Minimizing Surgical Blood Loss at Cesarean Hysterectomy for Placenta Previa with evidence of Placenta Increta or Placenta Percreta: The State of Play in 2020

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CONDENSATION

Limiting blood loss at Cesarean hysterectomy for placenta percreta.

ABSTRACT

The evolution of multidisciplinary team-based care for women with placenta accreta spectrum (PAS) disorder has delivered step-wise improvements in clinical outcomes. Central to this overall goal is the ability to limit blood loss at surgery. Placement of inflatable balloons within the pelvic arteries, most commonly in the anterior divisions of the internal iliac arteries, became popular in many centers, at the expense of prolonging surgical care, and with attendant risks of vascular injury. In tandem, the need to expose pelvic sidewall anatomy in order to safely identify the course of the ureters re-popularized the alternative strategy of ligating the same anterior divisions of the internal iliac arteries. With incremental gains in surgical expertise, described in 5 steps in this review, our teams have witnessed a steady decline in surgical blood loss. Nevertheless a subset of women have the most severe form of PAS, namely placenta previa-percreta. Such women are at risk of major hemorrhage during surgery from vessels arising outside the territories of the internal iliac arteries. These additional blood supplies, mostly from the external iliac arteries, pose significant risks of major blood loss even in experienced hands. To address this risk, some centers, principally in China, have adopted an approach of routinely placing an infra-renal aortic balloon, with both impressively low rates of blood loss and an ability to conserve the uterus by resecting the placenta with the affected portion of the uterine wall. We review these literature developments in the context of

safely performing elective cesarean hysterectomy for placenta previa-percreta, the most severe PAS disorder.

KEY WORDS/SHORT PHRASES

Cesarean Hysterectomy, Hemorrhage, Infra-renal aortic balloon, Internal iliac artery ligation Interventional radiology, Magnetic Resonance Imaging, Placenta accreta spectrum disorder.

INTRODUCTION

Over the past 20 years, the changing landscape of pregnancy risk factors and care has created several increasingly challenging scenarios to Obstetrician-Gynecologists, few are greater than the surgical risks associated with placenta accreta spectrum (PAS) disorders, particularly when placenta previa is associated with evidence of placenta increta and/or placenta percreta. As the incidence of PAS disorders has risen and the accuracy of prenatal diagnosis has improved,(1) the evolution of a range of multidisciplinary team-based skills and practices has improved clinical outcomes.(2) Advances in the development of effective screening programs, will further increase the proportion of affected women who will benefit from team-based care and planned elective surgery.(3) Many of the lessons learned in the past decade are now embedded within national-level guidelines in the United Kingdom,(4) Canada,(5) and the United States(6); these complement the recent guideline series issued by the International Federation of Gynecology and Obstetrics and the International Society for Abnormally Invasive Placenta (IS-AIP).(7-10) Ultimately, the major underlying cause of severe morbidity or mortality is the extent of surgical blood loss during surgery. The key objectives at surgery are a) the safe delivery of the fetus, and b) surgical measures to secure surgical hemostasis. For many women with less severe forms of PAS, especially in the absence of major placenta previa, surgical hemostasis can be safely achieved without recourse to hysterectomy. This goal is achieved via resection of the focally-embedded placental tissue followed by repair of the uterus. (7) (8). For women with more extensive PAS, especially those with intra-operative confirmation at delivery of placenta previa with evidence of extensive placenta percreta, directly resorting to a Cesarean hysterectomy is a definitive strategy to secure hemostasis. As many elements of multidisciplinary care continue to

improve for women with PAS disorders, especially in surgical strategy and expertise, they challenge the relevance of two key approaches to limit blood loss at Cesarean hysterectomy, namely the use of interventional radiology techniques and ligation of the anterior divisions of the internal iliac arteries.

SURGICAL DIFFICULTY BASED ON PLACENTAL LOCATION

Placental adherence and invasion present as a disease spectrum rather than as a singular common pathology. Varying degrees of invasion may be found in the individual placenta, and the areas of involvement varies widely between cases. Low placental implantation and invasion such as that which occurs in the setting of placenta previa poses distinct technical surgical challenges. Specifically, the placental bulk lies in the narrowest portion of the bony pelvis; extra-uterine invasion within this technically challenging region potentially obscures or envelopes critical structures, including both the origin of the uterine arteries from the internal iliac arteries, and the distal portions of the ureters. Even though these structures may not actually be *invaded* by trophoblast, their proximity to the highly perfused placental tissue, and surrounding neovascularization that accompanies placental invasion, greatly increases the risk of severe maternal morbidity from hemorrhage or urologic injury.(9,10) To more accurately categorize and compare cases, including those managed conservatively, members of the International Society for Abnormally Invasive Placenta (IS-AIP) developed a clinically-based grading system,(11) which was subsequently adopted by the International Federation of Gynecology and Obstetrics (FIGO), (Table 1).(12) It is recommended that clinicians prospectively report their imaging findings and surgical outcomes using this classification

system at the time of delivery, and that authors utilize this system in future studies to facilitate subsequent systematic review and meta-analysis of interventions. This discussion will focus on the surgical management of FIGO Class 2 & 3(a-c) cases of placenta previa with evidence of abnormal placental invasion, which encompasses focal placenta increta (e.g. invasion of the cervix) and placenta percreta (focal complete loss of myometrium in the anterior lower segment, with or without bladder and/or parametrial involvement.

RISK OF HEMORRHAGE DURING SURGERY FOR PLACENTA PREVIA-PERCRETA

The procedure of cesarean hysterectomy for placenta previa-percreta can be divided into 5 key steps, with varying risks of major hemorrhage:

Step 1: Midline Access and Hysterotomy. First, gently expose the entire gravid uterus and visually confirm the external features of this disease. Hysterotomy is then made to deliver the fetus, avoiding the placenta using an ultrasound-guided vertical incision towards the fundus. Blood loss may be as low as 20cc at this stage by using a uterine stapler if the myometrium is suitably thin (13); if opened by knife incision, elevating the uterine edges with a series of clamps followed by an efficient single layer closure will also minimize blood loss.

Step 2: Superior Devascularization. Release and ligation of the round ligaments and utero-ovarian pedicles bilaterally. This may be achieved using traditional methods or with a bipolar sealing device, taking care to advance incrementally, perpendicular to the vessels, within the optimal sealing width of the blades. Blood loss at this step again is often minimal and is normally not excessive using traditional suture ligation; the principal risk of bleeding is from

excessive upward traction on the uterus by lateral straight clamps, rather than by manual elevation.

Step 3: Retro-peritoneal Dissection. Skeletonizing the uterus down to the uterine arteries and para-vesical spaces poses minimal blood loss and may be achieved using electro-dissection. Step 3 may also include a cephalad pelvic sidewall dissection, medial to the psoas muscles, in order to locate the bifurcation of the common iliac arteries, the external iliac vein and the medially-located proximal ureters. This adjunct step leads to exposure of the anterior divisions of the internal iliac arteries as shown in Figure 1 and supplementary Video1, and can be followed by ureterolysis in a distal direction to establish the spatial relationship of the ureters to the cardinal ligaments.

Step 4: Bladder dissection. Separation of the hyper-vascular bladder wall away from the extremely thin lower uterine segment is often prolonged. It is here that protracted venous bleeding may be first encountered by experienced surgeons if inadvertent injury to the thin lower uterine segment occurs. Meticulous lateral to medial dissection of this plane on each side, dividing the engorged blood vessels and adipose layer down with the bladder, may exceed 30-60 minutes. It is at this stage that significant blood collection often begins when using a cell salvage system. Step 4 is concluded when there is sufficient inferior dissection of the bladder wall down to the level of the anterior vaginal fornix. In rare instances with bladder invasion, confirmation and localization by cystoscopy is advised, (14) this step is then modified to include intentional cystotomy and resection of the affected portion of the posterior bladder wall with the uterus, followed by bladder repair. (15) In rare instances where parametrial placental invasion is found, more extensive retroperitoneal dissection is required to excise the specimen

and secure hemostasis, (16) or alternatively a sub-total hysterectomy is performed, thereby omitting the final step.

Step 5: Colpotomy. Once adequate exposure for vault entry is created, the main uterine artery pedicles are ligated, followed by securing the vaginal angles, each containing well-developed branches of the vaginal and internal pudendal arteries. (17). Colpotomy, followed by a circumferential incision around the cervico-vaginal margin, results in removal of the uterus. The incised edges are clamped incrementally as the vault is opened, to minimize blood loss from the margins, followed by suturing of the vault. Once step 5 is *completed*, any ongoing bleeding is likely to be minimal, and easily controlled, such that the risk of intra-operative hemorrhage has largely passed.

Steps 4 and 5 represent periods of much higher risks of hemorrhage than in steps 1-3.

In the context of blood loss control across steps 4 and 5, several points deserve consideration. First, the arterial blood supply relevant to steps 4 and 5 may involve the territories of *both* the internal and the external iliac arteries, and may even involve the aorta. Consequently the predominant internal iliac arterial blood supply to the non-pregnant uterus may switch, in the presence of placenta previa-percreta, to one where substantial contributions arise from branches of the external iliac arteries. Second, step 5 gives the illusion of being straightforward, however it may be associated with considerable bleeding. Inferior dissection of the para-vesical spaces, below the vault, risks injury to the surrounding venous plexus supplied by the external iliac artery territory. Furthermore, if the placenta extends into the cervix or parametrial tissues, the vault margins may be extremely vascular. Clear identification of the anterior and posterior vault margins may be facilitated either using an EEA-Sizer for posterior entry,(13) or a Breisky

retractor for anterior entry as shown in Figure 2 and supplementary Video 2. Both approaches afford greater control during colpotomy, without sacrificing vaginal length. In the context of limiting blood loss, there is no substitute for a slow, meticulous execution of each of these steps as the principal strategy. Each of these steps take time, with skin-to-skin surgery typically taking 2-3 hours, even in experienced teams.(2)

PERCUTANEOUS INTERNAL ILIAC ARTERY BALLOONS

Previously, the pre-operative percutaneous placement of internal iliac artery (IIA) balloons prior to surgery for PAS, to be inflated following delivery of the fetus, gained popularity as a safety measure to avoid massive blood loss.(18) The literature is challenging to assess due the inclusion of all stages of suspected PAS, including those not pathologically confirmed and false positive cases. As examples, an early case-control series of PAS patients demonstrated no significant reduction in mean blood loss with the use of IIAL balloons compared to controls (2700 vs 3000cc),(19) while a subsequent publication that distinguished a subset of PAS patients with placenta percreta demonstrated a statistically significant reduction in mean blood loss (933 vs 1507cc).(20) In both reports, mean operating time was 2.5-3 hours. The more recent publication of a pilot randomized controlled trial, involving 27 subjects found no reduction in mean estimated blood loss (1600 cc in both arms) in women undergoing Cesarean delivery for suspected PAS with balloon placement and routine inflation.(21) These data are difficult to interpret in the specific context of surgery for MRI-confirmed placenta previa-percreta. Only half of the subjects had a hysterectomy (which was always sub-total), which may explain the relatively short mean operating time (84 mins) in each arm.

With evolving team-based surgical operating expertise, especially with being patient during the steps of bladder dissection (step 4) and colpotomy (step 5), the overall risk of major blood loss (>2 liters) has diminished. Consequently it is not surprising that pre-operative IIA balloon placement has not been shown to improve outcomes, yet this intervention extends resource utilization and overall costs, and is not without serious potential risks to pelvic structures and blood supply to the lower limbs.(19,22)

SURGICAL LIGATION OF THE INTERNAL ILIAC ARTERIES

An alternative to IIA balloon placement, surgical exposure and ligation of the anterior divisions of each IIA, as an extension of step 3, typically requires only 20 minutes to perform bilaterally. This technique is illustrated in Figure 1 and supplementary Video 1. Care must be taken to avoid injury to the laterally adjacent external iliac vein. Ligating the vessel at least 3-5cm distal to its separation from the posterior division will avoid inadvertent ligation of posterior division branches that arise as anatomical variants.(23) The exposed anterior division arteries may either be sutured or left exposed with a suture loop, for later rapid ligation if excessive bleeding is encountered. Alternatively, they may be occluded using a vessel clip. Classic experiments observed that bilateral ligation of the IIAs (in 17 non-pregnant women undergoing laparotomy) immediately reduced mean arterial pressure in the distal iliac artery segment by 24%, accompanied by a 48% reduction in blood flow.(24) Aortograms demonstrated that the low immediate effectiveness of this type of vascular ligation was substantially diminished by the presence of ilio-lumbar, sacral and hemorrhoidal anastomoses to the distal iliac

vasculature(24); consequently any clinically-meaningful benefit of this intervention is only likely to be short term, and less than 20 minutes in duration of effect. Therefore, if ligation is performed early on during the procedure, any benefit may be greatly diminished should significant bleeding be encountered during the prolonged meticulous step of bladder dissection, during uterine artery and cardinal ligament ligation, or finally during colpotomy. It is of interest that a recent Egyptian pilot randomized control trial found no benefit of routine vessel ligation during cesarean hysterectomy for placenta increta or percreta.(25)

PERCUTANEOUS AORTIC BALLOON PLACEMENT

The fear of encountering complex blood supplies to the uterus persistently lurks in the minds of even the most experienced PAS surgical teams. Each of our respective teams have had to resort to occasional infra-renal aortic compression, or clamping, in order to control massive blood loss during surgery for placenta previa-percreta. Clearly this is a highly undesirable and stressful experience. No method of limiting blood flow to the anterior divisions of the IIAs is effective in these acute situations. Fluoroscopic placement of a balloon in the infra-renal portion of the descending aorta, in theory, will permit temporary occlusion of arterial perfusion from most sources to the pelvis during surgery for placenta previa-percreta. However, this scenario is not readily predicted, and thus balloon placement may be performed electively directly before surgery commences. A recent meta-analysis of seven comparative cohort studies of over 500 women with a range of suspected PAS disorders reported on outcomes with elective infra-renal aortic temporary placement and intra-operative occlusion.(26) These studies are impressive for their reduced blood loss (mean reduction 1495cc), and their significantly lower rates of

hysterectomy (odds ratio 0.3[95% CI 0.19-0.48]). In one series of 230 women undergoing delivery for placenta previa with suspected PAS and pre-operative aortic balloon placement, no woman required a hysterectomy, despite 88 having a final diagnosis of placenta previa percreta, amongst which 29 had bladder wall penetration.(27) This literature is challenging to interpret and apply widely for two reasons. First, a common surgical strategy in these publications was to attempt removal of the placenta even in the context of a severe PAS disorder (placenta previa percreta). Second, mean reported operating times are remarkably short – only 64 minutes in the largest series reported to date. (27) The need for an aortic balloon, to control blood loss in the context of attempting placental removal for an intra-operative clinical diagnosis of placenta previa percreta, may indeed be an essential life-saving approach. Combining this approach with a fast operative technique is in stark contrast to our approach, along with that described in current international guidelines, which is to leave the bulging vascular placenta previa undisturbed, then performing surgery in a controlled and meticulous 5-step fashion. Reassuringly, these Chinese groups reported minimal rates of vascular complications,(26) and in one series, 53% (105/197) of women followed up had return of normal menses. (27) The utility of routine aortic balloon placement for placenta previa-percreta surgery in our settings is questionable, since predicted mean blood loss is reduced to an acceptable level (<1.5 liters) via our 5-step approach to cesarean hysterectomy. One recent North American publication in this context compared blood loss in 16 cases with an aortic balloon with 19 cases without a balloon over a 7 year period, and found no significant difference in mean blood loss(28), confirming our view. A variant of this strategy, originally described in Taiwan(29), and subsequently adopted both in Denmark(30) and in Japan(31) with

favorable initial results, is bilateral placement of balloons in the common iliac arteries. More recently, a Chinese group has compared outcomes between all 3 levels of balloons (infra-renal aortic, common iliac and anterior divisions of the internal iliac arteries) in a retrospective cohort of 112 women delivered with suspected PAS, where only 11.6% had confirmed placenta percreta at delivery.(32) Surgery with balloons placed in the infra-renal aorta or common iliac arteries had significantly lower mean blood loss (mean 1000cc) that surgery with internal iliac artery balloons (mean 2900cc), and cases with these higher-level balloons had significantly lower rates of hysterectomy. Only two procedure-related complications were described, namely thrombosis in the internal iliac arteries, without long-term complications.(32)

Our interpretation of this literature is that a subset of women with placenta previa and features of either placenta increta or percreta are at risk of excessive blood loss at Cesarean delivery of their baby, despite well-developed team-based surgical skills. However, contemporary outcomes for such women in large centers does not justify the routine use of an aortic balloon. Further advances in vascular imaging are needed in order that a subset of women, with a more extensive and complex pelvic arterial blood supply (especially where extra-uterine placental tissue invasion is demonstrated), may be identified to potentially derive significant benefit from this type of device.

MAGNETIC RESONANCE IMAGING OF THE PELVIC ARTERIES

Although multi-modal ultrasound in experienced hands can provide accurate diagnostic information in the context of a suspected PAS disorder, (33) magnetic resonance imaging (MRI) (T1 and T2-weighted imaging) can provide important diagnostic and staging information(34) for

women identified as screen positive by ultrasound. (3) In the context of placenta previa-percreta, MRI has additional capabilities that are relevant to uterine vascularization. MRI may be combined with intravenous gadolinium enhancement to improve diagnostic accuracy. (35) Due to concerns with gadolinium vehicle stability, this contrast agent is not commonly used, though newer agents are under development. (36) In addition to imaging of the uterus and placenta, advances in the time of flight modality of MRI may provide a window into delineating the major arterial vessel segments supplying the pelvis in pregnancies complicated by placenta previa-percreta(37), as shown in Figure 3. These MR sequences can be combined with standard T2 and T1-weighted imaging protocols presently used to confirm and stage the disease,(34) and is presently under further investigation in pregnant women in an attempt to detect a subset of women with PAS that have a substantial parasitic blood supply beyond the territories of the anterior divisions of the internal iliac arteries.

EMERGENCY INFRA-RENAL AORTIC BALLOON PLACEMENT

Recent developments provide insight into overcoming this challenge. By moving these surgeries to hybrid surgical suites,(38) with bedside interventional radiology and digital imaging, the process of selective aortic balloon placement may become a time-efficient option, so long as arterial pressure surveillance is switched from radial to femoral monitoring.

A variant of this approach, without recourse to a hybrid fluroscopy surgical suite, is the alternative method of rapid infra-renal aortic balloon occlusion.(39,40) This strategy uses the ER-REBOhybA™ system (Prytime Medical, Boerne, TX), a device that was originally designed for military battlefield resuscitation of victims with major lower body trauma. At a recently

reported robotic surgery training course of para-aortic node dissection, incorporating arterial monitoring via the femoral artery, each level of surgeon from resident to experienced surgeon could achieve effective infra-renal aortic occlusion in under 2 minutes.(41) A recent systematic review of 8 studies using aortic balloons in 392 women with PAS, included a small subset describing the experience of using the REBOA device, which reported favorable results and no major complications(42). A multicenter registry (www.obgynreboa.com) has recently been developed to address the utility of this selective vascular intervention in Obstetrics.

THE STATE OF PLAY IN 2020

In each of our respective PAS programs, we have either always utilized selective vessel ligation (Bristol, Houston, Oxford) or have evolved from balloon placement through routine to selective vessel ligation (Toronto). As our team-based surgical skills have evolved as described in steps 1-5, our centers have seen mean surgical blood losses stabilize at around 1200cc and in tandem have evolved to dissection and exposure of the IIAs at step 3, such that vessel ligation can be performed rapidly as needed during steps 4 or 5. At these surgical blood loss levels, combined with a more pro-active pre-operative hemoglobin optimization, we are left questioning the justification for the staff and equipment costs incurred to return low volumes (<500cc) of blood collected via cell salvage. In summary, there is no substitute for achieving a dedicated and experienced surgical team approach to this disease. The importance of nurturing such teams, including the careful mentoring of our next generation of PAS surgeons, is key to advancing our ability to tackle this evolving problem in a safe and expert fashion.

FIGURE LEGENDS

Figure 1. Schematic of the left pelvic sidewall during Cesarean hysterectomy, exposing the branches of the common iliac artery. Illustration by Dr. Evelyn Lockhart, University of New Mexico, Albuquerque, New Mexico.

Figure 2. Schematic of use of the Breisky retractor to identify the upper margin of the anterior fornix. The tip of the Breisky retractor blade is palpated to open the vault using electro-cautery (A). The positioning of the retractor in sagittal view (B). Illustration by Dr. Evelyn Lockhart, University of New Mexico, Albuquerque, New Mexico.

Figure 3. Oblique view time-of-flight magnetic resonance angiogram of the central abdominal arterial tree at 36 weeks gestational age in a healthy pregnancy. The reconstructed angiogram demonstrates the renal arteries (R) and the bifurcation of the common iliac arteries (B). Courtesy of Dr. Mike Seed, Department of Medical Imaging, SickKids Hospital, University of Toronto, Canada.

SUPPLEMENTARY VIDEO LEGENDS

Video 1. Dissection of the left pelvic sidewall to reveal and suture ligate the anterior division of the internal iliac artery during Cesarean hysterectomy. Prepared by Dr. Ally Murji, Department of Obstetrics & Gynaecology, University of Toronto, Canada.

Video 2. Use of the Breisky retractor to identify the upper margin of the vaginal vault at anterior colpotomy. Prepared by Dr. Ally Murji, Department of Obstetrics & Gynaecology, University of Toronto, Canada.

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