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Non-conservative Management of Placenta Accreta Spectrum in the Hybrid Operating Room: A Retrospective Cohort Study

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Abstract

Introduction Hysterectomy is the standard of care in placenta accreta spectrum (PAS). To reduce the risks of obstetric hemorrhage during surgery, endovascular interventions have been proposed. Our aim is to evaluate the feasibility and safety of the overall non-conservative management of PAS in the hybrid operating room (OR) to replace the classic two-step procedure (catheterization in the interventional radiology suite and transfer to conventional OR).

Materials and Methods This is a retrospective study of series of patients with histopathologic confirmation of PAS treated in the hybrid OR at the same university hospital. We used for comparison our historical cohort managed with the standard two-step procedure.

Results We included 110 patients, 80 in the conventional OR and 30 in the hybrid OR. There were no cases of major complications attributable to the endovascular procedures. In the two-step procedure, there were 10 (12.5%) intra-arterial catheter displacements that required repositioning in the conventional OR under mobile C-arm fluoroscopy and no cases in the hybrid OR ($p = 0.04$). The mean operative time was $380 + 42$ min in the conventional OR and $296 + 66$ min in the hybrid OR ($p = .00001$). There were no differences in the gestational age at delivery, postoperative length of stay, or large-volume blood transfusion. There were no maternal deaths.

Conclusions The overall non-conservative management of PAS in the hybrid OR has shown to be feasible and safe in our series, offering potential advantages to replace the classic two-step procedure. More studies are needed to evaluate whether this strategy is cost-effective and whether it may improve maternal and perinatal outcomes.

Keywords Hybrid operating room · Obstetric hemorrhage · Placenta accreta · Postpartum hysterectomy · Uterine artery embolization

Introduction

Placenta accreta spectrum (PAS) is the general term applied to abnormal adherence of the placental trophoblast to the uterine myometrium [1, 2]. The spectrum includes placenta accreta (attachment of the placenta to myometrium without intervening decidua), placenta increta (invasion of the trophoblast into the myometrium), and placenta percreta (invasion through the myometrium, serosa, and into surrounding structures) [1, 2]. Strong epidemiologic data support the concept that the increase in the prevalence of PAS is directly linked to the increase in cesarean delivery rates [1, 3]. Given that manually removal of the placenta in the PAS disorder typically provokes potential life-threatening bleeding, hysterectomy is the standard of care in multiparous patients that do not wish

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further pregnancies [1, 3]. Conservative treatment is only recommended in patients with a small limited area of accretism strongly wishing to maintain fertility [1].

To reduce the risks of obstetric hemorrhage during surgery and hysterectomy, endovascular interventions have been proposed [4, 5], but its role in the management of PAS remains controversial due to the lack of randomized controlled trials. However, several institutions worldwide include transarterial embolization or arterial balloon occlusion as part of their management protocol in the setting of PAS [6–9]. This treatment strategy usually includes a two-step procedure in different rooms: (a) epidural anesthesia and the insertion of arterial catheters in the interventional radiology (IR) suite because of the superior imaging capabilities compared to mobile C-arms available in the conventional operating room (OR), and (b) the transfer of the patient to the conventional OR for prophylactic ureteric catheterization (performed in order to check ureter location during the surgery), checking and eventually repositioning arterial catheters, cesarean delivery, transarterial placental embolization, and hysterectomy [6, 7].

The hybrid OR, which combines a general surgical room with high-quality imaging capabilities for interventional radiology, is increasingly being used for complex cardiovascular or neurovascular procedures [10–12]. The overall management of complex obstetric patients in a hybrid OR has been proposed as a better place for treatment, but publications exclusively addressing the management of PAS in this setting are scarce and include a limited number of patients [13–16].

The purpose of this study is to evaluate the feasibility and safety of the overall non-conservative management of PAS in the hybrid OR (one-step intervention) to replace the classic two-step procedure, comparing the results with our historical cohort.

Methods

This study is a retrospective chart review of a series of consecutive patients with PAS treated with the same one-step strategy in the hybrid OR from 2013 to October 2017 at a single university hospital. We used for comparison our historical cohort managed with the standard two-step procedure between 2002 and 2013 (catheterization in the IR suite and transfer to conventional OR for prophylactic ureteric catheterization, checking and eventually repositioning arterial catheters, cesarean delivery, transarterial placental embolization under mobile C-arm fluoroscopy, and hysterectomy) [6]. The study was subject to IRB approval. Inclusion criteria were patients with confirmed histopathology of PAS and treated with a strategy comprising bilateral uterine artery catheterization and embolization, cystoscopy for placement of bilateral ureteral stents and hysterectomy. For the purpose of the study and in order to compare the operative time and the rate of complications in the two different surgical locations, we excluded patients with uterine conservative treatment (without hysterectomy). Informed consent was obtained from all patients before treatment.

The overall management in the hybrid OR included preoperative multidisciplinary counseling, scheduled delivery around 36 weeks of gestation, and a surgical protocol including epidural anesthesia, cystoscopy with bilateral ureteral stent placement, bilateral uterine artery catheterization and angiography, midline laparotomy, hysterotomy and delivery of the fetus without attempt of placental removal, followed by general anesthesia, transarterial placental embolization, and total or subtotal hysterectomy. Two interventional radiologists with 15 and 30 years of experience performed the embolization procedures, and a single gynecologist with 20 years of experience performed the surgeries.

The endovascular procedures were performed in the hybrid OR using a simultaneous bilateral femoral approach with 5-F Cobra 2-type catheters (Glidecath, Terumo, Tokyo, Japan) that were introduced coaxially through 5-F introducers (Terumo, Tokyo, Japan). Each catheter was first placed in the anterior trunk of the contralateral internal iliac artery and then selectively in the uterine arteries. Angiography was performed with low-osmolar contrast medium (Hexabrix, Guerbet, Roissy, France). Immediately after the completion of the angiography, the robotic C-arm (Artis Zeego, Siemens, Erlangen, Germany) was parked automatically to liberate space for surgeons and laparotomy was performed. After delivery of the fetus and without removal of the placenta, the robotic arm of the angiography was automatically repositioned for fluoroscopy. Free-flow bilateral uterine artery embolization was performed with gelatin sponge (Gelfoam, Upjohn, Kalamazoo, Michigan) cut in slices (a maximum of two gelatin sponge sheets) until complete stasis. If the preoperative pelvic angiography showed significant uterine vascular supply from the vesical or vaginal arteries, these vessels were also catheterized and embolized.

Anesthesia time was calculated from the epidural anesthesia to the end of the surgery. Complications related to endovascular procedures were reported following the Cirse Classification System [17]. We defined "intravascular catheter displacement" as the need of repositioning the uterine artery catheter immediately prior to surgery. We defined "large-volume blood transfusion" as 4 or more units of packed red blood cells. We defined "bladder surgery" as the need to repair the bladder because of the occurrence of an injury during the surgery. Perinatal and

maternal outcomes were recorded (including maternal age, obstetric history, gestational age at delivery and maternal morbidity—including blood loss and the need of transfusions—and neonatal morbidity).

Statistical analysis

The data are presented with measures of central tendency and dispersion according to the distribution using the mean or median and standard deviation or interquartile interval. Proportions were used for categorical variables. The statistical significance of differences in continuous data was determined using Student's t test and the Mann–Whitney test for unpaired data. Differences in categorical data were determined using the Chi-square test or Fisher's exact test. Statistical analyses were carried out using Stata version 13.0 (StataCorp., TX, USA).

Results

Among 153 consecutive patients suspected prenatally to have PAS and managed with a multidisciplinary strategy between February 2002 and October 2017, we excluded 43 patients because acute early massive hemorrhage forced emergency delivery precluding prophylactic uterine artery catheterization and ureteral stents placement ($n = 7$) or because a conservative treatment was performed ($n = 36$). Thus, we included 110 patients, 80 managed in the conventional OR and 30 in the hybrid OR. Demographic and clinical characteristics of the patients managed in the conventional OR and in the hybrid OR are shown in Table 1, with no differences between both populations. Table 2 shows the perioperative management and morbidity of patients with PAS managed in the hybrid OR compared to our historical cohort. There were no cases of

major complications attributable to the endovascular procedures. One patient (1.2%) in the conventional OR group experienced a minor complication consisting of decreased temperature in the right lower limb and mild paresthesia 6 h after surgery. Both Doppler ultrasound and angio-CT showed patent lower limb arteries. Her symptoms resolved spontaneously in the following morning, and follow-up was uneventful. There were 10 (12.5%) intra-arterial catheter displacements in the two-step procedure and no cases in the hybrid OR ($p = 0.04$). The mean anesthesia time was 380 ± 42 min in the conventional OR and 296 ± 66 min in the hybrid OR ($p = .00001$). There were no differences in the gestational age at delivery and in the postoperative length of stay ($p > 0.05$). There were no maternal deaths. There were no differences in the need of blood transfusion (40/80 (50%) in the conventional OR and 12/30 (40%) in the hybrid OR, $p = 0.3$) or in the need of large-volume blood transfusion (16/80 (20%) vs. 6/30 (20%), $p = 1$).

Discussion

The hybrid OR is a feasible and safe scenario for multidisciplinary management of patients with PAS with the advantage of allowing both steps of the procedure (preoperative uterine artery catheterization and ureteral stent placement as well as C-section, arterial embolization, and hysterectomy) to occur in an single location. There was no difference in maternal and neonatal morbidity, but the hybrid OR showed advantages including the absence of patient transfer between two different surgical areas contributing to a significant reduction in the total anesthesia time. The absence of patient transfer was the most time-saving issue and may also be of potential interest in terms of patient safety. The latter may be relevant in the setting of

Table 1 Demographic and clinical characteristics of patients with placenta accreta spectrum managed in the conventional operating room and in the hybrid operating room		Conventional ($n = 80$)	Hybrid ($n = 30$)	p
	Age (years) (mean SD)	35.7 ± 4.6	36 ± 5.5	0.7
	Gravidity (median IQ)	4 (3–4)	4 (3–5)	1
	Parity (median IQ)	2 (1–3)	2 (1–3)	1
	Prior cesarean section (n/%)			
	0	1/1.2%	0/0%	0.5
	1	31/36.9%	10/33%	0.7
	≥ 2	52/61.9%	20/67%	0.6
	Prior uterine curettage (n/%)			
	Yes	23/29%	13/43%	0.1
	Placental occlusive (n/%)			
	Yes	72/90%	29/97%	0.2

SD standard deviation, *IQ* interquartile range

Table 2 Peripartum management and morbidity of patients with placenta accreta spectrum managed in the conventional operating room and in the hybrid operating room

	Conventional (n = 80)		Hybrid (n = 30)		p
Anesthesia time (minutes) (mean SD)[a]	380 ± 42		296 ± 66		0.0001
Ureteric stent placement (n%)	80	100%	30	100%	1
Uterine arteries embolization (n%)	80	100%	30	100%	1
Intravascular catheter dislodgement (n%)	10	12.5%	0	0%	0.04
Gestational age at delivery (weeks) (median IQ)[b]	36 (34.1–37)		35.8 (34–36)		0.5
Postoperative length of stay (days) (median IQ)	4 (4–6)		4.5 (4–6)		0.19
Blood transfusion (U/PRBC) (n%)	42	50%	12	40%	0.3
≥ 4	16	19%	6	20%	0.9
Complications (n%)					
Bladder surgery	39%	46.4	11	36.7	0.3
Others (not bladder surgery)	10[d]	11.9%	5[e]	16.7%	0.5
Due to endovascular procedures[c]	1	1.1	0	0%	0.5
ICU admission (n%)	17%	20.3	8%	27	0.4
Readmission (n%)	5%	7.5	1	3%	0.3
Birth weight (g) (mean SD)	2617	711	2691	731	0.6
NICU admission (n%)	50%	59.5	16	53%	0.5

SD standard deviation, IQ interquartile range, ICU intensive care unit, NICU neonatal intensive care unit

[a]Anesthesia times were calculated from epidural anesthesia to the end of the surgery

[b]Deliveries were scheduled around 36 weeks of gestation unless complications, usually bleeding, prompted earlier delivery

[c]Minor complication: decreased temperature in the right lower limb and mild paresthesia 6 h after surgery. Both Doppler ultrasound and multi-detector computed angiogram showed normal, patent vessels. Her symptoms resolved spontaneously the following morning, and follow-up was uneventful

[d]Coagulopathy/shock (n = 5); vault hematoma (n = 2); thromboembolism (n = 1); vesico-vaginal fistula (n = 1); wound infection (n = 1)

[e]Coagulopathy/shock (n = 2); vault hematoma (n = 1); evisceration (n = 1); unilateral ureteral trauma (n = 1)

a critically ill patient who is at increased risk of morbidity and mortality during transport [18]. Indeed, some studies reported multiple adverse events during intra-hospital transfers, including equipment failure, intravascular catheter displacement, and cardiorespiratory events [18, 19]. Keeping the patient steady on the same table during the entire procedure offers an additional advantage of avoiding the need to check or eventually reposition intra-arterial catheters, as it was the case in 12% of our patients managed in the conventional OR. Performing a one-step procedure in the conventional OR with a mobile C-arm could be an alternative to the hybrid OR, but being imaging capabilities and space requirements much better in the latter, the hybrid OR seems a more appropriate location for complex surgeries [12–14].

An additional factor that contributes to the reduction in anesthesia time and potentially contributes to patient safety is the speed of parking and repositioning of the angiographic equipment in the hybrid OR. In the conventional OR, mobile C-arms need to be manually positioned, even those with a motorized system that usually do not have an interface with the surgical table. Therefore, the operator needs to check every movement of the mobile C-arm to achieve proper position and avoid collisions. In contradistinction, in the hybrid OR the angiographic equipment can be controlled by a remote user interface with communication with the table, thus providing completely automatic movements. This allows the angiographic equipment to be easily brought to a parking position and back to the exact projection, which can easily be restored.

There were no cases of major complications attributable to the endovascular procedures and only one minor complication in the conventional OR (grade 1 of the Cirse Classification System) [17].

The literature describes two different types of endovascular interventions to diminish bleeding before hysterectomy in the management of PA: temporary balloon occlusion of the iliac arteries and bilateral embolization of the uterine vessels [9]. Although balloon placement is widely practiced, high rates of complications related to this procedure have been reported and its benefits have not been clearly demonstrated [20–22]. In a series of 19 patients who underwent prophylactic balloon catheter placement, Shrivastava et al. [20] reported a 16% rate of major

complications related to the intervention. One patient developed a groin hematoma that was associated with occlusive dissection of the iliac artery, and two patients developed iliac and femoral artery thrombosis as a consequence of the endovascular procedures The use of prophylactic bilateral uterine artery catheterization and embolization, on the other hand, has shown to be feasible and safe [6]. Moreover, although this study was not designed to establish the efficacy of prophylactic bilateral uterine artery embolization in diminishing intra-operative blood loss, it is interesting to notice that only 20% required large-volume blood transfusion (4 or more units of packed red blood cells) in this patient cohort. These figures appear to be lower than in other large series that used different strategies for managing PAS [23–25]. Mok et al. [23] reported large-volume blood transfusions as high as 58% in patients treated with prophylactic pelvic artery balloon catheterization ± uterine artery embolization. Hoffman et al. [24] reported that 41% of patients needed 4 or more units of packed red blood cells and Eller et al. [25] reported 40–70% of large-volume blood transfusions, depending on the type of medical care (tertiary multidisciplinary vs. standard obstetric).

The hybrid OR has the same lighting, infection control, air circulation standards and provides space for surgical, anesthetic and neonatology equipment as the conventional OR, but it has superior imaging capabilities compared to mobile C-arms [14]. The dedicated specific angiographic equipment of the hybrid OR has a better image quality with lower radiation exposure compared to mobile C-arms [12–14]. Indeed, a powerful X-ray generator allows better contrast quality in the angiographic series and supports high-end imaging even in long procedures. Images may be acquired at a very low-dose level of radiation with specific programs available in modern equipment that could help reduce maternal and fetal radiation doses [26].

In summary, the use of the hybrid OR offers some advantages: avoidance of patient transfer and intra-arterial catheter displacement, superior imaging capabilities with a theoretical lower radiation exposure and reduction in the anesthesia time. Because of the aforementioned reasons, management of PAS in the hybrid OR is now an established policy at our institution.

This study has some limitations including its retrospective nature, the small number of patients included in the hybrid OR, and the lack of recorded radiation doses. In our series, both strategies, the classic two-step procedure and the one-step procedure, showed similar clinical outcome despite the aforementioned advantages of the latter. However, the small number of patients in the one-step procedure may explain this issue and further studies with larger populations are mandatory to demonstrate its real advantages in terms of safety. Of note, we excluded 36 patients because no hysterectomy was performed, and the reason was that most of those patients (many of them false positive cases, with no intra-operative diagnosis of PAS) belonged to the conventional OR treatment group and, therefore, comparison of different outcomes, as operative time or maternal morbidity, would have been biased.

Conclusion

In conclusion, the overall non-conservative management of PAS in the hybrid OR has shown to be feasible and safe in our case series, offering potential advantages to replace the classic two-step procedure. More studies are needed to evaluate whether this strategy is cost-effective and whether it may improve maternal and perinatal outcomes.

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