximately 23% of subjects had unscheduled hysterectomy prior to their anticipated procedure date, similar to the rates of unscheduled hysterectomy in women undergoing conservative management.

CRediT authorship contribution statement

Luke A. Gatta: Writing - original draft, Data curation, Investigation, Project administration. **Paula S. Lee:** Conceptualization, Methodology, Resources. **Jennifer B. Gilner:** Conceptualization, Methodology, Validation, Resources. **Jeremy M. Weber:** Formal analysis. **LaMani Adkins:** Writing - original draft. **Julia R. Salinaro:** . **Ashraf S. Habib:** Resources. **Waleska Pabon-Ramos:** Resources. **Kyle C. Strickland:** Resources, Validation. **James Ronald:** Resources. **Alaattin Erkanli:** Formal analysis. **Jennifer E. Mehdiratta:** Resources. **Chad A. Grotegut:** Conceptualization, Methodology, Validation, Resources. **Angeles Alvarez Secord:** Conceptualization, Methodology, Validation, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

Acknowledgements

The authors would like to thank the contributions of Laura Havrilesky, MD, MHSc, Michael Miller, MD, Isabel V. Rodriguez, MD, Sarah Ellestad, MD, Andra James MD, MPH, and Brita Boyd, MD.

Informed Consent Statement

Written informed consent was obtained from the patient for publication of this case series and specifically for the accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Dr. Alvarez Secord discloses that her institution has received clinical trial grant funding from AbbVie, Amgen, Astellas Pharma Inc., Astex Pharmaceuticals Inc, Astra Zeneca, Boehringer Ingelheim, Bristol Myers Squibb, Clovis, Eisai, Endocyte, Exelixis, Incyte, Merck, PharmaMar, Roche/Genentech, Seattle Genetics, Inc., Tesaro/GSK, and VBL Therapeutics; she has honoraria for Advisory Boards from Aravive, AstraZeneca, Clovis, Cordgenics, Eisai, Janssen/Johnson & Johnson, Merck, Mersana, Oncoquest, Roche/Genentech, and Tesaro/GSK; and she is a member of GOG Foundation Board of Directors within the past 36 months.

Dr. Pabon-Ramos reports personal fees from Medtronic, non-financial support from Guerbet, outside the submitted work.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.gore.2021.100833>.

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