53

Initial Interventions to Combat Hemorrhage during Cesarean Section and Internal Iliac Artery Ligation

V. P. Paily

Editorial note: The material in this chapter duplicates that of many other chapters in this book. The editors present it because each surgeon possesses a 'voice' that is based on his/her personal experience. Readers of the entire volume will soon determine that many surgical points of view are unique and worthy of consideration. This is not to say that some are better than others, but rather to suggest that the novice surgeon would do well to read more than one description of specific operations. L.G.K.

INTRODUCTION

This chapter deals with the causes of bleeding and interventions to combat the bleeding during cesarean section. Many of the topics covered herein are discussed in other chapters in greater detail.

CAUSES OF EXCESSIVE BLEEDING

The etiology of excessive bleeding during cesarean section often is similar to that after vaginal delivery, but additional causes relate to the operative procedure itself (Table 1). For convenience, these causes are considered in the sequence in which one is likely to encounter them.

Bleeding from anterior abdominal wall

Ordinarily, bleeding from the anterior abdominal wall is not significant; however, in situations where the patient is already in coagulopathy or has been placed on anticoagulants or antiplatelet agents, anterior abdominal wall bleeding can be significant. The type of incision also makes a difference; vertical midline incisions causing less blood loss than transverse incisions. Less blood is lost if the muscles are not cut. In cases of re-entry through a previous scar, sharp dissection may be required to separate the rectus sheath.

It is important to avoid injury to the inferior epigastric vessels which lie under the lateral aspect of the rectus muscle. However, in case the inferior epigastric vessels are injured, they should be tied before proceeding further, as without ligature or coagulation, excessive blood loss and/or hematoma formation is possible.

The other usual site of abdominal wall bleeding is the lower peritoneal edge in the midline, especially if the incision is close to the apex of the bladder. Also, the median umbilical ligament (vestige of the urachus) may have a vessel with it, and bleeding is a possibility. Once the peritoneum is opened and the abdominal cavity entered, omental bands or fibrous bands from the anterior surface of uterus will have to be tied off.

Bleeding from the uterus

The most common cause of PPH during cesarean section is atony. Since that bleeding is from the placental site, it is dealt with later under placental site bleeding as is the next most common cause, laceration of the uterine vessels when the lower segment is incised for the extraction of the infant's head.

Table 1 Causes of excessive bleeding during cesarean section

From the anterior abdominal wall
Related to coagulopathy
Disseminated intravascular coagulation (DIC), e.g. abruptio placenta
Women on antiplatelet agents, e.g. aspirin or heparin
Women on anticoagulants, e.g. coumarine for artificial heart valve
Injury of inferior epigastric vessels
Extensive adhesions from previous surgeries
Bleeding from the uterus
From the uterine incision site
Thick lower segment
Due to coagulopathy or anticoagulants as noted above
Extension of incision involving uterine vessels
Classical cesarean section
From placental site
Atonic uterus
Retained placental or membranous tissues
Abnormal placental implantation
Lower segment implantation
Placenta invading deeper, e.g. accreta

Bleeding from uterine incision

Numerous factors influence bleeding from the uterine wound (Table 2). A thick lower segment is usually encountered in elective cesarean sections performed before the onset of labor. Proportionate to the thickness, the incision will have to be larger and hence blood loss will be greater. Trying to arrest bleeding at that point with cautery or ligation is not advisable. One has to proceed to deliver the fetus and then tackle the bleeding. A thick lower segment may demand use of forceps or ventouse to facilitate delivery of the fetus.

Increased vascularity and congestion of the lower segment is associated with various conditions such as use of prostaglandins and/or prolonged rupture of membranes with chorioamnionitis. Use of prostaglandins (both E1 and E2) also makes the lower segment, cervix and vagina more friable. In such cases, one has to anticipate excess bleeding and proceed briskly once incision on the myometrium has been made. Waiting for the assistants to clear the field with suction is an all too common mistake.

Previous scar on the lower segment can pose a challenge regarding the site of the present incision. If the scar lies in the middle of the lower segment and is within easy reach, then incision on the same scar is the ideal. If, however, the previous scar is too high in the upper part of the lower segment, one must decide whether to incise over the same scar or go lower to the middle of the lower segment. Incision on the previous scar helps reduce bleeding, whereas if the previous scar is too low or too difficult to reach with the bladder densely adherent, placing the incision at a higher level is safer.

Pelvic endometriosis leads to adhesion of the posterior wall of the lower segment to bowel, omentum, ovaries or tubes. Bleeding from the lower segment will be increased in these cases especially if the placental implantation overlies these areas. To arrest bleeding from such an open placental sinus, a simple method is to catch and lift up that part of uterine wall with an Allis forceps and take a purse string stitch around it with catgut or delayed absorbable suture material (Figure 1).

Placenta previa, either total or partial, increases the bleeding risk in several ways. This risk depends on the site (anterior or posterior), previous surgery (for example, previous cesarean scar increases risk of placenta accreta and is dealt with separately in this and other chapters) and the technique used. When blood vessels run vertically on the lower segment, especially if there are many, it may be wiser to make a vertical incision on the upper segment. In case few vessels are seen, on the other hand, it is advisable to tie them above and below the level of proposed incision (Figure 2). While trying to take the stitches around these vessels, care should be taken not to injure them, as a hematoma can form very quickly at the puncture point.

Once the incision on the myometrium is started, the surgeon should proceed swiftly to incise it up to the decidual level and extend laterally by cutting with scissors to either side for about two inches and then tearing with fingers laterally to get the final desired length. One should take care to avoid the uterine arteries at this time.

Table 2 Factors that influence bleeding from uterine wound

Thickness of lower segment
Congested/inflamed lower segment – prostaglandin induction of labor or chorioamnionitis
Previous surgery – cesarean, myomectomy or surgery for pelvic endometriosis
Lower segment placental insertion
Extension of incision involving uterine arteries or veins
Presence of fibroid or adenomyosis
Classical cesarean incision
Length of incision
Proximity to placental implantation site

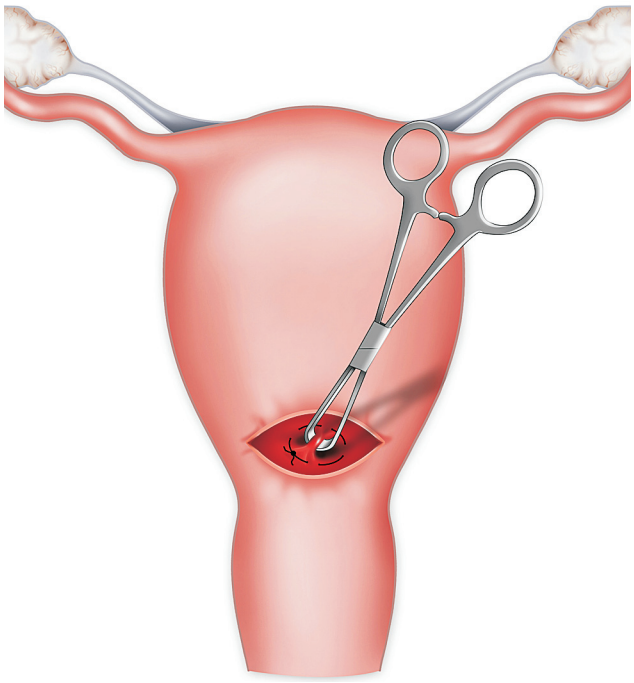

Figure 1 Purse string stitch around a bleeding sinus at the placental implantation site

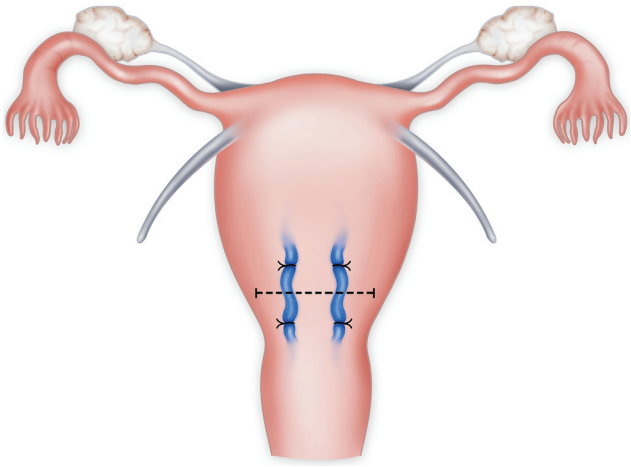

Figure 2 Underpinning vessels above and below the line of incision

We do not recommend cutting through placenta to reach the amniotic cavity, unless it is a very thin, membranaceous placenta under the incision. The preoperative ultrasound scan would have given an idea about the outline of the placenta and the thickness of tissue under the incision. After reaching the placental plane, separate the placenta towards the side which is closest to the membranes, after which the membranes will bulge. On rupturing the membranes the fetal head can be delivered with forceps or ventouse.

Incision of placenta may become inevitable if the placenta is accreta or membranaceous. On the fetal surface of the placenta, fetal vessels or cord may get cut in some cases leading to rapid blood loss from the fetal circulation. Since the total blood volume of the fetus is only about 400 ml, this loss can be catastrophic. Hence, before trying to deliver the fetus, the surgeon should identify the cord and clamp it. Delivery of the fetus can be difficult because the placenta will occupy part of the space created by the incision. Use of forceps or ventouse will help in delivering the fetal head. Quick delivery of the fetus is essential in this situation. Until the uterine volume is reduced by delivering the fetus and placenta, bleeding will be excessive and difficult to control. Once the fetus is delivered, oxytocics should be promptly administered. Exteriorization of the uterus helps to identify and control bleeding. The immediate blood loss will be primarily from the angles and edges of the wound, as well as from open placental sinuses which will continue to well up because the lower segment myometrium will not contract effectively to constrict the vessels.

Persistent bleeding from the placental sinuses in the lower segment can be arrested with purse string stitches described earlier (Figure 1). However, the priority should be to tackle the bleeders at the angles of the incision and any arterial spurters present at the incision edges. These may be temporarily controlled with Green Armitage forceps and later tied separately. For control of the arterial bleeders, however, one should not depend on the running stitch used to close the uterine wound. Almost always it is the left incisional angle that becomes involved, owing to dextrorotation of the uterus making the left side become more anterior and vulnerable. Exteriorization of the uterus and upward traction helps to reduce bleeding and identify torn vessels. Removal of the placenta should be completed as quickly as possible. If the tear has extended laterally or downwards, the bladder must be pushed down first, and this maneuver will help the ureter to drop down. Clamping and ligation of the vessels without this step may inadvertently include the ureter. If the incisional angle is torn irregularly it may be safer to tie the vessels away from the edges both above and below. Keeping the bladder and ureter safely away, stitches can be placed on the side of the uterus including part of the myometrium so that both arteries and veins are tied. If unfortunately a hematoma has already formed, it should be evacuated before searching for the bleeder, as torn arteries will have receded and gone into spasm. Unless the clots are removed and the bed of that space 'moped clean' the artery may not be visible.

As torn vessels at the angles of the uterine wound are the usual causes of excessive blood loss, we recommend securing the angles with mattress stitches before the running stitch is used to close the wound. Start at the angle on the right side and after securing the anchoring stitch, the same suture material is used to take a mattress stitch 1 cm medial to the angle to approximate the edges. The rest of the suture material can then be used for similar stitches on the left side followed by the running stitch to approximate the remaining part of the wound (Figure 3).

Fibroids and adenomyosis enhance bleeding risk. Even though submucous fibroids are not that common, intramural and subserous fibroids as well as adenomyosis are not uncommon findings. The main reason for excessive bleeding in these cases is atonicity. Subserous fibroids pose another threat. They may have large tortuous veins on their surface and may get torn while handling the uterus. Attempting to exteriorize the uterus through a small abdominal incision may lead to such trauma. Catastrophic bleeding can occur in posterior subserous fibroids if this possibility is not kept in mind and acted on. Once identified,

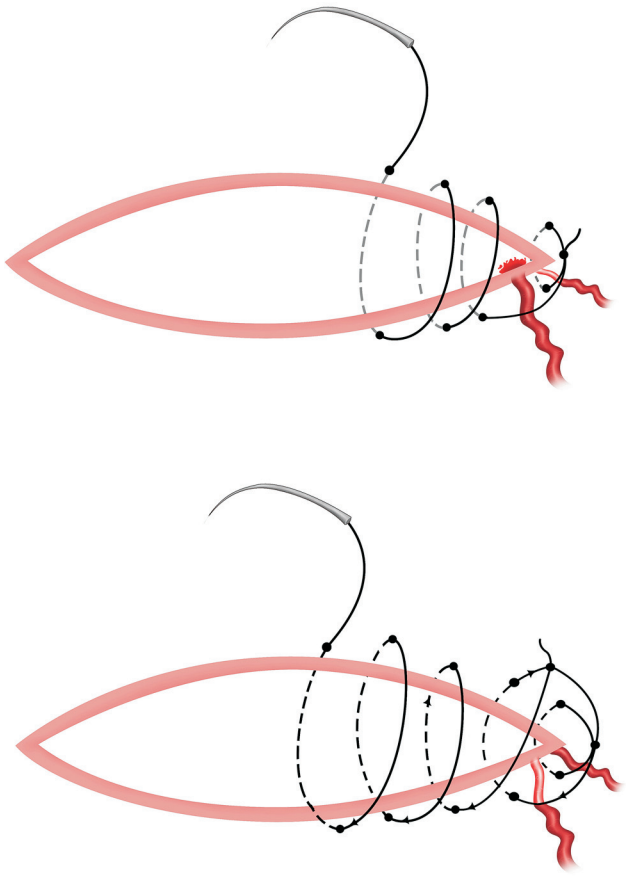

Figure 3 Mattress stitches at the angle and about 1 cm medial, to take care of the angle bleeder. Upper illustration shows usual anchoring stitch followed by running stitch, leading to ongoing bleeding from vessel joining medial to angle. Lower illustration shows the recommended additional mattress stitch 1 cm medially which includes such vessels

controlling such bleeding is easy if one tackles the base of the fibroid rather than trying to tie the vessel at the site of bleeding.

Bleeding in classical cesarean

Since classical cesarean is undertaken only in rare or special situations, many obstetricians may be unfamiliar with the technique. Both the thickness of the myometrium and the increased length of the incision lead to more blood loss. The chance of the incision extending to the placental site also is greater. Steps to tackle the hemorrhage in these circumstances will depend on the primary reason for resorting to this unusual uterine incision. For example, if it is a case of placenta previa accreta, the management described under that section may be resorted to (see section below). For other indications (fibroids or abnormal lie) the aim should be to complete the delivery of the fetus and placenta and proceed with closure of the uterine wound. The uterine wall being thick, one may need two or three layers to close it.

Bleeding from placental site

Atonic PPH

Atonic PPH during cesarean section occurs as a result of similar causes to atonic PPH during vaginal delivery or owing to factors specific to cesarean. The latter include effects of anesthesia and sedation. General anesthesia, especially if agents like halothane are used, will make the myometrium lose its tone. This is one of the reasons why regional anesthesia is preferred over general anesthesia for cesarean section. But there are some special situations (transverse lie) where relaxant general anesthesia is deliberately chosen and the obstetrician should anticipate some atonicity and bleeding after delivery of the fetus.

Once atonic PPH has developed, the management algorithm is the same as after vaginal delivery. It is well covered in other chapters, and only a few salient points pertinent to cesarean section are mentioned here. Cesarean actually provides the advantage of direct compression of the uterus by the operator or assistant. Whether the compression is effective can be ascertained directly by observing for blood welling up or the lack thereof. The first step obviously is to gently massage the uterine fundus. If the uterus remains flabby, bimanual compression can be used. Simultaneously, oxytocics should be administered, and the opportunity is present to administer methergin and prostaglandin F2α directly to the myometrium. If these measures fail, one has to consider surgical steps in a sequential manner. Our own practice is to approach in the order mentioned in Table 3 and discussed in great detail in other chapters.

Triple tourniquet Occasionally one may be forced to perform a cesarean when excess bleeding is expected. A typical case is severe degree of abruptio placenta or a patient on the verge of, or actually in coagulation failure, as is seen in amniotic fluid embolism. The uterus in these cases will be flabby and bleeding will be profuse. The uterus may not respond to normal oxytocic administration. In many settings, neither manpower nor immediate blood transfusion facilities are readily available. In such instances and in others where resuscitative therapies are available, a triple tourniquet is a very effective first aid measure to stop the profuse bleeding. Here, the blood flow to the uterus is totally cut off by a tourniquet applied at the isthmus and to both infundibulopelvic ligaments.

For the *isthmial tourniquet*, the bladder is pushed down as a first step. Then, by transillumination an avascular area on the broad ligament lateral to the side of uterus and uterine vessels at the level of isthmus is identified. This spot is bluntly pierced with the tip of an artery forceps and the end of a sterile plastic suction catheter (size 8 or 10 Fr) pulled from back to front on the left side. The other end is pulled through similarly on the right side after cutting away the dilated proximal part of the catheter. The two ends are crossed in front of the isthmus and twisted repeatedly so that the catheter constricts the isthmus tightly. An artery forceps is clamped on the catheter close to the isthmus to prevent it from getting loose (Figure 4). A clamp applied like this rather than a knot makes it easier to compress the isthmus tightly and release the tourniquet later.

Both *infundibulopelvic ligaments also have to be constricted using a tourniquet*. For this, we keep the round ligament and infundibulopelvic ligament of each side together. A tourniquet on infundibulopelvic ligament alone tends to cause damage to the slender ovarian

Table 3 Surgical steps to arrest atonic PPH

Triple tourniquet (in exceptional situations – see notes)
Bilateral ligation of uterine and anastomosing branch of ovarian artery
Brace stitch – B-Lynch or Hayman's stitch
Bilateral internal iliac artery ligation
Hysterectomy

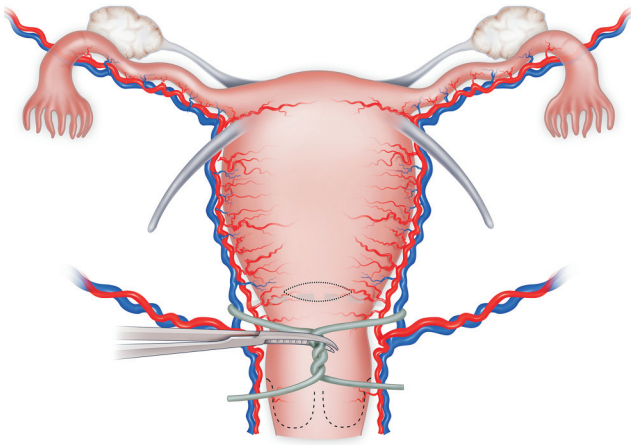

Figure 4 The technique of isthmial tourniquet. The artery clamp has to be close to the isthmus, keeping the tightness of the plastic catheter around the isthmus

veins and lead to hematoma formation. The same window created in the broad ligament for isthmial tourniquet can be used to take a catheter and tightening the tourniquet lateral to the ovary. We use a size 6 infant feeding tube. A sliding knot is placed, and a mosquito forceps applied to prevent the knot from getting loose (Figure 5).

A triple tourniquet applied as described above will totally cut off blood flow to uterus and stop the bleeding. However, a myometrium that is devoid of its oxygen supply will not contract. Hence, the tourniquet should be released as soon as IV fluids, blood and blood products are present and running, and the condition of the patient has improved. In other words, triple tourniquet in PPH is only a first aid measure. Other procedures, such as a stepwise devascularization or brace stitch should be used if needed and the tourniquet released unless one has decided to do hysterectomy.

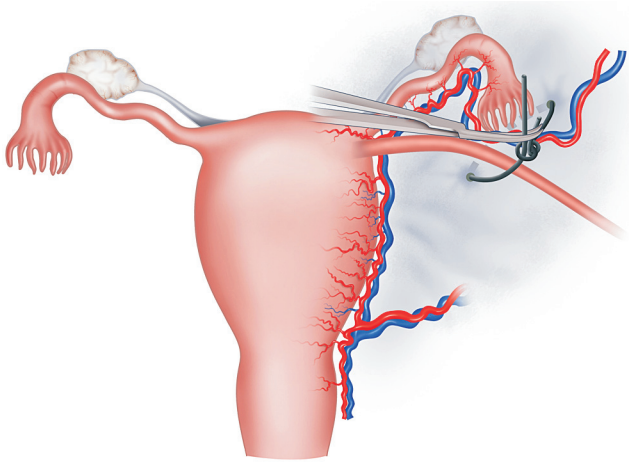

Figure 5 Tourniquet at infundibulopelvic ligament. Inclusion of round ligament helps to reduce damage to ovarian veins. The artery clamp should be applied after tightening the loop around the vessels (sliding knot) to prevent the loop from getting loose

Stepwise devascularization and brace stitch The sequence of steps, whether brace stitches should be taken before uterine and ovarian vessel ligation is debatable. Our own practice is to take uterine and ovarian vessel ligation as the first step and, if necessary, to proceed with brace stitches after that. Details of these procedures are not given in this chapter as they are described elsewhere. However, a few points worth emphasizing are mentioned here. For uterine artery ligation, we recommend taking the stitch including myometrium on lateral wall of isthmus to include uterine artery and vein as one bundle. Bladder should be pushed down for reasons mentioned above. While taking the stitch one has to be careful to avoid injury to bowel behind (Figure 6).

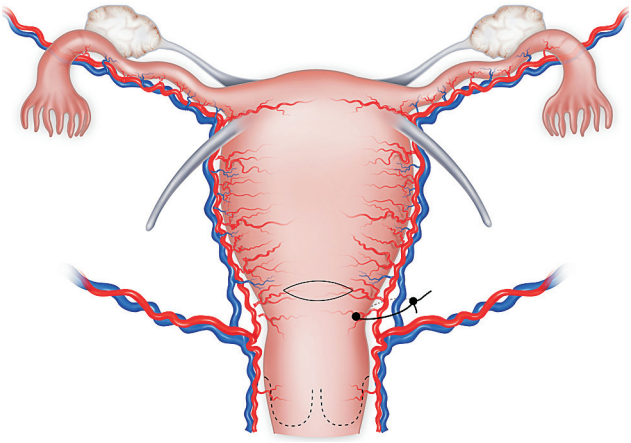

Figure 6 Uterine artery ligation at the isthmus of uterus. The stitch should include the vessels, with part of adjacent uterine wall, at the level close to where the uterine artery joins the uterus. Bladder has to be pushed down

The ovarian vessel ligation is shown at different sites in different textbook illustrations. Some even show ligation lateral to the ovaries which will lead to atrophy of ovaries. The commonest illustration is to tie the vessel on the side of the uterus below the cornual region. This will not include the arcuate vessel that takes off near the fundus of the uterus close to the tubal implantation site. We recommend taking the stitch between the tube and the vessel running under it and taking the needle medially to include part of the side of the uterus (Figure 7). This will stop the blood flowing to the fundus of the uterus which often is the placental implantation site.

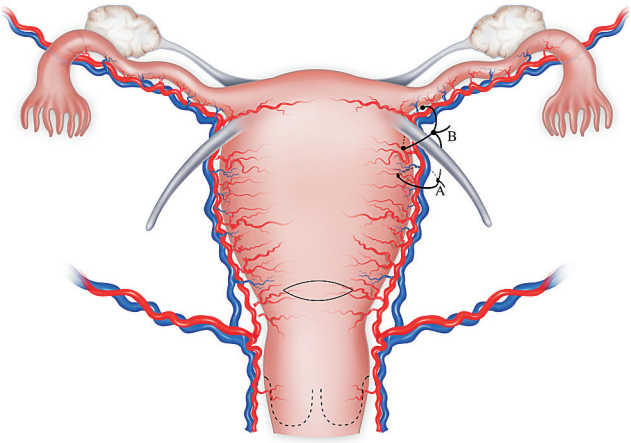

Figure 7 Tying of the anastomosing branches of uterine and ovarian arteries at the cornual region. (A) The usually seen illustration of stitch for the anastomosing branch. Blood flow to the fundus of uterus will continue unimpeded. (B) The recommended technique. The arcade of vessels on the mesosalpinx, from just under the tube to the side of the uterus, are included so that the branches supplying the fundal region are occluded

Regarding the brace stitch, we recognize and appreciate the procedure published by Christopher B-Lynch *et al.* in 1997[1]. This has revolutionalized the management of atonic PPH. However, we find that the technique suggested by Hayman, Arulkumaran and Steer is simpler and achieves similar results[2]. As the tissue passage is minimal in the Hayman technique, the #1 delayed absorbable braided stitch (polyglycolic acid or polyglactin) that is readily available in any operating theater can be used. The point to be emphasized is to tighten the stitch at the fundus medial to the tubal insertion site so that the tube is not damaged (Figure 8).

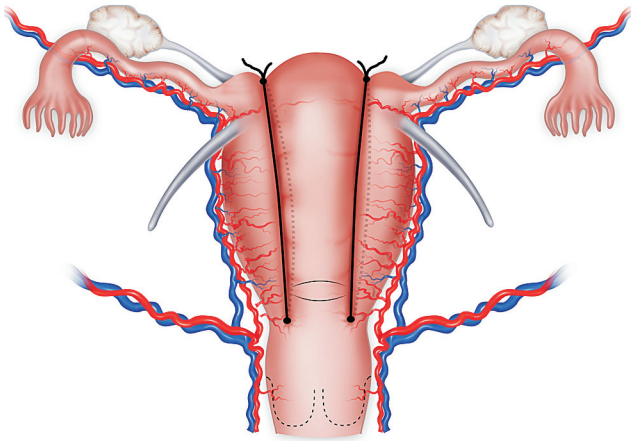

Figure 8 Hayman's uterine compression stitches

If these fail, in selected cases we proceed to bilateral internal iliac artery ligation which is described later in this chapter.

Obstetric hysterectomy If none of the above steps work and the patient is still bleeding, hysterectomy may have to be considered. Once a decision is made to perform a hysterectomy, the next steps have to be taken quickly. What we recommend is to put clamps on both sides, cut and proceed until the uterine arteries on both sides are clamped. Only after that are the stumps to be ligated. We recommend double ligation of all pedicles, as the risk of reactionary hemorrhage from the edematous stumps is high. Unless there is a tear or pathology involving the cervix, we perform subtotal hysterectomy. Trying to remove the cervix increases the risk of bleeding from the vault and is almost always unnecessary. The cervical stump is a much easier tissue to stitch than the thin vault of vagina. Any attempt to push down the bladder to remove the entire cervix can increase the risk of bleeding from the underside of the bladder or the azygos vessels of the vagina, and the time lost in such an effort could be critical.

Retained placental tissue or membranes

In the context of a cesarean section, retained placental tissue or membranes is an unlikely cause of bleeding. However, unless one makes a habit of inspecting the placenta for its completeness as well as palpating the uterine cavity for any retained cotyledons or membranes, this can happen. Digital exploration of the upper uterine cavity and fundus should be routine before closing the uterine wound. Occasionally, one will be rewarded with the diagnosis of an unsuspected septum or submucous fibroid in addition to the retained placental tissue or membranes. Placenta accreta can occur at any part of the uterus, especially if there are scars resulting from a prior myomectomy or cesarean delivery. Another factor is presence of infection as in chorioamnionitis. If retained placental tissue is suspected, the uterine cavity can be checked through the cesarean incision and any retained tissue removed. In case the placental bits are densely adherent, one may have to resort to sharp curettage under direct vision or local excision.

Deeper invasion of placenta (placenta accreta)

Editor's note: The surgery described herein is ideally not for the novice surgeon. If placental invasion is suspected, experienced help is mandatory. Additional material is found in Chapters 29–31. L.G.K.

Although in classical writings on the topic, conventionally morbid invasion of placenta was divided into accreta (into basal layer of endometrium), increta (into myometrium) and percreta (up to serosa and adjacent viscus, i.e. bladder); current literature uses the term accreta to include all three varieties. Placenta accreta can be present in the upper or the lower segment. The usual mechanism(s) of placental separation does not occur at these sites, leading to retention of placental tissue and bleeding from the normally implanted areas. This becomes more of a problem in the lower segment insertion, because in placenta previa accreta there is altered blood flow to the placental site. Anastomoses can occur between the lower uterine segment vessels with the vessels on the surface of the bladder which in turn can anastomose with blood vessels in the lower abdominal wall (branches of inferior epigastric artery). Similarly, the anastomosis between cervical and vaginal vessels will also be prominent, and tortuous vessels may be present under the bladder. Because of the altered blood flow described above, ligation of the internal iliac arteries alone may not control the bleeding from the placental site in cases of placenta previa accreta (Chapters 1 and 2).

Bleeding from placenta previa accreta during a cesarean can be torrential and lead to rapid exsanguination. This possibility calls for a prepared stepwise course of action. Preparations must include the availability of senior obstetricians, anesthesiologists and a urologist. Intravenous lines with wide bore cannula (two) and a central line to monitor central venous pressure are essential. Blood and blood products must be available in sufficient quantity for rapid use (see Chapters 4–6). Injury to the bladder and ureter is common, and unless the obstetrician is confident in tackling such injuries, a urologist should be on standby. It is crucial to prevent the rapid blood loss that will start once the placenta is disturbed, as tying the internal iliac artery will not be adequate in arresting the bleeding.

Many case reports describe occlusion of pelvic artery or aorta for management of placenta previa accreta (see Chapters 29–31). Ophir *et al.*[3] report their experience with preoperative balloon catheter placement in the internal iliac artery, prophylactic balloon occlusion after delivery of the fetus and resection of the invaded uterine wall conserving the rest of the uterus. After deflation of the balloon, bleeding came from branches of the uterine artery and was embolized. In their article, they reviewed the various options available for endovascular occlusion for

management of placenta previa accreta (this subject is also treated in the Chapters 1, 2 and 31).

Another option is the conservative management of the placenta by leaving it *in situ*. Some authors employ methotrexate to hasten the resorption of the placental tis0sue. On the whole, the failure rate is about 20% and failure can be followed by hysterectomy[4]. Conservative management should be tried in those cases where there is a desire for fertility and adequate technical support for intervention including massive blood transfusion. About 20% of conservatively managed cases subsequently require emergency hysterectomy. When the uterus is left *in situ*, the chance of recurrence of placenta previa accreta in a subsequent pregnancy varies from 0 to 100%. Kayem *et al*.[5] reported a recurrence risk of 100% in conservatively managed cases. Timmermans *et al*.[4] quoted a series of 26 patients with three pregnancies of which two had recurrence. The same authors quote other case reports of patients managed with adjuvant treatment such as methotrexate and selective arterial embolization[4]. In the methotrexate group there were 22 patients out of which five treatments failed, but two had subsequent uneventful pregnancies. In the arterial embolization group treatments failed in three out of five, but another three had subsequent pregnancies without recurrence.

Considering these limitations, it may be better for centers in the developing world to consider radical treatment (hysterectomy) as the best option. Centers in the developed world, on the other hand, have established strategies to tackle the problem that include a multidisciplinary team approach, intensive care facilities and arrangements for massive blood transfusion[6]. In the setting of a developing country, however, these preparations are difficult if not impossible to arrange. In the state of Kerala in India where confidential review of maternal deaths is practiced, five maternal deaths out of a total of 307 were as a result of placenta previa (four with previous cesarean) in the years 2004–2005[7]. Hence, we developed a strategy to tackle the problem with limited resources.

The salient steps are as follows:

- Establish the diagnosis and extent of placental invasion with ultrasound scan and/or magnetic resonance imaging in the antenatal period
- Ensure that adequate blood and blood products are available
- Ensure the presence of an experienced obstetrician and urologist
- Insert bilateral ureteric catheters and leave them *in situ*
- Keep a Foley catheter in the bladder
- Use regional or general anesthesia or a combination
- Do classical cesarean section to deliver the fetus
- Decide whether to remove the placenta or leave it behind. If the decision is for the latter, tie the cord close to its placental base and close the uterine wound
- If the decision is for hysterectomy, occlude the blood flow to the uterus by temporary clamping of the common iliac arteries for about 30–40 min with specially developed atraumatic vascular clamps (clamps developed by the author; patent pending). If these clamps are not available, bilateral internal iliac artery ligation may be employed. Both infundibulopelvic ligaments may be occluded with tourniquets
- For hysterectomy, proceed until the level of the uterine artery clamps and then separate the bladder from the uterus and continue with hysterectomy. Take special care at the previous scar area to avoid injury to the bladder. A subtotal hysterectomy ensuring that the placental implantation site is removed completely may be better than trying to remove the entire cervix
- Double check all pedicles. Ensure hemostasis especially at the bladder base. Double ligation of all pedicles is recommended. Close the abdomen after leaving a wide bore drain.
- Please note that the common iliac artery should not be kept clamped for more than 30–40 min. On removal of the clamps, the vessels should be massaged to relieve local spasm. Verify re-establishment of circulation to lower limbs. Postoperative thromboprophylaxis is highly recommended.

In case placenta previa accreta is encountered unexpectedly during a cesarean, further steps should be altered in the line with the above recommendations. A classical cesarean should be done. If massive blood transfusion and the assistance of experienced personnel cannot be arranged immediately, a conservative course may be followed; deliver the fetus through classical cesarean incision and leave the placenta intact. Even if a second surgery is required after 2 or 3 days, it will be less bloody and adequate help can be organized by that time. Alternatively the patient can be moved to a center with better facilities. During transfer, the non-pneumatic antishock garment (NASG) should be used (see Chapters 38 and 39).

If the placental invasion is recognized after placing the incision on the lower segment or attempting placental removal, bleeding can be torrential. The anesthetist should put in extra lines for fluid replacement. Additional help in the form of an experienced obstetrician and urologist should be summoned. Arrangements for blood and blood products should be made. If severe bleeding starts, the common iliac artery clamps described above should be applied and both ovarian vessels occluded with tourniquet at the infundibulopelvic ligaments. If common iliac artery clamps are not available, an assistant should directly apply pressure over the aorta (see Chapter 52) and the surgeon should remove as much of the placenta as possible and try to separate the bladder and proceed with hysterectomy.

INTERNAL ILIAC (HYPOGASTRIC) ARTERY LIGATION

Background

The internal iliac arteries supply all the pelvic organs – uterus, vagina, bladder, rectum and anal canal. It is thus only natural to assume that ligation of these arteries will stop bleeding from these viscera. This applies to PPH as well. However, all the pelvic organs possess extensive collateral circulations (see below) which act both as an advantage as well as a disadvantage. On the one hand, one can ligate the internal iliac artery without fear of ischemic necrosis of the aforementioned viscera. On the other hand, because of this extensive alternative supply, the ligation of the iliacs often fails to arrest the bleeding. This is all the more true when additional collaterals develop as in placenta previa accreta (see above and Chapter 1).

Anatomic considerations (Figure 9)

The internal iliac artery arises by the bifurcation of the common iliac artery at the pelvic brim; it takes a course medially into the pelvis to give off branches to the pelvic viscera as well as the gluteal region. *Usually*, after running as a single trunk for a short distance it divides into an anterior and posterior division. The posterior division *usually* takes off from the posterior aspect of the internal iliac and may not be easily visible. It supplies the gluteal region.

The anterior division gives off branches to the uterus, bladder, vagina, anorectum, perineum, clitoris and vulva. *Wide variation is present in the branching pattern of the internal iliac artery*. One anatomical principle that is *usually* maintained is for the uterine artery to be at right angles to the direction of the internal iliac artery.

The proximity of the internal and external iliac veins to the internal iliac artery is *crucial*. On the left side, the external iliac vein crosses the artery posteriorly near the bifurcation of the common iliac. The internal iliac vein lies posteromedially. When circulatory collapse is present, these veins may also be collapsed and not easily visible. It is quite easy to injure them in such circumstances unless the operator is especially conscious of this issue.

The internal iliac artery is *to a greater or lesser degree* enveloped in a sheath of fibroareolar tissue called the adventitia. The lymphatic vascular tissue lies in this envelope, and often lymph nodes and fat are present on the surface of these vessels. It is better to isolate the vessel from these tissues prior to having a suture passed under the artery.

It is often recommended that the ligation should be distal to the origin of the posterior division to avoid ischemia of the gluteal region; there are case reports of gluteal pain following iliac artery ligation. In practice, however, this happens extremely rarely. Tying the ligature about 2 cm below the origin of the internal iliac will help to avoid the posterior division. *[Editorial note: This was the technique I was taught by masters of this operation during my residency, and this is the technique that is used by most surgeons with whom I have discussed this issue. L.G.K.]*

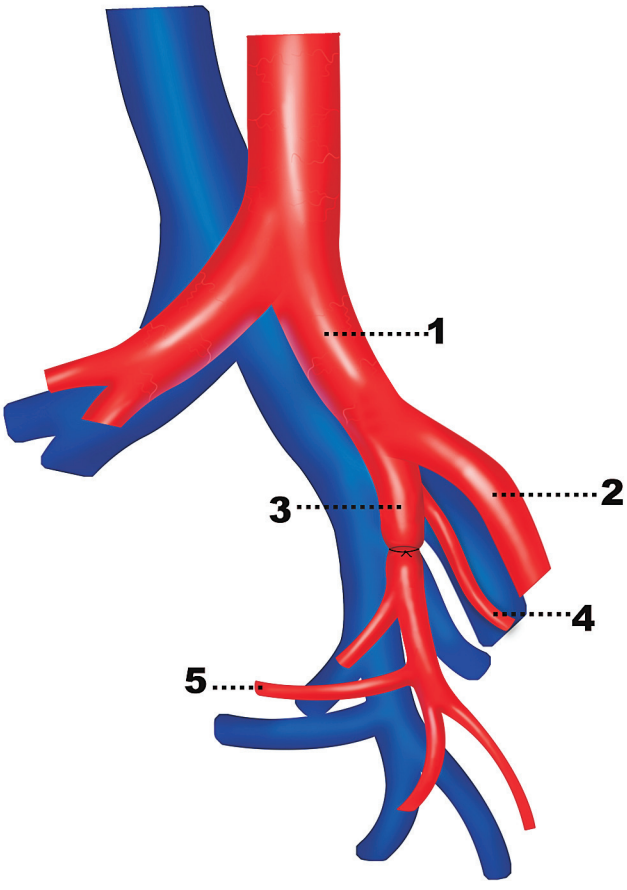

Figure 9 The internal iliac artery and its branches: (1) common iliac artery, (2) external iliac artery, (3) internal iliac artery (anterior division), (4) Internal iliac artery (posterior division) and (5) uterine artery

Procedure

There are two approaches to the internal iliac artery, and it is advisable to master both, as both may be needed depending on the clinical situation.

Broad ligament approach

At term, the internal iliac artery becomes easily accessible at the base of broad ligament if one opens the two leaves of it. The simplest way to achieve this is to open the uterovesical fold of peritoneum in front of the lower uterine segment (already undertaken in case of cesarean section) and extend the incision laterally up to the round ligament. The areolar tissue easily gives way allowing the surgeon to palpate the external iliac artery pulsations at the pelvic brim. It is important to avoid digging into the pelvis at this level. Follow the external iliac artery cranially by bluntly separating the tissue with fingers until the common iliac is reached. Keeping the superior leaf of the broad ligament intact helps to prevent the bowels and omentum from coming into the field. This can be achieved with the uterus

exteriorized or left inside the abdomen; our preference is to keep the uterus exteriorized. *The ureter will be seen at the bifurcation of the common iliac. It is better to move the ureter medially and hold it there with the blade of a long retractor.* The internal iliac artery is then traced caudally using a long clamp with a narrow tip; the fat and areolar tissue surrounding the internal iliac artery can be separated by just running the tip of the clamp (often with a pledget of dental roll cotton 1 cm in diameter) on both sides. A right angled clamp (Mixter) can be passed under the internal iliac artery about 2 cm below its origin, taking extreme care that its tip does not injure the veins nearby. Pulling up the internal iliac artery trunk with a Babcock forceps is helpful but not essential. The operator keeps the jaws of the Mixter clamp open (Figure 10). The assistant/nurse then feeds the tip of the suture between the jaws and the thread is then pulled out under the vessel. It is essential that the suture material be held on a long clamp and taken directly to the open Mixter clamp rather than be brought into the incision with the assistant's hand because the hand will obstruct vision and coordinated action will be difficult. We even suggest that if the surgeon and the nurse/assistant are operating together for the first time, they practice this step before the Mixter clamp is taken under the internal iliac artery. The suture material we prefer is catgut or one of the delayed absorbables like polyglycolic acid or polyglactin. A non-braided material has the advantage that it does not drag the areolar tissue with it when the suture is pulled through. One tie is enough because our aim is only a temporary occlusion. *[Editor's note: Other surgeons use a double tie by passing a loop to the Mixter which then is cut and makes two sutures. Silk or other non-absorable can also be used. L.G.K.]*

The procedure is then repeated on the other side. If the indication is pelvic sidewall bleeding or hematoma, unilateral ligation of that side may be enough. In all other situations, bilateral ligation is preferred.

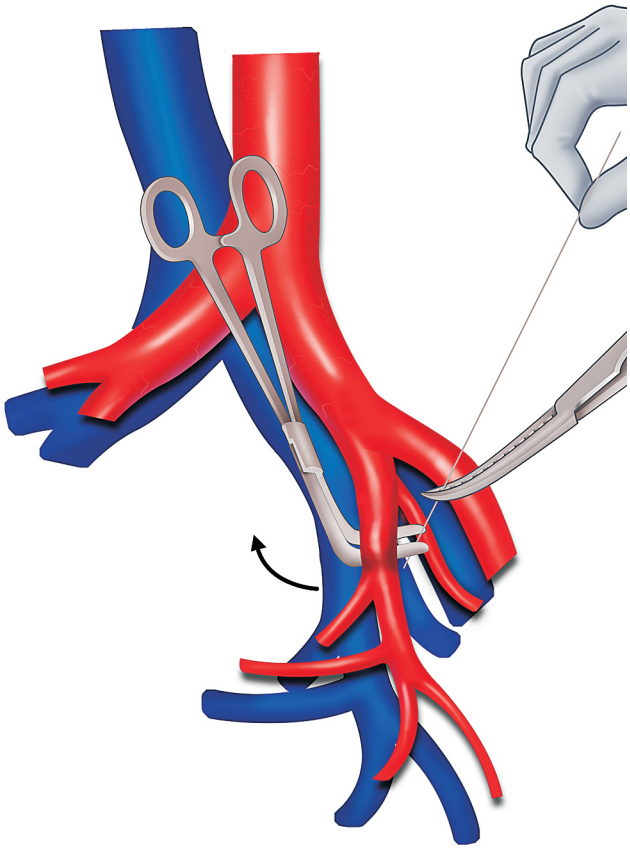

Figure 10 Taking sutures under the internal iliac artery with right angled clamp. The Mixter clamp is negotiated under the internal iliac artery without injuring the veins. The tip of the thread is fed to the open clamp with the help of a long forceps

Direct approach

In some cases, the uterus has already been removed or the pathology is such that it may not be possible to approach the artery between the two layers of broad ligament. In such instances, a direct approach over the internal iliac is essential. The vessel is identified by palpation of pulsation in either the common or external iliac. At a point about 2 cm below the bifurcation of the common iliac artery, the peritoneum is held up on Allis forceps and incised for about 2–4 cm. We prefer to incise longitudinally in relation to the vessel but lateral to the ureter. The peritoneum is separated craniocaudally and transversally, and the internal iliac artery isolated and tied as described for the broad ligament approach above. The peritoneal incision does not have to be closed.

Difference between right and left sides

Subtle differences exist between the right and left sides. The right side is more easily accessible and the venous relationship slightly different. On the left side, the root of the mesosigmoid mesentry overlies the area of the common iliac. In the direct approach, it is better to approach the vessels after keeping the sigmoid cranially. In the broad ligament approach, the sigmoid will be pushed cranially anyway.

The ureter overlies the bifurcation of the common iliac and is kept medially in the broad ligament approach as well as the direct approach.

Complications

The following complications may be encountered.

(1) *Bleeding as a result of injury to the main veins* described above is the commonest serious complication. It should be avoided by all means. If it happens, direct pressure can help to control it. Vascular clamps then have to be applied above and below, and the tears repaired. Help of a vascular surgeon is ideal. If this is not possible, attempts should be made to suture the defect with 6 '0' prolene. A tear of the internal iliac vein is less hazardous, as it can be tied off. In contrast, external iliac vein injuries have to be sutured and the circulation maintained. Otherwise, lower limb edema and eventually ischemia and necrosis will occur.

(2) *Inadvertent ligation of the external iliac artery* should also be avoided by all means. A safety check is to make a routine of palpating the femoral pulse immediately before and immediately after the internal iliacs are tied.

(3) *Injury to ureter* – the ureter should be identified before the peritoneal incision is made. This helps in avoiding inadvertent injury to the ureter. It is not necessary to isolate the ureter or separate it from the peritoneum. Displacing it with the blunt end of the retractor is enough.

(4) *Gluteal pain/ischemia* – when the ligature is placed close to the origin of the internal iliac, the posterior division also may be involved in the ligature and ischemia to the gluteal muscle is possible. If the ligature is taken about 2 cm below the bifurcation, this eventuality is unlikely to occur. Because of the anastomoses between the branches of the gluteal artery and the lumbar arteries arising from the aorta, ischemic necrosis in the gluteus maximus is very rare.

Reproductive function after internal iliac artery ligation

Normal menstruation and fertility have been described after bilateral internal iliac artery ligation[8].

Current status of internal iliac artery ligation

After the brace stitch became popular, the use of internal iliac artery ligation for atonic PPH changed. We now use it mainly for traumatic PPH and tear of lower genital tract. The internal iliac artery ligation helps in the control of bleeding at such sites and makes suturing possible.

CONCLUSIONS

This chapter details the surgical steps that help to control bleeding during cesarean section. Internal iliac artery ligation is discussed in detail, but other surgical steps are covered in other chapters.

References

1. B-Lynch C, Cocker A, Lawal AH, Abu J, Cowen MJ. The B-Lynch surgical techniques for the control of massive postpartum haemorrhage: an alternative to hysterectomy? Five cases reported. Br J Obstet Gynaecol 1997;104:372–5
2. Hayman RG, Arulkumaran S, Steer PJ. Uterine compression sutures: Surgical management of postpartum hemorrhage. Obstet Gynecol 2002;99:502–6
3. Ophir E, Singer-Jordan J, Odeh M, et al. Abnormal placental invasion – A novel approach to treatment Case report and review. Obstet Gynecol Surv 2009;64:811–22
4. Timmermans S, van Hof AC, Duvekot JJ. Conservative management of abnormally invasive placentation. Obstet Gynecol Surv 2007;62:529–39
5. Kayem G, Clement D Goffinet F. Recurrence following conservative management of placenta previa accreta. Int J Gynecol Obstet 2007;99:142–3
6. Hull AD, Resnik R. Placenta accreta and postpartum hemorrhage. Clin Obstet Gynecol 2010;53:228–36
7. Paily VP. Why Mothers Die, Kerala 2004–05. Thrissur 5, Kerala, India: India Kerala Federation of Obstetrics & Gynaecology (KFOG), 2009:30
8. Nizard J, Barrinque L, Frydman R, Fernandez H. Fertility and pregnancy outcomes following hypogastric artery ligation for severe postpartum hemorrhage. Hum Reprod 2003;18:844–8

EDITORS' SUMMARY OF KEY POINTS

INITIAL INTERVENTIONS TO COMBAT HEMORRHAGE DURING CESAREAN SECTION

Simple measures to combat hemorrhage during cesarean section include:

- Checking the angles of the uterus to make sure there are no missed vessel(s)
- Checking the uterine cavity to rule out any retained fragments of placenta
- Considering the use of a second or third uterotonic.

If bleeding is mainly from the fundus and the mid-part of the uterine body, examine the patient in the Lloyd Davies position and perform a manual uterine compression test to assess the feasibility of uterine compression sutures. If there is no bleeding whilst compression of uterus is being performed, uterine compression sutures are appropriate.

If bleeding still continues and the source of bleeding is from the lower segment or cervical region, the balloon tamponade test can be performed and assessment of continued bleeding carried out. If the tamponade test shows no bleeding, a uterine balloon (Bakri, Rüsch, condom catheter, etc.) can be used. The balloon is inserted via the uterine end and the stem passed down the cervical canal. It is inflated after closing the uterine incision and after inserting two simple vertical compression sutures. The balloon should be inflated whilst observing the closed uterine wound for any bleeding via the cervix. If there is no bleeding from the uterine incision wound or via the cervix and if there is no herniation of the balloon, then this 'sandwich technique' can be considered to be successful. A vaginal pack may help to keep the balloon *in situ* in the uterine cavity.

In the majority of circumstances, the above measures will stop bleeding during cesarean section. In a minority of cases, however, bleeding may still continue, and, in such circumstances, advanced procedures such as internal iliac artery ligation, as mentioned above, will help to control bleeding.