Anesthesia for the patient with peripartum hemorrhage

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INTRODUCTION

Peripartum hemorrhage is a major cause of maternal morbidity and mortality. Effective management requires a multidisciplinary, structured approach, with recognition that obstetric hemorrhage can rapidly become life threatening. This topic will discuss the anesthetic management of patients with peripartum hemorrhage or conditions that increase the risk of such hemorrhage.

Causes of postpartum hemorrhage, obstetric management of these patients, and the approach to the management of postpartum hemorrhage (PPH) are discussed in detail separately.

- (See "Overview of postpartum hemorrhage".)
- (See "Postpartum hemorrhage: Medical and minimally invasive management".)
- (See "Postpartum hemorrhage: Management approaches requiring laparotomy".)

PREANESTHESIA EVALUATION

Antenatal anesthesia consultation should be arranged for patients at high risk of peripartum hemorrhage and those for whom blood product preparation or transfusion may be complicated. (See "Overview of postpartum hemorrhage", section on 'PPH risk assessment tools and risk-based preparation'.)

All obstetric patients should be evaluated for potential difficulty with airway management to create a plan for safe airway management in case general anesthesia is necessary. (See "Airway management for the pregnant patient", section on 'Planning the approach to airway management'.)

In addition to the usual medical and prenatal history, and anesthesia-directed physical examination, the following considerations should be addressed antenatally whenever time permits.

- **Bleeding diathesis** – Patients with known bleeding diatheses should be evaluated, usually in consultation with a hematologist, to create a strategy for peripartum management. (See "Approach to the adult with a suspected bleeding disorder" and "Preoperative assessment of bleeding risk" and "von Willebrand disease (VWD): Gynecologic and obstetric considerations", section on 'Obstetric considerations'.)

- **Refusal of blood products** – Women who refuse blood products benefit from an antenatal discussion that addresses specific blood components, products derived from human plasma, alternative therapies, and strategies for blood conservation. As part of the informed consent process, the patient should specify which blood components and products and which therapies (eg, blood salvage, hemodilution) are acceptable (table 1). (See "Approach to the patient who declines blood transfusion".)

  Many patients who refuse blood products will accept transfusion of clotting factors and fluids that are not derived from human plasma. Lyophilized fibrinogen concentrate is derived from human plasma, but tranexamic acid (TXA) and recombinant factor VIIa are not (table 1).

- **Red blood cell antibodies** – Blood crossmatching may be difficult and prolonged for patients with alloantibodies or autoantibodies to red blood cells. The blood bank should be consulted regarding the significance of antibodies identified on

the antenatal blood type and screen to plan the timing and necessity for peripartum blood product preparation. (See "Red blood cell (RBC) transfusion in individuals with serologic complexity".)

GENERAL CONCERNS

General concerns regarding anesthesia for peripartum hemorrhage include the following:

- Neuraxial anesthesia (ie, spinal, epidural, combined spinal-epidural [CSE]) is usually the preferred technique for instrumental and cesarean delivery. However, the sympathectomy that accompanies these techniques can lead to **profound hypotension**, especially if the block is established rapidly and if circulating blood volume is significantly decreased by peripartum hemorrhage. Patients who are or have been bleeding should be resuscitated with intravenous (IV) fluid and vasopressors prior to initiation of neuraxial anesthesia. For hemodynamically unstable patients, general anesthesia is preferred. Specifically, lightheadedness or orthostatic hypotension in the sitting position indicates the need for general anesthesia.

- Neuraxial anesthesia may be contraindicated in patients who develop a dilutional or consumptive coagulopathy as a result of hemorrhage, because of the risk of spinal epidural hematoma.

- Two large-bore IV catheters should be placed for anesthesia for patients with obstetric hemorrhage. The decision to place an intra-arterial catheter for blood pressure (BP) monitoring and blood sampling should be individualized.

- Induction of general anesthesia in severely hypovolemic patients can also result in **profound hypotension** and cardiac arrest [1]. Patients should be resuscitated with IV fluid and supported with vasopressors prior to and during induction of general anesthesia. Capable assistance (preferably another anesthesia clinician) should be present during induction for patients with obstetric hemorrhage to maintain uninterrupted IV volume resuscitation and vasopressor administration and to assist with airway management. (See 'Induction of anesthesia in patients with postpartum hemorrhage' below.)

- Rapid sequence induction and intubation should be performed for general anesthesia. Anticipate difficulty with airway management, as IV fluid resuscitation and large doses of oxytocin used to treat uterine atony may cause upper airway edema. Alternative airway management devices (eg, videolaryngoscope, flexible intubating scope) should be available, as well

as a plan for a surgical airway, if necessary. (See "Rapid sequence induction and intubation (RSII) for anesthesia" and "Airway management for the pregnant patient", section on 'Preparation for airway management'.)

- Optimal transfusion of blood products requires careful attention to hemodynamics, oxygen delivery, and hemostatic function. Goal-directed therapy is preferred over fixed-ratio resuscitation, but standard laboratory tests do not always provide sufficiently rapid results to guide therapy.

  Increasingly, in obstetric hemorrhage, trauma-related hemorrhage, and other clinical situations, viscoelastic tests (ie, thromboelastography [TEG] and thromboelastometry [ROTEM]) are being used to assess coagulation and to guide hemostatic resuscitation. TEG and ROTEM are emerging as faster, cheaper, and more efficient than multiple standard coagulation blood tests and equally as effective [2]. Use of TEG and ROTEM in obstetric hemorrhage is discussed separately. (See "Postpartum hemorrhage: Medical and minimally invasive management", section on 'Viscoelastic testing'.)

ANTEPARTUM HEMORRHAGE

The most common causes for antepartum hemorrhage after 20 weeks gestation are placenta previa and placental abruption. Uterine rupture and bleeding from vasa previa are rare causes of antepartum hemorrhage.

Obstetric management is discussed separately. (See "Placenta previa: Management" and "Acute placental abruption: Management and long-term prognosis" and "Uterine rupture after previous cesarean birth: Prediction, clinical manifestations, diagnosis, management, and outcome" and "Uterine rupture of the unscarred uterus: Risk factors, clinical manifestations, management, and outcome" and "Velamentous umbilical cord insertion and vasa previa".)

The anesthetic goals include hemodynamic and hemostatic resuscitation and timely anesthesia to facilitate both delivery and surgical interventions to control the source of bleeding. Anesthetic concerns for specific etiologies of antepartum hemorrhage are discussed below. (See 'Placenta previa' below and 'Placental abruption' below and 'Uterine rupture' below and 'Vasa previa' below.)

Placenta previa — Most women who initially present with symptomatic placenta previa respond to supportive therapy and do not require immediate delivery. However, the frequency and severity of recurrent bleeding are unpredictable, and these patients

are at risk for massive hemorrhage before, during, and after delivery. (See "Placenta previa: Management".)

- **Choice of anesthetic technique** – Patients with placenta previa will almost always be delivered by cesarean. For scheduled, nonurgent cesarean delivery, neuraxial anesthesia is the preferred approach; the choice of anesthetic technique should be based on patient factors. (See "Anesthesia for cesarean delivery", section on 'Choice of anesthetic technique'.)

  Placenta previa is a risk factor for morbidly adherent placenta (ie, placenta accreta, increta, or percreta). Catheter-based neuraxial techniques (epidural or combined spinal-epidural [CSE]) may be preferred for cesarean delivery with placenta previa to allow extension of anesthesia for unexpected cesarean hysterectomy. Regardless, a plan should be in place for conversion to general anesthesia in the event of massive postpartum hemorrhage (PPH). (See 'Scheduled cesarean hysterectomy' below and 'Postpartum hemorrhage' below and "Placenta accreta spectrum: Clinical features, diagnosis, and potential consequences" and "Placenta accreta spectrum: Management".)

  For patients who are actively bleeding or for emergent cesarean delivery, general anesthesia is usually preferred.

- **Blood product preparation** – An active blood bank sample should be maintained at all times for patients who are hospitalized with placenta previa awaiting delivery. In the United States, the blood type and screen will have to be repeated every three days [3]. We crossmatch at least two units of blood for cesarean delivery for these patients.

Placental abruption — Obstetric management of patients with abruption may include expectant management, vaginal delivery, or cesarean delivery, depending on maternal and fetal condition and the gestational age. (See "Acute placental abruption: Management and long-term prognosis".)

Therefore, labor analgesia or anesthesia for instrumental or cesarean delivery may be required. Anesthetic concerns specific to placental abruption include the following:

- Partial abruption can become complete abruption at any time and may require emergent cesarean delivery or instrumental vaginal delivery.

- Patients with abruption are at increased risk of disseminated intravascular coagulation [4]. (See "Acute placental abruption: Pathophysiology, clinical features, diagnosis, and consequences".)

A complete blood count and coagulation studies, including fibrinogen levels, should be performed prior to neuraxial anesthesia procedures for patients with suspected abruption.

- Abruption is associated with preeclampsia, which has implications for both regional and general anesthesia. Anesthetic management of patients with preeclampsia is discussed separately. (See "Anesthesia for the patient with preeclampsia".)

- Patients with severe abruption are at increased risk for refractory postpartum uterine atony and the need for cesarean hysterectomy. (See "Acute placental abruption: Management and long-term prognosis", section on 'Couvelaire uterus' and 'Postpartum hemorrhage' below and 'Scheduled cesarean hysterectomy' below.)

Uterine rupture — Uterine rupture is a rare cause of antepartum, intrapartum, and postpartum hemorrhage. Most uterine ruptures in resource rich countries are associated with a trial of labor after cesarean delivery (TOLAC). In resource-limited countries, uterine rupture is often related to obstructed labor and lack of access to operative delivery. (See "Uterine rupture after previous cesarean birth: Prediction, clinical manifestations, diagnosis, management, and outcome" and "Uterine rupture of the unscarred uterus: Risk factors, clinical manifestations, management, and outcome".)

Standard epidural analgesia does not mask the signs or symptoms of uterine rupture, and the American College of Obstetricians and Gynecologists supports the use of neuraxial analgesia during TOLAC [5]. Breakthrough pain during a TOLAC should always prompt a careful evaluation of analgesic distribution and density, as well as maternal and fetal wellbeing. The most common clinical manifestation of uterine rupture is an abnormal fetal heart rate pattern, which is the presenting sign in 80 percent of patients with uterine rupture. (See "Uterine rupture after previous cesarean birth: Prediction, clinical manifestations, diagnosis, management, and outcome", section on 'Antepartum and intrapartum'.)

Urgent or emergency cesarean delivery is usually indicated for uterine rupture. As long as maternal hemodynamics are stable, neuraxial anesthesia may be appropriate, especially if a labor epidural catheter is in place. In cases of acute fetal compromise or severe maternal hypovolemia, general anesthesia is usually preferred. (See 'General concerns' above.)

Hemorrhage may be primarily intra-abdominal and may be difficult to quantify and appreciate. Unexplained hypotension unresponsive to fluid administration or expected doses of vasopressors may suggest concealed hemorrhage, especially with neuraxial analgesia in effect.

Vasa previa — Vasa previa refers to umbilical blood vessels that cross the cervical os, with abnormal, membranous insertion into the placenta. The bleeding from vasa previa is fetal and occurs most commonly when membranes rupture. The fetus can exsanguinate within minutes. (See "Velamentous umbilical cord insertion and vasa previa", section on 'Vasa previa'.)

Vasa previa is often diagnosed antenatally, with cesarean delivery scheduled at 34 to 35 weeks of gestation. These patients are often hospitalized between 30 and 34 weeks of gestation and may require emergent cesarean delivery, usually with general anesthesia, if membranes rupture, labor starts, or if fetal heart rate abnormalities occur.

POSTPARTUM HEMORRHAGE

Postpartum hemorrhage (PPH) is an obstetric emergency and is the most common cause of maternal mortality worldwide. In many cases, mortality due to PPH is preventable with appropriate resources and management. (See "Overview of postpartum hemorrhage", section on 'Epidemiology'.)

Most patients with PPH require analgesia or anesthesia for surgical interventions and involvement of the anesthesia clinician for hemodynamic and physiologic support. Etiologies for PPH include uterine atony, retained placenta, obstetric trauma (eg, lacerations, tears, uterine rupture), uterine inversion, and placenta accreta. With massive hemorrhage, hysterectomy may be required regardless of the etiology. Patients with hemodynamic instability should be moved to the operating room as soon as practically possible to expedite definitive treatment.

Multidisciplinary care and coordination — Management of PPH requires a team-based, structured approach. The keys to management of PPH are recognition of abnormal bleeding as soon as it develops, identification of the cause, and appropriate intervention. We suggest the use of a unit-standard, stage-based obstetric hemorrhage emergency management plan with checklists, as recommended by numerous obstetric and women's health organizations including the Alliance for Innovation in Maternal Health, to ensure timely diagnosis and treatment at the earliest possible stage of PPH [6-11]. Definitions of severity of PPH and multidisciplinary planning for and management of PPH are discussed separately. (See "Overview of postpartum hemorrhage".)

Anesthesia for postpartum hemorrhage — Options for anesthetic management for the procedures required to treat PPH depend on the type of delivery (ie, vaginal or cesarean), the required surgical procedure, the severity of hemorrhage, and the patient's hemodynamic status. For repair of perineal or vaginal lacerations, a short-acting sedative with or without local anesthesia may be adequate, although patients are typically more comfortable with neuraxial anesthesia. Neuraxial or general anesthesia is usually required for more extensive repairs, intrauterine manipulation, removal of retained placenta, and open procedures.

Two large-bore intravenous (IV) catheters should be placed for all patients with PPH. The decision to place an intra-arterial catheter for blood pressure (BP) monitoring and blood sampling should be individualized.

Neuraxial anesthesia for postpartum hemorrhage — Neuraxial anesthesia (ie, epidural or spinal) may be appropriate for patients who are hemodynamically stable and without evidence of coagulopathy. For repair of cervical or vaginal lacerations, a T10 spinal level is adequate, while a T4 block is required for uterine manipulation or open surgical procedures. Neuraxial anesthesia produces a sympathectomy and vasodilation and can cause severe hypotension or hemodynamic collapse in patients with clinically significant hypovolemia.

- **Epidural anesthesia** – Labor epidural analgesia with a dilute concentration of epidural drug solution is often inadequate for surgical manipulation. A labor epidural catheter may be used to achieve a surgical level of anesthesia by injection of more concentrated local anesthetic (eg, lidocaine 2%) for vaginal or cervical repair. (See "Neuraxial analgesia for labor and delivery (including instrumental delivery)", section on 'Analgesia for instrumental vaginal delivery'.)

  An existing epidural anesthetic may be extended for treatment of PPH after cesarean delivery. General anesthesia may be required if massive hemorrhage occurs or if epidural anesthesia is inadequate for extensive pelvic procedures. (See 'General anesthesia' below.)

  The epidural catheter should only be removed when coagulation is confirmed to be normal after PPH.

- **Spinal anesthesia** – Spinal anesthesia may be appropriate for patients without a labor epidural catheter in place, if bleeding is modest and the patient is hemodynamically stable (eg, for retrieval of retained placenta). If an epidural catheter was in place and has been removed (either because the patient is postpartum or because the epidural catheter failed to

provide effective anesthesia or analgesia), residual neuraxial blockade may be present. In such cases, full-dose spinal anesthesia should be performed with caution, because a high spinal anesthetic may result. (See "Anesthesia for cesarean delivery", section on 'Failed or inadequate neuraxial block'.)

- **Combined spinal epidural anesthesia** – A combined spinal epidural anesthetic can be performed, using a low-dose spinal, with the expectation that the epidural catheter may be used to extend the neuraxial blockade as needed. By limiting the spinal anesthetic dose, this technique reduces the risk of excessive neuraxial blockade and hemodynamic instability. (See "Epidural and combined spinal-epidural anesthesia: Techniques", section on 'Dose of spinal drugs'.)

Moderate sedation/analgesia for postpartum hemorrhage — Obstetricians often request sedation/analgesia if it is likely that bleeding will be easily controlled. The goal in this setting should be a level of sedation/analgesia no deeper than moderate sedation, which means that the patient responds purposefully to verbal commands, either alone or accompanied by light tactile stimulation, and maintains and protects her airway without support. Neuraxial and general anesthesia are more effective for controlling movement, so it is important to verify operative goals to ensure that movement (eg, leg adduction) would be acceptable during any procedure completed under sedation. (See "Monitored anesthesia care in adults", section on 'Monitoring depth of sedation and analgesia'.)

Sedatives and analgesics (eg, midazolam, fentanyl, dexmedetomidine) should be administered in small incremental doses and titrated to effect, to avoid deep sedation and compromised airway reflexes. Moderate sedation/analgesia does not provide complete analgesia but helps patients tolerate brief painful procedures and may prevent recall of discomfort.

Ketamine is often administered for sedation in this setting because it provides sedation, analgesia, and amnesia with minimal respiratory depression. We administer midazolam along with ketamine to reduce the risk of vivid dreams or hallucinations that can occur with ketamine. (See "Monitored anesthesia care in adults", section on 'Ketamine'.)

If conversion to general anesthesia becomes necessary, the patient should be moved to the operating room if not already there. She should be optimally positioned for endotracheal intubation prior to induction of anesthesia. This may require taking her feet out of stirrups and moving the patient to the top of the operating table. (See "Airway management for the pregnant patient", section on 'Patient positioning'.)

General anesthesia for PPH — General anesthesia is the preferred anesthetic technique if PPH is severe or likely to become severe. General anesthesia may also be appropriate if moderate sedation/analgesia provides inadequate pain control in situations in which neuraxial anesthesia cannot be performed.

Advantages of general anesthesia for patients with severe PPH include the following:

- **Secure airway** – General anesthesia with endotracheal intubation provides a protected airway for severely hypotensive patients who may lose airway reflexes and a means for controlled ventilation should airway edema or pulmonary edema occur with IV fluid resuscitation.

- **Muscle relaxation** – General anesthesia allows the administration of neuromuscular blocking agents (NMBAs) to relax abdominal and pelvic muscles to facilitate surgery.

- **Vascular access** – Large-bore IV catheters, arterial catheters, and central venous catheters (CVCs) are more easily placed in patients under general anesthesia rather than awake.

- **Unconsciousness** – General anesthesia allows the clinical team to focus on the patient's physical wellbeing. With an unconscious patient, clinicians can use direct, explicit, and unambiguous communication without concern for the awake patient's interpretation. This may facilitate accurate situational awareness and expeditious escalation in care.

  Induction of anesthesia in patients with postpartum hemorrhage — Induction of general anesthesia should not be delayed once the need for it is identified, because ongoing IV fluid resuscitation can cause airway edema and difficulty with endotracheal intubation. Induction of anesthesia **can cause cardiovascular collapse** in severely hypovolemic patients. Therefore, capable assistance (preferably another anesthesia clinician) should be present during induction for patients with PPH to maintain uninterrupted IV volume resuscitation and vasopressor administration and to assist with airway management. We administer etomidate (20 mg IV) or ketamine (0.5 to 1 mg/kg IV) rather than propofol for induction in hypovolemic patients to minimize the risk of hypotension. Airway edema and difficult airway management should be expected. (See 'General concerns' above.)

  Maintenance of anesthesia for patients with postpartum hemorrhage — Both volatile inhalation anesthetics [12] and propofol [13,14] produce dose-dependent uterine relaxation, which can contribute to uterine atony and hemorrhage. At

clinically relevant doses, propofol based total intravenous anesthesia (TIVA) may be less likely to contribute to uterine atony than general anesthesia when compared with inhaled agents, but clinically important differences in outcomes have yet to be demonstrated in high quality randomized trials conducted in women with PPH.

We administer midazolam 2 mg IV, and nitrous oxide (N_2O) 50 to 70 percent to allow a reduced dose of volatile anesthetic to 0.5 to 0.75 minimal alveolar concentration (MAC) while preventing awareness under anesthesia. Dexmedetomidine may also be used to reduce the required doses of inhaled or IV anesthetics, as it does not appear to inhibit uterine contractions, though is based on animal data [15].

Uterine relaxation — Nitroglycerin (50 to 200 mcg IV repeated every two minutes, or 400 mcg sublingual) may be administered for rapid, brief uterine relaxation, usually along with moderate sedation, to facilitate removal of retained placenta or for replacement of an inverted uterus [16-18]. IV fluid and vasopressors are required to prevent hypotension when nitroglycerin is administered in this setting.

General anesthesia with 1 to 3 minimum alveolar concentration (MAC) of a potent inhalation agent (ie, sevoflurane, isoflurane, or desflurane) may be required to relax the uterus if nitroglycerin is not effective.

Hemorrhage control — Control of hemorrhage during PPH involves surgical, medical, and minimally invasive techniques. Those that involve the anesthesia clinician are discussed here, while other techniques are discussed separately. (See "Overview of postpartum hemorrhage".)

Tranexamic acid — Consistent with guideline recommendations, we administer tranexamic acid (TXA; 1 g IV over 10 to 20 minutes) within three hours of hemorrhage onset (table 2), along with oxytocin and other uterotonics for women with PPH. This recommendation is based on the results of the World Maternal Antifibrinolytic Randomized Trial (WOMAN), an international, randomized, placebo-controlled trial that reported decreased death due to bleeding in patients who received TXA, without an increase in adverse events including thromboembolism [19].

We administer an initial dose of TXA for patients with severe and ongoing bleeding. Further doses can be guided by coagulation testing (including thromboelastography [TEG] or rotational thromboelastography [ROTEM]), if available.

Fatal drug errors have been reported where TXA was mistaken for a local anesthetic and inadvertently administered into the intrathecal space. Packaging and storage must be distinct to prevent this error [20,21].

The use of TXA for PPH and the WOMAN trial are discussed in detail separately. (See "Postpartum hemorrhage: Medical and minimally invasive management", section on 'Administer tranexamic acid'.)

Correction of clotting factor deficiencies — In patients with severe hemorrhage (ie, >1500 mL), it may be necessary to correct clotting factor deficiencies. Where thromboelastography (TEG) or rotational thromboelastometry (ROTEM) are available, they may be useful to guide therapy because they offer rapid assessment of fibrinogen concentration. Fibrinogen is the hemostatic protein that is most likely to decrease during PPH and predicts subsequent severe blood loss [22-26]. When values decline below 2 g/L, fibrinogen replacement with lyophilized fibrinogen concentrate or cryoprecipitate has been associated with decreased hemorrhage related morbidity and costs when compared with traditional resuscitation protocols that rely on large volumes of plasma and platelets [27-29].

Patients with suspected abruption, acute fatty liver of pregnancy, or amniotic fluid embolism are most likely to develop acute obstetric coagulopathy and to benefit from fixed ratio transfusion (see "Postpartum hemorrhage: Medical and minimally invasive management", section on 'Initial approach'). For all other causes of peripartum hemorrhage, only fibrinogen is consumed at a rapid rate, and dilutional coagulopathy requires at least 3 liters of blood loss before the other clotting factor concentrations in maternal blood fall below those found in donated plasma.

If necessary before laboratory testing results are available, it is reasonable to proceed with the use of fresh frozen plasma (FFP) while arranging for fibrinogen and waiting for lab results.

The use of cryoprecipitate, fibrinogen concentrate, prothrombin complex concentrate, and recombinant factor VIIA are discussed separately. (See "Postpartum hemorrhage: Medical and minimally invasive management", section on 'Clotting factors'.)

Resuscitative endovascular balloon occlusion of the aorta — In select situations, particularly in low-resource environments, in patients with anticipated massive hemorrhage, or in patients with hemorrhage who refuse blood transfusion, resuscitative endovascular balloon occlusion of the aorta (REBOA) may offer a minimally invasive approach to

resuscitation and allow time for definitive treatment. REBOA requires close coordination between the surgeon or interventionalist and the anesthesiologist, particularly prior to and during balloon deflation, to ensure adequate IV volume loading and administration of vasopressors. The use of REBOA is discussed separately. (See "Endovascular methods for aortic control in trauma", section on 'REBOA technique' and "Postpartum hemorrhage: Medical and minimally invasive management", section on 'Consider resuscitative endovascular balloon occlusion of the aorta'.)

Intrauterine hemorrhage control devices — The role of intrauterine hemorrhage control devices (eg, intrauterine balloons, vacuum devices, and packing) is discussed separately. (See "Postpartum hemorrhage: Use of an intrauterine hemorrhage-control device".)

Postoperative care after PPH — Patients with severe postpartum hemorrhage (PPH) may require postpartum intensive care for ongoing volume, hemostatic, and metabolic resuscitation and to monitor for recurrence or complications of PPH. (See "Overview of postpartum hemorrhage", section on 'Outcome'.)

For patients in whom a uterine pack or balloon is left in place after PPH, the plan for analgesia, and for anesthesia for potential emergent surgery or embolization, should be discussed with the obstetrician.

Delayed extubation, or extubation over an airway exchange catheter, should be considered for any patient who has had general anesthesia and received massive volume resuscitation, because of potential airway edema and obstruction after extubation. (See "Management of the anatomically difficult airway for general anesthesia in adults", section on 'Extubation'.)

SCHEDULED CESAREAN HYSTERECTOMY

Cesarean hysterectomy may be scheduled electively or semielectively and is most often performed after the antenatal diagnosis of a morbidly adherent placenta (ie, placenta accreta, percreta, or increta). These disorders of placentation may cause massive hemorrhage and are usually diagnosed based on risk factors and antepartum imaging. Unless otherwise noted, the following discussion of placenta accreta applies to all depths of placental invasion. (See "Placenta accreta spectrum: Clinical features, diagnosis, and potential consequences".)

Patients with placenta accreta are optimally managed by a multidisciplinary care team in a tertiary care facility. Antenatal anesthesia consultation should be part of multidisciplinary planning. (See "Placenta accreta spectrum: Management", section on 'Components of preoperative planning'.)

Placenta accreta may rarely be diagnosed when the surgeon enters the peritoneal cavity at the time of cesarean delivery. In such cases, the surgeon may choose to delay delivery while appropriate personnel and other resources are obtained or even to close the abdomen and transfer the patient to another facility. Subsequent anesthetic management will depend on the surgical plan and whether the existing anesthetic can be extended (ie, catheter-based neuraxial anesthesia versus single-shot technique). (See "Placenta accreta spectrum: Management", section on 'Unexpected placenta accreta'.)

Placenta accreta may also be diagnosed when massive, unexpected hemorrhage occurs after a vaginal delivery. Management of anesthesia for those patients is discussed above. (See 'Postpartum hemorrhage' above.)

Preparation for transfusion — Massive hemorrhage is always a possibility during planned cesarean hysterectomy, and the magnitude of blood loss is difficult to predict antepartum. Studies have reported median estimated blood loss of 2.5 to 7.8 liters [30-32]. Management of hemorrhage during cesarean hysterectomy should follow the same principles as for other causes of postpartum hemorrhage (PPH). (See 'Multidisciplinary care and coordination' above.)

- **Blood product preparation** – Institutional protocols for planned massive transfusion should prioritize erythrocytes and fibrinogen, with the first "pack" of blood products (eg, 4 units of erythrocytes, 2 units of fresh frozen plasma, and 1 or 2 cryoprecipitate pools [each pool is composed of 5 individual units]) prepared and delivered to the operating suite before surgical incision. In some institutions, lyophilized fibrinogen concentrate is available to replace cryoprecipitate. Platelets and additional plasma may be considered for patients with known abruption, pre-existing thrombocytopenia, or acute obstetric coagulopathy. The quantity of blood products that should be prepared in advance depends on the institutional capacity to rapidly deliver additional blood products and any patient-specific difficulty with crossmatch (eg, red blood cell antibodies) [33].

- **Cell salvage** – Intraoperative cell salvage may be used during cesarean delivery and is acceptable to some patients who refuse blood transfusion. (See "Surgical blood conservation: Intraoperative blood salvage".)

- **Acute normovolemic hemodilution** – Acute normovolemic hemodilution may be considered for patients with hemoglobin ≥11 g/dL and may also be acceptable to patients who refuse blood products. Antepartum administration of erythropoietin and iron may optimize hemoglobin in preparation for this technique [34]. (See "Surgical blood conservation: Acute normovolemic hemodilution".)

Venous access — At least two large-bore intravenous (IV) catheters should be placed. We usually place either an 8 French double-lumen central venous catheter (CVC) plus one large-bore peripheral venous catheter or a peripherally inserted central catheter plus two large-bore peripheral venous catheters, including ideally one 7 French rapid infusion catheter.

CVCs may be placed for venous access and/or for administration of potent vasopressors and calcium chloride in the event of a massive transfusion. Central venous pressure is of limited value for assessing volume status in this clinical context.

Monitoring — We frequently place an intra-arterial catheter prior to the start of cesarean delivery when placenta accreta is suspected to allow continuous blood pressure (BP) monitoring and to facilitate frequent blood sampling.

Choice of anesthetic technique — Neuraxial anesthesia, general anesthesia, or a combination of the two may be used for these procedures.

- **Neuraxial anesthesia** – A neuraxial catheter-based technique (ie, epidural anesthesia or combined spinal-epidural anesthesia [CSE]) may be appropriate when the risk of massive blood loss is expected to be low based on diagnostic imaging, the experience of the surgical team, and the specific surgical plan [35-40].

  Increasingly, catheter based neuraxial anesthesia techniques are used in centers with experience with these cases and a multidisciplinary coordinated plan for management [41].

  - In one review, 23 cesarean deliveries occurred between 2000 and 2008 at a center with a protocol for attempting uterine conservation for patients with antenatally diagnosed placenta accreta [35]. Uterine artery balloon catheters were placed preoperatively and inflated as necessary for temporary control of bleeding. Over the study period, with increasing experience using the balloon catheters to provide hemodynamic stability, neuraxial anesthesia became the norm, rather than general anesthesia.

- In another series of 129 cases of suspected abnormally invasive placenta between 1997 and 2015 in a tertiary care referral center, neuraxial anesthesia was used at the start in 122 cases, and conversion to general anesthesia was required in 15 of those [41]. There were no complications of conversion to general anesthesia, although three patients required advanced airway management techniques to achieve endotracheal intubation (eg, awake fiberoptic intubation, videolaryngoscopy, gum-elastic bougie). Cesarean hysterectomy occurred in 72 cases.

In one institution the typical anesthetic for CD with placenta accreta spectrum has evolved from lumbar epidural or CSE to a double epidural catheter technique (lumbar CSE plus a thoracic epidural catheter) [42]. The thoracic catheter is placed to provide anesthesia for supraumbilical extension of the incision. In a retrospective review of the cases performed over approximately 20 years, conversion to general anesthesia was more common after CSE compared with the double catheter technique (29.7 versus 5.7 percent), based on a small number of cases (37 and 35, respectively) [42].

Advantages of neuraxial anesthesia are those that relate to any cesarean delivery, including the following:

- Allows the parturient to be awake for the delivery
- Minimizes medication transfer to the fetus
- Avoids airway instrumentation
- Provides a means for postoperative analgesia, with neuraxial opioids

Disadvantages of neuraxial anesthesia for these procedures include the following:

- These may be long cases, and the dissection and surgical manipulation are more stimulating than during a routine cesarean delivery. Supplementation with sedatives or induction of general anesthesia may be required for pain, nausea, and vomiting.
- Induction of general anesthesia may become necessary during surgery after large volumes of IV fluid have been administered, increasing the risk of airway edema and difficult intubation.

- If general anesthesia becomes necessary because of massive hemorrhage, the sympathectomy induced by neuraxial block may increase the risk of severe hypotension or cardiovascular collapse with induction of anesthesia. (See 'Induction of anesthesia in patients with postpartum hemorrhage' above.)

If neuraxial anesthesia is chosen as the primary anesthetic, a plan should be in place for safe conversion to general anesthesia if it becomes necessary [35] . The epidural catheter should only be removed when coagulation is confirmed to be normal if significant hemorrhage occurs.

- **General anesthesia** – Controlled preoperative induction of general anesthesia is preferred in the following circumstances:
  - Patients with anticipated difficult intubation, severe obesity, or other characteristics that would make emergent intraoperative induction of general anesthesia unsafe
  - Practice settings without availability of multiple anesthesia clinicians who can assist with simultaneous conversion to general anesthesia and management of massive blood transfusion
  - Expectation of a difficult surgical procedure (eg, prolonged resection of pelvic organs for placenta percreta)
  - Patient preference or extreme anxiety
- **Combined approach** – A planned combined approach is also possible. Neuraxial anesthesia can be used for the delivery, with planned induction of general anesthesia immediately after the parturient sees her baby.

Anesthesia for arterial catheterization for embolization — In some centers, balloon-tipped catheters are placed in the internal iliac or uterine arteries, or the resuscitative endovascular balloon occlusion of the aorta device is inserted into the aorta, via the femoral arteries preoperatively to control hemorrhage after delivery. Some centers have the capacity to complete a cesarean hysterectomy in the interventional radiology suite [43,44]. (See "Placenta accreta spectrum: Management", section on 'Endovascular intervention for hemorrhage control' and 'Resuscitative endovascular balloon occlusion of the aorta' above.)

Appropriate venous access, arterial catheter placement, and blood product preparation should occur prior to balloon catheter placement; rarely, balloon catheter insertion may precipitate fetal bradycardia and urgent delivery [45].

If an epidural catheter is going to be used to provide anesthesia and perioperative analgesia, it should be sited prior to femoral catheter or sheath insertion since the patient will not be able to flex her hips to position for epidural placement with femoral catheters in place. The epidural catheter can then be used to provide analgesia for balloon catheter insertion.

Management of anesthesia for cesarean hysterectomy

General anesthesia — Rapid sequence induction and intubation should be performed as it would be for cesarean delivery. (See "Anesthesia for cesarean delivery", section on 'General anesthesia'.)

The interval from induction of anesthesia until delivery of the fetus is longer during cesarean hysterectomy than in a routine cesarean delivery because the surgeon must examine the uterus and plan the hysterotomy. In addition, any adhesions must be cleared from the uterus in order to facilitate timely hysterectomy after the delivery. After induction, adequate depth of anesthesia should be maintained to prevent awareness with recall, and the neonatal resuscitation team should be prepared to support a potentially anesthetized neonate.

If general anesthesia is required during a neuraxial anesthetic, the principles described for induction during PPH apply. For maintenance of anesthesia, we often keep the concentration of volatile anesthetic ≤0.5 minimum alveolar concentration (MAC) to minimize vasodilation and cardiovascular effects while assuring unconsciousness. (See 'Induction of anesthesia in patients with postpartum hemorrhage' above.)

Neuraxial anesthesia — A catheter-based technique (ie, epidural or CSE) is preferred for neuraxial anesthesia for cesarean hysterectomy to allow prolongation and extension of the neuraxial block. The neuraxial technique is the same as it would be for cesarean delivery without hysterectomy. (See "Anesthesia for cesarean delivery", section on 'Epidural anesthesia' and "Anesthesia for cesarean delivery", section on 'Combined spinal-epidural anesthesia'.)

Following delivery, neuraxial block should be maintained at adequate height (ie, T4) and density. Light sedation is often necessary, and a comfortable pillow helps the patient tolerate being awake.

Uterotonic drugs — With a fundal uterine incision, the controlled infusion of oxytocin may facilitate myometrial contraction, spiral arterial compression, and reduced blood loss. (See "Anesthesia for cesarean delivery", section on 'Administration of uterotonics' and "Prophylactic pharmacotherapy to reduce the risk of postpartum hemorrhage", section on 'Medications' and

"Postpartum hemorrhage: Medical and minimally invasive management", section on 'Administer additional uterotonic medications'.)

Oxytocin requires refrigeration to maintain efficacy. In clinical circumstances in which refrigeration is not possible, heat stable carbetocin may be used as an alternative. (See "Prophylactic pharmacotherapy to reduce the risk of postpartum hemorrhage", section on 'Active management in resource-limited settings'.)

Once the surgeons devascularize the uterus, systemic uterotonics can be discontinued.

Postoperative analgesia — A multimodal strategy for postoperative pain control should be employed, as it would be for other intra-abdominal surgery. (See "Approach to the management of acute pain in adults".)

SYSTEMS LEARNING FOR OBSTETRIC HEMORRHAGE

We agree with the Joint Commission recommendation that obstetrical staff should undergo team training and clinical drills and conduct debriefing after postpartum hemorrhage (PPH). (See "Overview of postpartum hemorrhage", section on 'Training and simulation'.)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Obstetric hemorrhage" and "Society guideline links: Obstetric anesthesia".)

SUMMARY AND RECOMMENDATIONS

- **Team approach** – Peripartum hemorrhage is an obstetrical emergency that requires a team-based, structured approach to management. Keys to management include recognition of excessive bleeding before it becomes life threatening, identification of the cause, and appropriate intervention. We suggest the use of a stage-based, unit-standard obstetric

hemorrhage emergency management plan with checklists (table 3) (**Grade 2C**). (See 'Multidisciplinary care and coordination' above.)

- **Preanesthesia evaluation** – Antenatal anesthesia consultation should be arranged for patients at high risk of peripartum hemorrhage. Preanesthesia evaluation should include the usual medical and prenatal history, airway assessment, anesthesia-directed physical examination, and assessment of factors that may make blood transfusion problematic. (See 'Preanesthesia evaluation' above.)

- **Neuraxial anesthesia** – Neuraxial anesthesia is usually the preferred technique for instrumental and cesarean delivery and for most procedures performed for postpartum hemorrhage (PPH). For patients who are or have been bleeding, the following concerns regarding neuraxial anesthesia apply (see 'General concerns' above):

  - The sympathectomy that accompanies neuraxial anesthesia can cause **profound hypotension** in severely hypovolemic patients. Patients who are or have been bleeding should be resuscitated with intravenous (IV) fluid and vasopressors prior to initiation of neuraxial anesthesia. For hemodynamically unstable patients, general anesthesia is preferred.

  - Neuraxial anesthesia may be contraindicated for patients who develop a dilutional or consumptive coagulopathy because of increased risk of spinal epidural hematoma.

- **General anesthesia**

  - Rapid sequence induction and intubation should be performed for general anesthesia for PPH. Induction of general anesthesia can also result in **profound hypotension** and cardiac arrest.

  - Hypovolemic patients should be resuscitated with IV fluid and supported with vasopressors prior to and during induction of general anesthesia. We administer etomidate or ketamine for induction, rather than propofol, to minimize the chance of hypotension. (See 'General concerns' above.)

- **Sedation –** Sedation for procedures for PPH should be no deeper than moderate sedation, which means that the patient responds purposefully to verbal commands and maintains and protects her own airway. (See 'Moderate sedation/analgesia for postpartum hemorrhage' above.)

- **Tranexamic acid** – We administer tranexamic acid (TXA; 1 g IV over 10 to 20 minutes) along with oxytocin and other uterotonics for women with PPH. (See "Postpartum hemorrhage: Medical and minimally invasive management", section on 'Administer tranexamic acid'.)

- **Placenta previa** – Patients with placenta previa are at risk for massive hemorrhage before, during, and after delivery and are at increased risk for morbidly adherent placenta. (See 'Placenta previa' above.)

- **Placental abruption** – Placental abruption may cause disseminated intravascular coagulation; a complete blood count and coagulation studies should be performed prior to neuraxial anesthesia for these patients. (See 'Placental abruption' above.)

- **Cesarean hysterectomy**

  - **Choice of anesthetic technique** – Depending on specific clinical circumstances, cesarean hysterectomy can be performed with general anesthesia, neuraxial anesthesia, or a combination of the two. (See 'Choice of anesthetic technique' above.)

    A catheter-based neuraxial anesthetic may be appropriate for cesarean hysterectomy when the anticipated risk of massive blood loss is low. A safe plan should be in place for conversion to general anesthesia if it becomes necessary. (See 'Neuraxial anesthesia' above.)

    Controlled preoperative induction of general anesthesia for cesarean hysterectomy is preferred in the following circumstances:

    - For patients with anticipated difficulty with airway management
    - Expectation of difficult or prolonged surgery
    - Lack of additional anesthesia clinicians who could assist with conversion to general anesthesia during neuraxial anesthesia
    - Extreme patient anxiety (see 'General anesthesia' above)

- **Preparing for hemorrhage** – Massive hemorrhage is always possible during cesarean hysterectomy. We prepare for hemorrhage as follows (see 'Preparation for transfusion' above):

  - We place two large-bore IV catheters for volume administration. We also place a central venous catheter (CVC) or a peripherally inserted central catheter for the administration of potent vasopressors and calcium chloride. (See 'Venous access' above.)

  - We coordinate a planned massive transfusion with the blood bank and obtain the first cooler of blood products for storage in the operating suite prior to surgical incision.

  - We consider the use of intraoperative cell salvage.

REFERENCES

1. Bonnet MP, Deneux-Tharaux C, Bouvier-Colle MH. Critical care and transfusion management in maternal deaths from postpartum haemorrhage. Eur J Obstet Gynecol Reprod Biol 2011; 158:183.
2. Wikkelsø A, Wetterslev J, Møller AM, Afshari A. Thromboelastography (TEG) or thromboelastometry (ROTEM) to monitor haemostatic treatment versus usual care in adults or children with bleeding. Cochrane Database Syst Rev 2016; :CD007871.
3. US Government Publishing Office. Electronic Code of Federal Regulations, section 606.151: Compatibility testing. http://www.ecfr.gov/cgi-bin/text-idx?SID=8f45b64ad21296576a284a6b1d0477e8&mc=true&node=pt21.7.606&rgn=div5#se21.7.606_1151 (Accessed on October 13, 2016).
4. Green L, Knight M, Seeney F, et al. The haematological features and transfusion management of women who required massive transfusion for major obstetric haemorrhage in the UK: a population based study. Br J Haematol 2016; 172:616.
5. Practice Bulletin No. 184: Vaginal Birth After Cesarean Delivery. Obstet Gynecol 2017; 130:e217.
6. Main EK, Goffman D, Scavone BM, et al. National Partnership for Maternal Safety: Consensus Bundle on Obstetric Hemorrhage. Obstet Gynecol 2015; 126:155.

7. Shields LE, Wiesner S, Fulton J, Pelletreau B. Comprehensive maternal hemorrhage protocols reduce the use of blood products and improve patient safety. Am J Obstet Gynecol 2015; 212:272.
8. Shields LE, Smalarz K, Reffigee L, et al. Comprehensive maternal hemorrhage protocols improve patient safety and reduce utilization of blood products. Am J Obstet Gynecol 2011; 205:368.e1.
9. Society for Maternal-Fetal Medicine (SMFM), Einerson BD, Healy AJ, et al. Society for Maternal-Fetal Medicine Special Statement: Emergency checklist, planning worksheet, and system preparedness bundle for placenta accreta spectrum. Am J Obstet Gynecol 2024; 230:B2.
10. Vogel JP, Nguyen PY, Ramson J, et al. Effectiveness of care bundles for prevention and treatment of postpartum hemorrhage: a systematic review. Am J Obstet Gynecol 2024; 231:67.
11. Ladfors LV, Butwick A, Stephansson O. A validation of The California Maternal Quality Care Collaborative obstetric hemorrhage risk assessment tool in a Swedish population. Am J Obstet Gynecol MFM 2024; 6:101240.
12. Yoo KY, Lee JC, Yoon MH, et al. The effects of volatile anesthetics on spontaneous contractility of isolated human pregnant uterine muscle: a comparison among sevoflurane, desflurane, isoflurane, and halothane. Anesth Analg 2006; 103:443.
13. Thind AS, Turner RJ. In vitro effects of propofol on gravid human myometrium. Anaesth Intensive Care 2008; 36:802.
14. Shin YK, Kim YD, Collea JV. The effect of propofol on isolated human pregnant uterine muscle. Anesthesiology 1998; 89:105.
15. Kimizuka M, Tokinaga Y, Azumaguchi R, et al. Effects of anesthetic agents on contractions of the pregnant rat myometrium in vivo and in vitro. J Anesth 2021; 35:68.
16. Chandraharan E, Arulkumaran S. Acute tocolysis. Curr Opin Obstet Gynecol 2005; 17:151.
17. Peng AT, Gorman RS, Shulman SM, et al. Intravenous nitroglycerin for uterine relaxation in the postpartum patient with retained placenta. Anesthesiology 1989; 71:172.
18. Hong RW, Greenfield ML, Polley LS. Nitroglycerin for uterine inversion in the absence of placental fragments. Anesth Analg 2006; 103:511.
19. WOMAN Trial Collaborators. Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN): an international, randomised, double-blind, placebo-controlled trial. Lancet 2017; 389:2105.

20. Moran NF, Bishop DG, Fawcus S, et al. Tranexamic acid at cesarean delivery: drug-error deaths. Am J Obstet Gynecol 2023; 228:1.
21. FDA Alerts Healthcare Professionals About the Risk of Medication Errors with Tranexamic Acid Injection Resulting in Inadvertent Intrathecal (Spinal) Injection. U.S. Food & Drug Administration. https://www.fda.gov/drugs/drug-safety-and-availability/fda-alerts-healthcare-professionals-about-risk-medication-errors-tranexamic-acid-injection-resulting (Accessed on January 12, 2025).
22. Charbit B, Mandelbrot L, Samain E, et al. The decrease of fibrinogen is an early predictor of the severity of postpartum hemorrhage. J Thromb Haemost 2007; 5:266.
23. de Lloyd L, Bovington R, Kaye A, et al. Standard haemostatic tests following major obstetric haemorrhage. Int J Obstet Anesth 2011; 20:135.
24. Gayat E, Resche-Rigon M, Morel O, et al. Predictive factors of advanced interventional procedures in a multicentre severe postpartum haemorrhage study. Intensive Care Med 2011; 37:1816.
25. Cortet M, Deneux-Tharaux C, Dupont C, et al. Association between fibrinogen level and severity of postpartum haemorrhage: secondary analysis of a prospective trial. Br J Anaesth 2012; 108:984.
26. Collins PW, Lilley G, Bruynseels D, et al. Fibrin-based clot formation as an early and rapid biomarker for progression of postpartum hemorrhage: a prospective study. Blood 2014; 124:1727.
27. Snegovskikh D, Souza D, Walton Z, et al. Point-of-care viscoelastic testing improves the outcome of pregnancies complicated by severe postpartum hemorrhage. J Clin Anesth 2018; 44:50.
28. McNamara H, Kenyon C, Smith R, et al. Four years' experience of a ROTEM® -guided algorithm for treatment of coagulopathy in obstetric haemorrhage. Anaesthesia 2019; 74:984.
29. Collins PW, Bell SF, de Lloyd L, Collis RE. Management of postpartum haemorrhage: from research into practice, a narrative review of the literature and the Cardiff experience. Int J Obstet Anesth 2019; 37:106.
30. Tikkanen M, Paavonen J, Loukovaara M, Stefanovic V. Antenatal diagnosis of placenta accreta leads to reduced blood loss. Acta Obstet Gynecol Scand 2011; 90:1140.

31. Pri-Paz S, Fuchs KM, Gaddipati S, et al. Comparison between emergent and elective delivery in women with placenta accreta. J Matern Fetal Neonatal Med 2013; 26:1007.
32. Eller AG, Porter TF, Soisson P, Silver RM. Optimal management strategies for placenta accreta. BJOG 2009; 116:648.
33. O'Brien KL, Uhl L. How do we manage blood product support in the massively hemorrhaging obstetric patient? Transfusion 2016; 56:2165.
34. Nagy CJ, Wheeler AS, Archer TL. Acute normovolemic hemodilution, intraoperative cell salvage and PulseCO hemodynamic monitoring in a Jehovah's Witness with placenta percreta. Int J Obstet Anesth 2008; 17:159.
35. Lilker SJ, Meyer RA, Downey KN, Macarthur AJ. Anesthetic considerations for placenta accreta. Int J Obstet Anesth 2011; 20:288.
36. Chestnut DH, Dewan DM, Redick LF, et al. Anesthetic management for obstetric hysterectomy: a multi-institutional study. Anesthesiology 1989; 70:607.
37. Weiniger CF, Einav S, Deutsch L, et al. Outcomes of prospectively-collected consecutive cases of antenatal-suspected placenta accreta. Int J Obstet Anesth 2013; 22:273.
38. Weiniger CF, Elram T, Ginosar Y, et al. Anaesthetic management of placenta accreta: use of a pre-operative high and low suspicion classification. Anaesthesia 2005; 60:1079.
39. Nguyen-Lu N, Carvalho JC, Kingdom J, et al. Mode of anesthesia and clinical outcomes of patients undergoing Cesarean delivery for invasive placentation: a retrospective cohort study of 50 consecutive cases. Can J Anaesth 2016; 63:1233.
40. Taylor NJ, Russell R. Anaesthesia for abnormally invasive placenta: a single-institution case series. Int J Obstet Anesth 2017; 30:10.
41. Markley JC, Farber MK, Perlman NC, Carusi DA. Neuraxial Anesthesia During Cesarean Delivery for Placenta Previa With Suspected Morbidly Adherent Placenta: A Retrospective Analysis. Anesth Analg 2018; 127:930.
42. Herbert KA, Gatta LA, Fuller M, et al. Anesthetic management of placenta accreta spectrum at an academic center and a comparison of the combined spinal epidural with the double catheter technique: A retrospective study. J Clin Anesth 2022; 77:110573.

43. Jeffrey A, Clark V. The anaesthetic management of caesarean section in the interventional radiology suite. Curr Opin Anaesthesiol 2011; 24:439.

44. Clark A, Farber MK, Sviggum H, Camann W. Cesarean delivery in the hybrid operating suite: a promising new location for high-risk obstetric procedures. Anesth Analg 2013; 117:1187.

45. Sadashivaiah J, Wilson R, Thein A, et al. Role of prophylactic uterine artery balloon catheters in the management of women with suspected placenta accreta. Int J Obstet Anesth 2011; 20:282.

Topic 94367 Version 16.0

GRAPHICS

Blood product and extracorporeal procedure informed consent checklist

The following points can be documented:		
Discussed the risks and benefits of accepting blood product transfusion.		
Discussed the risks and benefits of NOT accepting blood product transfusion.		
Discussed the risks and benefits of extracorporeal circulatory and salvage techniques.		
Specify whether consent was obtained privately or with family members/others present.		
Patient understands that if clinically significant bleeding cannot be stopped, then the patient will eventually die.		
Patient is aware that blood product refusal may result in organ or tissue damage or even death.		
Patient adamantly refuses the blood component therapies indicated below, even if faced with death.		
Patient realizes that with these restrictions, the care team may be forced to proceed more quickly to definitive procedures that have a chanc of stopping the bleeding (bowel resection, cesarean delivery, hysterectomy, amputation, etc) (this is due to the lack of a blood "buffer" that enables the treating team to replace the blood lost during preliminary attempts at hemostasis).		
Patient understands that he or she may reverse these restrictions at ANY time and accept blood. If this occurs, the care team will abide by al patient privacy standards and not discuss the acceptance of blood products in front of family or clergy without patient consent.		
Patient was given the option to allow blood transfusion in extremis if two physicians agree that death is likely imminent.		
Another health care provider was present during the consent process or, alternatively, was present when the patient verbally acknowledged the summary of acceptable and unacceptable products and interventions.		
Patient acceptance (Yes) or refusal (No) of the following items can be documented:		
Allogenic human blood and blood components		
▪ Whole blood	☐ Yes	☐ No
▪ Red blood cells	☐ Yes	☐ No
▪ Plasma	☐ Yes	☐ No

▪ Platelets	☐ Yes	☐ No
▪ White blood cells (granulocytes)	☐ Yes	☐ No
▪ Blood from specific donor(s)	☐ Yes	☐ No
Human blood fractions and medications that contain human blood fractions		
▪ Cryoprecipitate	☐ Yes	☐ No
▪ Cryosupernatant ("cryo-poor plasma")	☐ Yes	☐ No
▪ Albumin	☐ Yes	☐ No
▪ Plasma protein fraction	☐ Yes	☐ No
▪ Human immunoglobulin (eg, Rh immune globulin, IVIG)	☐ Yes	☐ No
▪ Plasma-derived clotting factor concentrates (eg, fibrinogen, factor VIII [F8], factor IX [F9])	☐ Yes	☐ No
▪ Tissue adhesives/fibrin glue	☐ Yes	☐ No
Intravenous fluids and medications not derived from human blood		
▪ Hydroxyethyl starch (eg, hetastarch, pentastarch)	☐ Yes	☐ No
▪ Balanced salt solutions	☐ Yes	☐ No
▪ Recombinant clotting factor concentrates (eg, factor VIII [F8], factor IX [F9], recombinant activated factor VII [rFVIIa; rF7a])	☐ Yes	☐ No
▪ Recombinant erythropoietin	☐ Yes	☐ No
▪ Antifibrinolytic chemicals (eg, tranexamic acid, aminocaproic acid)	☐ Yes	☐ No
▪ Chemicals to improve clotting (eg, desmopressin [DDAVP], vitamin K)	☐ Yes	☐ No
Extracorporeal techniques for blood conservation or treatment		
▪ Intraoperative hemodilution	☐ Yes	☐ No

▪ Intraoperative blood salvage (cell saver)	☐ Yes	☐ No
▪ Autologous banked blood (self donation)	☐ Yes	☐ No
▪ Cardiopulmonary bypass	☐ Yes	☐ No
▪ Chest drainage autotransfusion	☐ Yes	☐ No
▪ Plasmapheresis	☐ Yes	☐ No
▪ Hemodialysis	☐ Yes	☐ No
▪ Other: _____	☐ Yes	☐ No

This information is for use with patients who desire to restrict the use of blood products. Refer to UpToDate for futher information regarding the management of a patient who declines blood transfusion.

IVIG: intravenous immune globulin.

Courtesy of Kendall P Crookston, MD.

Graphic 106229 Version 5.0

Potential interventions for treatment of postpartum hemorrhage

Pharmacologic interventions	
Drug	**Dosing**
Oxytocin (first-line)	10 to 40 units in 500 to 1000 mL normal saline infused at a rate sufficient to control atony or 5 to 10 units IM.
Tranexamic acid (adjunctive agent)	1 g (10 mL of a 100 mg/mL solution) is infused over 10 to 20 minutes; if bleeding persists after 30 minutes, a second 1 g dose is administered.
Ergots (second-line)	Methylergonovine 0.2 mg IM or ergonovine 0.2 mg IM every 2 to 4 hours.
Carboprost (second-line)	0.25 mg IM every 15 to 90 minutes up to 8 doses.
Misoprostol	400 to 800 mcg sublingually as a single dose. Most useful in settings where injectable uterotonics are unavailable or contraindicated (eg, hypertension, asthma)
Recombinant human factor VIIa (adjunctive agent)	50 to 100 mcg/kg. It is preferable to start with a low dose (40 or 60 mcg/kg). The dose may be repeated once in 15 to 30 minutes if there is no response. Additional doses are unlikely to be effective.

Surgical interventions

- Repair lacerations
- Curettage
- Uterine compression suture (eg, B-Lynch suture)
- Uterine artery ligation
- Utero-ovarian artery ligation or cross clamp
- Pelvic packing
- Uterine tourniquet
- Focal myometrial excision
- Use of fibrin glues and patches to cover areas of oozing and promote clotting
- Placement of figure 8 sutures or other hemostatic sutures directly into the placental bed
- Resuscitative endovascular balloon occlusion of the aorta (REBOA)
- Internal iliac artery (hypogastric artery) ligation
- Aortic/iliac artery compression

- Hysterectomy, supracervical
- Hysterectomy, total

Interventional endovascular procedures

- Selective arterial embolization
- Intermittent aortic balloon occlusion
- Common iliac artery balloon occlusion

Blood bank

- Packed red blood cells
- Platelets
- Fresh frozen plasma
- Cryoprecipitate

Nonsurgical interventions

- Uterine massage
- Intravenous fluids
- Intrauterine tamponade
  - Intrauterine balloon or alternative device (eg, bladder catheter bulb, Sengstaken-Blakemore tube)
  - Intrauterine vacuum
  - Uterine packing (eg, 4-inch gauge packing)

Consultations

- General surgery
- Trauma surgery
- Anesthesia team
- Interventional radiology
- Gynecologic oncology
- Urology

IM: intramuscular; IV: intravenous; kg: kilogram; mcg: micrograms.

Data from:

1. *Dahlke JD, Mendoz-Figueroa H, Maggio L, et al. Prevention and management of postpartum hemorrhage: a comparison of 4 national guidelines. Am J Obstet Gynecol 2015; 213.e1.*
2. *Bienstock JL, Ahizechukwu CE, Hueppchen NA. Postpartum hemorrhage. N Engl J Med 2021; 384:1635.*

Graphic 73412 Version 17.0

Overview of management of postpartum hemorrhage based on estimated blood loss and hemodynamic stability

The obstetrical provider should initiate a sequence of nonoperative and operative interventions for control of PPH and promptly assess the success or failure of each measure. Intervention is based, in part, on the severity of hemorrhage.

- Quantify blood loss.
- Initiate additional measures to control bleeding based on severity of obstetric hemorrhage.
  - Blood loss >500 mL and <1000 mL at vaginal delivery or >1000 mL and <1500 mL at cesarean delivery with ongoing excessive bleeding and/or mild tachycardia and/or hypotension.
    - Get help and notify obstetric hemorrhage team.
    - Continue to monitor vital signs and quantify blood loss.
    - Ensure intravenous access with a large gauge catheter(s).
    - Begin bimanual uterine massage.
    - Increase oxytocin flow rate (avoid direct intravenous injection of undiluted oxytocin).
    - Volume resuscitation, preferably with blood and blood products if bleeding is heavy and coagulopathy is imminent.
    - Give a second uterotonic (eg, methylergonovine, carboprost tromethamine).
    - Examine for lacerations, retained products of conception, uterine inversion, and other causes of bleeding. Consider bedside ultrasound of uterus. Treat as appropriate (eg, repair lacerations, curettage, reposition uterus, etc).
    - If cesarean delivery: Apply conservative surgical interventions to control bleeding (eg, uterine artery/ovarian artery ligation, uterine compression sutures).
  - Blood loss >1000 mL and <1500 mL at vaginal delivery or >1500 mL at cesarean delivery with ongoing excessive bleeding and/or hemodynamic instability.
    - Do all of the above.
    - Draw blood for baseline labs (complete blood count, coagulation studies) and clot observation test.
    - Insert intrauterine balloon for tamponade.
    - Transfuse two units packed red cells and one to two units fresh frozen plasma. Activate a massive transfusion protocol if bleeding is heavy and transfusion of four or more units of blood is likely.
    - If vaginal delivery: Move the patient to an operating room to perform conservative surgical interventions to control bleeding.
    - Consider selective arterial embolization only if patient is hemodynamically stable. This should preferably be performed in an operating room or hybrid suite if available. Bleeding patients should only be moved to a radiology suite for embolization if they

are hemodynamically stable and blood products are being replaced at a rate that can exceed that of the bleeding. Arterial embolization outside of an operating room is not an option in situations where there is catastrophic bleeding in a decompensating patient.

- If cesarean delivery: Continue to apply conservative surgical interventions to control bleeding (eg, uterine artery/ovarian artery ligation, uterine compression sutures).

- Blood loss >1500 mL, ongoing excessive bleeding, and hemodynamic instability despite initial therapy.
  - Initiate massive transfusion protocol (transfuse appropriate ratio of red cells, fresh frozen plasma/cryoprecipitate, and platelets).
  - If conservative surgical interventions are not successful, perform hysterectomy. Hysterectomy should not be delayed in women who require prompt control of uterine hemorrhage to prevent death.
  - Keep patient warm.
  - Treat acidosis.
  - Check ionized calcium and potassium levels every 15 minutes once a massive transfusion protocol has been initiated and treat hypocalcemia and hyperkalemia aggressively. Continue until the emergency has been contained and the protocol for massive transfusion has been stopped.
  - Maintain oxygen saturation >95%.

Graphic 104583 Version 2.0

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Conflict of interest policy

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