Archives of Gynecology and Obstetrics (2019) 299:113–121
https://doi.org/10.1007/s00404-018-4947-6

MATERNAL-FETAL MEDICINE

Matsubara–Yano suture: a simple uterine compression suture for postpartum hemorrhage during cesarean section

Hironori Takahashi[1] · Yosuke Baba[1] · Rie Usui[1] · Hirotada Suzuki[1] · Kenji Horie[1] · Hitoshi Yano[1] · Akihide Ohkuchi[1] · Shigeki Matsubara[1]

Received: 18 March 2018 / Accepted: 17 October 2018 / Published online: 24 October 2018

Abstract

Aims The aims of this study were to clarify: (i) the effectiveness of Matsubara–Yano uterine compression suture (MY) to achieve hemostasis in the presence of postpartum hemorrhage (PPH) during cesarean section, (ii) the type of PPH for which MY is effective, (iii) post-operative complications of MY, and (iv) outcomes of pregnancy after MY.

Methods This retrospective observational study was performed using medical records of patients for whom MY had been performed between January 1, 2009 and December 31, 2017.

Results MY was performed for 50 patients, with hemostasis achieved in 46 (92%). The other four (8%: 4/50) patients required transarterial embolization or hysterectomy. Of these four, three patients had placenta accreta spectrum (PAS) disorder-related bleeding. Post-operative complications were observed in three (6%: 3/50) patients, with all showing intrauterine infection. All three patients recovered solely with antibiotics. Eight pregnancies were confirmed (five livebirths, two spontaneous abortions in the first trimester, and one case of ongoing pregnancy). Of the five livebirths, one resulted in cesarean hysterectomy due to placenta previa with PAS disorders.

Conclusions MY had a hemostatic effect on PPH. All cases except one with hemostatic failure were associated with PAS disorders, indicating that the hemostatic rate was lower in those with PAS than non-PAS disorders.

Keywords Cesarean section · Placenta accreta spectrum · Postpartum hemorrhage · Transarterial embolization · Uterine compression suture

✉ Hironori Takahashi
hironori@jichi.ac.jp

Yosuke Baba
ybabati@jichi.ac.jp

Rie Usui
satori@jichi.ac.jp

Hirotada Suzuki
killip@jichi.ac.jp

Kenji Horie
r0946kh@jichi.ac.jp

Hitoshi Yano
yanoh@yomogi.ne.jp

Akihide Ohkuchi
okuchi@jichi.ac.jp

Shigeki Matsubara
matsushi@jichi.ac.jp

[1] Department of Obstetrics and Gynecology, Jichi Medical University, 3311-1 Yakushiji, Shimotsuke, Tochigi 329-0498, Japan

Abbreviations

ART	Assisted reproductive technology
BW	Birth weight
CH	Cesarean hysterectomy
CS	Cesarean section
IQR	Interquartile range
MY	Matsubara–Yano uterine compression suture
MT holding	Matsubara–Takahashi holding the cervix
NICU	Neonatal intensive care unit
PAS	Placenta accreta spectrum
PPH	Postpartum hemorrhage
SA	Spontaneous abortion
TAE	Transarterial embolization
UCS	Uterine compression suture

Introduction

Postpartum hemorrhage (PPH) is sometimes life threatening. Uterine compression suture (UCS) frequently achieves hemostasis in the presence of PPH, precluding the need to employ more invasive procedures including hysterectomy or transarterial embolization (TAE). Several kinds of UCS, including B-Lynch [1], Hayman [2], and Cho [3] suture, have been devised, with all having both merits and demerits. B-Lynch suture requires penetration of the uterine wall six times with a single thread, which is a complicated procedure for less-experienced doctors. Hayman is simpler than B-Lynch (referred to as a "simple brace"), transfixing both the anterior and posterior uterine walls at around the lower segment hysterotomy site. However, the suture does not transfix the uterine cephalad part and, thus, it can slide off the uterine fundus. A simpler and more effective UCS has been awaited.

We devised the novel Matsubara–Yano UCS (MY) in 2000 and, since then, we have continued to employ it for PPH, with MY becoming our department's standard protocol. We preliminarily reported our experience in 2009 [4], after which MY gained in popularity in Japan and was cited in a Japanese textbook. In MY, two or three longitudinal and two transverse transfixing sutures are placed, thereby approximating the anterior and posterior uterine walls [4, 5]. MY is simple, overcoming the demerits of B-Lynch and Hayman sutures described above [5]. Other hemostatic procedures, such as intrauterine balloon use or "holding the cervix (Matsubara–Takahashi technique: MT holding)" [6–8], can be concomitantly used with MY. We believe that MY has several merits over other types of UCS, which we previously described [5]; however, due to the small study population, we could not objectively demonstrate its effectiveness.

The present retrospective observational study was conducted to determine: (i) the effectiveness of MY to achieve hemostasis in the presence of PPH during cesarean section (CS), (ii) the type of PPH for which MY is effective, (iii) post-operative complications of MY, and (iv) outcomes of pregnancy after MY.

Materials and methods

This retrospective observational study was approved by the Ethics Committee (Institutional Review Board: IRB) of our institute. Considering that MY has already been acknowledged in Japan and it has been performed safely in this institute since 2000 (as described later), and also considering that MY is frequently performed in emergent cases, the IRB considered that written informed consent (both for performing MY and reporting the results/data) from each patient was not necessary. However, to adhere to ethical standards: (i) we informed patients that hemostatic procedures including MY may be performed in the event of PPH, and (ii) we announced on our department website that patients could refuse the usage of their individual data. Our institution is a tertiary center, one of the largest in Japan, and it deals with 1000 high-risk deliveries annually. We retrieved medical records of patients for whom MY had been performed between January 1, 2009 and December 31, 2017.

Our protocol for PPH was consistent with the recommendations of ACOG [9] and Japanese Guidelines [10]. Briefly, perineal/cervical laceration or hysterotomy was sutured/closed after vaginal delivery or at CS, respectively. Uterotonics (oxytocin, methylergometrine, prostaglandin F2-alpha, or their combination) were administered intravenously or intramuscularly with uterine massage. When these procedures did not achieve hemostasis, MY was performed based on the judgement of experienced obstetricians: professors (SM, AO), associate professors (HT, RU), and assistant professors (YB, HS). They each have more than 15 years of experience as an obstetrician. Each doctor has attended more than 1000 CSs and conducted UCS using MY in more than 10 cases.

As previously described [4–6, 11, 12], MY was performed either during CS or after vaginal delivery, with the latter requiring laparotomy. In the case of vaginal delivery, an intrauterine balloon and/or MT holding (described later) was employed before MY. MY following vaginal delivery was applied for only two patients during the study period. For brevity, we excluded the two patients with vaginal delivery from this study. During the study period, CS was performed for 4844 patients and, of those, massive bleeding ($\geq$ 1500 mL) was noted in 460. A 70-mm round needle with No. 1 Coated Vicryl (Ethicon, Someville, NJ, USA) transfixes the uterine caudal part (lower uterine body) from the anterior to posterior sides and then transfixes the uterine fundus from the posterior to anterior sides (longitudinal suture) (Fig. 1a, b). Then, transverse sutures are deployed laterally to the longitudinal sutures (Fig. 1c). The transverse sutures prevent the sliding-off of threads or uterine bowing: in the former, longitudinal threads slide off from the uterine fundus and, in the latter, the uterus becomes anteflexed: both cause incomplete compression. The number of threads used depends on the situation (uterine size, hemorrhage area, or others) but usually two longitudinal and two transverse sutures are employed, with the final result shown in Fig. 1c.

Other hemostatic procedures were also used concomitantly with MY based on the obstetricians' judgement: intrauterine balloon use [7], MT holding [8, 13], or both. We initially performed MY in all patients. When attending

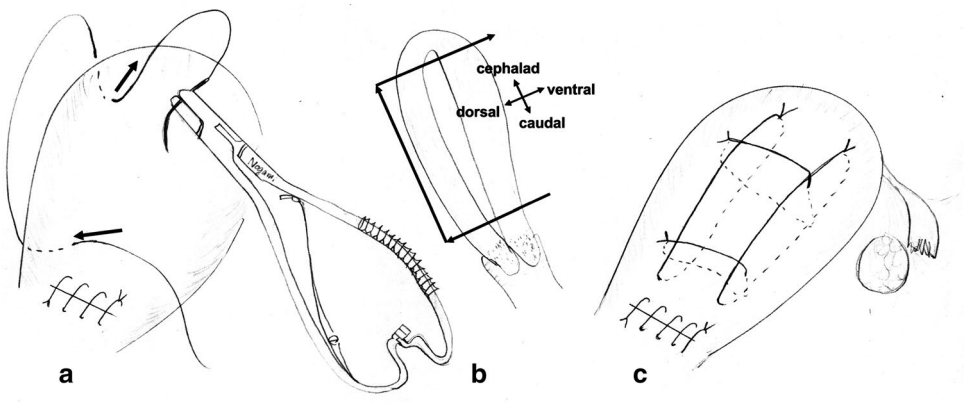

Fig. 1 Schema of the Matsubara–Yano uterine compression suture (MY). The schema is for a case with cesarean section. MY is also available in the case of vaginal delivery. **a** The first needle penetrates the uterine caudal part from the anterior to posterior sides (lower arrow) and then penetrates the uterine fundus from the posterior to anterior sides (upper arrow), facilitating the first longitudinal suture. **b** Sagittal view of the uterus after the first longitudinal suture. **c** The completion of MY. Usually two longitudinal and two transverse transfixing sutures are made, with the completed feature showing #

obstetricians employed the concomitant hemostatic procedures with MY, there were two situations. First, massive bleeding continued in spite of MY. Second, even if there was no or minimal bleeding following MY, hemostatic procedures concomitant with MY were employed preventively or prophylactically. As the intrauterine balloon, Neometro (a metreurynter, Softmedical, Tokyo, Japan) or Bakri balloon (Cock Medical, Bloomington, IN, USA) was used. The Japanese Ministry of Health, Labour and Welfare approved Bakri balloon use for PPH in 2015: the former and latter were used before and after 2015, respectively. In either case (Neometro or Bakri), the inflation volume was decided based on the achievement of hemostasis (tamponade test), with the final inflation volume being 100–300 mL. The balloon was removed after 12–24 h. The procedure of MT holding was described previously [8]. In brief, the anterior and posterior cervical lips were held with round (Atom Medical, Tokyo, Japan) or L-shaped (Sanritsu, Tokyo, Japan) forceps to close the external cervix. The forceps were removed after 12–24 h.

We analyzed the profiles and outcomes of patients with PPH managed using MY. The following information was retrieved from the medical records: maternal age, parity, mode of conception, history of CS, mode of delivery, operative time (CS including MY), weeks at delivery, birth weight, neonatal intensive care unit admission, placental weight, cause of PPH, concomitant use of other hemostatic procedures (intrauterine balloon and/or MT holding), blood loss, lowest level of hemoglobin, lowest level of fibrinogen, autologous transfusion, and intensive care unit admission. Next, we investigated the success rate of MY. We defined hemostatic "success" as when the following conditions were all fulfilled: (1) bleeding stopped after MY placement, (2) ultrasound revealed no intra-abdominal bleeding, and (3) vital signs were stable. "Failure" was defined as cases requiring hysterectomy or TAE. Short-term post-operative complications (e.g., uterine infection, intestinal obstruction, and uterine necrosis) associated with MY were examined. Lastly, we followed up the subsequent pregnancies in patients managed with MY.

The terms used were defined as follows: (1) blood loss: bleeding volume [weighing gauze and directly measuring blood volume (1 g = 1 mL)] during surgery (including amniotic fluid at CS and hysterectomy) + up to 6 h postpartum, and (2) atonic bleeding: PPH in which uterine body contraction was not evident and all other etiologies of PPH were ruled out.

Regarding placental adherence and/or invasive abnormality, we use the term placenta accreta spectrum (PAS placenta creta, increta, percreta) disorders [14–16]. When increta or percreta was suspected based on image analyses, cesarean hysterectomy (CH) leaving the placenta in utero was scheduled and, thus, such cases were excluded from this study. We prenatally diagnosed this condition when patients met all the following [17]: anterior placenta, loss of clear zone, abnormal multiple placenta lacunae of ≥ 1 cm in diameter, and uterovesical hypervascularity. For some patients in the present study population, a presurgical diagnosis of PAS disorders was not made. In these patients, if hysterectomy was performed, a histological diagnosis of PAS (creta, increta, or percreta) disorders was made. If hysterectomy was not performed, we diagnosed some patients with "clinical PAS disorders", in which a subdivision of PAS disorders was not made.

Exclusion criteria were: (1) amniotic fluid embolism, which was suspected based on clinical and/or laboratory findings, and (2) conditions preventing MY such as severe intra-abdominal adhesion or multiple leiomyoma.

To clarify the procedural simplicity of MY, we performed an anonymous questionnaire survey involving ten attending obstetricians in our institute. They were asked to consider: whether or not, MY: (1) is clinically useful, (2) should be applied more widely, and (3) is simple to apply compared with B-Lynch suture. The responses were: (1) totally disagree, (2) partly disagree, (3) partly disagree and partly agree, (4) partly agree, (5) totally agree, and (6) I don't know. All analyses were performed using JMP version 10 (SAS Institute Japan, Tokyo, Japan).

Results

MY was performed in 50 patients. Table 1 shows their backgrounds. Pregnancies after assisted reproductive technology and patients with prior CS accounted for 24% (12/50) and 12% (6/50), respectively. The median overall (CS + MY) operative time was 57.5 min.

Table 2 shows PPH characteristics of these 50 patients. Atonic bleeding (36%: 18/50) and placenta previa without PAS disorders (36%: 18/50) were the most common causes of PPH, followed by placenta previa with PAS disorders (12%: 6/50). Approximately, a half (48%: 24/50) had placenta previa with or without PAS disorders. The concomitant use of a hemostatic procedure with MY was employed for 36 (72%: 36/50, MY + intrauterine balloon: 8, MY + MT holding: 12, MY + intrauterine balloon + MT holding: 16) patients. The median blood loss was 1587 mL: 3 (6%: 3/50) showed blood loss of > 5000 mL. Approximately, one-third of patients (32%: 16/50) received blood transfusion. Five (10%: 5/50) patients were admitted to the intensive care unit.

Table 3 shows the hemostatic outcomes. Of the 50, hemostasis was achieved in 46 (92%: 46/50) ("success"). The other four (8%: 4/50) patients showed "failure", requiring TAE or hysterectomy. Table 3 also shows the post-operative complications. Three patients (6%: 3/50) showed high-grade fever, uterine tenderness, and malodorous discharge. All three were clinically diagnosed with intrauterine infection,

Table 1 Patient background

	$n = 50$
Age (years), median (IQR)	35 (30.5–37.3)
Primipara, *n* (%)	29 (58)
Pregnancy by ART[a], *n* (%)	12 (24)
Multiple pregnancies, *n* (%)	17 (34)
Prior CS, *n* (%)	6 (12)
Leiomyoma, *n* (%)	3 (6)
Operative time[b] (min), median (IQR)	57.5 (49.8–72.3)
Delivery date (weeks), *n* (%)	
< 32 + 0	4 (8)
32 + 0–36 + 6	16 (32)
37 + 0 ≤	30 (60)
Birth weight (g), median (IQR)	2476 (2269–2875)
Male infant, *n* (%)	41/67 (61)
Fetal death[c]	1 (2)
NICU admission, *n* (%)	28/67 (42)
Placental weight[d], median (IQR)	610 (513–719)

ART assisted reproductive technology, *CS* cesarean section, *IQR* interquartile range, *NICU* neonatal intensive care unit

[a]Included in vitro fertilization and intracytoplasmic sperm injection

[b]Included the duration required for hysterectomy

[c]One fetus died due to placental abruption

[d]Limited to singleton pregnancy

Table 2 PPH characteristics of patients managed with MY

	$n = 50$
Cause of PPH	
Atonic bleeding	18 (36)
Placenta previa without PAS disorders	18 (36)
Placenta previa with PAS disorders	6 (12)
PAS disoders in normal placental position	4 (8)
Inversion[a]	1 (2)
Placental abruption	3 (6)
Concomitant use of hemostatic procedure	36 (72)
MY + intrauterine balloon, *n* (%)	8 (16)
MY + MT holding, *n* (%)	12 (24)
Triple procedure[b], *n* (%)	16 (32)
Blood loss (mL), median (IQR)	1587 (1008–2465)
2500–5000, *n* (%)	9 (18)
5000–, *n* (%)	3 (6)
Lowest level of hemoglobin (g/dL), median (IQR)	8.3 (7.0–9.4)
Lowest level of fibrinogen (mg/dL), median (IQR)	245 (135–322)
Transfusion, *n* (%)[c]	16 (32)
Autologous	10 (20)
Red blood cells (units[d])	10 (20)
Fresh frozen plasma (units[d])	10 (20)
Platelet concentrations (units[d])	6 (12)
ICU admission, *n* (%)	5 (10)

ICU intensive care unit, *IQR* interquartile range, *MT holding* Matsubara–Takahashi holding the cervix, *PAS* placenta accreta spectrum, *MY* Matsubara–Yano uterine compression suture, *PPH* postpartum hemorrhage

[a]Of the three, the inverted uterus could not be repositioned transvaginally in two patients. We conducted laparotomy, repositioned the uterus, and performed MY. The other patient repeatedly showed inversion during cesarean section. We performed MY to prevent recurrence

[b]MY + intrauterine balloon + MT holding

[c]Including autotransfusion

[d]One unit contains 140, 120, and 20 mL of red blood cells, fresh frozen plasma, and platelets, respectively

Table 3 Outcomes of patients managed with MY

	$n=50$
Success, *n* (%)	46 (92)
Failure, *n* (%)	4 (8)
Hysterectomy	3 (6)
TAE	1 (2)
Post-operative complication, *n* (%)	
Uterine infection[a]	3 (6)
Intestinal obstruction	0 (0)
Uterine hematoma	0 (0)
Sepsis	0 (0)
Uterine necrosis	0 (0)

MT holding Matsubara–Takahashi holding the cervix, *MY* Matsubara–Yano uterine compression suture, *TAE* transarterial embolization

[a]Myometritis, and/or endometritis. Of the three, tiny placental fragments remained in the uterus in one patient

which resolved with antibiotic administration. No patients suffered intestinal obstruction, uterine hematoma, sepsis, or uterine necrosis.

Table 4 shows the hemostatic effect of MY only vs. the concomitant use of a hemostatic procedure with MY. Concomitant use, compared with MY only, was significantly more likely to be employed in placenta previa (MY only 14%: 2/14 vs. concomitant use 61%: 22/36; $p=0.004$) and less likely to be used for atonic bleeding (MY only 57%: 8/14 vs. concomitant use 28%: 10/36; $p=0.10$). Although patients with concomitant use bled more than patients with MY only [MY only 920 (630–1798) mL vs. concomitant use 1815 (1273–2518) mL; $p=0.003$], the success rate (hemostasis achieved) was similar between the two groups (MY only 93%: 13/14 vs. concomitant use 92%: 33/36; $p=1.00$).

Next, we focused on hemostatic failure cases managed with MY (Table 5). The causes of PPH were atonic bleeding ($n=1$), placenta previa with PAS disorders ($n=2$), and PAS disorder in the normal placental location ($n=1$). Thus, of the four, three patients had PAS disorder-related bleeding. The remaining patient showed recurrent atonic bleeding 3 h after CS: MT holding was incidentally declamped and the intrauterine balloon prolapsed into the vagina, causing the recurrent bleeding.

Lastly, subsequent pregnancy outcomes in patients managed with MY were examined (Table 6). Eight pregnancies were confirmed (five livebirths, two spontaneous abortions in the first trimester, and one case of ongoing pregnancy). Of the five livebirths, one resulted in CH due to placenta previa with PAS disorders at 33 weeks of gestation, in whom placenta creta (PAS disorders nomenclature) was histologically diagnosed (case 7 in Table 6).

The questionnaire survey demonstrated that doctors were satisfied with MY. All ten obstetricians gave "full marks = 5" in response to all three statements (is clinically useful, should be used more widely, and simple to apply compared with B-Lynch suture).

Table 4 Hemostastic effect of MY only in comparison with concomitant use

	MY only ($n=14$)	Concomitant use ($n=36$)	*p* value[b]
Age (years), median (IQR)	36 (31.8–39)	34 (30–36)	0.13
Prior CS, *n* (%)	4 (29)	2 (6)	0.04
Cause of PPH, *n* (%)			
Atonic bleeding	8 (57)	10 (28)	0.10
Placenta previa[a]	2 (14)	22 (61)	0.004
PAS disorders[a]	3 (21)	7 (19)	1.00
Inversion	1 (7)	0 (0)	0.28
Placental abruption	1 (7)	2 (6)	1.00
Operative time (min), median (IQR)	54 (49–66)	61 (51–73)	0.31
Success (hemostasis achieved)	13 (93)	33 (92)	1.00
Blood loss (mL), median (IQR)	920 (630–1798)	1815 (1273–2518)	0.003
Transfusion, *n* (%)	2 (14)	14 (39)	0.18
Lowest level of hemoglobin (g/dL), median (IQR)	8.9 (7.8–9.7)	8.1 (6.7–9.3)	0.16
ICU admission, *n* (%)	0 (0)	5 (14)	0.30

MY + (intrauterine balloon and/or MT holding)

ICU intensive care unit, *IQR* interquartile range, *PAS* placenta accreta spectrum, *MY* Matsubara–Yano uterine compression suture, *PPH* postpartum hemorrhage

[a]One and five patients were complicated with placenta previa with PAS discorders in "MY only" and "Concomitant use" groups, respectively

[b]The significance between group differences was calculated using Fisher's exact test and the Wilcoxon rank sum test, and *p* values < 0.05 were considered to show significance

Table 5 Hemostatic failure cases managed with MY

Age	Parity	Prior CS	Mode of conception	Mode of delivery	Delivery week	Cause of PPH	Intrauterine balloon	MT holding	Additional procedure	Blood loss (mL)
30	1	–	Natural	CS	37+1	Atonic bleeding	+[a]	+[a]	Hysterectomy	7205
36	0	–	ART	CS	36+5	Placenta previa with PAS disorders	+	+	TAE	7000
35	0	–	Natural	CS	37+1	Placenta previa with PAS disorders	+	+	Hysterectomy	9000
35	1	+	Natural	CS	37+1	PAS in normal placental position	–	–	Hysterectomy	2660[b]

ART assisted reproductive technique, *CS* cesarean section, *MT holding* Matsubara–Takahashi holding the cervix, *MY* Matsubara–Yano uterine compression suture, *PAS* placenta accreta spectrum, *PPH* postpartum hemorrhage, *TAE* transarterial embolization

[a]Intrauterine balloon and MT holding incidentally prolapsed 3 h after CS

[b]The bleeding volume is considered to be underestimated. Twelve units of red blood cells and 20 units of fresh frozen plasma were required for this patient

Discussion

Four important findings were obtained. MY had a marked hemostatic effect on PPH. All cases excluding one with hemostatic failure were associated with PAS disorders, indicating that the hemostatic rate was lower in those with PAS than non-PAS disorders. There were no severe short-term complications: 6% of patients (3/50) suffered intrauterine infection, with all cases resolving with antibiotic treatment. Subsequent pregnancy outcomes were generally favorable, although placenta previa with PAS disorders occurred in one patient.

MY had a marked hemostatic effect on PPH. Except for B-Lynch suture, outcomes of various UCS have been reported solely based on case series [18–20]. We introduced MY in 2000; it has gained in popularity among Japanese obstetricians, and a Japanese textbook cites B-Lynch [1], Hayman [2], Cho [3], and MY as the four most common types of UCS. Here, we analyzed more than 50 patients receiving MY. The hemostatic rate was 93%, which approximated or is superior to that of previous reports [18–20]: in all these previous reports, B-Lynch was mainly employed. Among various types of UCS, B-Lynch [1], Hayman [2], and Cho [3] sutures are well known. However, each procedure has its demerits, as stated in "Introduction". We believe that MY is simple, overcoming the demerits of B-Lynch and Hayman sutures described above [5]. Although we did not measure the MY procedural time, it usually required 2–3 min: MY + CS required a median of 58 min. The present questionnaire survey results support the simplicity and usefulness of this procedure.

Hemostatic failure occurred in patients with PAS disorders. In PAS disorders, marked bleeding can occur from the placental separation site. MY does not usually compress the lower parts of the lower uterine segment and, thus, if PAS disorders occur at this site, MY may not achieve hemostasis from this caudal portion. This agrees with the results of a previous study in which hemostasis was more difficult in those with PAS disorders [8] than non-PAS disorders. Of four "failure" cases, three involved patients with PAS disorders, meaning that it mainly involved those with PAS disorders; however, from another perspective, of ten PAS disorder patients, hemostasis was achieved in seven (70%: 7/10). CH without removing the placenta is a basic strategy for prediagnosed PAS disorders [21]. However, the preoperative diagnosis of PAS disorders is sometimes difficult and diagnosis is difficult even during surgery. The presence of PAS disorders may first be recognized after partially removing the placenta, meaning that unexpected PAS disorders exist in real-world practice. In such patients, MY can be attempted even in cases of

Table 6 Subsequent pregnancy outcomes in patients managed with MY

Case	Age	Indication of MY at previous pregnancy	Mode of conception	Outcome	Intra-abdominal adhesion	Birth weight (g)	Blood loss (mL)	Transfusion
1	34	Placental abruption	Natural	CS at 36 weeks[b]	–	2678	650	–
2	26	Atonic bleeding	Natural	SA at 7 weeks	NA	NA	NA	–
3	40	Placenta previa	Natural	CS at 38 weeks	–	2528	640	–
4	29	Atonic bleeding, twin pregnancy	ART	CS at 37 weeks	+	2994	440	–
5[a]	26	Placenta previa with PAS disorders	Natural	SA at 8 weeks	NA	NA	NA	–
6[a]	27	Placenta previa with PAS disorders	Natural	Ongoing pregnancy (third trimester)	NA	NA	NA	NA
7	36	Atonic bleeding	Natural	Placenta previa with PAS disorders, CH at 33 weeks	–	2222	5880	+
8	35	Placenta previa without PAS disorders	Natural	CS at 37 weeks	–	2480	810	–

ART assisted reproductive technology, *BW* birth weight, *CH* cesarean hysterectomy, *CS* cesarean section, *MY* Matsubara–Yano uterine compression suture, *NA* not applicable, *PAS* placenta accreta spectrum, *SA* spontaneous abortion

[a]Cases 5 and 6 are the same patient

[b]Elective CS was performed at 36 weeks of gestation to prevent the recurrence of placental abruption

PAS disorders, depending on the situation. Hysterectomy or MY should be decided in a patient-by-patient manner. Hysterectomy conducted either too early or too late should be avoided.

The combination of other hemostatic procedures such as intrauterine balloon use and MT holding with MY may be a practical option. An intrauterine balloon or MT holding was concomitantly used with MY in nearly three-quarters of the patients, and the triple procedure was applied in one-third of the patients. We previously reported the possibility of combining hemostatic procedures (MY, intrauterine balloon, and MT holding) for PPH [6–8]. These three procedures may achieve hemostasis via different mechanisms. MY apposes the anterior–posterior uterine wall and compresses the bleeding uterine luminal surface. As the intrauterine balloon mainly tamponades the uterine luminal surface, it is especially useful to compress the caudal parts (lower segment) of the uterus. MT holding, holding the cervical isthmus and cervix, tamponades the uterine surface and also accelerates uterine contraction. Thus, the combination of these three may lead to a "double" or "triple" effect if used appropriately. In our study, the hemostatic success rate was comparable between the two groups (MY only vs. concomitant use). The interpretation of this is difficult. The patients with concomitant use, compared with those with MY only, had significantly higher rates of placenta previa, although they bled significantly more. The decision regarding concomitant use was based on the attending obstetrician's judgement. Even if hemostasis was achieved by MY only, the balloon or MT holding was sometimes employed as a prophylactic measure, but the rate of use is unknown. Furthermore, the indications for these additional hemostatic measures are not always definitely classified into therapeutic vs. prophylactic. However, data showed that their concomitant use may have a hemostatic effect on patients with placenta previa. Further studies are needed to determine when an additional suture is needed and the optimal type.

As described, of four "failure" cases, three involved PAS disorders and the remaining one patient had atonic bleeding. In the latter case, the combined procedures (MY, intrauterine balloon, and MT holding) achieved hemostasis for 3 h after surgery, and then MT holding incidentally detached, leading to balloon prolapse. Marked bleeding occurred, necessitating hysterectomy. In retrospect, if the forceps had not detached, this triple procedure may have achieved hemostasis. Further modification of our procedure may be needed.

There were no severe post-operative complications after MY. Three patients (6%) developed intrauterine infection, which resolved with antibiotic administration or did not progress to sepsis. Uterine necrosis after UCS is widely known [22, 23]. Theoretically, if the compression is too tight, leading to inadequate blood flow to the uterus, uterine necrosis may occur. In general, tighter compression is more likely to achieve hemostasis but also more likely to cause uterine necrosis: this indicates a "trade-off" relationship [5]. We do not claim that MY avoids uterine necrosis based on the number of cases studied here. Uterine necrosis can occur based on the balance between compression and uterine blood supply. It may be necessary to bear in mind that uterine necrosis could occur after MY.

Subsequent pregnancy outcomes were generally favorable. The largest study to date ($n=63$) revealed that pregnancies following B-Lynch showed no adverse outcomes [24]. However, abnormal placentation should be paid attention to. A recent report described 13 deliveries following B-Lynch suture [25]. Of those, two patients showed massive PPH of more than > 3000 mL. One patient was repeatedly managed with B-Lynch suture, and the other patient had PAS disorders necessitating hysterectomy. Another study demonstrated that the rates of placenta previa and PAS disorders were 7.9 and 1.6%, respectively, in subsequent pregnancies following B-Lynch [24]. In the present study, one of the eight pregnant patients showed placenta previa with PAS disorders requiring CH. UCS decreases the uterine blood flow for a certain period, which may cause endometrial damage, possibly leading to abnormal placentation.

There were some limitations of this study. Firstly, this was a retrospective study in a single institution. Secondly, a selection bias existed. The need for MY was decided by experienced obstetricians during the surgery: there was no "pre-surgical" protocol for MY employment. Thus, the data should be interpreted with caution: MY achieved this high rate of success when it was employed by staff experienced in this procedure; experienced to the extent that MY vs. hysterectomy can be decided during the surgery. Thirdly, as described, combinations of hemostatic procedures (intrauterine balloon and/or MT holding) were employed in some patients and, thus, whether MY only or its combination was effective for achieving hemostasis on an individual-by-individual basis was unclear. However, the present data may represent "real-world practice". We would never claim that MY is superior to other types of UCS or other procedures. Lastly, UCS can induce uterine synechia and Asherman syndrome, inducing secondary sterility [26]. We did not perform hysteroscopy to identify their presence. Although eight subsequent pregnancies were noted, it is unknown whether MY induces secondary sterility in other patients.

In conclusion, MY showed a hemostatic effect on PPH without severe post-operative complications. The combination of other hemostatic procedures including intrauterine balloon use and MT holding with MY may also be effective. MY was simple and feasible even for less-experienced obstetricians. MY also achieved hemostasis in patients with PAS disorders, but its effect on hemostasis may be weaker than that on atonic bleeding. Pregnancy outcomes after MY were generally favorable, although the occurrence of PAS disorders should be considered. Further prospective studies based on larger populations are necessary to confirm the present results.

Author contributions HT: Contributed to the conception and design of the study, data collection, data analysis, and writing of the manuscript. YB and RU: Contributed to the investigation and writing of the manuscript. HS and KH: Contributed to the investigation. HY and AO: Contributed to the conception. SM: Contributed to the conception of the study and writing of the manuscript.

Funding None.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest and received no funding regarding this study.

Ethical approval All procedures performed in studies involving human participants were conducted in accordance with the provisions of the Declaration of Helsinki. This study was approved by the Ethics Committee of Jichi Medical University.

Informed consent Not needed (situation described within the manuscript and response letter).

Approval of Institutional Review Board (IRB) Obtained.

Patients' anonymity Preserved.

References

1. B-Lynch C, Coker A, Lawal AH, Abu J, Cowen MJ (1997) The B-Lynch surgical technique for the control of massive postpartum haemorrhage: an alternative to hysterectomy? Five cases reported. Br J Obstet Gynaecol 104:372–375
2. Hayman RG, Arulkumaran S, Steer PJ (2002) Uterine compression sutures: surgical management of postpartum hemorrhage. Obstet Gynecol 99:502–506
3. Cho JH, Jun HS, Lee CN (2000) Hemostatic suturing technique for uterine bleeding during cesarean delivery. Obstet Gynecol 96:129–131
4. Matsubara S, Yano H, Taneichi A, Suzuki M (2009) Uterine compression suture against impending recurrence of uterine inversion immediately after laparotomy repositioning. J Obstet Gynaecol Res 35:819–823
5. Matsubara S, Yano H, Ohkuchi A, Kuwata T, Usui R, Suzuki M (2013) Uterine compression sutures for postpartum hemorrhage: an overview. Acta Obstet Gynecol Scand 92:378–385
6. Matsubara S, Kuwata T, Baba Y, Usui R, Suzuki H, Takahashi H, Ohkuchi A, Suzuki M (2014) A novel 'uterine sandwich' for haemorrhage at caesarean section for placenta praevia. Aust NZ J Obstet Gynaecol 54:283–286
7. Ogoyama M, Takahashi H, Usui R, Baba Y, Suzuki H, Ohkuchi A, Matsubara S (2017) Hemostatic effect of intrauterine balloon for postpartum hemorrhage with special reference to concomitant use of "holding the cervix" procedure (Matsubara). Eur J Obstet Gynecol Reprod Biol 210:281–285
8. Takahashi H, Ohkuchi A, Usui R, Suzuki H, Baba Y, Matsubara S (2018) Matsubara-Takahashi cervix-holding technique for massive postpartum hemorrhage in patients with placenta previa with or without placenta accreta spectrum disorders. Int J Gynaecol Obstet 140:357–364
9. American College of Obstetricians and Gynecologists (2006) ACOG practice bulletin: clinical management guidelines for obstetrician-gynecologists number 76, October 2006: postpartum hemorrhage. Obstet Gynecol 108:1039–1047
10. Minakami H, Maeda T, Fujii T, Hamada H, Iitsuka Y, Itakura A et al (2014) Guidelines for obstetrical practice in Japan: Japan

Society of Obstetrics and Gynecology (JSOG) and Japan Association of Obstetricians and Gynecologists (JAOG) 2014 edition. J Obstet Gynaecol Res 40:1469–1499
11. Matsubara S (2010) Uterine compression suture may be useful not only for hemostasis in postpartum hemorrhage but also for prophylaxis of acute recurrence of uterine inversion. Arch Gynecol Obstet 281:1081–1082
12. Matsubara S, Baba Y (2013) MY (Matsubara-Yano) uterine compression suture to prevent acute recurrence of uterine inversion. Acta Obstet Gynecol Scand 92:734–735
13. Matsubara S, Kuwata T (2011) Holding the uterine cervix may induce uterine contractions in atonic bleeding. Acta Obstet Gynecol Scand 90:1454–1455
14. Jauniaux E, Ayres-de-Campos D, FIGO Placenta Accreta Diagnosis and Management Expert Consensus Panel (2018) FIGO consensus guidelines on placenta accreta spectrum disorders: introduction. Int J Gynaecol Obstet 140:261–264
15. Jauniaux E, Collins S, Burton GJ (2018) Placenta accreta spectrum: pathophysiology and evidence-based anatomy for prenatal ultrasound imaging. Am J Obstet Gynecol 218:75–87
16. Allen L, Jauniaux E, Hobson S, Papillon-Smith J, Belfort MA, FIGO Placenta Accreta Diagnosis and Management Expert Consensus Panel (2018) FIGO consensus guidelines on placenta accreta spectrum disorders: nonconservative surgical management. Int J Gynaecol Obstet 140:281–290
17. Collins SL, Ashcroft A, Braun T, Calda P, Langhoff-Roos J, Morel O et al (2016) Proposal for standardized ultrasound descriptors of abnormally invasive placenta (AIP). Ultrasound Obstet Gynecol 47:271–275
18. Sentilhes L, Gromez A, Razzouk K, Resch B, Verspyck E, Marpeau L (2008) B-Lynch suture for massive persistent postpartum hemorrhage following stepwise uterine devascularization. Acta Obstet Gynecol Scand 87:1020–1026
19. Mallappa Saroja CS, Nankani A, El-Hamamy E (2010) Uterine compression sutures, an update: review of efficacy, safety and complications of B-Lynch suture and other uterine compression techniques for postpartum haemorrhage. Arch Gynecol Obstet 281:581–588
20. Kayem G, Kurinczuk JJ, Alfirevic Z, Spark P, Brocklehurst P, Knight M (2011) Uterine compression sutures for the management of severe postpartum hemorrhage. Obstet Gynecol 117:14–20
21. Sentilhes L, Goffinet F, Kayem G (2013) Management of placenta accreta. Acta Obstet Gynecol Scand 92:1125–1134
22. Joshi VM, Shrivastava M (2004) Partial ischemic necrosis of the uterus following a uterine brace compression suture. BJOG 111:279–280
23. Gottlieb AG, Pandipati S, Davis KM, Gibbs RS (2008) Uterine necrosis: a complication of uterine compression sutures. Obstet Gynecol 112:429–431
24. Cowan AD, Miller ES, Grobman WA (2014) Subsequent pregnancy outcome after B-Lynch suture placement. Obstet Gynecol 124:558–561
25. Fuglsang J (2014) Later reproductive health after B-Lynch sutures: a follow-up study after 10 years' clinical use of the B-Lynch suture. Fertil Steril 101:1194–1199
26. Rathat G, Do Trinh P, Mercier G, Reyftmann L, Dechanet C, Boulot P et al (2011) Synechia after uterine compression sutures. Fertil Steril 95:405–409