

Cesarean Hysterectomy and Uterine-Preserving Alternatives



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KEYWORDS

- Cesarean • Hysterectomy • Postpartum • Hemorrhage • Atony • Previa • Accreta • Conservative

KEY POINTS

- Postpartum hemorrhage remains a primary cause of maternal morbidity and mortality.
- Major causes of postpartum hemorrhage are atony, laceration, invasive placentation, sepsis, and coagulopathy.
- Management of postpartum hemorrhage requires an understanding of available medical and surgical treatments at each facility and a plan of care on how to access regional referral centers.
- Early identification of patients with clinically significant bleeding and prompt treatment to prevent the most likely complications is recommended.
- Multidisciplinary teams improve care by providing a systematic approach to postpartum complications, many of which have a common endpoint of hysterectomy or uterine-preserving techniques.

BACKGROUND

Peripartum hysterectomy is the removal of the uterine corpus at the time of delivery or during the immediate postpartum period. No commonly accepted definition places a limit on when the period ends. When performed at the time of cesarean delivery, it is termed a *cesarean hysterectomy*. A *postpartum hysterectomy* is performed after delivery of the fetus, with studies varying on whether a hysterectomy is performed within 24 hours, during the same hospitalization for delivery, or within the 6-week postpartum period.

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The incidence of peripartum hysterectomy is on the rise.¹ Bateman and colleagues¹ performed a national cross-sectional study looking at more than 56 million deliveries from 1994 to 2007 and reported an increase in the overall rate from 71.6 to 82.6 per 100,000 deliveries. During that time, the rate of hysterectomy for abnormal placentation increased by 23%, from 32.9 to 40.5 per 100,000 deliveries, and uterine atony by 130%, from 11.2 to 25.9 per 100,000 deliveries. Hysterectomies not related to abnormal placentation, atony, delayed hemorrhage, or uterine rupture decreased during that period.¹ In the past, commonly accepted indications for hysterectomy included definitive treatment aimed to control bleeding or infection and even sterilization. Uterine atony and abnormal placentation continue to be common indications after vaginal delivery, primary cesarean, or repeat cesarean.¹⁻³ The contemporary use of hysterectomy indicators was detailed by the Maternal-Fetal Medicine Units Network looking at cesarean hysterectomy in a cohort of cesarean deliveries.² The most common indication for hysterectomy in their study was placenta accreta, which was the indication in 38.2% of the hysterectomies; other indications are listed in **Table 1**.² There were often measures taken to avoid hysterectomy, including uterine artery ligation (48%), ovarian artery ligation (20%), uterine packing (6%), hypogastric artery ligation (5%) oxytocin (9%), and uterine tamponade (14%).²

Adverse events related to peripartum hysterectomy are substantial.^{3,4} The most common injury is to the bladder, which occurs in 9% of peripartum hysterectomies and only 1% of nonobstetric hysterectomies.^{3,5} Other common risks include ureteral injury, hemorrhage, wound complications, and venous thromboembolism, which are increased with peripartum hysterectomies.³ The risk of death with a peripartum hysterectomy is 1% (odds ratio [OR] 14.4; 95% CI, 9.84–20.98) compared with 0.04% for nonobstetric hysterectomy.³ The risk of perioperative mortality, however, is 71% lower in high-volume centers compared with low-volume centers.⁴

Hysterectomy is a shared endpoint for postpartum hemorrhage after vaginal or cesarean delivery that is complicated by uterine atony, placental invasion, uterine rupture, leiomyomas, laceration extension, coagulopathy, or sepsis.^{1,6} The techniques to manage these complications overlap and are often identified by recognizing unexpected bleeding or hemorrhage. Systematic protocols for postpartum hemorrhage

Table 1
Common indicators for peripartum hysterectomy

Indication	Wright et al, ³ 2010 ^a		Shellhaas et al, ² 2009 ^b	
	Overall (%)	Overall (%)	Primary Cesarean Delivery (%)	Repeat Cesarean Delivery (%)
Placenta accreta	36.2	38.2	16.3	54.7
Atony	31.2	34.4	52.5	20.8
Cervical cancer	N/A	7.0	11.3	3.8
Uterine rupture	1.3	5.4	2.5	7.5
Leiomyoma	7.1	4.8	7.5	2.8
Extension	1.2	1.1	2.5	0.0
Other	N/A	9.1	7.5	10.4

^a From vaginal deliveries and cesarean deliveries.

^b From cesareans, primary cesarean, and repeat cesarean deliveries.

Data from Wright JD, Devine P, Shah M, et al. Morbidity and mortality of peripartum hysterectomy. *Obstet Gynecol* 2010;115:1187–93; and Shellhaas CS, Gilbert S, Landon MB, et al. The frequency and complication rates of hysterectomy accompanying cesarean delivery. *Obstet Gynecol* 2009;114(2 Pt 1):224–9.

emphasize uterine atony as the most likely cause for bleeding and may not distinguish management based on diagnosis until unresponsive to initial therapy.^{7,8} Conservative or uterine-preserving management refers to the management of peripartum complications by any method that avoids hysterectomy, which is intended to reduce the risk of complications and is generally the initial management for many of these indications.⁶⁻⁹

POSTPARTUM HEMORRHAGE

Hemorrhage remains a significant cause of maternal mortality worldwide and is currently the cause in 27% of all maternal deaths.¹⁰ From 1987 to 2006, the percentage of deaths in the United States attributed to hemorrhage decreased and is currently responsible for 11.4% of maternal mortalities.¹¹ It is the 4th leading cause of mortality in the United States and the leading cause worldwide.¹⁰ In the United States, maternal mortality from hemorrhage occurred most frequently with ruptured ectopic (3%), other causes (2.1%), uterine atony (1.8%), abnormally invasive placentation (1.4%), uterine rupture (1.1%), abruption (1.1%), placenta previa (0.3%), retained products (0.2%), and coagulopathy (0.2%).¹¹

Postpartum hemorrhage is typically defined by the amount of blood loss after delivery, which is a vaginal delivery, with greater than or equal to 500 mL, and cesarean section, with greater than or equal to 1000 mL. Reported mean blood loss approximates these cutoffs for each route of delivery. The incidence of postpartum hemorrhage is reported to be 1% with active management and up to 3% without.^{12,13} The most common cause of postpartum hemorrhage is uterine atony,⁷ although the rate of abnormally invasive placentation as a cause for postpartum hemorrhage is increasing.^{1,6}

UTERINE ATONY

The effective treatment of uterine atony includes prophylactic administration of medications, prompt recognition of atony as a cause of bleeding, and immediate treatment. It is important to have a thorough understanding of the mechanism of action for each medication and to understand the contraindications to their use. A summary of the medications is included in [Table 2](#). Uterine atony may be encountered at the time of vaginal delivery or cesarean delivery or may present as a delayed complication in the postpartum period.

SURGICAL SITE BLEEDING AND ARTERIAL LIGATION

The original description by O'Leary and O'Leary¹⁴ used a suture to compress the uterine artery along its expected anatomic location in the lateral aspect of the broad ligament. The original report included 90 patients with 6 failures; included among the failures were 3 patients with placenta accreta.¹⁴ They also theorized that in placenta previa, blood supply arising from cervical or vaginal branches, may not be sufficiently occluded with ligation of the uterine artery, which was consistent with their observations. Since the initial report, uterine artery ligation at the time of cesarean or laparotomy has been a simple and effective initial step. To place an O'Leary suture the following steps are recommended:

- The uterine artery is palpated along the lateral aspect of the lower uterine segment.
- While compressing the uterine artery, the uterine artery and broad ligament are retracted by the surgeon laterally.

Medication	Dose and Route	Frequency	Comments
Oxytocin (Pitocin)	10–40 U diluted in normal saline or lactated Ringer solution	Continuous infusion	1–6 min half-life
	10 U intramuscular or intramyometrial	One time, unclear when to repeat	3–5 min onset, duration 3–5 h, 2–3 h duration
Methylergonovine (Methergine)	0.2 mg intramuscular or intramyometrial	Every 2–4 h	Contraindicated if hypertensive
15-Methyl prostaglandin F _{2a} (carboprost [Hemabate])	0.25 mg intramuscular or intramyometrial	Every 15–90 min up to 8 doses	Contraindicated if asthma Common gastrointestinal side effects
Dinoprostone (Prostin E ₂)	20 mg rectal or vaginal suppository	Every 2 h	May cause bronchospasm
Prostaglandin E ₂ (dinoprostone [Cervidil, Prepidil])	1000- μ g rectal suppository	One time	Side effects include fever

- A suture is passed from the anterior uterus to the posterior uterus 2 cm to 3 cm medial to the uterine artery superior to the bladder and without requiring a bladder flap.
- The suture is then passed posterior to anterior through an avascular window of the broad ligament.

Today an O'Leary suture is a standard tool of obstetricians to reduce blood loss from unexpected surgical bleeding and manage postpartum hemorrhage to prevent peripartum hysterectomy. Unexpected bleeding may occur during cesarean delivery from laceration of the uterine artery during extension of the hysterotomy incision, lateral or low placental implantation site bleeding, coagulopathy, large leiomyomas, and uterine atony. Postpartum hemorrhage that is unresponsive to initial medications, uterine tamponade, or genital tract lacerations may be converted to laparotomy, and often the first intervention is placement of an O'Leary suture.^{6,15} Prophylactic use of an O'Leary suture for patients with a leiomyoma can also reduce blood loss, improve postoperative hemoglobin, and reduce leiomyoma size.¹⁶ Complications of an O'Leary suture can include hematoma, bleeding, ureteral injury, or inadequate control of bleeding.

Hypogastric artery ligation, also known as internal iliac ligation, is used to control bleeding with postpartum hemorrhage.^{6,15} Ligation of this vessel reduces the pulse pressure into the pelvic organs by 85%. There is a trend away from using this technique due to the risk of complications and lack of familiarity with the anatomy. Ligation of the hypogastric artery also precludes endovascular embolization beyond the hypogastric vessels. There is likely a need for using this technique at facilities without access to interventional radiologist.^{2,6} If the operator is inexperienced with the technique, an experienced surgeon is recommended to assist. Performing this procedure involves the following:

- Open the anterior leaf of the broad ligament to identify the external iliac.
- Trace vessel to origin of common iliac. Identify the anterior division of the internal iliac.

- Use nonabsorbable suture to tie lateral to medial.
- Complications may involve ligation of the external iliac, which leads to loss of lower extremity pulses or injury to the internal iliac vein.

COMPRESSION SUTURES

The B-Lynch suture and other variations are designed to provide compression to the uterus by mechanical force. This technique may be used at the time of cesarean or during an exploratory laparotomy. The original description used a chromic suture, although a monofilament, such as a no. 1 polyglactone 25 suture, is less likely to cause trauma. A B-Lynch procedure is performed with the following steps:

- Placing a vertical anchoring suture in the lower uterine segment and at the corner of hysterotomy
- Pulling the suture superiorly and looping over the uterine fundus
- Placing a horizontal suture along the posterior aspect of the lower uterine segment
- Pulling the suture superiorly and looping over the uterine fundus
- Placing a second vertical anchoring suture across from the initial suture at the corner of the hysterotomy
- With compression from an assistant, tightening and tying the suture

There are other techniques that are similar in principle to the B-Lynch suture. Recent reviews concluded that the strength of evidence to evaluate effectiveness and harms of compression sutures is low.^{9,15} As a secondary measure to control bleeding, success of the suture depends on the decrease in bleeding related to compression. If compression of the uterus by the surgeon or assistant does not seem effective in decreasing blood loss, then placement of a suture for that purpose is not likely to be successful, and consideration for other causes for bleeding, such as laceration, invasive placentation, and coagulopathy, is recommended.

UTERINE TAMPONADE

Uterine balloon catheters are designed to tamponade placental bleeding sites within the uterine cavity. This is most effective when the catheter is able to apply direct pressure to the bleeding site. Uterine balloon devices designed specifically for the tamponade of uterine bleeding after vaginal or cesarean delivery include the Foley catheter, Bakri balloon, B-T Cath device (Utah Medical Products Inc., Utah, USA), and the double-balloon Ebb device (Clinical Innovations, Utah, USA), which is also designed to tamponade cervical bleeding.^{6,17} The Foley catheter may be instilled with 60 mL to 80 mL of saline, with placement of multiple catheters,⁶ and the various balloon catheters have manufacturer limits on the amount of fluid recommended for each device. The Bakri balloon is recommended to be filled to 300 mL to 500 mL, although the devices can be filled with 300 mL to 1200 mL of fluid to distend the uterus.^{6,17,18} To effectively exert pressure against a bleeding surface area, the balloon may require additional distension.¹⁹ Ineffective use of the device can occur with distortion of the uterine cavity from anomalies or leiomyomas, retained placenta, expansion of the cavity by clot or debris, loss of uterine tone, or laceration extending into an open or intra-abdominal space may not allow the device to apply sufficient pressure to tamponade bleeding.

INTERVENTIONAL RADIOLOGY

Interventional radiology has remarkably advanced minimally invasive management of postpartum hemorrhage, placenta accreta, and pelvic abscess drainage. Endovascular embolization for postpartum hemorrhage allows rapid and selective control of bleeding.⁶ A recent systematic review, which defined success as requiring no additional procedures, estimated an 89% to 91% success rate.^{9,15} For patients with placental invasion or placenta accreta, success is reported with uterine artery, hypogastric artery, or aortic balloons as prophylactic treatment when placed prior to delivery and then insufflated after delivery if needed.²⁰⁻²³ A drawback with preoperative placement is the need to expose the fetus to ionizing radiation and the need to transfer patients between the radiology suite and operating room,²⁴ although newly designed hybrid operating rooms eliminate the need to transfer unstable patients intraoperatively. It is also possible to place balloon catheters prior to delivery and then after delivery selective embolization is used. Uterine artery embolization is technically feasible in 97% of placenta accreta cases,²⁵ with reported decreases in blood loss and transfusion requirements.^{25,26} This method is reportedly used by multidisciplinary teams, and improvement in select cases is also reported.^{24,27} Complications with balloon catheters are reported and rupture of the vessels cited as the primary complication encountered.²¹⁻²⁴ A staged procedure that involves embolization after delivery holds promise for reducing blood loss and hysterectomy rate, but additional studies are needed.²⁸ One advantage of embolization is the ability to selectively embolize uterine arteries, hypogastric arteries, significant collateral arteries, or parasitized blood supply.

MASSIVE TRANSFUSION

Massive transfusion protocols were developed after recent military use.²⁹ It was recognized that significant morbidity and mortality occurred when bleeding continued after adequate replacement of red blood cells. After the initial blood loss, red blood cell replacement, and volume resuscitation, ongoing blood losses would continue and eventually other signs of coagulopathy would manifest. By early and systematic replacement of fresh frozen plasma and platelets, there is a decrease in significant and ongoing blood loss. Red blood cells acquired for storage are separated into packed red blood cells, plasma, cryoprecipitate, and platelets, and, therefore, the packed red blood cells are lacking sufficient coagulation proteins and platelets when used. The largest amount of stored proteins is in fresh frozen plasma.

The clotting cascade is extensive and involves multiple factors and platelets for coagulation.

- Initially tissue factor and factor VIIa bind to form a complex that activates factors X and IX.
- Factor Xa binds to complex with factor Va, which then activates prothrombin (factor II) to thrombin (factor IIa).
- Thrombin (factor IIa) activates fibrinogen to fibrin and promotes additional activation of factor V to factor Va. There is further amplification from thrombin (factor IIa) activating factor VIII, allowing factors IXa and VIIIa to complex. Thrombin (factor IIa) also activates factor XI to factor XIa, which amplifies activation of factor IX to IXa. Lastly, thrombin activates factor XIII to factor XIIIa, which cross-links fibrin polymers.

The guiding principle for massive transfusion protocols is to replace equal amounts of red blood cells, coagulation factors, and platelets. After the initial resuscitation of crystalloid and blood, transfusion of fresh frozen plasma and platelets are typically done in a 1:1:1 fashion, although the exact units may vary by institution.²⁹ Massive

transfusion protocols have been implemented in obstetrics and used by many tertiary referral centers. It is important to identify how each facility manages massive transfusion protocols because variation exists, and there are many resource-lacking areas that do not have the capability to provide massive transfusions. Facilities that do not have the ability to provide massive transfusion need to identify at-risk patients and facilitate early and appropriate transfers of care prior to delivery.

ANTIFIBRINOLYTICS

Tranexamic acid is an antifibrinolytic medication used for preventing massive bleeding in the setting of hemorrhage, trauma, or menstrual bleeding and prior to procedures for patients with hemophilia. It is a synthetic analog of lysine, an amino acid that binds to lysine receptors on plasminogen or plasmin. The resultant effect prevents degradation of fibrin polymers. When used as a prophylactic medication, there is decreased blood loss at delivery (261.5 mL \pm 146.8 mL vs 349.98 mL \pm 188.85 mL; $P < .001$) and reduced postpartum hemorrhage at the time of vaginal delivery (relative risk [RR] 3.76; 95% CI, 1.27–11.15; $P = .01$).³⁰ A study of 144 patients evaluated use of tranexamic acid after a postpartum hemorrhage greater than 800 mL and found that there was less blood loss, shorter duration of bleeding, and less red blood cell transfusion.³¹ A recent Cochrane review looked at 12 trials comprising 3285 patients and concluded that blood loss after either vaginal delivery or cesarean was decreased with tranexamic acid use even when routine uterotonics were used.³² Further studies are needed to determine the optimal dosing regimen.

TOPICAL HEMOSTATIC AGENTS

Topical hemostatic agents take advantage of their biochemical and chemical properties to control persistent bleeding arising from large surfaces or coagulopathy. In pregnancy the increased edema makes tissue more friable and likely to bleed with extensive manipulation. Coagulopathy can result from postpartum hemorrhage; severe preeclampsia; hemolysis, elevated liver enzymes, and low platelets (HELLP) syndrome; thrombocytopenia; abruption; sepsis; and uterine rupture. At that point, the patient lacks essential components to form clot, and after an initial activation of the clotting cascade, the fibrinolytic system becomes more active, which quickly breaks down the formation of any clot. Adequate treatment with uterotonics, compression, or arterial ligation does not effectively address the underlying cause of ongoing blood loss once coagulopathy is present. Topical agents with fibrinogen and thrombin allow clot to form at the application site even when coagulopathy persists. Agents are available in a variety of application methods, which includes powders, sheets, liquids, and sprays, which can be applied over a wide area.

There are several extensive reviews available that discuss the use of hemostatic agents to control intraoperative bleeding.³³ The agents most commonly used in obstetric are summarized in **Table 3**. The initial use and experience of these agents were from trauma, cardiovascular surgery, orthopedic surgery, urology, and neurosurgery. The effectiveness of these agents in preventing the need for hysterectomy is unknown, but case reports on products like combat gauze seem promising.³⁴ Despite currently lacking data to guide use, these agents are valuable approaches to control obstetric blood loss and may hold promise for uterine preservation.

Not all topical hemostatic agents may be safe to use during pregnancy. Bone wax is used for controlling bleeding along the surface of the bone by occlusion of bleeding channels within bone. Although this may not be encountered during obstetric surgery, its use after orthopedic trauma is worth discussing. A study in rats identified teratogenic potential when bone wax was used on pregnant rates.³⁵

Table 3
Topical hemostatic agents for use during pregnancy

Product	Mechanism	Types of Bleeding	Disadvantages	Trade Names
Absorbable agents				
Gelatin foam	Physical matrix <ul style="list-style-type: none"> • Film • Sponge • Powder 	Small vessel bleeding Hemostatic plug wrapped in oxidized cellulose Absorbed by the body within 6 wk Nonantigenic Neutral pH, can use with biologics	Swells with hydration and can cause damage in small spaces Embolization if in intravascular space	Gelfilm Gelfoam
Oxidized cellulose	Physical matrix Low pH	Antimicrobial effect from low pH Easy to handle, does not stick to instruments Dissolves within 6 wk	Low pH <ul style="list-style-type: none"> • Inactivates other biologics, such as thrombin • Inflammation 	Surgicel Fibrillar Surgicel Nu-Knit
Microfibrillar collagen	Adheres and activates platelets	Control wide areas of bleeding Effective in heparinized conditions	Decreased efficacy with thrombocytopenia Caution with recollection devices because product passes through filter Adheres to instruments/surgical gloves	Avitene Avitene Flour Endo Avitene Avitene Ultrafoam Avitene UltraWrap Instat Helitene Helistat

Biologic agents

Thrombin	Converts fibrinogen to fibrin Activates clotting factors	Minor bleeding from capillaries, small venules unresponsive to pressure Rapid acting	High immunogenicity with bovine derivatives	Thrombin-JMI (bovine), Evithrom (human derived) Recothrom Recothrom (recombinant human)
Thrombin with gelatin	Gelatin cross-links into matrix to tamponade Thrombin effect	Moderate arterial bleeding due to gelatin tamponade effect	Required contact with blood Increases size rapidly after application	Floseal
Fibrin sealant	Thrombin and fibrinogen mix at application site Thrombin cleaves fibrinogen to fibrin	Effective with heparinization Venous oozing from denuded surfaces	Time to prepare	Tisseel Evicel Crosseal
Platelet gel	Microfibrillar collagen and thrombin combined with patients plasma, which contains fibrinogen and platelets	Arterial and venous use. Utilizes patient's platelets, facilitate tissue regeneration	Caution with blood scavenging systems	Vitagel

ACTIVATED FACTORS

Activated factors are available, and approved by the Food and Drug Administration for use in promoting hemostasis for patients with acquired or inherited defects in coagulation. Recombinant factor VII is approved for use in patients with hemophilia, autoantibodies to factors VIII or IX, and congenital deficiency of factor VII. Of all of the available activated factors, factor VIIa has been used off-label to control bleeding from postpartum hemorrhage or surgical bleeding. Lavigne-Lissalde and colleagues³⁶ studied a total of 84 women and treated 42 patients with a single dose of recombinant factor VIIa or standard care for patients with postpartum hemorrhage unresponsive to uterotonics. There were 22 of 42 (52%) patients who required additional therapies when treated with factor VIIa compared with 39 of 42 (93%) patients with standard care who required additional therapies.³⁶ There were no deaths, but there were 2 venous thrombotic events after treatment.

INVASIVE PLACENTATION, MORBIDLY ADHERENT PLACENTATION, PLACENTA ACCRETA, PLACENTA INCRETA, AND PLACENTA PERCRETA

Placenta accreta is a risk factor for maternal morbidity and mortality. The Centers for Disease Control and Prevention in the United States reported that from 2006 to 2010 the risk of maternal death from placenta accreta was 1.4% of all obstetric deaths.¹¹ The incidence of placenta accreta seems to be increasing for referral centers, with a reported rate of 1 in 4027 prior to 1980 that increased to 1 in 533 in a single referral center.³⁷ Another large multicenter study of 25 academic centers found the rate of morbidly adherent placentation to be 1 in 731.³⁸ In contrast to referral centers, a large health care delivery system reported only 1 death from placenta accreta in a review of 1,461,270 deliveries.³⁹

Morbidly adherent placentation refers to the clinical recognition of delayed placental separation during the third stage of labor that is often associated with placenta accreta, placenta increta, or placenta percreta. Placenta accreta is invasion of the trophoblasts into the myometrium with failure to transform maternal spiral arteries and form Nitabuch layer, which is responsible for separating during the third stage of labor. Placenta increta is trophoblastic invasion deep into the myometrium. Placenta percreta is invasion of trophoblast up to and beyond the uterine serosa.

Risk factors for placenta accreta are present in a majority of patients who are diagnosed with the disorder, although this is not required. The strongest risk factor is placenta previa with a risk of 3%,³⁷ and the risk for placenta accreta increases with the number of prior cesareans.^{40,41} When previa is present, there is an 11% risk of placenta accreta with 1 prior cesarean, 40% with 2 prior cesareans and 60% with 3 or more prior cesareans.^{40,41} Even when there is no placenta previa, the risk for placenta accreta increases with the number of prior cesareans, reaching 4.7% with 6 or more prior cesareans.⁴⁰ The risk for placenta accreta is associated with several conditions, many of which involve injury to the endometrium or myometrium and include myomectomy, uterine curettage, endometrial ablation,⁴² Asherman syndrome, leiomyoma, and pelvic radiation.⁴³ Other risk factors include age greater than 35 years,³⁷ multiparity,³⁷ abortion,³⁷ and cesarean scar ectopic.^{44,45}

Understanding the definitions and histopathology of placenta accreta, placenta increta, and placenta percreta helps explain the antenatal diagnostic criteria used to diagnose abnormal placentation. Trophoblasts seem more heterogeneous in the transformation of spiral arteries, particularly when implantation occurs in areas of endometrial or myometrial damage. A study evaluated vessel diameter size from patients with abnormal placentation and compared this with controls. They identified

greater heterogeneity of vessel distribution containing fewer capillaries with larger capillary diameters, and larger diameter vessels compared with controls.⁴⁶ Normal placentation seems to have a more uniform distribution of small, medium, and large vessel diameters, and the overall total area occupied by vessels was not different between placenta increta and controls.⁴⁶ These changes can help explain the ultrasound findings associated with abnormal placentation. In a multivariate analysis, ultrasounds with placental lacunae (OR 1.5; 95% CI, 1.4–1.6), loss of the retroplacental hypoechoic zone (OR, 2.4; 95% CI, 1.1–4.9), or abnormal color Doppler (OR, 2.1; 95% CI, 1.8–2.4) may be more likely in patients with the disorder.⁴⁷ The use of ultrasound findings to increase the sensitivity or specificity of detecting abnormally invasive placentation is highly dependent on the clinical history,⁴⁸ and MRI has similar diagnostic capability.⁴⁹ Reported findings associated with abnormally invasive placentation are

- Cesarean scar ectopic
- Loss of retroplacental hypoechoic zone
- Vascular lacunae or large venous lakes, which may have turbulent flow
- Irregular serosal border and bladder interface
- Myometrial thickness along retroplacental area less than 1 mm
- Large coalescing vascular flow within the placenta

Antenatal diagnosis of placenta accreta, placenta increta, and placenta percreta occurs in only 50% to 53% of patients prior to delivery.^{38,50} Surprisingly, 18% of patients diagnosed with invasive placentation are nulliparous, and 37% have no prior cesarean deliveries.³⁸ When the diagnosis is suspected antenatally, there is likely to be less blood loss (2750 vs 6100 mL; *P* = .008) and less need for transfusion (59 vs 94%; *P* = .014) and fewer attempts to remove placenta.⁵⁰ **Table 4** provides the distribution of outcomes for patients diagnosed prior to delivery and those at the time of delivery. One possible explanation for the difference in outcomes is that when placental invasion is more clinically significant, there may be more than 1 associated finding for invasive placentation, which may also indicate deeper invasion, and result in significant complications being experienced at delivery.

Knowing that placenta accreta is suspected allows referral to centers of excellence for placenta accreta.⁵¹ The advantages of such centers are the expertise, experience, and dedication of resources that are needed in managing complex cases of placenta accreta. Centers often have a defined multidisciplinary team, which is associated with

Table 4 Outcomes observed when placenta accreta, placenta increta, or placenta percreta is suspected antenatally		
	Antenatal Diagnosis Prior to Delivery	Undiagnosed Prior to Delivery
Large blood loss (>2750 mL)	33%	19%
Hysterectomy	92%	45%
Admission to ICU	39%	22%
Gestational age at delivery (wk)	35.6% (33.6–36.9)	37.8 (35.4–39.6)
Neonatal ventilator support within 24 h	28.6% (18.9–38.2)	10.8 (3.7–17.9)
Neonatal ICU admission	65.5% (55.3–75.6)	33.8 (23.0–44.6)

Data are percentages with CI (5%–95%).

Data from Bailit JL, Grobman WA, Rice MM, et al. Morbidly Adherent placenta treatments and outcomes. *Obstet Gynecol* 2015;125:683–9.

reduced blood loss and morbidity.^{52–54} There is often a systematic approach to treating patients, which can include administration of antenatal corticosteroids, timing for delivery, use of ureteral stents, skin incision, uterine incision, involvement of interventional radiology, decisions and counseling for expectant management or uterine preservation, consultation with surgical specialists, management of massive transfusion, and ICU support.^{4,52–55} Suggestions for criteria to designate a center of excellence for placenta accreta are in **Box 1**.⁵¹

A center of excellence serves to function as regionalized care to prevent complications and improve outcomes. Appropriate management focuses on making an accurate prenatal diagnosis, access to consultants, and predelivery planning.^{27,54} Centers are experienced in making clinical care plans for complex invasive placentation,^{24,54} planning preterm delivery,⁵⁶ and when to perform embolization.^{26,54}

Criteria when considering referral to a center of excellence for placenta accreta have been proposed and are found in **Box 2**.⁵¹ A patient is suspected of having a placenta accreta either from clinical risk factors or from sonographic factors on prenatal ultrasound. Clinical risk factors include current or prior placenta previa, current or prior cesarean delivery, multiple previous cesarean deliveries, history endometrial ablation, previous uterine surgeries, and first-trimester or second-trimester bleeding, with other risk factors for placenta accreta.^{37,40,41,44,51,57} Ultrasound sonographic risk factors include identification of an abnormal placenta, abnormal uterine shape, abnormal vascularity of the myometrial wall, or current or previous cesarean scar ectopic.^{44,45,47,48,51}

UNEXPECTED PLACENTA ACCRETA

Placenta accreta may not be suspected prior to delivery in approximately 47% to 50% of cases.^{38,50} Clinical recognition after vaginal delivery is a delayed separation

Box 1

Suggested criteria for center of excellence for placenta accreta

1. Multidisciplinary team
 - a. Experienced maternal-fetal medicine physician or obstetrician
 - b. Imaging experts (ultrasound and MRI)
 - c. Pelvic surgeon (ie, gynecologic oncology or urogynecology)
 - d. Anesthesiologist (ie, obstetric or cardiac anesthesia)
 - e. Urologist
 - f. Trauma or general surgeon
 - g. Interventional radiologist
 - h. Neonatologist
2. ICU and facilities
 - a. Interventional radiology
 - b. Surgical or medical ICU
 - i. 24-Hour availability of intensive care specialists
 - c. Neonatal ICU
 - i. Gestational age appropriate for neonate
3. Blood services
 - a. Massive transfusion capabilities
 - b. Cell saver and perfusionists
 - c. Experience and access to alternative blood products
 - d. Guidance of transfusion medicine specialists or blood bank pathologists

From Silver RM, Fox KA, Barton JR, et al. Center of excellence for placenta accreta. *Am J Obstet Gynecol* 2015;213(6):755–60; with permission.

Box 2**Criteria for consideration of delivery in center of excellence for placenta accreta**

1. Suspicion for placenta accreta on sonogram
2. Placenta previa with abnormal ultrasound appearance
3. Placenta previa with 3 or more prior cesarean deliveries
4. History of classic cesarean delivery and anterior placentation
5. History of endometrial ablation or pelvic irradiation
6. Inability to adequately evaluate or exclude findings suspicious for placenta accreta in women with risk factors for placenta accreta
7. Any other reason for suspicion of placenta accreta

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unresponsive to uterotonics and gentle traction. Expulsion of the placenta may also occur with ensuing postpartum hemorrhage unresponsive to uterotonics and no evidence of genital tract laceration, coagulopathy, leiomyoma, or uterine inversion. During exploratory laparotomy or cesarean delivery, findings on the serosal surface, such as large varicosities, distended lower uterine segment with bulging, or direct extension of placenta onto the uterine surface, bladder, or pelvic sidewalls may provide clues although may be nondescript with placenta accreta.⁵¹ **Fig. 1** is an example of an anterior wall placenta percreta, and **Fig. 2** is a lateral wall placenta percreta. A proposed management strategy is suggested and is seen in **Box 3**.

The delivering physician must decide whether to proceed with delivery or transfer based on maternal medical needs need like excessive bleeding or clinical instability, rather than based on fetal indication. If a delivery site is not equipped or prepared, then if at all possible the patient should be transferred to a referral center.⁴ Care for the mother over the fetus still remains paramount. If delivery needs to proceed, then avoid disturbing or removing the placenta by using a fundal or posterior uterine



Fig. 1. Anterior wall placenta percreta with evidence of neovascularization across the uterine serosa, distortion of the serosa, and varicosities on the surface.



Fig. 2. Lateral wall placenta percreta with serosal vessels and distortion of the lower uterine segment.

incision if needed.⁵⁰ If available, uterine mapping with an ultrasound and sterile probe cover may assist in placing a uterine incision opposite to placental location. The maternal abdominal incision may require a vertical midline incision or creation of a T-shaped incision. Avoid manipulating the uterus after delivery of the neonate and ligate the umbilical cord close to placental insertion with an absorbable suture, which may be left in utero for conservative management.⁵⁰ Close the hysterotomy site with an absorbable suture and ensure hemostasis at incision site. Oxytocin may be used to ensure uterine tone, although it is unclear if this increases partial separation of the placenta. If the patient is then stable, transfer may be facilitated at this time.

Box 3

Management of unsuspected placenta percreta discovered at laparotomy

- Delay uterine incision if survey seems abnormal
 - Distorted or ballooned lower uterine segment
 - Blood vessels on uterine serosa
 - Invasion into bladder or surrounding tissue
- Assess location and extent of placental invasion visually and by ultrasound
- Evaluate for presence of active bleeding
- Inquire about available resources: blood or blood products, surgical consultants, necessary equipment, and location
- If patient is stable and facility is not currently prepared
 - Cover uterus with warm laparotomy packs and await assistance and supplies before proceeding with intervention.
 - Close fascial incision, place staples in skin, and consider transfer to tertiary facility with experience in management of placenta percreta.
- If patient is actively bleeding, apply local pressure to bleeding areas (other than areas where placental tissue is at risk), then prepare for hysterotomy and delivery followed by surgical or conservative management of placenta percreta.

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CONSERVATIVE MANAGEMENT

Conservative management of placenta accreta is used to describe management without using a hysterectomy at delivery and involves expectantly managing patients, which may require adjunctive surgical or medical treatment. The largest and most complete study on using conservative management as the primary strategy was reported by Sentilles and colleagues.⁵⁸ They looked 167 of 311 patients diagnosed with placenta accreta from 25 institutions in France where hysterectomy or cesarean hysterectomy was not planned and reported their observations. They were able to successfully treat 78.4% of their patients with expectant management, but significant morbidity was encountered.⁵⁸ Hysterectomy occurred in 21.6% (36 patients), with half resulting from primary postpartum hemorrhage at delivery, and delayed hysterectomy occurred at a median of 22 days.⁵⁸ Morbidity for the cohort included⁵⁹ the need for extensive antibiotics (32.3%), transfusion (41.9%), ICU (25.7%), and secondary postpartum hemorrhage (10.8%), with 1 maternal death.⁵⁸ Complications requiring hysterectomy include secondary postpartum hemorrhage, sepsis, vesicouterine fistula, uterine necrosis, arteriovenous malformation, or if indicated by maternal request.^{58,60} Other reported complications include disseminated intravascular coagulation.^{58,59,61}

When a placenta remains in situ and bleeding remains minimal, no further procedures are required and expectant management may be pursued. Uterotonics may be used initially to maintain uterine tone, which can assist with bleeding at the hysterotomy site and is commonly used for retained placenta as an initial measure. For expectant management, the abdominal incision is closed and close surveillance is done in the postpartum period. No standardized approach to postpartum follow-up exists but typically involves frequent visits, ultrasound, and laboratory work to identify resolution and complications.

Methotrexate use has become standard first-line treatment of early ectopic pregnancies and is selectively used for medical management of cesarean scar ectopic pregnancies.⁴⁵ Methotrexate acts on rapidly dividing cells, but in the third trimester the placenta is no longer rapidly dividing. This likely explains why methotrexate has not been demonstrated to show added benefit for conservative management of placenta accreta. Routine use of methotrexate for placenta accreta is not recommended at this time.⁶²

Removal of the placenta may occur because invasive placentation was not suspected, only a focal area was suspected, premature separation of the placenta, or when multidisciplinary teams at centers of excellence are attempting to utilize methods for uterine preservation. Perioperative placement of uterine artery balloon catheters may improve outcomes.^{20,21} Placement of artery balloon catheter is technically possible in the iliac arteries²² and aorta,²³ but improvements in maternal outcomes are uncertain. Prophylactic uterine artery embolization is possible after delivery and helpful for reducing blood loss and for uterine preservation but may be limited based on availability.^{25,28} Bakri balloon placement is reported if the placenta is removed, which is passed from intra-abdominal route to vagina with an assistant pulling the infusion ports through to the vagina. The balloon is filled with water, traction applied, and the hysterotomy may be closed over the balloon.

CESAREAN HYSTERECTOMY PROCEDURE

Performing a peripartum hysterectomy involves a similar approach to hysterectomy in nonobstetric patients. Preparations include positioning of the patient in a manner that allows the operator to accomplish the goals of the surgery. This may include either a supine position or dorsal lithotomy position.

Antibiotic prophylaxis reduces the risk of surgical site infection when given preoperatively. In a Cochrane review of 95 studies, use of antibiotics reduced the risk of wound infection (RR 0.4; 95% CI, 0.35–0.46), endometritis (RR 0.38; 95% CI, 0.34–0.42), and serious maternal infection (RR 0.31; 95% CI, 0.2–0.49).⁶³ The most commonly used regimen was cephazolin, 2 g intravenous. An alternative regimen was used for patients with a penicillin allergy, most commonly clindamycin, 900 mg, plus gentamicin, 5 mg/kg. A recent study on surgical site skin preparation demonstrated superiority of chlorhexidine-alcohol with a 4% risk of associated surgical-site infection compared with iodine-alcohol with a risk of 7.3% (RR 0.55; 95% CI, 0.34–0.90).⁶⁴

The choice of incision is based on the need for anticipated complications during surgery. A Pfannenstiel incision is commonly performed for routine primary or repeat cesarean delivery or may be used for nonobstetric abdominal hysterectomy. The disadvantage with this type of incision is limited access and visualization to the upper pelvis and abdomen. A vertical skin incision is chosen to minimize bleeding, reduce entry time, provide adequate exposure to the upper abdomen, and allow extension of the incision if required. A vertical skin incision may be preferred in the settings of coagulopathy, need for emergent delivery, and placenta previa, which may preclude delivery of the fetus through a transverse uterine incision. For a situation in which a hysterectomy is planned, or the surgery is expected to be difficult, a vertical skin incision may be more advantageous.

TECHNIQUE

A decision to proceed with hysterectomy may be based on a patient's desire for future fertility, partial placental separation, active bleeding, presence of placenta percreta extending to pelvic structures, availability of resources, role as a referral center or center of excellence, access to adequate blood products, and clinical instability. The steps of a peripartum hysterectomy are the same as for nonobstetric hysterectomy:

- Separation of round ligament
- Separation of broad ligament (Figs. 3 and 4)
- Dissection of bladder and perivesicular space
- Palpation, clamping, and separation of the cardinal ligament and uterine arteries (Figs. 5 and 6)



Fig. 3. Separation of broad ligament. An avascular window is identified and with electrocautery the window is created. Surgical clamps or free ties may be used to suture ligate.



Fig. 4. Clamping across broad ligament. Clamps are placed across the pedicle of the broad ligament created by the avascular window. This may be further ligated with suture for additional hemostasis.

- Separation of the uterosacral ligament (**Fig. 7**)
- Closure of the vaginal cuff

Pregnancy changes may further complicate surgery, especially from the increased uterine blood flow during pregnancy. There is an approximate 10-fold to 30-fold increase in uterine blood flow that approximates 450 mL/min to 650 mL/min by term.^{65,66} The risk for sudden and catastrophic blood loss is much greater during late gestation than for traditional hysterectomy. Tissue fragility and edema is increased, which makes handling tissue more difficult. Normal anatomic relationships to other structures may be displaced. The ureters may be tortuous, distended, and with significant hydroureter or hydronephrosis. The enlarged uterus itself poses challenges to visualization and palpation.

Traditionally surgical techniques relied on double clamping and double tying of suture for a peripartum hysterectomy. Newly advanced techniques with vessel sealing



Fig. 5. Palpation of uterine arteries. The surgeon is able to palpate uterine arteries prior to placing clamps across the uterine arteries. This is also done to ensure integrity of the myometrium before placing clamps. Placing the clamp may traumatize the tissue or disrupt the placenta if there is little myometrium present.

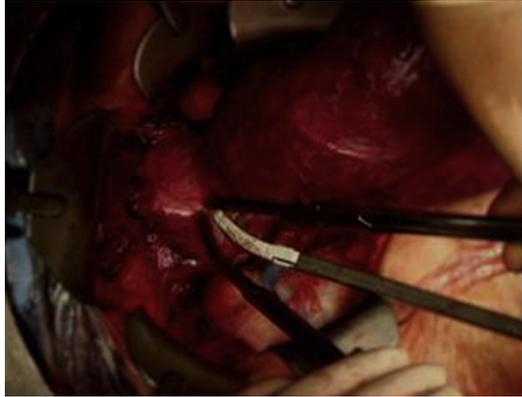


Fig. 6. Clamping across uterine arteries. Clamps are placed across the uterine arteries. Two clamps are placed for compression and control of additional bleeding.

devices (LigaSure [Medtronic, Minneapolis, MN]) allows for coagulation, desiccation, and sealing of vascular pedicles. The use of vessel sealing devices limits tissue trauma and replaces 1 step for clamping and tying the tissue. These devices are considered most effective with vessels less than or equal to 7 mm. One study compared surgical outcomes for peripartum hysterectomy when the LigaSure device was used and when it was not. It reported less operative time, less blood loss, and reduced incidence of massive blood loss during the procedure with the use of LigaSure.⁶⁷

Completion of the hysterectomy with either a subtotal or total hysterectomy is operator dependent. The goal of surgery is to achieve hemostasis, reduce infection, remove necrotic material or abscess, remove the placenta when morbidly adhered, and reduce maternal morbidity. The goal is not to remove the cervix unless it is the cause of bleeding, requires histologic evaluation, or can be safely removed without compromising hemostasis. A survey for possible injuries, evaluation of other areas of bleeding, use of topical hemostatic agents, assessing the integrity of the bladder,

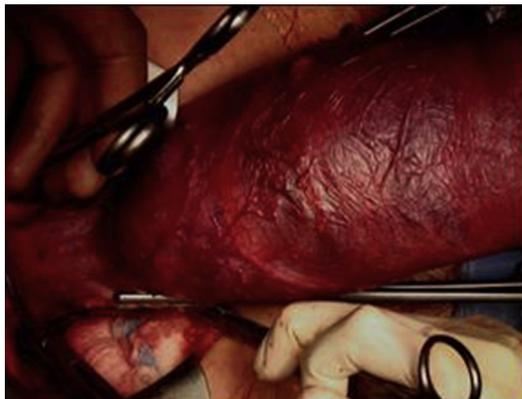


Fig. 7. Clamping across the uterosacrals. Once bladder dissection is achieved, clamping across the uterosacral ligaments below placenta percreta and placenta previa allows removal of specimen as either subtotal or total hysterectomy.

and possible removal of the fallopian tubes to reduce ovarian cancer is also recommended.

SUMMARY

Hysterectomy is an uncommon procedure for the obstetric patient. It is a procedure reserved to be lifesaving and the indications for its use are associated with maternal morbidity and mortality.

- Hysterectomy is a final endpoint for postpartum hemorrhage protocols, but the success of protocols requires early identification and active management of bleeding patients.
- Postpartum hemorrhage from uterine atony remains the most common indication for peripartum hysterectomy, although there is now an increased incidence of abnormally invasive placenta accreta, placenta increta, and placenta percreta.
- Abnormally invasive placentation is diagnosed antenatally in 50% to 53% of patients requiring hysterectomy. Antenatal diagnosis of this disorder improves outcomes.
- Uterotonics, balloon tamponade, and postpartum hemorrhage protocols remain the first steps in managing postpartum hemorrhage.
- Postpartum hemorrhage unresponsive to uterotonics and compression may be caused by genital tract laceration, coagulopathy, or abnormally invasive placentation.
- Early and aggressive use of massive transfusion protocols may prevent large blood volume loss.
- Multidisciplinary teams along with improvements in interventional radiology achieve improved outcomes for complicated postpartum patients.

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