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Uterine artery ligation as the first-line surgical treatment for postpartum haemorrhage during Caesarean section: a retrospective study

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Objective: To examine the efficacy of uterine artery ligation (UAL) with or without subsequent haemostatic procedures in management of postpartum haemorrhage (PPH) during Caesarean section.
Methods: Women who underwent UAL with or without subsequent haemostatic procedures were compared in terms of maternal demographics, antenatal risk factors, delivery details, causes of PPH, sequence of treatment modalities used, and short-term complications.
Results: A total of 173 women underwent UAL with or without subsequent haemostatic procedures. The success rate of haemostasis was 96.5% (167/173) after UAL with or without subsequent haemostatic procedures; it was 81.5% (141/173) after UAL alone. Multivariate analysis revealed that women with prior PPH had a higher risk for haemostasis failure after UAL alone (adjusted odds ratio [aOR]=10.35, p=0.027), whereas women with placenta praevia had a lower risk for haemostasis failure after UAL alone (aOR=0.05, p=0.001). Compared with UAL alone, UAL followed by haemostatic procedures resulted in a higher risk of postoperative complications including haemorrhagic shock (p=0.012), disseminated intravascular coagulopathy (p<0.001), and intensive care unit admission (p<0.001). There were five cases of bowel injury and one case of pelvic vessel injury.
Conclusions: UAL is an effective and safe first-line surgical procedure for management of PPH during Caesarean section, especially for women with placenta praevia.

Keywords: Postpartum hemorrhage; Treatment outcome; Uterine artery

Introduction

Postpartum haemorrhage (PPH) is defined as blood loss ≥500 ml after delivery; it accounts for 27% of maternal deaths worldwide each year[1,2]. Common causes of primary PPH include uterine atony, genital tract trauma, retained products of conception, and coagulopathy.

In the event of failed haemostasis after medical treatment, in haemodynamically stable women, various uterine-sparing procedures (including intrauterine balloon tamponade, compression sutures, uterine artery ligation [UAL], stepwise uterine devascularisation, and pelvic artery embolisation) should be considered before a hysterectomy is performed[3]. Specifically, UAL, the first step in stepwise uterine devascularisation, can reduce 90% of blood flow to the uterus. It is a simple surgical procedure and has a haemostasis success rate ranging from 42% to 97%[3]. UAL is safe and associated with a few short-term complications such as retroperitoneal haematoma and arteriovenous malformation secondary to vessel injury[4,5]. Therefore, UAL is proposed as the first-line surgical procedure for PPH refractory to medical treatment[6]. Combinations of various uterine-sparing techniques have also been reported[7]. This study aimed to evaluate the efficacy of UAL with or without subsequent haemostatic procedures for management of PPH during Caesarean section.

Materials and methods

We retrospectively reviewed medical records of women who underwent UAL with or without subsequent haemostatic procedures for management of primary PPH during Caesarean section at Tuen Mun Hospital between 1 January 2008 and 31 December 2023. Patients with an antenatal diagnosis of placenta accreta were excluded because they opted for a Caesarean hysterectomy if the placenta failed to separate spontaneously. Data collected included demographics, antenatal risk factors, delivery details, causes of PPH, sequence of treatment modalities used, and complications.

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Before delivery of placenta during Caesarean section, routine prophylactic uterotonics of synthetic intravenous oxytocin was administered, and intravenous carbetocin and 40 IU of oxytocin infusion were given to women with risk factors for haemorrhage. Routine prophylactic antibiotics were administered before Caesarean section (1 g of intravenous cefazolin) and after uterine-sparing treatment (750 mg of intravenous cefuroxime and 500 mg of intravenous metronidazole).

UAL was performed unilaterally or bilaterally, depending on the degree of haemostasis and disease pathology. The uterus was exteriorised, and the bladder was reflected until 3 to 4 cm below the uterine incision site. Ligation was made with no. 1 Vicryl (polyglactin 910) and placed 2 to 3 cm below the level of the uterine incision through the myometrium (but not into the uterine cavity) and exited at the avascular area of the broad ligament. If UAL failed, subsequent haemostatic procedures and their sequence were decided on by senior obstetricians. For compression sutures, both the B-Lynch suture and the Hayman suture were performed with no. 1 Monocryl (polyglecaprone 25), whereas the Cho suture was performed with no. 1 Vicryl (polyglactin 910). Pelvic artery embolisation with gelatine sponges was performed by an interventional radiologist. Postnatally, pelvic examination and ultrasound were performed to assess short-term complications.

Data were analysed using SPSS (Windows version 21.0; IBM Corp, Armonk [NY], United States). Women who underwent UAL with or without subsequent haemostatic procedures were compared using the Student's *t* test or Mann-Whitney *U* test for continuous variables and the Chi-squared test or Fisher's exact test for categorical variables. Univariate and multivariate analyses were performed to identify factors associated with successful haemostasis after UAL alone. A p value of <0.05 was considered statistically significant.

Results

Over the 16 years, 173 women underwent UAL with or without subsequent haemostatic procedures for management of PPH during Caesarean section. Of these, 141 (81.5%) achieved haemostasis after UAL alone and 32 (18.5%) required subsequent haemostatic procedures. Of the latter, 30 underwent compression suture with the B-Lynch suture (n=15), Hayman suture (n=13) or Cho suture (n=2), and two underwent hysterectomy. After the compression suture, one woman required pelvic embolisation and four women required hysterectomy. The primary causes of PPH in the six women who required hysterectomy were uterine atony (n=2), placenta praevia (n=2), and placenta accreta (n=2). All the six women experienced persistent uterine atony, coagulopathy, or unstable haemodynamics.

In terms of the primary cause of PPH, UAL alone could achieve haemostasis in 92.5% (74/80) of women with placenta praevia, 87.5% (21/24) of women with tears over the uterine incision during Caesarean section, 86.2% (25/29) of women with placenta accreta, 66.7% (2/3) of women with coagulopathy, and 51.4% (19/37) of women with uterine atony.

Compared with women who required subsequent haemostatic procedures, women with UAL alone were associated with a higher rate of regional anaesthesia (38.3% vs 15.6%, p=0.015) and a lower rate of conversion to general anaesthesia (9.2% vs 25.0%, p=0.030). More women with placenta praevia underwent UAL alone (52.5% vs 18.8%, p=0.001), whereas more women with uterine atony required subsequent haemostatic procedures (56.3% vs 13.5%, p<0.001). More women who required subsequent haemostatic procedures received bilateral UAL (100% vs 85.8%, p=0.027), had longer surgical time (149 vs 83 minutes, p<0.001), more total blood loss (3800 vs 1900 ml, p<0.001), and lower intra-/post-operative haemoglobin level (7.2 vs 8.3 g/dl, p<0.001), and required more units of blood product transfusion (red blood cells: 5 vs 2, p<0.001; platelets: 4 vs 0, p<0.001; fresh frozen plasma: 4 vs 0, p<0.001) and additional medical treatment (recombinant factor VIIa: 12.5% vs 0.7%, p=0.004; carboprost: 93.8% vs 75.2%, p=0.021).

Compared with women with UAL alone, women who required subsequent haemostatic procedures had higher rates of haemorrhagic shock (15.6% vs 2.8%, p=0.012), disseminated intravascular coagulopathy (46.9% vs 9.9%, p<0.001), re-laparotomy (15.6% vs 1.4%, p=0.003), paralytic ileus (18.8% vs 4.3%, p=0.010), inotropic support (34.4% vs 2.8%, p <0.001), and admission to an intensive care unit (78.1% vs 23.4%, p<0.001), as well as longer duration of hospitalisation (median, 5.5 vs 4 days, p<0.001).

Multivariate analysis showed that prior PPH was a predictor for UAL failure (adjusted odds ratio [aOR]=10.35, 95% confidence interval [CI]=1.30-82.29, p=0.027), whereas placenta praevia was a predictor for successful haemostasis after UAL alone (aOR=0.05, 95% CI=0.01-0.32, p=0.001) [Table].

Table. Characteristics and outcomes of women who underwent uterine artery ligation (UAL) with or without subsequent haemostatic procedures for postpartum haemorrhage (PPH) during Caesarean section

Characteristic	UAL alone (n=141)*	UAL with subsequent haemostatic procedures (n=32)*	Odds ratio (95% confidence interval)	p Value	Adjusted odds ratio (95% confidence interval)	p Value
Maternal age ≥35 y	67 (47.5)	13 (40.6)	0.76 (0.35-1.65)	0.480	1.12 (0.36-3.50)	0.851
Body mass index ≥25 kg/m^2	32 (22.7)	5 (15.6)	0.63 (0.23-1.77)	0.379	0.32 (0.07-1.45)	0.138
Nulliparity	46 (32.6)	19 (59.4)	3.02 (1.37-6.64)	0.005	3.35 (0.86-13.05)	0.081
Previous Caesarean section	44 (31.2)	7 (21.9)	0.62 (0.25-1.54)	0.296	0.22 (0.04-1.21)	0.081
Prior PPH	5 (3.5)	4 (12.5)	3.89 (0.98-15.39)	0.062	10.35 (1.30-82.29)	0.027
Assisted conception	14 (9.9)	6 (18.8)	2.09 (0.74-5.95)	0.216	2.45 (0.38-15.77)	0.346
Multiple pregnancy	6 (4.3)	6 (18.8)	5.19 (1.55-17.36)	0.010	2.70 (0.34-21.26)	0.347
Polyhydramnios	1 (0.7)	0	-	>0.99	-	>0.99
Uterine fibroid/adenomyosis	13 (9.2)	5 (15.6)	1.82 (0.60-5.54)	0.334	2.18 (0.40-11.88)	0.369
History of antepartum haemorrhage	68 (48.2)	12 (37.5)	0.64 (0.29-1.42)	0.272	0.73 (0.16-3.42)	0.690
Hypertensive disorders of pregnancy	4 (2.8)	5 (15.6)	6.34 (1.60-25.16)	0.012	4.81 (0.52-44.60)	0.167
Fetal macrosomia	8 (5.7)	1 (3.1)	0.54 (0.07-4.45)	>0.99	0.42 (0.03-5.26)	0.502
Preterm delivery	64 (45.4)	10 (31.3)	0.55 (0.24-1.24)	0.144	1.03 (0.23-4.65)	0.974
Preoperative haemoglobin <10.5 g/dl	26 (18.4)	5 (15.6)	0.82 (0.29-2.33)	0.708	0.73 (0.15-3.63)	0.701
Reason for Caesarean section						
Placenta praevia	98 (69.5)	7 (21.9)	0.12 (0.05-0.31)	<0.001	0.05 (0.01-0.32)	0.001
Abruptio placentae	2 (1.4)	6 (18.8)	16.04 (3.07-83.86)	0.001	5.67 (0.37-88.00)	0.215
Intrauterine infection	3 (2.1)	0	-	>0.99	-	>0.99
Labour progress failure	6 (4.3)	4 (12.5)	3.21 (0.85-12.14)	0.090	0.59 (0.08-4.63)	0.619
Non-reassuring fetal status	6 (4.3)	4 (12.5)	3.21 (0.85-12.14)	0.090	1.11 (0.15-8.15)	0.922
Anaesthesia						
Regional	54 (38.3)	5 (15.6)	-	0.015	-	-
General	74 (52.5)	19 (59.4)	-	0.480	-	-
Conversion from regional to general	13 (9.2)	8 (25.0)	-	0.030	-	-
Type of Caesarean section						
Elective lower segment	44 (31.2)	8 (25.0)	-	0.489	-	-
Emergency lower segment	93 (66.0)	23 (71.9)	-	0.520	-	-
Emergency classical	4 (2.8)	1 (3.1)	-	>0.99	-	-
Primary cause of postpartum haemorrhage						
Uterine atony	19 (13.5)	18 (56.3)	-	<0.001	-	-
Uterine tear	21 (14.9)	3 (9.4)	-	0.575	-	-
Placenta praevia	74 (52.5)	6 (18.8)	-	0.001	-	-
Placenta accreta	25 (17.7)	4 (12.5)	-	0.475	-	-
Coagulopathy	2 (1.4)	1 (3.1)	-	0.461	-	-
Laterality of UAL				0.027		-
Bilateral	121 (85.8)	32 (100)	-		-	-
Unilateral	20 (14.2)	0 (0)	-		-	-

* Data are presented as No. (%) of patients or median (range)

Table. (cont'd)

Characteristic	UAL alone (n=141)*	UAL with subsequent haemostatic procedures (n=32)*	Odds ratio (95% confidence interval)	p Value	Adjusted odds ratio (95% confidence interval)	p Value
Haemostatic procedure				-		-
Compression suture	-	30 (93.8)	-		-	
Pelvic embolisation	-	1 (3.1)	-		-	
Hysterectomy	-	6 (18.8)	-		-	
Duration of surgery, min	83 (38-235)	149 (66-339)	-	<0.001	-	-
Estimated blood loss, ml	1900 (400-6350)	3800 (1400-12000)	-	<0.001	-	-
Blood product used						
Red blood cells, units	2 (0-9)	5 (1-22)	-	<0.001	-	-
Platelets, units	0 (0-8)	4 (0-16)	-	<0.001	-	-
Fresh frozen plasma, units	0 (0-10)	4 (0-18)	-	<0.001	-	-
Cryoprecipitate, units	0 (0-10)	0 (0-6)	-	0.935	-	-
Fibrinogen	9 (6.4)	5 (15.6)	-	0.141	-	-
Recombinant factor VIIa	1 (0.7)	4 (12.5)	-	0.004	-	-
Use of uterotonics						
Oxytocin/ergometrine	88 (62.4)	22 (68.8)	-	0.501	-	-
Carbopost	106 (75.2)	30 (93.8)	-	0.021	-	-
Use of tranexamic acid	63 (44.7)	20 (62.5)	-	0.069	-	-
Preoperative haemoglobin, g/dl	11.7 (8.9-14.2)	11.4 (8.6-15.6)	-	0.539	-	-
Lowest intra-/post-operative haemoglobin, g/dl	8.3 (3.3-12.8)	7.2 (4.7-9.7)	-	<0.001	-	-
Maternal mortality	0	0	-	-	-	-
Haemorrhagic shock	4 (2.8)	5 (15.6)	-	0.012	-	-
Disseminated intravascular coagulopathy	14 (9.9)	15 (46.9)	-	<0.001	-	-
Re-laparotomy	2 (1.4)	5 (15.6)	-	0.003	-	-
Inotropic support	4 (2.8)	11 (34.4)	-	<0.001	-	-
Admission to intensive care unit	33 (23.4)	25 (78.1)	-	<0.001	-	-
Paralytic ileus	6 (4.3)	6 (18.8)	-	0.010	-	-
Puerperal pyrexia	15 (10.6)	5 (15.6)	-	0.539	-	-
Wound infection	6 (4.3)	1 (3.1)	-	>0.99	-	-
Venous thromboembolism	0	0	-	-	-	-
Bowel injury	4 (2.8)	1 (3.1)	-	>0.99	-	-
Bladder injury	0	0	-	-	-	-
Ureteric injury	0	0	-	-	-	-
Broad ligament haematoma	0	0	-	-	-	-
Pelvic vessel injury	1 (0.7)	0	-	>0.99	-	-
Duration of hospitalisation, d	4 (1-18)	5.5 (2-19)	-	<0.001	-	-
Re-admission within 90 days of discharge	6 (4.3)	1 (3.1)	-	>0.99	-	-
Attendance to 6-week follow-up	135 (95.7)	31 (96.9)	-	>0.99	-	-
Women without hysterectomy	n=141	n=26				
Secondary PPH	4 (2.8)	1 (3.8)	-	0.576	-	-
Retained products of conception	4 (2.8)	1 (3.8)	-	0.576	-	-
Endometritis	0	0	-	-	-	-
Haematometra	0	0	-	-	-	-
Pyometra	0	0	-	-	-	-
Uterine necrosis	0	0	-	-	-	-
Uterine erosion	0	0	-	-	-	-

There were five cases of bowel injury (full-thickness puncture of the sigmoid colon [n=2], serosal tear of the sigmoid colon during dissection for pelvic endometriosis [n=2], and serosal tear of the large bowel during dissection from the posterior uterine wall during hysterectomy [n=1]) and one case of uterine artery pseudoaneurysm injury, which was asymptomatic and was managed conservatively. At week 6, ultrasonography and computed tomography of the pelvis showed a 1.9-cm left adnexal vascular shadow with turbulent flow (Figure). There was no bladder injury, ureteric injury, broad ligament haematoma, mortality, endometritis, haematometra, pyometra, uterine necrosis, or erosion. At postnatal follow-up, five women had secondary PPH attributable to retained products of conception.

Discussion

UAL is an effective and safe first-line surgical treatment for PPH during Caesarean section; 81.5% of women achieved haemostasis after UAL alone. Prior PPH was a predictor for haemostatic failure after UAL alone, whereas placenta praevia was a predictor for successful haemostasis after UAL alone.

In a study of 265 women with UAL (10 of them required additional therapy) in 1995, only six hysterectomies were performed and thus the efficacy of UAL was 97.7%[4], which was comparable to the 96.5% in our study. However, a higher proportion of women in our study required subsequent haemostatic procedures (mostly compression sutures). This could be due to a larger proportion of women with uterine atony as the primary cause of PPH. Since the introduction of compression sutures in 1997[8], obstetricians are more inclined to perform compression sutures when bleeding is not effectively controlled after UAL with suboptimal uterine contraction. Although both UAL and compression suture have similar haemostatic potential in atonic uterus[9], various international guidelines recommend compression sutures as the first surgical approach, followed by UAL[2,10-12]. In the International Federation of Gynaecology and Obstetrics guidelines, compression sutures are regarded as an effortless, fast, and conservative surgical procedure for uterine atony; UAL can decrease bleeding and allow additional time for compression sutures[13]. However, compression sutures can be complicated by uterine synechiae, necrosis, and haematometra, despite low overall incidence[14-16]. Prompt and effective uterine compression can reduce blood loss and the need for blood product transfusion, shorten the surgical time, and avoid the use of other immediate and short-term morbidities. Heavy bleeding leads to hypocalcaemia, which is associated with uterine atony and coagulopathy, which in turn exacerbate bleeding and may result in hysterectomy[17,18]. Therefore, UAL may not be the best option as a first-line surgical procedure in women with uterine atony. However, when compression sutures are technically difficult in cases of dense upper segment visceral adhesion, Müllerian anomaly, distorting fibroid, or adenomyoma, upfront UAL for haemostasis is recommended.

In our study, UAL alone could achieve haemostasis

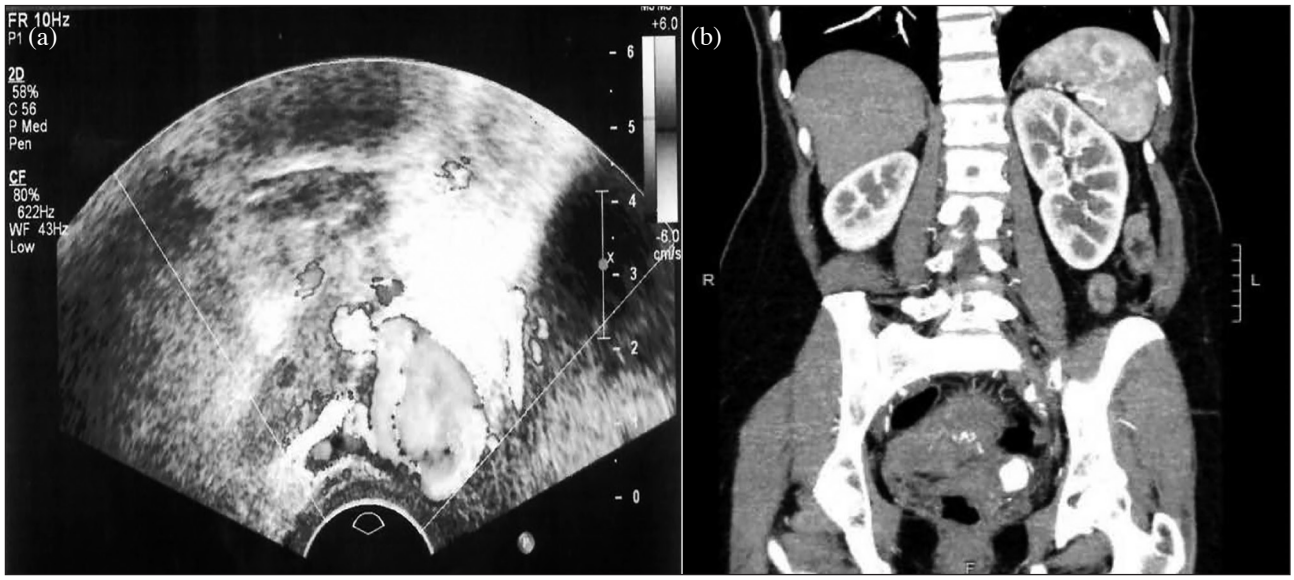

Figure. At 6 weeks after uterine artery ligation in a patient with a pseudoaneurysm at the left uterine artery: (a) ultrasonography showing a blood flow signal at the adnexa and (b) computed tomography showing an arterial-enhancing lesion measuring 1.9 cm in size at the left adnexa, arising from a branch of the left internal iliac artery.

in 92.5% of women with PPH secondary to placenta praevia. Two women with placenta praevia required hysterectomy: one after failure of the second ligatures caudal to the first one and another after failure of the Hayman sutures with complications of atony and coagulopathy. In hindsight, the failures could be associated with major placenta praevia, in which some of the arterial supply came from the cervical and vaginal arteries. In such a case, hypogastric artery ligation should be considered, although it is more time consuming and technically challenging. Alternatively, intrauterine balloons can be used for placental bed bleeding, especially in women with extensive adhesion across the lower uterine segment, bladder, or bowel, in women with diffuse vascularity at the site of needle entry, or in women with unusual uterine arteries secondary to concurrent pathology. However, it is more time-consuming to perform balloon placement, uterine wound closure, and then balloon inflation to achieve haemostasis. In cases of torrential bleeding from the placental bed, generalised devascularisation by UAL, which can be completed within 2 to 5 minutes in experienced hands, can enable more secure haemostasis by reducing uterine blood flow, compared with balloon tamponade.

In our study, UAL alone could achieve haemostasis in 86.2% of women with PPH secondary to placenta accreta. This can be explained by a mild degree of morbid adherent placenta. However, placenta accreta is associated with a higher rate of haemostasis failure when managing with UAL alone[17]. In a meta-analysis, haemostasis and uterine preservation were more likely to achieve when UAL was combined with other modalities[7]. This is probably related to the extensive collateral vasculature of the abnormal placentation hindering the success rate of UAL alone. Importantly, in cases of placenta percreta invading laterally, torrential bleeding can occur if the needle accidentally punctures through the abnormal placentation, especially in a bloody surgical field with active haemorrhage.

To prevent bladder injury, the bladder should be reflected at least 3 to 4 cm below the uterine incision. The bladder blade should be well placed to avoid accidental puncture of the bladder. To prevent ureteric injury, traction to the contralateral side and fenestration of the broad ligament can keep the ureter out of the way. After achieving haemostasis, the course of the ipsilateral ureter should be checked to ensure no ligation. To prevent bowel injury, abdominal packing with warm pads and passage of the suture from posterior to anterior can prevent direct puncture. In cases of dense visceral adhesion not amenable to dissection within a short time, intrauterine balloon tamponade should be considered. To prevent pelvic vessel injury, repeated needle entry and the figure-of-eight suture should be avoided, and a substantial amount of the myometrium with entry directly perpendicular to the uterine axis should be included in the ligature. The needle should exit through the avascular area of the broad ligament to prevent a haematoma.

Prophylactic UAL before placental delivery is suggested to reduce the incidence of PPH in high-risk women[19] such as women with placenta accreta[20]. Nonetheless, further studies on its long-term morbidity, menstrual return, and reproductive potential should be conducted to determine its effectiveness.

One limitation of our study was its retrospective nature; causal relationship cannot be established. In addition, women with placenta accreta detected antenatally were excluded; the sample size of women with placenta accreta was too small to make any conclusion.

Conclusions

UAL is an effective and safe first-line surgical procedure for management of PPH during Caesarean section, especially in women with placenta praevia. UAL combined with subsequent haemostatic procedures may be required in women with prior PPH.

Contributors

All authors designed the study, acquired the data, analysed the data, and critically revised the manuscript for important intellectual content. MSY drafted the manuscript. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have no conflicts of interest to disclose.

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Data availability

All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics approval

The study was approved by the Central Institutional

Review Board of Hospital Authority, Hong Kong SAR, China (reference: CIRB-2023-053-1). The patients were treated in accordance with the tenets of the Declaration of Helsinki. The patients provided written informed consent for all treatments and procedures and for publication.

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